Tomohiko Sakao
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Editors

Introduction to Product/Service-System Design

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Foreword

During the last couple of decades, the increase in environmental knowledge available to engineers has helped them realize how critical design is for tackling environmental problems. As a result, the concept of ecodesign, a "front-of-the-pipe" approach, has obtained much attention.

Recently, the increase in holistic activities by engineers has received attention. One manifestation is enlarging the target to services as well as products; manufacturing companies traditionally focused on their physical products in the design or development phases. Another is manufacturing companies expanding their activities to the entire life-cycle, i.e. not only design/production/maintenance but also end-of-life treatment (e.g., reuse, remanufacture and recycle).

We find there are numerous opportunities for companies to face this movement. One dimension is economic; it is quite obvious that companies may have more diverse chances to earn money thanks to various types of services after (or before) products are designed. The other is environment, as they can generate and optimize solutions in a better way from a life-cycle perspective with a combination of products and services.

Therefore, we, the Swedish Association of Graduate Engineers, regard this as a strategically important area within engineering. As a result, we have awarded our environmental professorship (2007-2009) to this theme. We are happy to see this book published, as one of the outcomes of the professorship. It can be used as a textbook to study how to practice Product/Service System (PSS) design/development using various theories from different viewpoints.

It is our wish that engineers and managers in companies, as well as university students, will use this book to study how to design and develop PSS, and take further opportunities to learn and implement its practices. We believe this is one promising way that engineers in developed countries like Sweden can contribute to a better future in terms of environment and economy.

Peter Larsson

Head of Professional and Liaison Development
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Foreword

In both trade and industry, services like consulting, renting out equipment and maintenance have long existed. Consumer goods industries, such as the automobile or fashion industries, first began enriching their offers of physical products with services. Today, the manufacturing industries regard services as vitally important for improving market acceptance and market share in global competition. The concept of the Product/Service System (PSS), a combination of physical products and services, has increasingly gained attention and is growing into a dominating economic factor for many companies. Since the markets for many types of consumer goods are saturated, companies increasingly use services to differentiate themselves from competitors. Pre-use, use, and post-use services accompany the product on its life-cycle, and deliver benefit as well as increased value to customers.

Most PSSs in the market today are developed conventionally, adding services to an already existing physical product. This, of course, creates value, but the benefits for customers and producers mostly remain modest, since the full potential of integrated PSS development is seldom realized. In pursuing the classical route of designing products and subsequently adding services, businesses miss out on the potential to increase customer value by avoiding the repercussions from services on the properties of products and the way of designing them. In addition, current PSS development is carried out conventionally, which means intuitively and often more on a trial-and-error basis than with a structured approach. To design and develop PSS efficiently and effectively, the way companies design and develop must be changed.

Traditionally, design theories and methodologies were disseminated into industries primarily to address the creation of physical products. Originally concerned with the design of mechanical products, a second step of developing design methodology during the last decade was to widen the scope to include mechatronic products, and to give advice and support for design. Nowadays, a third step of evolution takes place in considering services as non-physical products fulfilling customer needs and wishes. Whereas former methodologies of service development were especially articulated in the economic sciences, the big challenge now is to treat services on an equal basis to physical products, and to step forward in creating a holistic design methodology for Product/Service-Systems. This brings new challenges, but at the same time there are great opportunities which have been demonstrated in several recently published case studies. However, it seems to me that attention on to this important issue is still insufficient, and the need for combined activity within a global network of researchers is obvious.

This book is devoted to design and development of PSS. The content is based on several workshops with an international group of researchers working on PSS methodology. The editors of this book, Dr. Tomohiko Sakao and Dr. Mattias Lindahl as well as other authors, are among the leading researchers who have been tackling challenges in this area.

It is my wish that this book contributes to disseminating knowledge and experiences in this area, especially into industry, to demonstrate the power of an integrated PSS approach and to support the development of PSS in practice. Besides that, the book should also drive further development of theories and methodologies in PSS research and practices in this important area.

Prof. Dr. h. c. Dr.-Ing. Herbert Birkhofer

Founding President of the Design Society
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Foreword

Allow me first to say that I am convinced that the improved understanding of the essential positioning and development techniques described in this book makes all who read it even slightly better, either in their daily tasks as an entrepreneur, as a researcher in the field, or as a consultant or someone otherwise involved in the development of their business.

For about a year I have had the privilege as a non-scientist to participate in a research project and work together with a number of researchers and company managers in pursuit of innovation for better business processes combining product and service sales.

There I found, and was fascinated by, the amazing power and dynamics of people-scientists and entrepreneurs-meeting in a group and working together with common problems and with the common intention of finding solutions. Doing this *together* definitely increases the usability of the presented findings and proposals.

With long experience from working with business development, especially for smaller companies, I think it's important to give them all the available support and all the available models and tools to improve their business. Increased understanding of their business status and market position also improves understanding of which way they should go to achieve better results.

Many companies and entrepreneurs are unsure of where they are actually positioned for the sale of products and services. There are many, understandably enough, that perceive themselves as producers and suppliers of clean artifacts, while their customers are to a large extent at least as interested-and willing to pay for-what they consider delivered around services.

This book takes up many interesting examples and models that can and should be advantageously used for the development of profitability and stability in the business-it is important.

Read it!

Ronny Mårtensson

CEO of Åtvidabergs Sparbank (Savings Bank)
Chairman of the Board at CAM, Centre for Applied
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Preface

Manufacturers in developed countries today regard service activities as increasingly important. Not surprisingly, some manufacturing firms are strategically shifting from "product seller" towards "service provider" (Oliva and Kallenberg 2003). One reason is the severe competition among hardware manufacturers; another is regarding services as critical value-added. Yet another reason, from the demand side, is the "servicification" of customers' activities, which in some cases means a shift from customers' owning physical products to getting access to the functionality of products. On the supply side, on the other hand, and parallel to the trend above, concepts such as Product/Service Systems (PSS) (Tukker and Tischner 2006; Mont 2002), Integrated Product Service Offering (IPSO) (Lindahl *et al.* 2006), and Functional Sales (Lindahl and Ölundh 2001) are already found, not only in theory, but also in industry. What these concepts have in common is that they comprise combinations of hardware and support services. It has also been argued that PSS has great potential for decreasing environmental impacts as well (Tukker 2004).

Importantly, service activity is beginning to be increasingly incorporated into the design space, an area which has been traditionally dominated by physical products in manufacturing industries. This has a great impact on the business in such companies. Fulfillling PSS design is a complex task, and may force companies to change development process, organizational structure and their mindsets along with PSS design. This issue is also relevant to service industries, as they often have power to develop the hardware utilized in their business offerings; developing a good combination of hardware and services is key in those cases.

In order to encourage industrial practitioners to consider or fulfilll PSS design/development, especially from an engineering viewpoint, this book will serve as a guide for learning the state-of-the-art in theory and practice. It will be useful as a textbook for university students for learning or researching this new and critical theme for industries today and tomorrow.

Introduced here are three dimensions of PSS design: *the offering*, *the provider*, and *the customer/user* dimensions based on (Sakao *et al.* 2009). The first dimension refers to both "product" and "service" elements of PSS. In addition, the other two dimensions, i.e. the provider and the receiver, are indispensable in addressing PSS.

The offering dimension addresses the elements and activities in the offering's life-cycle. It includes the lives of physical products being a part of the PSS, as well as service activities. Successful design of PSS depends on a thorough understanding of the solution life-cycle and active design of beneficial linkages with heterogeneous systems.

The customer/user dimension addresses the evolving needs of service receivers. It is crucial for the provider of services and products to be able to anticipate the receivers' reaction to new offerings.

The provider dimension addresses the evolution of product/service providers' organisation and operations. This covers such issues as the setup of development projects, organisational streamlining of the company towards service delivery and the identification of necessary partnerships for the successful operation of services.

In principle, any PSS design is supposed to address at least something on all three dimensions, since service includes activities of customers and providers, and since products are included. As such, these three dimensions are fundamental for PSS design. In addition, anticipating and utilising the dynamics along each dimension is crucial.

The remainder of the book is, with the three dimensions, structured as follows. Obviously, every chapter does not belong only to one of the themes; rather, each chapter belongs to the most relevant part.

Part I addresses the offering dimension

- **Chapter 1 PSS Layer Method - Application to Microenergy Systems**
  This chapter addresses three topics: a new method for developing Product-Service Systems (PSS), a commendable example to explain the theory of Product-Service Systems, and finally, sustainability as driver for Product-Service Systems and microenergy systems.
- **Chapter 2 Life-cycle Perspectives of Product/Service-Systems: In Design Theory**
  Besides presenting several considerations and theories for the different stages of the PSS life-cycle, this chapter elucidates how manufacturers can develop their PSS with a life-cycle perspective.
- **Chapter 3 Life-cycle Perspectives of Product/Service-Systems: Practical Design Experiences**
  This chapter elucidates how manufacturers have worked with, or could adapt their products for, Product/Service-Pystems. Several design improvements, all of which are fairly inexpensive and easy to implement, are described.
- **Chapter 4 Systematic Generation of PSS Concepts Using a Service CAD Tool**
  A systematic method and a computer-aided design tool to generate design concepts for integrated product/service offerings, or PSS, is presented with an example from the health care service industry.

- **Chapter 5 Value Creation in PSS Design through Product and Packaging Innovation Processes**
  This chapter reviews research on the integration between product and packaging development, and highlights some important challenges and opportunities related to improved value creation in the PSS paradigm.

Part II focuses on the customer dimension

- **Chapter 6 Service Engineering – Methods and Tools for Effective PSS Development**
  This chapter presents a design process model for services or service-oriented products based on Service Engineering. In addition, a method for evaluating service solutions is introduced along with a method for designing service activity and products concurrently and collaboratively.
- **Chapter 7 Addressing Uncertainty of PSS for Value-Chain Oriented Service Development**
  Based on a literature review which identifies uncertainty as a critical concept in PSS along with interviews conducted with nine Swedish companies, this chapter presents a simple tool for managing uncertainty when developing PSS offerings.
- **Chapter 8 Value Visualization Strategies for PSS Development**
  The concept of value visualization is concerned with the way that firms communicate and demonstrate the value of their PSS. This chapter presents a visualization strategy framework for PSS development.

Part III describes the provider dimension

- **Chapter 9 Using Company-Academia Networks for Improving Product/Service Systems at Large Companies**
  This chapter describes challenges faced by large PSS providers in Sweden when developing PSS offerings, and how these can be explored and discussed within a PSS company-academia network setting.
- **Chapter 10 Service-Oriented Strategies for Manufacturing Firms**
  PSS can be seen as a strategy for manufacturing firms to gain competitive advantage in the marketplace. This chapter establishes PSS approaches in the context of manufacturing firms, and presents a path for manufacturers to make the change from product to service-orientation.
- **Chapter 11 People, Product and Process Perspectives on Product/Service-System Development**
  In this chapter, the authors elaborate on product and service development processes models, as well as system models, to propose a frame of reference for multiple perspectives on PSS development.

- **Chapter 12 Managerial Recommendations for Service Innovations in Different Product-Service Systems**
  This chapter provides guidelines on how to develop service innovation, what phases of the development process to focus on, and how to involve customers throughout the development process.

Tomohiko Sakao
Mattias Lindahl

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Contents

Part I Offering Dimension

Chapter 1
PSS Layer Method – Application to Microenergy Systems

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Abstract Within this chapter three main topics are wrapped. First, a relatively new method for the development of Product-Service Systems (PSS) called PSS Layer Method is introduced. Second, microenergy systems are introduced as a commendable example to teach the theory of Product-Service Systems. Third, sustainability as a driver for Product-Service Systems and microenergy systems will be emphasized. All three topics are set in relation to an industrial case where the PSS layer method had been applied to a microenergy system which in this case is a solar home system. Such systems are used for energy supply in off-grid installations in rural regions, e.g., in weak infrastructures of developing countries. The reader will learn the basics of the PSS layer method, be introduced to microenergy systems and get an insight on a discussion on sustainability concerns in this case. The chapter closes with reflections on experiences, recommendations for an industrial application of the PSS layer method and an outlook.

Keywords Development of Product-Service Systems, Modelling of PSS Ideas and Concepts, Sustainability

1.1 Industrial Challenges

In a company implementing new mindsets, imparting new development methodologies, teaching developers in consistent method application and rolling out related business processes is tough business. Especially if more than one domain is involved and when each domain has its own particular approaches which are not directly compatible with others. As approaches for Product-Service System (PSS) development, viz. approaches for product-service integration, are relatively new to industry, those challenges will also become evident in this topic.

Furthermore, creative work in groups with members of different competencies in product development, marketing, management or business development lacks under differing terminologies and foci. Particularly in PSS development, a mixture of such competencies in early development phases is inevitable to generate innovative solutions. The design of a sustainable business model is type of a strategic task, whereas the design of the technical solution or enabler (core products, service resources and activities, deliverables, etc.) is type of an engineering task. Nevertheless, the business model and the technical solution have to complement and support each other appropriately to efficiently satisfy customer needs and sustainability requirements.

The PSS layer method is one of our approaches to facing such challenges. Briefly said, it integrates the views of customers, engineers and economists, it defines a common "language" and a simple, graphic modelling scheme. It is supposed to be applied mainly in early development phases to analyse and synthesize ideas and concepts of PSSs. It helps to generate requirements, to become aware of PSS functions and to derive tasks for further development.

1.2 From Product-Service Systems to Sustainable Microenergy Systems

1.2.1 Introduction to Product-Service Systems

Product-Service Systems (PSSs) is a concept that integrates products and services in one scope for planning, development and delivery, thus for the whole life-cycle. It is predominantly used in academia but widely unknown by industry. Nevertheless, solutions integrating products and services are attracting attention. Some providers consider themselves as solution providers who essentially offer solutions including products and services. For several years many research projects all over the globe have concentrated on product-service integration. Many terms with nearly equivalent meanings have been introduced into the PSS landscape from engineering, economic or social viewpoints. Close to PSS there are concepts like

"Service Engineering" (Tomiyama 2001, Lindahl *et al.* 2005, Bullinger and Scheer 2006), "Integrated Product Service Engineering" (Integrated Product Service Engineering 2009), "Functional Sales", "Functional Product Development" (Functional Product Development 2009) or "Industrial Product-Service Systems" (Transregio 29 2009). Furthermore, PSS have been linked tightly to sustainable development or eco-design, (McAloone and Andreasen 2004). As all those concepts are close to each other they are within the scope of this contribution and summarized under the concept of Product-Service Systems.

> The value provided by the concept of product-service systems is a broad, holistic view on technical systems by taking into account actors, technical artefacts, services, business models and drivers like sustainability and dematerialization. Constraining is the premise of providing added value to satisfy customer needs and to meet ecologic, economic and social requirements along the whole life-cycle of a product-service system.

Customer needs are not simply reduced to a single need for product ownership. The basic idea is not to sell products and services separately, but to sell a defined result, a system's availability or functionality to add value. The integration of products and services finally can maintain or enhance functionality of a product or a service or implement new functions which are not available without integration. To make this approach successful there is a need for long-term commitments within the stakeholder network. Specific business models (see Tukker 2004) are used to reach that aim and bound customers to their providers over long periods. Maintenance, system adoption to changing needs and boundary conditions, reconfiguration or upgrading can be part of a PSS business model. This requires the partial substitutability of products by services and vice versa. By contract, it is defined how risk, responsibilities and costs of an integrated delivery and operation of product and service shares are distributed among the stakeholders, (Steven *et al.* 2008). An important aim is a value co-creation among the stakeholders during the integrated delivery process. Supplemental systems and tools have to be taken into account to enable the delivery of products and services and the exchange of information. Fig. 1.1 illustrates in a simplified, minimal architecture the PSS core elements.

1.2.2 Introduction to Microenergy Systems as an Example of PSS

Microenergy systems have an interesting combination of strongly interlinked technical, economic, ecologic and social aspects, and thus they are a convenient PSS example. A microenergy system is a small decentralized energy conversion unit that meets the energy demand of households and small enterprises. Microenergy systems play a crucial role in regions with poor infrastructure and low incomes in developing countries where households and small enterprises often have insufficient access to modern energy services. These regions are denominated "Microenergy Sector" (Philipp and Kebir 2004). According to the World Bank, more than 1.6billion people lack access to electricity and 2.4billion rely on traditional biomass for cooking and heating (World Bank 2004).

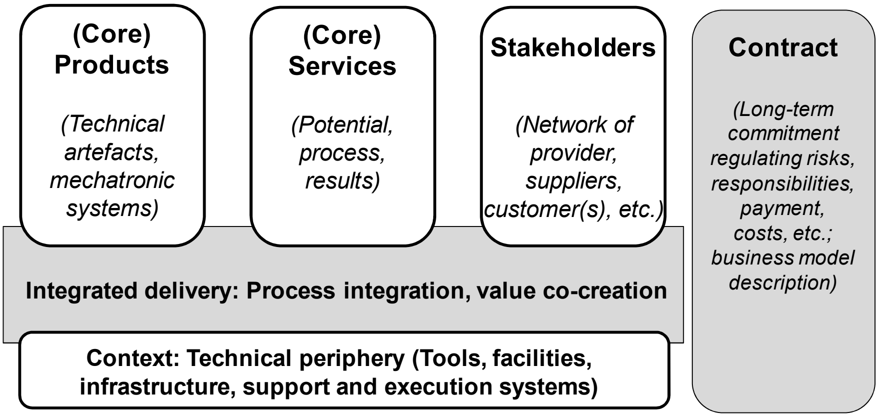

Fig. 1.1 Core elements of a product-service system (Müller and Stark 2008)

Several field and market studies have shown that a rise in trading with appliances using and converting energy takes place in the microenergy sector; in particular the demand for TVs, radios, kerosene cookers and petroleum lamps is tremendous. Diesel generators help to actuate pumps and supply small decentralized grids with electricity. With the help of accumulators, especially car batteries, electrical power is stored and transported to regions which are situated many miles away from the electricity source or the generator (Hammond *et al.* 2007, Schneider 2003). Fig. 1.2 shows a typical example of batteries and lamps used in rural households. Fig. 1.3 gives insight into a battery shop.

SME and households are facing increasing energy costs. In certain regions, they can reach up to half of the monetary monthly income. The usual inefficient microenergy systems can reach costs up to 1.50 € per kWh (compared to an average of 0.20 € per kWh in a European context), and thus offer a great economic substitution potential for modern energy systems which are more efficient and can be run with renewable energy (Schneider 2003, Philipp and Kebir 2004). Thus, running costs for fuel can be decreased or eradicated completely. The result is recourse savings, higher productivity and a range of indirect economic impacts on health and education of the users. Furthermore, quality of life increasingly becomes tangible. All these results and impacts will be discussed later in detail.

In most cases, efficient microenergy systems have higher investment costs than common technologies and therefore often require financing options, e.g., based on micro credits. The savings customers make on running costs and the additional income they earn due to higher productivity can both be used to refinance the loan. Furthermore, there is a need for services accompanying installation, maintenance, etc. Businesses with microenergy systems require such services to become efficient, those systems can be considered as product-service systems.

Fig. 1.2 Example of a battery and petroleum lamp in a rural household

Fig. 1.3 Example of battery types offered in a battery shop

The example discussed in this chapter is a solar home system (SHS)–an efficient microenergy system that is based on photovoltaic technogoly: a technology that converts solar energy into electricity. The photovoltaic cell panels are fixed on the roof of a customer's house. During sunshine, they load an accumulator. The stored energy is used to run lights and several small electrical applications like TVs and radios. Fig. 1.4 shows an example of the installation of a solar panel which belongs to a solar home system. Fig. 1.5 shows a typical situation where components of a solar home system are being transported on a bike.

Fig. 1.4 Example of the installation of a solar panel on a roof

Fig. 1.5 Typical situation where components of a solar home system are transported on a bike

1.2.3 Introduction to Sustainability

Although PSS has a historical background in eco-design (McAloone and Andreasen 2004) a PSS is not automatically sustainable; but, as it will be shown in the following example, the PSS approach can be very helpful to describe and design a system with requirements toward sustainability (Tukker 2004).

According to the 1987 report of the World Commission on Environment and Development to the United Nations Assembly, sustainability is defined as development which meets the needs of today's generation without compromising the ability of future generations to meet their own needs (World Commission on Environment and Development 1987). In order to develop sustainable solutions in that sense, three dimensions have to be taken into account and also be aligned (e.g., Deutscher Bundestag 1998, Finkbeiner 2007):

- The *ecologic dimension* includes the protection of natural resources such as climate, soil, water and air, but also the diversity of species and ecosystems. The ecological sustainability of products and processes depends on their emissions and resource consumption during the entire life-cycle.
- The *economic dimension* means to evaluate the increase of the economy and the long term welfare, security and prosperity of the society. An essential objective is safeguarding the market functions as, for example, competitiveness.
- The *social dimension* requires the evaluation of lifestyles to leave future generations opportunities to satisfy their own needs and the fairness of distribution systems.

For this purpose, it is crucial to evaluate PSS by these three dimensions. Nevertheless, the three dimensions are not directly applicable as design dimensions for products, services or processes as system properties and characteristics are not directly expressed by them. Designers concentrate on system characteristics and properties such as power consumption in standby mode or frequency of battery exchange which can be more or less sustainable depending on a use process and on the comparison scale. Finally, these three dimensions can be applied to an “assessment-for-sustainability” rather than to a “design-for-sustainability”. Thus, in our case, we assess the sustainability of the solar home system investigated by reflecting relevant system properties and characteristics on the three dimensions of sustainability.

1.3 The PSS Layer Method

The theoretical basis of the PSS layer method is explained in this section. In Sect. 1.4, a detailed description is given accompanied by the application case solar home systems of the company MicroEnergy International (MEI) in Tanzania. The application case delivers concise insight into our findings.

1.3.1 Purpose and Use

The PSS layer method is supposed to be applied mainly in early development phases, thus its purpose is supporting the clarification of the design task and the conceptual design phase according to the terminology of Pahl *et al.* (2007), see Fig. 1.10. It is a method to analyse and synthesise PSS ideas and concepts.

The method has a discursive bias; it proceeds stepwise and iteratively, and enables a structured documentation of an existing or a future PSS. It defines a meta-model of nine main element classes for a PSS.

As a result the user gets a structured outline and the “big picture” of his PSS idea or concept. This big picture helps to hightlight requirements and tasks for the PSS design.

1.3.2 How it Works

1.3.2.1 Main Classes

As mentioned, nine main classes have been defined. The central class is the *Life-cycle activities* class. Activities performed by a customer and/or provider are mapped horizontally along the timeline on a layer for this class. Activities can be part of the product use or product and service provision. The classes *Needs* and *Values* are used to represent the customer’s perspective. The class *Deliverables* summarizes all material and immaterial results (information, products, materials, health improvement, etc.) provided to the customer during an activity. The designer’s view, or the particular “technical solution” to satisfy the customer needs, is represented by a whole set of classes, namely *Actors*, *Core products*, *Periphery*, *Contract* and *Finance*. These classes contain basic elements which are related to the life-cycle activities as types of resources and boundary conditions and thus are important to implement the future PSS. Vertically all elements which “belong” to one activity of the life-cycle activities class are interconnected. Finally, activities are kinds of connectors of resources which result in deliverables.

1.3.2.2 Modelling of Class Elements in Layers

All classes are graphically layered to simplify the representation; this is where the method derives its name; see Fig. 1.7. Each layer has to be filled by simple scratches, models or text in order to model single elements of the particular class. The layer scheme can be used as a whiteboard method, paper-based or with computer support.

If a technical artefact is chosen as a starting point, its product context (vertical dimension) is analyzed over life-cycle perspectives (horizontal dimension) in detail. If a customer need is chosen as the starting point, the designer can define new system elements on each layer in order to satisfy that need. System elements which have direct connections are mapped vertically one above the other. Already detected or determined system elements can help to identify other system characteristics which have to be detailed in the form of infrastructure or resources or which have to be ensured in the contract. The layers can be used to elaborate on single phases/episodes of the PSS life-cycle, if not on the whole life-cycle.

In principle, the order of the layers is not important, although the ordering in Fig. 1.7 is recommended. The designer may reorder them or even add new optional layers to bring in new points of interest. For instance, the costs might be a good example. Fig. 1.6, Fig. 1.8 and Fig. 1.9 show filled layers and particular details.

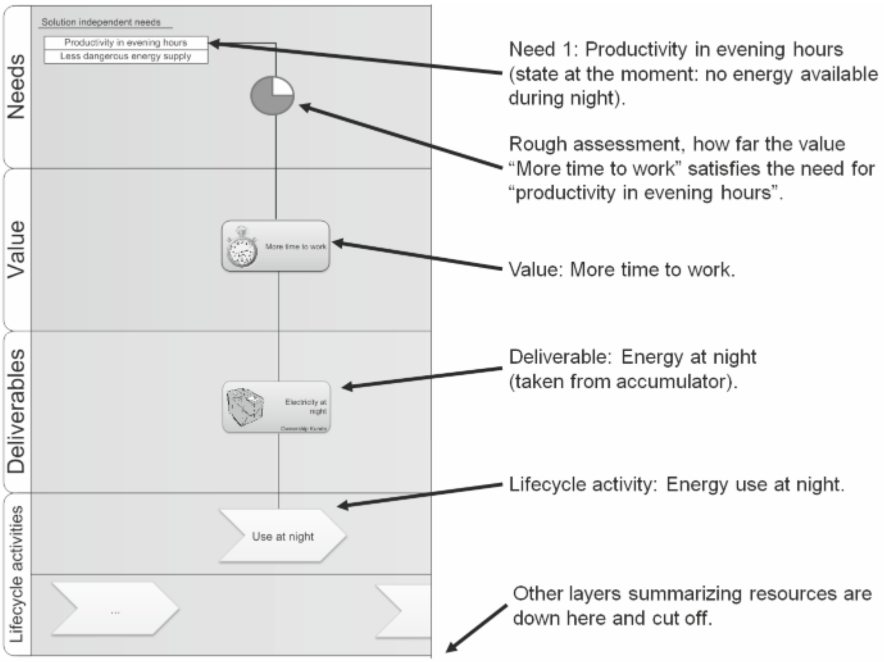

Fig. 1.6 Reduced layer scheme and element number to illustrate how needs and values are used to assess a deliverable. A software toolbox for Microsoft Visio has been implemented to create layer plots with predefined symbol sets for each layer class

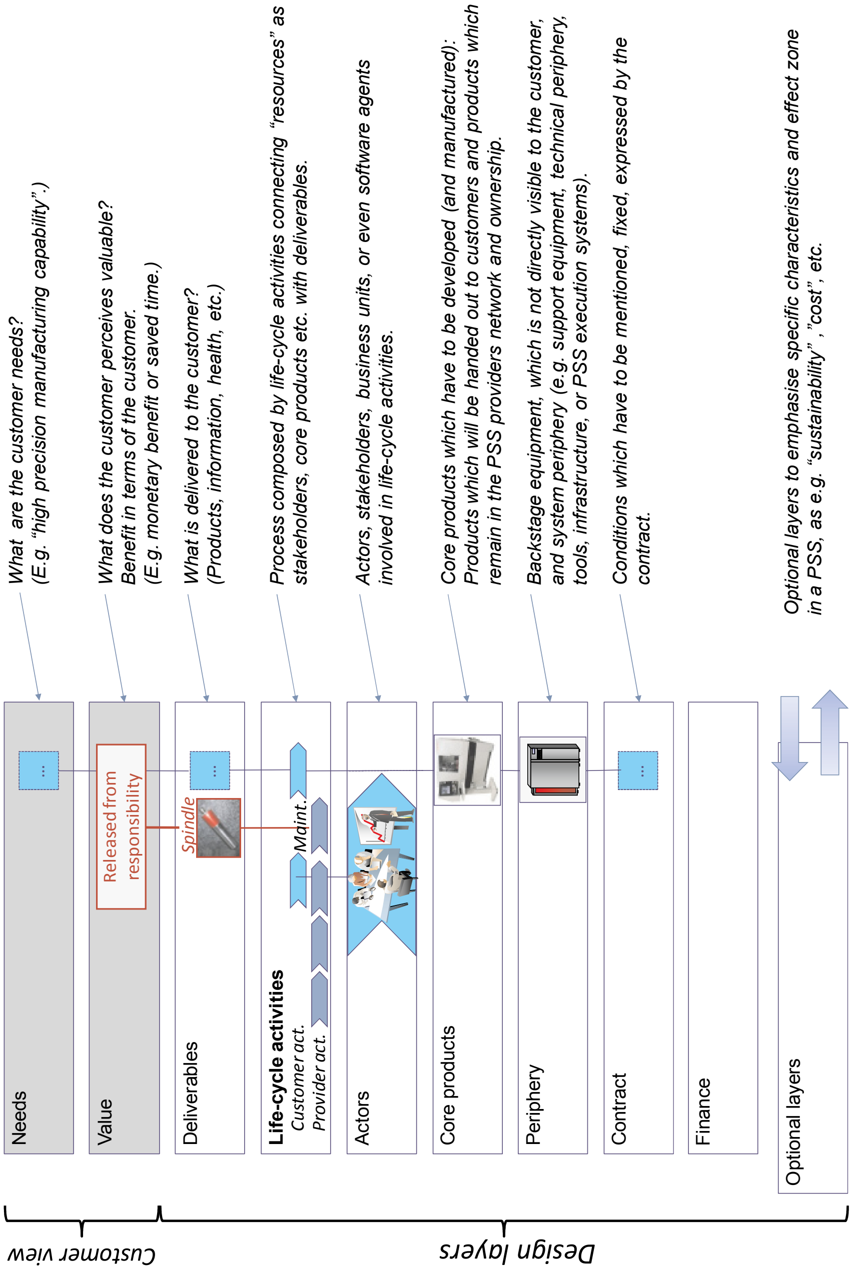

Fig. 1.7 Modelling scheme of the Layer Method. The example indicates elements of a PSS manufacturing system where the provider carries the responsibility for maintaining a rotating spindle; details have been left out.

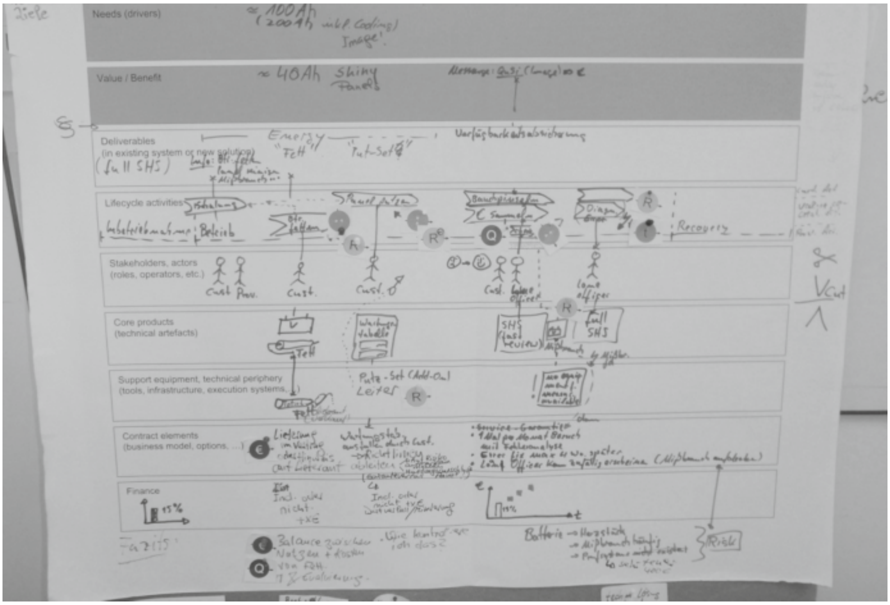

Fig. 1.8 Picture from an earlier layer version used during a workshop on solar home systems. The layer names in this version were changed later. The starting point was the solar panel; needs and values were modelled later. Several of these DIN A1 sheets have been filled

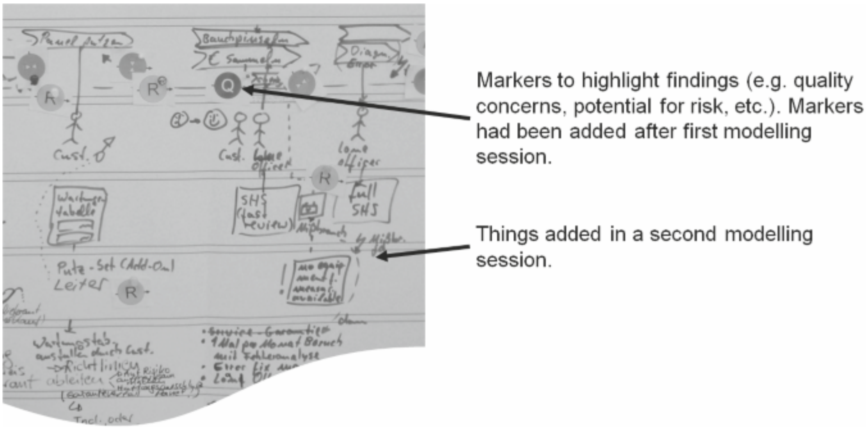

Fig. 1.9 Cut-out of Fig. 1.8 to highlight some details. For each modeling session different colors were used. Between different sessions removable markers were used to highlight findings

1.3.2.3 Remarks on the Representation of Services

The services are not directly modelled. The PSS is interpreted as a process or an activity chain which leads to (added) value.

According to (Bullinger and Scheer 2006 after Hilke) services are built in three dimensions: The result dimension, the process dimension, and the potential dimension. The first dimension defines the outcome of a service which is analogue to the deliverable in this PSS modelling approach. The second dimension has its analogy in the life-cycle activities layer. The third is represented by all other layers in the designer perspective. Even core products, infrastructure or contracts are interpreted as a type of resource and analogue to the potential dimension.

1.3.2.4 Application Process

For an effective use of the method for PSS planning and concept design it is important to have all prerequisites collated. Information on the customer point of view, the market and the company's strategy should be available. This is important to decide whether to design a solution to satisfy customer needs, to evaluate a solution in terms of customer value and, for example, to make robust make-or-buy decisions for product and service development and delivery. Therefore, a phase for the collation of prerequisites is included in Fig. 1.10.

Accompanying the modelling detected requirements, important system functions and new development tasks should be written down for later deployment.

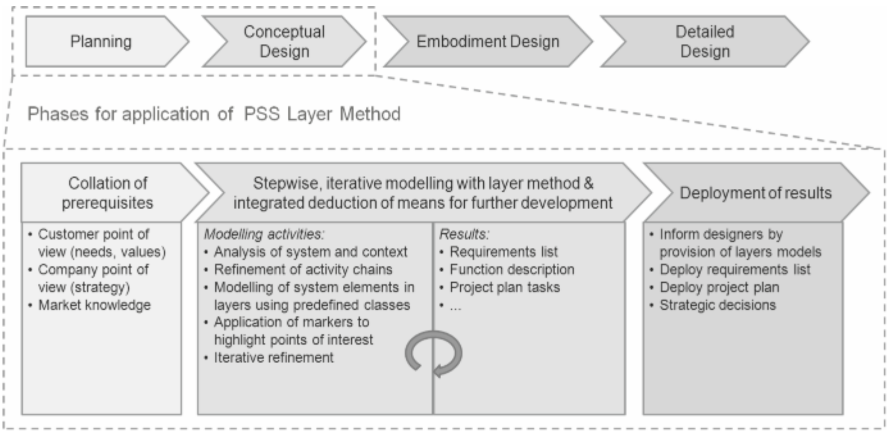

Fig. 1.10 Integration of the PSS Layer Method in generic development process phases

In general the process in Fig. 1.10 is valid for the following cases:

- Development of a new PSS (starting at customer needs)
- Transformation of a product into a PSS (starting with a product)
- Assessment and improvement of a system (product or PSS)

Depending on the case the modelling iterations may differ.

1.4 Industrial Application Case in Detail – The Solar Home System of MicroEnergy International

The industrial case that has been chosen for the study is about the PSS offered by MEI in Tanzania. MEI, a company with headquarters in Germany supports access to microenergy systems through microfinance in several countries in Asia and Africa. The intention during the study was to improve products and services around a solar home system (SHS) implementation.

Since 2005 was declared to be the United Nations Year of Microfinance, Muhammed Yunus and the Grameen Bank got the Nobel Price for Peace in 2006 and microfinancing became well known as a successful tool to reach the poor in regions with weak infrastructure and low incomes (Yunus 2003).

Microfinance is not only an instrument that splits high investment costs into affordable monthly instalments, it is offered through microfinance institutions (MFI) that entertain a whole network with close relationships to their customers. Credit clients have to be assessed, credits have to be disbursed, instalments have to be collected and failures have to be followed up and, in the last case, guarantees have to be recovered.

MEI works closely with microfinance institutions, using their local knowledge and action network for the dissemination of microenergy systems. In Tanzania, MEI cooperates with a local microfinance institution in Kyela, a small town in the south of the country.

The pure investigation about the PSS of MEI consumed time of four full work days plus time for preparations and post-processing. The participants had an engineering background and different roles in the company. This investigation was done in various meetings under application of the PSS Layer Method. The aim was to clarify development tasks to enhance the originally planned business model including the solar system, micro credits and service provision.

1.4.1 Collation of Prerequisites

1.4.1.1 Introducing the Customers Point of View

To apply the method successfully some information on the context of the company and the customers has to be available or collected beforehand, see Fig. 1.10. Customer needs, for instance, should be clarified e.g., by market analyses. Some lead questions are as follows:

Who is my customer?

In Tanzania, MEI cooperates with local MFIs – their clients are the potential customers for the PSS.

Where is my customer? How many customers are there?

The pilot project is realized in Kyela, a small town in the south of the country. The 600 clients of that MFI are mainly cocoa farmers. They live in surrounding villages that are not connected to the electricity grid.

How can we reach our customer(s)?

These farmers are not only getting loans but also training and trading facilities for their products. They are organized in councils of 15 to 50 members. Once a month, staff of the MFI meet the councils, collect the instalments and distribute new loans. Furthermore, the councils report to the staff their specific needs for the development of their livelihood and business situation. The council meetings are a good opportunity to reach the potential customers with marketing, financing and educational activities. For installation and service activities on the solar home system, customers will have to be visited personally by motorcycles.

Acceptance of technology?

During earlier council meetings, the farmers came up with their need for electricity; especially the need to run electrical light, radio, TV, fridges and irons. Some of them had heard of solar systems and asked their MFI for support to get and finance them. To meet this request, the MFI started to look for a partner specialized in the field of rural energy supply and in this way approached MEI. Both cooperate today in a joint-venture company.

MEI proposed to start by implementing solar home systems. They are considered to be simple technology. Furthermore, they are already proven in the field; although a solar home system does not fulfilll all the needs of the customers, for instance refrigeration and ironing are not possible.

Some of the clients already operate car batteries as electricity storage and use it to run radios or TVs. For this purpose they already had some DC-wiring in their house. In this way, an important part of the solar home system technology is already known to them. New, is the solar panel, and the fact that the battery becomes a stationary accumulator. They do not have to remove it anymore for recharging. This is done automatically by the panel if the sun shines.

Willingness and ability to pay of potential customers?

The solar home system, depending on its size, costs between 350 and 800 €. MEI will offer a financing opportunity. Clients can choose to repay the loan over 12 or 18 months.

After a first marketing activity, 36 clients have applied for a loan to get a solar home system. After an internal assessment, the MFI identified 16 of them as having the ability to pay the loan back in 12 to 18 months.

Based on former experiences (Philipp and Kebir 2004), it is assumed that the applications will increase once some systems are installed and people can experience that these systems work.

The quality of the market research plays a crucial role in PSS development. Too many assumptions and missing knowledge about the customer can lead to wrong designs of product and services. A discussion on the customer's point of view can help to sensitize the designers regarding some points of view and may require further investigations before taking the last decision on product or service performance. This process can already be used to define "tasks" for the company.

1.4.1.2 The Company Point of View – Targets and Philosophy

The designers should also be aware of company targets (short, medium, long term) to apply the model successfully. This prerequisite is considered to be essential in product, service or PSS development and thus hopefully available in firms.

In the case of MEI, a short-term target is to prove the viability of the technology by a successful implementation of the first 16 solar home systems. A medium-term company target is fulfillling the remaining identified customer needs (using their energy systems for refrigeration and ironing). This is part of the strategic business plan and requires further product development activities. On a longer term all kinds of technical products and services will be offered. The long-term relationship to the customer that is developed during the repayment phase of the loan is very specific to the business model: it is not only about selling goods, but about developing a commercial infrastructure through regular services in a new, almost untouched market.

Although MEI is a for-profit-company, it considers itself as a social enterprise (Yunus 2008). The focus is to maximize the social and not the financial profit. At the same time, the project must be economically sustainable. Generated profits are reinvested to grow and develop the business.

1.4.2 Stepwise, Iterative Modelling – Detailed Discussion on Layer Classes and Modelling Results

1.4.2.1 Class "Needs" (Customer Perspective)

Description

This layer summarizes customer needs. The idea is to capture non-solution-oriented needs, for instance the need for access to broadcast information. Nevertheless, some needs will be solution- or context-related, for instance, the need to operate TV and radio with a solar home system. This layer does not contain requirements, which describe how a system function has to be designed; cp. (Ericson *et al.* 2009). The needs can be summarized, based on the outcomes of the prerequisites.

Discussion of the Class "Needs" of the Customers of MEI

The assessment regarding customer needs done by MEI have been solution-oriented. Customers want to run with their energy system lights, TV, radio, ironing and refrigerator. The non-solution-oriented needs can only be assumed as need for high social status, high quality of life, access to information, entertainment and education and the need for enablers to generate income in the evenings and early mornings.

1.4.2.2 Class "Values" (Customer Perspective)

Description

The customer value is equal to the benefit a customer gains by a deliverable. From an economic viewpoint, the value can be reduced to monetary measures in the end, but a differentiation is helpful to show differences in how PSS ideas and concepts work. The major four types of benefits are economic, environmental, social and technical benefits. Less precisely defined benefits are information and knowledge advantages, saved time or time advantage, health preservation or enhancement, prestige, measures for process robustness, agility, flexibility, etc. Briefly, the realization of competitive advantages by state protection and enhancement belong to this layer.

Discussion of the Class "Values" for the PSS of MEI

The value and benefit customers expect from a solar home system are summarized in the following:

- Economic aspects: after repaying all the instalments, customers start saving money due to the substitution of kerosene and battery recharging.
- Environmental aspects: the environmental aspect from the customer's point of view is more a security and sanitary aspect. In the case of solar home systems, the value they expect is mainly avoiding the risk of fires and dangerous inhalation of evaporated kerosene.
- Social aspects: a solar home system is an expensive technology. Due to the solar panel which is installed on the roof, it is very visible and considered as a status symbol. Furthermore, it facilitates social interaction at night, information and entertainment.
- Technical aspects: customers are getting a professional electrical installation in their houses. The solar home system is more reliable and robust than the technology that was used before. The product warranty and the service assure a long-term use of the product.

1.4.2.3 Class "Deliverables"

Description

Deliverables is what the PSS provider delivers to its customer. Deliverables can be material or immaterial. Technical artefacts, software, information, knowledge or "health" are the main deliverables. It is important, that a deliverable is a result of an activity or an activity chain, which can be interpreted as part of a service or business process. Not every deliverable has value for a customer. For instance, the delivery of out-dated information might be counter-productive for a customer. Thus it is important to differentiate between deliverables and customer values. (This layer correlates with the result dimension of services.)

Discussion of the Class "Deliverables" for the PSS of MEI

In the case of the PSS of MEI, some deliverables were already determined:

- The solar home system, a technology that will partly fulfilll electricity-related needs
- The installation of the system, including the wiring in the house

- The training to learn about how the system operates, the opportunities it opens and the limitations it has
- A financing facility: a solar loan that can be repaid in 12 or 18 months
- During financing time, the customer gets a service guaranty: once a month, when the solar loan officer comes to collect the instalment, he will look after the system, maintain it if something does not work or exchange a spare part
- All components of the solar home system have a guaranty of at least 18 months

1.4.2.4 Class "Life-cycle Activities" (Designer Perspective)

Description

This layer contains activities performed by the PSS provider and/or the customer. Activity chains result in deliverables which are supposed to have value for the customer (and of course for the PSS provider). Sometimes it can also be used to change or optimise already existing deliverables. The working principle behind this layer is comparable to process modelling or service blueprinting. (This layer correlates with the process dimension of services.)

Discussion of the Class "Life-cycle Activities" for the PSS of MEI

Figure 1.11 shows the general life-cycle of a solar home system and the related financing mechanisms.

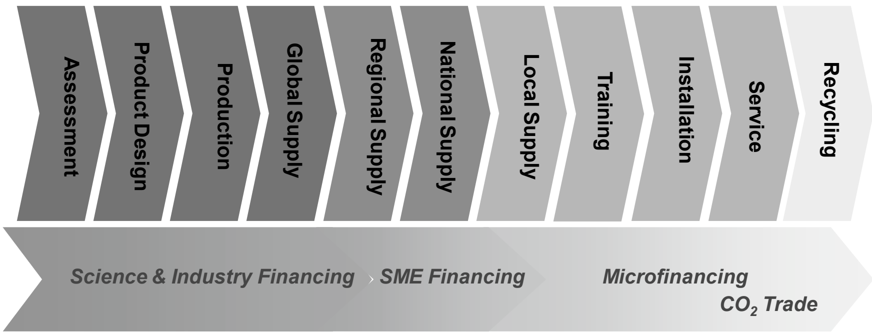

Fig. 1.11 General life-cycle of a solar home system

The financing along the life-cycle is already a first hint for the location and the different institutional forms of the involved stakeholders. For the development of the product-service system in Tanzania, the last phase, which is dominated by microfinancing, is the most interesting one. Following is a more detailed overview of the local phase that is operated by the MEI, see Fig. 1.12.

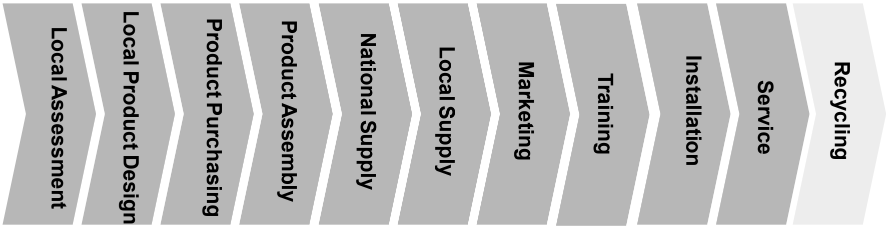

Fig. 1.12 Tanzanian life-cycle phases

The detailed product development process with the layer method required to pick out an even more detailed phase. During the workshop, the "using phase" was chosen, see Fig. 1.13.

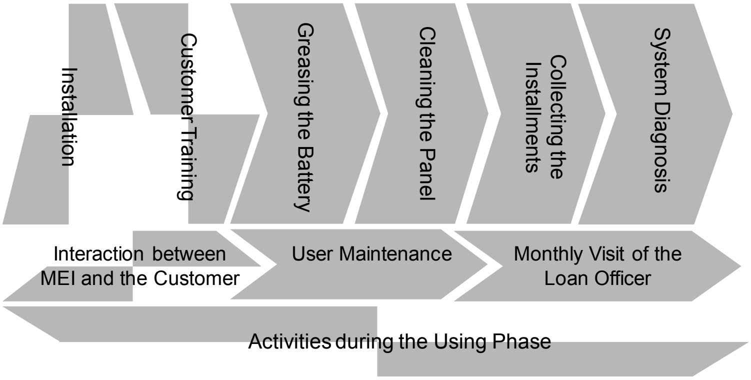

Fig. 1.13 Activities during the using phase

The phases "User Maintenance" and the "Monthly Visit of the Loan Officer", who are both parts of the "using phase", have been discussed in detail. The last one is even more detailed as Fig. 1.14 shows.

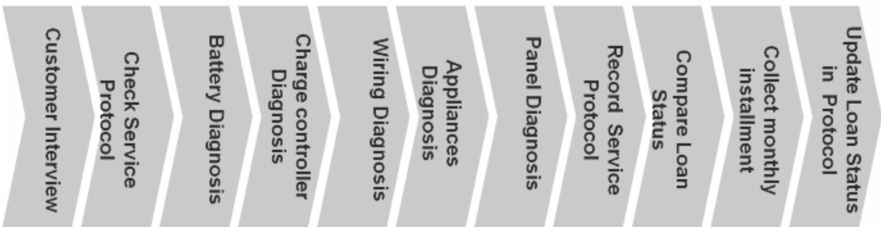

Fig. 1.14 Detailed activities during the monthly visit of the loan officer

1.4.2.5 Class "Actors" (Designer Perspective)

Description

Single actors (players), stakeholders, enterprises and enterprise units or divisions as well as even software agents are classified as actors. Actors participate in activities and they have an aim and a perception of delivered values. Software agents also have aims and interaction although they are not physical. To allow software agents to be actors might be important in case of replacing a manual executed service by a technical artefact communicating with a provider agent platform.

Discussion of the Class "Actors" for the PSS of MEI

Although a lot of actors are involved during the whole life-cycle of the Product-Service-System in Tanzania, only two have been identified being relevant during the "Using Phase":

- First, the client or one of his household members representing him. Second, the solar loan officer, a technician that has been trained in microfinance methodologies. He has to check the different technical components of the system and to collect the instalment.
- If the solar loan officer finds out during his monthly visit that there is a problem with the solar panel, it can happen that a third actor, able to climb on the roof, is required. This needs to be a man, as it is not usual in that cultural context to leave this kind of task to a woman.

1.4.2.6 Class "Core Products" (Designer Perspective)

Description

Products which have to be designed or at least offered in a package by the PSS provider are attached in this layer. The most important aspect of such core products is that they have high relevance for the final PSS value generation. Products, which have to be designed, adopted or configured viz. those where engineering tasks have to be performed by the PSS provider (network), are modelled within this layer.

Discussion of the Class "Core Products" for MEI

The core product is the solar home system consists of:

- A solar photovoltaic panel that converts solar radiation to electricity.

- A rechargeable battery (accumulator) used as storage allowing the use of electricity for 4h per day.
- A charge controller, installed between panel, accumulator and loads.
- Appliances: in general, loads consist of a few lamps and sometimes also a radio or a TV.

All components are connected through DC wiring. Specific to solar home system is their modular structure. This makes installation, maintenance and handling easy – even users and technicians with rudimental education can manage it after short training. The accumulator is the most sensitive component. It is the limiting factor as it is storing the electricity and misuse is quite easy. Fig. 1.15 shows all components of a solar home system.

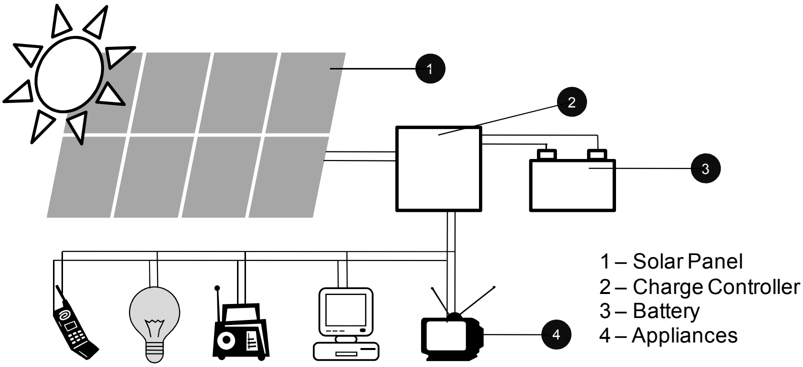

Fig. 1.15 Components of a solar home system

1.4.2.7 Class "Periphery" (Designer Perspective)

Description

Support equipment, technical periphery, tools, infrastructure, or PSS execution systems which are type of platform, outer condition, support or constraint for the PSS delivery should be captured on this layer.

Discussion of the Class "Periphery" of the PSS of MEI

Additional support equipment for the "User Maintenance Phase" has been identified. Some tasks for the company are derived:

- The clients have to grease the accumulator regularly.
  Task 1: If grease is not sold in the village, MEI has to assure access and provide it.

- If there is too much dust on the solar panel it loses capacity. For this reason, the user has to clean it regularly. For this purpose, he needs a ladder to access the roof. He also needs a cleaning set to avoid damaging the glass of the panel.
  Task 2: MEI has to make sure a ladder is available in the house of the customer or in the house of one of his neighbours.
  Task 3: MEI has to provide the cleaning set.

Also during the "Monthly Visit" equipment and related tasks for the company have been identified:

- For quality control purposes, MEI has to make sure that the solar loan officer checks all the components.
  Task 4: A maintenance check list has to be developed. It should be part of a customer card that stays at the client's house – after every check customer and loan officer have both to sign.
- MEI has to make sure that the solar loan officer is equipped with required measurement and maintenance tools. A challenge is to check the status of the accumulator and to make sure that it not misused, for example by connecting other loads or by using it more than 4h per day. Most existing tools require a whole laboratory which is not transportable during monthly visits and too expensive to be installed in the Kyela branch.
  Task 5: A manual for the loan officer, where possible failures and troubleshooting strategies are described has to be developed.
  Task 6: Find a solution for how to check the status of the accumulator under the given conditions.
- To check the panel on the roof, a ladder is again required.
  Task: Same as task 2.

1.4.2.8 Class "Contract" (Designer Perspective)

Description

As the contract is one basic element of the product-service system, remarks on the contract design should be made early to detail out the business model. Examples are the implementation of obligation, options, exception handling, duration, fines, regulations of payment, take-back conditions, warranty, transfer of ownership, responsibilities, etc.

Discussion of the Class "Contract" for the PSS of MEI

The discussion of the class "Periphery" has already been very helpful for the development of important elements of the contract between MEI and the customer:

- MEI has to provide grease and a cleaning set for the "User Maintenance" tasks.

- The “customer card” with the “maintenance check list” that has to be signed by customer and solar loan officer after every monthly visit is an important element to record the service guaranty activities during the loan repayment period.
- If the solar loan officer registers any kind of misuse of the accumulator, the customer loses the service and product guaranty.
  Task 7: The solution looked at in Task 6 “Find a solution for how to check the status of the accumulator under the given conditions” should also include a possibility to prove the misuse towards a third party.
- As long as there is no other solution to check if the accumulator has been misused, the solar loan officer has the right to look after the system any time he wants. This regulation stays in place as long as the solar home system is not completely repaid and it is still remaining in the ownership of MEI.

1.4.2.9 Class “Finance” (Designer Perspective)

Description

This layer shows when a customer is paying for deliverable(s) and how much. For instance flat rates, pre-paid, scheduled incremental payment, or payment on tickets may be possible entries. One way to model that can be simple bar charts.

Discussion of the Class “Finance” for the PSS of MEI

The “using phase” that was discussed in the workshop correlates with the “Microfinancing Phase” as shown in Fig. 1.13. Before the installation of the system, the customer has already paid a down payment of 15% to MEI. During the “using phase”, the solar loan officer collects the monthly installments and services the system as described. In this way, the customer feels the direct impact of his payments.

1.4.2.10 Class “Optional” (Designer Perspective)

Description

If there is a need to consider some special design aspects or a specific entrepreneurial view the Layer Scheme can easily be extended by layers like *Cost drivers*, *Quality* or *Law*. In the case of the PSS of MEI, the additional layer *Cost* has been used.

Discussion of the Class "Costs" of the PSS of MEI

The new tasks identified during the workshop, as, for example, providing grease and a cleaning set, are creating new costs or the development and implementation of a new solution to check and control the accumulator. On the other hand, these activities are assuring the sustainability of the system and minimizing the risks of failures.
Task 8: The new cost structure has to be integrated in the price calculation of the system.

1.5 Evaluation of the Sustainability of the System

A solar home system has a huge potential in terms of sustainability. But the deployment of these potentials is highly dependent from the implementation strategy and the business model, as discussed in the following paragraphs.

Ecologic Dimension

The use of solar energy and saving fossil fuels helps to protect natural resources. Nevertheless, accumulators are another crucial point. Without assuring a recycling procedure in the business plan, they can create a serious ecologic problem due to the acid and lead stored inside.
Task 9: Develop a recycling system for used accumulators and adapted incentives for customers.

Economic Dimension

In the long term, saving fossil fuels and developing an energy sector based on renewable energies will secure the prosperity of all societies (Scheer 2006). Still, one of the main components of the solar home system, the accumulator, consists of lead which is a limited natural resource. But while lead is recyclable, petrol, once burned, cannot be reused.

In the actual Tanzanian context, the only competition MEI is exposed to, are the retailers of fossil fuels like kerosene. But with the development of the infrastructure, the training of local technicians and the development of the market, other competitors will start offering systems as well. This development has already been seen in the Bangladesh context (Infrastructure Development Company Limited 2007).

Because the market is very small, the actual prices of the components of solar home systems are still very high. Also, here a growing market will help to cut production costs down.

The customers of MEI have a huge potential to substitute their running energy costs for kerosene and transporting and recharging batteries, but it requires that the system does not fail till it is repaid. For this purpose, MEI has introduced the product and service guaranty.

Social Dimension

The evaluation of the change in lifestyles due to the system cannot yet be done in the Tanzanian context because it needs to be observed over a longer period. The social dimension that can be taken into consideration in the described product-service system is the opportunity for a brighter distribution of solar home systems among social classes with smaller incomes due to the microfinancing system which is adapted to already existing energy expenses.
Task 10: Develop a monitoring and evaluation methodology for quality management and sustainability purpose.

1.6 Reflection and Findings

During our case study the method was customized several times resulting in the way it is presented here. The analysis helped to shed light on weak points, e.g., drivers for cost and risk, in service provision and product-use activities. Finally, new tasks for product and service design have been derived. The potential to enhance the sustainability of MEI's solar home system has been made explicit.

1.6.1 Experiences and Opportunities

- The methodology is very supportive of the documentation and description of the solar home system. It makes important aspects explicit, particularly, the required services and their performance in the social, ecologic and economic context.
- It supports the analysis and synthesis of product-service systems.
- It is a helpful instrument to introduce stakeholders in particular parts of the business.
- The method is supportive for the development of contracts, as you can develop and discuss scenarios along the life-cycle phases.
- For the same reason, the method is helpful for the price calculation. Every activity, including supporting resources and the deliverable, can be priced and included in a simple tabular calculation.

- Precise tasks can be derived for the PSS designer or for a development roadmap. Requirements for the system design can be derived and included in the requirements list. In particular, process-related requirements or requirements on technician qualification become more tangible.
- Although the purpose is an application in early design phases (planning and conceptual design), the method can be used during the whole development process and even during the operation phase as tool for documentation, discussion and evaluation. In particular, services are changing regularly and can be adapted based on experiences during operations. In this case, the layers help to directly interlink changes with other relevant aspects like “core product”, “periphery” and, in particular, “contract”.
- The method is powerful in raising awareness on the importance of detailed knowledge of the customer needs and values. The method “forces” the designer to take needs and values of the customer into consideration in every step.

1.6.2 Limitations and Potential for Improvement

- The chronological orientation on the live cycle is helpful in the first step. It still has to be proved on a longer term, that it is not limiting the view as some aspects impact on different live cycle phases. Activities which run in parallel are difficult to model.
- The quality of the results is extremely dependent on the quality of the market studies done on the needs and values of the customers.
- The method does not offer a systematic way to discuss variants, so far.
- The method reflects only the point of view of the customer and the provider. The points of view of other stakeholders are not directly visible.
- The evaluation has been made in two small companies and the participants had economic and engineering experience. (Some additional experience was made in teaching.)
- omputer support of the method to transfer results easily into digital models was not available during the first two case studies. Transferring models into the computer was time consuming.

