Modeling Services and Service-Centered PSS Design

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Abstract

In recent years, manufacturers have dealt with various requirements of customers and serious environmental problems. As an effective approach to deal with those problems, the concept of *product-service systems* has attracted attention. The authors have been conducting research on *Service Engineering* for effective and efficient *service design* and development in an engineering manner. In this chapter, the authors explain the service-centered design approach and concrete design methods for *product-service systems* in *Service Engineering*. In addition, the authors introduce a computer-aided design system of services based on these design methods.

1 Introduction

As society ages, services and knowledge have become more important in many industries (Tomiyama 1997). As the term "*servitization*" indicates (Vandermerwe and Rada 1988), a service and knowledge provided through a product are regarded as more important elements than the product itself even in the manufacturing industry. Under such circumstances, "*product-service systems* (*PSS*s)" that create value by coupling a product and a service have been attracting attention (Goedkoop et al. 1999). For the effective and efficient design of PSS, the introduction of engineering methods is considered as a promising approach. However, compared

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with research on product design, there have been fewer studies on the design of services from the engineering viewpoint (Shostack 1981; Aurich et al. 2004; Tukker 2004).

To correct this situation, several researchers have started to conduct *Service Engineering* research (e.g., Shimomura and Tomiyama 2002). The aim of Service Engineering is to provide a fundamental understanding of a service as well as concrete engineering methods to design and develop it. In this chapter, the authors first explain a concept of service and its design approach in Service Engineering. Based on the concept and the approach, the authors introduce several service models and design methods used in each service design phase. In addition, the authors introduce a computer-aided design (CAD) system based on the proposed design methods.

2 Limitations of Product-Centered Manufacturing Approach

Nowadays, it is commonly agreed that product functionality is just a part of a product's value, and services coupled with a product have taken an important role to satisfy customers. An attractive service is considered as a major success factor in business even in the manufacturing industry. On the other hand, there have been few innovative and successful *PSS* cases. Most of the current PSSs are the combination of traditional product-related services, such as rental and maintenance, and conventional products. One of the reasons is that a service is still considered as a supplemental element of a product and the design of services is performed based on the result of conventional product design. To realize high value for customers, an approach to the concurrent design products and services is crucial. This concept can be explained by using the metaphor shown in Fig. 36.1. The current problem is that many manufacturers still focus excessively on the design of physical products. A box filled with water in Fig. 36.1 describes a design object, and two jacks under the box represent the axes of a product and a service, which are regarded as important components of PSSs. The fish in the water represents the value level produced by a combination of a product and a service. If a manufacturer wants to design a valuable PSS