1.6.3 Recommendations

The method should be considered to be applied in workshops where product-service integration and/or customer and life-cycle orientation is important. A moderator who is familiar with the method should accompany the first application to moderate its use. This moderator needs relevant skills to lead the workshop, e.g., to collate and discuss the prerequisites and to start modelling during the discussion until the other participants understand the concept. Furthermore, he/she has to be familiar with theoretical basics of product-service systems; the other participants should have an idea of what PSS is. We assume that not more than four or five participants should attend.

Blank layer plots should be prepared beforehand. Markers or stickers to highlight important issues should also be prepared beforehand. Filled layers can be used to inform others on workshop findings and as a type of system architecture image.

Remark: as this is a relatively new result of basic research more evaluation in different branches is necessary.

1.7 Outlook

We assume that the layer method is compatible with most other PSS approaches, as it supports most basic PSS characteristic, e.g., the life-cycle perspective, the consideration of stakeholders or the need-orientation. Additional workshops will be held to investigate if this method is applicable to other PSS examples. Finally, the aim is to embed the layer model in a PSS development methodology.

A toolbox for computer support is being developed. It defines standardized elements for each layer so that the transfer of paper-based results into a digital model becomes faster. Modelling directly with computer support also becomes possible. Using the meta-model of the method as type of "product structure" will be one of the next steps. The possibility of attaching requirements, functions and project plan tasks to elements is being tested. Furthermore, export interfaces to process modelling tools are being planned.

Finally, a more comprehensive documentation including detailed modelling examples for different application cases is on the agenda.

1.8 Acknowledgments

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Chapter 2
Life-Cycle Perspectives of Product/Service- Systems: In Design Theory

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Abstract Manufacturers are moving more and more towards the business approach of Product/Service Systems (PSS) in order to achieve greater revenue. PSS have many benefits such as achieving closer customer connection and generating increased profit from manufactured products. However, in order to achieve a PSS which is adapted for this business approach, the products and services used need to consider a life-cycle perspective. The business approach of PSS allows for the provider to control the flows of physical products, both the forward flow to the user and the reverse flow of products back to the provider. This new logic of material/product flows allows for adaptations along the product life-cycle. For example, maintenance and end-of-life strategies such as remanufacturing can become more beneficial due to the new circumstances that PSS provide the manufacturer. The aim of this chapter is to elucidate how manufacturers can develop their PSS with a life-cycle perspective. It shows the many aspects that should be considered throughout the life-cycle of both physical products and services. In addition, several considerations and theories are presented for the different stages of the PSS life-cycle. Finally, this chapter presents theory on product/service design with a life-cycle perspective, which serves as a base for the practical design considerations presented in Chapter 3 of this book.

Keywords Life-cycle, PSS, Industrial Product/Service-Systems, DfX

2.1 Introduction

Manufacturing companies around the world are striving to increase their revenues and profitability through, for example, obtaining a larger share of the market and controlling a greater share of the product value chain. This can potentially be achieved, in concert with environmental benefits, through a change or at least a move towards a higher degree of integrated product/service offerings instead of just physical products. Furthermore, there are promising economic opportunities in the aftermarket of the products, as exemplified in the automobile industry. Because of this, many manufacturing companies are changing their production philosophy from a traditional focus on the manufacturing of the physical product towards a focus of the life-cycle of the physical product. As a result, more emphasis is now put on the use and end-of-life phases, including maintenance and remanufacturing. Given the above, the aim of this chapter is to elucidate how manufacturers can develop their product/service-systems with a life-cycle perspective.

2.2 What Are Product/Service-Systems?

The phenomenon of product/service-systems (PSS) has become more prevalent in current consumer patterns, and its emergence is primarily market-driven, although some companies also mention environmental issues as important for starting their PSS business models. The importance of services gets larger as the economy of our society matures. Service activities are provided as the source of core value in the tertiary industry. In addition, the secondary industry has recently become increasingly interested in services (Oliva and Kallenberg 2003). The importance of services is also recognized in the marketing field (Vargo and Lusch 2004). As a result, new concepts such as Product/Service-System (PSS) (Goedkoop *et al.* 1999, Morelli 2003, McAloone and Andreasen 2004, Mont 2004, Tukker and Tischner 2006, Aurich *et al.* 2006), Functional Sales (Sundin *et al.* 2000, Lindahl and Ölundh 2001, Sundin and Bras 2005), Functional Products (Alonso-Rasgado and Thompson 2006, Alonso-Rasgado *et al.* 2004), Integrated Product Service Engineering (IPSE) (Sundin *et al.* 2006), and Service/Product Engineering (SPE), formerly called Service Engineering (Sakao and Shimomura 2007), have been developed. What these concepts have in common is the incorporation of a service into the design space, a space which has been traditionally dominated by physical products in manufacturing industries. In PSS, a very strong focus is placed on how to fulfilll customer needs and create customer value (Lindahl and Ölundh 2001); thus, the main focus is not on producing new products. Furthermore, Sakao *et al.* (2009) provide a good overview of recent research direction in the PSS area.

Today, value is added to products in a variety of ways, including technological improvements and non-material aspects such as intellectual property, product image and brand names, aesthetic design and styling. These aspects help producers to differentiate and diversify their products to better respond to customers' demands. According to Mont (2004), this means a change from mass production to mass customization. The issues of combining the development of mass-customized products used in PSS are further described in Sundin *et al.* (2007). Kimura (1997) states that a paradigm shift is needed to change from traditional product selling to more service-oriented product sales. In addition, the traditional boundary between manufacturing and services is becoming increasingly blurred (Mont 2004). Within PSS, the function-providing company decides how to fulfill the function that the customer is buying, whereas in leasing the physical product used for the function is known by the customer. In the cases of renting, leasing and PSS offerings, the product is not sold, and a contract is written between user and provider; however, this contract is more advanced for the PSS offerings concept. Leasing is a contract form that often is used for financial reasons, as products are often sold to the customers who leased them when the contract has run out. Tischner *et al.* (2002) have studied the links between PSS and traditional products and services. The general image of a PSS can, as shown in Fig. 2.1, be broken down to three main categories: product-, use- and result-oriented PSS.

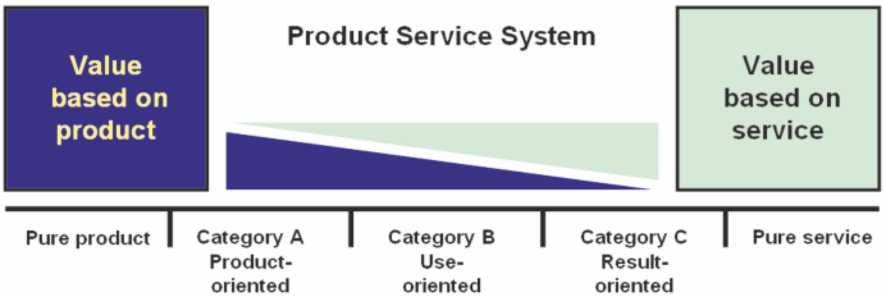

Fig. 2.1 Placing Product/Service Systems in a perspective to products and services (Tischner *et al.* 2002)

Category A Product-oriented Services: product is owned by the user/consumer.

- **Service Integration** A new service is added to an existing product, often initiated through availability of new technology such as a modem for a computer.
- **Product Extension Service** The value of a product is increased through an additional service; examples include upgrades, repairs and guarantees.
- **Vertical Integration** Modified delivering strategies to supply products to customers, retailers, and/or customers, who become directly involved in the process of production; for example, production on demand.

Category B Use-oriented Services: product is owned by the service provider, who sells functions instead of products by means of modified distribution and payment systems; for example, sharing, pooling and leasing.
Category C Result-oriented Services: in a product-substituting service, products are substituted by new services, often driven by new technologies. Examples include virtual answering machines instead of a machine at home; pest control services instead of pesticides; and facility management. In all these cases, the supplier provides incentives for the customer to consume more efficiently and optimizes a system, for example, by using modified payment systems such as contracting.

An example of PSS is when a company provides the function of washing clothes instead of the actual washing machine performing the function. Here, customers pay for the laundry loads they require instead of buying the washing machine, as illustrated in Fig. 2.2. This example, called pay-per-wash, is further described in Sundin *et al.* (2000).

Fig. 2.2 Example of a washing function offered traditionally and as a PSS called pay-per-wash (modified from Sundin *et al.* 2000)

When providing a function instead of a product, a contract must be signed between the customer and the service provider. Here, the connection between the stakeholders becomes more formal, and the contracts that regulate what the offer includes are of importance (Lindahl and Ölundh 2001). Thus, if the manufacturing company provides the function, then it becomes increasingly knowledgable about how its products perform during use. This product control can be achieved through web monitoring, and thus can be facilitated by today's information technology. Monitoring the product for PSS allows the company to learn more about how it performs throughout its life-cycle. The whereabouts of *product life-cycle* is explored further in the next Sect..

2.3 What Is Life-Cycle Perspective?

The concept of the *product life-cycle* has been discussed widely in research (see the overview by Kotler (2003). In the theory, at least two conflicting definitions about the product life-cycle can be found. The first refers to the progress of a product from raw material, through production and use, to its final disposal as illustrated in Fig. 2.3. This is also the perspective of the *product life-cycle* considered in this chapter.

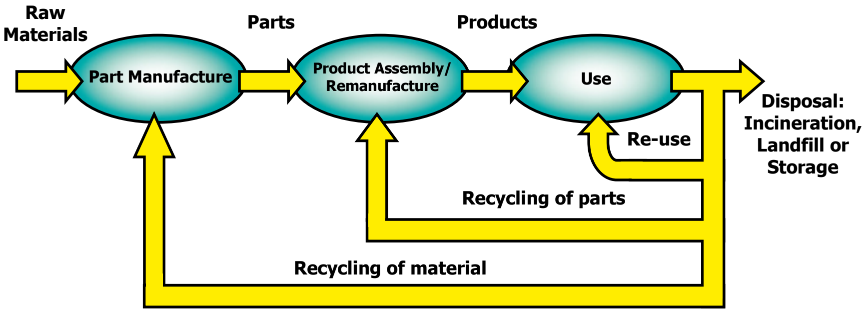

Fig. 2.3 The physical product life-cycle (Sundin 2004)

The second definition of the product life-cycle describes the evolution of a product, measured by its sales over time, as seen in Fig. 2.3. Every product passes through a series of phases in the course of its life, referred to as the product life-cycle. The phases that a product goes through during it life-cycle are the introduction, growth, maturity and decline stages (Cox 1967). The product life-cycle can be analyzed on different levels, from the main product type (product class) down to different product models, as illustrated in Fig. 2.4 (Tibben-Lembke 2002). The characteristics of the life-cycle and its effects on the reversed supply chain have been discussed by Tibben-Lembke (2002).

When the historical sales data (product distribution) is known, this data can be used as a basis for forecasting when these products are likely to be returned (product disposal distributions). Research about this economically related product life-cycle has also been conducted by Umeda *et al.* (2005) and Östlin *et al.* (2009). Umeda *et al.* (2005) present a model based on empirical data from return rates for remanufacturing of a single-use camera and the remanufacturing of a photocopier. In this model, a simple normal distribution function has shown sufficient results in predicting returns when using average life as an indicator for timing of returns. In the study performed by Östlin *et al.* (2009), life-cycle perspective influences on product remanufacturing have been further explored in detail.

If the product is returned to the manufacturer for remanufacturing, it is possible to evaluate how the product has performed throughout its life-cycle and what needs to be improved. This knowledge allows the manufacturer to improve its products accordingly; it could, for example, be used to help reduce the need for service throughout the use phase, or to discover latent design errors more quickly and thus obtain better knowledge of how the product is used. Having an ownership-based relation to the customer, i.e. the provider owning the product during use, has been found to be one of the most preferable relationships in achieving a successful remanufacturing business (Östlin *et al.* 2008).

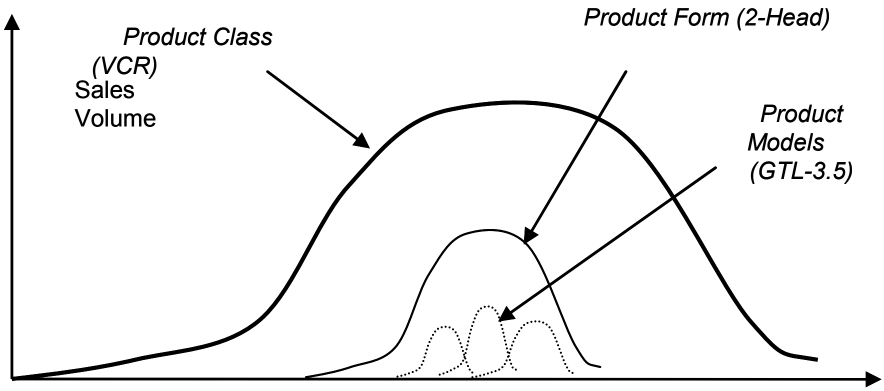

Fig. 2.4 The product life-cycle of a VCR (Tibben-Lembke 2002)

2.3.1 Environmental Concerns of Product/Service Systems

According to Kimura (1997), a paradigm shift is needed to move from traditional product selling to more service-oriented products sales, as illustrated in Fig. 2.5. People often buy things not because they want the things themselves, but rather for what they can do, as Magretta (1997) states in her paper *"nobody wants his or her own carpet just to walk on it."* What would happen if the carpet manufacturer owned the carpet and promised to come in and remove it when it required replacing? It might be that if we got the carpet back, we could afford to put more cost into it in the first place in ways that would make it easier for us to recycle. Substituting services for products is one solution. Selling a carpet service instead of a carpet could be more sustainable (Magretta 1997). The PSS-providing company may satisfy customer needs by providing hardware in the form of physical products. This generally means that the physical product that performs the service is owned by the PSS-providing company, and not by the customer. By doing this, customers only pay for the actual function that the physical product provides.

However, when asking PSS providers, they answer that most ownership is still transferred to the customers (Lindahl *et al.* 2009).

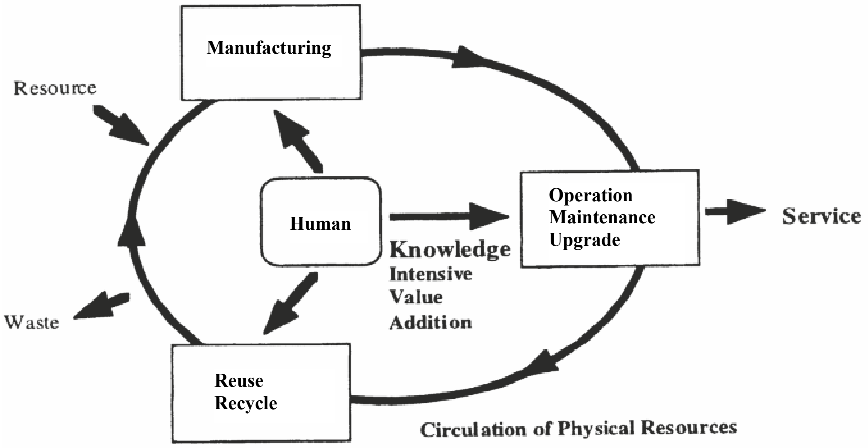

Fig. 2.5 Paradigm shift: from products to services (Kimura 1997)

PSS have the potential to be environmentally benign because they address current levels of material consumption, seeking options that may provide function/service to consumers without lowering their level of welfare (Mont 2000). Prevailing environmental advantages for PSS are (Agri *et al.* 1999):

- Decreased use of virgin materials in production
- Increased lifetime of each part of a product
- Minimised number of times materials pass through the production cycle

The absence of ownership transfer would also facilitate implementation of new, more advanced and resource-efficient technologies, which in turn can reduce the environmental impact (Agri *et al.* 1999). Kimura (1997) states that it is obvious that the concept of PSS based on remanufacturing (inverse manufacturing) will be a definite solution for our environmental problems caused by manufacturing. PSS could in some cases, depending on the solution for fulfillling customer need, be a way to move towards a more sustainable society, but this is not always the case. Some goods do not change in design although they are intended for leasing (Lifset 2000), and/or when being a part of a PSS (Sundin & Bras 2005, Lindahl *et al.* 2009).

2.4 Life-Cycle Perspective of Product/Service Systems

Having a life-cycle perspective on combined services and goods means that life-cycle considerations must be considered for both physical products used in the PSS and the services used during and between the contract times. The physical products can be adapted in various ways for the product life-cycle according to DfX (Design-for-X) methodologies. For this, there exist many engineering methods that would result in adaptation for manufacturing, delivery, usage, service, disassembly, reassembly, testing, recycling and/or remanufacturing. The following paragraphs describe what issues to consider for products and services during the life-cycle phases of:

- Manufacturing;
- Usage;
- Delivery;
- Maintenance;
- Recycling; and
- Remanufacturing.

2.4.1 Manufacturing

For the manufacturing phase there are many guidelines for "Design for Manufacturing" (DfM), which includes, e.g., the adaption of products at levels of company, product family, product structure, and components (Eureka 1999). Manufacturers have saved much in production lead time and overall manufacturing costs by performing DfM, as well as through Design for Assembly (DfA) efforts. Examples of DfA design guidelines from Boothroyd and Dewhurst (1986) are:

- Reduce parts and part numbers;
- Eliminate adjustments;
- Make components self-guided and secured;
- Facilitate access and visibility during insertion;
- Minimize the need for reorientation;
- Eliminate assembly faults;
- Maximize component symmetry or maximize asymmetry; and
- Minimize the importance of component tolerances.

DfA can be seen as a part of DfM, but with a focus on assembly in the manufacturing process. For the service part of the PSS, this would include the finalization of service books and user guides. Also, this phase could include the finalization of the contract writing between the product/service provider and the customer. Most focus is traditionally put on the manufacturing of products.

2.4.2 Delivery

The delivery phase includes the delivery of the products and installation. This phase has extensive inclusion of services, which should be conducted accurately, with good quality, and fast so that the customer can start using the product/service paid for. This phase could be supported by Design for Delivery, meaning that the products are easy to pack, stack and install. Regarding services, the providing company could include technicians for installation of the products and/or good support through staff available online or by phone for those installing the products.

2.4.3 Usage

During usage, it is important for the products to be monitored for uptime and performance. Here, it could be beneficial to have warning systems installed to avoid breakdowns. As a service to the customer, instructions on how to use the products should be clear. Also, it could include how to fill up necessary consumables such as toner cartridges in printers or motor oil in cars. Furthermore, different ways of using the products could be declared, from low performance (with inexpensive usage and lower environmental impact) to high performance (with more expensive usage and higher environmental impact). Some car manufacturers have adopted this example and refer to it for their customers as "eco-driving." Furthermore, this phase could include changes in capacity for the customer by increasing or decreasing the number of products used in the PSS, all according to the contract setup. This is, for example, included in the flexible fleet rental programs provided by Toyota Material Handling Group (TMHG) (Sundin *et al.* 2005).

2.4.4 Maintenance

This phase refers to the moments of the use-phase when technical service is needed. This could include for example preventive and unplanned maintenance. The products could be adapted for easy maintenance by having maintenance points easily found and accessed. Adaptation such as this is also called Design for Service (DfS). This phase also includes guidance on how the provider should react to malfunctions – depending on what is written in the contract. For instance, sometimes the downtime could be paid for by the provider.

Usually, manufacturers have a time horizon that considers their physical products' performance until the time of warranty. However, the PSS approach requires a larger scope, including the entire product life-cycle and encompassing the phases after the first warranty/use phase. For this reason, end-of-life options "recycling of materials" and especially "recycling of parts," e.g., remanufacturing in Fig. 2.3 will be explored in greater detail in this chapter than the previous life-cycle phases.

2.4.5 Recycling

According to Furuhjelm (2000), much research effort has been put into developing design guidelines and manuals for Design for Recycling (DfR). Many of these guidelines are linked to Design for Disassembly (DfD), and these cases are also valid from a Design for Remanufacturing perspective. A big difference here is that in recycling it is important to achieve material chunks that are compatible with one another. In addition, for the remanufacturing alternative, it is important that the components and joint can withstand being assembled at least once again.

Some guidelines that Furuhjelm (2000) has collected from research in the 1990s are shown in the following list:

- Product Structure
  - Integrate functions and make the design modular
  - Minimize overall number of parts
  - Allow a linear and unified disassembly direction
  - Make valuable/hazardous parts/materials easily accessible
  - Cluster parts that have to be removed
  - Avoid metal inserts and reinforcements molded into plastic parts
- Materials
  - Minimize the number of different types of materials
  - Make inseparably connected parts of compatible materials
  - Mark all plastic parts with identification markings
  - Eliminate incompatible labels on plastic parts
  - Mark hazardous parts
- Fasteners and connectors
  - Minimize the number of fasteners
  - Minimize the number of fastener removal tools needed
  - Ensure that fasteners are easy to access
  - Use fasteners of materials compatible with the parts connected
  - Eliminate adhesives unless compatible with both parts joined

2.4.6 Remanufacturing

There are different definitions for the term "remanufacturing." The US Automotive Parts Rebuilders Association (APRA) states "*Remanufacturing is the process of restoring worn and discarded durable products to like-new condition.*" In this chapter, remanufacturing is defined as "*the process of rebuilding a product, during which: the product is cleaned, inspected and disassembled; defective components are replaced; and the product is reassembled, tested and inspected again to ensure it meets or exceeds newly manufactured product standards*" (Sundin and Bras 2005).

If the remanufacture of the product is not extensive, i.e. few parts are replaced, either of the terms "reconditioning" or "refurbishing" are more suitable. Reconditioning typically refers to the restoration of parts to a functional and/or satisfactory condition by surfacing, painting, sleeving, etc. (Amezquita *et al.* 1995). In addition, some researchers use the term reconditioning/refurbishing when the product is only remanufactured to its original specification without exceeding it (Ijomah *et al.* 1999).

2.4.6.1 Levels of Remanufacturing

In the remanufacturing environment, the life-cycle of a product and the disposal rate for both products and components has great impact on the possibility to perform profitable remanufacturing. Previous research has shown that issues such as the age of the generation of the product, the expected life (reliability), the rate of technological development and the willingness to return products for remanufacturing will influence these distributions (Guide & Jayaraman 2000). This Sect. will focus on shedding light on these issues, as well proposing strategies that have the potential to make the overall remanufacturing system more efficient. In the following Sect., the stages of the life-cycle will be addressed according to three different remanufacturing scenarios (adapted from Umeda *et al.* (2005)):

- **Product remanufacturing** Used products are remanufactured to "as-new" or upgraded status; an example of this category is the remanufacturing and upgrading of Tetra Pak filling machines.
- **Component remanufacturing** Used components are remanufactured to "as-new" or upgraded status; an example of this category is the remanufacturing of automotive components and toner cartridges.
- **Component cannibalization** Used products are cannibalized for components, and the components are then remanufactured to an "as-new" or upgraded status. An example of this category is the cannibalization of components from heavy trucks and forklift trucks; in these cases, the component cannibalization option is mainly a supporting activity for the product and component remanufacturing scenarios.

Moreover, designers may lack remanufacturing knowledge because there is a paucity of remanufacturing knowledge and research (Guide 1999, Ferrer 2001, Ijomah 2002). Research indicates that Design for Recycling has received more attention among design and manufacturing engineers than Design for Remanufacturing (DfRem) (Ishii 1998a), even though remanufacturing may provide greater environmental and financial benefits than recycling. For example, many designers are reluctant to use recycled materials because of uncertain quality or supply standards (Chick and Micklethwaite 2002). Furthermore, additional energy is required to reform recycled materials into manufactured products because the energy embodied in the materials and purchased parts assembled in the initial manufacture of the product is lost during the recycling process (Jacobs 1991). Research by Lund (1984) has shown that when the total energy used in initially producing a product is summed up and compared to the energy required to remanufacture the product, the ratios are in the order of 4:1 and 5:1. This is because energy is used in every stage of manufacture, from ore smelting, assembly, and refining, through testing.

As Shu and Flowers (1988) also contend, the reliability of the part is very important since it must go through at least one life-cycle, including all remanufacturing steps, and still work satisfactorily. Sundin (2004) has studied which product properties are important to facilitate remanufacturing. By looking at what properties are suitable for the different remanufacturing steps (inspection, cleaning, disassembly, storage, reprocessing, reassembly and testing), a matrix called RemPro, shown in Fig. 2.6, was created. In case studies performed at remanufacturing companies in Sweden, Canada and Japan, it was shown that the remanufacturing process steps of inspection, cleaning, and reprocessing were the most crucial (Sundin 2004).

To facilitate these steps, the RemPro-matrix presented below shows that designers of new products should focus on giving the products the properties of ease-of-access and wear resistance, since these are important for both the cleaning and reprocessing steps. Following this, the designer should prioritize the properties of ease-of-identification, ease-of-verification, ease-of-handling and ease-of-separation, since these properties are also included as preferable for the crucial steps, but not to the same extent.

The remanufacturing company should first investigate which steps are crucial for its specific remanufacturing business area, and thereafter try to facilitate this according to the RemPro-matrix, as well as place effort on making the crucial steps in the remanufacturing process as efficient as possible. By doing so, many obstacles could be reduced, and the remanufacturer would have an advantage over its competitors (Sundin 2004). In efforts to use remanufacturing to assist PSS, in addition to decisions on how to conduct DfRem, consideration should also be given to the need to design the product for remanufacture. Only products satisfying environmental legislation can be introduced into the market. Thus, DfRem guidelines must help to ensure that products can meet current environmental legislative requirements and have at least good potential to satisfy future ones, either in their original design or because of their ease of redesign after first life. Since products may have different types and levels of environmental impacts at different stages, DfRem guidelines must consider the whole life-cycle to target key environmental impacts and therefore reduce potential penalties. However, research by Ijomah *et al.* (2007) indicates that there appears to be a lack of DfRem guidelines based on life-cycle thinking.

From a service perspective it is important to have supporting systems to support the reverse logistics. The remanufacturing of products is often a more complex operation than ordinary manufacturing, since the timing and condition of the used products is seldom known. Therefore, it is important to have systems in place that could inform the remanufacturers beforehand about the products' conditions and expected arrival to the remanufacturing facilities. Having this information can shorten the lead times and improve the quality of the remanufactured products, which in turn can be used in new PSSs, see Sundin *et al.* (2005).

Remanufacturing Step / Product Property	Inspection	Cleaning	Disassembly	Storage	Reprocess	Reassembly	Testing
Ease of Identification	×		×	×			×
Ease of Verification	×						
Ease of Access	×	×	×		×		×
Ease of Handling			×	×	×	×	
Ease of Separation			×		×		
Ease of Securing						×	
Ease of Alignment						×	
Ease of Stacking				×			
Wear Resistance		×	×		×	×	

Fig. 2.6 The RemPro-matrix showing the relationship between the preferable product properties and the generic remanufacturing process steps (Sundin and Bras 2005)

2.5 Discussion

Manufacturers using the business approach of PSS face many challenges. In order to achieve good PSS performance, they need to take a life-cycle perspective on their physical products and services.

There are several ways to identify design improvements for PSS. In this study, focus was put on manufacturing, usage, delivery, maintenance, recycling and, especially, remanufacturing.

"Design-for-X" is an umbrella term for the many design philosophies and methodologies developed to address designers' lack of knowledge in important product life-cycle areas. The 'X' in 'DfX' may stand for one of the aims of the methodology, for example, assemblability or manufacturability (Boothroyd and Dewhurst 1986, Kuo *et al.* 2001). DfX practices aimed at integrating environmental considerations into product and process design, as well as design-for-environment (DfE), can be particularly applicable to remanufacturing, as seen through developments including the reverse fishbone diagram (Ishii and Lee 1996), the application of modularity and clumping to the recylability issue (Ishii 1998b) and the End-of-Life Adviser (ELDA) by Rose and Ishii (1999). Other tools developed to assist DfRem include Repro2, by Gehin *et al.* (2005), for assessing the remanufacturability of proposed designs via their comparison to current remanufacturable products. Amezquita *et al.* (1995) developed guidelines based on design features that assist remanufacturing, and use these to identify design changes to improve automobile door remanufacturability. Bras and Hammond (1996) used the Boothroyd and Dewhurst design-for-assembly metrics as a foundation for remanufacturability assessment metrics based on product design features. Mangun and Thurston (2002) presented a decision tool to help decide when products should be taken back as well as the most appropriate component end-of-life options. The tool includes a model to help introduce redesign issues in product design. Ijomah *et al.* (2007) provide information obtained via industrial case studies and workshops of the features and characteristics that assist and hinder remanufacturing, while Ijomah (2008) provides high-level guidelines to assist DfRem. The high-level guidelines are being used to educate Masters-level design students, and have formed the basis of lower-level guidelines which in turn are being used as the basis for robust design for remanufacturing software tools. Another source of information about product design and remanufacturing is a report written by Gray and Charter (2007).

DfRem requires products to be designed for ease-of-disassembly, with no damage to the product affecting functional performance for parts hidden from the customer, and no damage affecting performance or aesthetic appearance for parts visible to the customer (or providing good mechanisms to rectify damage). Various DfRem guidelines have been proposed, the most useful being those that are not general guidelines and that also simultaneously consider product features and remanufacturing process activities. Furthermore, research by Ijomah *et al.* (2007)

indicates that there is opportunity to build on previous work by introducing new parameters to enable the development of enhanced DfRem guidelines, for example, based on life-cycle thinking. In fact, the World Summit for Sustainable Development (WSSD) identified product life-cycle-based tools, policies and assessment tools as key sustainable production requirements (United Nations General Assembly 2002).

Analyzing the products and having a good knowledge of the product use was also a focus of this study. To have these issues in mind when developing new products, designers can use the RemPro matrix (Sundin and Bras 2005), design guidelines, etc. Products' potential for remanufacture can be enhanced using remanufacturability-specific design guidelines and by applying, individually or in combination, other DfX practices, provided that remanufacturing priorities are considered. Thus, application of design-for-disassembly to remanufacturing is for a special case requiring that parts are not damaged during separation to preserve their "fitness for reuse". Shu and Flowers (1995) exemplify this sentiment by showing that joints designed for ease-of-assembly and recycling may not facilitate remanufacturing because methods assisting assembly do not always support disassembly without component damage. This is not an issue for recycling, but is vital in remanufacturing as components must be "fit for reuse" following disassembly.

When adapting products for any of these life-cycle phases, for example, remanufacturing, all of the operational steps should be considered. For instance, if one step such as reassembly is very difficult to perform on a product, it does not matter, in respect to remanufacturing, how much effort has been put into adapting the product for disassembly. One should remember that the essential goal in remanufacturing is part reuse. Thus, if a part cannot be reused as is or after refurbishment, the ease of cleaning or reassembly will be of no consequence in the case of remanufacturing (Shu and Flowers 1988). This means that much effort can be made in product design without obtaining any expected benefits.

Looking at the different DfX guidelines, one can see that there are conflicting goals that need to be considered. If a product and service is to be included in a PSS, it is important to have the full life-cycle perspective to avoid the suboptimization of any specific life-cycle phase. Considering the categories of PSS shown in Fig. 2.1, according to Weissenberger-Eibl and Biege (2009), most design guidelines and principles are developed for product-oriented PSS rather than use-oriented and result-oriented PSS, which would require more attention in industry and research.

2.6 Recommendations

To the industrial practitioners I would like to recommend the following:

- Go through the product life-cycle of the physical product and services used in the PSS and identify any challenges and pitfalls that require attention.
- At the same time, seek opportunities for new services that traditionally do not exist for a manufacturer.
- Try to keep the life-cycle perspective when developing new PSS, and thus avoid sub-optimizing any specific life-cycle phase.

2.7 Conclusions

To conclude, this chapter has presented issues for a product/service system provider to consider from a life-cycle perspective. This includes both considerations regarding the product and the services used during the life-cycle phases. Chapter 3 will continue this discussion from a more practical perspective, showing how the life-cycle perspective could be performed in practice.

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Chapter 3

Life-Cycle Perspectives of Product/Service-Systems: Practical Design Experiences

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Abstract Many manufacturers are moving more and more towards the business approach of Product/Service-Systems (PSS) in order to achieve more revenues. The business approach of PSS puts new requirements on products in comparison to traditional selling. In order to achieve a PSS adapted for this business approach, the products and services used need to consider a life-cycle perspective. Having a life-cycle perspective on products and services in the business strategy of PSS is becoming increasingly important as the strategy emerges and more companies see the benefits of controlling a larger share of the product-value chain. The objective of this chapter is to elucidate how manufacturers have worked with, or could adapt their products for, PSS. Supporting this are results from several case studies, performed at companies that manufacture household appliances, soil compactors and forklift trucks. A key factor when developing products for PSS is to design the product from a life-cycle perspective, considering all the product's life-cycle phases, e.g., manufacturing, use, maintenance and end-of-life treatment. Several design improvements, all of which are fairly inexpensive and easy to implement, are described. Many of these improvements deal with the accessibility of parts and components during maintenance and remanufacturing operations, and several of the design improvements could reduce the need and cost for maintenance, repair and remanufacturing.

Keywords Life-cycle Design, Industrial Product/Service Systems, PSS, DfX

3.1 Introduction

Preceded by a theoretical chapter on the same theme (Chap. 2), this chapter consists more of practical design experiences. This introduction to the chapter includes background, objectives and methodology.

3.1.1 Background

Manufacturing companies around the world are striving to increase their revenues and profitability through, for example, obtaining a larger share of the market and controlling a larger share of the product-value chain. This can potentially be achieved, in concert with environmental benefits, by a change or at least a move towards a higher degree of offering integrated product/services instead of only physical products. Furthermore, there are good economic opportunities in the aftermarket of the products, as exemplified in the automobile industry. Because of this, many manufacturing companies are changing their production philosophies from a traditional focus on the manufacturing of the physical product towards a focus of the life-cycle of the physical product. As a result, more focus is now put on the use and end-of-life phases, including, for example, maintenance and remanufacturing.

3.1.2 Aim

The aim of this chapter is to elucidate how manufacturers have worked with, or could adapt their physical products for, Product/Service-Systems (PSS). A focus is put on exploring the adaptation for maintenance, repairs and remanufacturing, since these steps were where the providers have contact with their products during their life-cycles.

3.1.3 Case Study Methodology

To fulfill the aim of this chapter, previous research was studied along with newly collected empirical data and information. This previous research includes, for example, guidelines and design properties that have been shown to be beneficial for PSS, such as those presented by Sundin and Bras (2005). New empirical data was obtained from three Swedish manufacturers: Electrolux (household appliances), Swepac International AB (soil compactors) and Toyota Material Handling Group (forklift trucks).

The companies studied had varying experience as PSS providers (see Table 3.1). In addition, the products studied at these PSS providers were selected because they were all good candidates for Design for PSS; this was important as the ability to remanufacture has significant impact on the success of PSS. All three products were appropriate candidates for redesign for enhanced remanufacturing potential because they were mature, pervasive products, providing an ample supply of used products to remanufacture and to cannibalize for remanufacturing. Additionally, they were not fashion-affected products, and were not placed in a prominent position in the home. Thus, age, make and model were far less important than their functionality.

Table 3.1 Case study company characteristics

Company	Products	PSS experience
Electrolux AB	Household Appliances	Pay-per-wash
Swepac International AB	Soil Compactors	Rental Contracts
Toyota Material Handling Group	Forklift Trucks	Rental Plans

Each of the case companies was visited several times in order to find out how they worked with design and PSS issues. By doing so, a good understanding of how the products were used in the PSS was achieved. Information was obtained through semi-structured interviews of personnel from each company, e.g., managers, designers and operators. The studies analyzed, through observations and interviews, how the companies maintained and remanufactured their products. Personnel from the companies' maintenance and remanufacturing departments were interviewed to determine their views about their products' designs. Also, employees at both the management and operator levels were interviewed, and questionnaires were used to gather information about their views on how their product designs could be improved to better fit PSS. As part of each case study, each company's product was studied in a laboratory at Linköping University. Researchers analyzed each product, for example, by disassembling and assembling it many times in order to uncover design improvements. The origin of the redesign proposals came from the researchers when disassembling/reassembling in the university environment. Furthermore, in order to verify the results from each case study, additional mechanical engineers and designers were interviewed to determine the design department's views about the proposed design improvements.

3.2 Industrial Case Study Results

The results from the industrial case studies are presented in this Sect., one company at a time, with their existing designs and also some suggestions of design improvements.

3.2.1 Case A: Household Appliances

AB Electrolux is a global leader in home appliances and appliances for professional use, selling more than 40 million products to customers in 150 countries every year. The company focuses on innovations that are thoughtfully designed and based on extensive consumer insight, in order to meet the real needs of both consumers and professionals. Electrolux products include refrigerators, dishwashers, washing machines, vacuum cleaners and cookers sold under esteemed brands such as Electrolux, AEG-Electrolux and Zanussi. Consumer Durables account for 93 percent of company sales, and comprise a range of appliances for kitchens, fabric care and floor care. In this study, a washing machine and refrigerator were investigated.

3.2.1.1 Washing Machine

The studied washing machine – one of the company's typical washing machines – was manufactured by Electrolux under the brand Zanussi FL12. The washing machine was analyzed from a PSS perspective, i.e. the perspectives of use, maintenance and remanufacturing. The washing machine, in production at the Swedish manufacturer AB Electrolux, was one of many household appliances that were remanufactured at Electrolux's remanufacturing facility in Motala, Sweden. As Fig. 3.1 illustrates, the Zanussi FL12 contains five large exterior parts: the top cover, the control panel, a base plate and the front and back steel sheets. All of these parts are made of plastic, except for the two steel sheets. In the existing design, only the top cover, control panel and back steel sheet are removable, since the ground plate and the front steel sheet are used to stabilize the machine during use.

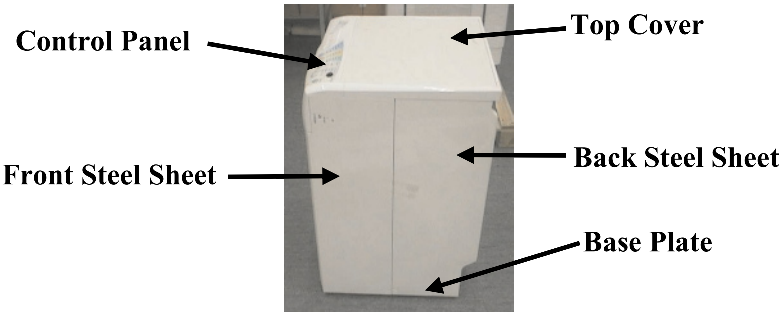

Fig. 3.1 The studied washing machine (Zanussi FL12) displaying its exterior parts (modified form Sundin *et al.* 2009).

Taking off the top cover, the washing machine looks like the sketch shown in Fig. 3.2. In this sketch, one can see some of the major components and where they are located, in comparison to the other parts, i.e. the product structure.

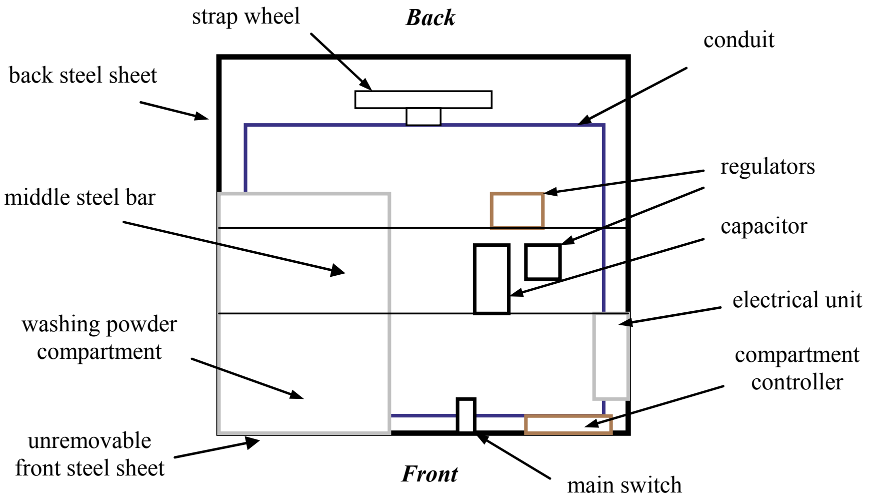

Fig. 3.2 A sketch view from above when removing the top cover (modified form Sundin *et al.* 2009).

When the washing machines arrive at the remanufacturing facility, a decision is made whether to material recycle or remanufacture. If the washing machine has any of the following faults it will be material recycled:

- Cracks on front weights
- Conduit faults
- Large flaws on front metal sheet

However, if the faults are not severe the washing machine will go through the remanufacturing process. Examples of faults that are treated in the remanufacturing process are:

- Engine and electrical faults
- Regulator faults (water level)
- Minor flaws on front metal sheet
- Flaws on back metal sheet

This means that the existing design does not facilitate the changing of all components needed to achieve a sellable product, i.e. a remanufactured product that has sufficient quality to be sold again. This existing machine is, therefore, not adapted by design for maintenance and remanufacturing.

The product structure needed to be changed, and, in this study, two alternative designs were suggested. The conduit of the washing machine was very heavy and thus hard to remove. Therefore, as a starting point the suggestion was made to enable the ability to change all interior parts without disassembling the conduit. Fig. 3.3 shows the existing design (Type A), alongside the two other suggested design alternatives (Types B and C).

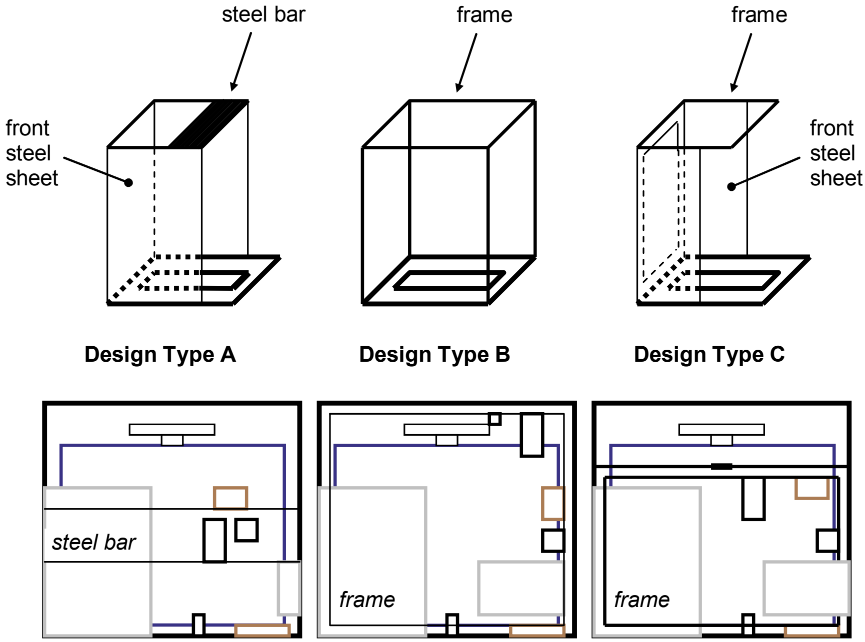

Fig. 3.3 The top row of sketches show the stabilisation principles of Design Types A, B and C. In Type A (existing), the washing machine is stabilized by the front steel sheet and a steel bar. Type B has a frame to stabilise and hang the front and back steel sheets on. Type C is similar to Type A, but with a service door access at the front of the washing machine. The bottom row of sketches show the design types from above with the top cover removed. In this row, one can see how the components can be attached and accessed by service and remanufacturing staff. (A close-up of Type A is shown in Fig. 3.2.) Based on Sundin *et al.* (2009).

Design Type Descriptions

- **Type A** The existing design is stabilized at the top with a central steel bar, and the front steel sheet is not removable. The back steel sheet is removable, as well as the top cover and control panel.

- **Type B** In this alternative design, both the front and back steel sheets are removable, and stabilization is achieved through an internal frame fastened to the base plate. Since the middle steel bar is removed in this concept, a regulator and a capacitor must be mounted elsewhere, e.g., on the frame.
- **Type C** This alternative design has the front steel sheet functioning as a stabilizing part, complemented with a service door at the front. The top frame is used in this design to house the regulators, the capacitor and the cable contact, and for stabilization.

The alternative design types clearly provide advantages over the existing washing machine design when it comes to accessibility for maintenance and remanufacturing. Table 3.2 shows the advantages and disadvantages of the three design types.

Table 3.2 Advantages and disadvantages with the existing (Type A) and the alternative (Type B and C) designs

Design Type	Advantages	Disadvantages
A	-Easy access to: - the circulation pump - the back weights - engine - strap	- The front steel sheet and steel bar obstruct access to many interior components. - It is difficult to remove: - the front steel sheet and front weights - the arm that controls which powder compartment to flush - the sewage pump and electrical unit
B	- All exterior parts are easily disassembled - Increased accessibility without the steel bar - Removable weights	- Extra manufacturing costs of the frame are required
C	- Removable service door - Increased part accessibility - Minor redesign changes	- Extra manufacturing costs of the service door are required - The front steel sheet is difficult to remove

As the alternative design types show what could be made on a structural design level, other improvements can also be made in the washing machine on a component level. These kinds of improvements concern, for instance, what kinds of joints are used. For example, the circulation pump in the washing machine could have better access and better snap-fits that would prevent the snap-fits breaking when disassembled and reassembled. In addition, the reduction of screws and screw types could also improve the maintenance and remanufacturability of the washing machine. In summary, regarding component level changes one can say that for the washing machine it is possible to introduce snap-fits and slide-slots to enhance maintenance and remanufacturing. Snap-fits are used for easy assembly and disassembly, while slide-slots enable a simple fixation in many directions, and without extra joints.

3.2.1.2 Refrigerator

The refrigerator, Model KF-3517, utilizes its surrounding steel sheet as a stabilizing construction. The refrigerator has only been analyzed at part-level since it contains relatively few parts: the steel sheets, the doors, the compressor, the shelf tracks and the printed circuit board. Since cleaning was found to be one of the most important steps of maintenance and remanufacturing, an interior design improvement example is given.

To be able to access the parts that need to be cleaned, it is important to give them a suitable shape (SIK 1997). According to The Swedish Institute for Food and Biotechnology (SIK), one should follow the following guidelines for the hygienic design of corners, illustrated in Fig. 3.4.

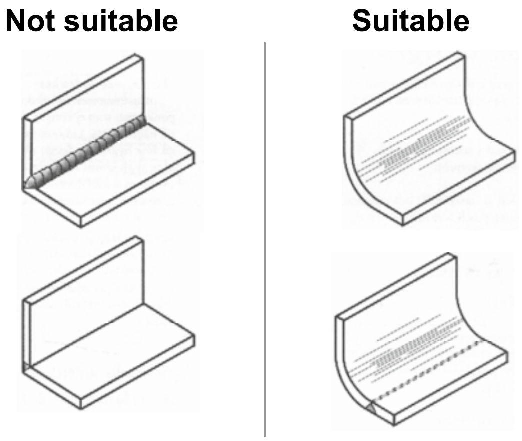

Fig. 3.4 Design recommendations for hygienic design of corners to facilitate cleaning accessibility (SIK 1997; Sundin and Lindahl, 2008).

As an industrial example of poorly designed products for remanufacture, we can look at the design of shelf holders in an Electrolux refrigerator, seen in Fig. 3.5. In the remanufacturing process of this refrigerator, the cleaning stage is often relatively time consuming. To the left, one can see the existing design of the shelf holders; to the right, an improved suggestion.

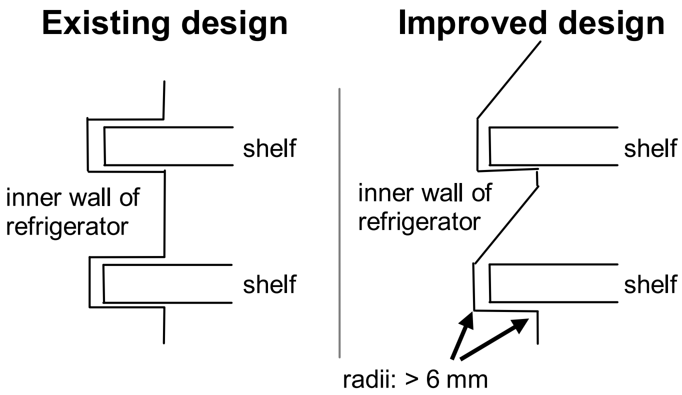

Fig. 3.5 Design recommendations for making a refrigerator easier to clean according to the rules put forward by SIK (1997). Modified from Sundin and Lindahl (2008).

3.2.2 Case B: Soil Compactors

Swepac International AB is a Swedish manufacturer of soil compactors. The company offers a various types of soil compactors to its customers, which for the most part consist of construction firms. The company aims to produce soil compactors that can withstand tough conditions in difficult environments. Swepac's designers have tried to reduce the cost for spare parts and maintenance. The company provides its customers with a fast supply of spare parts, technical service and support, to pure service agreements where the customers have a list of service levels to choose from.

In order to prolong the technical and economic lifetimes of its soil compactors, Swepac also conducts remanufacturing. This could also be included in the customers' service agreement. Since the remanufacturing process generates costs for Swepac, they are trying to reduce them. Therefore, the designers are trying to reduce the maintenance and remanufacturing costs by choosing a smart design for their products. The plan for Swepac is to develop soil compactors which have longer service intervals, and components and material will be chosen to ensure that they last throughout a normal life-cycle.

Since Swepac have worked extensively with their product adaption, the next paragraph will describe how they have progressed. Following this, some minor suggestions for improvements will be described.

Fig. 3.6 An example of a soil compactor and how it is used (Swepac 2009)

3.2.2.1 Swepac PSS Design Improvements

In order to avoid unnecessary costs for maintenance work and remanufacturing, the company has introduced new materials to replace the traditional selection. Fig. 3.7 shows how these design improvements have progressed for a type of soil compactor of similar size.

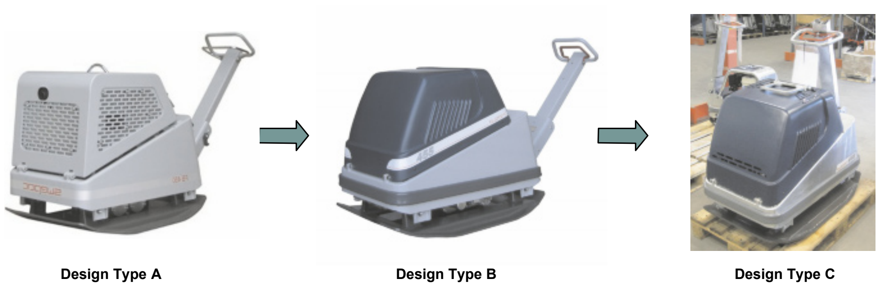

Fig. 3.7 Evolution of soil compactor designs at Swepac to match their PSS needs (based on Sundin *et al.* (2009)).

The Chassis

The chassis is of the Type A design, made of painted steel. This type of chassis was found to be easily damaged, and when remanufacturing the soil compactor, much time and effort was put into the repainting operations needed to return it to newly-manufactured condition. To increase quality and reduce damage and the need for repainting, a rubber bellow was added as seen in Design Type B of Fig. 3.7. For the latest design, Type C, the designers also decided to galvanize the painted steel with zinc. The galvanized steel was found to reduce scratches even more than the rubber bellow-only configuration, and keep the maintenance requirements to a minimum, since the zinc has a self-healing effect when damaged. This change was made clear by the CEO when studying trailers. As the CEO once stated: *"who would buy a painted steel instead of galvanized trailer today?"*

The Hood

In the Type A design, the hood was made of painted steel, just as the chassis. To reduce amount of visual scratches and repainting jobs, the hood was changed to coloured-through plastic; this also enabled a faster changing of the hood if necessary.

The Transport Device

The Type A design has an unfoldable metal loop for the user when grabbing and transporting the soil compactor up and down from the ground. This is usually accomplished with a tractor or a forklift truck. The loop, however, was hard to reach, and if missed the soil compactor could be damaged. In the Type B design, a foldable textile strap with a chain is introduced, along with a larger loop area (Fig. 3.8). This allows for easier transport with less chance of damage. However, some drawbacks of this design solution were that it could wear out eventually, and was a bit tricky to change. For the latest design, Type C, the designers instead introduced a foldable metal loop which is not as strongly attached to the soil compactor as in Type A. The good thing with this type of transport device is that it is long-lasting, and can easily be changed if necessary.

In all of the design types, some previous design adaptations for PSS have been conducted by Swepac. For example, the base plate is made of hardox steel which is very hard and will not require any maintenance and/or changes during the soil compactor's technical lifetime (see Fig. 3.9). In addition, the filter for the air-inlet to the engine is enlarged to stop more particles. Also, the air inlet was placed at a spot where fewer particles were flying around in the air. Since the compactors are used in a highly particle-filled environment, this kind of filter prolonged the technical lifetime of the engine significantly. Since Swepac was not an expert in the area of engines and how to service them, this was a good option for them to reduce maintenance and repair efforts. The adapted air filter is shown in Fig. 3.9.

Fig. 3.8 The FB-455 soil compactor in use with the transport textile strap erected (modified from Sundin *et al.* (2009)).

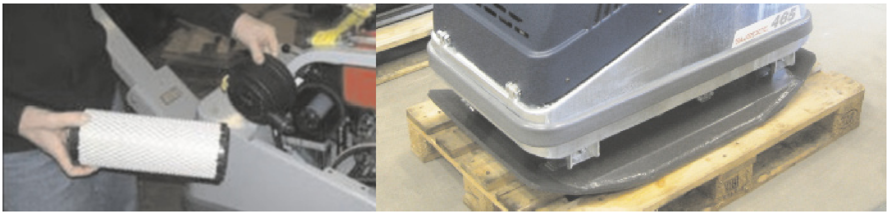

Fig. 3.9 The adapted air filter (to the left) and the hardox steel plate (to the right)

Summarising the design evolutions made by Swepac designers, one can summarise the following advantages:

- Less visible damage during use
- Reduced need for repainting during remanufacturing
- Easier change of cover during maintenance and remanufacturing
- Reduced wear during transport and easier change of transport device

3.2.2.2 Future Design Improvements

Investigating one of the soil compactors at Linköping University, the FB-200H, the researchers found some minor areas for improvement. The FB-200H soil compactor was disassembled and reassembled several times in order to identify areas where the design could be improved. During the product analysis, several design improvements were elucidated. Some of these improvements are presented below, while the rest are presented in a technical report by Murremäki *et al.* (2006). Here are two of the suggestions and their consequences:

- **Introducing snap-fits** at the strap cover for the strap between the motor and the revolving vibration cylinders. Using snap-fits would eliminate the use of tools, hence making the assembly and disassembly of the cover more time-efficient. Snap-fits are preferable if they provide the same quality as the existing four screws do.
- **Standardize the screws** used in the entire compactor design. This would reduce the number of tools used for the assembly and disassembly of the compactor parts. In addition, costs would be reduced due to a lower number of articles to keep track of in databases and storage facilities.

3.2.3 Case C: Forklift Trucks

The forklift truck manufacturer TMHG offers customized material handling solutions to improve its customer's business efficiency. TMHG is a complete supplier of manual trucks (i.e. forklifts), electric-powered warehouse trucks and counter-balanced trucks (Fig. 3.10). In order to satisfy its customers throughout the forklift truck's entire life-cycle, high demands are placed on the product itself and its functionality, as well as on service and spare parts availability. While sometimes the solution is to purchase a new truck, TMHG's forklift trucks are being rented with increasing frequency. With rental plans, the customer can attain greater flexibility, reflecting the changing needs of its operations.

Fig. 3.10 An example of a forklift truck and how it is used (Toyota Material Handling Sweden AB 2008)

TMHG offers numerous combinations of rental plans, enabling customers to manage truck-related activities with both flexible capacity levels and lower, more predictable costs. Examples of rental programs offered are: core fleet rental (long-term rental), flexible fleet rental (long-term rental), payback rental, short-term rental, and standby rental. According to those interviewed, TMHG currently manufactures around 40,000 electric forklift trucks per year. Those interviewed for this study estimated that 50-60 percent of the business for TMHG Europe was through rental plans.

Forklift trucks within rental plans are remanufactured by TMHG in their own remanufacturing workshops. In some cases, the same forklift truck may go out on different rental contracts during a year, and in order to guarantee its quality, the truck is more or less remanufactured between these different rental plans. Since the rental portion of Toyota Material Handling Group is growing, remanufacturing issues are becoming more and more important, e.g., in product design.

3.2.3.1 Design Improvements

In this case, a forklift truck, used for rental plans, was analyzed from a PSS perspective, e.g., the perspective of use, maintenance and remanufacturing at Linköping University (see detailed description in Sundin *et al.* 2005.). Here are some examples that we found:

Introduce fewer screws or snap-fits for the maneuver consol (Fig. 3.11). The console is currently attached with 11 screws, all of which are inserted from below. The use of all these screws when assembling and disassembling the consol appears to be both unnecessary and time consuming. If a service were to be performed on the console, it would take an unnecessarily long time to disassemble and reassemble it, especially if done by a single person. A suggestion for improvement would be to replace the screws with durable snap-fits. If necessary, for additional securing of the parts, screws could still be used. By using non-destructive snap-fits, the number of screws could be reduced and the disassembly and reassembly facilitated. This would reduce the time for assembly, maintenance and remanufacturing if the parts of the maneuver console, or its interior parts, needed to be accessed.

Introduce durable bushings to extend the technical product life-cycle. TMHG told us that they had problems with their suspension bushings holding the engine since they wore out too quickly when operating in harsh environments (Fig. 3.12). To deal with these issues, TMHG changed from metallic to plastic bushings and then back. In theory, the plastic bushings were said to be maintenance-free due to lubrication treatment. The problem with this lubrication is that when the forklifts are painted, the grease dries out and is not replaced. During use, the bushings collect dirt and thus the lifetime of the bushings is shortened. Having a broader life-cycle perspective on the use of forklift trucks, the metallic choice was preferable since it allowed easier and better maintenance when the forklift trucks had been used for a few years. The technical lifetime of the forklift truck depends greatly on the extent of its use and in which working environment. The problem with the plastic bushings is therefore more critical for the forklift truck that runs many hours a day and in dirty environments, such those found in fish processing-related industries.

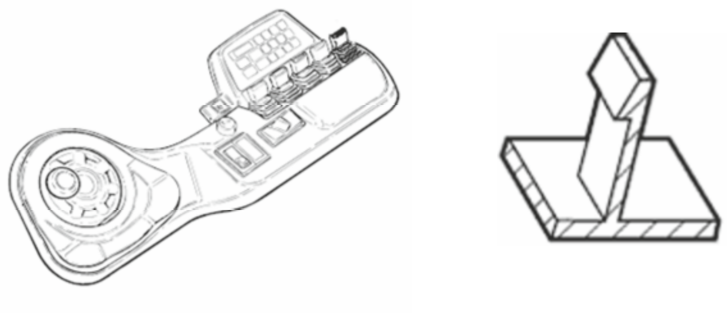

Fig. 3.11 Illustration of a maneuver console in the analysed forklift truck (to the left) and a snap-fit example (to the right). Modified from Sundin *et al.* (2009).

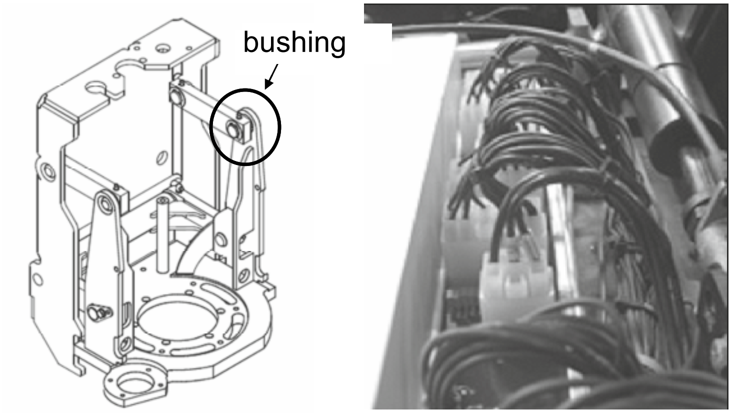

Fig. 3.12 Suspension of an engine (to the left) and electronic sockets (to the right). Modified from Sundin *et al.* (2009).

Protect the electronic sockets to avoid short circuits and incorrect failure reports when performing maintenance and remanufacturing. The electronics in a forklift truck are exposed to harsh environments; for example, they are often operated in freezer rooms with temperatures reaching down to -30^{o}C. When the forklift trucks change environments, for example moving between room and freezing temperatures, the electronics are exposed to condensation. These issues should be considered when designing forklift trucks so that the water from condensation does not enter the electronic components and cause short circuits or similar problems. The electronic sockets are exposed and inserted from above without any protection from above, as illustrated in Fig. 3.12. As these sockets are placed today, they allow for dirt to collect and water from condensation to form in small pools.

These problems could be avoided by covering the electronic sockets, or by inserting them from another direction that would prevent the collection of dirt and water. Another way of dealing with the condensation of water is to build in zones of drainage. This would make the forklift more robust and last longer. The robustness of the electronics is very important when performing maintenance and remanufacturing, since the operations performed are dependent on which codes of errors the forklift truck generates when tested.

3.2.4 Reflection on the Case Studies

As the case studies have shown, there are various design adaptations that can be made in order to facilitate PSS, and especially the maintenance and end-of-life phases of the product life-cycle.

Many adaptations concern how to make the physical products more durable, extending their lives for several PSS contract periods. By doing so, the same physical hardware can be used several times in an economically and environmentally preferable manner. The adaptations also often focus on achieving good accessibility for cleaning and/or replacement of components during maintenance and remanufacturing. In addition, standardization of components reduces maintenance costs, as fewer parts need to be stored and the chance of taking the wrong component is reduced.

The feedback from the case companies has most often been positive. However, some design change suggestions, such as service door implementations, have been seen as too expensive to use, and quality issues concerning stabilisation were brought up as possible disadvantages from the case companies. However, most of the design changes were seen as easy to implement, along with their previously conducted efforts of changing their product design to better facilitate PSS.

For the three case companies, the driving forces for product adaptation look different due to company size and the number of their products that are sold through PSS. For example, Swepac and TMHG sell many of their products in PSS, and therefore have more interest in facilitating PSS, while Electrolux still sells most of their products traditionally, and thus does not have as much interest in adapting their products for PSS. In addition, the small company of Swepac has the ability to change faster in design, and only a few people from the company's staff need to be involved, leading to quicker decisions.

3.3 Discussion

The design of products is important when they are to be used in a PSS. However, it is also important to have a well-functioning system of reverse logistics and end-of-life treatment. For example, the relation between the PSS provider (sometimes also remanufacturer) and the customer is important for remanufacturing success. According to Östlin *et al.* (2008), there are seven different kinds of relations that currently occur between the customer and the remanufacturer. When products are sold through PSS these kinds of systems are easier to build up, since, for example, the ownership of the products is still with the PSS provider.

In our research at my division, we have seen that companies build up a fleet management function for monitoring their fleets of products out at the customer location. The main task is to monitor and manage the fleet of products, and to ensure that the flows of used products going to end-of-life treatment, for example remanufacturing, are as efficient and effective as possible. This means that used products with a quality or technology not useful for remanufacturing should instead be selected for final treatment. If the distance from the customer to the reverse manufacturing facility is a long one, the unusable product should not initially go to the remanufacturing facility; instead, the unusable product should go directly to scrapping. Another common task is making the exchange of one used product for a new one as smooth as possible.

A key component in PSS is keeping control of ingoing products during the use and end-of-life phases. This is important in order to ensure the delivering company's ability to best benefit from built-in features in the ingoing products, for instance ease-of-remanufacture or reuse of ingoing components. An example of this is the FUJI Film single-use camera, that can be remanufactured several times (Sundin *et al.* 2008), or the Rank Xerox photocopier, with components that can be reused in new machines (Kerr and Ryan 2001). These companies' increased control and possibility to reuse implies that they can invest more in ingoing components than in traditional products, since they can split the cost over more than one use-phase.

When designing for PSS, a broad perspective over the product life-cycle is needed. This includes, for example, the stages of manufacturing, maintenance, logistics and remanufacturing. In a survey conducted at Swedish, Japanese, Italian and German manufacturers using the PSS offering approach, the companies were found to seldom adapt their products for PSS offerings (Lindahl *et al.* 2009). Earlier research by Kerr and Ryan (2001) and Sundin and Bras (2005) also show that there are several benefits to be gained from adapting PSS offerings for remanufacturing. The significance of Design for Remanufacturing (DfRem) - and indeed of any other elements of Design for Service - is that design is the stage that has the strongest influence on environmental impact, and which sets the product's capabilities.

The need to simultaneously consider all of the remanufacturing process activities is highlighted by Ijomah *et al.* (2007), who illustrate that particular product features may simultaneously impact several remanufacturing activities, and that the nature and intensity of that impact may vary between the different activities. For example, material type influences the remanufacturing steps of cleaning (of core and components), remanufacture components, and test. In all of these process steps, high material strength has a positive impact since it enhances durability, and hence the potential of the component to withstand the stresses of each process step. On the other hand, product features such as type of bonding may have a positive impact on one remanufacturing activity, and at the same time have a negative impact on another. For example, strong adhesives such as epoxy resin may facilitate assembly due to ease-of-application, but at the same time hinder disassembly. This will hinder component cleaning and internal component rectification because of accessibility issues. This is a key remanufacturing benefit in assisting PSS, since it can help to reduce the service company's financial outlay by providing a lower cost but effective method for maintaining products. Thus, design features that may impede remanufacturing should be identified at the design stage, and investigated to eliminate them or determine how to reduce their negative impacts so that PSS could be optimized.

3.4 Conclusions

This chapter, which was based on the results of case studies performed at three Swedish companies, elucidated how PSS providers have worked with or could adapt their physical products for PSS, with a particular focus on maintenance, repairs and remanufacture. In order to identify these kinds of improvements, one can use the RemPro matrix (Fig. 2.6, in Chapter 2) and/or conduct a product analysis.

From a business perspective, the adaptations have proven positive, for example, Swepac, helping them to achieve a "win-win" situation with the customer. For example, one benefit of having the product adapted for maintenance is that the customer can perform the repairs themselves, something which saves both time and money for Swepac, as it does not need to send out a technician. Also, many of the adaptations and product training conducted by Swepac are considered as goodwill, and strategically strengthen customer relations.

In addition, TMHG has experienced positive effects in their adoption of PSS, and their number of rental plans is increasing, along with greater profit margins than those sold via traditional product selling. In general, TMHG's forklift trucks have easy-to-perform maintenance and remanufacturing. However, some improvements in design could be made, as was shown in this chapter. Due to the increased volumes of products being sold though PSS offerings, these design issues need to be considered on a larger scale, such as seen at TMHG.

Concluding this chapter, PSS place new requirements on products in comparison to traditionallysold products. With a more optimized product design, obstacles can be reduced and profits increased. The products used in PSS should have easy-to-perform maintenance and remanufacturing/repairs in order to reduce costs. The results of this chapter have shown that designers can make many changes to facilitate PSS.

3.5 Recommendation to PSS Providers

For PSS providers, this chapter contributes with the following recommendations:

- Plan how the product life-cycle should look for the physical products used in your PSS, including e.g., delivery, use/maintenance, take-back system and end-of-life treatment (e.g., recycling and remanufacturing).
- Set up a system that works for the entire life-cycle - including the use and end-of-life phases that include, e.g., maintenance and remanufacturing.
- Uncover any problems during the life-cycle - and make sure that the product design facilitates solving these problems - in order to reduce cost in, e.g., maintenance, take-back and end-of-life treatment (e.g., material recycling and remanufacturing).
- Study how different levels of design, e.g., structural and component, can affect PSS performance, customer value and the overall business of your company.

3.6 Acknowledgments

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Chapter 4

Systematic Generation of PSS Concepts Using a Service CAD Tool

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Abstract In this chapter, a systematic method to generate design concepts of integrated product-service offerings, or Product/Service-Systems (PSS), is proposed. This method uses formal PSS modelling and reasoning facilities of a service CAD tool. Such a formal modelling method and reasoning facilities are crucial to overcome the limitations of existing tools and methods to support PSS design, in reflecting research findings about the PSS concept, in representing design information, and in supporting systematic design. The method is applied to concept generation of product-service offerings in the health care service industry from the perspective of medical instrument manufacturers. Possibility and limitation of the method in finding explicit relation between service receivers (e.g., patients, instrument operators) and the manufacturers, in dealing with interrelations among the generated offerings within a concept, in presenting and understanding a concept as a whole (by designers), and in separating design tasks to improve the quality of concepts and productivity of the design process, are analyzed. This chapter is prepared not only for potential users and developers of such modelling methods and tools, but also designers of service-oriented business models in industry to organize and utilize their product-service information.

Keywords PSS modelling, Service CAD, Systematic Design

4.1 Introduction

Computer-aided design (CAD) tools have been widely used in the manufacturing industry to increase productivity in (product) design processes. A few service CAD tools have been proposed for the design of services, integrated product-service offerings, or Product/Service-Systems (PSSs) (e.g., Tomiyama and Meijer 2003, Arai and Shimomura 2004, 2005, Sakao and Shimomura 2007, Komoto and Tomiyama 2008, Hara *et al.* 2008, Sakao *et al.* 2009). For the effective use of these tools in the design process (e.g., modelling, simulation, evaluation), information about products and services utilized in the design process should be organized on these tools. In this chapter, a method to generate PSS design concepts using a service CAD tool is presented, and organization and utilization of the design information used in the method is analyzed.

This chapter is considered useful for two types of readers. First, potential users and developers of PSS modelling methods and service CAD tools will learn the methods and tools currently developed in academia. Second, designers of business models in industry will also benefit from this chapter in organizing information about their products and services included in their business plans. Furthermore, describing business plans following a PSS modelling method will help the designers systematically analyze the roles of these products and services to jointly satisfy the needs of customers.

Among the service CAD tools developed by the researchers quoted above, Integrated Service CAD with Life-cycle Simulator (ISCL) supports various steps in PSS design process, including concept generation and evaluation, in which formal PSS modelling methods are required to realize the supports (Komoto and Tomiyama 2008). In this chapter, the tool is used to study organization and utilization of design information in a service CAD tool for systematic generation of PSS design concepts.

In Sec. 4.2, three issues in PSS design are presented and analyzed. Analysis of these issues specifies the challenges of researchers studying PSS modelling methods and service CAD tools. The challenges are formulated by the observation of insufficient functionality of the existing methods and tools to represent information used in systematic PSS design, while considering utilization of research findings about the concept of PSSs (Mont 2002, Tukker and Tischner 2006) during the design process. With respect to each issue, related work is presented and the challenges are summarized.

In Sect. 4.3, a PSS modelling method used for systematic generation of PSS design concepts using ISCL is introduced. The modelling method is based on the service formalization (Tomiyama *et al.* 2004). Information about products and services are used to describe both design concepts and their specifications. Part of the reasoning facilities in ISCL supports evaluation of the correspondence between them and suggests products and services that potentially improve the correspondence. Use of such computational facilities on service CAD tools is a solution to systematic PSS design.

In Sect. 4.4, the method is applied to systematic generation of integrated product-service offerings in the health care service industry from the perspective of medical instrument manufacturers. Design of such offerings in the industry is diverse in terms of ownership structure, service contracts, and machine selections according to the needs and wishes of such involved stakeholders as machine owners, doctors, and patients (Sistrom and McKey 2005, Levin *et al.* 2008). For the systematic generation, information about products and services offered by some manufacturers are collected. The collected information is organized following the present modelling method. Furthermore, the possibilities and limitations of the method in relating service receivers (e.g., patients, instrument operators) and the manufacturers, in dealing with interrelations among the generated offerings within a concept, in presenting and understanding a design concept as a whole (by designers), and in separating design tasks to improve the quality of design concepts and productivity of design processes, are analyzed.

In Sect. 4.5, this chapter is concluded with future trends regarding the design of product-service offerings in the health care service industry, and the role of service CAD tools considering the trends.

4.2 Issues and Challenges

In Sect. 2, three issues in PSS design are considered. They are partly derived from insufficiency of the existing PSS modelling methods and service CAD tools in supporting the following aspects in PSS design process:

- Reflection of research findings about the PSS concept into PSS design
- Representation of information used in PSS design process
- Systematic PSS design

The challenges of researchers studying PSS modelling methods and developing service CAD tools can be formulated by analyzing the issues described below.

4.2.1 Reflecting Research Findings

Empirical studies showed that function/sales business models, shared service business models, or similar business models brought about economic benefits to the stakeholders in both manufacturing and service sectors, while decreasing the total environmental impacts (Bartolomeo *et al.* 2002, Maxwell and van der Vorstb 2003, Michelini and Razzoli 2004, Sundin and Bras 2005). They concluded that the design of such business models requires careful adjustment of the balance between economic and environmental performances and conflict resolution among the stakeholders. These studies were used to clarify the concept of PSSs (Mont 2002) and formulate the theoretic framework for PSS design, development, and implementation (Tukker and Tischner 2006).

These empirical studies were also used to develop design tools such as a PSS design guideline (UNEP 2002). Designers took the initiative of tool development with a motivation to use them as supports for generation and presentation of conceptual business blueprints (Tukker and Tischner 2006). They assumed that the entrepreneurs implementing the blueprints in practice would perform such verification tasks as quantitative evaluation and risk analysis.

These tools based on the above motivation could not sufficiently help the tool users in the following contexts in PSS design. First, the tool users were instructed to use multiple (e.g., economic, environmental, and socio-cultural) performance indicators to evaluate PSS design concepts from the perspective of multiple stakeholders (e.g., manufacturers, governments, product users). However, the tools could not explicitly deal with conflicts regarding the performances among the stakeholders. Using the tools, such conflicts and the trade-off performances derived from the conflicts would be overlooked. Second, uncertainty in a PSS design concept developed at early design stages is a cause of difficulties in evaluating its performances. The uncertainty includes preferences of consumers to particular product-service offerings and the proportion of customers in a market regarding the preferences. To deal with such uncertainty, these tools were used with checklists and SWOT (Strength, Weakness, Opportunity, and Threat) analysis methods. However, they could not quantitatively assess the uncertainty. Third, these tools did not include instructions about how to describe a PSS design concept (i.e. a PSS modelling method). As a result, the tool users would face difficulty in deriving the performances of a design concept from the concept description, in modifying the concept description so as to increase the performances, and in comparing and integrating the concept description with other concept descriptions.

Based on the above observation, a challenge for the researchers studying PSS modelling methods and service CAD tools regarding this issue is to develop techniques to deal with trade-offs among multiple stakeholders with respect to multiple performance indicators, while considering the uncertainty that appeared in the early design stages. Such techniques can be borrowed from science and engineering domains (e.g., multiple objective optimization technique). Nevertheless, appropriate PSS modelling methods are crucial to realize these techniques on service CAD tools.

4.2.2 Representation of PSS Design Information

A variety of information is used to develop and complete a PSS design concept. Such information includes information about products and services to form a PSS design concept, and information to support the PSS design process. Examples of the latter information are PSS design guidelines and research literature about PSS design mentioned in Sect. 2.1. Difficulty in disseminating this information from academia to industry is considered as one of the causes limiting successful development of business models based on the PSS concept in practice (Cook *et al.* 2006).

Information about products and services is mostly owned by manufacturers and service providers in diverse product and service domains. Research findings about the PSS concept have shown that there are two major perspectives regarding the initialization of business models based on the concept, and each requires different types of information for the initialization. First, the industrial Product/Service-Systems (IPS2) concept is aimed at value addition in the life-cycle of a product (or product platform) by providing diverse service offerings to customers, in which the product is treated as the core service channel (Transregio29 2008). PSSs based on this concept are referred to as product-oriented PSS type or use-oriented PSS type according to Tukker and Tischner (2006). In practice, such PSSs are initiated by manufacturers (Williams 2007), whose marketing department analyzes the information collected from product users. Second, PSSs can solely be initiated by the aims of customers without assuming ownership and usage of products by customers. PSSs based on this concept are classified into result-oriented PSS type (Tukker and Tischer 2006). The core of such PSSs is the service receiver that specifies the results to be delivered, while flexibility in selecting products and services remains. This kind of PSS therefore requires information about products and services in relatively wide domains.

In Fig. 4.1, design information used to initiate a PSS concept in context of the health care service delivery from the above perspectives is shown. On the left, services offered by a manufacturer associated with the life-cycle of medical instruments as core service channels are listed. On the right, quality criteria specified by the service receivers (e.g., patients) are listed. Fig. 4.1 implies that additional information (e.g., intermediate service providers and service channels, logical connections among them) should be defined to complete a PSS design concept initiated by the manufacturer to satisfy the requirements specified by the patients. Supplying such information to support selection of products and services is one of the major required functionalities of service CAD tools.

Considering the diversity of products and services included in a PSS design concept, PSS modelling methods and service CAD tools should be independent from particular product and service domains. Service formalization (Tomiyama *et al.* 2004), Serviset (Hara *et al.* 2006), and a service model related with receiver state parameters (Sakao and Shimomura 2007*,* Sakao *et al.* 2009) are examples of domain independent methods that can represent products and services in an integrated form. These methods are based on the definition of service as a set of activities to deliver service contents from service providers to service receivers through service channels (Tomiyama 2001). Furthermore, Hara *et al.* (2008) proposed an integrated representation of products and services for service design by combining service representations in marketing fields (e.g., Shostack 1981) and product representation in engineering design fields (e.g., Pahl and Beitz 1996).

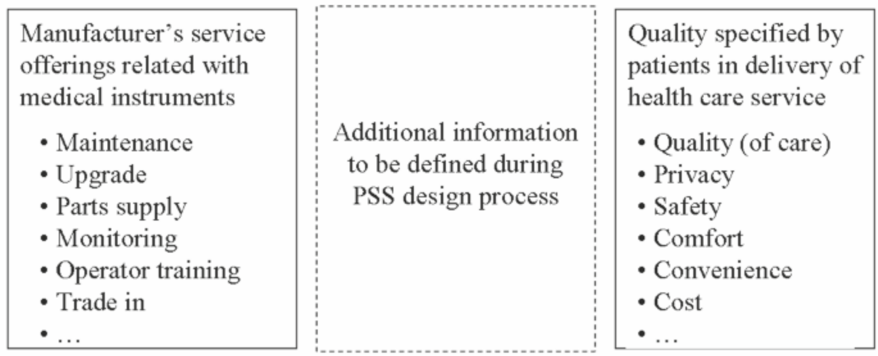

Fig. 4.1 Design information to initiate a PSS concept from different perspectives

4.2.3 Systematic Design

Systematic design is necessary in maintaining design quality and increasing design process efficiency without overlooking potential design solutions. From the engineering design perspective, systematic design is accomplished by decomposing the entire design problem into sub-design problems, and by finding solutions to sub-design problems (Pahl and Beitz 1996). For instance, Quality Function Deployment (QFD), function decomposition, definition of working principles to satisfy decomposed functions, are the main tasks of the conceptual design process that complete the conceptual design of products as the output using market information obtained from customers as the input.

Service Explorer (Arai and Shimomura 2004, 2005, Sakao and Shimomura 2007), as a service CAD tool, supports systematic service design following the above design problem decomposition approach. A service design procedure using the tool was proposed in Sakao and Shimomura (2007). According to the procedure, the tool first supports designers to relate quality criteria of services perceived by customers with product attributes, and then calculate the importance of the attributes based on customer's quality evaluation. Hara *et al.* (2008) extended the functionality of Service Explorer using an integrated model of function, service activity, and product behaviour.

However, the tool has limitations in functionality to support systematic PSS design. For instance, the tool cannot treat activities that change the state of products, which influences the quality specified in a PSS. The reason is that activities in the tool are defined as frames that organize the set of quality criteria and product attributes in focus. For instance, the designers can answer a query like "Why cleanliness of hotel rooms matters for customers?" by tracing relations between the quality and the attribute (because customers evaluate the quality of hotel in terms of cleanliness of hotel rooms). However, the designers cannot answer a query like "What is the role of room cleaning activity?" Lack of functionality in answering such a query inevitably limits systematic addition of service as an activity in a specific context. Furthermore, the tool does not have reasoning functions to answer such a query in place of the designers.

Considering these studies about systematic service design methods and corresponding tools, there are many remaining challenges for researchers of PSS modelling and service CAD tools regarding this issue. To develop a function to answer the abovementioned queries can be one of the challenges. As observed above, the limitation of service CAD tools is partly derived from representation of the design information on the tools (e.g., definition of activities). Therefore, service CAD tools should be developed together with PSS modelling methods. The PSS modelling method and the service CAD tool introduced in Sect. 3 will provide some insights to deal with this issue.

4.2.4 Requirements of Service CAD Tools

Requirements of PSS modelling methods and service CAD tools for the design of integrated product-service offerings have been identified through the above analysis and they are listed below:

- To deal with trade-offs among multiple stakeholders with respect to multiple performance indicators, while considering quantitative information and its uncertainty.
- To represent design information to relate service receivers (in terms of goal and quality criteria) and service providers (in terms of their products and services).
- To systematically support finding relations service receivers and service providers. For this reason, the relations should be represented in a formal PSS model.

4.3 Systematic PSS Concept Generation Using ISCL

In Sect. 2, the requirements of PSS modelling methods and service CAD tools for systematic design of business models based on the PSS concept were presented. To deal with the requirements, ISCL has been developed for systematic PSS design (Komoto and Tomiyama 2008). The PSS design process using ISCL is divided into concept generation and quantitative and probabilistic concept evaluation. In this Sect., information about products and services is analyzed in terms of the organization to constitute design concepts following a PSS modelling method and the utilization for systematic PSS concept generation using ISCL.

4.3.1 PSS Information Collection and Classification

At the beginning, information about existing products and services is collected so that it is used as the constituents of objective PSS design concepts. Various sources (e.g., Internet) can be used for the information collection. At this step, quantitative precisions of the collected information are not specified on ISCL. However, the collected information has to be defined as elements of the service formalization (Tomiyama *et al.* 2004) in order to use the computational facilities of ISCL used in the design process.

4.3.1.1 Service Formalization for PSS Modelling

The service formulation classifies the above information into service goal, quality, service (as activity), and service environment. Note that the information includes not only products and services themselves (design objects corresponding to product design), but also functions of products and aims of services (specifications of design objects corresponding to product design). The service environment consists of service providers, service receivers, service channels, and service contents. Based on the classification, ISCL defines the properties of these elements and relations among these elements as follows:

- Service goals (G): They are binary measurable elements (realized or not realized). A service goal is decomposed into a set of sub-service goals. Each root service goal is specified by a service receiver. They are realized by either execution of activities, or state transitions of a service environment as a result of executing activities. Functions of products are treated as service goals of service receivers (e.g., users), and they are realized when products are used.
- Quality criteria (Q): They are qualitatively or quantitatively measurable elements (in other words, quality has its value). Each quality criterion is specified by a service receiver. They are similar to Receiver State Parameters (RSPs) used in the service model defined by Sakao and Shimomura (2007) in that each quality criterion is related with the attributes of elements (e.g., service channels) in a service environment. It is different from RSPs in that its value is determined by the state of a service environment dynamically changed by execution of activities. For this reason, the timing of evaluating quality should be explicitly defined.

Relations between the above specifications and service receivers are manually added by designers, or collectively stored in the form of primitives introduced in Sect. 3.1.2. However, these primitives are not like persona models in Sakao *et al.* (2009) that represent the overall structure of the specifications:

- Service environment (E): It consists of a set of service providers, service receivers, service channels, and service contents. Attributes of constituents and relations between constituents are defined. Existence of constituents, existence of relations between constituents, and the value of attributes of constituents determine the state of a service environment. The state transitions are caused by executing activities.
- Activities (A): An activity is defined by conditions and consequences of their execution. The conditions are necessary to evaluate whether an activity can happen when the service environment is at a certain state. The consequences explicitly define the results of executing an activity. The consequences include realization of service goals, evaluation of quality criteria, and state changes of a service environment. Designers also define an expected sequence of activities independently from their conditions and consequences, while inconsistency between an expected sequence of activities and possible sequences of executions determined by the conditions and consequences of the included activities is detected by ISCL.

Using the above formulation, services (S) are activities that contribute to the realization of service goals or to the increase of quality. Furthermore, this formulation gives such service classifications as enabling, and enhancing services, as classified by Tomiyama *et al.* (2004). Enhancing service increases the specified quality. Enabling service changes the state of a service environment so that enhancing and other enabling services can happen. Furthermore, the formalization defines direct service, or service that directly realizes the specified service goals in comparison with indirect (enabling and enhancing) service.

For instance, activity 1 and activity 2 in Fig. 4.2 are direct services realized by executing activity, and by changing the state of the service receiver, respectively. Fig. 4.2 also shows that the service receiver evaluates the quality based on the state of the service channel at activity 3. Activity 2 becomes an enhancing service in terms of the quality, because it enhances the state of the service channel from the perspective of the quality.

4.3.1.2 Information Organization in ISCL

Collected information is classified into the elements of the service formalization and stored in ISCL. Since the information is collected from different resources, relations among the classified elements are partially given. In ISCL, a relational network of these elements is defined as a primitive. Fig. 4.3 shows some primitives defined on ISCL. With a set of primitives stored in ISCL, the designers refine a design concept by instantiating primitives and giving relations among the instantiated primitives and the design concept (see Fig. 4.5 in comparison with Fig. 4.3). The size of each primitive should be small enough so that the meaning is easily understandable by the designers, although no objective instruction concerning the primitive size has been proposed. Some activities in a primitive are not related with service goals and quality criteria. They can also become services when they are appropriately introduced as parts of a design concept.

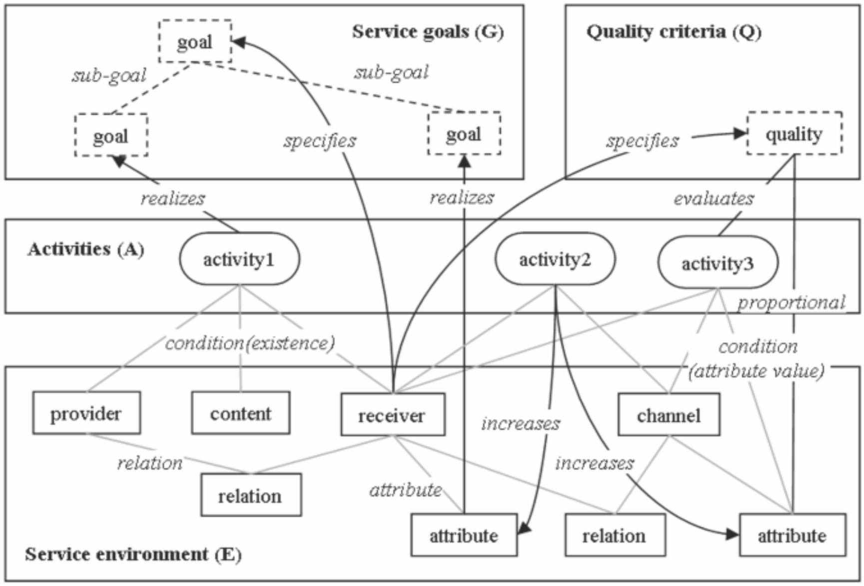

Fig. 4.2 Service formalization for PSS modelling

4.3.2 PSS Concept Generation

In the next step, PSS design concepts are generated based on the organized information. This step is performed with the help of reasoning facilities in ISCL. In this sub Sect., the procedure of the reasoning facilities is briefly described. The formal procedure is described in Komoto and Tomiyama (2009).

The approach to systematic concept generation presented here is similar to those developed by researchers with a motivation to identify and formalize various types of problems and solutions in service design (e.g., Edvardsson and Olsson 1996, Clark *et al.* 2000). ISCL computationally supports such a concept generation process.

In ISCL, the elements introduced in Sect. 3.1 are classified into specifications and design objects. Service goals and quality criteria are specifications, while activities and service environment are design objects. The reason of the separation is that ISCL is used to suggest the abovementioned service types by evaluating correspondences between the specifications and the design objects. The evaluation and suggestion functionalities are briefly described in the following subSect.s.

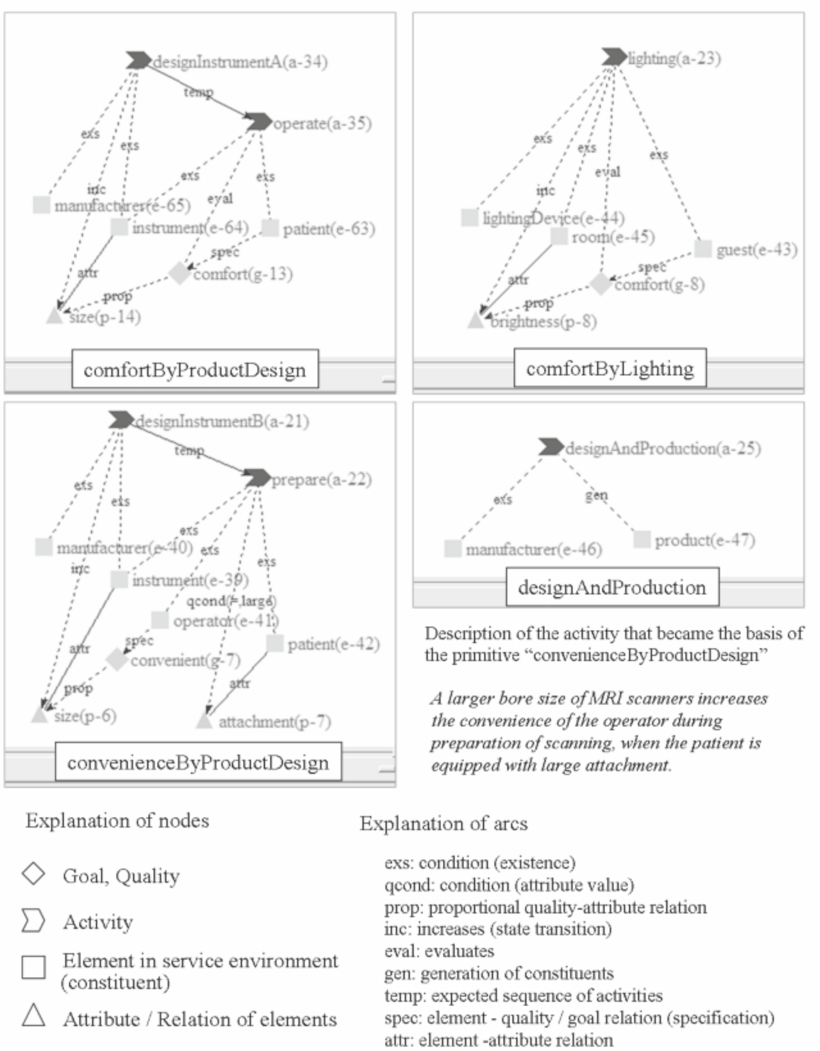

Fig. 4.3 Examples of primitives stored in ISCL

4.3.2.1 Concept Generation Procedure

A PSS design concept is generated using ISCL following these steps. First, the initial state of a service environment and a set of specifications (goals and quality criteria) are defined. After that, activities are added to the service environment so that they satisfy the defined specifications. For instance, a doctor, medicine, a medical instrument, and a patient are defined in a service environment of a health care service, in which the doctor examines the health of the patient to deliver advice and/or medicine that increases the health state. Designers can manually add arbitrary elements and relations to a design concept as far as they are defined in the formalization described above. Designers can use the following evaluation and suggestion functions for systematic concept generation.

4.3.2.2 PSS Model Evaluation Based on Reasoning

The evaluation function identifies such elements in a PSS design concept as unrealized activities, unsatisfied service goals, quality criteria that are not measured, not enhanced, and not maintained. In the above example, quality of the consultation service should be explicitly related with the attributes of elements in the service environment (e.g., skill of doctor, type of medicine). Furthermore, it identifies unnecessary elements in a service environment. In the above example, the medical instrument is treated as unnecessary, unless the need of the instrument during the consultation is explicitly defined. The identified elements should be modified in order to realize the specified service goals and increase the specified quality criteria in a design concept. Such model modifications are performed with help of the following suggestion function.

4.3.2.3 Addition of Elements Through Suggestion

The suggestion function suggests primitives added to a PSS design concept. A set of primitives are stored in ISCL as described in Sect. 3.1. This function utilizes the result of the evaluation function in order to search appropriate primitives to realize the identified service goals and change the state of a service environment evaluated from the specified quality criteria. In the above example, training of the doctor (to improve his/her skill) is considered as an activity to improve the quality of the service.

Another use of the suggestion function is to find potential activities that increase the performance of a PSS design concept. It is done by suggesting additional service goals and quality criteria, which originally belong to the suggested primitives stored in ISCL. This utility is based on the assumption that an activity is associated with multiple interpretations in terms of the roles in a design concept. In the above example, remote diagnosis of the medical instrument can be introduced as an activity to transfer information between the instruments and a central diagnosis server as a potential element in the service environment. The information can be interpreted not only as a necessary content for the diagnosis but also as source for the central management of the health state of the patient at a hospital level (also as a potential service element in the service environment) rather than management by the doctor.

4.3.2.4 Refinement of Product-Service Information

Information about products and services in a PSS design concept is refined, as new service elements are introduced and new relations among the service elements are defined during the design process. The refinement is partially supported by the above functions, while the direction of the refinement is defined by the designer. In the above example, introduction of the diagnosis activity specifies the functional state of the instrument, and its deterioration during the consultation (using the instrument). Furthermore, the suggestion function provides primitives with activities that can become direct, enabling, and enhancing services (e.g., maintenance of the instrument). After that the designer selects a primitive among them and defines relations between elements in the primitive and those in the design concept.

4.4 Demonstration with Examples in Industry

Reformation of health care and long-term care systems is crucial for all European countries taking into account the aging of populations (EU 2006). Design of integrated product-service offerings can be a solution to systematically realize such reformation in the health care service industry, while considering continuous development of health care products, capacity limitation in terms of the number of professionals such as doctors. Efforts to design such offerings have been found in existing services of the manufacturers of medical instruments. They have been diverse in terms of ownership structure, service contracts, and machine selections according to the needs of machine owners, doctors, and patients (Sistrom and McKey 2005, Levin *et al.* 2008).

In this Sect., generation of PSS design concepts in the health care service industry is demonstrated from the perspective of a manufacturer of medical instruments (e.g., magnetic resonance imaging (MRI) scanners, image processing tools). First, information about products and services are collected. The collected information is organized and utilized for systematic PSS concept generation using ISCL. After that, some findings of the concept generation process are analyzed and discussed.

4.4.1 Information Collection and Organization

First, information about integrated product-service offerings of several medical instrument manufacturers was collected from the public domain (e.g., website, product catalogues, and information about service contracts). The information included services of manufacturers, activities of other stakeholders, and automated operations of medical instruments. After that, elements in the information were classified into the service formalization as described in Sect. 3. Conditions and consequences of these activities, and related services goals and quality criteria were also defined to form primitives to be stored in ISCL. Some of the primitives are shown in Fig. 4.3.

The above collection and classification steps were subjective, for no collection guidelines compatible with the service formalization and no executable programs to automatically perform these steps have been available. Although subjectivity of the collection step does not influence the analysis about the information utilization at the concept generation step, influence of the subjectivity on the generated design concepts is analyzed in Sect. 4.3.

Utility of the stored primitives in generating PSS design concepts is analyzed by adding them to a base design concept using the suggestion function of ISCL. The base design concept was built on the modeller of ISCL (Fig. 4.4). It included a simplified workflow in a health care service, starting from the preparation of a medical instrument to the consultation by a doctor about the health state of a patient. Note that it included a doctor, a patient, a medical instrument, and an operator of the instrument as the constituents in the service environment, but it did not initially include the manufacturer of the instrument.

4.4.2 Generating PSS Design Concept

In Fig. 4.5, a result of the PSS design concept generation is shown. A manufacturer was introduced as a service provider in the base design concept, and relations between the manufacturer and the patient were systematically added. The result was obtained by adding pre-defined primitives using the suggestion function, as follows (alphabetical symbols in Fig. 4.4 and Fig. 4.5 correspond to those in the following paragraphs).

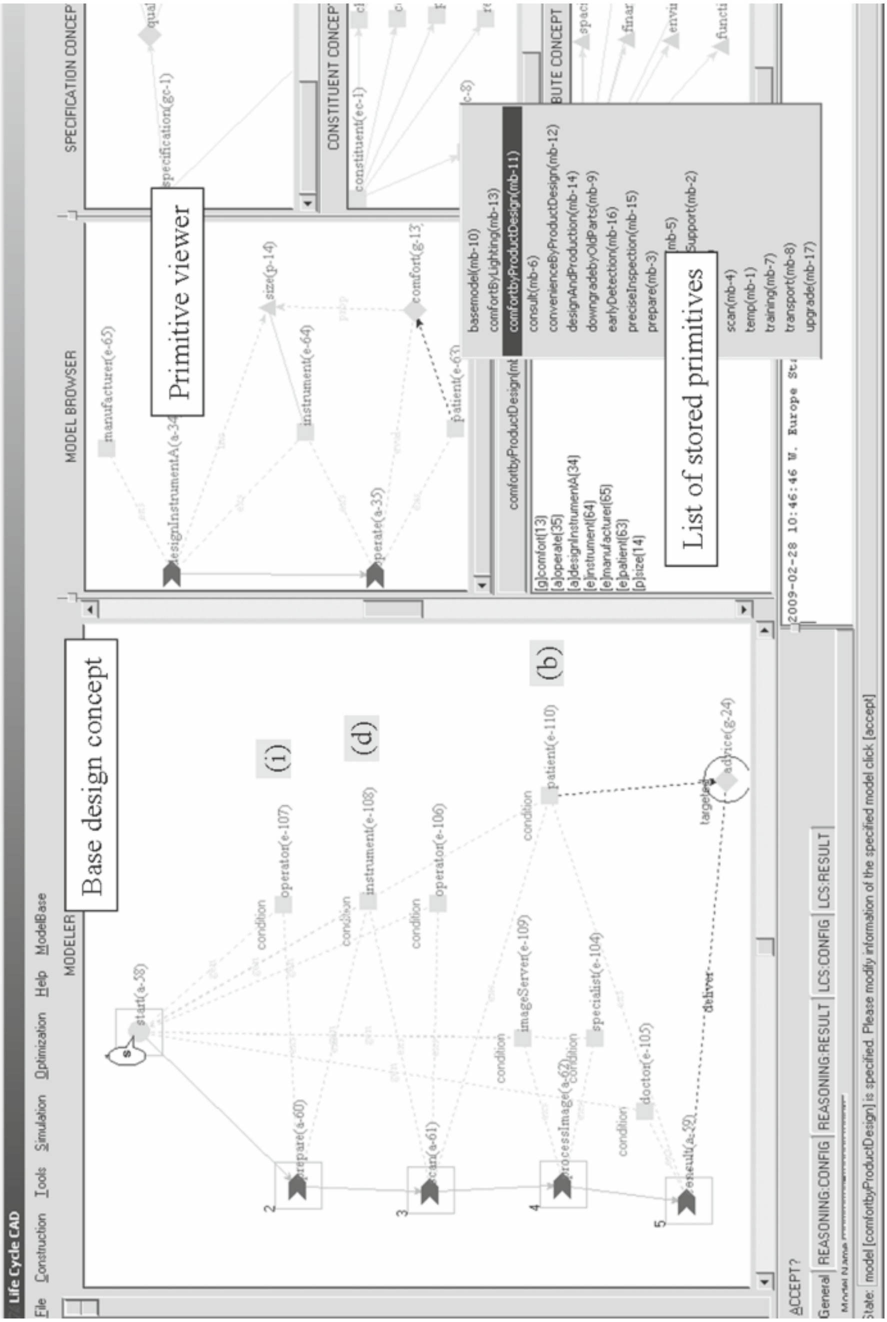

Fig. 4.4 Screenshot of ISCL

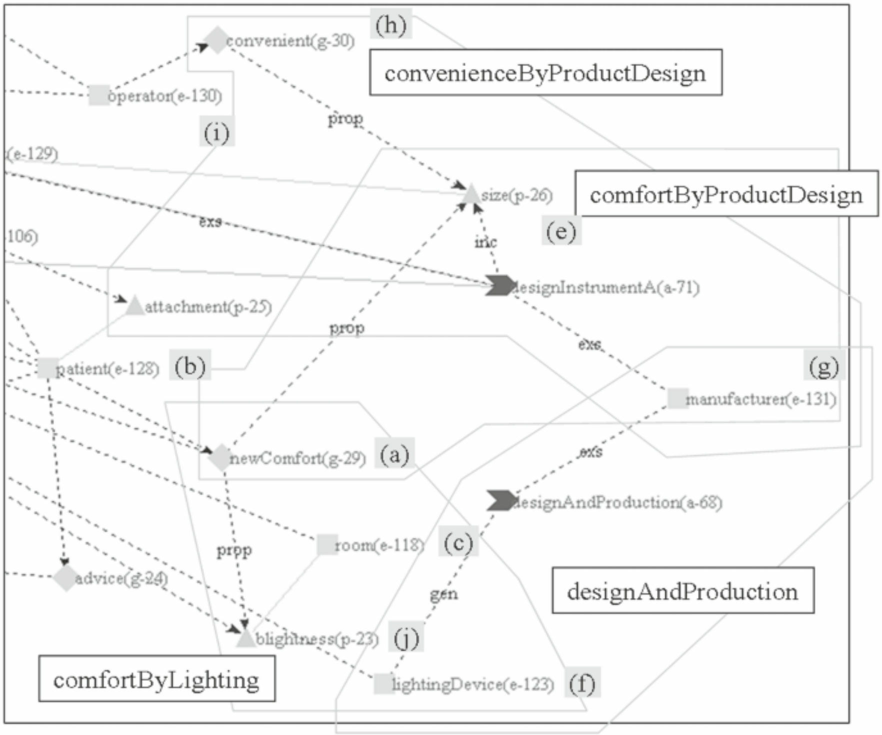

Fig. 4.5 Extension of a PSS design concept by introducing primitives in Fig. 4.3

First, the designer added “comfort (a)” as a quality criterion evaluated by the patient (b). Two primitives “comfortByLighting” and “comfortByProductDesign” in Fig. 4.3 were suggested by ISCL, because the primitives included an activity to change the brightness of a room, or the size of a product, and these attributes were also related with the comfort of the respective service receiver in the primitives (see Fig. 4.3). After introducing the primitives in the base model, the designer defined the room (c) as a new service channel, and the product as the instrument (d) in the base concept, respectively. In consequence, size (e) is introduced as an attribute of the instrument. After that a primitive “designAndProduction” in Fig. 4.3 was suggested, because the manufacturer of the lighting device (f) was not defined in the base concept. The designer defined it as the manufacturer of the instrument (i.e. manufacturer (g)). Introduction of “convenience (h)” as a quality criterion evaluated by the operator (i) becomes a trigger of introducing a primitive “convenienceByProductDesign” in Fig. 4.3.

As a result of adding these primitives to the base concept, multiple roles of the instrument manufacturer to increase the quality specified in the concept were clarified. Furthermore, the attributes of products corresponded to the added activities (e.g., brightness of the operation room (j)) were specified.

The resulting PSS design concept can vary in accordance with the quality criteria specified by patients. Assume that patients take health care service with such diverse purposes as “early detection of diseases” and “precise diagnosis”. The patients with the former purpose specify “cost” and “convenience” as quality criteria for the service, while those with the latter purpose specify “quality of diagnosis” as quality criteria for the service. Primitives in ISCL are used to store such information (see Fig. 4.6), and these primitives are introduced in the base design concept, in which the activities to represent utilization of the instrument (i.e., “preciseDiagnosis” and “earlyDiseaseDetection” in Fig. 4.6) are unified with the corresponding activity in the base design concept (i.e., “scan” in Fig. 4.4). After that, different primitives can be suggested by ISCL regarding these quality criteria and related attributes of the elements in the primitives as illustrated in Fig. 4.6.

Other life-cycle-oriented services offered by the manufacturer of a medical instrument can be added to the base concept. As illustrated in Fig. 4.6, the upgrading service, which has been added to enable the precise diagnosis, can be added in case of malfunction of the instrument, as an alternative of maintenance service.

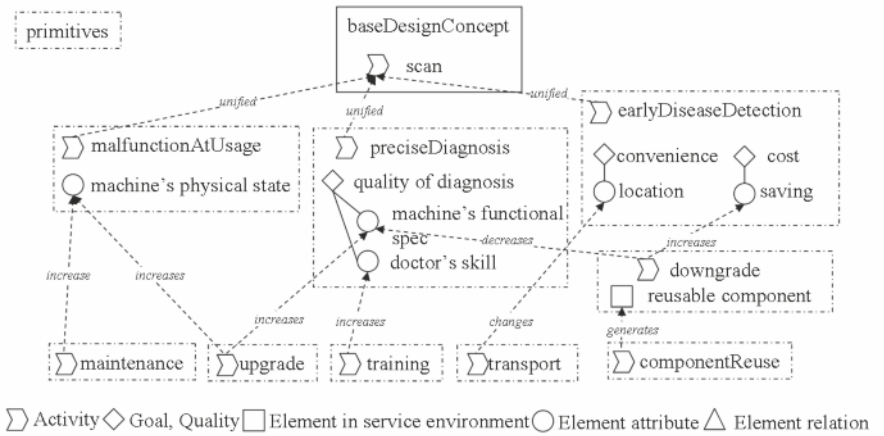

Fig. 4.6 Introduction of diverse primitives in PSS concept generation process

4.4.3 Analysis and Discussions

4.4.3.1 Relating Service Providers and Service Receivers

As discussed in Sect. 2.2, it is a fundamental task in generation of PSS concepts to define information to connect service providers (and their products and services) and service receivers (and their goals and quality criteria). The existence of such a relation and its explicit presentation are crucial for service providers to market potential service receivers with non-traditional forms (i.e. other than product ownership delivery). For instance, patients normally do not know the manufacturer of medical instruments (as they are not the owners of them). In this case, however, the manufacturer should present the advantage of its instrument from the perspective of not only the owners of instruments (e.g., hospitals) but also the patients, for the owners might purchase instruments considering the preference of patients.

In the demonstration, ISCL has been used to support the relating of activities of the manufacturer to improve the performances of products to the comfort of the patient and convenience of the operator. The suggestion function of ISCL combines existing information stored in individual primitives. This is why finding such relations using ISCL is limited by the collected and organized information about products and services. This indicates that subjectivity in collecting and organizing such information influences the quality of PSS concepts generated based on such a computational method.

4.4.3.2 Evaluating the Holistic Performance of Integrated Service Offerings

Evaluation of the holistic performance of a generated PSS concept is crucial for verification. The proposed method has been effective in suggesting multiple activities within a concept. This is why, the holistic performance of a generated concept is evaluated considering multiple activities included in the concept. For instance, instrument manufacturers can offer diverse contracts with instrument users in the life-cycle of instruments. These contracts typically include such service types as scheduled maintenance, parts supply, remote diagnosis, and online consultation by service engineers. Optimization of service types is studied in the field of industrial Product/Service-Systems (Transregio29 2008). The optimization in this context means not only exclusive selection of the offerings among the suggested alternatives, but also the timing of the selected service offerings. Therefore, further research is necessary to combine such a qualitative PSS concept generation method presented in this paper with a concept evaluation method from a holistic perspective.

One such approach is integration of a service CAD tool with a life-cycle simulator, and ISCL has been developed for this purpose (Komoto and Tomiyama 2008). Life-cycle simulation technique (Shu *et al.* 1996 and Umeda *et al.* 2000) supports the evaluation of a PSS design concept considering its quantitative and probabilistic aspects. Although appropriate conversions of a generated PSS design concept into an executable life-cycle simulation program, and additions of quantitative and probabilistic information to the program are necessary steps for the evaluation, description of the procedure is beyond the scope of this chapter. For reference, ISCL has been used to evaluate PSS design concept including shared services (Komoto *et al.* 2005) and design service packages (Komoto and Tomiyama 2009).

4.4.3.3 Representing PSS Design Concepts

In the example, a generation process of PSS design concept was presented instead of presenting the entire concept. One of the reasons is that a concept in general consists of a number of elements and relations, and presentation of the entire information does not help designers understand the concept and communicate with other designers about it.

One of the potential methods to improve the interpretability of a complex PSS design concept by designers is to present partial models according to the tasks of designers. For instance, the flow model, scope model, scenario model, and view model defined in the service model proposed by Sakao *et al.* (2009) can be used for this purpose. However, consistency among these partial models has to be maintained.

Another information source to help designers understand the PSS design concept can be to present the progress of the design concept during its design process. Using ISCL, such progress is formally represented by a sequence of decisions by designers in the design process as selection and instantiation of primitives, and unification of elements in the primitives.

4.4.3.4 Separating Concept Generation from Information Organization

In the demonstration, the information organization step to develop primitives stored in ISCL was separated from the information utilization step to generate PSS design concepts using the primitives. These steps can be performed by a team of experts and PSS designers. In other words, the experts in specific product and service domains are engaged in information collection and organization, while PSS designers systematically generate concept by effectively using the information.

Separation of those functions suggests a chance for an organization to design competitive offerings by combining existing products and services offered by other stakeholders. At the same time, information related to these products and services (rather than products and services themselves) becomes a marketable managerial resource for these stakeholders.

4.5 Conclusions

In this chapter, a method to systematically generate a PSS concept using a service CAD tool was presented. The method is based on formal PSS modelling and the corresponding computational facilities of the tool. Through the demonstration of a PSS concept generation in context of the health care service industry, organization and utilization of information about the products involved and services were investigated.

From the perspective of medical instrument manufacturers, the concept of integrated product-service offerings, or PSSs, is used to diversify their business models to deal with systematic reformation expected in the future. Systematic design of such offerings is achieved by relating their products and services with patients and other stakeholders. In this context, service CAD tools will play a crucial role in organizing and utilizing such information for systematic PSS design.

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Chapter 5

Value Creation in PSS Design Through Product and Packaging Innovation Processes

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Abstract Consumer packaging has become increasingly important as a value-adding element, since packages shape the consumer's experience of the product during use, as well as accelerating the purchase decision. From a Product/Service-System (PSS) perspective, the strategic benefits of viewing packaging as a central value carrier are evident. To consumers, the product and its packaging are often perceived as closely integrated and consumers' initial impression of the quality and value of a product is sometimes determined by their judgment of the package. Therefore, the product, the package and its integrated benefits and features can be regarded as one product/package/service system. However, product developers tend to over-emphasize the value of the functional properties related to the 'core product', overlooking the differentiating benefits that might come from the integration of product and packaging innovation processes. The move towards developing integrated product/service offerings, rather than traditional artefact based products, implies that the role of packaging needs to be reconsidered in light of, e.g., total life-cycle provisions and environmentally sustainable offerings. This chapter reviews previous research on the integration between product and packaging development, and highlights some important challenges and opportunities related to improved value creation in the product/service system paradigm.

Keywords Integrated product packaging, Packaging development, Service addition, Value creation, Product/package/service system, Value communication

5.1 Introduction

Consumer packaging is becoming increasingly important as a value-adding element, since packages can shape the consumer's experience with the product during use, and have the potential to accelerate purchase decisions. In light of a product/service system perspective, there are evident strategic benefits of viewing packaging as a central value carrier throughout the life-cycle of the product or service.

From a consumer perspective, the product and its packaging are often perceived as closely integrated and the consumers' initial impression of the quality and value of a product is sometimes determined by their perception of the package. Packages are often called the "silent salesman", addressing the role packaging has when consumers purchase a product. In service literature, this moment is called the first moment of truth (Löfgren 2005). Customer satisfaction, however, does not only reflect the first moment of truth. The consumer experience with the product/package use after purchase is equally or even more important for customer satisfaction. This, the second moment of truth, when the consumer uses, consumes and/or disposes the product and the package, is therefore as important to understand at the development of user-oriented packaging systems, as the first moment of truth. Therefore, the product, the package and its integrated benefits and features in the entire consumption process from purchase to disposal, can be regarded as one product/package/service system.

5.2 The Packaging System

According to the definition of the European Parliament and Council Directive 94/62/EC, packaging is defined as follows:

> Packaging shall mean all products made of any materials of any nature to be used for the containment, protection, handling, delivery and presentation of goods, from raw materials to processed goods, from the producer to the user or the consumer. "Non-returnable" items used for the same purposes shall also be considered to constitute packaging.

The product and its packaging need to be regarded as a system, since almost all products have packages that bridge the product with the supply chain environment. The packaging system may be classified as primary packaging reflecting the consumer package, and classified as secondary or tertiary packaging for the retail and transport level (see Fig. 5.1). The classification reflects the levels of usage and these definitions should be used together with the consideration of packaging as an integrated system (Olsson *et al.* 2004).

An integrated product/packaging system adds value to consumers in, for example, communication and usability aspects, but it also adds value to other actors in the supply chain in terms of efficiency aspects in handling, distribution and transport (Bowersox & Closs 1996, Saghir 2004, Rundh 2005). Such effects are also beneficial in the larger perspective of sustainable development and reduced climate influence. An extension of the traditional product/package system into a product/package/service system is therefore relevant from a value adding as well as from a sustainability perspective.

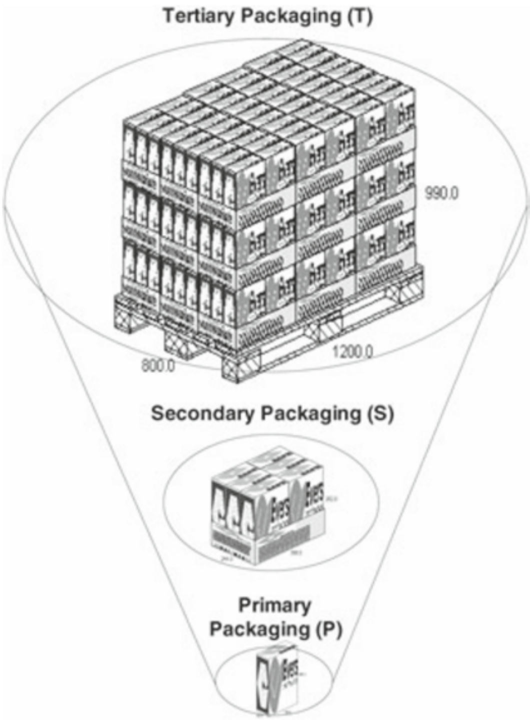

Fig. 5.1 Different levels of a packaging system (Saghir 2004)

In relation to climate influence, an important concept to consider in the packaging logistics area is the filling rate, which means the degree to which a package is filled with product. From a packaging logistics perspective, the product should fill as much as possible of a primary package. The secondary package should then be designed to contain primary packages to 100%, and the tertiary package should stack and fill its space with secondary packages. The aim is to transport as little air as possible in and between packages. This means that an optimal packaging system should have as little air as possible in the entire system. Due to trade-offs in needs between different actors in the supply chain, the development of 100% air free packaging systems is rare. This means that many existing systems still have room for improvement in terms of filling rate.

5.2.1 Integrated Product and Packaging Development

Traditionally, product development is usually conducted in more or less structured development processes, where different activities need to be closely integrated to achieve an effective and efficient process. In accordance, integrated product development is an established research area, and the integration of different organizational functions and processes such as design, marketing, production and technology is already widely implemented. The reason might be that design and engineering in the manufacturing industry already have a long tradition, yet research in the product development area still focuses on all or parts of these established product development processes, with the aim of identifying models for successful product development (Olsson 2006). To support the integrated product development vision, there are several methods and approaches that target the integration between, for instance, design and production, such as Design for Manufacture (DFM, i.e. the design for ease of manufacture of the collection of parts that form the product after assembly), and Design for Assembly (DFA, i.e. the design of the product for ease of assembly) (Boothroyd *et al.* 2002).

However, although traditional product development can be considered fairly well integrated between different functions and activities, at least in the engineering domain, the traditions of integrating product development with packaging development are not well established and still immature. The development of the primary package of the product is seldom integrated with the development activities concerning the product itself, and packaging size (i.e. mass) is often merely one of many trade-off parameters when choosing among several competing concepts–implying that packaging is primarily considered as a risk element, rather than as a source of value creation.

Today, the product developer and the package developer constitute different parties in the supply chain with different core focus and different development processes. In the aspects of technological development and innovation, packaging design and development traditionally start when the core product is ready for production in the commercial launch phase of the innovation process (Jönson 1993). Little or no consideration is therefore given to packaging in the product development process of the core product. As noted, if such consideration is taken, it is usually related to how to handle the logistical aspects (e.g., how many products will fit on a pallet?) rather than to how the added value for the consumer can be improved. On the other hand, retrospective research by Beckeman (2006) suggests that the packaging system may actually drive product development to a certain extent, since the packaging system, once installed, might be used for adaptation of new products.

Sonneveld (2000) identifies the need for integrated product and package development, particularly with respect to market differentiation and value addition. But integrated product and packaging development is also needed from a quality and efficiency perspective throughout the supply chain from production to consumption. Consequently, the more the package and the product can be functionally combined, the greater the possibility of them being competitive (Harckham 1989). Therefore, if the package is to be integrated into the product to form an integrated system, the development of the product and the development of the package have to take place in parallel (Bramklev 2007, Dominic *et al.* 2000).

However, in general, product developers tend to over-emphasize the value of the functional properties related to the 'core product', leading them to overlook the differentiating benefits that might come from the integration of product and packaging innovation processes, and adding value through the integrated product and packaging system.

5.2.2 Service as a Value Creator in the Product/Package/Service-System

When companies intend to add value to a product they need to change mindset from identifying themselves with their core product to regarding themselves as a value-creating part in the customer´s system. As with development of products, the development of packages with a feature-oriented view and a perspective of the package as demarcated will delimit the opportunity to view the package from the value-adding customer perspective (Olsson 2006). The combined value of the product and packaging is therefore vital in the process of delivering value-adding products, packages and services to the customers (Sonneveld 2000). Therefore, to expand the traditional product view and to involve the consequences for the consumer when using the package is to view the product/package system from a larger perspective, and involves understanding the consumer process.

Contrary to traditional feature-oriented product development, as described earlier, service development emanates from an understanding and knowledge of customer needs and expectations. This includes knowledge about consumer situations and behaviours, since the aim of services is to fulfill the needs of customers and users. In many manufacturing industries, therefore, the visions have been redefined to a service-oriented approach. The service content is identified to have an increasingly significant meaning through its role in differentiation and competitive advantage of the physical products from manufacturers (Echeverri & Edvardsson 2002). The service sector, however, does not have the same tradition of development processes and is argued to be slow in developing models and processes for design of services (Gummesson & Kingman-Brundage 1992). The benefit of integrating services to products in order to add value is obvious, but the enhancement of service development through integration in the product development process is less explored but still necessary.

In packaging development, the understanding of the value the consumers perceive or experience, based on the consequences of using a package, will enlarge the product/package view to a product/package/service system view. This expansion is necessary since it is the customer who judges the value of an offering at the end (Olsson 2007, Echeverri & Edvardsson 2002). Customer orientation is a prerequisite for the development of aligned services into value-added product/packaging offerings. A closer view to consumers and users and their processes and awareness of the value-creating activities is one step in the right direction for product and package producers. Therefore, beyond the integral system of a product and its package, the users and their expectations in the use situation need to be integrated. The implication is that organizations need to explore how their products and services fit into the life of the different users, rather than regarding their product/package, as the system per se that should be delivered to the customer or ultimately to the consumer (Olsson 2006).

5.2.3 Communication: A Value-Added Service to Consumers

In the business-to-consumer domain, the package is the interface of the product to the consumer and must be seen as an integrated part of the product. The integrated product and package system needs to maintain and communicate the value perception, since packaging gives a promise of what the enclosed product has to fulfill (Downes 1989). In this interface between the product and the consumer, one service provided through the package, is the service of communication. The communication function of packaging is threefold: communication of necessary information, communication of promotion, and interactive communication with consumers. The importance of the communication function as a marketing or promotion tool is especially eminent in market channels with considerable competition at the retail point of sale (Hellström & Saghir2007). The interactive communication can also be part of a product producer's marketing strategy, in the way they get interaction with consumers.

At the moment of purchase, a consumer wants to have information about the product inside the package. If the product is food some information is legally stipulated and other information is additional. The information on packages is, however, not always developed from a user perspective and a lot of information does not add value to the consumer. Several consumers complain about information that is hard to understand due to abbreviations, such as E-numbers on food, or unnecessary, such as language different to their own, or irrelevant, such as fat content in a carbonated soft drink.

With regard to the value perception from a consumer perspective, the package can help communicate to the user what kind of outcome they can expect from using the product or service. Consumers might not possess enough knowledge about technologies or services contained in the package, which might lead them to actually miss the unique selling points with the product or service they hold in their hands. For example, when buying auxiliary headlights for the car, the consumer might or might not know what actual difference there is between a 50 W and a 100

W bulb, between a halogen bulb and a xenon bulb, or between 1,000 lumen and 3,000 lumen. Here, it makes sense to assist the consumer in choosing a lighting system that offers a light pattern that fits well with the consumer's use situation (e.g., in northern Sweden, a wider but shorter light pattern to spot animals on the side of the road might be preferred to a far-ranging, but narrow light pattern.)

Naturally, communication as a value-added service covers a wide range of aspects where packaging can play an important role in both discovering and promoting innovations. Self-heating cans for beverages are becoming increasingly common, and it is safe to assume that much of the unique selling point of these beverage brands is dependent on the package. Another example from the beverage industry is thermochromic bottle labels which indicate that the product is at the recommended serving temperature. From a food safety perspective, most current packaging solutions rely on a simple best-before date, which does not take into account if the product has been exposed to elevated temperatures during storage or transportation. Taking an integrated view on product and packaging development, an innovation from the consumer perspective could be visual indicators on the food packaging, which could give consumers a clear, accurate and unambiguous indication of product quality and shelf-life condition. Thus, such a smart label serves the dual purpose of informing personnel whether or not food and storage temperatures are satisfactory, and assuring the consumer that the food is safe to eat (Rönnow 2006).

5.2.4 Environmental Aspects on the Integrated System

The move toward developing integrated product/service offerings, rather than traditional artefact based products, implies that the role of packaging needs to be reconsidered in light of, e.g., total life-cycle provisions and environmentally sustainable offerings. The entire life-cycle of the product and its package is important and therefore the knowledge regarding product use is of key importance, already in the design phase of the product. Furthermore, to make a truly useful impact on Product/Service-System design, the packaging perspective needs to be included from the very start of the development process. It is most advantageous to make changes at the preliminary design phase, since it will become more expensive, more difficult, or even impossible to compensate or correct the shortcomings of a poor design concept in the later life-cycle phases. So, in order to provide products, or functions, that truly meet the full range of life-cycle demands and needs, it is highly important to investigate how downstream knowledge (e.g., from the first and second moments of truth) could be used to improve early-stage decision making in cross-functional product development teams. (Larsson *et al.* 2008) In terms of environmental concerns, packages as such are most commonly regarded as a necessary evil and an environmental burden. This view emanates from the view of the package as a demarcated artefact neither integrated with the product nor with the society. The typical perspective in this view is to minimize packages and if possible eliminate them. The holistic system perspective, however, regards the total environmental impact of product and package waste. A minimal package may cause waste of product that either gets mechanically destroyed due to a weak package or spoiled due to bad safety protection. In that case, both the product and the package end up as waste, rather than only the package if it has protected the product properly. From an environmental perspective it is therefore better to optimize the product packaging system, rather than striving to solely minimize the package at the sacrifice of the product quality.

A consequence of the Product/Service-System approach is that customers (both in business-to-business and business-to-consumer settings) increasingly want to pay only for the result of the product or service use, i.e. what they perceive to ultimately add value. When the provider, while aiming to produce that added value, is responsible for the creation and disposal of all packaging elements used across the life-cycle and throughout the value chain, the environmental impact of a Product/Service-System needs to be considered as early as possible in the development. If not, there is an apparent risk that the environmental, and financial, winnings will be severely reduced over the lifetime of the product.

5.3 Industrial Examples of Integrated Development

The core competence of a packaging producer is to develop and provide packages. The goal, however, is to continuously provide maximal consumer value and hence profit through the performance of the packaging system, including the product, during all stages between production, consumption and disposal. Some industrial examples illustrate this.

5.3.1 The Paper Packaging Material Producer – Environmental Service Addition

From the focus of producing paper packaging material to the nearest customer, with the lowest possible weight per m^2, the paper producer started to develop solutions that satisfied customer needs at retail level for packaging systems for fruits and vegetables (Olsson 2006). With the view of learning more about the market and customer needs, the scope of their supply and value chain was redefined and extended to cover not only their immediate customer, but also the customers' customer, i.e. the manufacturers of, for example, food products. The paper material producer put itself in the role of the customer, in order to better understand the needs of fresh fruit packaging at retail level (Olander & Olsson 2007). The need from retailers and consumers to get fresh non-damaged fruits and vegetables resulted in the development of a secondary carton package that can be stapled in storage and retail locations, and that protects from mechanical stress and impact on the product. The development process included a deep understanding of the customer and the product process from harvest to consumption.

Fig. 5.2 The service of providing paper material to boxes in order to secure less waste of food and packaging

The product/package/service system provides a solution that is good from an environmental perspective but also from a customer value-adding perspective. Fruit and vegetables of a value of 100 billion € are delivered in Europe each year, out of which 10% is destroyed on its way to the consumer, which corresponds to losses of 10 billion € per year. Part of this waste is due to packaging solutions that do not protect the fresh produce in a proper way (Billerud 2009).

"*A packaging that functions well is one of the best investments in the environment you can make*" is a statement from the homepage of the company (Billerud 2009). The new package solution helps prevent fresh fruits and vegetables from being destroyed through the new package that protects the fruits and vegetables from mechanical impact and stresses. By saving the fruit, which is the most obvious improvement for the environment as well as from a customer satisfaction perspective, resources are also saved in terms of time and resources spent on harvest, transport, storage, handling and packaging, which means that savings can be multiplied taking all steps in the supply chain into account.

The package makes up about 1/20 of the product's retail price, but spending some extra effort on the package will result in savings not only on the fresh product but also on an additional amount of activities throughout the supply chain (Billerud 2009).

As illustrated by the example, there are obvious potentials to increase customer satisfaction and at the same time decrease the environmental impact of the food-packaging system, especially when the packaging design helps to decrease food losses. The decrease in environmental impact can further be used as a marketing tool for the company who wants to promote its environmental or "green" values.

5.3.2 The Package Producer – Value-Adding Services to Supply Chain Actors

Tetra Pak is well known for its distribution-driven innovation, the Tetra Brik carton package, originally developed for milk. The idea was generated by Ruben Rausing during his stay in the USA, where self-service stores for food started to develop in the 1950s (Leander 1995). About 50 years later a new Tetra Pak package innovation for retorted food was brought to light. The Tetra Recart package is specially designed for products traditionally packed in cans, glass jars and pouches. The innovation is the first carton-based retortable package for food. That means that with the Tetra Recart package, food products, such as beans, vegetables, tomatoes, soups and sauces, can be sterilized inside the carton package. The food inside a Tetra Recart is shelf stable up to 24 months (Tetra Pak 2009).

The package and the product are highly integrated in the food processing and packaging production, and therefore an integrated development is needed for the understanding of requirements in production. But the package is not only adjusted and developed based on production needs. User and brand owner needs have also been integrated in the packaging development, in order to secure value-added services to consumers, retailers and brand owners. As with other rectangular shaped packages, the possibilities for high filling grade is obvious. The replacement of the traditional can compared to the new Tetra Recart ensures better logistical performances from production to consumption. The major advantage from a logistics perspective is on transport and logistic activities prior to filling and processing, i.e. the transport and handling of empty packages. The Tetra Recart is delivered to the filling process flat, while cans are delivered empty but in the same shape as when they are filled. That means transportation of cans is equal to transporting large volumes of air, while the Tetra Recart packaging system lowers the transportation load with approximately 55% (Fagerstöm 2008), which is shown in Fig. 5.3.

From an environmental point of view the logistics consequences such as handling time, weight and amount of transport, secondary packages, etc. for the Tetra Recart give a positive environmental impact compared to the can. The carton is also produced from renewable packaging material.

From a retail perspective a squared package makes shelf space in storage and retail more efficient, and also allows for better communication through more efficient exposure of brand name and other communicative aspects. From a consumer perspective, the added value is in handling since this package does not require tools for opening, and is considered easier to dispose and flatten (Tetra Pak 2009). The innovation process of this integrated product and package system, needs a deep understanding of user needs and what different users in the supply chain value. The Tetra Recart is an example of an innovation where there are obvious benefits from a range of company-internal perspectives, such as logistics and production, which also bring positive effects for retailers, brand owners, consumers, and the environment. Understanding user and stakeholder needs from a total life-cycle perspective, makes it possible to deliver services that present unique selling points based on the different actors' needs, such as opening ability without tools, brand exposure, handling efficiency and environmental values.

Fig. 5.3 The difference in transport load with different packaging systems (Photo: Erik Andersson, Design Sciences, Lund University)

5.3.3 The Environmental Impact of Integrated Product and Package Development

The idea of concurrent and integrated product and packaging development is that the product and the package can be interdependently adjusted in size, strength, form and function depending on the requirements put on the system from the user and environmental perspective. A company well-known for its tradition of integrating product and packaging development for strengthening its environmental profile is IKEA. At IKEA, packaging is an explicit part of the product and hence included in the product development process. The IKEA package should not only protect the product during distribution, it should also expose the product to consumers and facilitate handling operations at warehouses and in stores. When in the store, the package needs to be intact since a consumer would reject a damaged package even if the product inside is intact (Klevås 2005a).

Most changes on the product/package system at IKEA takes place in the package, since the product is already specified and produced. The optimal solution might however, be to change some dimensions of the product in order to get better integrated packaging systems. One example of integrated package and product development is a high-volume product of IKEA, the tea-light. For the tea-light project, the product was justified together with the package for more efficient handling and distribution. In its original version, the tea-lights were packed 100 pieces in a plastic bag. These primary plastic bag packages were distributed in one large carton that held 252 bags. The large carton was put on a euro pallet. IKEA sells approximately 60,000 m^3 of tea-lights annually. After considering the package system from an environmental and "air hunt" point of view, a reconstruction of the primary package *and* the product took place. After the reconstruction, 100 tea-lights were stacked into each other with the help of the new tea-light construction, packed 100 by 100 in a plastic shrink film and put into a large carton on a euro pallet. The large carton was later found unnecessary since the tea-lights were stackable. The new product/package system now fitted 360 packages per pallet; a reduction of 18.571 pallets which is about 30% less (Klevås *et al.* 2006). With the new packaging system transport, secondary and tertiary packages are reduced by 30%, and, in addition, handling time and handling costs for reduced transport and packaging also need to be taken into account. The handling time for unpacking in retail stores was, for example, reduced by 186 working days annually. The new construction of the tea-light also resulted in the use of 6,000 km less wick for the tea-lights per year. In order to add consumer value of the new product/package system, developers from IKEA had followed the consumer process during the construction of the new tea-light. The understanding of the consumer process led to measurements of the new package that correspond to the standard measurements of drawers in kitchen cabinets, which makes storage and handling in the consumer home easier.

Another example of IKEA's integrated view on product and package development is illustrated in the package development for the modelling clay sold at the children's department in IKEA. The modelling clay was previously packed in a plastic bucket. By replacing the bucket with a corrugated paper box, the filling rate of one pallet increased from 550 to 800 packages per pallet, which meant a decrease in the number of containers shipped from 18 to 8, and an increase in filling rate of 43%. The new solution corresponded better to the IKEA image of flat packages, and contrary to expectations an increase in sales occurred, probably since the new system allowed for a decrease in sales price to consumers (Klevås 2005b). In this case, the package was changed without any impact or changes on the product, but from the integrated perspective and value-added consumer view the new carton was “open” with a plastic film wrap, in order to still make the product visible to the consumer in the store. Even though the volume of modeling clay is substantially lower than the volume for tea-lights, the changed package has an impact on number of journeys, packages and the environment as well as on handling time and thereby resource allocation.

The examples illustrated from IKEA are typical since a main activity among package developers and designers in a range of projects at IKEA aims to reduce air in “the air-hunt.” Reducing the air in the packages, and thereby increasing the fill rate, results in a reduction of transported pallets and unit loads, in turn affecting the environment and handling time in all steps from production to consumption, and ultimately also resulting in a lower sales price to consumers.

5.3.4 Service Addition Through Interactive Communication

In relation to the communicative services of packages mentioned above, a new trend is visible in Japan, where consumer packages have much more impact and have much more design attention than elsewhere. Quick response (QR) systems are frequently found on Japanese consumer packages. In the quick response system, the “intelligent” matrix-like two-dimensional code is readable through the digital camera system in the mobile phone. With direct internet access in the phone, consumers get directed either to the producers homepage or to specific pages for allergic communities, green societies or similar. This allows consumers to get necessary as well as interesting information about the product they are about to purchase. By developing the package with an intelligent bar code, in cooperation with the product manufacturer, the product/package system provides an extra service to consumers in the area of interactive communication. From an environmental perspective this system has indirect effects, since better informed consumers will not purchase products that they need to throw away due to allergy (content and ingredients), attitudinal or different sets of values (producers, origin, content), etc. Another example from Japan is taken from the women's shoe department at the Mitsukoshi Department Store, where sales clerks spent a large amount of time in the stock room, going back and forth from the floor to arrange stock, look for stock or carry out other back-end duties. By manually tagging all its stock with Radio Frequency Identification (RFID) tags, they empowered customers to find the right size and colour, with accuracy and in real time, without having the staff move back and forth between the floor and the stock room. Staff time could instead be invested with customers, and wait times for customers were greatly reduced. In the Mitsukoshi case, this was an add-on solution having little to do with the shoe brands themselves, but with a better integration between development and packaging, the added value through interactive communication could easily have been a way for these brands to stand out in the competition and help Mitsukoshi to bring exceptional value to its customers. Mitsukoshi has expanded their RFID trials to the cosmetics department, where the technology allows customers to obtain details about each product and try on virtual makeup, while also providing statistics on how often items are sampled. (Swedberg 2007)

Another similar "intelligent tags" application is used for the measurement of the accumulated temperature and time exposure on chilled and frozen food, from production to consumption. Such tags can be seen as an integrated part of the product/package system, with the service to consumers and retailers to read the quality status of the product with a handheld scanner. This is an example of an intelligent system, a service addition. The added service provides the possibility of measuring the "real shelf life" of a chilled food product, rather than the fictive shelf life stamped on the package as a best-before-date by a food producer. The temperature exposure from production to consumption is one important factor affecting shelf life of fresh products. This means that a newly produced product with temperature exposure above the stipulated storage temperature, might have shorter shelf life than an older product that has been kept in the stipulated temperature from production to consumption.

In the long run, the stamped best-before-date might be replaced by such intelligent systems giving information about real shelf life of fresh products. From an environmental point of view such a system might change retail handling behavior, in the way that the products with the shortest "real shelf life" are sold first, independently of the stamped estimated best-before-date. The tag is also a service to the retail location to be able to measure which products need to be taken out of stock due to passed shelf life. This will reduce claims and the risk of selling and handling outdated products.

In a similar way, consumer behavior might change if consumers were informed about the real shelf life, through scanners or at the cashier. This means that consumers might buy the oldest products first, at least if they are to be consumed directly. This means that fewer products will be thrown away, as today when consumers buy the products with longest "stamped shelf life" even if they are supposed to be consumed directly, leaving older products still on retail shelves. Another example of user benefits not easily available today is the concept of notifying customers both when fresh products have been put on the shelves, and when certain products are out of stock. Today, customers are normally required to visit the store in person to figure out such information. Of course, there are strategic perspectives to consider when it comes to how much information the stores *really* would like to provide to their customers, but rather than focusing on the limitations of such approaches, it is important to also recognise the enormous potential that can be found in integrated product/package solutions, throughout the supply chain, and for providers, customers and the environment alike.

Rather than forcing each stakeholder in the system to develop customized solutions for their particular purposes, without the concern for the needs of other stakeholders, there is a need to integrate product/package and service development, so that, for instance, food producers cooperate closely with package producers to design and provide an intelligent tagging system that offers added value from several complementary perspectives.

5.4 Conclusions

It can be argued that packaging has a long history as a value-adding element, much since it can help accelerate the purchase decision or help shape the consumer experience during product use, but there is still an untapped potential when it comes to viewing packaging as a strategic instrument to achieve differentiation in the marketplace. Traditionally, product developers have often over-emphasized the added value coming from the functional characteristics of the ‘core product’, and in a Product/Service-Systems perspective, the integration of product and packaging innovation processes would bring a more holistic approach to the exploration of which parts of the added value are related to the packaging elements and which are related to the core product.

Such cross-functional integration is undoubtedly crucial between any domain in the innovation process, but while techniques to improve and prepare for effective and efficient manufacturing and assembly are widely deployed already in the early phases of design, design and development of the packaging is commonly not started until the core product is ready for production in the commercial launch phase of the innovation process. Little or no consideration is therefore given to packaging in the product development process of the core product, and if such consideration is taken, it usually relates to how to logistical aspects rather than to the added value for the consumer. To make a truly useful impact on Product/Service-System design, the packaging perspective needs to be included from the very start of the development process.

Examples such as giving consumers information about the real shelf life of products in the food store, providing them with real-time access to detailed product or stock information when buying shoes or cosmetics, or offering them food packaging solutions that do not require openers and which are easy to flatten and dispose of, points to an increased awareness of how packaging and core product characteristics are truly intertwined in the consumer’s perception of added value.

The goal of packaging development is to continuously provide maximal consumer value and hence profit through the performance of the packaging system, including the product, during all stages between production, consumption and disposal. However, to reach this goal in light of a Product/Service-Systems approach means that we need to rethink the role of packaging in the innovation process. Just as knowledge from other domains, processes and activities (e.g., manufacturing and marketing) have been brought into the early stages of design, also packaging needs to become an integrated part of the value creation process.

While traditional product development has largely focused on achieving certain performance characteristics tied to a physical artefact, traditional packaging development has perhaps focused too closely on the task to protect and preserve these performance characteristics on the artefact's way to the consumer. In light of improving the service offers made to consumers, we believe that packaging can play a stronger role—in essence by helping to provide the added value that ultimately distinguishes products of similar technical performance from each other. In our view, this improved value creation can only be realized if product development teams, through the integration of packaging expertise, are made aware of and are encouraged to consider packaging performance as a crucial performance characteristic to pay close attention to in the front-end development process.

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Part II Customer Dimension

Chapter 6

Service Engineering – Methods and Tools for Effective PSS Development

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Abstract Manufacturers face new circumstances, such as servicification of consumers and seriousness of environmental problems. An effective avenue may be pursuing qualitative satisfaction rather than quantitative sufficiency. This chapter aims at proposing a design process model for services or service-oriented products based on Service Engineering, to increase the level of customer satisfaction. Then, a method for evaluating service solutions is introduced. For this purpose, Quality Function Deployment (QFD), used widely in product design, is employed. This method makes it possible to realize evaluating effects of a service on its receiver. Mathematical methods are introduced to differentiate functions and structures. Then, the proposed method is applied to evaluate a model service in order to verify its effectiveness. The results indicate that a specific function is the most important among multistage structure of the target service. Furthermore, a method for designing service activity and product concurrently and collaboratively is also proposed. Design of services and products should be integrated in order to maximize customer value, considering the mutual effects of synergy, alternative and complementarity. For this purpose, first, a fundamental unified representation scheme of human process and physical process in service delivery process is given. Second, the authors evaluate these processes with Quality Function Deployment manner. In the rest of this chapter, the authors describe a detailed process to represent unification of human processes and physical processes by applying the proposed method to an actual service case.

Keywords Service CAD System, Service Evaluation

6.1 Introduction

Nowadays, we should reduce the production and consumption volume of artifacts to an adequate, manageable size to solve environmental problems although we do not want to make our quality of life lower than now. Consequently, we must aim at qualitative satisfaction rather than quantitative sufficiency, and thus the decoupling of economic growth from material and energy consumption (Tomiyama 1997). This is a new paradigm, which is free from the mass production paradigm of twentieth century. To achieve this paradigm, products should have more values, supplied largely by knowledge and service contents, rather than just materialistic values. This dematerialization of products requires the enrichment of service contents. To this end, we need a novel engineering method to evaluate services and to design the services. This novel engineering is called service engineering, which includes design methodology of both products and services. This novel engineering differs in the definition of value from Value Engineering (Miles 1971), where value is defined as function over cost. Conventional design methodology (Rodenacker 1971, Pahl and Beitz 1988) also deals with only functions of the object rather than satisfaction of the consumers by the functions.

6.2 Service Engineering

A service is defined as an activity that changes the state of a service receiver (Tomiyama 2001). In Fig. 6.1, a provider causes, usually with consideration, a receiver to change from a state to a new state that the receiver desires, where both contents and a channel are means to realize the service. Hence, a service receiver satisfies with just contents, which are any of material, energy, and information. A service channel is used to transfer, amplify, and control the service contents. In this definition, artifacts can change from contents to channels and vice versa. Artifacts have their own functions, behaviours, and states, and therefore they can be designed with conventional CAD systems. Since both service channels and service contents also have the above-mentioned characteristics, we introduce a similar methodology into the design of services. The term "service" is defined. Then what is service engineering? It is a design methodology to increase the value of artifacts and to decrease the load to the environment by reasons of focusing service. Note that service engineering has both analytical and synthetic aspects. In this chapter, we discuss both. Service engineering aims at intensifying, improving, and automating this whole framework of service creation, service delivery, and service consumption. To increase the total satisfaction of receivers, we can improve functions and/or quality of both channels and contents. Traditionally, engineering design has aimed to improve only function. A better function of a new product, we believed, makes consumers satisfied. In service engineering, however, not only the functions of artifacts but also meaning of contents must be matched to the specifications given by receivers. Then the satisfaction of receivers increases.

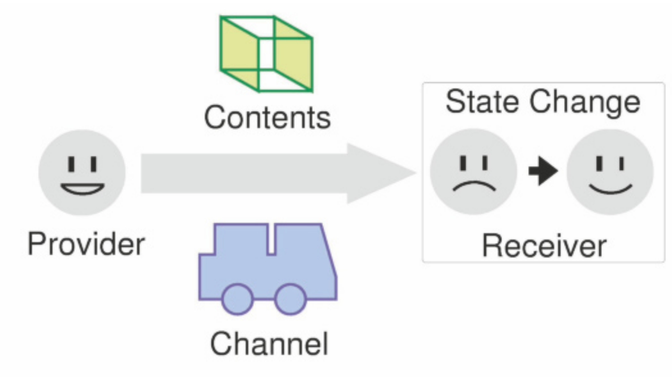

Fig. 6.1 Definition of a service

6.3 Service Modelling

6.3.1 The Outline of a Service Model

Let us define the design procedure of a set of services. In the argument regarding the design process (for example Suh (1997), Umeda (1996) and Shimomura (1998)), it is widely accepted that design might be a search for a physical structure matching the required function. The design of a service is also a search for both physical and non-physical structure, but it differs from the conventional design in terms of evaluation. Conventional design regards mainly the performance of the channels; it does not consider the state change of the receiver except for a happiness that comes with owning the products. The design of a service is based on the degree of satisfaction with the state change of the receiver. Therefore, it is necessary to express state changes by means of the received contents.

6.3.2 Receiver's State

Change of a receiver is represented by a set of receiver state parameters (RSPs). Thus, a service can be represented by a set of RSPs necessarily and sufficiently.

Since a RSP consists of quantitative values, including Boolean logic and multi-value logic, we can compute any comparison between two RSPs. In addition, we introduced a new assumption that all RSPs are observable and controllable. This assumption has been unproven with human receivers because we have not had a reliable method to measure the consumer behavior. The RSPs change by received contents as shown in Fig. 6.1. Hence, in this research, we assume that contents consist of various functions, whose name is Function Name (FN), whose operating objects are Function Parameters (FPs) and whose effect is represented by Function Influences (FIs). Since both channels and contents are described by the functions with FPs and FIs, RSPs also belong to functions. As the receiver's states may change with respect to supply of contents, RSPs can be written as functions of contents. Parameters expressing contents are called content parameters (CoPs). In the same way, the parameters of channel, which make the flow of CoPs change and thus influence RSPs indirectly, are called channel parameters (ChPs). Hence, in this research, we assume that both contents and channels consist of various functions. These parameters create a network with one another. We studied several examples and chose different sets of parameters; some of the examples are from daily life such as restaurants, travel agents, and laundries. Other studies are from manufacturing sectors such as disposable camera suppliers, copy services and elevator maintenance services. The details are not discussed in this chapter but we need to point out that the selection of contents within various parameters is subjective. It seems the greatest reason that services have not been dealt with in engineering issues.

6.3.3 Flow Model

One of the typical services is a travel agent, which arranges and purchases various tickets on behalf of customers. Contents are different from the tickets, even if the tickets are delivered to the customers. In this way, services can be delivered through complex multiple structures consisting of various go-betweens. The intermediate agents have double characteristics of a receiver and a provider, which is represented by a symbol of smiling circle "intermediate agent" as illustrated in Fig. 6.2. Providers can be defined as an agent whose receiver side (left half) inside of the agent is hidden by the system, and in the same way receivers do as that whose provider side is hidden. When we focus on the relationship between a receiver and a provider, many intermediate agents exist among them. In this research, we call the sequential chain of both contents and channels "a flow model of a service". An example of a flow model is shown with respect to a car in Fig. 6.2. At the top of the figure, each step from part maker to a consumer is illustrated.

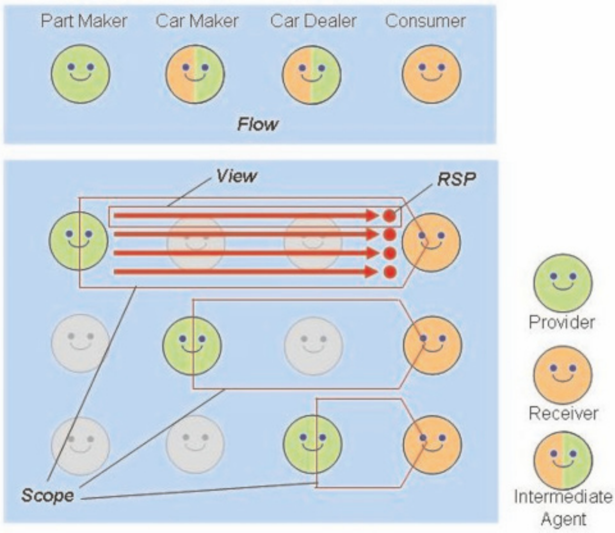

Fig. 6.2 Flow model, scope model and view model

6.3.4 View Model

Receiver state parameters (RSPs) change according to how the receiver evaluates subjectively the received contents. A single RSP may consist of several CoPs because the receiver evaluates the contents as mentioned in Sect. 6.2. The CoPs may be supported by several ChPs existing in the chain of several agents in the flow model. A view model is defined as a tree of CoPs and ChPs with a single RSP at its root. It is also illustrated as a line in the lower figures in Fig. 6.2. An example is shown in Fig. 6.3. The view model is expressed in a directed graph that consists of nodes and arcs. The entities in Fig. 6.3, i.e. nodes, are functions, which are expressed by FNs as lexical expressions and FPs. The body of each function is expressed by function influence (FI). In the current implementation, both positive and negative influence can be implemented. The view model illustrates visually the relationships among the parameters (RSP, ChP, and CoP) by means of directing arcs. Thus, it helps the improvement of RSP by changing FPs.

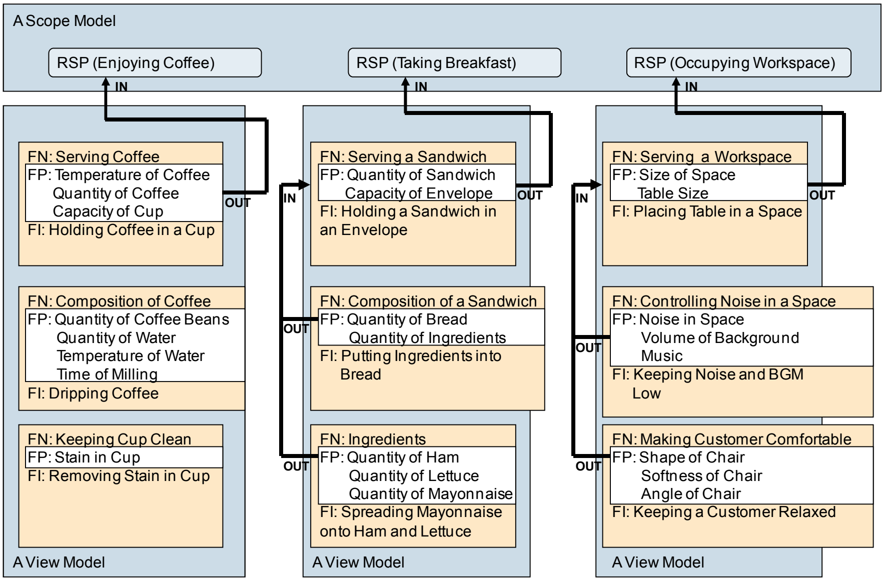

Fig. 6.3 An example of a view model

6.3.5 *Scope Model*

Practical services have very complicated structures of intermediate agents, connected to one another on an infinite chain. Therefore, it is necessary to specify the effective range of the service from an initial provider to a final receiver as illustrated in Fig. 6.2. In comparison to the view model in which a single RSP is expressed, the scope model can deal with all RSPs within the providers and the receivers. In other words, a scope model handles multiple view models, namely multiple RSPs. Thus, it helps designers to understand the real activities between the two.

6.3.6 *Service Evaluation Using the QFD*

In this Sect., a method is proposed for evaluating service using Quality Function Deployment (QFD) (Akao 1990), which corresponds to the service modelling in Sect. 6.3. The proposed method can obtain an indicator used in service design by means of evaluating the effect of the service on the receiver through QFD. The view model, which is represented by the graph structure, is converted into a matrix expression. A table similar to QFD is generated to reflect the Engineering Metrics (EM) of a product appropriately, i.e., a product's quality characteristics, to meet the customer's needs, or the Voice of the Customer (VOC). In addition, the Dematel (Decision-Making Trial and Evaluation Laboratory) method (Warfield 1976) is used to make quantitative analysis possible by classifying the FPs into CoPs or ChPs, depending on whether they directly affect the RSP. The proposed method consists of the following seven steps:

1. Setting the importance of the receiver
2. Creation of a service quality table
3. Structuring RSPs and obtaining their importance
4. Obtaining CoP importance
5. Considering indirect interactions using the Dematel method
6. Obtaining ChP importance
7. Function/mechanism deployment

		FP-1		FP-2		FP-3	
	RSP importance	+	-	+	-	+	-
RSP-1	20.0	1.0		0.5			
RSP-2	10.0	Relevance Ratio					
RSP-3	5.0		0.5	1.0		0.5	
RSP-4	2.5						1.0
FP importance		20.0	2.5	15.0	0	2.5	2.5

Fig. 6.4 An example of a view model

Step 1: Setting the Importance of the Receiver

Generally speaking, a service is supplied through a multistage structure involving numerous agents; therefore, when conducting service design, it is also necessary to consider the changes of RSPs belonging to different agents. First, all agents are extracted from the appropriate scope model for the target service in the flow model. Next, with regard to the extracted individual receivers, the Analytic Hierarchy Process (AHP) (Saaty 1980) is applied to establish the importance of the receiver from the provider's perspective. AHP is a method in operation research used widely in decision making. The method is employed to determine the relative importance of individual elements on a subjective scale.

Step 2: Creation of a Service Quality Table

Next, a service quality table is created as shown in Fig. 6.4. The table consists of quality items in vertical columns and functions in horizontal rows in the same way as the existing QFD. RSPs are therefore placed in vertical columns as they represent service evaluation components corresponding to VOC. FPs, showing the manifestation extent of the functions related to the RSP, are placed in the horizontal rows. Namely, the target service is characterized by pairing an RSP and the corresponding FP. RSP and FP can be extracted using the given description of the view model.

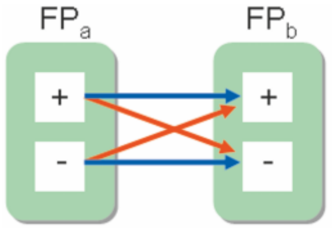

Fig. 6.5 Effect of the FP

Step 3: Structuring RSPs and Obtaining Their Importance

When evaluating a target service, RSP weighting in Step 1 is carried out using AHP in order to determine which RSP is to consider. As a result of this RSP weighting process, RSP importance is derived (see Fig. 1.4). If different levels of abstraction exist in RSP representation within a target service, RSP restructuring must be carried out in order to coordinate the abstraction levels on RSP. Once that is done, RSPs on an equal abstraction level of hierarchy are compared, and their weights are allocated.

Step 4: Obtaining CoP Importance

After obtaining the RSP importance, a binary table for the degree of association is used, and the RSP importance is converted into the FP importance by multiplying the RSP importance and FP's relevance ratio (see Fig. 6.4). According to the representation scheme of a service, the FP with a direct effect on the RSP is the CoP. In other words, only FPs that belong to CoPs can have their importance defined directly, and can deploy their importance by the binary table. On the other hand, under the definition of the service, an effect that is a functional manifestation of FP is defined as a Function Influence (FI). In this way, an evaluation is adopted by simplifying FI as the change direction (positive (+) or negative (-)) of FP (see Fig. 6.4). Using this process, the CoP relevance ratio vector, w^{co}, can be obtained as defined in (6.1); their degrees of importance of CoPs are enumerated. However, this relevance ratio vector is defined in relation to the entire FP, and the corresponding elements of a FP that do not have a CoP are set to 0 in (6.1):

$$w_{co} = \left(w_{co1}^{+} \ \cdots \ w_{con}^{+} \ \ w_{co1}^{-} \ \cdots \ w_{con}^{-} \right) \tag{6.1}$$

Step 5: Considering Indirect Interactions Using the Dematel Method

In a view model, there are direct and indirect interactions between FPs. Therefore, it is possible to conduct quantitative weighting of the state of the interactions, and the Direct Influence Matrix X* that describes the direct influence of these FPs can be obtained as (6.2), where xlm represents the strength of the interaction from xm to xl. Considering the interaction of the FPs, the influence of FPa onto FPb can be positive or negative. Thus, the matrix includes all four combinations such as ++, +− and −+, −− as illustrated in Fig. 6.5.

From the Direct Influence Matrix of the defined FPs, the Dematel method (Warfield 1976) is used to obtain the Entire Influence Matrix A as defined from (6.2) to (6.4). In this process at (6.3), the constant s, that represents the strength of the indirect influence, is necessary. It is measured in this experimental process. Subsequently the Entire Influence Matrix A is obtained as written in (6.4). It therefore represents the strength of the influence of the FPs on the RSP considering all the direct and indirect interactions among the FPs.

$$X^{*} = \begin{pmatrix} x^{++}{}_{11} & \cdots & x^{++}{}_{1n} & x^{+-}{}_{11} & \cdots & x^{+-}{}_{1n} \\ \vdots & \ddots & \vdots & \vdots & \ddots & \vdots \\ x^{++}{}_{n1} & \cdots & x^{++}{}_{nn} & x^{+-}{}_{n1} & \cdots & x^{+-}{}_{nn} \\ x^{-+}{}_{11} & \cdots & x^{-+}{}_{1n} & x^{--}{}_{11} & \cdots & x^{--}{}_{1n} \\ \vdots & \ddots & \vdots & \vdots & \ddots & \vdots \\ x^{-+}{}_{n1} & \cdots & x^{-+}{}_{nn} & x^{--}{}_{n1} & \cdots & x^{--}{}_{nn} \end{pmatrix} \tag{6.2}$$

$$X = sX^{*} \tag{6.3}$$

$$A = X + X^{2} + X^{3} + \ldots = X(I - X)^{-1} \tag{6.4}$$

Step 6: Obtaining ChP Importance

Using the Entire Influence Matrix of the FP and FIs, obtained through the process outlined in the previous paragraph, the ChP importance is obtained. This process is based on a hypothesis: "the ChP, which strongly influences the CoP, is more important." Namely, the equation below provides the ChP relevance ratio vector, w^{ch} (6.5). The individual CoP and ChP relevance ratio vectors are obtained using (6.5).

$$w_{ch} = \left(w_{ch1}^{+} \quad \cdots \quad w_{chn}^{+} \quad w_{ch1}^{-} \quad \cdots \quad w_{chn}^{-} \right) = w_{co} A \tag{6.5}$$

By combining the equations, the relevance ratio vector w is obtained for the entire FP as follows:

$$w = \left(w^{+} \quad \cdots \quad w^{+} \quad w^{-} \quad \cdots \quad w^{-} \right) = w_{co} + w_{ch} \tag{6.6}$$

Step 7: Function/Mechanism Deployment

By using the QFD, it is possible to know a detailed design indicator by deploying the importance of the quality elements, obtained through quality deployment, into their function/mechanism importance. Namely, in QFD, the process of either a function deployment or a mechanism deployment is performed to extract the functions and mechanics of the quality elements in order to obtain a design indicator for a product. In the proposed service modelling scheme, the relationships are described using a view model among the FPs (equivalent to the quality elements), the functions and the entity. Furthermore, a relevance ratio is then quantitatively given to the relationships among the FPs, the functions and the entity. It is possible to create a function deployment table and a mechanism deployment table.

These two-way charts allow the conversion of FP importance into either function importance or entity importance. As a result, the following information can be obtained as service design indicators:

1. **FP Importance** An importance concept on service, corresponding to the importance of quality elements in traditional product design, can be obtained in consideration of the concept of service channels/contents.
2. **FP Reciprocal Influence Matrix** Regarding the realization structure of the target service, it is possible to gain an overview of the interactions among FPs. By representing any complementary or interfering relationships among FPs in a matrix, it is possible not only to enhance the synergy relationships among the FPs but also to grasp the interfering relationships among the FPs should be solved by tradeoffs.
3. **Function Importance and Entity Importance** Because it is possible to obtain the importance of the functions and entity respectively involved in the

service realizing structure, the information to perform design operations can be used, such as the addition, replacement and deletion of the functions or of entity.

6.4 Service Activity Design

In service marketing field, service blueprints are used widely by marketers to describe service activities visually, sequentially and dynamically (Kingman-Brundage 1989). A service blueprint answers these questions: "who does what, to whom, how often, under what conditions?" (Kingman-Brundage 1989). Furthermore, it represents service activities as flow charts with interactions among providers and customers. The original service blueprint proposed the following two lines as shown in Fig. 6.6, to specify the scope of mutual effects among customers and providers.

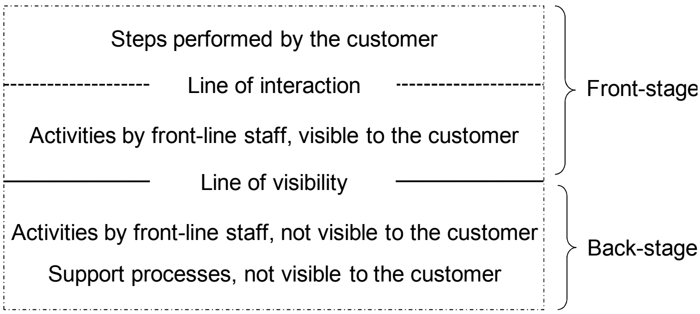

Fig. 6.6 Schematic illustration of service blueprint (Pires and Stanton 2004)

Line of Interaction

Separates the customer action area from provider activity area, representing the direct interactions among customers and providers. Above this line, i.e. customer's side, activities, choices and interactions performed by customers are found.

Line of Visibility

Differentiates visibility of provider's activities to the customer. However, the original blueprint has the following weaknesses, to apply to actual services. While "front-stage" is the place where provider's activities are perceived by customer, "backstage" is where provider's activities are not perceived by customer.

Lack of Design Information

Although customers evaluate services from various points of view, it is difficult to represent all information that customers perceive by only means of the flowchart style diagram. For example, the interactions of customers with facilities such as seating chairs cannot be depicted richly using the original blueprint (Ma 2002).

Insufficient Normative Notation

The service blueprint was basically proposed as a traditional flowchart, and thus has insufficient definition in normative notation. Consequently, the meanings of symbols are often ambiguous and inconsistent (Congram and Epelman 1995). By the same token, very few attempts have been made for studying service design methodology; namely, service organizations have focused on the service operations mainly from operating perspective, but not from design perspective. That is, a service blueprint itself is not sufficient to design practical service, however, it can be enhanced by combining conceptual design models such as the view models proposed by Service Engineering.

6.5 A Unified Representation Scheme of Service Activity

According to above-mentioned discussion, not only human processes but also physical processes must be described in service blueprints for increasing customer value in service. In this chapter, service blueprints are innovated to include physical processes to connect with view models that represent service contents. Consequently, the problems of the original service blueprint mentioned in Sect. 6.4 are solved. Service design process based on the extended service blueprint is made up of three phases: identifying customer value, design of service contents, and design of service activity. Fig. 6.7 illustrates the relationship among RSP, the view model and the extended service blueprint.

6.5.1 Extended Service Blueprint

The extended service blueprint represents both human processes and physical processes defined as follows:

- **Human processes** Activities performed by humanware and its related software
- **Physical processes** Activities performed by hardware and its related software

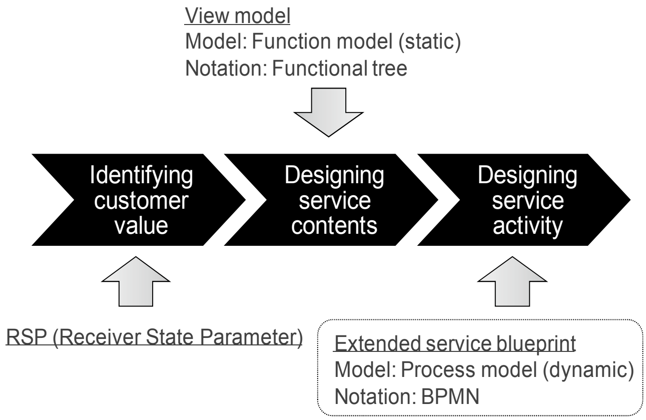

Fig. 6.7 Relationship among RSP, the view model and the extended service blueprint

The extended blueprint, based on the concept of original service blueprint, employs the Business Process Modelling Notation (BPMN) (White 2004) as its notation. BPMN is a common notation for the business process, and models business processes from the viewpoint of "who does what, in what sequence?" To understand BPMN more, some examples are discussed. A "pool" denotes an entity that implements processes. It represents not only human resources such as customers and providers, but also mechanical/informative systems that involve collaboration with customers. A pool is divided by "lane," to clarify visibility from the customers. The benefits of this blueprint are as follows. Firstly, it can be understood and used without special knowledge. In order to design high value services, various experts need to participate in design cooperatively. By representing interactions among providers and customers using this message flow, service designers can understand how the processes in one pool may influence those in other pools. Engineers often design their products without considering either customer needs or use phases. This method identifies the roles of products in entire service. Consequently, engineers enable design product fulfillling customer needs by referring above information.

6.6 Application to an Actual Service

6.6.1 Elevator Operation Service

The aforementioned method is applied to an elevator operation service. This business is chosen for working on heightening the value of the product throughout its life-cycle. In addition to regular maintenance of elevators, this elevator company tackles and develops novel service including building security control.

6.6.2 RSP Identification

The authors worked out a customer survey collaborating with the elevator company. As a result, six RSPs are identified from the survey. In this Sect., we focus on following four RSPs: "the security and safety of the service," "ease of movement," "service availability," and "comfortable environment."

6.6.3 View Model Construction

According to the results of above RSP identification, the target service is expressed with the view model scheme. Fig. 6.8 shows the upper part of a view model that corresponds to the RSP "security and safety." The root function for this RSP is decomposed into three functions: "responding quickly and certainly to an emergency," "deterring crime in elevators," and "maintaining the reliability of elevators." These three functions themselves are decomposed further into several sub-functions. Consequently, the following entities are associated with the lowest-level functions: humanware entities are monitoring staff, staff for emergency, and maintenance staff; hardware entities are an elevator, a control system, a disaster sensor, an intercom in elevator, a monitoring system, etc.

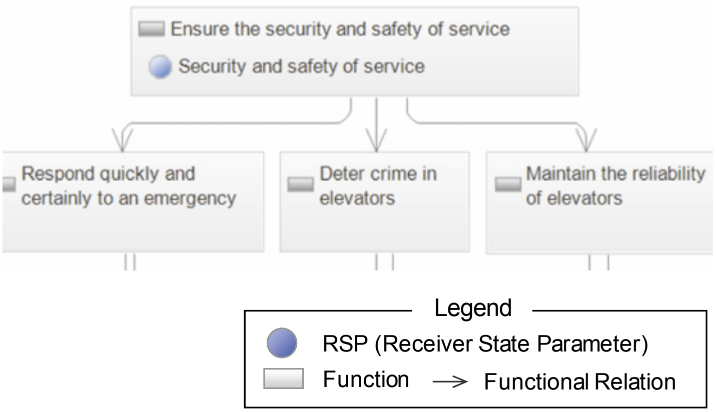

Fig. 6.8 The upper part of a view model regarding the RSP "security and safety of service" blueprint

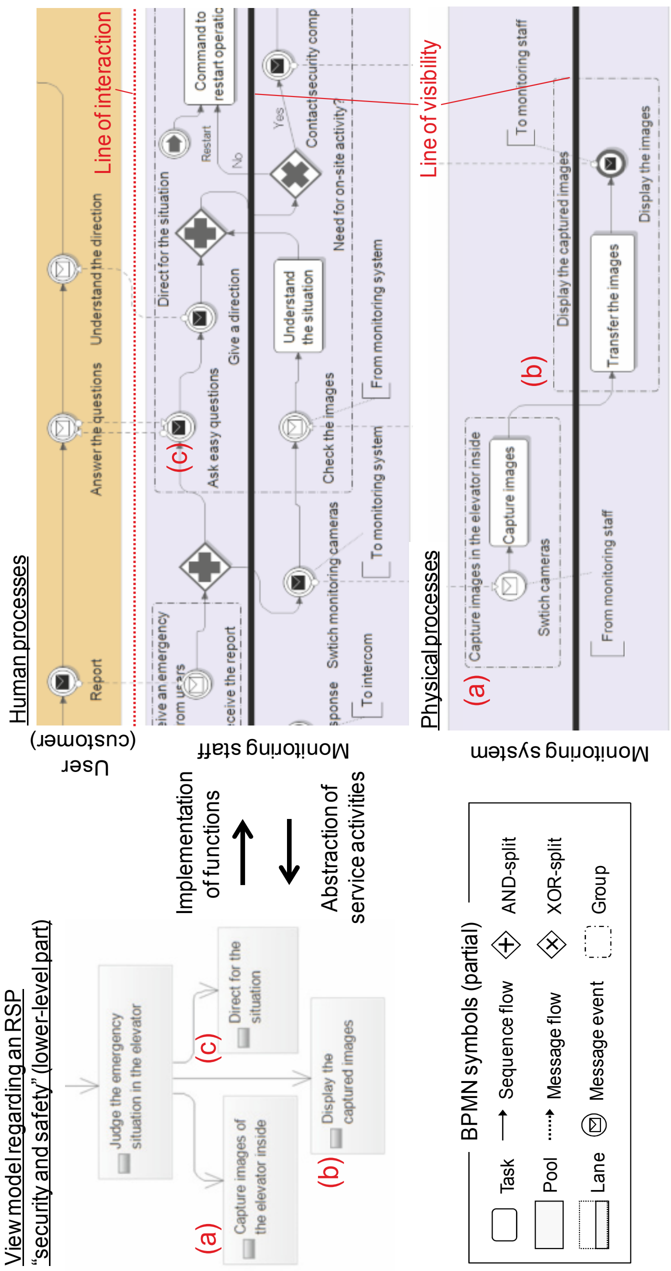

Fig. 6.9 View model and extended service blueprint (part)

6.6.4 Blueprint Construction

After constructing view models, each of the lowest-level functions in the view models are deployed into a series of activities. Fig. 6.9 illustrates a part of the extended service blueprint and its relationship with functions in the view model regarding the RSP "security and safety." This blueprint mainly shows the activities of the monitoring staff, who "responds an emergency request" from an elevator user via an intercom installed in the elevator. The portions describing the processes of the monitoring staff and the monitoring system both can be split up into two Sect.s by the line of visibility as explained in Sect. 6.4. The processes in the upper Sect. are visible to the user, while processes in the lower Sect. are invisible. BPMN objects, grouped by the broken lines in Fig. 6.9, represent functions in service activities: e.g., "capture images of the elevator inside (a)" is executed in the monitoring system. The function of judging an emergency situation in elevators, which contributes to responding to the emergency, can be implemented by collaboration among the user, the monitoring staff, and the monitoring system. Deployed processes for the function are parallel processes and include a conditional branch of directions about the emergency. As shown in Fig. 6.9, human processes and physical processes are unified explicitly and effectively by using the extended service blue print.

6.6.5 Evaluation of Process Importance

The processes described in the proposed blueprint are evaluated according to QFD manner aforementioned in Sect 6.3.6 . Table 9.1 indicates the result of process importance analysis concerning RSP "the security and safety of the service." In this table, service processes drawn in the proposed blueprint are sorted in descending order of their importance weight. By referring this table, service designers can find out how much each process and its entity contribute to the customer value "security and safety."

6.7 Service CAD System

The solution space of service design can be much broader than that of the conventional product design, which makes the derivation of design solutions difficult. In this Sect., a computer-aided design (CAD) system for service design, called a Service CAD, is introduced to provide computerized support for service design.

Table 6.1 Result of process importance analysis (part)

Entity	Service activity/product behavior	Importance weight
Elevator	Emergency stop	10.65
Sensors	Detect thermal change	10.65
Sensors	Detect acceleration change	10.65
Maintenance staff	Check parts	6.93
Maintenance staff	Clean up the inside of elevators	6.66
Staff for emergency	Decide coping process	5.55
Staff for emergency	Cope with the emergency	5.55
Staff for emergency	Rush to the elevator	4.99
Maintenance staff	Change old parts	4.16
Monitoring system	Capture images	3.08
Control system	Analyze the earthquake data	2.46
Control system	Analyze the fire data	2.46
Control system	Assess needs for stop operation	2.46
Control system	Assess needs for stop operation	2.46
Monitoring staff	Give directions	2.38
Monitoring staff	Understand the situation	2.38
Monitoring staff	Assess needs for on-site activity	2.38
Monitoring staff	Contact security company	2.38
Monitoring system	Display the images	2.31
Monitoring staff	Receive an emergency call	2.22
Control system	Diagnosis	1.89
Control system	Assess needs for repair	1.89
Control system	Repair	1.89
Staff for emergency	Prepare for rush	1.66
Monitoring system	Transfer the images	1.39
Intercom	Connect	1.01
Control system	Command to stop operation	0.82
Monitoring staff	Ask user questions	0.79
Monitoring staff	Check the images	0.79
Monitoring system	Switch cameras	0.62
Intercom	Outgoing call	0.61
Intercom	Incoming call	0.61

The results of service design, including the quality of the solutions and the efficiency of the service, depend largely on the designer's knowledge and methods. Issues regarding the management of design in various fields have been discussed. Research into knowledge-based CAD (e.g., Tomiyama *et al.* (1996) is one research field where such issues have been tackled. According to studies, knowledge of design is important when using CAD systems to derive a creative design solution. In other words, it is desirable for a CAD tool to support the design of a completely new solution that could not be conceived by one designer relying on his or her knowledge and experience alone. By providing design knowledge based on existing service cases and realizing a partially automated design operation, a Service CAD can facilitate competitive service design and development. An analysis of existing service designs revealed that most service designs fall into the following categories (Shimomura and Tomiyama 2002):

1. (Re-)design of a new service by enhancing components of and improving existing services
2. Application of existing service to a different field
3. Creative new design

For the first two categories of service design, the success or failure, the quality, and the efficiency of service design depend largely on knowledge of service design and existing service cases. However, a systematized knowledge base of service design hardly exists, while in mechanical design, the existing design knowledge base can be stored in a reusable form. In the first categories of service design, there are at least three patterns of operation (Shimomura and Tomiyama 2002):

1. Substitution of components
2. Removal of a part of service
3. Combination of different existing services

Pattern 1 is an operation in which a component of an existing service is substituted by another. Patterns 1 and 2 are operations to build a new service by changing and modifying an entire or a partial structure of the target service, while pattern 3 creates a new combination of services. Based on the above-mentioned analysis, we have proposed the concept of a Service CAD (Shimomura and Tomiyama 2002) to support engineers in designing services. A Service CAD serves as an environment which aids in the development of a service by providing information about existing service cases and various operational rules stored in the database. Fig. 6.10 shows a conceptual scheme of a Service CAD, which consists of the following components:

1. Service case base: a database of existing service cases.
2. Design rule base: a database of operational rules for service design.
3. Reasoning engines: reasoning engines which analyze various properties of service, such as similarities. A pluggable mechanism is employed so that the necessary reasoning engine is selected based on the designer's request.
4. Service evaluator: a module to evaluate a service design solution.
5. Service design process organizer: a module to support service design processes based on a specific design methodology by means of other components.

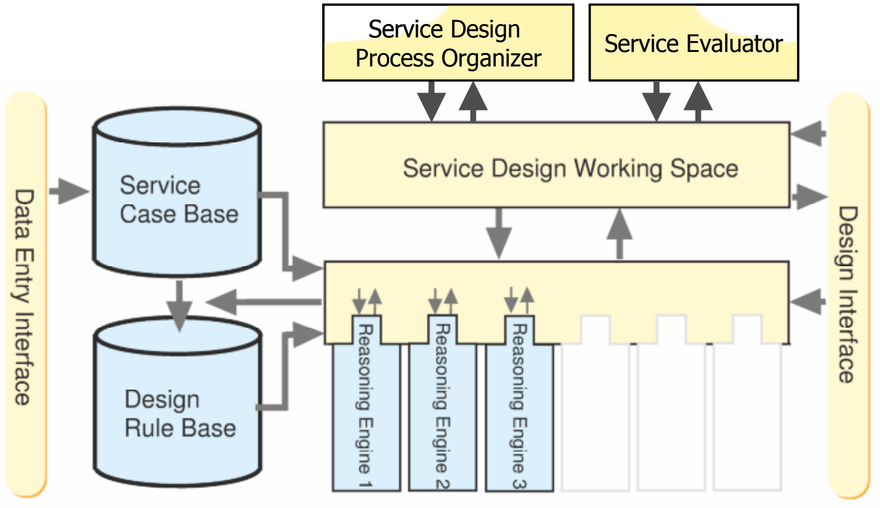

Fig. 6.10 Conceptual scheme of service CAD

The Service CAD presented in this study is programmed to collect existing service cases. In addition, the Service CAD reuses design rules derived from the design procedures of previous service design cases and registered as information used to operate and modify other service design cases in a database. By applying the design rules to all or part of a service in a partially automated manner, the time required for service design can be reduced. In other words, one of the methods to design a new solution is to apply various sets of design rules to existing service cases. This study suggests a reasoning mechanism using service case databases and several reasoning engines to realize various design operations as a fundamental element of the Service CAD. The prototype system of the Service CAD, called Service Explorer, has been developed. The system has the following five functions:

1. To allow a user to input and edit a service model
2. To display component elements on which designers focus
3. To register service cases in a service database
4. To search in the service database
5. To reuse service model data stored in the service database

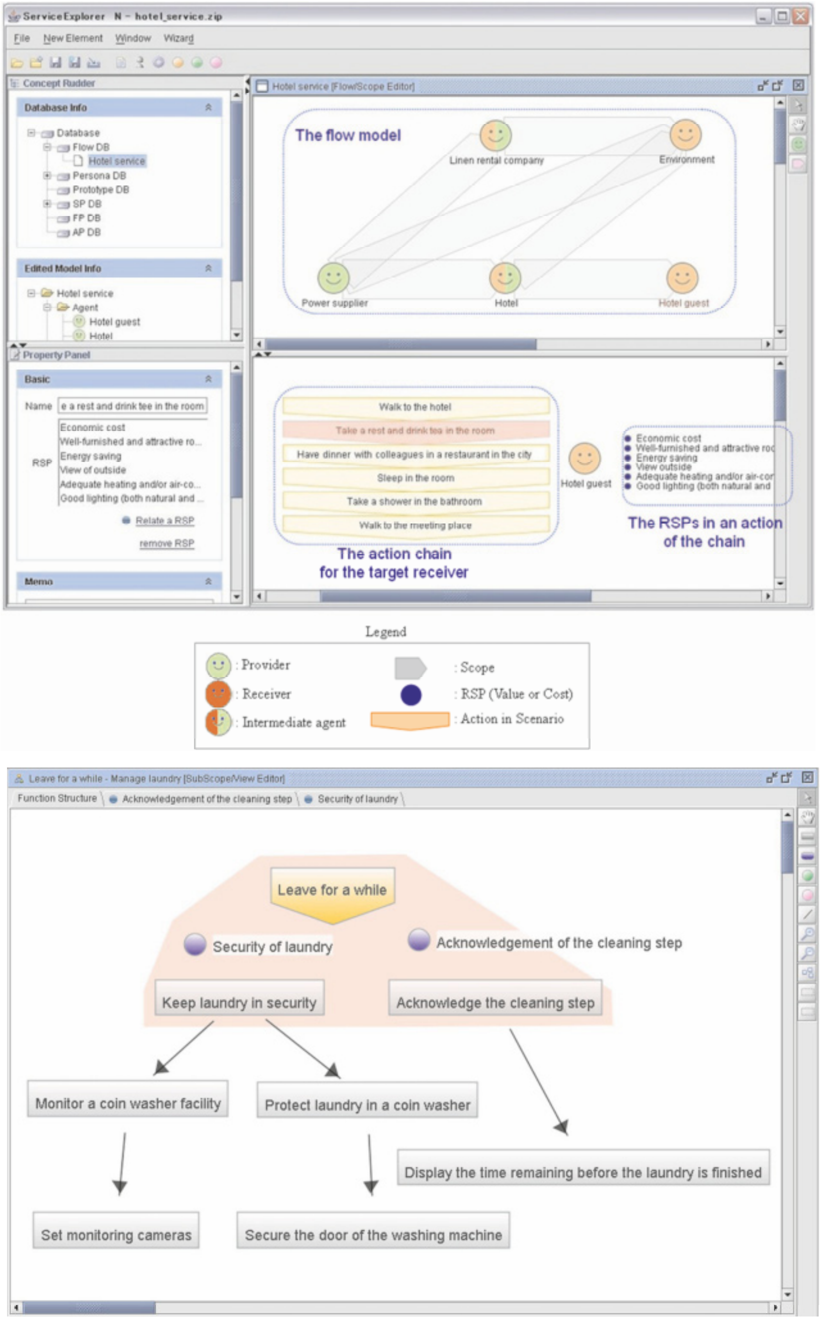

Fig. 6.11 Screen images of the prototype service CAD system

The requirements and details of the implemented specifications are as follows.

1. To Allow a User to Input and Edit a Service Model

This is the most fundamental function of Service Explorer. In order to acquire information about service cases for efficient service design, an easy graphical interface to describe a service model is needed. A service model is described as a graph structure consisting of nodes and arcs.

2. To Display Component Elements on Which Designers Focus

The system must selectively display component elements depending on designers' demands so that they can understand the structure of the service. Service Explorer provides a function to display the function topology and the parameter structure.

3. To Register Service Cases in the Service Database

Because it is desirable that the service database store service cases independently of the specific OS/application, Service Explorer employs XML as the database description language.

4. To Search the Service Database

Service Explorer is equipped with a search function to look up the service database depending on each designer's requests. Using the current Service Explorer, designers can search for service models with keywords contained in the composition elements.

5. To Reuse Service Model Data Stored in the Service Database

This function allows composition elements to be reused or the structure of a service model to be stored in the service database when a designer inputs and edits a service model. Based on the above-mentioned functional specifications, Service Explorer has been developed in Java SDK 1.4.1 and XML version 1.0. The MVC model (Krasner and Pope 1988), which has been used widely in general GUI applications, was adopted as the basic architecture of Service Explorer. By applying the MVC model, the high flexibility and reusability of Service Explorer and the robustness of the service model data were achieved. Fig. 6.11 shows screen images of Service Explorer currently under development.

6.8 Conclusions

Although current product and service designs are done separately, they are strongly related one another. To maximize the service value for customers, both human processes and physical processes should be unified.

In this chapter, first, we introduced fundamental concepts of service engineering. A service model consists of a provider, a receiver, a service channel, and service contents. The satisfaction of the receiver is represented by receiver state parameters. To deal with services, we introduced three different kinds of models, a flow model, a view model and a scope model; a view model is used to describe the structure of a RSP; a scope model covers the relations among RSPs in a service receiver.

Second, an evaluation method of a service is introduced. The evaluation is performed by applying the QFD to the service model, which consists of parameters as defined in Service Engineering. In regard to the realization of the service, relationships among individual parameters are defined as quantitative evaluations of their interactions through the Dematel method. In addition, by reapplying QFD to the obtained information, it is possible to calculate both the function importance and the entity importance, which are the structural elements of service, considering the contents and channels as the fundamental concepts of services.

Third, a method called “extended service blueprint” is introduced, which enables us to design service activities that consist of both human processes and physical processes, concurrently and collaboratively during the early phase of design.

Furthermore, a computer-aided modelling tool called Service Explorer has been developed to analyze a service and its related parameters. Service Explorer has proved to be useful in understanding a structure of a set of services.

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Chapter 7

Addressing Uncertainty of PSS for Value-Chain Oriented Service Development

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Abstract Services are becoming increasingly important in today's manufacturing industry. As a result, it has become common for companies to provide a combination of services and products as an integrated offering. This chapter focuses on such business and development processes. It begins with a literature review which identifies uncertainty as a critical concept to be addressed properly in such business. Then, based on interviews with nine Swedish companies interested in the PSS offering business, it uncovers findings such as how companies lack a systematized tool to support their development process. In addition, there is a wish to have a tool for companies to address uncertainty. In response to this, and as a solution, this chapter recommends that firms utilize a simple tool addressing the uncertainty of customers' business processes based on a model for "Process Service Channel", so that a service provider can effectively generate business process-driven service bundles. Through a case in the printing industry, this chapter demonstrates the effectiveness of the tool. This tool has potential for value-oriented optimisation of production processes and for a strategic customisation of the customer's business.

Keywords Development methodology, Requirement Analysis

7.1 Introduction

In today's industrial market, capital goods producers not only sell an appropriate device solution (hardware and software), but also customise their offerings with their own or additionally purchased services. Consequently, such producers play an active part in their customers' business processes as well. This has been recognized as a subject of PSS design. In spite of recent attention on PSS design by industry, knowledge/experience to support those companies is, at present, insufficient. To fill this gap, this chapter first aims at analysing what properties are peculiar to PSS and how industry addresses them, based on a literature review and company interviews, respectively. Then, it focuses on such development processes considering customer uncertainty and provides a tool for value-chain oriented service development as a solution. Finally, it illustrates how our tool supports service providers in developing industrial services together with products.

7.2 Industrial Challenges in Developing PSS

7.2.1 Literature Review

Morelli (2003) argues that the design of a PSS falls in a different domain than that of a product. He points out that the new variable includes the time dimension, assuming that is its final result is co-produced by a network of social actors. Furthermore, he states that the design discipline has no methodologies to operate in such domains, and proposes the use of envisioning with a scenario.

Oliva and Kallenberg (2003) propose two axes for manufacturers to shift their business from products toward services: one axis is from product-oriented services to process-oriented services, while the other is from transaction-based services to relationship-based services. The shift along the latter axis has an effect that the manufacturer is supposed to assume the risk of equipment failure. They further argue that the profitability from maintenance service depends on how accurate the organization is in assessing the failure risks for the equipment. In addition, this requires a new set of skills within the service organization and information gathering capabilities to better determine risk.

Alonso-Rasgado *et al.* (2004) state "business risk is an important criterion in the design of Total Care Products" and propose a five-stage design process in Total Care Products creation: business ambition, potential business solutions, "core" subsystem definition of a service support system, advanced product modelling and simulation, and product and business risk assessment. In addition, they argue the importance of considering the risk to both the supplier and the customer. They further argue that the human element provides the biggest source of uncertainty. Evans *et al.* (2007) report, from their observation of a PSS development case, that a number of techniques to negotiate benefit–cost–risk sharing among stakeholders are needed.

Based on analysis of a solution developed by a service division within an electro-technical conglomerate, ABB, Windahl *et al.* (2004) describe how potential savings and profitability may be unclear in such a solution. Playing an especially significant role, as far as the provider's internal planning is concerned, is the length of the contractual period.

Dausch and Hsu (2006) developed a qualitative reference model providing static knowledge on the structuring of service processes/resources and the dynamic assessment of their costs and risks, useful for both providers and customers. This has been tested with satisfaction by the Power Systems Division, Aircraft Engines Division and Transportation Systems Division of General Electric Corporation.

In the marketing area, on the other hand, an article of much relevance to PSS-design research (Vargo and Lusch 2004) does not handle such a concept explicitly. Instead, it suggests that value is determined by customers on the basis of "value in use" in a new, dominant and service-centred logic for marketing, while it is determined by providers in terms of "exchange value" in goods-centred logic. In addition, a foundational premise is presented: the customer is always a co-producer. This implies more uncertainty is added for a provider in the case of PSS than in the case of product-sales type contract, but the article does not go into further detail.

In summary, one of the most crucial impacts on business of PSS originates from the shift of these offerings from a static to dynamic state. This is quite obvious, since a contract for service has a time dimension and connotes future events, as opposed to that for a physical product (except for a period of quality guarantee as free service).

As a result, uncertainty becomes one of the new critical elements to address when designing/developing PSS. The consequence of uncertainty is regarded as risk, which should cover the risk of provider as well as customer, in some literature. Thus, it becomes critical to share the information of risk between a provider and a customer, and for a provider to make a decision on which risks to take or leave out. Regarding provider risk, for instance, the profitability from maintenance service is argued to depend on the preciseness of risk assessment (Oliva and Kallenberg 2003). However, it should be noted that risk is the negative effect of uncertainty, while opportunity is the positive one. As proposed in Jabagchourian and Cvetko (2002), risk and opportunity should be managed in an integrated manner.

Through reviewing academic contributions tackling these issues, it was found that uncertainty is a critical concept that needs to be properly addressed. Here, uncertainty originates from product functioning, service delivery, and customer demands.

7.2.2 Company Interviews

7.2.2.1 Interview Method and Questions

Based on the results of Sect. 7.2.1., the current status of industries was investigated with the following research questions (RQ), listed below and depicted in Fig. 7.1:

- **RQ1** What are the uncertainty factors for customers and companies in providing PSS?
- **RQ2** How do companies currently address customer uncertainty during their planning/design, and how do companies wish to address them in the future?
- **RQ3** What is a good way to support companies in addressing customer uncertainty with PSS during their planning/design?

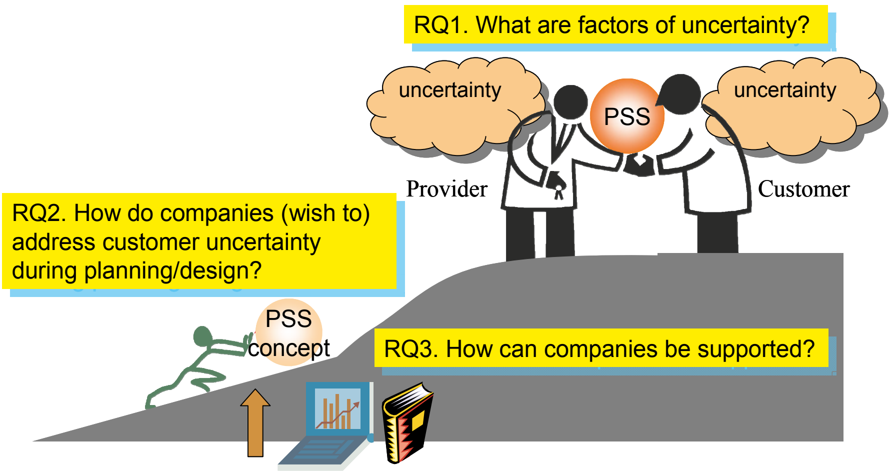

Fig. 7.1 Schematic presentation of the three research questions

The reason why customers and companies were focused on in RQ1 is that the uncertainty of physical products is well known from the traditional sales type of business. The following list defines three important differentiated terms used in the questions and dialogue during the interviews:

- **Uncertainty** The state of deficiency of information related to a future event
- **Risk** The negative effect of uncertainty on objectives. Risk can be expressed in terms of a combination of the consequences of an event and their likelihood
- **Opportunity** The positive effect of uncertainty on objectives

In addition, the categorization of the services, i.e. product-oriented service, use-oriented service, and result-oriented service, was adopted from that made in the EU-funded project on PSS (Tukker and Tischner 2006):

- **Product-sales type contract** A contract in which a company sells a physical product to a customer with a fixed period of quality guarantee, and without any extra price.
- **Product-oriented service** Extra service provided in addition to the sale of a product, such as supply of consumables, maintenance, financing, take-back, and advice on product usage; this is labelled "Type A" in this chapter.
- **Use-oriented service** Product leasing/renting/sharing (without ownership transfer) and pay-per-service unit (e.g., contract for using a copier); this is referred to here as "Type B".
- **Result-oriented service** Activity management service (e.g., office cleaning service and catering) and providing functional result (e.g., keeping harvest losses to an agreed minimum level); this type of service is denoted as "Type C".

For the company interview, nine companies were selected from large-sized manufacturers in Sweden interested in providing PSS. All interviews, with the exception of one done over the telephone, were carried out in face-to-face meetings during the period May to September 2008. The length of each interview was targeted at 1 h at maximum, but ranged from1 to 1.5 h.

A semi-structured approach with the above questions in mind was adopted for the interview. However, the depth of the dialogue for each question varied depending on the relevance of the company business. The information obtained during the interviews was analyzed along with other information, such as company brochures.

7.2.2.2 Results of the Interviews

It was found that most of the nine companies wanted to increase their service-oriented business. Namely, they wished to begin or increase the amount of use-oriented service (Types B) or/and result-oriented service (Type C) they conducted, although their major service business could be described as product-oriented (Type A). This is quite natural, because the nine companies selected were known to be interested in the PSS initiatives.

One of the major findings was that there is a difference in how providers view PSS depending on the maturity of providers in their PSS business: providers with extensive experience (including Companies A and B) recognize that the major uncertainty exists in customers, while others consider their services as the most uncertain. Consistent with this, the matured providers raised convincing customers and changing themselves as their major challenges, while others consider understanding the meaning of PSS internally to them is their current challenge. What the latter wish to have is, for example, support to identify their business case with PSS. However, it should be noted that main issues for each company varied. This is natural, as providing PSS forces firms to address various issues including identification of customer needs.

The chapter will then focus on a tool for supporting the more matured companies. Thus, customer uncertainty will be the main issue. Among the matured companies, another finding is that a company which already had extensive PSS activities (Company B) regarded uncertainty as a critical concept, and wished to have a quantitative tool to help design/develop PSS. Interview results from companies A and B are summarized in Table 7.1, as they have important implications regarding customer uncertainty. The information below is of a more complementary nature, while the complete information can be found in Sakao and Sundin (2009).

Table 7.1 Summary of the results from the interview of two companies

		Company A	**Company B**
Industrial sector		Heavy-machine provider for industrial use	Control-machine provider for industrial use
PSS Business in general			
	Experience	Much experience	Much experience
	Current ratio of contracts with services	50%	40%
	Current types of services provided	Product-oriented service predominant	Product-oriented service is prevalent at present, although the company has begun to provide use-oriented and result-oriented services
	Desired combination of service types	They wish to shift to use-oriented service, but not to result-oriented service	They wish to enlarge use-oriented and result-oriented services
The major uncertainty with PSS (RQ1)		Factors from customers (operation)	Factors from customers
How to address customer uncertainty (RQ2)			
	Current situation	The opportunity/risk is evaluated, before either product or service is fixed	Not in a formalized way, sometimes depending on the person
	Desired situation	The company wishes the service development Sect. to be more involved in the process	In a formalized way, leading to measurement and management
How to support planning PSS (RQ3)		Establishing a more rational procedure and a system by making use of past experiences	Providing a formalized procedure providing quantitative economic data to be shared and managed by different divisions

Company A

In Company A, 50% of the business is product-sales type contracts, while the other half consists of other contracts with services. The company wishes to shift its services from Type A, product-oriented services, to include more Type B, use-oriented services, but not Type C, result-oriented services.

Company A is trying to develop a system to support generation of offerings based on its past experiences. The system is supposed to take advantage of successfully closing contracts on the world market and generating a type and included elements of a contract. It is also supposed to calculate the TCO (total cost of ownership) of customers. Note that the mindset of the customers is an obstacle for Company A in providing more services; customers that are prepared to focus on their core business find it easier to receive service offerings.

In the cases of Type B, use-oriented services, and Type C, result-oriented services, uncertainty comes from customer factors. A key to generate such uncertainty is the complexity of product usage: as certain specific skills are needed in such cases, at the same time there emerges uncertainty.

To obtain information regarding a customer's operation, some techniques have already been implemented. However, there is still an abundance of information that cannot be retrieved. Thus, sending an employee to a customer site is meaningful.

Although Company A did not utilize any methods/tools to address uncertainty, it wanted to develop helpful methods/tools in the form of a system (see above).

Company B

Company B provides industrial machines which consume high amounts of energy in the usage phase. In general, about 75% of the total cost borne by customers is in energy cost. The cost to the customer, importantly, could be reduced by 30–40% through efforts of the provider. This is critical for Company B to be successful in the PSS business.

Company B aims to reach a win–win situation (higher availability/less cost for the customer and higher profit for the company) together with the customer (e.g., by applying the company's knowledge). The company wishes to expand the types of services it offers from Type A, product-oriented services, to include more of Type B, use-oriented services, and Type C, result-oriented services. At the same time, the company is interested in including as variable as possible content in its offerings. However, an operator (human) does not need to be sent from Company B to the customer site, since only software is needed for the operation.

Company B considers uncertainty to be among the critical issues associated with PSS. In the case of Type C, result-oriented service, uncertainty both for the company and the customer is the bottleneck. Here, customer factors have the largest uncertainty.

Company B regards the size of the consequences of risk on customers as an indicator of how much customers are interested in buying Type C, result-oriented services. The complexity of a provided system would be an indirect indicator.

7.2.2.3 Discussion

From the previous Sect., the research questions are answered as follows:

- *RQ1* What are the uncertainty factors on customers and companies in providing PSS?
- *A1* Factors from customers were the most prevalent for the more experienced companies, while services are the major factors for the less experienced companies. This appears to be rational, assuming experienced companies have overcome their own service uncertainty.
- *RQ2* How do companies currently address customer uncertainty during their planning/design, and how do companies wish to address them in the future?
- *A2* Some companies had tested tools for the dynamic assessment of risks; however, this was not widespread. Even a company with extensive experience did not address (quantitatively and qualitatively) uncertainty in a formalized way. "Trial" service was employed by some companies to demonstrate the service at the customer site.
- *RQ3* What is a good way to support companies in addressing customer uncertainty with PSS during their planning/design?
- *A3* One way would be to adopt a formalized and quantitative tool (software) calculating the financial situation of the provider and the customer using data from the past. Such a tool should address information concerning the usage of products at the customer. This originates partially from interpretation of the interviews by the authors, since sufficient spoken needs from the companies were not available. However, this is in line with the future research implication in other literature (Sakao *et al.* 2009).

In conclusion, there is a reasonable wish for relatively mature companies to obtain a formalized system leading to the quantitative/qualitative management of uncertainty.

7.3 The Solution: A Tool for Value-Chain Oriented Service Development

7.3.1 Overview

From Sect. 7.2, establishing a formalized way to support designers in companies was identified as a wish. Therefore, as a first step, this Sect. suggests a qualitative tool developed in the engineering field (the tool was originally published in Panshef *et al.* (2009)). This allows designers to explore the consequences resulting from uncertainty during the customer process, and to find possible business opportunities, especially in the areas where no service is given.

7.3.2 Overall Description of the Adopted Model

In the customer's production process, certain risk of failure exists, and customers are certainly not pleased when a failure occurs. Therefore, the service provider can successfully provide services which take over some of the customer's risks. Through this "risk sharing" (Alonso-Rasgado *et al.* 2004), both the customer and the provider can profit as long as the provider is able to create the appropriate service content. Hence, the provider has a greater chance of receiving higher income.

First, a model is needed to describe customers. There are two main focus areas within this model. Firstly, it aims to obtain the "value-added chain" as an iterative course of technology-driven methods as well as to obtain the business processes in commercial and micro-economic structures. Secondly, it aims to exploit all resources of a service-support chain efficiently when considering the possible level of service escalation.

In addition, this model also maps out a new field in the industrial support service by means of classifying the configuration of different service content, primarily in failure prevention. The proposal of separating the service activities in reactive and preventive activities introduces a new dimension into industrial service with great potential and far-reaching scope.

7.3.3 Structural Design of the Model

In order to systematically design the model, it is necessary to clarify its construction rules and the general conditions. The framework in Fig. 7.2 illustrates the basic structure and properties of the model.

The design of the model basically consists of three elements: first, the customer's value chain (x-axis); second, the level of service escalation (y-axis); and third, the level of service development (z-axis). These are described below.

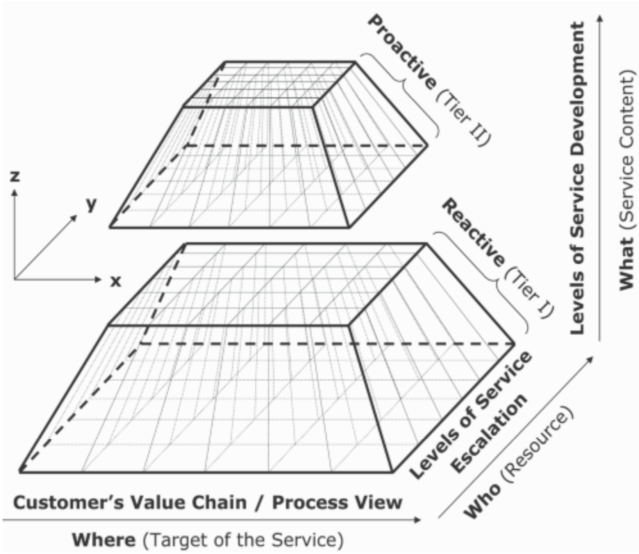

Fig. 7.2 3D framework of the model for the "Process Service Channel" with the description of the service content (Where, Who and What). Source: Panshef *et al.* (2009)

7.3.3.1 Customer's Value Chain (x-axis)

The value of a product or a service consists of many different components, which are fixed in relation to the production (for products) or to the supply of services. The individual manufacturing processes, or the process organisation in the provision of a service, consist of many small sub-processes and organisational units (Vahrenkamp 2004). Each of these sub-processes and organisational units influences the quality and the value of the final product or service in a certain manner. Thus, each of them contributes to the total value of the product or service. The total of the "value increments" for each individual manufacturing process or organisational unit is described in this research, in accordance with Porter (1985), as the "Value (-Added) Chain."

The main task when obtaining the customer's value chain is to capture and illustrate its elements. The elements of the value-added chain within the customer's large-scale production process are defined as the "Customer's Value-Added Chain" in this research. It should be defined individually for every single manufacturer and for every manufacturing process. This means that each "Customer's Value-Added Chain" has different structures and qualities. Accordingly, primary and secondary processes of "added value" should be equally defined (Porter 1985).

In contrast to the "Life-cycle" concept presented by Aurich *et al.* (2006), this element within the x-axis proposes a "Business-to-Product" view of the PSS design. By use of this description, a process view of the customer's production value chain can be designed.

7.3.3.2 Levels of Service Escalation (y-axis)

The possible levels of service escalation refer to all possible procedures when handling and preventing a "crisis" in production value chains. Similar to the concept of "Crisis Management of Organisations" (Smith 2005), the concepts "crisis" and "emergence" should be precisely defined. In this context, a "crisis" is a set of conditions that generate task demands on a production value chain that exceed (or come to exceed) a value chain's ability to cope with the use of considerable additional (possibly external) resources. In the same way, "emergence" can be defined in relation to the resource's network interaction that takes place around a customer's production value chain and to its core activities.

When defining possible levels of service escalation, all resources should be utilised. This will help to avoid a "crisis" in the customer's production value chain. Correspondingly, all involved human resources, organizations and techniques that guarantee the stability of the customer's production value chain must be identified and properly structured. These resources should be distributed along the y-axis (see Fig. 7.2) with respect to their spatial proximity (e.g., machine internal, customer internal and customer external, as well as machine manufacturer internal and external or neutral measures) and their reaction/action time (e.g., simultaneous, immediate, indirect, after some period of time, etc.). Thus, a network is formed between the customer's production value chain and the "service supply chain", determined by the definition of possible levels of service escalation (see the base of the pyramid in Fig. 7.2).

7.3.3.3 Levels of Service Development (z-axis)

The design of several service contents aims to create the appropriate service activities for each (or one particular) element of the customer's value chain and for each (or a determined) level of service escalation. The existing models for innovative and value-oriented service engineering are often sector-specific because of the heterogeneity of the service contents, and are therefore generally seldom valid (Jaschinski 1998). Our model attempts to be rather generally applicable to different sectors.

The design of the actual service content has to first be completed by considering all possible reactive service content (known in this research as "Service Contents Tier I"), and second by considering all possible proactive (preventive) service content (known in this research as "Service Contents Tier II"). In this way, a view of the service content and all implemented service activities is defined. The description of the "Reactive Service Contents" (Tier I) and "Proactive Service Contents" (Tier II) is presented in detail below.

a) Reactive Service Contents in Tier I

Relating to the model, the service content from Tier I is understood to be reactionary measures on the part of the possible level of service escalation. This level can refer to demand, fault or disturbance in the whole value chain within the customer's target production process. It is a kind of "Quality Management", according to Linß (2002), where firstly the fault is eliminated as a reaction and secondly it is cared for as a prevention. In consequence, the customers obtain a stable value chain. All these elements (see the x, y and z axes in Fig. 7.3) which are carried out as a reaction to malfunction in the production process or to a customer's enquiry have three tasks. Firstly, it is important in each case to react with concrete corrections as fast and effectively as possible. Secondly, the efficiency of the model presented in this article takes into account an in-depth fault analysis and suitable fault avoidance measures. Thus, the model should ensure that the cause of this fault and all further possible sources of fault are eliminated. This should minimise the risk of further system disturbances in the future. Thirdly, by means of suitable preventive measures, this concept should ensure that the costs caused by subsequent damages are minimized. In fact, a closed sphere of activity is created to reduce the consequential damages by means of a more intensive treatment of the fault causes and fault avoidance.

Just like the "Self-Maintenance Machine" defined by Shimomura *et al.* (1995), this concept of reactive service includes reactive computerisation content as well. Nowadays, all these reactive tasks, which are defined in this article as "Reactive Service Content in Tier I', are a common practice in the sales and service units of all industrial manufacturers.

b) Preventive Service Contents in Tier II

The "Preventive Service Contents in Tier II", which are presented in the "Model for Process-Driven Service Bundling", refer to all support measures that can be preventively implemented and determined with regard to "measurable uncertainty" or "measurable risks" in the process of a customer's large-scale production. This preventive service support includes actions such as preventive maintenance, performance upkeep and/or process monitoring, which can be recognised and processed, e.g., according to the model approach of Lavidge and Steiner (1961) for predictive measures of advertising effectiveness. That is, if a breakdown in the customer's production process is going to occur in the long run, something (a type of indication) must appear in the short run. Thus, this indication can be measured in order to provide "Preventive Service Contents" approaching a comprehensive evaluation of the effectiveness. Such measurement, according to

Lee (1999), can help operators set up machines for a given criterion in order to determine whether the machine is running correctly and to predict problems before they occur.

In contrast to the “Reactive Service Contents in Tier I”, the “Preventive Service Contents in Tier II’ are characterised by two main properties. First, the service content and service activities can be realised without recognising faults or disturbances in the production process. Second, the “Preventive Service Contents’ can be realised without customers asking for them. That is, they are a proactive service action regarding the “Customer’s Value (-Added) Chain” of all involved in a given large-scale production process. The concept of proactive service activity is related to the extent to which service specialists generate new services on the different levels of service escalation. Thus, it considers the strategic objectives and long-range needs of a customer’s large-scale production process (Bunn 1993).

7.3.4 Profile View of the Model

The aim of this model is to identify the most critical production elements or organisational units within the “Value (-Added) Chain” and optimise these elements by suitable support activities. Thus, a structured “Process Service Profile” of the “Process Service Channel” is created. A simplified example of a “Process Service Profile” is presented in Fig. 7.3.

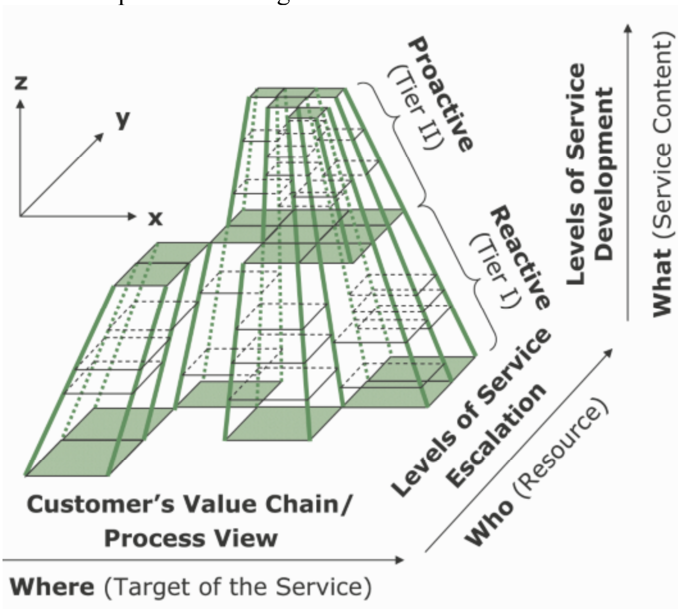

Fig. 7.3 Example of a “Process Service Profile” as a matter of the “Process Service Channel”. Source: Panshef *et al.* (2009)

This profile ensures that an efficient and process-adjusted design of the elements is considered. It also represents a structured view of the targets (x-axis), resources (y-axis) and contents (z-axis) of the service activities. This can also be used during the negotiation of "service-level agreements". The areas indicated by the three axes (x: where, y: who and z: what) show the variety of services that should be produced in a certain customer's production business. Here, each field (defined by the x, y and z axes) may contain several service contents.

7.3.5 Use of the Model

For the application of the model, a "task force" should be formed consisting of the following groups: the customer's own production team, the customer's support team (if one exists) and specialists on the side of the service provider, the production supplier as well as others involved in the production process. The responsibilities of this "task force" are defined by the structural design (x-, y- and z-axis) of the model (see Sect. 7.3.3). The customer's support team plays an essential role in the modelling process within the application of the model. This team should provide all information about its own production process and thus guarantee access to all of its own "Value (-Added) Chain" devices.

Furthermore, the customer's support team should recommend service potentials used in their own businesses, as well as their own production processes. They can provide suitable information for the service proposed because they know best their own production value chain, their capability and their structure of the possible levels of service escalation, as well as their own business needs and risks. Consequently, this "task force" can guarantee the process performance of each one of the customer's large-scale production chains.

By using the model, both the provider and the customer can identify business opportunities within two main areas. First, they can improve the services currently provided by means of this model. Second, by using the taxonomy tables built by the x and y axes (see Fig. 7.1 and Fig. 7.2), they can visualise significant potential for the creation of new service contents. The model helps designers of industrial service contents to find out what kind of services can be provided to one specific production and business process. Thus, the matter of the model is to design a framework for capturing (provider) and ordering (customer) of possible industrial service contents.

7.4 Application

This Sect. focuses on the commercial viewpoint of large-scale production processes, in particular for the printing industry, and generates additional potential within industrial business-to-business services. Addressing the model of customers' business processes, this chapter contributes to the field of value-chain oriented PSS development.

7.4.1 Basic Conditions for the Simulation

The model presented in Sect. 7.3 is simulated on the supposition of a print production company as an example of a large-scale manufacturer by means of a "desktop simulation" modelled after Rathburn and Weinroth (1991). For this, the customer will be assumed to be a small print shop (10 employees) with a "fully-integrated part of self-manufacturing" in the "commercial print field". This "fully-integrated part of self-manufacturing" refers to the production process and means that the company operates in all of the three areas of print production (prepress, press and post-press). Furthermore, for the purpose of the simulation, this print shop has a basic business administration without an internal control and overhead cost management. The term "commercial print" refers to the specialisation of the occasional printed matter of the print shop. These are non-periodic print products such as leaflets, letters, forms, advertising supplements, business cards or admission tickets.

In the next Sect. the model has been built up in the 2D tables, according to the given framework in Sect. 7.3.3.

7.4.2 Construction of the Taxonomy Table for Service Contents

The 2D view of the "Model for Process-Driven Service Bundling" illustrates a theoretical combination of services by means of a two-coordinate system as part of the pyramid presented in this research (see Fig. 7.1). On the abscissa (the x-axis of the pyramid) is displayed a process view of the complete large-scale production and manufacturing process. This process view relates to the approach for obtaining the customer's production value chain described in Sect. 7.3.3. The print production process is structured in four areas: pre-press, press, post-press (so-called "finishing") and logistics.

On the ordinate (the y-axis of the pyramid) of the two-coordinate system, all the possible levels of service escalation are derived and entered into the 2D table. For the purposes of this "desktop simulation", three escalation fields have been defined. These are firstly the customer's own resources; secondly the resources of the device manufacturer or the local service provider; and thirdly the resources of other service providers. The escalation field "Other" refers mainly to two types of "service provider". Firstly, it can be an insurance company for covering damage costs in the case of a defect. Secondly, this escalation field can also refer to various associations, which can lead to a settlement solution by means of an independent consultant in case of disputes (see Fig. 7.4).

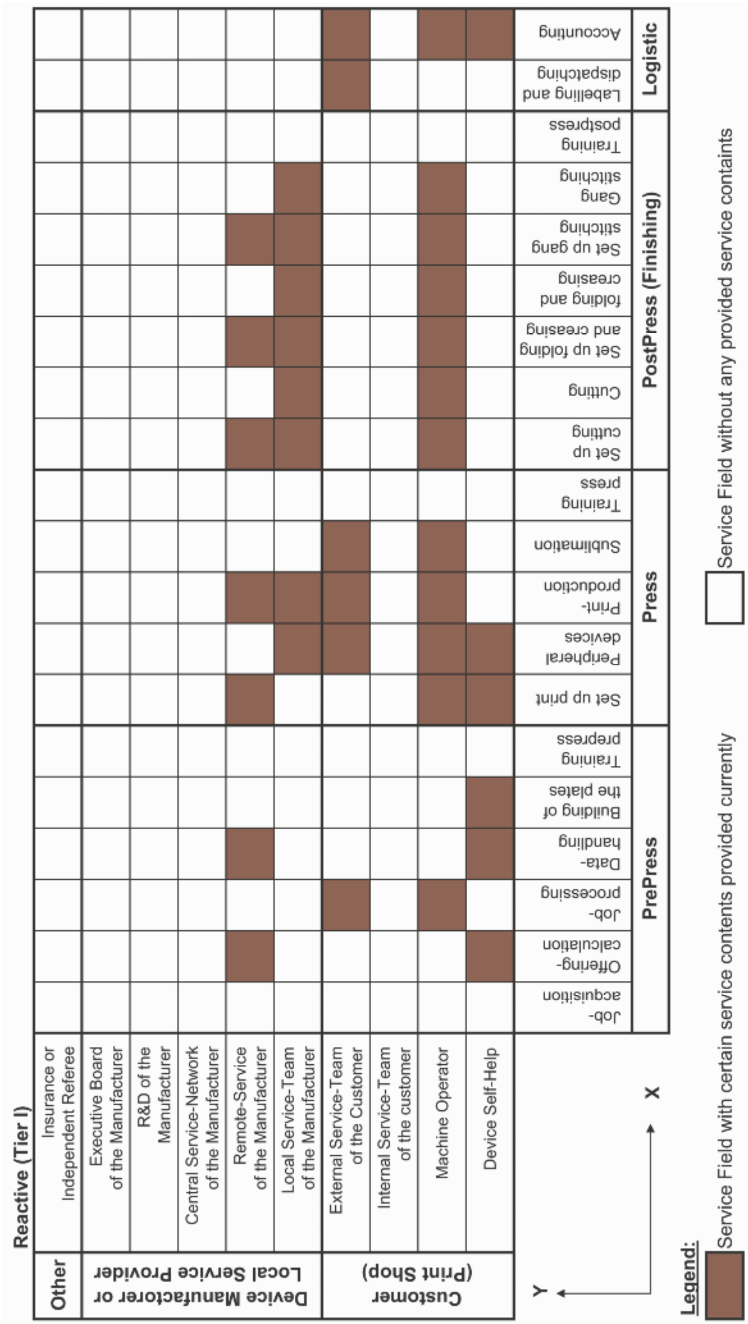

Fig. 7.4 Taxonomy Table for the "Value-Chain-Oriented Service Development" of the model for print production,"Reactive (Tier I)". Source: Panshef *et al.* (2009)

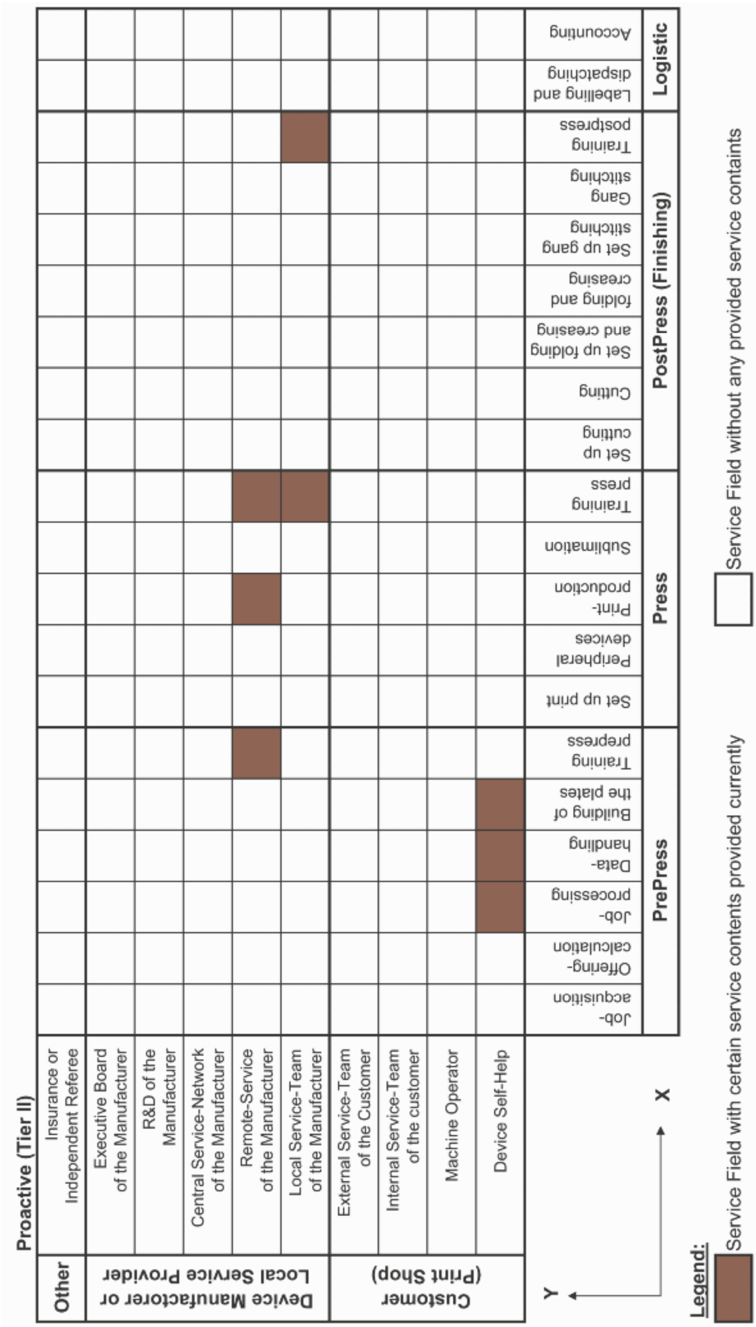

Fig. 7.5 'Taxonomy Table for the "Value-Chain-Oriented Service Development" of the model for print production, "Proactive (Tier II)", Source: Panshef *et al.* (2009)

By matching the acquired "Customer's Value Chain of the Print Production" (x-axis) with the specified "Levels of Service Escalation" (y-axis), a matrix-like combination of target processes and resources for the possible service contents is generated. This is defined within this research as the "Service Field". By allocating different services into the "Service Fields", a 2D profile of the "Process Service Channel" is generated. This 2D profile represents the composition of different service contents created within the scope of the "Process Service Channel". At the same time, the outlines of the pyramid presented in Fig. 7.3 are determined for the "Reactive Service Contents in Tier I" (see Fig. 7.4) and for the "Preventive Service Contents in Tier II" (see Fig. 7.5).

These two figures build the platform of the "Model for Process-Driven Service Bundling", and show the "Taxonomy Table for Value-Chain-Oriented Service Development" towards a large-scale manufacturing process as well.

In the example of the small print shop, a high concentration of the reactive services was initially observed for the areas of press and post-press (compare Fig. 7.4 with Fig. 7.5). Consequently, a new business opportunity can be identified by the design of new service contents with focus on the pre-press area. Therefore, in terms of the possible levels of service escalation, an involvement up to the level of "Remote Service of the Manufacturer" will be considered in this model. By using the next highest level, the service provider can improve the efficiency of the service escalation provided to the customer. For instance, in order to improve the reactive service contents in the area of pre-press, new service contents for "Data Handling" can be created and provided by the "Central Service Network of the Manufacturer". These can be, for example, consulting activities about the retrieval of data. Furthermore, no internal service team on the customer's side is considered in this example. This observation opens up new business opportunities by removing service tasks from a current service provider to a new one within the "Service Support Chain". For instance, in order to improve the business process, several reactive service activities, which are currently provided by an "External Service Team of the Customer", can be taken over to an "Internal Service Team of the Customer". This example shows just one of the operational areas of the taxonomy table for the "Reactive Service Contents in Tier I" (see Fig. 7.4).

A significant business opportunity arises for both the provider and customer (e.g., print shop) by the implementation of the taxonomy table for the "Preventive Service Contents in Tier II" (see Fig. 7.5).

By displaying the bundle of preventive service contents, a new dimension for the design of preventive service activities is presented. This awareness provides a huge business potential in two main directions. Firstly, the service providers can plan their own resources by providing preventive service activities. Secondly, the "Service Customer", in this case the print shop, obtains a stable print production process throughout its own production "Value (-Added) Chain". By using the taxonomy table for the "Preventive Service Contents in Tier II", a set of possible service contents can be obtained to compensate collectively exhaustive risks for the customers (e.g., insurance or warranty of the "Central Service Network of the

Manufacturer"). Hence, using the bundle of several preventive service activities, this table provides the base for creating "service level agreements" between a provider and a customer.

Furthermore, by the intensive exchange of information between the providers and the customers required for the application of this taxonomy table, the service providers obtain very useful information about their customers' business process. This knowledge can be used by the manufacturer's R&D for further customisation of the next machine supplied to the customer.

These are just a few of the beneficial aspects of the "Taxonomy Table Concept", which could be identified in the desktop simulation. An actual application of the concept will provide many more benefits to everyone involved due to the new preventive perception and feeling for the problems within a business process.

7.4.3 Effectiveness of the Model

The taxonomy tables (see Fig. 7.4 and Fig. 7.5) show the possible "Levels of Service Escalation" and the "Customer's Production Value Chain", and illustrate the advantages of using the model (see Sect. 7.3). In addition, this model would provide new business opportunities for all participating parties. The 2D profile of this model enables the improvement of existing service content (even removing the current service provider) by recognising and understanding the less significant service capability provided by the reactive service.

Furthermore, the active role of the customers in the generation of their own production "Value (-Added) Chain" allows them to better understand their own better core competence" (Hamel and Prahalad 1994) within their own business processes as well as their own potential risks. Moreover, the separated consideration of the preventive services presents a new dimension for "service engineering" regarding the potential of designing proactive industrial service activities.

The example in this Sect. was taken from the printing industry. However, the applicability of the model is not limited to this particular industry. Rather, it is applicable to such industries that adopt highly complex machines, and may face the pressure of time in the production processes.

7.5 Future Trends

As implied in Sect. 7.4, PSS design may force firms to reconsider their core businesses. This is in line with a general trend of outsourcing and focusing on core competitiveness in industries. However, a method or a tool to support designers in such situations is scarce. One of the few instances is a qualitative method to analyse the customers' activity cycles developed in the marketing field (Vandermerwe 1993). Development of methods/tools in this topic is encouraged.

7.6 Conclusions

The conclusions of this chapter are that PSS offerings are associated with different types of uncertainty as compared to product sales. Providers should understand the implication of this new way of providing offerings. From the design perspective, PSS brings more opportunities to firms, who will need new support tools.

As a solution, it demonstrated that a service provider is able to set up a suitable and effective strategy to design a customised service for business processes. This has been attained by a deeper understanding of the business structure within the production processes of a customer. Quite often the production process structure, based predominantly on machine conditions, stands alone and does not sufficiently exploit the maximal potential gained by using a customer business model. An increased efficiency can be achieved by the implementation of certain taxonomy tables. These tables (see Fig. 7.4 and Fig. 7.5) simply generate suggestions (a pool of ideas), and thus do not include the most important part of the optimisation, namely the evaluation.

7.7 Acknowledgments

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Chapter 8

Value Visualization Strategies for PSS Development

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Abstract The concept of value visualization is concerned with the way that firms communicate and demonstrate the value of their Product-Service Systems (PSS), both internally and externally. In this chapter, a visualization strategy framework for PSS development is proposed. It is particularly tailored for industrial companies that are strategically shifting from selling products to becoming providers offering PSS. Value visualization strategies have traditionally focused on external sales activities. However, companies need to have a broader approach to visualization in all PSS development phases, as well as including different visualization techniques. Furthermore, different visualization strategies are needed for each particular development stage of the PSS. Companies need be able to make use of several different visualization strategies, depending on the actual content of the Product-Service System and its position in the development process. Whereas the product development process is rather heavy at the back, successful PSS development projects with high levels of service need to be heavy at the front (that is, they need to not only develop the system but also ensure its rollout). Examples are provided from eight market-leading companies in different industries, each of which are undertaking a strategic shift from identifying themselves as product sellers toward becoming providers offering PSS. To conclude, value visualization has become vital for winning new contracts and retaining existing ones. It is therefore a strategic resource that managers need to pay attention to, and continuously develop, in order to compete with PSS offerings.

Keywords Value visualization, Value creation, Offering development, Product-service integration

8.1 Introduction

Managers and scholars alike have pointed out that it is in many ways challenging for manufacturing firms to carry out a PSS strategy (e.g., Jacob and Ulaga 2008, Kowalkowski *et al.* 2009, Mathieu 2001). The strategic shift from products to integrated offerings involves not only adding auxiliary services to the core product offering; it also requires redefining the company's business and changing the mindset of managers, employees and customers. KONE, for example, instead of defining its business as a provider of elevators and escalators, markets itself as dedicated to facilitating the flow of people through Product-Service Systems. That is, their objective is "to offer the best people flow experience by developing and delivering solutions that enable people to move smoothly, safely, comfortably and without waiting in buildings in an increasingly urbanizing environment." Not only does such a repositioning require a new development and marketing approach, it also requires the ability to visualize the value of new integrated offerings (which consist of both products and services). Clearly, this is more complex than the communication of traditional product-based values and technical features.

In this chapter, we put forward visualization strategies as a means of trying to understand how industrial companies can develop ways to approach customers in order to show the value of integrated PSS offerings. Empirically, in the light of increased service infusion in manufacturing firms, addressing visualization is of utmost interest. Theoretically, this is of particular relevance, since the existing research in the area of visualization has focused on traditional service industries and/or primarily in the B2C sector (e.g., Hill *et al.* 2004, Mittal 1999). Furthermore, visualization in B2B marketing tends to be limited to what Berry and Clark (1986) call "documentation strategies," and it has an external focus, mainly on selling (cf. Anderson *et al.* 2007). However, visualization of value is a broader concept that includes the way companies quantify, communicate, illustrate and demonstrate the value of their offerings, not only to prospective and existing customers, but also to other actors in the extended business network and internally (within the organization). Based on a general model for service offering development, consisting of four stages (Kindström and Kowalkowski 2009), visualization strategies that take the entire process (from idea generation to the delivery of the integrated PSS offering) into consideration, are discussed.

8.2 Issues and Challenges

Visualization often involves communicating and demonstrating the value of intangible aspects that are difficult for individuals to understand, due to, among other things, immaturity in developing services and integrated PSS offerings. The most common strategies focus on sales management, and Fig. 8.1 shows a conceptualization of the customer value management process.

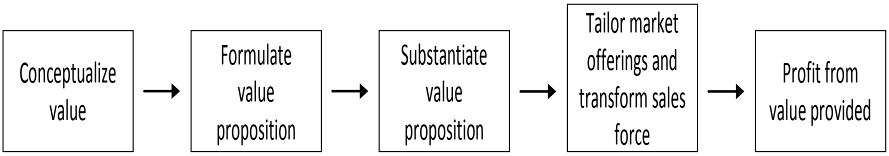

Fig. 8.1 Customer value management (Anderson *et al.* 2007)

The first step is conceptualizing value. This includes identifying elements whose value comprises basically the same elements competitors offering, as well as elements which are different (superior or inferior) to the offerings of competitors. Visualization becomes particularly important for those elements of the offering where the supplier and customer disagree with regard to the value relative to the value of competitors' offerings.

The next step is to formulate a competitive value proposition. As managers in charge of successful value-based selling point out, this does not equal listing all possible benefits customers receive from the offering (Kindström 2009). Rather, it implies that suppliers should highlight a few elements that will create the greatest value for the customer. This requires knowledge of not only their own offering, but also of the business processes of competitors and customers.

The third step is substantiating the value proposition. This can be assisted by use of case histories and value calculators. Case histories document the value that reference customers have received from the supplier's offering. Value calculators are often spreadsheet applications that salespeople, service technicians and specialists can use to demonstrate the monetary value that the customer will receive.

Finally, suppliers need to tailor the right PSS offering for each customer segment and profit from the value provided by both understanding the cost to serve and the customers' willingness to pay (Anderson *et al.* 2007).

The sales management approach to value visualization proposed by Anderson *et al.* (2007) and illustrated in Fig. 8.1 is a useful starting point for a further discussion about visualization strategies. However, complex, integrated PSS offerings are typically not sold on an operational level. Rather, these investment decisions are made on a strategic management level, where other forms of visualization and also different skills are necessary (compared to more basic, low-value offerings). Hence, this requires a different approach from sellers as well as buyers to product and service sales. Furthermore, in the different stages of a PSS development process there are different visualization needs, and even before entering a development process of a particular offering, companies must visualize concepts on a broad level. This broad approach is needed in order not only to build up an understanding and acceptance of new concepts and ideas internally, but also to create an external demand pull (Kindström 2009).

8.2.1 Visualization in the PSS Development Process

Using a generic offering development model based on the four stages *market sensing*, *development*, *sales*, and *delivery* that is adapted to manufacturing companies (Kindström and Kowalkowski 2009), the scope of visualization is widened to include all stages of PSS development; from sensing market opportunities to actual value creation. In this way, a process dimension is added to the research on visualization strategies.

Table 8.1 offers a brief description of the different stages and selected key aspects of these stages. Very often, not only in new product development (NPD) literature but also in new service development (NSD) literature (e.g., Scheuing and Johnson 1989), the process tends to be limited to what we view as the development stage. Although the development stage with no doubt is critical, Kindström and Kowalkowski (2009, p. 159) argue that "there is a need to make explicit also the other three stages of the development process in order to fully grasp the complexities of and prepare the organization for its new offerings."

Consequently, market sensing is regarded as a distinct stage which is critical regardless of the extent of actual, formalized development in Stage 2. It involves a thorough scanning of existing and potential customers, the installed base, competitors, the business network, etc. before explicitly addressing promising ideas in the development stage. Furthermore, the development of the offering alone is not sufficient for a successful market launch and implementation process, but also to ensure the sales and the delivery of the offering is fundamental (Edvardsson 1997). Thus, the sales and the delivery processes need to be taken into consideration in an extended PSS development framework, especially in companies with a sales force that is predominately used to selling products and not services and/or solutions (Kindström and Kowalkowski 2009).

Accordingly, compared to previous studies, the latter two stages of the framework in Table 8.1 (Kowalkowski 2008b). This requires not only a long-term orientation of the development process, but also a genuine understanding of the customers' unique usage contexts, in which the value is created (Vargo and Lusch 2008).

By combining research on visualization strategies and research around PSS development, it is possible to increase understanding in how and where in the development process companies can use value visualization strategies.

8.2.2 Value Characteristics of Integrated Offerings

When developing PSS, it is vital to understand what value potential these offerings have, what customers expect from these offerings and ultimately what value to visualize. It is possible to identify three broad categories of value:

1. Product-based values
2. Service-based values
3. Relationship-based values

Table 8.1 A four-stage process for integrated PSS offerings

Stage	Description/rationale	Key aspects
1. Market sensing	A continuous process taking place within the company and in dialogue with customers. Although the customer is in focus, sensing internal business units and the wider business network is also needed.	Balancing an internal and external focus. Local and central innovation and learning. Structuring the existing portfolio and its inherent values.
2. Development	Development requires the involvement of customers and several functions, including more cross-functional and intra-organizational elements and coordination aspects than required for product development. The local organization and its front-line employees should be involved during all steps of this stage (idea generation, concept development, pilot study, etc.).	Designing development process with customer involvement (not only blueprinting complex product development models).
3. Sales	It is essential to help customers appreciate the distinctiveness and benefits of the new PSS offering and, thus, to ensure that the front-line employees have sufficient knowledge in order to convincingly sell. Companies often emphasize the processes of designing and defining new offerings, and seldom put much effort into developing tangible actions for how to commercialize and scale up the new offering.	Developing measures and sales tools that better reflect PSS. Changing existing mindset, norms, and values.
4. Delivery	It is in the delivery stage that the difference between visualization of products and services become most evident. Services are created in an interaction with the customer during the delivery process, and are often highly localized. If integrated PSS offerings are to be delivered effectively and efficiently, an PSS delivery infrastructure needs to be in place. This infrastructure often is different from a 'pure' product delivery infrastructure with no local service organization.	Making integrated offerings visible for customers who are used to receiving products.

Traditionally, most suppliers have focused on product-based values, and therefore are good at visualizing these. Typical values derived from this focus include product performance, quality and unit price. These values used to be 'order winners' and many product-oriented companies still put a heavy emphasis on these values. However, they alone are no longer enough as differentiators.

Service-based values are more difficult to evaluate and quantify, due to intangibility, and thus harder to visualize. Since many services are regarded as add-ons that can be given away in order to close a product deal (Anderson and Narus 1995, Oliva and Kallenberg 2003) these values have traditionally been obtained by customers free-of-charge to stimulate product sales. Typical service-based values include operation costs, customization benefits and service consistency.

Finally, relationship-based values are founded in idea that that the supplier and the customer maintain a relationship over time (Grönroos 1997, Vargo and Lusch 2008). As for service-based value, relationship-based value is difficult to monetize and visualize, and is therefore often neglected when formal contracts are established. Typical values include proactivity, trust, long-term commitment and shared norms and mindsets. For integrated PSS offerings, all three categories of value are central (see Fig. 8.2).

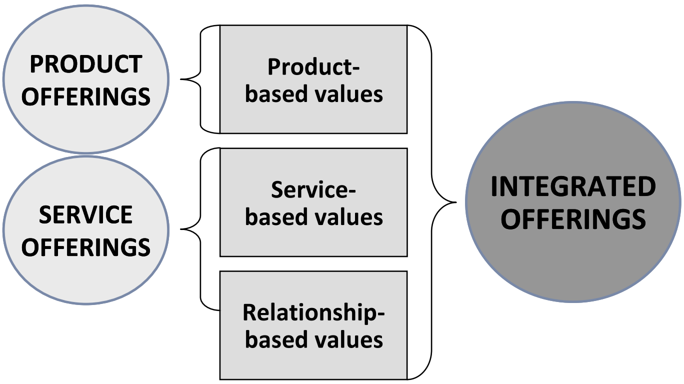

Fig. 8.2 Customer perceived value in different types of offerings

Table 8.2 summarizes the primary product-, service- and relationship-based values, the focus of visualizations in the different stages of the PSS development process and the associated key measures (Kindström 2009). Since the simplified division of the development process into the four stages does not fully capture the shifting focus of visualizations, Table 8.2 includes a more fine-grained division (where the development, sales and delivery stages are further divided into sub-stages).

Table 8.2 Internal and external value focus in the different stages

Stage	Internal value focus			External value focus			Key measures
1. Market sensing	–	–	–	–	S	R	Profitability, revenue growth, customer needs
2. Development							Profitability, revenue growth, customer needs, market growth
Concept	–	S	R	–	S	R	
Realization	P	S	–	–	–	–	
3. Sales							
Pre-sales stage	P	S	–	–	–	R	Reward systems
Pre-contractual stage				–	S	R	Long-term commitment
Negotiation and contract stage				P	S	–	Cost, price
4. Delivery							
During delivery	–	–	–	–	S	R	Trust,commitment
Post-delivery	–	–	–	–	S	R	Customer's production and business performance

Legend: P = Product-based values, S = Service-based values, R = Relationship-based values

From a value perspective, what distinguishes PSS offerings from industrial products is the emphasis and inclusion of service- and relationship-based values. This means that, in order to differentiate PSS offerings from more basic ones (i.e. products) and to be able to justify a higher price, manufacturing firms need to focus their external visualization efforts on service- and relationship-based values. Similarly, service- and/or relationship-based values are pivotal to visualize internally in Stages 2 and 3 (Stages 1 and 4 are more explicitly externally oriented) in order to balance the product-oriented culture prevailing in many firms and business units. Nevertheless, product-based values also have to be explicitly addressed during development and sales in order to succeed with the integration of the product and service elements of the PSS offering.

8.3 Solutions and Recommendations

Traditionally, value has been seen as relatively easy to communicate (as the focus was on product-based values). However, as companies are moving towards PSS, it becomes increasingly difficult to find effective ways to communicate and demonstrate value. In parallel with a move from cost-plus pricing to value-based pricing, companies must move towards value-based visualizations.

This requires a shift in focus and expectations, from basic product performance metrics to more complex measures, addressing productivity and customers' business performance. Since services are inherently intangible, except for the often tangible results and customer experiences (Lovelock and Gummesson 2004, Vargo and Lusch 2004), it becomes more difficult to produce 'product-like' fact sheets that convey the full meaning of a PSS offering before use. It is often more difficult to visualize the potential value of a service than a product, due the nature of a service (with a high interactive content) and also due to the inexperience of many buyers when evaluating services and PSS offerings (Lindberg and Nordin 2008). This implies that suppliers need to find ways to translate intangible arguments into unique selling points. Calculating cost savings, increases in revenue and the value of productivity enhancements and dynamic effectiveness are all examples of new ways to visualize the value of integrated offerings.

Different offerings require different visualizations, and also have different visualization needs, depending, for example, on the buyer's disposition and the importance of the offerings to the customer's business and production processes. A number of different factors that influence the need for visualization and the strategies employed can been identified:

- The complexity of the offering
- Whether the offering is radically new to the market or if it is an incremental change
- The importance of offering for customer's business and process
- The degree of intangibility of the offering

One way to approach the visualization of soft values is to use bundling strategies, to combine soft value elements with hard value elements (i.e. both services and products, and design PSS bundles that have both aspects and thus attract customers with a complete value bundle). This is traditionally done when offering added services, although these services are often added for free. Typically, this is especially attractive when having to address a large installed base.

An additional benefit from a bundling strategy is the possibility of leveraging the understanding of the core product (when visualizing the value of the integrated PSS offerings), for both the customer and the internal organization. Thus, a bundling strategy might decrease the need for difficult visualizations of service-based and relationship-based values. Furthermore, many companies need to use the product as leverage, despite the increased focus on services. By showing the interactions and linkages between the services and the core products in the PSS (for example in a film sequence or in a simulation), companies find it easier to find resonance with the customers (Anderson *et al.* 2007). By including various forms of tangible evidence, companies can get around the problem of having integrated PSS offerings consisting mainly of intangible elements. It is often easier for customers to understand these offerings if the supplier uses associations with tangible aspects, such as the role of the equipment. This implies that product-based, hard visualizations are more important in order to win new customers than retaining existing customers. Likewise, it implies that soft, service-based and relationship-based visualizations are central to cultivating and further developing an existing relationship (for example, through increased service provision).

From a design engineering perspective, a key aspect of value visualization of PSS becomes the design not only of the product offering but of the design of the complete system. This means that product design and development skills need to be combined with service engineering methods and tools. The starting point should be sensing and seizing opportunities for value creation (for the customer, but also for the supplier) rather than product technology per se. This resonates with Table 8.2 where the visualization focus initially should be on service-based and relationship-based values rather than product-based ones. The extended service blueprint (Shimomura and Arai 2009), with the modelling of parameters and human and physical processes, and similar tools can serve as points of departure. Thus, the design engineering task requires the ability to integrate not only the product(s) (i.e. on a component or subsystem level), but to integrate human and physical processes and bundle PSS offerings. Furthermore, it concerns various degrees of technical integration between internal organizational units and between supplier and customer (Kowalkowski and Brehmer 2008).

Evident in all the companies in this research was that the value of traditional products was relatively easy to communicate, both internally and towards customers, because the focus was on product-based, hard values. However, as companies are moving towards integrated PSS offerings, it becomes difficult to determine which value to communicate and how to demonstrate this. Having the capability to visualize the new values is regarded as central for succeeding with service infusion, and to subsequently successfully develop and sell PSS offering. Not surprisingly, this is something that all companies (to various degrees), also find challenging.

8.3.1 A Process Framework for Visualization Strategies

Evidence from the case companies show that manufacturing companies offering services and integrated PSS offerings must expand their visualizations beyond the traditional techniques used for products. Table 8.3 provides empirically grounded findings for a number of key issues related to the different stages of the offering development process. The purpose is both to show best practice methods and the focus of visualizations in the different stages, as well as to illustrate the wide variety of the visualization techniques used by the companies studied.

Table 8.3 Value visualization strategies in practice

Stage	Focus of visualization	Visualization techniques used	Key stakeholders	'Best practice' visualizations identified
1. Market sensing	External	Trade shows, community activities, top management presentations	Industry in general, top management and internal product organization	None mentioned
2. Development	Internal	Case studies, reference sites, business cases, top management promotion, "the successful example"	Top management, business area managers (with investment budgets), key customers	Simulations, virtual reality demonstrators
3. Sales	External	Case studies, reference sites/customers ("the successful example"), value calculators/demon strators (typically spreadsheets), film sequences, role play	Customer purchasing organization (higher up than operational level only)	Simulations (showing revenue, sales, costs), virtual reality demonstrators, case histories
4. Delivery	External	Reports, follow-up meetings, statistics, news letters stickers	Mainly customer operational organization	Reports, productivity statistics, comparisons, service plans/ booklets

An issue that the companies frequently encounter is the importance of getting top management support and understanding (Kowalkowski *et al.* 2009). This is not just a matter of educating top management about the need for integrated PSS offerings, but also to direct the same effort into understanding both services and products. Top management commitment results in higher demands for structured processes, deadlines and for well-developed ideas, and it communicates a sense of importance and urgency to the entire organization. Typically, top management needs hard, tangible visualizations and evidence in terms of market potential and profitability, and this can be somewhat problematic with integrated PSS offerings that have a high service content, since it can be more difficult to show in short-term effects of services than products. Middle management working with business development can often feel frustration if traditional performance metrics are not complemented with new that better reflect and, thus, better visualize the value of integrated offerings. PSS development requires a longer time horizon, and measurements such as customer equity and return on relationship need to complement return on investment and other short-term ones (Gummesson 2004, Rust *et al.*

2004). Hence, it is short-sighted to only focus on the short-term gains of single product and service sales, rather than the potential value creation of the entire PSS throughout the customer relationship lifetime.

8.3.2 Visualization Strategies and the Intangible Nature of PSS

Although physical products are, by definition, tangible, Product/Service Systems also have an intangible nature. This is not only due to the characteristics of the offering's service elements, but also because of the inherently process-oriented nature of PSS offerings (Kowalkowski 2008a). Previous research has emphasized that making services tangible deserves special attention when visualizing their value (Berry and Clark 1986, Berry and Parasuraman 1991, George and Berry 1981). In studies of service advertising, it has been found that service marketers provide more factual information, or performance cues, than are provided for products and that, as offerings become more intangible, this tendency is emphasized (Grove *et al.* 1995). However, visualization must not be limited to advertising and promotional activities (as tends to be the case in B2C marketing), but should permeate all marketing activities and support value creation for both customer and supplier (cf. Grönroos' (2007) view on marketing).

In order to understand how to visualize the value of services and integrated offerings to different actors and in different situations, companies make use of so-called 'tangibalization' strategies (Berry and Clark 1986, Hill *et al.* 2004, Mittal 1999). Four general strategies have been put forward, and these can be used to convey the value of a service offering: *envisioning* (this tangibalization strategy is termed 'visualization' by Berry and Clark), *association*, *documentation* and *physical representation*:

- *Envisioning* involves the use of vivid cues in order to persuade customers and to assist them to experience the service mentally. Such a strategy evokes a clear and vivid mental image of the positive outcomes associated with the service. Virtual reality simulations and interactive spreadsheet applications are examples of possible techniques. Narrative (such as case stories and dramatization or so-called service scripts) is another example of an envisioning technique.
- *Documentation* refers to the provision of relevant information regarding key attributes, features and benefits of the offering. There are three types of documentation:
  - consumption (the activity of customers in their consumption role)
  - systems (facts and statistics linked to the service delivery system)
  - performance documentation (reference cases and cost calculations)
- *Association* means linking an object (such as John Deere's deer, or Scania's griffin), place (such as the perception of a national company, despite foreign ownership) or a person (such as Tiger Woods and Accenture) to the offering.

- *Physical representation* is similar to *association*, but focuses on core attributes that (directly or peripherally) are part of the offering. Examples of this are buildings, vans and employees (such as service technicians) in company uniforms being helpful and knowledgeable. This also includes the design of the product (such as a robust pump) signalling durability and quality.

If these four visualization strategies are compared with the value demonstrators generally discussed in a B2B context, those B2B strategies can often be narrowed into one strategy, that of *documentation* (e.g., case histories, value equations and value calculators). As a matter-of-fact, when looking at how manufacturing companies have worked with visualization in the past, and how many companies still deal with this, a documentation strategy is what first comes to mind. Furthermore, since the interaction is more present in B2B settings of reasonable complexity, demands on visualization competence are higher on the supplier than in B2C settings where messages are more one-directional (i.e. advertising and promotion rather than two-way communication and dialogue).

Table 8.5 maps the four visualization strategies into the offering development framework. One conclusion is that it is not enough to rely on just one specific strategy. If a company is hoping to launch integrated PSS offerings managers must broaden their perspective and probably address all four visualization strategies, in order to maximize the chances of success. In particular, managers need to pay attention to the sequence of strategies, and also to whom they should apply what strategy.

It is also interesting to note that the focus shifts not only between the different stages, but also within each stage. A clear trend is, that in order to inspire customers and to get their attention, intangible visualizations are of great use, especially to convey relationship-based values early on in the different processes. However, as decisions are to be made by the customer, more tangible elements must be included, most notably documentations and/or demonstrators. To sum up, finding the right visualization strategies is not easy, but it is essential for most companies and, particularly so, for companies aiming at increasing the service content in their integrated PSS offerings.

8.4 The Visualization Process: Examples in Industries

The visualization strategy framework is based on in-depth studies between 2004–2009 (Kindström 2009, Kowalkowski 2008a) of business development at eight international, market-leading manufacturers. During this period, each of these were (to various degrees), undertaking a strategic shift from product sellers towards service and solution providers (see Table 8.4).

Table 8.4 Manufacturing firms included in the study

Manufacturing firm name	Industry	PSS offerings
Aleph	Garden and forestry equipment	Extensive service and support contracts with uptime guarantee
Beth	Fluid handling	Customized service level agreements, systems engineering and rental
Gimel	Mining equipment	Life-cycle services, capacity-related and gain-sharing agreements
Daleth	Gas supply	Automatic gas supply, liquid management, process management services and solutions
Zayin	Welding and cutting	Systems selling, customized welding solutions, process and application support
Yodh	Material handling	A wide array of rental plans, fleet management and specific full service agreements
Lamadh	Aviation	Systems engineering agreements, customized technical sytems and aircraft availability
Semekh	Buses and bus chassis	Vehicle and transportation management, extended coverage contracts, uptime contracts

The transition from products to integrated offerings with an increased service content has major implications for the traditional product development processes. It implies that business, market and customer aspects need to be taken into account to a much higher degree early in the process. That is, as service development projects take a more central role, emphasis shifts from technology push to demand pull. Whereas the traditional product development process is rather heavy at the back (a lot of time and resources are spent on the technical core in R&D projects), successful service development projects need to be heavy at the front (Kindström and Kowalkowski 2009). This means that the rollout of services as well as integrated PSS offerings may require more time and resources than the traditionally resource-heavy development stage. This can be further emphasized by the example of business development managers at an industry workshop, as illustrated in Fig. 8.3. Although somewhat simplified, Fig. 8.3 shows the relative focus on the different stages in the development process. Hence, even if the toll gates between the formalized stages are the same, the amount of resources (such as money, competencies or time) spent in the different stages of the development process will depend on the service content of the integrated PSS offering. In order to address the communication and demonstration of value throughout the development process, the four-stage development framework in Table 8.5 will be used, as this is a way to approach and structure the visualization concept and demonstrate it with industry examples. By doing this, it is possible to better understand what visualization strategies to use, who is involved in utilizing them, and to whom they should be directed.

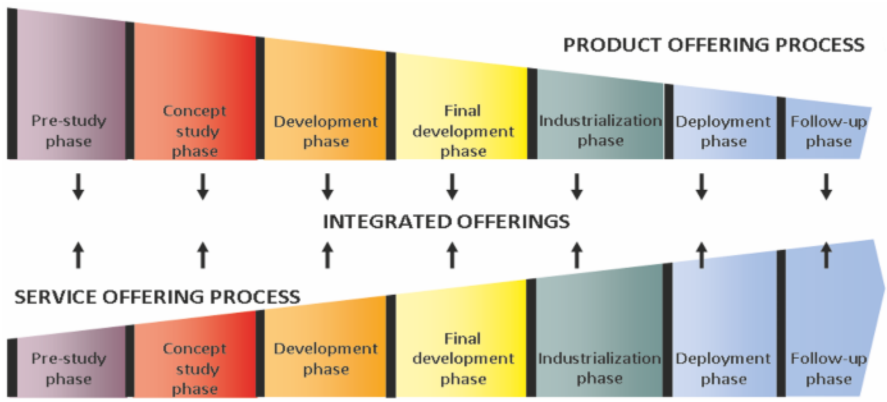

Fig. 8.3 The changing focus in offering development processes: an industry example

8.4.1 The Market Sensing Stage

The visualizations at the market sensing stage take place at a very general level, as this stage occurs before the PSS offering enters any specific development process. This stage should not be regarded as a one-way, outside-in sensing of customers and the external environment alone, but should also encompass a broader view of communication and dialogue with both external and internal stakeholders. Rather than focusing on any specific PSS, visualization in this stage is related to the overall marketing and service strategies of the company. In a way, the market sensing stage is also about shaping the environment, not only reactively adapting to it (Normann 2001, Teece 2007).

Senior management formulates market strategies and targets, including whether or not to reposition the firm in the marketplace through integrated PSS offerings. This also includes market communication, such as the CEO's statement towards employees or stakeholders. The president of Beth, for example, has articulated the transition into services in the corporate magazine by stating that customers need total solutions and that both customers and suppliers stand to benefit from "servitisation" (Kowalkowski 2008a). In other companies, which have a larger share of PSS offerings and sales, senior management have made similar statements, both internally and externally. The senior management for Yodh, for example, argued that "we are today essentially a service organization; it is the total service offering that is the key thing." In many markets, more than 50% of Yodh's new products are sold through rental plans (i.e. integrated PSS offerings), something which requires a different business and revenue model, and more extensive visualization strategies.

8.4.2 The Development Stage

Initially, the development stage revolves around internal visualization, in an attempt to find internal support for new forms of offerings. This focus is primarily based on the fact that most companies operate in a rather product-oriented culture where services and PSS solutions can be difficult to gather support for. However, different biases are obtained depending on maturity in developing and delivering services and whether or not services are an integral part of the PSS offerings:

> To be able to take advantage of the opportunity of selling integrated offerings, we have to start internally to show our sales personnel that also services are important and a good thing. Business development manager, Zayin

Companies that already have a portfolio including services which they are developing incrementally, tend to start with internal visualizations in order to expand service-related sales and to convince sales staff to focus on services. On the other hand, companies that go from a product-dominated offering portfolio and develop more radically new PSS offerings tend to focus the visualizations towards external actors in order to create a market pull that can be used internally to get the necessary support needed.

> You cannot break through internally, but will get to a certain level and then hit a wall if you cannot show on customer interest and pull. Without this interest it is difficult. Business development manager, Lamadh

Since the companies are often relatively new to PSS, there is frequently a need to visualize how the actual process works. Gimel, for example, employs an advertising agency to identify and communicate how the actual service development and innovation process works. It is no longer possible just to use slides and spreadsheet applications for this.

The emphasis on product development means that when visualizing values, in most cases, companies will employ similar methods and techniques for services and products. Many companies emphasize the need to begin with internal visualizations, in order to obtain support and reach investment decisions. These visualizations are often based on previously defined templates, developed for products but used for both products and services. The use of templates minimizes the personal traits of the presenter and is supposed to provide a more objective summary, and they discuss basic aspects of development, such as the "business idea" and the value to be delivered to the customer. Unfortunately, this documentation strategy is used as decision support for business management, but does not typically involve an understanding of market potential and direct customer input, and this is something that can create difficulty in later stages. They way in which customer value is presented is often not specified in these templates, and this is an important omission, as it is essential for the successful development of PSS offerings that customer values and associated visualizations resonate with the values of the brand.

Table 8.5 Mapping the visualization strategies into the development framework.

Stage	Visualization strategies				Typical managerial activities	Typical outcomes	Key actors
1. Market sensing	–	–	A	P	Addressing larger scale change efforts instead of specific. Creating a champion. Building a brand.	An increased level of service understanding internally and externally. Loading brand and company with service values.	Senior management, marketing organization
2. Development						Internal understanding	
Concept	E	–	A	–	Communicating the idea.	A description of how the offering works	NPD and R&D units, NSD units
Realization	–	D	–	–	Providing market, revenue, and customer data (a business case) as well as internal demands (such as infrastructure)	Decision support for investment	Business development, business intelligence
3. Sales							
Pre-sales stage	E	D	A	–	Finding emotional levers and communicating a feeling. Producing reference cases.	Arouse customer interest; make them believe in the concept.	Marketing organization, ICT specialists
Pre-contractual stage	E	D	–	P	Producing facts, figures, calculations and measures.	Give the customer decision support for an investment.	Sales managers, sales staff, service managers
Negotiation and contract stage	–	D	–	–	Agreeing on contract details.	Measurements and evaluation procedures.	Sales managers, key account/ project managers
4. Delivery							
During delivery	–	D	A	P	Customer-facing personnel must be relationship oriented	Customer feels secure and trusts the supplier – peace of mind.	Technicians, engineering and/or application specialists
Post-delivery	–	D	A	P	Designing interaction/touchpoints and evidence of presence	Service reports, measurement evaluations (such as performance)	Key account/ service managers

Legend: E = Envisioning, D = Documentation, A = Association, P = Physical representation

There are, nevertheless, examples of companies successfully developing and launching offerings that employ a different approach with less a less rigid process and less reliance on formal documentation. In these cases, business developers have greater freedom of input into their own projects, over a longer time period. Furthermore, these individuals (because it is often an individual effort based on a personal conviction) usually work closely with a select few "lead user" customers in their development efforts. Generally, once a project needs a budget, a more traditional approach is needed, including a business case and cost calculations.

Distinguishing between a prototype (or a test installation) and a full launch (scaling up) is another aspect of visualization at the development stage. For many companies, it is relatively easy to get approval and funding for a test drive or a prototype, when this is aimed at a well-known customer (one the company has an established relationship with). However, obtaining approval and resources for a full launch is much more difficult, and requires strong visualizations, often based on hard facts such as market potential and revenue. The challenge here is often to get the visualization across with the softer issues. However, as pointed out by many companies, and also in research (Magretta 2002), it is a matter of being able to combine both hard and soft facts. Common visualizations include quotes and active promotion from top management. Another visualization involves the 'successful example', where a customer uses the PSS offering of another company (a competitor or a firm from another industry), or another company succeeds with similar service offerings. A more novel approach uses storytelling, developing stories around the offering in order to increase understanding and achieve a commitment.

Daleth uses stories internally, mostly stories depicting what can happen if the product or service does not work. For Daleth, this is a simple way to visualize, in words, an offering. They also use drawings (comic strips, for example) to show a sequence of activities, in order to create a sense of recognition. People then reach an understanding without crunching numbers. The company has used this approach to explain roles in reference to new offerings—it visualizes how things work for employees. Where many roles are involved, one can visualize the work of other people, and through this get the complete picture. Daleth only uses this internally to obtain support for new offerings.

8.4.3 The Sales Stage

The sales stage can be divided into the pre-sales and pre-contractual phase, and the actual contract negotiation phase. Visualization in the pre-contractual stage is rather traditional, in that the companies use documentation strategies, such as cases and reference customers, projects, sites, and tests, to communicate the value of their PSS offerings to a customer. Basic value word equations can enable the supplier to illustrate the difference in value between the best offerings of the supplier and their main competitor (Anderson *et al.* 2007). For example, the value of a new cost-efficient pump solution for sewage plant customers could be illustrated as follows:

Total energy savings = (Energy used [kW] × annual run time [h] × Cost per kWh ×number of years solution in operation)$_{\text{Competitor offering}}$ − (Energy used [kW] ×annual run time [h] ×cost per kWh ×number of years solution in operation)$_{\text{Supplier offering}}$

With service offerings and agreements including a wider array of parameters, the equations can become very complex, but the basic idea remains the same: quantifying and visualizing the value of the offering relative to the competitors. Value calculators (such as spreadsheet applications) can also be used internally to facilitate the decision making (for example, deciding whether to repair or replace broken equipment at customer sites, something that traditionally has been done in a more ad hoc way and by rules of thumb, rather than systematically and with the data needed available). Pilot cases are often used to gather information and create tangible evidence (such as folders and online applications) to show how the offering works.

Gimel works on visualization of their new offerings and service for trade shows, in order to increase understanding in general. However, managers have experienced that they need something to show something tangible in order to create a dialogue or to build up interest. Without hardware it is difficult to do this.

In the negotiation phase, visualizations become more factual. Whereas earlier in the sales stage the relationship dimension and values (such as trust and commitment) are emphasized, hard facts become more important towards the end of the sales stage. These usually include product-based values, costs, penalties and other legal issues. However, as integrated PSS offerings become more complex, the factual dimension, exemplified by the inclusion of a legal department, is put into focus earlier in the process, even as early as in the development phase. This necessitates suppliers finding ways to monetize the soft values inherent in their offerings. In general, the contract negotiation process becomes more important for more complex offerings. One consequence of this is that the supplier and the customer need to agree on measures that decide the success of an offering, such as how to measure productivity and uptime in availability contracts.

Aleph has a number of highly complex spreadsheet applications that are used to show the value-creating potential of their new integrated offerings, identifying reduced total costs and increased total revenue. However, these spreadsheets are often too sophisticated to use, and therefore Aleph has also developed stripped down versions, illustrating key points (such as customer profitability) in diagrams and graphs, which are often interactive. Gimel works with key indicators: numbers that influence the price (such as energy consumption, wear and tear material, capital and output), but they also try to include some less tangible aspects, such as trust.

More complex visualizations include case studies from major reference customers and scenarios. Scenario discussions are becoming more and more interesting, particularly since computers and virtual simulations are accessible for almost all industries, allowing advanced visualizations, even for softer aspects of the offering (such as service interactions).

During the sales stage, the prevailing focus is often on product. A consequence of this is that sales pitch will often focus on technical matters related to the products. When selling more complex, integrated offerings with higher service content, this is not enough. Instead, the focus must be on customer value and processes. Sales personnel have a tendency to 'teach' the customer the technology, whereas with more complex offerings, the buying decision is often made higher up. Thus, the initial focus must be on business issues; technical issues come afterward. The sales person is obviously an important actor when selling integrated offerings. Generally, sales persons that are proficient in selling services and solutions are also good at building relationships on several levels in the buyer's organization, at information exchange and understanding the customer's reality (e.g., when an investment decision is on the horizon), and at finding connections to customer perceived values in existing solutions. A competent PSS sales force is also competent in finding unique selling points and a selling focus that resonates with the customer (Anderson *et al.* 2007). Finally, they have to have the ability to listen and sense customer's expressed and latent needs.

> You add many more layers to the sales person when approaching services. For example, completely new contact persons, instead of purely operative personnel they need to approach e.g., financial staff. You add more knowledge, create new forums for interaction and new rooms for discussion and sales. Not everyone is comfortable or proficient in this new role. Business developer, Semekh

Evidently, training the sales force becomes important. However, not every product sales person is suitable for selling solutions (Krishnamurthy *et al.* 2003) and they will therefore not be able to visualize the new values. This means that new competences must be added. Therefore, a gradual change of skills, processes and personnel takes place.

8.4.4 The Delivery Stage

Transition from the sales stage to the delivery stage is the part of the process where many companies are the least thorough and systematic. The handover from sales to delivery is critical, yet it is in many cases not working well. Once the PSS offering is sold, little effort is put on visualizing the value delivered. A company that has recognized the importance of visualization in the delivery stage is Daleth, which has developed a "Photo Service" concept to use internally as part of the training material for technicians.

However, the entire service and support organization must understand what it is that has been sold, and must be aware of the expectations of the customer. A close coordination between sales and delivery is often pivotal to ensure a successful delivery of the complete PSS offering. This becomes even more important when dealing with long-term contracts, as these include relationship dimensions and mutual development (that is, not only static, but also flexible and dynamic business development).

Similarly, the customer must be aware of what it is they have purchased. If, for example, this is a fixed price contract specifying availability, that at the same time specifies certain activities that the customer must perform, all parties have to be on the same page. Here it is crucial to agree on the evaluation criteria and create a mutual image of what the offering constitutes, that is, to establish the shared foundations for visualization. Obviously, this becomes more difficult as the complexity of the PSS offering increases.

A perennial problem with delivering services as part of a PSS offering is to show that a good job has been done, since many services are difficult to notice unless something is not working. For example, uninterrupted people flow systems in high-rise buildings and continuous supply of gas to the process industry are two critical processes that are particularly evident, and therefore tangible, when the system is not operating. Suppliers need to visualize the value delivered so the customers understand what it is they received. Similarly, it is important to reinforce the customers buying decision during the delivery phase and also afterwards, to instill a sense that they made the right decision. This is an important aspect of offerings with a high degree of intangible benefits such as trust.

Traditionally, most companies do not address this stage during their visualization discussions. At the same time, during this phase there are many opportunities to reinforce the relationship and visualize intangible relationship-based values, in order to increase the likelihood of customer retention through renegotiation or new sales. Reports, stickers, regular meetings (with customer representatives), and ICT solutions (which provide real-time data) are some of the techniques used to achieve this reinforcement. Daleth offers continuous and trouble-free supply of gas, and uses stickers (that the technicians put up at the customer's site) to illustrate their presence and the value delivered. Aleph uses reports sent regularly to show actions taken and to provide added value during the delivery phase. Similarly, they use a web-based system to reinforce relationship values through real-time information on operations and processes. In a sense, this means closing in on basic process-consulting activities.

The visualization of intangible values during the delivery stage is a critical, yet often neglected, activity. For companies with long product life-cycles and long-term contracts, the ability to visualize values in the context of customer use is particularly vital.

8.4.5 Future Trends

With Product/Service Systems becoming technologically more complex, the ability to not only visualize externally towards customers and key stakeholders, but also internal visualization becomes more critical. Therefore, a promising avenue for future research, in collaboration with industry, is to develop value visualization techniques and strategies for the development and management of large technical systems (Hobday *et al.* 2005). The catastrophic opening of London Heathrow Airport's brand new Terminal 5 in early 2008, and the many failures of ICT implementation across industries, indicate the importance of clear internal visualization for complex systems. As more software is integrated into new PSS offerings, reliability becomes increasingly important (Nightingale *et al.* 2003), which further suggests the need to be able to visualize value in an uncomplicated manner. Furthermore, collaborative projects with marketing scholars, manufacturing firms and organizations for applied research (such as Fraunhofer-Gesellschaft in Germany) possess major potential for visualization innovations, and can therefore increase the potential for manufacturers to remain competitive.

Finally, visualization seems to have become a key capability for winning new PSS contracts as well as retaining existing customers. Therefore, it is a strategic resource that managers need to pay attention to and continuously develop in order to successfully compete with integrated offerings (Kindström 2009). Future studies should analyze not only ways to visualize the value of specific integrated offerings, but also ways to visualize the firm's dynamic capabilities, such as systems integration competence.

8.4.6 Conclusions

This chapter contributes a number of insights managers need to be aware of. Firstly, if moving towards PSS offerings with a high service content, companies cannot merely extrapolate the traditional visualization strategies used for product based offerings. Furthermore, managers not only need to formulate new visualization strategies, but they must also understand the new underlying values, notably the relationship oriented and outcome based aspects that build up the customer perceived value of the new PSS offerings.

Secondly, suppliers must adapt to the fact that most customers are still very much within a product-oriented domain, and must not venture too far in their visualizations. Otherwise, they run the risk of alienating customers instead of enticing them. While important internally, this awareness is more pronounced towards external customers.

Thirdly, by taking the entire offering development process as the starting point, it becomes clear that several visualization strategies are necessary and also that the focus of visualization changes throughout the process. An implication of this is that it is not enough to rely on just one specific visualization strategy for successful PSS development and sales, but rather, companies must address several strategies in order to maximize the chances of success. Particularly, managers need to pay attention to the sequence of visualization strategies and also for whom (i.e. what actors) they should use what strategy. It is also interesting to note that the focus shifts not only between the different stages but also within each stage.

A trend seen in the industries studied is that using value visualization as a strategy to communicate intangible benefits and create mental models (in the mind of the customer) is of great use, especially to convey relationship-based values early on in the different stages. Value visualization clearly helps to get the attention of customers, and to inspire them. However, since many buyers focus on low-priced offerings and product-based values (Anderson *et al.* 2000), tangible elements need to be included also, most notably hard facts and value demonstrators. In this way, visualization strategies should influence the development of products as well as services and integrated systems.

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Part III Provider Dimension

Chapter 9

Using Company–Academia Networks for Improving Product/Service Systems at Large Companies

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Abstract Many manufacturers are shifting focus for different reasons from being providers of mainly physical products to providing increased services in their customer offerings. Traditionally, the focus of manufacturing companies has been more on product development than service development; this is one reason why it is important for Product/Service Systems (PSS) developers to meet others who understand this situation. This chapter describes challenges large PSS providers in Sweden are facing, and how these can be explored and discussed within a PSS company–academia network setting. It is concluded that during the three first years of network meetings, this approach has been a success. In addition, the experiences gained from participation in this network have resulted in recommendations for PSS providers and researchers thinking of starting up similar networks and/or building ones has already begun.

Keywords Knowledge Transfer, Learning Network, Integrated Product Service Engineering (IPSE), Product/Service Systems

9.1 Industrial Needs

Manufacturers are continuously looking for new ways to increase their competitiveness and business "bottom line." Among many of these manufacturers there is a trend towards service infusion, i.e. increasingly providing customers services rather than only selling physical products as with the traditional model. There are several potential benefits for companies following this trend now known as "servicising". Most of these drivers are market driven, e.g., to achieve a closer relation to customers, to increase control over products during use, to secure the aftermarket, or to achieve a more economic and environmental sustainability. In an international survey conducted among manufacturers in Germany, Italy, Japan and Sweden, it was found that the most important drivers for Product/Service Systems (PSS) providers were *customer connection*, *customer demand* and *increased competition* (Lindahl *et al.* 2009).

Although the idea of Product/Service Systems (PSS) is also known in the literature as *functional economy*, *product service combinations*, *product-to-service*, *servicizing*, *Integrated Product/Service Offering (IPSO*) and *Industrial Product/Service Systems (IPS*^{2}), the authors mean the same thing (Lifset 2000). With PSS, focus is shifted from the traditional sale of goods to the function that the customer wants to achieve. Today, more people are working within the service sector than ever before. In addition, more value is being added to products through technological improvements and also with immaterial aspects, such as intellectual property, product image and brand names, aesthetic design and styling. These aspects help producers to differentiate and diversify their products to better respond to customer's demands. This means a change from mass production to mass customisation (Mont 2000), which could be achieved through the PSS business approach (Sakao *et al.* 2007). The PSS-providing company may satisfy customer needs by providing hardware in the form of physical products. This generally means that the physical product that performs the service is owned by the PSS-providing company, and not by the customer. By doing this, customers only pay for the actual function that the physical product provides. However, when PSS providers are questioned, most answer that ownership is still transferred to the customers (Lindahl *et al.* 2009). The absence of ownership transfer would also facilitate implementation of new, more advanced and resource-efficient technology, which in turn can reduce the environmental impact (Agri *et al.* 1999). Kimura (1997) states that it is obvious that the concept of PSS based on remanufacturing (inverse manufacturing) will be a definite solution for our environmental problems caused by manufacturing, which is in line with Sundin *et al.* (2000). PSS could in some cases, depending on the solution for fulfillling customer needs, be a way of moving towards a more sustainable society, but this is not always the case. Some goods do not change in design, when they are intended for leasing (Lifset 2000) and/or when being a part of a PSS (Lindahl *et al.* 2009).

In order to move towards service providing rather than product selling, there are a number of changes for manufacturers to overcome, as further described in the next section.

9.2 Experiences from a Network of Large PSS Providers

Having a forum for learning and reflection is very supportive for actors that have the challenging task of developing PSS and guiding their own company, as well as customers and suppliers, in the service infusion process. The task is very complex and often new for many companies. Since fall 2007, the authors of this chapter, together with other Swedish research colleagues, have run a network of PSS providers from large manufacturers in Sweden in order to support them in dealing with this issue. The participants from the providers are, for example, after-sales managers and business developers. In addition, the providers all have a strong ambition to develop their service development and introduce new PSS offerings. In addition, the team of participating researchers represents a multi-disciplinary expertise, covering areas such as eco-design, product take-back, marketing, economics, and development of services and products; however, they all had mutual interest in the development of products and services.

9.2.1 The Aim of the Network

A crucial aim for the PSS providers was to obtain knowledge transfer between one another; this could, for example, include discovering how PSS challenges such as the ones described in Sect. 9.2.3 have been tackled by other companies. Furthermore, the challenges could be discussed among the participants, and solutions could be found which would make the companies more competitive in their respective markets. The network would be a meeting place for learning, with reflection and knowledge transfer, and a place where new knowledge could be developed. While the companies provided company-specific data, the researchers contributed with a general view of problem solving, knowledge built in academia on the specific issues, and by putting the companies' challenges and reflections into the perspective of the general knowledge built by researchers. Besides knowledge transfer, the network works as an arena for developing research ideas and developments for new PSS offerings.

To summarize, the aim of the network is to exchange experiences among the participating providers within the development of PSS offerings which, among other things:

- Identify challenges and discuss how to handle the challenges
- Avoid pitfalls and drawbacks
- Use potentials and advantages

The goal of the network was to transfer knowledge among the providers, and with generic knowledge from the researchers, achieve increased competitiveness through well-developed offerings.

9.2.2 Why Have Networks for Learning for PSS?

There are different approaches that PSS providers can choose to meet the challenges that providers face when developing PSS. One would be to solve the challenges themselves or within the company group. In our research in Sweden, we have found that one very fruitful manner of tackling these challenges is to start up a network of manufacturers that deal with these same kinds of challenges, but within different industry sectors. To participate in a network, companies and researchers should have similar roles in their organizations and face the same kinds of challenges in order to highly stimulate learning and reflection.

Representatives from larger PSS providers in Sweden have asked for a forum where they could meet with other companies in order to learn from one another, and to build up a network of colleagues since they do not have this within their own organizations. They have further argued for the need for a long-term learning environment that is more far-reaching and company-directed than traditional one- or two-day seminars. Based on the researchers' earlier discussions with company representatives, they have stated that the seminars with speakers were seldom enough. Those types of seminars provide little support and inspiration for the company representatives, since the speeches are often too "speaker-oriented" and general in character, e.g., not really based on the actual needs of the companies.

There are a number of driving forces for creating a network of PSS providers:

- Since PSS business logic is often a new phenomenon within their companies, the number of colleagues is often limited.
- Since the PSS concept is often new, PSS providers also lack experience with developing PSS; i.e., many providers are in the beginning of building up their PSS capacity.
- The PSS business approach is often treated as an "odd duck" by the traditional parts of the organization. One reason for this is that the concept is new and differs from the traditional focus, upon which the company's structure is often built.
- An important aspect for a company when moving into the PSS area is to focus on internally marketing the new concepts and creating a mindset of how to perform business within the organization. This is an issue that the members of the network can support one another in.

- The transition is ongoing in several branches, and the actors face very similar problems. There is great potential for finding relevant speaking partners in non-competitive companies in different branches, leading to valuable insights.
- Many PSS providers are often focused on the day-to-day work at their companies, and simply lack time for the reflection that this type of PSS network would give them.

For the researchers, the aim in this case, besides supporting the companies, is also to learn more about PSS in companies and better understand the processes within the companies. This is an opportunity with great potential, but must be handled carefully and in discussion with the participating PSS providers.

Knowledge transfer is made to the researchers who can reflect on research issues that are important to learn more about; this will, in the long run, also benefit the companies. Research projects can also be set up together with companies in the learning network. This also provides valuable input for ongoing research, since the network meetings also provide empirical data and highlight the latest issues for the researchers. The network meetings have been thoroughly documented by the researchers; for example, notes have been taken and the meetings were sometimes recorded. The notes were then sent out to the workshop participants. This has enabled feedback to the companies regarding the meeting's discussions, as when, for example, describing the challenges that the companies face, to be described in the next section.

9.2.3 Challenges for Network Members

The kinds of challenges that we have recognized within this network of large PSS providers are described below.

9.2.3.1 How Should PSS Development Be Organized?

In many of the PSS providers we studied, the development of products and services has been separated by tradition. This means that one part of the company has worked with product development, while another part has developed the services. Given this, the challenge for PSS providers is to achieve efficient integrated development of the products and services that are to be included in their PSS.

PSS development teams should, to a larger extent, consist of those in multidisciplinary functions than found in, e.g., traditional product and/or service development. Also, the life-cycle perspective gives opportunities that the PSS-providing companies should properly manage, e.g., adapting product/service design for this purpose. This means, for example, finding new ways for retrieving information about the PSS from the use and end-of-life phases. Some examples of product design adaptations of products are illustrated in Chapter 3.

In the development phase, there is also a challenge regarding uncertainty, and some providers recognize the importance of addressing uncertainty during the entire process of PSS development. Another dimension of divisions should be considered in addition to being able to obtain a more optimal manner of PSS development, especially in the case of large companies.

9.2.3.2 How Should PSS Be Marketed?

Among PSS-providing manufacturers we have found that there is a challenge to market their PSS offerings well, both internally within the company group but also to their dealers, customers and/or users. Both providers and their customers find that the PSS business logic is different than the product selling-based logic that they are used to. Customers have problems validating PSS offerings, e.g., since many PSS offerings also cover the use and end-of-life phases in the product life-cycle and the costs that are generated there. This kind of new logic needs a life-cycle, cost-thinking approach from both manufacturer and customer to really understand the business logic.

Internally, within the company or the company group, bonus systems and other measurement options can exist that work well for traditional business logic, but not for PSS business logic. This requires attention for change in order to better facilitate the PSS business logic approach. Marketing towards dealers, customers and/or users, some PSS providers have successfully managed to market their PSS offerings with a life-cycle cost prediction (Sundin *et al.* 2009a). Using the kind of marketing shown in Fig. 10.1 below can be a way of marketing PSS and changing the mindset of the customers' way of thinking about PSS.

9.2.3.3 How Should the Price Be Set?

Setting the price of the PSS offerings is sometimes a big challenge for the providers. It is important that both the provider and the customer get the feeling of making a good deal. For some companies, services were given away for free as good will that within the PSS logic need to be paid for. The price of the PSS needs to be balanced with how much the customer values the PSS created at the customer. These issues have also been previously researched by Rosvall and Rosvall (2001).

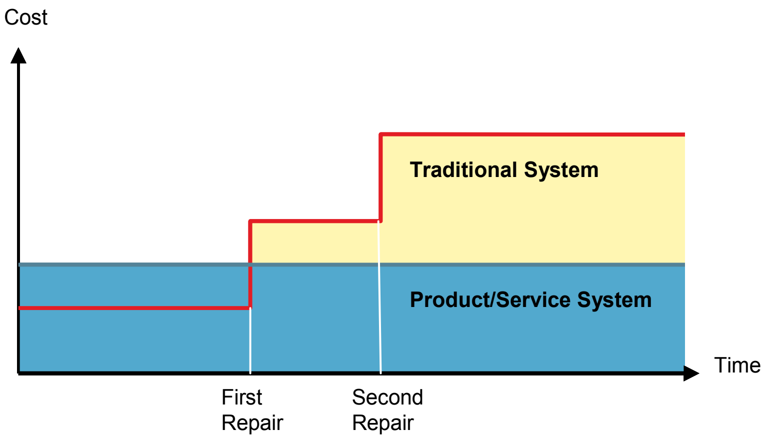

Fig. 9.1 Cost prognosis for a customer using a PSS vs. traditional product buying (modified from Sundin *et al.* (2009a))

9.2.3.4 How Can New Technology Be Used?

PSS providers also try to find out how to use new technology that supports the PSS business logic. Current rapid technology development allows manufacturers to insert intelligent parts in their products that can be used in their PSS. For example, this could include usage logs and smart sensors that with some intelligence can alert the PSS provider when a malfunction is about to occur. Furthermore, this information from the usage phase could be used in the development of new PSS offerings in order to make them perform better during use.

An example of this new technology is the GSM network for data information of product usage. This data could be used for pricing the PSS and knowing when to perform maintenance on the physical products used in the PSS. In addition, RFID technology could be used for similar purposes and to achieve necessary knowledge of how to treat the products during their life-cycle.

9.2.3.5 How Can Potential Environmental Benefits Be Captured

In order to retrieve the potential environmental benefits that were stated in the introduction, PSS providers need to dig deeper into what environmental challenges they could meet with the PSS they are providing from a life-cycle perspective. One aspect that has to be met is how to get the PSS providers, dealers, customers, and/or users interested in the environmental potential of PSS, and include those aspects to fully reach the environmental potential.

At least one member of the large company network is realizing the potential of having the same physical product used several times in several PSS offerings before being scrapped. By doing so, more function is used by the same kind of product as in traditional sales. Also, the environmental impact is lowered from the perspective of natural resource efficiency.

9.2.4 Workshops Conducted

Since the network kick-off meeting held at Linköping University, we have had four network meetings in a workshop setting as detailed in Table 9.1.

During these workshops, the participants presented and discussed PSS themes decided by the network members. The themes were chosen from industrial needs and challenges that the members have experienced. Other more detailed topics that have been discussed are:

- Organizing PSS development
- Too few working with service development
- Changing the mindset of sales force and retailers
- Changing the mindset of customers/end-users
- Selling PSS offerings
- Price setting strategies
- Developing new aftermarket services

Table 9.1 Workshops held within the network displaying date, theme and number of participants from PSS providers (Comp.) and researchers (Univ.)

No.	Time	Theme	Participants:	
			Comp.	Univ.
WS-0	Nov-07	Start of network (kick-off meeting)	12	6
WS-1	Apr-08	Bundling & Pricing, Innovation & Value creation	8	4
WS-2	Oct-08	Organizing the development, sales & delivery	7	5
WS-3	Mar-09	Research presentations from the network	14	6
WS-4	Oct-09	To be decided by the organisers	N/A	N/A
WS-5	Apr-10	To be decided by the organisers	N/A	N/A

Thus far, the company and research participants have been satisfied with the network meetings that have taken place twice a year at one of the participating provider’s companies or at a university. The number of participants has increased, and there have been some changes in the list of participants, although the core is still the same. Fig. 10.2 shows a photo from the kick-off meeting held at Linköping University.

Fig. 9.2 Photo taken at the kick-off (WS0) held at Linköping University in November 2007

More information about this network can be found in Sundin *et al.* (2009b). Running these workshops and learning network for large PSS providers in Sweden has generated experiences on the topic which will be further described in next Sect..

9.3 Recommendations for Learning in PSS Networks

A network of actors from companies, or a network of actors from companies and academic representatives, can be a strong source of support, inspiration and new knowledge for the participants in their work to develop PSS in their own companies. The participants in the PSS learning network can get good discussion partners, and the time for reflection is often very appreciated by the network members. We highly encourage other companies and actors within academia to set-up their own networks for learning. Based on the experiences of the network of large PSS providers in Sweden, we would like to give the following recommendations to participating companies (PSS providers) and network meeting facilitators.

9.3.1 Recommendations for Participating PSS Providers

Participating PSS providers at network meetings should consider the following recommendations:

- Joining a company network, giving time for reflection and the possibility of discussing common challenges and problems with people in similar situations in their companies.
- Network meetings and workshops, allowing you as a provider to dig deeper into a specific PSS topic.
- Preferably, there should be at least two participants from each company; the reason is to ensure a discussion partner in your own organisation that experiences the same reflections and learning, which in turn makes it easier for you to continue the dialog and the discussions within your own organisation. This is more effective when wanting to realise, apply or further develop the new knowledge in-house.
- Try to understand the other participants' advantages and drawbacks found in their PSS development in order to improve your own company's PSS business.
- Allow yourself to trust the members in the company network in order to achieve fruitful discussions. The more you share—the more you get back!
- Use the contacts from the network between the meetings as discussion partners for any specific issue that you need support for.
- Prepare your presentations and/or discussion points well before the network meetings/workshops to get as much as possible out of the sessions.

9.3.2 Recommendations for Participating Researchers

When organising the network meeting and workshops for the large PSS providers, there are several things to be aware of. For example, since some of the companies provide different types of PSS offerings, they would like to be divided into groups of companies with similar situations in order to get as much as possible out of the meetings. To be able to benchmark with companies having the same kind of PSS made the participants in the presented network eager to invite new companies. This is important in order to facilitate one's own need to discuss specific challenges and obstacles within PSS.

Examples of such a group are companies that focus on *after-sales-related services***,** such as companies with capital-intensive products with long lifetimes. Another group is companies that have more *knowledge-intensive services* such as advice and supporting customers with training and business advice, or companies that use services for selling products. A third group of companies could be those in *a crisis situation*, which are forced into changing their business logic for serving the market.

For researchers, the network meetings also provide empirical examples and new insights into understanding PSS development in companies. Of course, using information from a research perspective has to be agreed upon within the companies, and treated carefully and with respect. It can, for example, provide insights into new research areas, or generate the possibility of new research projects.

Some more generic recommendations to the facilitators/researchers that are organising these network meetings and workshops are:

- Have themes for each meeting, and have the participants prepare a presentation to especially address issues and to be able to contribute into discussions. Having a small task to prepare also supports the participants' reflection on the issue in their own organisation. Preferably, the themes are decided on by the participants, and presentations and workshops are held around that theme.
- Try to have an expert on the theme present at the meetings, or prepare input from research that could support the discussion and provide feedback to the companies.
- Organise the workshops so that time is given for reflection and for the participants to give one another input on how different challenges could be met.
- Allow an appropriate number of participants that will foster creativity in each workshop. If necessary, split the group into smaller groups in order to improve the discussion climate.
- Create trust and openness between the participants. For example, it is important to discuss non-disclosure agreements or some kind of "gentlemen's agreement" in order to achieve an open discussion climate. The more the participants share —the more they get out of it. Having meetings from lunch-to-lunch gives the participants a chance to get to know each other better, and holding meetings at the companies' facilities also increases their understanding of one another's businesses better.
- Have an open discussion on which companies to invite. Be aware if there are any participants that are working for PSS providers that could be competitors and/or customers, as this will affect the openness of the discussions.
- Create a sound financing structure in order to effectively plan the network meetings and workshops including time, travel, accommodation and preparation.

9.4 Conclusions and Outlook

Within this chapter, we have explored the benefits of using company–academia networks considering PSS issues. Our experiences from the network of large PSS providers in Sweden have shown that this is a beneficial manner of tackling PSS challenges for the PSS providers, as well as being beneficial for the participating researchers. We will continue to perform these kinds of network meeting and workshops within the network in Sweden at the same time that we recommend other PSS providers and researchers in other countries to do the same.

9.5 Acknowledgments

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Chapter 10

Service-Oriented Strategies for Manufacturing Firms

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Abstract This chapter establishes PSS (Product/Service-Systems) approaches in the context of manufacturing firms and their existing product-oriented business. PSS can be seen as a strategy for manufacturing firms to gain competitive advantage in the market, but what market conditions and organisational factors (e.g., structure, processes, capabilities, measurement and reward systems, people and competencies and culture) support service orientation? The development of PSS is not just a task of initiating a service-oriented development project, but requires careful coordination with business units, customers and partners in business planning and strategy to reap the full benefits. Finally, a path to how manufacturers can make the change from product to service orientation is traced.

Keywords Product/Service-Systems (PSS), Service-oriented strategies

10.1 Introduction

Global competition and demands for greater company responsibility for products throughout their entire life-cycle are driving manufacturing companies to reconsider their current product-oriented and transaction-based business strategy. Product/Service-Systems (PSS) offer manufacturing firms a way to change to a more service-oriented business model that reveals new revenue streams based on their current product and service competencies. However, the shift to these new business strategies is not a trivial undertaking and many firms face many barriers and challenges when implementing service-oriented strategies.

Not all manufacturing companies and business environments are well suited to PSS approaches. There are certain generic configurations of strategy, structure and environment that are more opportune to service-orientation than others. In this chapter we attempt to establish PSS approaches in relation to generic business strategies. Based on contingency theory, we investigate how PSS approaches can be a good ‘fit’ between certain market conditions and organisational factors. The shift to service-orientation for manufacturing firms requires an expansion and augmentation of key organisational capabilities. These capabilities are identified and possible organisational configurations that support these are discussed. Finally, we provide a process for how manufacturing companies can make the move to PSS.

10.2 PSS as a Service-Oriented Strategy

Business strategies are coordinated plans for how a company can establish and maintain a competitive position in the market place. Although there are many different schools of thought regarding the formulation of strategy (Mintzberg & Lampel 1999), in this chapter we base our discussions of PSS on contingency theory. Contingency theory asserts that the performance of an organisation depends on how well the fit is between the external market environment, strategy and the internal configuration of the organisation. Bowman (2008) stresses that a robust competitive strategy needs to address the following five questions:

1. Where should the company compete?
2. How can the company gain and sustain advantage?
3. What assets, capabilities, structures, systems and culture does the company need to deliver the strategy?
4. What is the current state of the company?
5. How can the company change?

In the following, the above questions are related to PSS approaches.

10.3 Opportunities for PSS in the Market

A manufacturer will very rarely abandon its current business completely and establish itself in a completely new industry. Although often given as examples, the transformations of Nokia (from wood pulp to telecommunications) and IBM (from computers to consulting) are exceptional and the result of long-term change processes. For PSS, in the context of manufacturing firms, the underlying assumption is that they can capitalise on their substantial experience and expertise of their products, and thus create service offers that would not be feasible for other players in the market (Mathieu 2001b). Given these strengths, manufacturing firms should start by considering their existing market and customers to determine where PSS approaches might hold strategic opportunities to leverage their competitive position.

There are two general directions in which companies may search for opportunities on the market: (1) along the product's life value chain, i.e. installation, operation, maintenance, disposal, etc., or (2) along the customer's activity chain, i.e. design, financing, training, managing, resale, etc. Manufacturers typically have strong technology, product and manufacturing competencies and capabilities, but not necessarily close relations with their end users or competencies in the management and operation of their products. PSS approaches are generally more appropriate for companies that have or can get access to their end-users and their products in use. Otherwise it can prove difficult for manufacturers to add value to the downstream life phases of their products (Wise & Baumgartner 1999). Here, the opportunity to support the activities and enhance the utility of products is greatest.

The manufacturer's product itself also indicates how suited service-oriented offerings are to the market. Capital equipment seems to hold many promising opportunities for PSS (Windahl 2007), but in general PSS approaches seem to work well for manufacturers if any of the following conditions apply (Tukker & Tischner 2006):

- Products with high costs to operate and/or maintain
- Complex products that require special competences to design, operate, manage and/or maintain
- Products with considerable consequences or costs if not used correctly or appropriately
- Products where operational failure or downtime is not tolerated
- Products with long life
- Products with only a few major customers on the market

Business strategies are dependent on the maturity of the product technology and its adoption in the market, but this does not necessarily determine how apt it is to PSS approaches. Successful PSS can be found in both the case of the introduction of new technology (e.g., the use of electrophotography in Xerox's Model 914

(Chesbrough & Rosenbloom 2002)) and the case of mature products (e.g., SKF ball bearings (Reinartz & Ulaga 2008)).

10.4 PSS as a Business Strategy

Porter's (1985) generic strategies are often cited as the reference for competitive business strategies. Porter defines three generic competitive strategies based on how broadly the market is targeted and which core competencies of the company are applied:

1. **Cost Leadership** Offering products and services at the lowest price on the market
2. **Differentiation** Offering unique products and services that customers are willing to pay a premium for
3. **Narrow focus** Focusing on a clearly defined market segment either by
   (a) **Cost Focus** Offering the lowest price
   (b) **Differentiation Focus** Offering unique benefits

According to Porter, companies should stick to one these generic strategies and not risk being 'stuck in the middle' in order to be successful. Although widely adopted by many, this has since been challenged. In their book *Blue Ocean Strategy*, Kim and Mauborgne (2005) claim that the most successful firms are those that master *both* cost leadership and differentiation. Another classification of competitive business strategies that has received attention in industry is provided by Treacy and Wiersema (1993):

1. **Operational Excellence** Providing the best total price of products and services in the most convenient manner for the customer (similar to cost leadership)
2. **Customer Intimacy** Delivering what customers want in a close, long-term relationship (differentiation through customer focus)
3. **Product Leadership** Developing state-of-the-art products and services continuously (differentiation through product innovation)

Applying Porter's categorisation, PSS can be seen as a differentiation strategy (Tukker & Tischner 2006), as the provider complements the manufactured products functionality with a set of unique service offerings based on the provider competences. When compared to Treacy and Wiersema's strategies, PSS approaches seem to be a combination of best total price and close customer support. It would seem that PSS can be seen as a strategy for manufacturing firms to gain competitive advantage when differentiation on product properties alone in the market is difficult.

Manufacturers must, however, be wary that their new service-oriented offerings might compete directly with (their own) product sales. In order to establish PSS in the market, manufacturers must demonstrate convincingly that the total cost of product ownership (or operation) is lower for customers with PSS compared to just product sales. The services offered could cannibalize product sales by keeping products operational for longer or using them more efficiently, so that the purchase of new products are postponed.

The type of service offered also influences the business strategy. In a large study of successful business units in European business-to-business manufacturing firms, Gebauer (2008) identified configurations of service strategies that correspond well to certain market conditions:

- **After-sales service** providers seem to follow cost leadership strategies as the market here is typically highly competitive. Customers are price sensitive and expect service providers to react quickly to breakdowns and failures. After-sales services are therefore often standardised, predefined and priced separately (unbundled).
- **Customer support** providers tend to differentiate themselves through their products and services. Customers of these services value high product quality and reliability backed with process-oriented services that prevent breakdowns altogether. Customer support services are bundled together in customised packages, i.e. Service Level Agreements, where customers pay a fixed price.
- **Operational services** combine cost leadership and the differentiation of their products and services. Customers that outsource expect that their initial investment, operational expenses and risks can be reduced and managed more efficiently. Outsourcing partners have to assume full responsibility for their customer's operation processes, and therefore a clear legal agreement regarding division of responsibility and delivery scope is necessary. This means that operational services are standardized to ensure efficiency and typically high quality products are used to reduce breakdown and failures.
- **Research and development services** are often specific and differentiated offerings. Development partners collaborate closely with their customers, giving them a strong position on the market that creates strong barriers for competitors. As it is difficult for customers to assess the value of these types of services, the service provider uses their identity and reputation from their other products and services as a proxy for the value of their professional services. Given these conditions the competitive intensity is very low with these services.

10.5 Service-Oriented Capabilities and Organisation

A strategy is based on the company's overall mission, vision and goals, and aligns the organisation. Consultants and scholars in strategy formulation mention the following essential dimensions of organisations that should be consistent with strategy and among themselves (Peters & Waterman 1982, Andreasen *et al.* 1989, Galbraith 2002), see Fig. 10.1:

- **Structure** The organisation of tasks, responsibilities and resources representing the decision making structure
- **Processes and methods** The processes, procedures and methods used in the organisation to perform the many tasks
- **Capabilities and physical assets** The technical resources and physical space available to the organisation
- **Measurement and rewards** The manner in which performance is measure and people are motivated
- **People and competencies** The knowledge and skills of the people in the company
- **Culture** The norms, values, attitudes and social behaviour of groups and individuals in the organisation

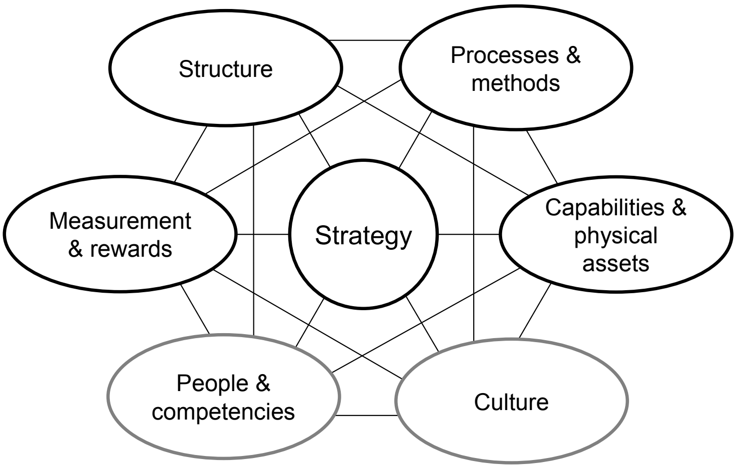

Fig. 10.1 The essential dimensions of an organization related to strategy (after Peters & Waterman 1982, Andreasen *et al.* 1989, Galbraith 2002)

In the above, it is possible to distinguish between hard and soft organisational dimensions. The first four dimensions are hard dimensions that can be 'designed' into an organisation, whereas the last two can only be influenced indirectly through management and the other dimensions.

10.5.1 Structure

In the innovation management literature there is an on-going discussion on whether it is best for established firms to create separate organisations to develop, sell and provide radically new business offerings, or whether it is possible to build new capabilities within the current organisation's structure (Bower & Christensen 1995, Chesbrough & Rosenbloom 2002). This discussion is also relevant when it comes to PSS. With PSS approaches, should a manufacturer establish independent service-oriented business units, or integrate service-orientation into all business units?

Several researchers (Mills *et al.* 2008) believe that it is necessary to separate the service organisation as an independent profit centre, so that it can act as a shelter for the development and support of a service culture. In this way, the business unit can create an explicit service strategy, business model and identity. Others think that this will omit the competitive advantages that manufacturers have by integrating products and services (Matthyssens & Vandenbempt 2008). Davies *et al.* (2006) suggest establishing *'front-end customer-facing units, back-end capability providers and strong strategic centers'* to mediate between the business units. The service-oriented business units develop integrated product and service solutions for customers whilst the traditional product-oriented units continue with "business as usual." The degree of integration between the business units in a service-oriented organisation depends on four dimensions (Galbraith 2002):

- **Type of solution** Vertical (industry and customer specific) solutions require a more customer-centric organisational unit than do the horizontal (broad application) solutions
- **Scale** (number of products and services offered) and **scope** (number of different kinds of products and services that are combined in the solution)—the larger the scale and scope the larger the number of organisational units that must be coordinated
- **Integration of the solution** The more interdependent the components, the more interdependent the organisational units responsible for those components need to be
- **Revenue from solutions** The percentage of total revenues that comes from solutions, higher percentages justify stronger customer-oriented business units

The higher the potential is for synergy effects, the greater the need for tight links between business units (Sandberg & Werr 2003). In order to fully benefit from the advantages of PSS approaches the firm's business strategy must be broken down into clear objectives for each of the functional units in the organisation. These objectives determine the task, structure and strategy of each unit and how they mutually support each other.

10.5.2 Process and Methods

The core business processes that should be considered with PSS are product development management, supply chain management and customer relationship management (Antioco *et al.* 2008). The importance and dominance of each business process in the company is mirrored in Treacy and Wiersema's (1993) strategies: *product leadership*, *operational excellence* and *customer intimacy*.

According to Aurich *et al.* (2004) there are three strategies for how manufacturing firms may integrate their product and service development, being:

- **Systematic product design, then intuitive service design** This describes the traditional situation for most manufacturers. The development and manufacturing of products are the company's core competencies. Services are mainly liability oriented to guarantee product functions and their development is ad hoc. Although this is a common approach to the development of services, it is hardly a proactive and predictive approach to service-orientation.
- **Systematic product design, then systematic service design** Based on a range of developed products, a set of services are subsequently systematically developed to enhance the functionality of the products. Preventive maintenance is an example of this.
- **Integrated design** Products and services are developed in an integrated manner based on customer needs.

Although true on the practical level of the single development project, a service-oriented strategy requires the integration of product and business development on a higher and more strategic level in the development function of the company and often involves the customer and partner companies.

The development strategies described by Aurich *et al.* (2004) are all related to the projects executed in the level entitled Development Projects in Fig. 10.2. As illustrated in the figure, these concrete development projects are framed by two parallel activities relevant for the company's development function, being the gathering of experiences and life-cycle data from the operational activities (operations) and the long-term planning of the company's future portfolio of products and services (portfolio strategy).

The initial definition and planning of a coordinated product/service mix takes place on the portfolio strategy level. Through the subsequent development of service delivery capabilities and products supporting them, the foundation for the PSS operation is laid out. The integrated planning and prioritisation of product and service development projects on the portfolio strategy level ensures synergy effects, timing of implementation and balancing of functionalities.

The operational level of product and service delivery on the other hand, holds the opportunity to learn about the product's performance throughout its life. Information needs to be gathered, stored and analysed regarding two life-cycle systems: (1) the life-cycle of the physical artefact; and (2) the activity life-cycle relationship between the providing company and customer, representing a product-oriented and a service-oriented view respectively (Tan *et al.* 2006).

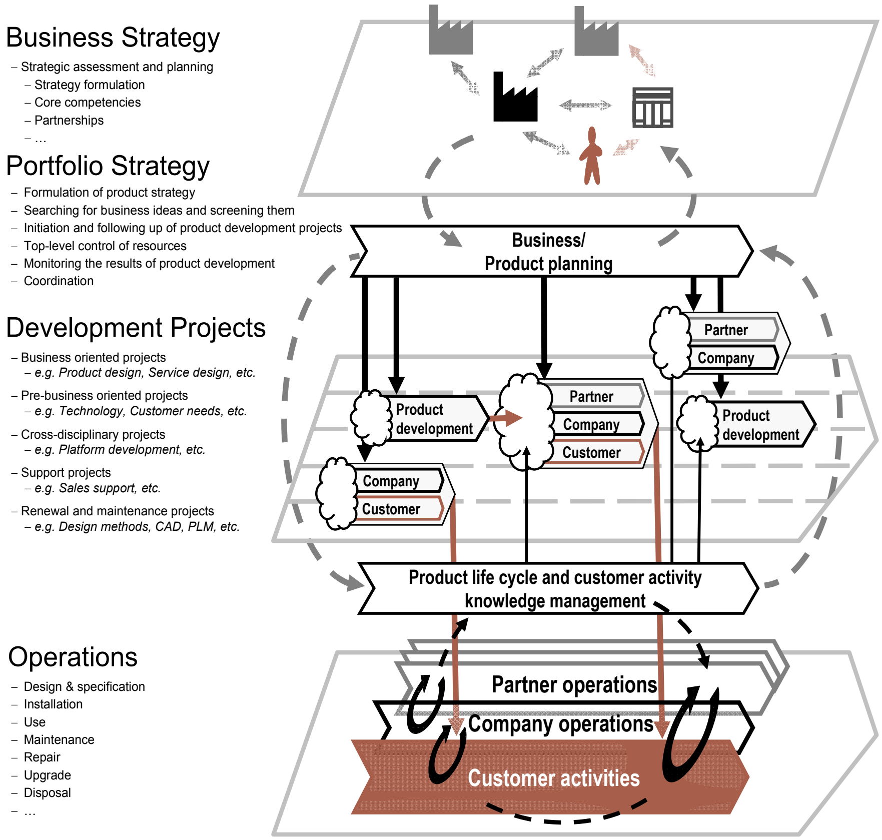

Fig. 10.2 A model for PSS development showing how product and service development projects must be coordinated with the business planning and strategy with customers and partners (Tan *et al.* in press).

Rolls Royce (power systems) is often cited as one of the companies that have made the transition from *'offering a Service around an existing Product'* to *'designing a Service and the Product that supports it'* (Harrison 2006). Using the term *'Design for Service'*, Rolls Royce implemented a new development programme that strongly focused on life-cycle costs that covered: Infrastructure & Capability Investment; Product Acquisition; Product Operation and Support; and Product Disposal. The identification and quantification of life-cycle costs relies heavily on operational systems capable of extracting and managing information on the operational level as indicated in Fig. 10.2. To do this Rolls Royce had to integrate additional sensors and processing power on their engines, and develop remote monitoring capabilities that could analyse operational data and provide guidance to customers and maintenance personnel.

10.5.3 Capabilities and Physical Assets

PSS approaches require an expansion of competencies necessary to develop integrated solutions. Davies *et al.* (2006) studied several manufacturers that developed services in addition to their product offerings and identified four key capabilities as key for migrating into integrated solutions:

1. **Systems integration** The capability to specify, design and integrate physical (software and hardware) components of a solution. The manufacturer is not restricted to only using own components, but should select the best suited technologies and products from other leading manufacturers. The objective is to create value by ensuring that all parts work well together in synergy.
2. **Operational services** Capabilities that allow the manufacturer to operate, support, maintain and upgrade a system efficiently throughout its life. Technologies that can remotely monitor and diagnose the performance of the systems are often employed here. The gathering and analysis of a customer's operational information is vital to forming the base for what value the provider can deliver to the customer.
3. **Business consulting** The capability to consult professionally about operational and strategic issues related to improving the customer's business processes. Here the manufacturer must understand the customer's business needs and develop their customer relationship skills.
4. **Financing** In return for continued business, manufacturers must be able to finance or reduce the upfront price of products with integrated solutions. Sometimes even joint ventures may be established so that both provider and customer reap the benefits of future business.

In order to obtain these capabilities manufacturers may choose to

1. *Develop* these competencies and capabilities in-house
    (a) Either by changing the entire *current organisation*
    (b) Or developing a *separate organisation* within itself
2. *Acquire* an organisation with the necessary competencies and capabilities
3. *Partner* with an external organisation with the necessary competencies and capabilities

The choice amongst the above options is based on the organisational structure and degree of integration between the business units as discussed in Sect. 10.5.1. The last two options would seem to be the quickest way to establish service-oriented capabilities, but face the challenges of integration. Tidd *et al.* (2005) argue that developing a separate unit within the organisation itself is the most efficient, as this venture would have the entrepreneurial benefits of a small organisation with the resources of a large one.

10.5.4 Measurement and Rewards

Performance measurement systems in organisations provide information that is essential for the management and development of its activities. Performance is based on how well the organisation achieves its objectives and implements its strategy. The incentive schemes and rewards for employees in the company must reflect the logic of the service-oriented business and encourage cross-functional collaboration. Service-oriented companies have different business objectives and therefore also different key performance indicators and business than product-oriented companies. For example, in product-oriented companies the amount of product sales is essential for the business, whereas for a service-oriented company customer satisfaction and profitability are a better indication of performance (Anderson & Narus 1995). In manufacturing firms services are typically not valued and their costs not tracked. Activity-based costing provides a manner in which companies may analyse the contribution of their services to profits. This will help manufacturers in defining what kind of services hold potential for greatest profit.

For PSS it is important that companies can track and demonstrate how their customers save or generate more value through integrated solutions instead of buying discrete products and service. This requires in-depth knowledge of the customer's activities and own performance. Currently, manufacturing companies have two types of IT systems that attempt to cater for this, Product Life-cycle Management (PLM) and Customer Relationship Management (CRM). Each system has its own focus, PLM systems administer product specific data and information throughout their entire life-cycle, but as companies are rarely responsible for the use and disposal phases of their products, the gathering and processing of information here is rather poor. On the other hand, CRM systems capture, store and analyse customer information and communication, but again not much information is obtained from the activities where the product is actually in use. From a product development point of view, a systematic gathering of information of product use would be extremely valuable to the development of new products and services. If a perpetual coupling of product and customer information during operation was possible, insights and knowledge could be gained to ensure that the customer's activities were continuously aligned with their customer's needs and behaviours. But for now the management, accessibility and relevance of knowledge to product development and designers is still not well established. The ability to gather, store and analyse data about products and customers that can then provide information on how to enhance the value of their customer activities, would seem a prerequisite for the development of PSS. Companies can also use this information to motivate customers, suppliers and other actors to behave in a manner that is more beneficial for all, both economically and environmentally (Frei 2008).

SCA, the world leader in incontinence care products, mainly sell directly to health care institutions and nursing homes in Denmark. Here, in addition to their products, they offer a whole range of services from planning how to achieve improvements in incontinence care, to training and coaching health care personnel on how to best use their products, including monitoring product consumption and intervening when deviations occur. This integrated approach to products and services allows SCA to improve the well-being for the users of incontinence products, the work conditions for health care providing personnel and the total economy for incontinence care for the health care institution. Regular visits are made to each nursing institution to follow-up on the achievement of objectives and management of consumption together with consulting and guidance on how to continuously improve on the performance of costs and care. In order to do this SCA uses an integrated IT system that registers all orders of individual residents in nursing homes in relation to their level of incontinence. SCA can then extract data to create reports that help their customers monitor their consumption of pads over time and point out deviations. Based on data from other nursing homes they can benchmark their customers, which permits them to provide their customers with an idea of saving potentials and suggest action to achieve these. Studies done in several large municipalities in Denmark show that, in this way, SCA can help nursing homes reduce their pad consumption by 20%, whilst also enjoying much greater satisfaction amongst pad users and care providers.

10.5.5 People and Competencies

The profile of people and their skills in service-oriented organisations are different to those employed in traditional manufacturing companies (Bowen *et al.* 1989), see Table 10.1. Literature on service operations emphasises that employees and their behaviour during customer contact are highly related to the customer's perception of quality (Vandermerwe *et al.* 1989). This is particularly true of services that involve a high degree of customer contact.

The recruitment and selection of personnel with good interpersonal competencies are crucial. For example, it is common for manufacturers to recruit experienced employees from well-established consulting firms for their management consulting services (Ploetner 2008) as services of this kind call for personal trust and reputation. On the other hand, employees with experience in the organisation's product business make it easier to access knowledge and people internally allowing better integration between the product and service units. If necessary, these employees can be retrained to become more 'service-savvy' (Reinartz & Ulaga 2008). Cornet *et al.* (2001) claim that the ideal solutions team will include a mix of internally and externally recruited people to combine existing knowledge with the right entrepreneurial and consultative skill set.

PSS can be seen as an *architectural innovation* as the change relates to the architecture of products and services and not changing the individual components. However, this does not mean that companies can expect to easily develop new architectural innovations. The knowledge within the organisation will be based on the current dominant product architecture which makes it ineffective in recognizing and learning about other architectures.

Table 10.1 The difference in competencies between product-oriented and solution-oriented business (after Sharma & Molloy 1999)

Area	**'Product' Focused**	**'Solutions' Focus**
Role	• Working alone and controlling the show	• Leading cross-functional teams
Product knowledge	• Narrow range (but deep)	• Broad market knowledge
Customer relationship	• One-on-one • Functional purchasing • Personal trust	• Multiple (team) • Multiple levels (e.g., CEO/CFO) and functions • Trust in team competency
Analytical skills	• Less advanced	• More advanced business building
Selling skills	• Transactional • Sell 'widgets'	• Relationship • Consultative • Solutions
Background	• Functional (e.g., sales)	• Cross-functional experience • Across the value chain

Brady *et al.* (2005) list a broad range of skills solution-oriented companies need to acquire or develop. These include key account management, risk analysis and management, understanding of whole life costing and customer lifetime value, legal skills, information management, value chain management, etc.

Steelcase is the world's largest manufacturer of office furniture. The development of their products, services and new business ventures is based on user-centred insights where work, workers and workplaces are studied intensively to create new solutions. With the acquisition of IDEO, the renowned design consultancy in 1996, Steelcase has developed user-centred design to be one of its key strategic competencies. User-led insights form the basis of many of its offerings:

- In product development, new products are developed based on how to best support an observed activity or task in the office workspace, and not just on redesigning existing furniture
- Steelcase's range of services (e.g., workspace planning, leasing, handling moves, ergonomic training, reparations, refurbishment, inventorying, asset management, etc.) is structured around helping customers when exploring, planning, purchasing, managing and measuring their physical workspace

- The company's corporate consulting team uses a user-centred methodology for engaging users in the co-design of their new workspaces where workspace strategies are linked to the overall objectives of their client's organisation
- Nurture, a new thriving business unit, was established based on insights from their user-centred design methodology applied to healthcare work environments

10.5.6 Culture

There is a unanimous agreement amongst researchers and practitioners that a service culture or mindset is key to the success of PSS. This relates to the whole manufacturing organisation realizing and endorsing services as not just add-ons to products, but as value-adding activities central to business. Attitudes to services and cooperation can however vary across the organisation. This can hinder the organisation's effectiveness to develop and deliver integrated solutions. For example, product-oriented engineers might feel that the customer-oriented corporate consultant's way of working is 'quick and dirty' compared to their own systematic and meticulous processes (Sandberg & Werr 2003). The difference between product and service-oriented cultures can be a strain in a service-oriented manufacturing organisation with units sceptical of each other and disputing what is the best way to provide value to customers. PSS approaches will shift the power and influence in the organisation to the more service-oriented units, which can cause dysfunctional conflicts and rivalries. The challenge is to balance and maintain the symbiotic relationship between the cultures rather than totally substituting one value set for the other (Bowen *et al.* 1989).

Close customer contact is built on trust and good relationships. With PSS, customers should feel that the providing company is on the same side as themselves, eager to support them in their objectives and not biased to simply increasing product sales (Galbraith 2002). Service-oriented companies should be willing to learn and understand what is critical to their customers and dedicate themselves to finding the best solutions for them. At the same time, companies must be willing to be open and share their knowledge and processes with their partners (Vandermerwe *et al.* 1989).

10.6 Readiness for Service-Orientation

Although many manufacturers are lured by the promising potential for business, companies should first clarify whether they are ready to deliver integrated solutions. There are certain conditions and contexts that make service-orientation more opportune for some than others. Wise and Baumgartner (1999) list a number of factors that would indicate the potential for service-oriented business downstream:

- **Attractiveness of downstream opportunity, measured in, for example:**
  - Ratio of installed base to new product sales is greater than 15 to 1 (i.e. there are more than 15 products in use for each new product sold)
  - Total life cost of the product is over four times the initial purchase price
  - The downstream margin is over 5% greater than the product margin of the purchase price

- **Importance of customer relationships, given by, for example:**
  - Products are considered as commodities (minimal differentiation) on the market
  - Market share of the top five customers is over 40%
  - Share of total profit earned from top 20% of customers is over 50%

- **Power of distribution channel, described as, for example:**
  - Distribution and selling costs are over 25% of the product price
  - Degree of channel concentration - the market share of the top five distributors is over 40%
  - Degree of channel innovation is very dynamic

Gebauer *et al.* (2005) observed that although many manufacturing companies have invested heavily in extending their service business, they failed to achieve the expected returns. Sharma *et al.* (2002) list a number of internal organisational issues that should be considered prior to committing to service-orientation:

- **Trust** The trust between organisations and the willingness to share essential information
- **Collaboration** The organisation's ability to work in an integrated manner internally
- **Innovation** The ability to systematically turn customer insights into solutions and use this knowledge with other customers
- **Risk Profile** The degree of risk involved with increasing responsibility of customer's activities and fortitude that returns are achieved over the long term
- **People and leadership** The people and management that are able to make the transition and develop the right mindset and skills for service-orientation and close customer collaboration

10.7 The Transition from Product to Service-Orientation

There are many paths to becoming a service-oriented manufacturer. Some companies build upon a consolidation of their product-related services and then enter the installed base market (Oliva & Kallenberg 2003). Others make the migration by building up competences in systems integration, operational services, business consultancy and financial services to deliver integrated solutions (Davies *et al.* 2006). Most often, however, companies are not that well coordinated and simply attempt to adhere to customer's requests provisionally. No matter what the chosen path will be, a coordinated approach guided by the strategic commitment of the company is necessary to yield the largest benefits from the migration. Based on the recommendations of several researchers and practitioners (Foote *et al.* 2001, Oliva & Kallenberg 2003, Booz Allen Hamilton 2004, Sawhney *et al.* 2004, Gebauer *et al.* 2005, Davies *et al.* 2006) the process for transition from product manufacturer to service provider should involve the following steps:

1. **Identify customer and market opportunities** Based on existing strategic customers, explore and assess the overall market opportunities for more service-oriented offerings. Investigate the possibilities along the product life-cycle and the customer activity cycle. Determine the attractiveness, viability and risks of the business.
2. **Consolidate internal service capabilities** Assess the value and costs of existing services across the organisation and monitor their performance. Design a well-defined service platform that can deliver the existing services efficiently. Eliminate and add services accordingly. Improve productivity by automation, standardization or delegation of activities and responsibilities.
3. **Determine the value proposition and service-oriented strategy** Working with lead customers define the value proposition and formulate the strategy for the service operations. Match the organisation to the strategy and value proposition. Identify and support beneficial interrelations horizontally and vertically in the organisation. Develop the business model by defining the value chain and revenue mechanisms.
4. **Gain access to customers and build capabilities** By internal development, acquisition or partnering—establish service channels. Recruit employees with service-oriented skills and mentality. Develop strategic partnerships with customers and suppliers to form a value network. Form dedicated customer-focused front end and product-focused back end units or teams. Establish relations on multiple levels of the customer's organisation.
5. **Co-develop the integrated PSS** With the customer and relevant actors—understand the customer's objectives and activities. Benchmark and identify cost savings or value generation potential. Establish and scope out the integrated solution and pricing. Determine the delivery system and process for gathering, storing and analyzing information. Devise an implementation

plan. Assign roles and responsibilities for all actors. Agree formally to proceed.

6. **Implement and operate** Support and manage actors, activities and relationships. Lead, monitor and drive the processes of the integrated solution. Document cost savings or value creation performance. Balance the front end and back end units.
7. **Learn, adjust and improve** Exploit the learnings of the product in operation and relate them to customer activities. Perform economic value analyses. Share insights across the organisation. Continuously improve the integrated solution's processes. Optimise and enhance the productivity and quality of the service delivery. Systemize the integrated product and service development process.
8. **Extend services** Expand service operations on a greater scale to other customers. Develop new or reconfigure existing activities within primary or adjacent customer value chains using the formalized development process. Achieve cost advantages through economies of scale, learning curve and network effects.

Although the move towards integrated solutions is portrayed here as linear and straightforward, this is not the case in reality (Windahl 2007). The above is merely a guideline. Manufacturers will experience the process as being of a more dynamic and complex nature with many barriers and challenges along the way. As an alternative to a radical organisational change to a total solutions provider, where the competence gap may be too high, smaller, incremental steps over time may be made instead. The following first steps have been observed in industry (Sandberg & Werr 2003, Allmendinger & Lombreglia 2005, Matthyssens & Vandenbempt 2008):

- **Develop system integration capabilities** Assess the product portfolio and identify the technical systems they are part of. Design well-defined product modules that can easily be combined and configured in total systems. If appropriate integrate sensor and communication technologies into the products so that they can be remotely controlled and monitored.
- **Take over customer activities or responsibilities** Based on customer requests, take over specific administrative, engineering, financing and/or logistical tasks. Leveraging existing knowledge, optimise and package these services and offer them to other customers interested in outsourcing operations. Build up knowledge of the customer's activities. This strategy is common for companies that operate close to their end-users.
- **Establish corporate consulting** Based on the traditional business' products or expertise, establish a team of high level customer-oriented consultants. Develop an approach to professional knowledge-intensive services such as systems integration and business consulting. Leverage the close relations with the customer to develop new products, services and business opportunities. This strategy is

applicable to business-to-business companies to generate synergy effects with their product business and learn about, and from, their customers.

Although still challenging, these steps are simpler to implement in manufacturing firms, involve less risk and allow the traditional product-oriented business to go on with "business as usual." In all three cases the company will have to deal with products and components that are not designed and manufactured by themselves. Companies should embrace this opportunity to learn about their competitors' products and use the insights to develop new products or create new partnerships.

Danfoss, a large manufacturer of refrigeration controls, in its transition from product to service orientation leveraged upon the development of their products' remote control functionalities, which enabled them to offer operational services. The service organisation was initially created through the merger of key account sales units with system design consultants and an externally acquired service delivery firm. The resulting service department then developed by alternating between focusing on the optimisation of the product and service alignment and the geographic expansion of activities. The regional market context was identified as such an important factor for the offer definition that the integrated development of product and service offers was given a low priority compared to the adaptation of a basic PSS concept to specific regional markets.

10.8 Future Perspectives

The move to more service-oriented approaches seems imperative for many manufacturing firms. Although PSS holds potential for growing the business, the challenges of innovating must not be underestimated. Changes in strategy and organisation take time and rarely happen quickly. For example, IBM's renowned shift to consulting services happened over a decade (Ploetner 2008). As long as the product business still generates revenue, manufacturers are reluctant to introduce a new service-dominated logic. However, if the market changes and a competitor does succeed in demonstrating a new business model, such as has been observed with photocopiers and aeroplane engines, the other manufacturers are quick to follow.

The past years' intensive focus on core competencies has driven companies to outsource their non-core activities and grown the market for operational services. But manufacturing firms have been slow to address this growing market. The reason for this may be that they themselves focus on their own core competencies, being the development, production and sales of products, not their operation and maintenance. The market for operational services is then left to other service providers, and the opportunity to establish closed loops of learning and material flows are not realised. There is need for more research to determine whether the alluring potential benefits of PSS can actually be realised in practice. If this is feasible, then under what conditions is it possible, and what steps need to be taken?

PSS often requires multiple actors working together and devising schemes (e.g., Public-Private Partnerships (PPP) and Build-Operate-Transfer (BOT) projects) for how to share risk and responsibility in return of a part of the cost savings or value generation. Orchestrating and balancing these long-term partnerships is a challenging undertaking. Often opportunistic behaviour must be managed and disputes over responsibilities and rewards dealt with (Manzini *et al.* 2004). The understanding of how to integrate and manage multiple and diverse actors in PSS is still limited and many companies struggle to collaborate.

Servitisation, the shift from product-orientation to service-orientation uses a service-dominant logic (Vargo & Lusch 2004) to create value. The service-dominant logic focuses on the value derived from intangible components of an offering, which is difficult to specify and evaluate beforehand. Although this kind of logic works well on a strategic and top management level, it falls short in operations in most companies. At the moment, purchasers and legal specialists cannot rely on trust in the customer–supplier relationship. They need to be able to define and specify service requirements as well as objectify the offering (goods-dominant logic) in order to compare it with offerings from other companies to ensure the best value for money (Lindberg & Nordin 2008). PSS are in need of both the goods-dominant and service-dominant logic in order to be communicated and establish a shared understanding amongst all actors. How this is done and what "language" is used to communicate PSS is still an open question.

The research in PSS has, from the beginning, been encouraged by the potential for '*dematerialisation*' where economic growth is decoupled from material and energy consumption. However, PSS approaches in themselves do not guarantee improved environmental performance (Tukker & Tischner 2006). Services may seem less material demanding but are not altogether free of environmental effects. Nonetheless, it is generally recognised that due to the system's perspective PSS approaches do hold a potential for more efficient use of natural resources, but this can only be achieved if it is designed into the system from the start (Baines *et al.* 2007). It would seem that environmental and social concerns are becoming inherent to all business decisions. This could help with the adoption of service-oriented approaches in industry. In particular, PSS solutions that manage customer's energy usage and/or their consumption of products have a great environmental potential. It would be highly interesting to investigate PSS concepts with the basic value proposition to fulfill the needs of customers sufficiently, whilst reducing costs and environmental effects.

10.9 Conclusions

This chapter has attempted to plant and establish PSS approaches as a business strategy in the context of manufacturing firms and their existing business. The interdependencies between PSS offering and strategy, market conditions and organisational dimensions have been described to provide insight and an overview, but the complexity and multiple perspectives of the issues have only been touched upon. Service-oriented approaches are intriguing ventures for manufacturing firms, but caution still needs to be applied in order to achieve the potential benefits. The insight provided here will help business leaders understand whether PSS approaches offer any potential for their future business. The appropriateness of certain generic constellations of service-oriented strategies, organisational factors and the existing business environment aid companies in determining what is the most advantageous strategy given their position. An outline for how manufacturing firms may make the transition to PSS provides inspiration and a map of the steps necessary to implement a service-oriented strategy in their own organisation.

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Chapter 11
People, Product and Process Perspectives on Product/Service-System Development

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Abstract The adaptation of Product/Service-Systems (PSS) calls for new development models. On one hand this gives the manufacturing firm possibilities to redesign, upgrade and replace the discrete device that provides the performance their customers are asking for. On the other hand, this new situation has to address aspects that are normally not addressed in early product development, i.e., services. In this chapter, we elaborate on product and service development process models, as well as system models to propose a frame of reference for multiple perspectives on PSS development. These perspectives are of people, product and process. Also, this chapter puts forward implications for the development of PSS models.

Keywords Product-Service System, Innovation, Engineering design, Development models, Service perspective

11.1 Product/Service-Systems

When selling products, services are important for the customer to be able to use the device or for the device to perform well, e.g., cars need the services of gas stations and the engine needs maintenance. And, vice versa, to provide services tangible support is needed, e.g., rooms and furniture for the hotel business and phones for telecommunication companies. Thus, the integration of products and services to meet the customers' requirements is well known, but, depending on perspective, it seems that development processes favor one of them at the expense of the other. Service literature emphasizes that the discrete device is one of several elements in strategic relationships (Grönroos 2000), hence putting the customer relationship first. This is because services are activities in collaboration with customers. Product development literature points out how the product is first settled and then services take form to complement that thing (Ulrich & Eppinger 2008). In the engineering industry, the word "*after*market" is commonly used to describe the life of a product *after* it has been designed and developed. Calling this aftermarket indicates that a service perspective comes in second place for engineering firms (Normann 2001). These two perspectives, product perspective and service perspective, argue that the value carrier for the customer is either the product *or* the service, yet customers tend to view their purchase from a more holistic perspective (Mello 2002). In the last decade, the vision for the engineering industry has been to provide their customers with functional offers, meaning that what is sold is the function or the use of the product (Fransson 2004). Hence, engineering firms' business models extend to incorporate a service perspective. This is what is commonly called a Product/Service-System (PSS) offering, and it can be described as a special case of servitization (Bains *et al.* 2007).

Fransson (2004) has developed a model for how the service degree increases in engineering firms, calling such offerings "functional offers." A functional offer starts from a traditional product perspective where the discrete device is supported by services (at bottom left in Fig. 11.1). In the next degree of functional offerings, the service part is extended with services that are not usually offered, e.g., customized offerings of expertise from production processes. Then, there are two middle degrees of offerings which put forward that the shift towards a service perspective changes how the customer is invoiced, i.e., the engineering firm is paid on the basis of the performance of the device including some services, and at the next degree, *all* services are included. Here, the sharing of responsibilities to uphold the functionality of the device also comes into play.

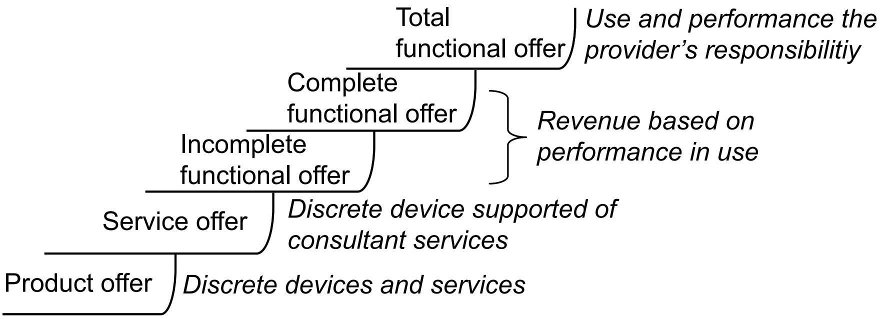

Fig. 11.1 A progress model for functional offerings, after Fransson (2004, p.128)

In a complete functional offering, the engineering firm is completely responsible for the reliability in operation of the device. On one hand, this means that if the device is not functioning, the manufacturer is not delivering what is contracted. On the other hand, the manufacturer can control and eliminate risks early on. Here, the customer's usage of the device becomes important. Do they use it as agreed or not? Too much load? Other material than contracted? And so forth. Therefore, Fransson (2004) suggests that companies should aim for as complete functional offerings as possible, where he propose the engineering firm to own, use and handle the device in the customer processes as the highest degree of functional offerings (a total functional offer, at the top in Fig. 11.1).

Obviously, taking on functional offerings including all services rests on collaboration beyond the company's competences. This kind of business models are suggested to incorporate an organisational structure of a virtual enterprise, i.e., where the collaboration takes place cross several company boundaries (Johansson *et al.* 2008). There are challenges to realising PSS and providing successful functional offerings, for example, to understand the voice of the customer more profoundly than merely obtaining the requirements (Ericson 2007), and to implement an innovation approach there are both internal and external issues to tackle (Parida 2008). These examples illustrate that additional capabilities besides the classical engineering ones are part and parcel of developing products for a successful PSS offering. Yet, if the challenges can be handled the advantages abound. For instance, the collaboration in PSS development are expected to reduce some competition through making the business relationships more stable (Alonso-Rasgado *et al.* 2004), also, PSS triggers changed use patterns that reduce waste, i.e., provides for ecological sustainability (Mont 2002, Mont *et al.* 2006).

The integration of products and services into systems in PSS development provide the opportunity to find a variety of solutions to meet the contracted functions, i.e., different degrees of services have an effect on the design of the product. This indicates that the guiding product development process models need to address innovation. Today, engineering firms state that they continuously, on an every-day basis, deal with innovation due to developing products; however, such innovation is focusing on, e.g., new features on a known end-product, here called incremental innovation. As discussed above, classical product development seems delimited when it comes to manage and progress innovation in view of PSS. That is, such innovation that ends in breakthrough products, here called radical innovation. A radical innovation situation has similarities with wicked problems (Rittel & Webber 1973), where several aspects are vague and not fully understood, e.g., What is going to be designed? What should it do? Who is going to use it? And, in what circumstances? (Randall *et al.* 2007). To deal with these questions the design task needs to be addressed from different point of views, i.e., multiple perspectives

For various development projects, distinct process models give the team guidance on how to begin and proceed, as well as pointers to what is needed to fulfilll their missions. These processes, whatever they intend to finally produce, are vital. Also, there is a link between industry and applied research, to develop better products and to become better designers, the processes must be continually improved (Dubberly 2009), this motivates engineering design researchers to study them. Process models are not blueprints of reality; rather they are representations of the design world to deal with the relational complexity in the processes. In view of this, the models depend on how the team's actors interpret and perceive them (Engwall *et al.* 2005). Further, the logics for products and services are different, thus not straightforward to integrate. Yet, the interplay between these points of view is at the core for PSS development. One industrial challenge for turning into PSS provision is to internally communicate a changed mindset and culture. Besides describing how to do the work, process models are important tools to change peoples' mindset in their design thinking.

Thus, here, we will elaborate on development processes, their models and their appearance. We will do this on an abstract level to propose a frame of reference for a multiple perspective on PSS development. We embark from the parts in PSS, namely product, service and system in light of process models. Also, bear in mind that the examples and discussions here are outlining the issues as either/or. Emphasizing the distinct entities and their underpinning logics is a way towards integration and combination of a product perspective and a service perspective, not a question of favoring one of them. Further, the point of view in this chapter is delimited to engineering design taking in additional issues from other disciplines.

11.2 The Role of Models in Product Development

Roughly, models in general can be seen as managing models, i.e., they are intended to manage some aspects of a process. There are models that aim to accomplish more accurate project planning, easier coordination, shorter lead times, more efficient knowledge transfer, and effective quality assurance. Conceptions of models in product development have been analyzed into five categories: administrating, organizing, sense giving, team building and engineering (Engwall *et al.*

2005). The comparison between the conceptions sense giving and engineering is interesting. From a sense giving category, project models provide a view of the complex and confusing web of activities and relations. Such project management models aim to make sense of a confusing world, and the formal models give a common language for making sense of 'chaos' (Engwall *et al.* 2005). From the engineering perspective, the project models visualize a set of technical challenges. Such project management models are used to solve technical problems, and formal models convey documented best practice to support work efficiency (Engwall *et al.* 2005). The sense giving and the engineering categories describe two distinct perspectives; the first views the problem as concerning human aspects and the latter focuses on technical aspects. Seemingly, these models support distinct aspects of the process. The use of the models depends on how they are interpreted by their users and, also, how they are applied within each user's conceptual framework. Also, the same model can be used in several different ways. Yet, it has been identified that the role of models is to enable communication within and between projects, and that they provide common models and concepts (Engwall *et al.* 2005). Hence, it seems that visualizing a point of view in a model makes people work and think together. Simply, they focus a dialogue towards a topic from a certain point of view. By the same token, models are not rigid; they evolve when combined and improve during the use and interpretation of them.

11.3 Changed View for Development

Broadly, looking on products, a discrete device is more or less stable over time, for example a quill pen and a pen can be seen as an enhancement of a comparable product, embodying incremental innovation. Also, a typewriter and a printer can be seen in the same way. When put into so-called s-curves, the interface between a pen and a typewriter can be seen as a breakthrough technology and also as a radical innovation (see Fig. 11.2). In a situation where a company has an agreement on a 20 year contract to deliver "functionality" or "performance in use" to a customer, as exemplified here with "text on paper", providing that function with a pen throughout the contracted time is not viable. During such a long time period, new needs, new goals, new missions, etc. come up within the context for the product. The world around us changes and opens up for innovation opportunities to find new solutions and products. In a PSS situation, it is vital that firms see such "opportunity leaps" and that they have processes able to handle them.

Further, since use is key for PSS, providing service activities as, for example, leasing (Mont *et al.* 2006) becomes do-able. Going from selling printers to the leasing of printers, including the delivery of paper and ink, is possible and also done by companies today. Hypothetically, the degree of services can increase if the provider takes the responsibilities for the printer to be always functioning. Practically, to provide that performance will be really challenging, for example, how to handle a paper jam? If the provider "attacks" the problem from a service perspective, a lot of people on the move are needed, or, from a product perspective the printer as a discrete device needs to be designed differently. Can it alert that a paper jam is coming up? Can it adjust automatically to avoid it? Can it interact with users to avoid the paper jam? Hence, increasing the degree of services towards providing functionality or performance in use brings the manufacturer to consider how to develop the devices to make that PSS offer viable.

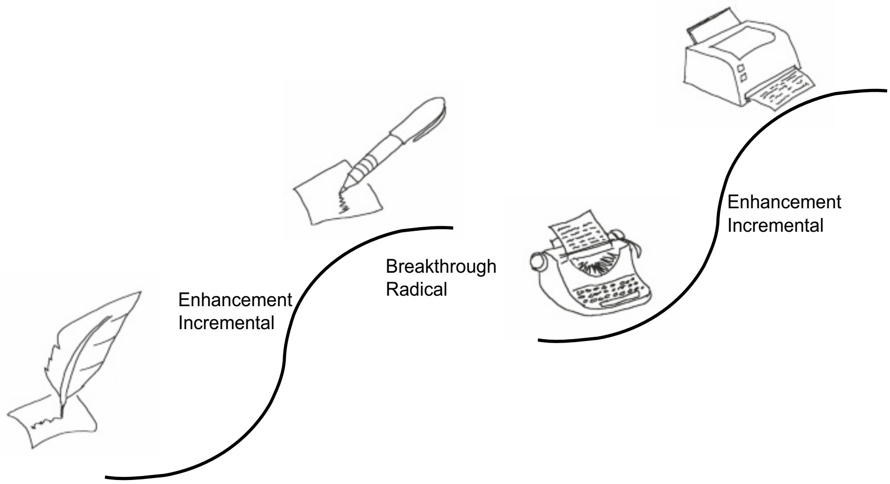

Fig. 11.2 "Text on paper"— enhancement/incremental and breakthrough/radical

11.3.1 Product

The input from, e.g., a market need or a technical invention, sets the early phases of product development into motion. The initial phase is important since the product is settled in these activities. An approach to, as soon as possible, narrow down uncertainties and converge the information flows to focus the design task at hand is commonly applied to increase efficiency. In general, a product development process comprises of a number of sequences, going from early design phases to the launch of the discrete device (Ulrich & Eppinger 2008). Today, most models emphasize an integrated, parallell or concurrent approach. Also, the importance of iterations is stressed in these models. However, on an abstract level, the phases in a product development process can be outlined as at the top of Fig. 11.3.

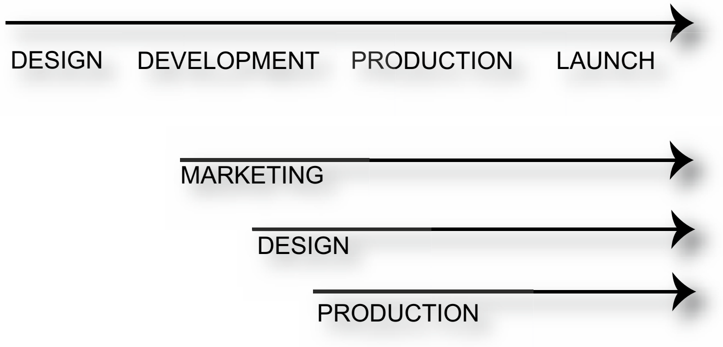

Fig. 11.3 Phases in a generic product development process at top, integrated process at bottom

Such a model emphasizes the stages that need to be taken to be able to release a commodity, i.e., selling excellent goods, not services. At the bottom of Fig. 11.3, a symbolic representation of an integrated process is presented. In an integrated process, the coordination and communication between marketing, design and production is vital (Andreasen & Hein 1987). This might be a reason for the fact that organizational functions are in focus in integrated product development models, rather than the stages to make a thing. Another reason might be that the leap from previous models to integrated ones was based on the perception that the previous models gave rise to an "over the wall" process (Ullman 2003). An "over the wall" process describes that information emerges within the organizational functions, respectively, and that information then is passed on in a stepwise manner, making the activities separate. This stepwise manner decreased effectiveness and gave long lead-times. The introduction of integrated process models was aiming to prevent this.

Today, commonly, a product life-cycle perspective is important to take environmental design aspects into consideration. Thus, a circle-shaped form can symbolize, for example, that taking care of and/or reducing waste is vital. In such models, the phases recycle, delivery of the product, its maintenance and its use are visualized as additional aspects to consider (see Fig. 11.4). One firm's capabilities and competences are not enough to take care of all life-cycle aspects of a product. For example, taking responsibilities for the products impact on environment, e.g., chosing material and production methods with respect to their eco-friendliness, can be done within the manufacturing company. And, for example, recycling is provided by another company. So, at the same time, the picture of several companies working together cross-company is starting to evolve in the models.

Further, collaborating with other companies is necessary and a reality for many manufacturing firms, since they, commonly, are suppliers or partners in a business-to-business context.

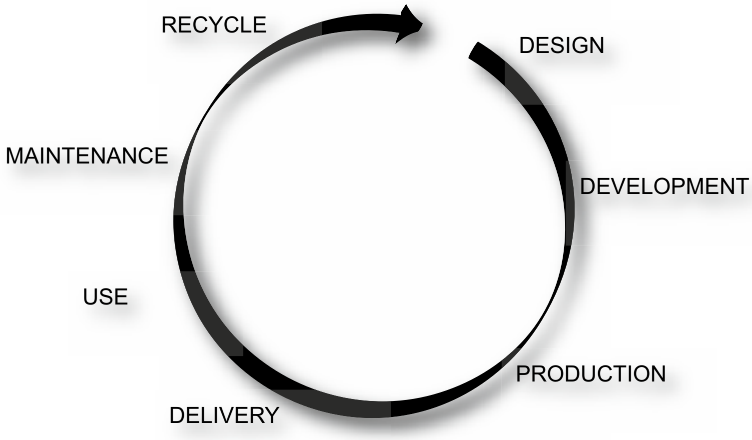

Fig. 11.4 A product life-cycle

11.3.2 Service

For service development, visualization of process models becomes problematic since services are partly produced by the customers and regarded as activities (Grönroos 2000). In this sense, services are partly intangible and unfold in relationships, i.e., people interacting with each other to achieve a goal. Due to this interaction the users are co-producers in services, thus also have an effect on the outcome. Therefore, the customer's own processes are part of the service concept and affect the quality of the service. For example, if maintenance on a machine is planned together with the customer to avoid interrupting their production, the customer will probably be more content with the service. Besides adding flexibility into the service process, the customer decides if the service fulfillls their needs or not. So, the goal of service development is to make up the conditions for the right customer outcome (Edvardsson 1996).

A service offer is built upon three main development components, namely, a service concept, a service process and a service system. The service concept describes the customer needs, and links these to how the service should fulfilll them. The service process describes what has to be working for the service to be produced. Since partners and customers are co-producers in a service process, they are included to some extent in the model (see Fig. 11.5). Within the service company the internal services (middle of Fig. 11.5) shows that a service perspective is used throughout the whole process. That is, the internal organizational functions should also be seen as a supplier-customer relationship. So, even though within the same company, the subsequent process steps in the model are to provide services, for example the marketing department is suppliers to their customer—the design department. And, accordingly, a relationship between these occurs and makes them co-producers for the sake of fulfillling the end-customer's needs which, in turn, are also partners in the service process. A service is always seen from a customer point of view (Grönroos 2000), meaning that suppliers should take the perspective of their customer. "Value adding activities in a business relationship" are words that are generally used to describe the interlinked flows in a service process (Grönroos 2000). Thus, also the internal organization should focus on providing added value to the own company.

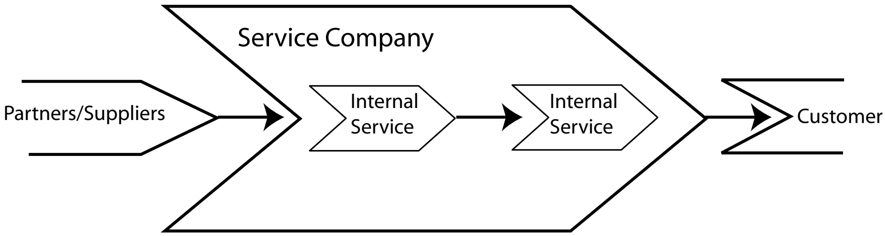

Fig. 11.5 A service process, after Edvardsson (1996)

The service system represents the resources to provide the service, as seen in Fig. 11.6, this model takes on a customer point of view. The customer is placed in the center at the bottom of the model. The line of visibility is an important aspect for service development, what should the customer's see and get in direct contact with, and what should they not. For example, in a restaurant, seeing into the kitchen area can be perceived as positive if it aligns with the need of smelling and seeing the raw-material become a dish. And, seeing the staff taking a coffee break is perceived as negative for customers standing in a line waiting for their turn (Edvardsson 1996).

Looking at the service resources from a manufacturing firm perspective and for the sake of adapting a PSS business illuminates at least three issues to consider. First, the customers, be they partners in a business-to-business relation or "ordinary" customers, have to change their way of communicating their needs. They have to go from talking about what kind of physical device they require, to expressing what kind of performance they would like to achieve. Also, the supplier or the manufacturer has to have a successful way to find the basic needs in these expressions. Second, the organization has to adapt a service perspective. This highlights that, for example, having a product structure might be a barrier. A product structure can prompt people to regard the company as a provider of those specific things. Third, the culture has to change into a service culture. A simple interpretation of this is that all connections and relationships should be seen from a customer point of view, no matter whether they are internal or external. A culture can be described as the result of different actions over a long period of time, thus cannot be instilled overnight nor fully managed (Grönroos 1996). For a firm focusing on producing excellent goods and providing additional services to complement those devices, the cultural change will be a really challenging issue. This is particularly true, if the development processes are firmly focusing on the commodity as the main carrier for customer value and services are, more or less, something developed haphazardly. Starting from scratch in such a situation, what actions are needed to build up service experiences? Requisites for a service culture concern, not only organization and strategy, but also management, knowledge and attitude (Grönroos 1996). These issues, it can be argued, concern people and their views on the world. Hence, to instill a service culture, the motion towards it has to be built bottom up deriving its origin from individual perceptions and thinking. A suggestion would be that the shift into a PSS business needs some service perspective training and education for product developers.

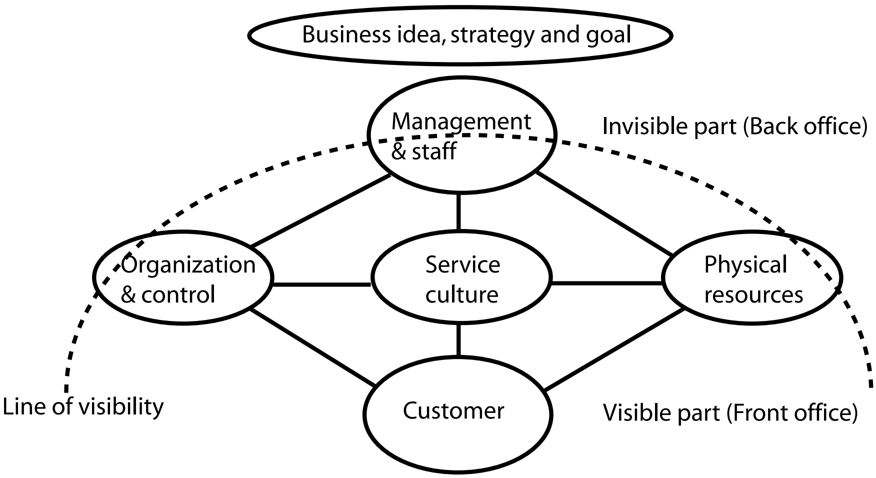

Fig. 11.6 A service system, after Edvardsson (1996) and Edvardsson *et al.* (2000)

The physical resources (middle row at right in Fig. 11.6) are, from a service perspective, focused on the equipment, premises, technical systems, etc. (Edvardsson *et al.* 1996). From a service perspective, this means that all actors' resources are included in the production process, e.g., partners, suppliers, customers and so forth. For instance, the service provider—a hotel—can provide a wireless internet connection, and the customer—a hotel guest—brings his or her own laptop to make the service complete. In a PSS context, the product, which is traditionally sold as the discrete device, becomes part of these physical resources. Taken to the extreme, the manufacturing firm develops products for their own users (compare the total functional offer at the top in Fig. 11.1), but for some other's needs.

In service literature, “invisible services,” i.e., activities hidden in the production processes and not seen by the manufacturer as a competitive advantage (Grönroos 2000) are stressed. One example could be expertise about material properties and their behavior when machined in the users’ processes. This is often added value for customers and can be a main reason for buying products from the company, while this might be unknown for the seller. Today, services are hidden and not visible in manufacturing companies. But, for a future PSS situation, if the goods are seen as “just a resource among others,” this could bring about ‘hidden products’ instead. This is a reason for understanding the perspectives, respectively, and to take in several perspectives in supporting models.

11.3.3 Systems

A PSS business firm is forced to understand services, use and performance in a more holistic way than in a classical product situation. As denoted in the PSS concept, the products and services have the companionship of “systems.” Already, in 1968, Ludwig von Bertalanffy stated that the concept systems had become popular in all fields of science and made its way into popular thinking, jargon and mass media. And, still, used in everyday language, the word system can be used to label all sorts of systems, a software application can be a system, the roads and traffic signs are systems, and the laws and regulations in a society are yet another system. Within the area of systems theory there are different types of systems, for example, abstract or concrete, but also, for example, natural or designed. These different systems cannot build up the same system, therefore the interfaces between systems, that is how they are linked and how they have an effect on each other is an important issue for understanding wholes (Checkland & Holwell 1998). Socio-technical systems, for example, comprise a human system (yes, we can be seen as a biological system) and a designed system. The interplay between these systems is in focus for a development process built on a socio-technical view, e.g., in the development of a dashboard in a car it is vital to understand what actions the alert signals are prompting humans to do.

Taking in a systems theory view, a system comprises a set of interdependent real or abstract entities that forms a whole (Checkland & Scholes 1999, von Bertlanaffy 1968). Archetypically, a system is described as having an input, transformation process, an output, a feedback loop and a boundary (see Fig. 11.7). Thus, in the example of the dashboard above, the input for the dashboard can be a signal from the engine in the car, which is transformed into a red light alert as dashboard output. The transformation process is not a “magic box” (Checkland & Scholes 1999), what goes in (in the example—a signal) comes out even though in a changed form (another type of signal). It is acknowledged that engineered systems exclude, for example, social structures and ecosystems (Kossiakoff & Sweet 2003). Thus, the input of a discrete device cannot be transformed to the output of a service and vice versa. So, sad to say, the integration of product and services will not as a default come true by putting in them in the context of one system. Here, one implication for PSS seems to be found in the basic idea of integrating products and services into a system.

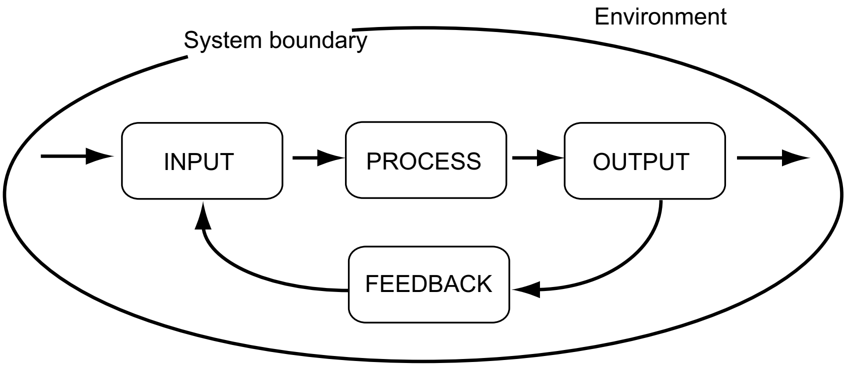

Fig. 11.7 A generic system model

A hard systems view and a soft systems view are used to differentiate between two fundamentally distinct logics. Commonly, an engineering perspective focuses on technical processes, builds on the hard perspective and strives to understand causes and effects. From this point of view, the product developer is encouraged to focus on problem solving and decision making. The generic systems model in Fig. 11.7 is useful for understanding causes and effect, but the transformation process is not transparent, i.e., takes the role of a "black box." A hard view is apt to deal with technical systems, but has been found as delimiting to handle social processes, i.e., the activities performed by human beings (Checkland & Scholes 1999). Thus, a soft perspective is recommended and, in turn, this changes the appearance of the system model. In Fig. 11.8, an activity system model is outlined, i.e., a conceptual model to enable dialogue between actors. These kinds of models emerge in the dialogue as a tool to give insights into different reasoning about the problematic situation.

When drawing a conceptual model, the underlying rationale for the activities, or the worldview of the actor, is important to elaborate on. This worldview is what makes the activities meaningful for the actor; note that the same activities can be seen as irrelevant for another actor. Therefore, making activity models based on each worldview is recommended. Then, the activity models can be seen as a "logical machine" that can be used to make people aware of their different perspectives, and from those distinct worldviews take collaborative actions. The activities put into the model should be based on verbs and linked to describe the activities (Checkland & Scholes 1999). Thereby, a soft system view strives to open up the "black box" and make the transformation process transparent, i.e., outline the meaningful activities humans do to change their situations into a new preferred one. In the example with the dashboard, the perspective here changes to the human activities that the red light will prompt. Some people might find the activity to immediately hit the breaks as meaningful, while others might find it more appropriate to go to the nearest garage, and also, there may be people that have a reason for ignoring the alert. A conceptual model can reveal the underpinning ideas that make people behave in a certain way. To make sense of users or customers, but also team mates in a multidisciplinary team, the practical use of comparing and contrasting several conceptual models has shown useful in a number of development cases (Checkland & Scholes 1999).

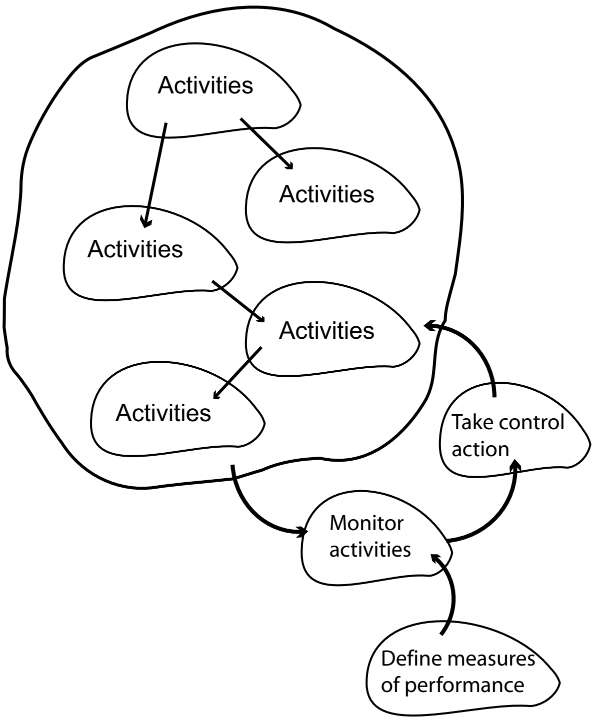

Fig. 11.8 An activity systems model, after Checkland and Holwell (1998)

11.4 A Multiple Perspective on PSS Development

From an engineering perspective, the implementation of PSS business calls for the engineer's insights into three main types of models, namely models for products, models for services and models for systems. Being *exposed* to customers is a daunting task for an engineer. Engineers are commonly used to do field tests, in these the device is in focus and used as a mediating tool to communicate with customers. The choice of the word "exposed" comes from empirical data generated in industry and gives some ideas for what the engineers feels about entering the field of customer interaction. Yet, the importance of involving those that should propose a technical solution, e.g., engineers, designers, and/or developers, in the early phases of understanding human activities and needs was identified a long time ago (Faste 1987). Still, such an approach is implemented in a few industrial cases. Some spokesmen argue that the barriers are found within the delimitations in the ways of thinking about product development, and also, the attitude among engineers (Kelley 2001).

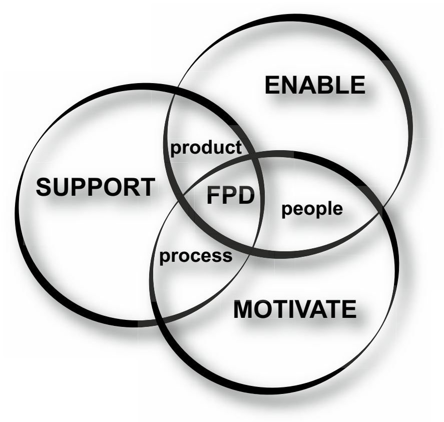

Fig. 11.9 An FPD perspective model for PSS development

In general, the designer or engineer is trained in problem solving, thus seeing users as a problem to be solved, instead of a source of creativity (Kelley 2001). Also, the trained problem solver has a tendency to jump into solutions (Patnaik & Becker 1999), without understanding the "real" problem or human behavior. Due to the service perspective in PSS, the innovations should emerge from customers/users needs, rather than merely on technology innovations within a company. So, one implication to implement PSS is to train engineering designers to feel comfortable in interaction with customers. Also, engineers have to be trained to "switch on and off" their technical skills, depending on whether they are looking for needs or if they are generating solutions. Bridging the distinct logics of services and product development into a cohesive "logical machine" for dialogues in team-based innovation projects is another suggestion. If such a model emerges the communication in and between teams would be supported. An important aspect for a product/service integrated team is that they need to be able to understand each others' perspectives, and they also have to be able to build a shared understanding based on them.

Based on the argumentation in this chapter, a frame of reference for the progress of a PSS development model is presented in Fig. 11.9. This frame of reference could guide the development of models to incorporate multiple perspectives. FPD (Functional Product Development) in the middle of the figure, represent a modern product development process for PSS. PSS is not put in the middle because the research perspective on PSS is broader than engineering design. And, also industries name their PSS intentions differently, for example, total care, through life capabilities and soft products. Thus, FPD is chosen to represent an engineering development point of view, thus the focus for such modern product development is to bring in service aspects in early phases.

The frame of reference proposed in Fig. 11.9 visualizes that at least three perspectives have to be considered, namely people, process and product. Taking these perspectives, the engineering team is likely to be able to combine, build on, and refine ideas for new PSS solutions, for example, whether they take the point of view of people (the actors at the customer), process (the customer's processes), and product (what meets the customer's goal and objective). Going to the outer circles, the team can consider what motivates (e.g., finding needs), what supports (e.g., benchmarking existing solutions) and enables (e.g., identify resources) the situation from the three perspectives, respectively.

Even this framework can be differently interpreted and used. From a research perspective the framework describes research areas for PSS development. In this view, the outer circle address three main areas that calls for attention: (1) the development team should be supported, for example by tools, methods, methodologies; (2) the team's work should be enabled, for example, by relevant knowledge, expertise, information; and (3) the team activities should be motivated by, for example, creativity, collaboration, and communication. All these research areas should also be addressed from the perspectives of people, process and product.

11.5 Implications and Suggestions for Industry

This chapter has illuminated a number of implications for the realization of PSS. At the heart of PSS is the provision of added-value to the customer, hence a suggestion for realization is to focus efforts to bring in users and customers into the early phases to increase value development. First, PSS involves going from a product perspective to a service perspective. A service perspective means that it becomes necessary to initially understand users/customers as well as their goals and achievements, i.e., needs, in a completely different way. A recommendation for connecting such needs to the solutions is to let product developers take an active part in gathering information about the users. Here, the implication is that the contemporary engineer is trained to be a focused problem solver, yet PSS development also requires the engineer to be skilled in *defining* the problematical situation on a level that takes more than the commodity into consideration. In practice, the marketing and the engineering staff interact with users/customers with different agendas and from different points of view. Marketing are those generating the initial information from users/customers, while the design engineers mainly are responsible for field tests of products. Such a situation also means that it is the marketing people that initialize and frame the technical solutions, and not the trained engineers.

Second, product development models and service development models convey distinct logics, and they are interpreted from divergent conceptions and worldviews. Bridging these distinct perspectives is vital, and not trivial, for PSS development. Making the core ideas for each view visible is a suggested initial step. Practically, the existing models within the company for service development and product development, respectively, have to be used as a basis for conversations in project teams striving to work together. At first, preserving the basic models separately can make the similarities and differences apparent, but also, support understanding for where the dilemmas for PSS lie. Doing so, it seems likely that an interrelated model, that takes both perspectives into account, will emerge.

Third, based on the discussion that system models provide no "magic box," one implication concerns the basic idea of integrating products and services into a system. In view of a service culture (Grönroos 1996), this system should conceptualize a service system. At this level, the whole company will be challenged to develop new models not only for the development, but also for organization, business, management, project, partnerships, etc.

11.6 Suggestions for Further Research

We have not considered PSS from a service research area, however, this is not neglected. Scrutinizing engineering design and product development with service glasses on has proven to contribute to the understanding (e.g., Fransson 2004), a continuation of this research is anticipated and encouraged. Further, besides an effort for further research on process and system models, there are other areas within the engineering design that we would like to suggest for future studies.

The service engineering area is a promising way to put forward support, based on computer applications. Here, the simulation of service activity flows (Sakao *et al.* 2007) is interesting. Putting such simulations into the hands of product developers in the early phases of the development of the discrete device seems practical, yet the gap between a service mindset and an engineering mindset, visualization of results seems a key issue. A typical engineering concern might be how the decisions made for the device per se are likely to affect the customers' perceptions of the service provision. That is, the engineer has to start studying PSS from an engineering point of view to try out and understand different solutions for how to provide services.

PSS development opens up for innovations in a more radical way than classical product development. By the same token, it also challenges the processes to deal with a ubiquitous and deliberate innovation process. Many breakthrough products have their origin in mistakes or become true thanks to informal management. In the innovation research area, going from how individuals can be encouraged to step out of their comfort zone via the facilitation of creativity in teams to changes in management styles, is of utmost concern. Finally, the academic education of engineers seems to call for a new curriculum. The future engineer has to be trained to think, communicate and work in a different way, that is, possess the qualities necessary to deal with multiple perspectives to support PSS innovation.

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Chapter 12

Managerial Recommendations for Service Innovations in Different Product-Service Systems

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Abstract In order to meet the increasingly complex needs of customers and to respond to decreasing product margins, typical product manufacturers have developed a growing interest in extending their service business. The extension of the service business requires a systematic development of innovative services. Unfortunately, in business practice it has been observed historically that manufacturing companies often fail to develop services systematically. Some customers asked for services and these desires were often fulfillled. Thus, the extension of the service business reflects a rather unstructured service innovation approach, which has not been consciously pursued. Rather than developing more formal structures to elicit ideas for new services, it is mostly performed ad hoc. Only a limited number of firms use formal approaches to service innovation and have implemented necessary determinants to success. Furthermore, the innovation of services in manufacturing companies captures two specific idiosyncrasies. First, manufacturing companies have to balance product and service innovations. Second, services can be either developed during the product development process or during the product usage. The major challenge to success in innovating services is to combine specific product-service systems with the right service strategy and way to develop service innovations.

Keywords Service innovations, Product-Service Systems

12.1 Introduction

In many industry sectors the year 2007 was one of the best ever, but 2008 and 2009 have the potential to become very tough years. In a very short time period, excellent profits have turned to losses and lay-offs of personel. Companies continue to worry about their long-term efficiency and performance. In many cases, the service division is the only part of the company that provides any return on investments. But to continue to improve the share of service revenues there is a need to develop service innovations on a regular basis. In many markets there is a lack of service innovations, which represent a vital lever in terms of earnings. This lack of service innovations is a direct threat to the profitability of industrial companies. But there are exceptions, the mid-sized specialist for measuring instruments, Testo, increased its total sales by 17% to 144 million euros in 2007. Hilti, the global business partner for construction companies, increased its sales by 26% to 4.7 billion Swiss francs while improving its operative margin (EBIT) to 12.1%. In these two cases, service innovations are a key driver of this success and with the examples of Testo and Hilti, service innovations, measurement and calibration services, and fleet management all have a vital part to play in this profitable growth. In Testo's case, the specialist service provider Testo Industrial Service GmbH (e.g., calibration, qualification, training, etc.) experienced a sales growth of 21% and thus outstripped the growth rate for the product business. Hilti's fleet management accounts for up to 40% of total sales generated in the individual markets.

The motivation for companies to develop service innovation can be summarized in three main factors (Oliva and Kallenberg 2003, Neu and Brown 2005, Martin and Horne 1992). Firstly, services follow on from strategic considerations. From a customer perspective, the fleet management example at Hilti ensures improved fleet transparency, reduced idle time and simplified budgeting. It also opens the door to the following strategic options: displacement of competitor products, an increase in related consumable sales, and improved customer loyalty. So from a strategic perspective, services can be used to differentiate a company from the competition while also being a vital source of information. The service staff have regular contact with customers, which gives them an opportunity to gather valuable information about customer needs and expectations. This information then flows into the development of new services and products, and often forms the basis for long-term competitive advantage.

Secondly, services have a large financial potential. While the profit margin for products may be somewhere in the region of 2 to 3%, industrial companies with product-related services (e.g., spare parts, repairs, and maintenance) can generate an operative margin of up to 20% or in some cases even more. Considering successful practice companies such as Kone, IBM or General Electric with service revenues of 50% or more of the total business, it is clear that services have the potential to improve overall profit margins of a company's business. Service sales also tend to fluctuate less than product sales with high levels of new investment in products strongly linked to economic development, thus making them highly volatile. This can be seen in the results of the Swedish truck manufacturer Scania. In the last quarter of 2008, the orders for new trucks dropped by 91 % while the sales of service increased by 3%. The relatively low investment levels for services are far less volatile, companies can postpone new investments in machinery but cannot put off buying spare or wear parts.

Thirdly, services have to follow the changing customer needs. Where customers were once happy for product faults simply to be rectified, in future they will expect faults to be prevented and demand support when it comes to increasing product effectiveness and efficiency within the customer process. In addition, customers want to reduce their capital commitment as well as receive increased support in the form of solutions to problems, and at the same time benefit from the service provider's development skills.

Despite this potential, industrial companies are faced with major challenges when it comes to service innovations. The priority in many companies is a focus on product innovations, while there is a lack of resources devoted to service innovation. Often the service idea is communicated using brochures and catalogues, but the actual development of the service only really takes place if the customer asks about the service communicated in the brochure or catalogue. This ad hoc service development as a response to a specific customer may not fit with the existing Product-Service System. For these reasons, in many companies sales of developed services fall short of expectations and the reliability and efficiency of service delivery may be low.

In order to develop the service business of a firm, align it with the existing product business and to secure that service innovations are introduced in the market in a steady stream companies need to answer two questions:

- In which Product-Service Systems can we promote innovations?
- How do we need to align service innovations to the selected Product-Service Systems?

Based on the present problems with service innovation, the objective of our chapter is to show how manufacturing firms can overcome these problems by aligning their way to develop service innovations with the existing Product-Service Systems and the service strategy. Dependent on the chosen service strategy we provide guidelines for how to develop service innovations, what phases of the development process to focus on and how to involve customers throughout the development process.

Next in the chapter the problems that are related to service innovations in a manufacturing context are outlined. This is followed by a description of different service strategies that a manufacturing company could use. Different innovation strategies are then related to the different service strategies. The chapter is then summarized.

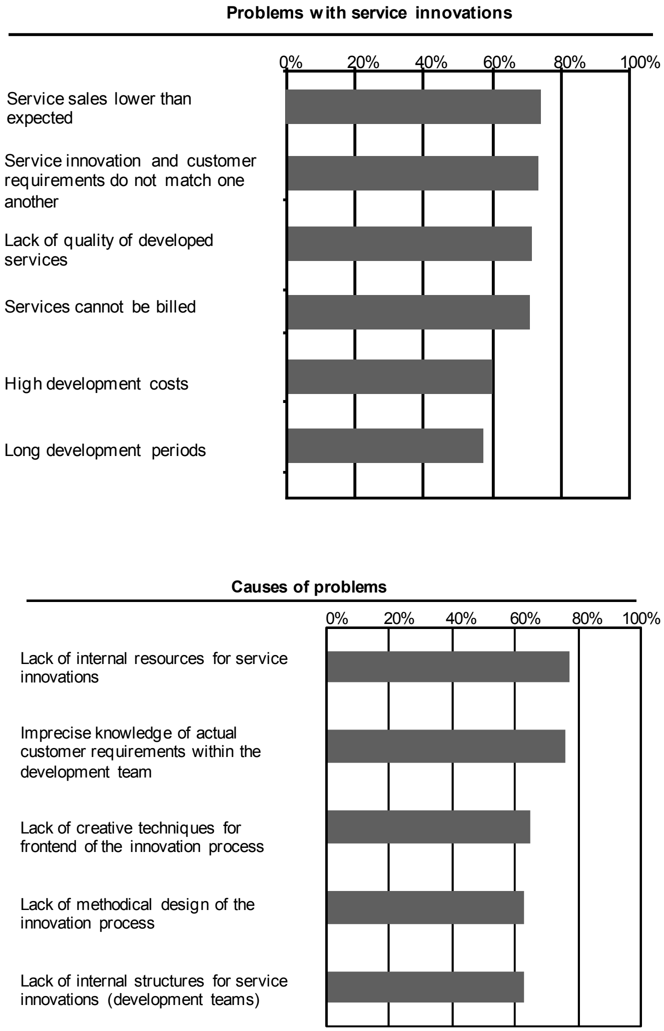

Fig. 12.1 Problems and causes—service innovations (n=123)

12.2 Problems with Service Innovations

It has become inherently more difficult to compete and differentiate a company's offerings in the market place using pure product systems. Service innovations have become essential to differentiate Product-Service Systems. The problem is that there are few systematic approaches on how to conduct service innovation. It seems more common for a manufacturing firm not to have a systematic approach to develop new services compared to having one. Consequently, many industrial companies face major challenges when it comes to service innovations. There is, for example, a lack of models for how to conduct service development, the service concept is developed in a development project, while the operationalization of the service only takes place if the customer orders the service. Additionally, a rather unstructured ad hoc service development may lead to a mismatch with the existing product-service system and conflicts in the strategic directions of product and service business. This is the case, for example, when strongly promoted spare parts and breakdown repair services meet with high quality product reputation or when advanced preventive maintenance services to optimize customer processes meet with a low priced product strategy.

In a survey of 123 European industrial companies carried out for the purpose to better understand service innovations, the companies revealed that the developed service and customer requirement did not always match one another, that the service quality was below par, and that the services are difficult to calculate. The causes of these problems can be attributed to a lack of internal resources, structures and defective methods throughout the innovation process. In addition, there is a general lack of understanding for what the customer actually needs, and very few creativity techniques are actually used to generate ideas (Fig. 12.1). It is also revealed that the scope of service innovation might need to be widened to include business models, service delivery and finance. We argue that some of the causes to these problems can be eliminated by aligning the way to develop service innovations with the existing product-service systems and the service strategy.

12.3 Product-Service Systems and Corresponding Service Strategies

Services can be categorized using the selected service strategy and product-service systems. A service strategy comprises the service offering and categorization within a growth portfolio for how to expand the business. Each service strategy reflects a specific Product-Service System, where a service offering and a product offering correspond with each other. The growth portfolio consists of two dimensions. The first dimension shows where there is growth potential and differentiates between primary and supplementary customer activities. Primary customer activities have a direct link to the offered product and thus have an effect on its functionality and availability. These primary activities can generally be split up again into presales, sales and usage phases. Supplementary customer activities are not directly linked to the product and thus have no direct effect on the functionality and availability of the product. Typical examples of such activities include logistic or administrative customer processes. The second dimension describes how growth potential comes about. Growth potential can, on the one hand, be generated by extending the service offering for customer activities, while, on the other hand, it can be created by shifting responsibility for performing customer activities and processes to the service provider.

Maintenance is an example of a primary customer process with activities such as cleaning, inspection or repair. Companies can achieve profitable growth either through maintenance agreements or by taking on maintenance tasks. When it comes to innovating maintenance agreements, a company supports the maintenance customer process. If maintenance tasks are taken on, the service provider carries out maintenance activities on the customer's behalf, meaning that the maintenance process has been outsourced. Training for machine operators is one such example of service innovations within supplementary customer activities. When recruiting temporary personnel, the customer outsources the training process to the service provider. The service provider then trains its own personnel. The staff are then recruited and operate the machines with the service provider bearing the responsibility should the machine be operated incorrectly.

It is not possible to fully distinguish between primary and supplementary customer activities. Companies have to decide as to which activities they see as being primary (support for the functionality and availability of the product) or supplementary (no direct link to functionality and availability of the product).The combination of both dimensions results in five potential service strategies that we have called "After-Sales Service Provider," "Customer Support Service Provider," "Development Partner," "Supplementary Service Provider" and "Outsourcing Partner" (Gebauer 2008*,* Gebauer *et al.* 2008) (Fig. 12.2). These five service strategies are described below by way of short examples.

The *After-Sales Service Provider* supports customers when using products and ensures that product faults are remedied. After-sales service providers form a value proposition by providing products at attractive prices and guaranteeing a proper functioning of the product through after-sales services. Because of the unbundling pricing approach, the customer can choose after-sales services that are really needed. The customer can compare the prices for services and obtain price discounts. The service offering comprises spare and wearing parts, repairs, inspections and troubleshooting. One such example is Mikron (a manufacturer of production solutions for companies that produce goods in very large quantities), which focuses on basic services such as spare parts, repairs, inspections and commissioning. Mikron's service organization is set up in such a way that it can quickly and reliably react to product faults.

The *Customer Support Service Provider* also concentrates on expanding the service offering within product usage. Instead of merely reacting to faults, the Customer Support Service Provider focuses on services that prevent product faults, including those that lead to an increase in product availability within the customer process. Their market consists of customers who are looking for outstanding product quality. Product performance and reliability are the main purchasing attributes. Customers not only invest in reliable products, but also increasingly demand services that increase the efficiency and effectiveness of the product in the post purchase phase of operating Customer Support Service Provider's products. Compared to After-sales Service Providers, Customer Support Service Providers are not faced with such a high competitive intensity in terms of price competition and intensity of price discounting. Customer Support Service Providers are still able to achieve elements of the differentiation through technical superiority.

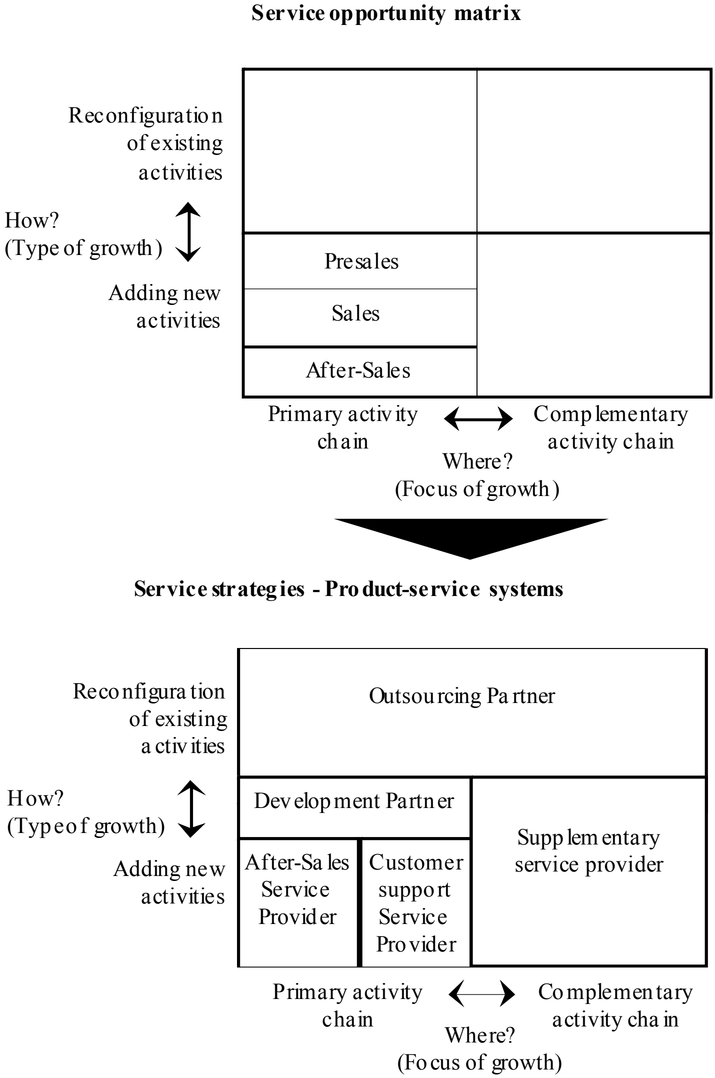

Fig. 12.2 Growth portfolio and service strategy

Typical examples of such services are preventive maintenance, maintenance agreements and process-oriented optimization. Trumpf, a company focusing on production and medical technology, promotes a service plus concept in its role as Customer Support Service Provider. This concept is limited in a very small part to fault elimination while its main focus is on avoiding faults and optimizing the efficiency and effectiveness of Trumpf products. The combination of above-average product quality with the service plus concept allows for a targeted improvement of the parameters MTTR (Mean Time To Recovery) and MTBF (Mean Time Between Failures). On an individual level, Customer Support Service Providers carry out individual customer activities such as maintenance, cleaning or repairs. In contrast to the Outsourcing Partner, however, the Customer Support Service Provider does not cover the entire maintenance process.

A *Development Partner* tends to offer services in the phase prior to the actual product acquisition. Its customers expect specific solutions for the operating processes. A greater specialization of customer processes and a clearer definition of operating processes as core competencies seem to be the drivers for a higher demand on innovative solutions for customer processes. Development Partners also report that competitive equality has been reached in the field of products and after-sales services, leading to essentially greater competitive intensity. Sustainable competitive advantages derive mainly from designing individual solutions for customer processes.

A Development Partner does not just develop its own products, it also offers customers its development skills as a service. Such companies position themselves in the area between development activity support and shifting responsibility for performing individual development activities. Knowledge-intensive services such as customized design or supporting research and development tasks allow Development Partners to align themselves as strategic partners to the customer. By creating a customized design or development, specific knowledge is transferred between the customer and Development Partner. This knowledge is hard to replicate and therefore makes it difficult for competitors to gain access to the customers. When it comes to these services, the customer outsources certain activities within the development process to the Development Partner. One such example is that of the automobile supplier Magna-Steyr, which supports vehicle manufacturers from the vehicle design stage through to the ready-for-series production stage, i.e. it offers them the opportunity to outsource certain development tasks. Despite an increase in vehicle manufacturer quality requirements from companies such as BMW, Chrysler, or Peugeot, Magna-Steyr as a Development Partner has succeeded in reducing the product creation process. Magna-Steyr targets automobile manufacturers with a broad range of development services for vehicle assembly/equipment, engine installation, drivetrain, design and electrics/electronics. Together with customers such as BMW, Chrysler, and Peugeot, Magna-Steyr acquires knowledge in terms of optimizing vehicle development with a view to subsequent series production. Competitors such as Karmann struggle to keep up with these advances in knowledge.

Supplementary Service Providers focus on services in supplementary customer activities that have no direct effect on the product's availability and functionality. Fraisa, a manufacturer of cutting tools, is a typical example of a Supplementary Service Provider. As well as actually carrying out the cutting process, customers need to select the right cutting tools and optimize the range of tools. Fraisa uses the service innovation ToolCare® to address customer requirements of supplementary activities such as financing certain tools, optimizing their range of tools, and assuming logistics tasks. ToolCare® is an integrated holistic service for cutting tools and is aimed at customers who want to reduce their capital commitment and costs for cutting tools. With these services, Fraisa is positioned between expansion of the service offering for supplementary customer activities and the assumption of individual customer activities.

Outsourcing Partners take on the responsibility of carrying out an entire customer process, which may consist of primary and/or supplementary customer activities. Hilti's fleet management illustrates the opportunities that can be gained by taking on the supplementary administration customer process. At Hilti there is an overlap between the Outsourcing Partner and Supplementary Service Provider. Voith Railservices B.V., on the other hand, takes on the maintenance of rolling stock and is an example of outsourcing primary customer processes. The assumption of responsibility for an entire customer process enables customers to pay exclusively for the rendered service. One such example can be found in the automation systems industry with the company ABB, which carries out maintenance work at the nine Nokia plants in Europe. Here, outsourcing maintenance is not just limited to in-house automation systems, it also covers production plants from other manufacturers. The assumption of maintenance tasks by ABB allows Nokia to reduce its fixed costs for in-house maintenance and thus leads to an improvement in OEE (Overall Equipment Effectiveness). ABB's billing for maintenance takes the improvement in OEE into account.

An Outsourcing Partner combines cost leadership with service and product differentiation to offer attractive prices for operational services. The goal is to assume the operating risk and full responsibility for the customer's operating processes. The value proposition is simply based on reducing the customer's capital employed and managing the corresponding risks. In contrast to Customer Support Service Providers, Outsourcing Partners do not create customized service packages. Operational services are standardized and focus on efficiency, economies of scale, and the belief that service customization is costly. However, offering attractive prices for the performance of the outsourced process without a sufficient product and service quality is insufficient. If the product breaks down frequently, troubleshooting, repairs, and spare parts will increase service costs, leading to a possible erosion of overall profitability.

Table 12.1 provides a summary of the five service strategies including company examples and describes the value proposition and focus of the service offering. The first column contains the service strategy. In our studies of European industrial firms, the Customer Support Service Provider category heads the list with

35% while 32% of companies concentrate on remedying product faults as an After-Sales Service Provider. 13% of companies have positioned themselves as a Development Partner and 12% as a Supplementary Service Provider. Only 8% of companies focus mainly on outsourcing services (Table 12.1).

Table 12.1 Description of the service strategies (Product-Service Systems)

Service strategy (PSS)	Value proposition	Focus of the service offering	Company examples of PSS
After-Sales Service Provider	Remedying product faults	Spare parts, repairs, inspections, hotlines, installations, commissioning	Mikron (manufacturing technology and assembly automation): Joint development of repair service and technical inspection to combine knowledge from product development and product sales (product functionality and product use)
Customer Support Service Provider	Avoiding faults and increased efficiency and effectiveness of customer processes	Preventive maintenance, process optimization, extensive user training	Trumpf (production and medical technology): Combination of above-average product quality with service plus concept focusing on avoiding faults and optimizing product efficiency and effectiveness
Development Partner	Reduced development times and costs with higher quality at same time	Development and construction services	Magna-Steyr (automotive systems): Total vehicle concept development service for vehicle manufacturers where knowledge in terms of optimizing vehicle development with a view to subsequent series production is acquired together with customers
Supplementary Service Provider	Wide coverage of customer problems and high customer loyalty	Supplementary services without any direct effect on product functionality and availability	Fraisa (cutting tools): Integrated holistic service ToolCare® to address customer requirements of supplementary activities such as financing tools, optimizing the range of tools, and assuming logistics tasks
Outsourcing Partner	Reduced capital commitment and continual improvement of the outsourced processes	Assumption of customer processes (e.g., maintenance, operator models ...)	Hilti (professional construction tools): Fleet management service for customer's tool fleet taking over the supplementary administration customer process including services such as repairs and device exchanges Voith (machinery and equipment for paper, energy and mobility industries): Voith Railservice offers maintenance of rolling stock and incorporates responsibility for technical availability ABB (automation systems): Maintenance for Nokia production plants which is not limited to in-house ABB automation systems to reduce Nokia's fixed costs and improve overall equipment effectiveness

12.3.1 Determinants to Success for Service Innovations

The success factors for developing services concentrate either on the management of key activities in the new service development process or on the creation of a climate for continuous innovation. Managing key activities enhances an effective implementation of new services. It includes different organisational characteristics that directly improve the development of services. Some of the organisational characteristics aim at the role of key people and formal structures that are most suitable for new service development (de Jong and Vermeulen 2003).

Management support represents the first people-related success factor for an effective implementation of new services. It is important that senior management constantly encourages service innovation. De Brentani (2001), for example, states that it is important to provide leadership to stimulate moving into "uncharted [service] areas." According to de Jong and Vermeulen (2003), management support is all about the daily behaviour of managers who are responsible for key activities in the development process. Several scholars argue that managers should not only emphasise the importance of innovation, but also encourage creative behaviour and the development of ideas. Furthermore, Schneider and Bowen (1984) and Van de Ven (1986) argue that those who are responsible for sales and service delivery usually play an essential role in innovating new services. For example, frontline employees' knowledge of customers and competitive offerings support firms in defining the appropriate level of service customisation (Martin and Horne 1993). They usually have an excellent perception of latent customer needs and are able to recognise opportunities for innovations (de Brentani 2001, de Jong and Vermeulen 2003). Research in service firms indicates that the existence of a "service champion" is another people-related success factor in organizing new service development. Service champions play a critical role in the implementation stage of an innovative development project. Thus, successful firms are more likely to use and keep service champions (de Jong *et al.* 2005).

Structure-related success factors refer to using specific funnel tools and multi-functional teams as well as the availability of resources, market testing and market research. De Brentani (2001) recommends formally structuring the market launch as a part of a new service development process. Market testing reflects the extent to which firms undertake service testing, personnel training, and an internal and external promotional programme during any new service launch. Market research helps firms to gain a better understanding of customer needs. It allows firms to design services packages to fit different customer profiles (Storey and Easingwood 1993). Formal market tests create customer feedback for evaluating and further redefining new services (de Brentani 2001). Specifically, de Jong *et al.* (2005) stress that service firms should not completely refrain from testing new services. Service firms should evaluate new services with early adopters and use their feedback to further refine the service concept, delivery system, etc. The availability of resources includes time and money that are necessary to develop new services (de

Jong and Vermeulen 2003). Multifunctional teams also contribute to the overall effectiveness of service development. Funnel tools also contribute to development success. They include formal systems and tools to trigger and channel employee creativity. Typical examples are creativity techniques such as brainstorming, screening instruments for the identification of promising ideas, and rules and procedures to guide the development process (Scheuing and Johnson 1989). Scholars also recommend establishing a formal and planned development process.

The essential feature of the planned development process is that at regular moments in time, selection of ideas (by individuals not involved in the development themselves) takes place. At such points, progress can be monitored and (additional) resources can be committed (Tidd *et al.* 2001). Thus, firms with outstanding new service products use planned stages such as carefully mapping or "blueprinting" alternative processes (Shostack 1984).

In order to develop services successfully, people- and structure-related success factors for managing key activities are not sufficient (de Jong and Vermeulen 2003). Successful services also require success factors to create a climate for continuous innovations. Again, de Jong and Vermeulen (2003) distinguish these success factors according to people and structures. The latter refers to strategic focus, training and education, internal organisations and information technology (IT). Strategy provides a firm with general directions for the future. Strategic focus to innovation keeps a service firm from viewing innovation as an ad hoc process and provides guidelines for the distribution of resources (Cooper *et al.* 1999). Strategic focus is important for planning and introducing new services which enable the firm to sustain its competitive advantage (de Brentani 2001). According to de Jong and Vermeulen (2003), the knowledge and skills of current staff, in general, and those who are responsible for implementing innovation, in particular, should be improved through training and education. However, it is the lack of detailed knowledge about trends and developments in a firm's basic technologies, customers and delivery processes which normally constitutes the barrier rather than the shortage of qualified development staff. Furthermore, several scholars highlight the great importance of the internal organisation in creating a more innovative climate. Specialised innovation departments and job rotation, for example, are important triggers for enhancing a firm's creativity (de Jong and Vermeulen 2003)

Having an open culture within the firm is generally considered to be relevant for an innovative climate. Developing services require a corporate environment that encourages and supports openness, creativeness and "stepping out" beyond the norm (de Brentani 2001). People-related success factors to create an innovative climate include external contacts, information sharing and employee autonomy (de Jong and Vermeulen 2003). Frequent external contacts pave the way for opportunity exploration and the generation of ideas (Martin and Horne 1993, de Brentani 2001). If information is shared rather than protected between departments, this enhances the firm's innovation climate. The last people-related success factor refers to providing sufficient autonomy. In an organizational culture that stresses autonomy, employees are allowed to do their work freely and independently. They can choose their own approaches as to how to do their work. In the context of service development, the amount of autonomy that is perceived by coworkers is associated positively with their innovative efforts (de Jong *et al.* 2005).

Based on the the rich literature on success factors for service innovation we have developed recommendations on how to deal with them in the context of different service strategies.

12.4 Aligning Service Innovations with Service Strategies

Below are a number of dimensions used as parameters for how to set up and run development project for service innovations dependent on the service strategy of a firm. The dimensions can be split into the following points:

1. Determination of responsibilities within the innovation process (e.g., product development, product and service management, sales organization with product, and service sales)
2. Division of the innovation process into individual phases (e.g., brainstorming, development and market launch) and the subdivision of the phases into single steps (e.g., brainstorming: generation of ideas, evaluation and selection of ideas; development: basic concept, business plan, detailed concept; market launch: market testing, market preparation and market release)
3. Contextual design of every step along the innovation process
4. Specification of the company divisions or customers that need to be integrated into the individual steps of the innovation process

The following image (Fig. 12.3) is a typical outline of the parameters of a Customer Support Service Provider's innovation process. The guidelines offered for aligning service innovations with service strategies comprise the various recommendations of success factors for service innovation.

12.4.1 Service Innovations with After-Sales Service Providers

With an After-Sales Service Provider it is recommended that responsibility for the innovation process and service innovations be anchored within product management. During the brainstorming phase, new service ideas are generated during the course of a workshop-driven process. Product management, product development and product sales are all part of this process. The workshops conducted involve typical product faults and potential service ideas designed to remedy the fault. The innovation process then continues with the development and market launch phases. The brainstorming phase can be split into idea generation, evaluation and selection. The development phase only involves a basic concept being drawn up and contains a description of the actual services and definition of the processes to provide and market the service. During the market launch phase, the sales organization and market launch are prepared.

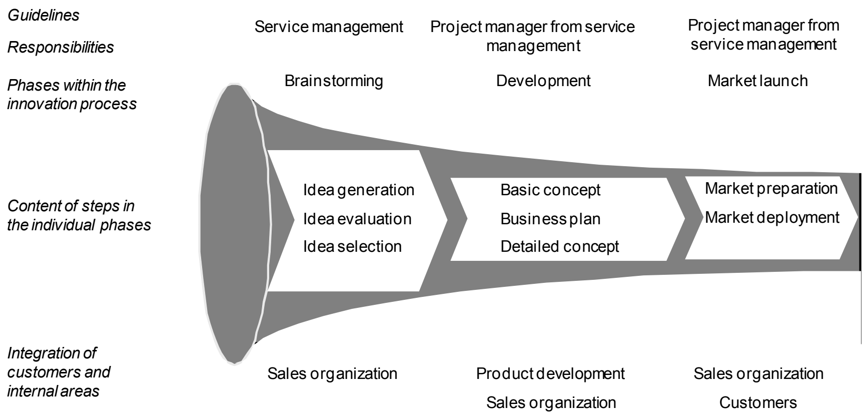

Fig. 12.3 Parameters to allocate service innovations for a Customer Support Service Provider

The entire development phase is managed by a selected product manager. The choice of product manager depends on the product for which the new service is planned. The product manager integrates product sales and product development into the concept design. The devised concept contains a description of the service content, processes and requirements. Product development and product sales are integrated into the development of this concept. One example of this is represented by the repair service innovations and technical inspection at Mikron where knowledge of product functionality from product development and knowledge of product use from product sales were pooled into a joint development team. This in turn ensures that both the technical features of the product and knowledge of typical product faults are taken into consideration with the developed services.

As part of market preparation, the product manager is responsible for formulating the necessary competences required to generate and market the service innovation together with product sales. A requirements profile for the service staff is drawn up at the same time in preparation for the market launch. Should this requirements profile exceed the existing competences of the service staff, the product manager will define the necessary training activities which concentrate on technical knowledge in order to quickly remedy faults and enable product sales to independently implement the developed services on the market.

12.4.2 Service Innovations with Customer Support Service Providers

In contrast to After-Sales Service Providers where the service department is integrated into product management, Customer Support Service Providers establish independent service organizations. An increase in the level of independence among service organizations improves utilization of the services' financial potential. This independent service organization bears profit-and-loss responsibility for the service products and is responsible for service innovations. The phases of the innovation process are subdivided into the following steps: idea generation, evaluation and selection, basic concept, business plan and detailed concept, as well as market preparation and implementation. The creation of a business plan during the development phase is required by Customer Support Service Providers for two reasons. Firstly, due to its own profit-and-loss responsibility, the service management has to determine potential sales and costs of the service innovation. Secondly, in order to sell services such as maintenance agreements or process orientations, the sales organizations need to invest in additional service technicians. A detailed business plan helps to support the sales organizations when making a decision regarding this investment. The business plan contains typical financial estimates as well as a draft of benefits for the customer and procedure on how to implement the service innovation. The draft of benefits for the customer comprises the anticipated increases in efficiency from the customer's perspective (e.g., increase in machine availability from 90% to 95% by means of a maintenance agreement). This increase in efficiency is then analyzed and serves as a check for the potential prices of a maintenance agreement. This in turn serves to verify the financial estimates.

The brainstorming phase is workshop-driven and, together with the marketing and sales organization, the service management identifies customer requirements in order to avoid product faults and to optimize product efficiency within the customer process. The grouped customer requirements form the basis for generating service ideas which are then analyzed and selected. Once the interesting service ideas have been selected, a project team for the development phase is put together. This team is made up of staff from the sales organization and service management, and is generally headed by a project manager from service management. Once the product has been successfully launched, it is recommended that the project manager assumes the role of product manager for the developed service. During the first step of the development process, the development team comes up with a basic concept of the service innovation consisting of a description of the service content, processes and requirements. Trumpf's experience in developing application support shows that integrating the sales organization into the development team improves the quality of the information for the business plan and simplifies the sales estimate and investment decision. When drafting a detailed concept, the development team conducts workshops in order to distinguish the standardized and customer-specific service elements and then describe them so that the service concept can be better suited to meet different customer needs. These workshops usually result in two to three service variants for individual customer groups. The required competences to provide and market the services are then defined by the development team. During market preparation, the development team creates a corresponding requirements profile for the service staff which is not just used to define necessary personnel development measures, it is also used for job advertisements and to recruit new service staff.

12.4.3 Service Innovations with Development Partners

Development and construction service innovations require extensive technical knowledge, which is generally only present in product development and not in product management. For this reason, with Development Partners, service innovations are anchored in product development from an organizational perspective. Development and construction service work is headed by a product development innovation manager.

The steps of the individual phases of the innovation process are identical to those of the Customer Support Service Provider. When working through these development process steps, there is one particular feature to look out for. Development partners have to integrate a loop between creating the detailed concept and the market test since with development services there is initially a lack of definition when creating the detailed concept. With Magna-Steyr's total vehicle concept development service, it was not clear which components should be included in the development service (e.g., assembly, electrics, drivetrain, chassis, prototyping, production planning, purchasing, marketing, quality). Detailing the total vehicle concept service was only possible by using information from the market tests and adapting it to the concept, meaning that there is a loop between the detailed concept and market test. In Magna-Steyr's case, the loops provided the following points for the total vehicle concept development service: strategic product planning, product definition, styling check/evaluation of appearance, concept package with regard to ergonomics, acoustics, vehicle safety and technological comparisons.

These loops require time and resources. The above innovation manager is thus able to ensure efficient and targeted development. Organizationally, the innovation manager reports to product development while heading various innovation projects. He coordinates the loops between detailed concept and market test while generating ideas and basic concepts for service innovations. Workshops are regularly conducted in product development in order to exchange experiences with customer-specific development projects. The innovation manager documents these experiences and uses them to derive service ideas. Initial concepts are then created for the derived service ideas, which are then discussed with the development department. After the basic concept has been devised, a development project is defined together with a development team. This team is headed by an innovation manager and consists of product development and product sales staff who then start working on the development project by defining a business plan. With the business plan, the development team is charged with coming up with a clear sales estimate and specific project plan. The specific project plan is used in particular to correctly plan the sparse resources available to the development team. The sales estimate requires billing to be defined and demand to be evaluated. The aim of this should be to bill development services separately rather than integrate them in the product price. Enforcement of separate billing means that the innovation manager is required to overcome potential resistance from product management and product sales. Product managers and sales staff often worry that development service billing puts potential customers off buying products. In order to avoid such resistance, innovation managers can use the following billing concept in their business plan. Customers are initially billed for development services. If the customer is interested in the developed product once the development service has been rendered, the development service price is then refunded. This means that the product price is reduced by the amount of the development service. Determining demand levels not only helps to correctly estimate sales, it also allows the required resources to be defined. As a result, potential resource bottlenecks in the development department can be avoided. Once the business plan is in place, the development team then moves on to work on the detailed concept.

Due to the high level of customization of development and construction services, it is recommended that a number of customers are involved in developing the detailed concept. The development team can use customer-specific workshops to define the various processes (internal, interactive and external processes) required to render a development service. A recommended method in this regard would be a service blueprint. The development team can test the developed processes and defined billing concept by means of a market test involving a selected sales organization. The knowledge gleaned from the market test can be used directly with the detailed concept. The definition of a requirements profile for sales organization is not necessary as development and construction services are rendered by product development rather than the sales organization. The reason for this is also down to the specific technical knowledge required to render development construction services, which is generally only present in product development. For this reason, special market preparation does not appear to be necessary.

12.4.4 Service Innovations with Supplementary Service Providers

In a similar way to that of Development Partners, service innovations that expand the service portfolio of the supplementary customer activities are best promoted by an innovation team within product development. This innovation team is charged with permanently looking for solutions to problems. The key to supplementary services is a strong opening of the innovation process and utilization of a continual information exchange between in-house staff, customers, and third parties such as suppliers or industry experts. A whole range of information is gathered and used as the basis for brainstorming. When exchanging information with customers, the innovation team should not only involve existing customer contacts, but it should also look at customer problems as a whole. Fraisa's service innovation ToolCare® (ToolCare® comprises the following services: engineering, customer inventories, Rent-a-Tool, EasyAdmin, service and recycling) bundles needs into various customer contact points. The service contains, e.g., an investment appraisal for the choice of tool and tool reconditioning. This in turn streamlines the customer's cutting tool range. For individual cutting tools from the reduced range, Fraisa offers a Rent-a-Tool concept allowing customers to rent tools rather than having to buy them. When it comes to the customer inventories service, Fraisa assumes inventory risk, and manages and updates stock levels. The recycling component means that Fraisa guarantees to take back all used tools. Such comprehensive solutions can only be developed if the innovation team succeeds in incorporating the various needs in the individual customer contact points during the brainstorming phase.

Throughout the entire brainstorming phase it is recommended that the individual customer contact points be interlinked using customer activity chains. The customer activity chains can be used by the innovation team as an initial basis for determining customer needs. To this end, the innovation team can conduct a series of customer-specific workshops and enter the results in a table with customer activities and other needs categories (e.g., functional, success-related, emotional or solution-oriented needs). Such a table then allows a number of ideas to be identified. The innovation team avoids having to make too strong a selection and evaluation of ideas by drafting initial basic concepts. The innovation team thus assumes the first step of the development phase. The basic concepts use keywords to describe the customer problem, customer benefits, service content, the required competences and an estimate of the financial outlay and return. The initial formulation of the customer problem and benefits and the description of the service content often lead to the idea being overworked. There are loops between the brainstorming phase and development of a basic concept which arise from the necessity to develop ideas in more detail before evaluating and selecting them. The initial idea for the ToolCare® service was, to put it simply, an "all-round care-free package". Such a service idea naturally requires more detail before any useful evaluation can be made. It is only during the subsequent description of content such as financing, logistics, return of tools and range optimization by means of a basic concept that a sufficient foundation for the evaluation and selection of service ideas can be laid.

The innovation team then creates a business plan and initiates a development project. The procedure used during the business plan and detailed concept is similar to that used with Customer Support Service Providers and Development Partners. Key elements here are the definition of standardized and customized service features along with the development of internal, interactive and external processes. Both customers and the sales organization are involved in creating the detailed concept. Similar to Development Partners, with Supplementary Service Providers there are often loops between the detailed concept and market test. Initial experiences are made during the market test which are then used to adapt the definition of service variants and service processes. During market preparation, the innovation team creates a requirements profile for sales staff and determines the measures required for staff development purposes.

12.4.5 Service Innovations with Outsourcing Partners

Innovating outsourcing services to assume selected customer processes requires intensive cooperation with customers. The core content of this cooperation is risk management. The example of Voith's rail service demonstrates the typical risks associated with outsourcing services. With its rail service, Voith carries out maintenance work on rolling stock. While Voith only used to assume responsibility up to acceptance and focused solely on the spare parts business, its rail service now incorporates responsibility for technical availability (including post-acceptance). This means that Voith is in daily contact with the customer and thus has full transparency over the state of the rolling stock. This can lead to high payments being made if the rolling stock is out of use when not expected.

In order to minimize such risks, innovation projects involving outsourcing services are recommended in order to create special developments with selected customers. With such customized developments, it is difficult to distinguish the actual innovation from the rendering of the outsourcing service. Customers also expect continual improvement of the outsourced processes. Initial outsourcing projects are headed by existing customer managers from the sales organization. Once initial experiences have been gained from outsourcing projects, Outsourcing Partners can establish experts for these services. Specialist teams are then responsible for the actual development and subsequent service rendering. This ensures continual quality improvements, including during the time where outsourcing services are actually being rendered. With the example involving ABB and Nokia, an industry specialist heads a joint project team, which continually promotes improvement of the OEE (Overall Equipment Effectiveness). This key figure is broken down into availability (uptime versus downtime—planned and unplanned), service efficiency (actual versus design capability) and yield percentage. The entire organization of the innovation process is therefore similar to that of a project organization covering both development and rendering of the service.

Only very few service innovations are redeveloped during the actual development phase. Outsourcing services are heavily based on existing services. Hilti's fleet management contains, e.g., existing services such as repairs and device exchanges. Core elements of the innovation process are therefore not service innovations but risk management as well as intensive investigation and coordination of the cooperation and agreements of outsourcing services.

During the brainstorming phase, ideas for outsourcing services are evaluated and selected based on risks and benefits. Only if the risk is justifiable in proportion to the benefit will an outsourcing project be launched in the form of a customer-specific pilot scheme. An industry specialist heads the outsourcing project and uses, e.g., the quality function deployment method to start investigating the customer's requirements with regard to outsourcing a business process as well as the service indicators of existing services. Nokia's requirements of OEE (Overall Equipment Effectiveness together with the service parameters availability, service efficiency and yield) combined with ABB's existing services result in a precise requirements profile for the outsourcing service. In order to achieve 95% production system availability, operators need, e.g., extensive training in order to eliminate operating errors and conduct maintenance activities twice a year. Also required are operating staff who work in three shifts and a team of process engineers who optimize the production process once a year.

Despite in-depth information regarding the services required to ensure the service parameters, there is still a certain amount of risk involved. This remaining risk has to be incorporated into the billing model for outsourcing services and then quantified (priced). Risk estimate and pricing form a key part of the business plan. The subsequent detailed outsourcing service concept involves outlining the services related to the outsourced customer process and definition of a method that can be used to implement that outsourcing service. The developed outsourcing service is then trialled during the course of a prolonged pilot test conducted with the customer. The outsourcing services innovation process does not just end with the roll-out of the service at the selected customer, it also involves continual adjustment of the outsourcing services after market launch.

The gathering of initial experiences in connection with risk is expected to push the core content of the Outsourcing Partner's service innovations towards intense investigation and coordination of the cooperation and agreements with the customers. With Voith's rail service, this is used in a targeted manner to devise the risk management. The associated potential can be seen in the success of Voith Industrial Service's (an outsourcing specialist and part of the Voith Group) business. This business area currently generates 19% of the Voith Group's sales.

12.5 Future Trends

There are a number of issues that follow a focus on service innovation and its relation to specific Product-Service Systems and service strategies. The first issue concerns how much research a company need to invest in the development of service innovations. At the present, most companies use 90 to 100 % of their available resources for development projects related to products. We argue that it within the development projects for pure projects to include service innovators to prepare the product both technologically and ergonomically to be included in Product-Service Systems. If the service part of the business is given too little resources it will reflect in the type of priorities that are made within a company. If almost all resources are used in order to develop the hardware this will reflect the priorities made inside a firm. The question then is why the employees' prioritise services should if the company does not?

Another important issue is that most development models and tools have their origin in the development of products. The question is, if these models and tools are suited to develop service innovations. Most engineering methods are based on tangibility, accuracy and reliability—requirements that often are not fulfillled working with service. There is a need for models and tools based on a service logic focusing on the moment of truth, service delivery process and human issues of service. Engineers working with service need training and the right tools to be able to design a service that is able to provide a good service experience. Services need a tool set on its own and it should not be left with "hand-me-downs" from their big brother, i.e. hardware. We need tools that capture customers using the service or what sometimes is called in-situ methods.

12.6 Conclusions

Taking the present problems with service innovation as our point of origin, we have shown how industrial firms can overcome these problems by aligning their way to develop service innovations with the existing Product-Service Systems and the service strategy. By answering the two questions *"In which service categories can we promote innovations?"* and *"How do we need to align service innovations?"* we show how industrial firms should work with service innovation. The outlined service strategies and our guidelines on how to develop services are however not isolated from one another. From a company perspective, it is not an either/or decision between the two service strategies: After-Sales Service Provider and Outsourcing Partner. Companies could well combine service strategies with one another and/or switch between service strategies. Mikron, for example, moved in the last few years from *After-Sales Service Provider* to *Customer Support Service Provider* with service innovations such as an exchange service, product support and business consulting. In the individual areas of business consulting, Mikron is also gathering initial experiences as a Supplementary Service Provider. Testo is following a similar approach. In product-related areas, Testo is a typical Customer Support Service Provider, while Testo Industrial Service GmbH has positioned itself as a Supplementary Service Provider. Hilti with its fleet management has switched directly from being a Customer Support Service Provider to an Outsourcing Partner.

There is of course the option to stick with a service strategy and therefore concentrate on the associated potential for growth. A change to the service strategy and/or the combination of service strategies only makes sense for companies if there is a clear strategic or financial motivation, or if customers are expecting a change or combination of service strategy. When selecting or combining service strategies, companies have to take account of the following three points:

1. Strategic view: a change of service strategy or the combination of service strategies opens the door to new differential potential or makes it more difficult for competitors to gain access to the customer.
2. Customer perspective: customer requirements and expectations of the service offering have changed. This change requires a change of service strategy.
3. Financial perspective: stagnation of the current service strategy requires an investigation into new growth potential and a change of service strategy.

To succeed with the introduction of service innovation on the market, the services that are offered must be based on the customers' problems and value-creation processes. Traditionally, service innovations have been introduced based on what is technologically feasible instead of what are the customers' real problems. A service innovation strategy based on a true customer perspective provides an opportunity to identify service innovations that has a growth potential in the market.

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Breif Biographical History and Interests

Professor Tamio Arai has been a full professor since 1987 in the Dept. of Precision Engineering, The University of Tokyo, from which he graduated in 1970 and obtained his doctorate in of Engineering in 1977. His specialties consist of three fields: robotics, assembly and service engineering. Multi-agent systems have been applied to multiple mobile robots including the legged robot league of RoboCup, and to the Holonic Manufacturing System in IMS program. He contributed to industrial robot standardization in JIS and ISO. Service Engineering has been proposed by his group in Research into Artifacts, Center for Engineering (RACE), The Univ. of Tokyo, where he was a director from 2000 to 2005. He is very active IAS, IEEE, CIRP, RSJ and JSPE. He is now president of the Japan Society of Precision Engineering.

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Breif Biographical History and Interests

2007–Present Vice-Rector for Research, Professor in Engineering Design and Methodology, Université du Luxembourg
2000–2007 Professor in Engineering Design and Methodology, Berlin Uni-

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1992–2000	Senior Research Associate, Deputy Director (from 1995), Engineering Design Centre, Cambridge University, UK
1984–1992	Lecturer, Department of Mechanical Engineering, University of Twente (NL)

Education: 1984 MSc Industrial Design Engineering, Delft University of Technology, 1994 PhD University of Twente

Research interests include: the product development process, diversity (culture, age and gender), user-technology interaction, design methodology, design research methodology and fatigue testing of machine element pairs.

Other: Co-editor of the journal Research in Engineering Design (Springer Verlag), translator with Ken Wallace (UK) of the German standard book on Engineering Design from Professors Pahl and Beitz into English in 1994 and 2004, co-organiser of the International Summer School on Engineering Design Research since 1999, founding and Management Board member of the Design Society since 2000 and Advisory Board member since 2005, (co)author of nearly 150 publications. Supervised 27 PhD students, 12 of whom successfully defended their thesis, and co-supervised 5 further PhD students.

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Breif Biographical History and Interests

2003–Present	Professor at the Darmstadt University of Technology, Germany
1994–2002	Manager, R&D-Department of MAN Roland Druckmaschinen AG, Germany
1989–1994	Scientific Assistant and Doctoral Graduation, Chair of Mechanics and Machine Elements, TH Darmstadt, Germany
1983–1989	Machinery Engineer Student, TH Darmstadt, Germany

His main research fields include colorimetry, automatization of printing processes, industrial management and advanced technology for printed functionality. A strong partnership has been established with Merck KGaA in Darmstadt for inorganically printed electronics and close contacts have been maintained with machine manufacturers and materials suppliers.

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Breif Biographical History and Interests

2008–Present Researcher, Luleå University of Technology, Sweden
2004–2007 PhD student, Luleå University of Technology, Sweden

Received an MSc in Systems Science and Informatics at Luleå University of Technology in 2002, and a PhD in Functional Product Development in 2007. Her research efforts have their origin in user-oriented design and participatory design, and are applied in the area of product/service systems development. Currently, her research focuses on collaboration, communication and innovation aspects in multidisciplinary teams.

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Breif Biographical History and Interests

Research interests include industrial service management and the internationalization of the value chain. He holds a diploma degree in Industrial Engineering and Management from the University of Siegen, Germany, and a master's degree in Mechanical Engineering from Ecole Nationale d'Ingénieurs de Saint-Etienne, France.

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Dr. Heiko Gebauer is a project manager at the Institute of Technology Management at the University of St. Gallen. His research focuses on service management in manufacturing companies, the internationalisation of the value chain and healthcare services. He holds a PhD in Business Administration from the University of St. Gallen.

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Breif Biographical History and Interests

2004–Present	Professor, Karlstad University, Sweden
1999–2004	Associate professor, Karlstad University, Sweden
1998–1999	Assistant professor, Karlstad University, Sweden
1996–2000	Assistant professor, Quality Technology and Management, Linköping Institute of Technology, Linköping University

Anders Gustafsson is a professor of business administration in the Service Research Center at Karlstad University, Sweden. He has a Master of Science degree in Industrial Engineering and Management, a Licentiate degree, a PhD degree and a docent title all in the subject of Quality Management from Linköping University.

Dr. Gustafsson is the author of nine books including: *Competing in a Service Economy: How to Create a Competitive Advantage through Service Development and Innovation* (Jossey-Bass, 2003), and *Conjoint Measurement - Methods and Applications (*Springer, 2007, 4th edition). In addition, Dr. Gustafsson has published over 100 academic articles, book chapters and industry reports. He has published articles in journals such as the *Journal of Marketing*, *Journal of Economic Psychology* and *Journal of Service Research*.

Dr. Gustafsson works on issues such as customer orientation, customer satisfaction and loyalty, new service development, service infusion in manufacturing, and management of customer relationships.

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Breif Biographical History and Interests

2007–Present	PhD Project within the Graduate Program Microenergy Systems
2003–Present	Managing Director, MicroEnergy International, Germany
1993–2003	Technician at Siemens Corporation

The combination of practice and science has always been specific to the career of Noara Kebir. She started as a trainee for machines and systems at Siemens Corporation and graduated while working part-time as a technician for service and maintenance in the same company. She got her diploma with great distinction in energy and process engineering at the Technische Universität Berlin in 2004. After an energy research project in cooperation with the microfinance institution Grameen Bank in Bangladesh, she founded the company MicroEnergy International in 2003. The company supports microfinance institutions developing energy programs and is active in many countries in Africa and Asia. Currently, she is completing her PhD at the University of Luxembourg.

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Breif Biographical History and Interests

2005–Present	Assistant Professor, Linköping University, Sweden
2004	Visiting Fellow, Massachusetts Institute of Technology, USA
1999–2001	Business Development Consultant

Daniel Kindström is an Assistant Professor in Industrial Marketing at Linköping University. His current research focuses on the development of industrial offerings and the value-creation potential of increased service content in traditionally product-focused companies. Other topics of interest are e-business and the impact of ICT on business models.

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Breif Biographical History and Interests

He is currently a researcher at Delft University of Technology, the Netherlands, since 2004. He received a BS and a Dipl- Ing. in mechanical engineering from the University Karlsruhe (TH), Germany, in 2003 and 2004, respectively. His research interests include product-service systems design, life-cycle simulation, service CAD, and system architecting of adaptable mechatronic systems.

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Breif Biographical History and Interests

2008–Present Assistant Professor, Linköping University, Sweden
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He received an MSc, a LicSc, and a PhD in Industrial Marketing from Linköping University in 2004, 2006, and 2008, respectively. His research focuses on service infusion in manufacturing firms, service logic, and on possibilities and challenges associated with enhanced industrial service offerings (in terms of organizational requirements and capabilities, marketing strategies, business development and value co-creation).

Larsson, Andreas C.

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Breif Biographical History and Interests

Larsson received his BSc (1999) and MSc (2000) degrees in Computer Science with emphasis on Human Work Science at Blekinge Institute of Technology, Sweden. He earned his PhD degree (2005) in Computer Aided Design at Luleå University of Technology, Sweden. At the core of his research agenda is the creation of a rich blend of needs-motivated research activities dealing with cross-functional knowledge sharing, local and distributed teamwork, and participatory innovation. These interests can be summarized in the overarching aim to support product developing individuals, teams and organizations in effectively and efficiently sharing knowledge across a wide range of boundaries (i.e. teams, organizations, cultures, languages, time zones, etc.)

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Breif Biographical History and Interests

2007–Present Professor, Luleå University of Technology, Sweden
2005–2007 Associate Professor, Luleå University of Technology, Sweden

Professor Tobias C. Larsson earned his PhD at Luleå University of Technology in 2001 within the area of simulation-driven design with respect to vehicle dynamics. The applications were within the automotive sector and high-speed trains.

His core focus today is within Engineering Product Development, Knowledge Based Methods and Functional Product Development (Product Service Systems). The product development process design and efficiency is of interest. His focus is on Functional Product Development where the combination of physical artefact development and services development is joined in the early concept stages with support of knowledge-based methods for faster development of new solutions to industrial needs and opportunities. Automation of engineering work tasks with use of design rationale analysis and simulation approaches are in focus.

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Breif Biographical History and Interests

2003–present Assistant Professor, Linköping University
2008–present Board member Polyplank AB
1997–2003 PhD Student, Department of Technology, University of Kalmar

Mattias Lindahl has been doing research and teaching activities in Design for Environment (DfE) since 1997 when he completed PhD (his thesis is entitled: *Engineering Designers' Requirements on Design for Environment Methods and Tool*), and in Integrated Product Service Engineering (IPSE) since 2000.

His research has mainly been in co-operation with companies and he has also been project leader for five major research projects. He is also of the founders of and a steering committee member of the Design Society's special interest group in eco-design. He is also actively involved in the International PSS Design Research Community.

He has published articles in journals such as the *International Journal of Automation Technology*, *Journal of Systems Science and Systems Engineering*, *Journal of Cleaner Production, Journal of Engineering Design* and *International Journal of Internet Manufacturing and Services.*

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Breif Biographical History and Interests

2005–2009 PhD project, "A systematic approach to service-oriented product development", Technical University of Denmark
2003–2005 Product development consultant, Dansk IngeniørService A/S, Denmark

Detlef Matzen achieved a MSc in engineering design and product development in 2003 from the Technical University of Denmark. His research interests include design methodologies and sustainability issues, such as development support for PSS.

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Breif Biographical History and Interests

1998–present Associate Professor, Technical University of Denmark
1998–present Consultant for Danish and international industry related to Institute for Product Development
1993–1998 Research Assistant, Cranfield University, UK

Tim McAloone has been a member of staff at DTU since 1998. He works closely with Danish industry, finding new methods and models for a wide range of product development issues, such as environmental issues, mechatronics, product/service-systems, product innovation and the process of product development itself.

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Breif Biographical History and Interests

2008–Present	PhD student and research assistant; Industrial Information Technology, TU Berlin
2006–2008	PhD student and research assistant; Engineering Design and Methodology, TU Berlin
2006	Diploma in Mechanical Engineering, TU Berlin

Mr. Müller is active in research on the integrated development of products and services. He is working on a German research project on Industrial Product-Service Systems, called Transregio 29, and he is a member of the International PSS Design Research Community. His further research interests include product development, information technologies and process modeling.

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Breif Biographical History and Interests

2006–present	Assistant Professor, Lund University, Sweden
2003–2007	Tetra Pak Business Support AB, marketing manager (part time)
2000–2005	Lund University, Design Sciences, PhD Student (part time)
1986–2001	Alfa Laval & Tetra Pak, Prohject manager & Global Product manager

Olsson received her MSc in Food Engineering at Lund University in 1986, an International MBA at Baldwin Wallace College, USA, in 1997 and a PhD in Packaging Logistics at Lund University in 2006. Her research area includes user-oriented product and service development, service innovation, value addition and innovation and learning. The research is applied and carried out in close cooperation with relevant industry and with a specific focus on packaging development and the packaging industry.

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Breif Biographical History and Interests

2009–Present	Sales Manager, Koenig & Bauer AG, Germany
2003–2008	Scientific Assistant and Doctoral Graduation, Chair of Printing Science and Technology, Darmstadt University of Technology, Germany
1999–2003	Service Technician, MAN AG, Mexico and Germany
1996–2002	Master Degree Student in Economic and Mechanical Engineering, Ilmenau University of Technology, Germany

He specialized in Process Quality Management and in 2002 acquired a degree as a "Quality Systems Manager" from the European Organization of Quality. His research interests include quality aspects of customized production and sales processes as well as environment engineering of machine manufacturers. His research focuses on the question how manufacturers should customize their own value-added chain from purchasing management through profitable regional sales management up to on-site after-sales service for customers around the world.

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Breif Biographical History and Interests

2007–present	Professor, Linköping University, Sweden
2005–2007	Guest Researcher, Darmstadt University of Technology, Germany
1998–2005, 2007	Researcher/Senior Researcher, Mitsubishi Research Institute, Inc., Japan

He received a BS, an MS, and a PhD in precision machinery engineering from the University of Tokyo in 1993, 1995, and 1998, respectively. His research interests include engineering aspects in industrial management (e.g., Integrated Product Service Engineering), environmental engineering (e.g., Ecodesign), and intelligent machinery (e.g., self-maintenance machines and cellular machines).

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Breif Biographical History and Interests

2005–present	Professor, Department of System Design, Tokyo Metropolitan University
2001–2005	Associate Professor, Research into Artifact, Center for Engineering (RACE), the University of Tokyo
1998–2001	Research Group Leader, Kawasaki Heavy Industry Co., Ltd
1984–1998	Engineering Group Leader, Mita Industrial Co., Ltd

He has been a Professor in the Human Mechatronics Systems Course, Faculty of System Design, Tokyo Metropolitan University, since 2005. Prior to this appointment, he was an Associate Professor in Research into Artifacts, Center for Engineering, The University of Tokyo. He received his PhD in precision machinery engineering from the Graduate School of The University of Tokyo in 1997. Dr Shimomura's research interests include service engineering, life-cycle engineering, design theory and methodology, intelligent systems, reasoning mechanism, and soft machines (self-maintenance machines and cellular machines).

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Breif Biographical History and Interests

2008–Present	Director Industrial Information Technology, TU Berlin, and of the division Virtual Product Creation, Fraunhofer IPK, Berlin
1994–2008	Research & Development at Ford Motor Company:
1994–1997	System Development in Body Engineering

1997–2002	(Senior) Technical Specialist / Supervisor C3P Digital Solution Development in Research & Vehicle Technology
2002–2008	Global Technical Leader / European Manager C3P Next Generation and digital methods development & deployment
1989–1994	Research Assistant at the Chair of Design Engineering / CAD at the Technical Faculty, University of Saarland, and at the Center for Innovative Production in Saarbrücken, PhD
1984–1989	Study of Mechanical Engineering at Ruhr-University Bochum and Texas A&M University, Diploma

Memberships and Collaborations:

- VDI (Verein Deutscher Ingenieure): Member of the Fachbeirat Produktentwicklung und Systeme
- ASIIN (Akkreditierungsagentur für Studiengänge der Ingenieurwissenschaften der Informatik, der Naturwissenschaften und der Mathematik e.V.)
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Breif Biographical History and Interests

2008–Present	Associate Professor, Linköping University, Sweden
2004–2008	Assistant Professor, Linköping University, Sweden
1999–2004	PhD Student, Linköping University, Sweden

Erik has been an Associate Professor since fall 2008. His doctoral studies were focused much on remanufacturing and his Ph.D. thesis from 2004 was entitled: *Product and Process Design for Successful Remanufacturing*. Erik holds a MSc degree from 1998 in Applied Physics and Electrical Engineering. His research and teaching interests are in the area of integrated product and service engineering (ISPE), product/service systems (PSS), service engineering, life-cycle engineering, remanufacturing, recycling and ecodesign. Erik is a member of the International PSS Design Research Community. He has published research papers in journals such as *Journal of Cleaner Production*, *Journal of Industrial Ecology, International Journal of Production Economics*, *Journal of Manufacturing Technology Management* and *Computer-Aided Design.* More information can be found at: www.iei.liu.se/mt/personal/eriksundin.

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Breif Biographical History and Interests

2005–2009	PhD project, *Service-oriented product development strategies*, Technical University of Denmark
2004–2005	Mechanical design engineer, RADIUS Product Development, Denmark
2001–2003	Product development consultant, Institute for Product Development, Denmark

Adrian Tan achieved a MSc in mechanical engineering in 2001 from the Technical University of Denmark. His research interests include design methodologies and sustainability issues, such as ecodesign and product/service-system development.

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Breif Biographical History and Interests

He has been a Professor of Intelligent Mechanical Systems in the Faculty of Mechanical Maritime and Materials Engineering, Delft University of Technology, since 2002. Between 1998 and 2002 he was a Professor, Research into Artifacts, Center for Engineering (RACE), The University of Tokyo. Between 1987 and 1998 he was an Associate Professor, Department of Precision Machinery Engineering at the same university. He received BS, MS, and a PhD in Precision Machinery Engineering from the University of Tokyo, Japan in 1980, 1982, and 1985, respectively. He is a fellow of JSME and CIRP. He is a member of JSPE, IPSJ, JSAI, AAAI, ACM, ASME, IEEE, and the Design Society. His research interests include Design Theory, Design Methodology, Knowledge Intensive Engineering, Service Engineering, Life-cycle Engineering, Maintenance.

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Breif Biographical History and Interests

Lars Witell received a Master of Science degree in Industrial Engineering and Management, a Licentiate degree, a PhD degree and a docent title all in the subject of Quality Management from Linköping University. His research focuses on service management in manufacturing companies, product and service development, customer orientation, and quality management. Lars has run several research projects on the topic of service transition of manufacturing firms such as "Value Creation through Service" and "Service Innovations in Manufacturing firms."

Ölundh Sandström, Gunilla

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Breif Biographical History and Interests

2006–Present	Assistant professor, Machine Design, KTH,
2000–2006	PhD Candidate, Machine Design, KTH, Research school ProViking,
1998–2000	Project leader and environmental administrative officer, Stockholm Energy

The research interests of Gunilla Ölundh Sandström are within the areas of Product Service Systems (PSS), Integrated Product and Service Engineering (IPSE) ecodesign. Her research interests and research projects are also focused on innovation management and innovation capability. Gunilla is a member of International PSS Design Research Community. More information can be found at www.kth.se/itm.

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Breif Biographical History and Interests

2007–present	Director of the Center for Applied Management for Small and Medium-sized Enterprises
2005 – Present	Board member Åtvidabergs Sparbank.
2002 – Present	Project Manager Result Center, a national forum for product realization research in Sweden, involving appr. 400 researchers (www.resultcenter.com)
2002 – Present	Assistant Professor Industrial Economics and Management
1994 – 1997	Project manager and development engineer (Dental CAD/CAM system, Optronic Group, Skellefteå, Sweden)

In 2002 she received her PhD in Industrial Economics and Management from the International Graduate School of Management and Industrial Engineering (IMIE) at Linköping University. Research areas include collaborative product development, and technology-based business development, especially for small and medium-sized enterprises (SMEs), which is also her area for teaching. Since 2007 she has been a Director of the Center for Applied Management for SMEs at Linköping University.

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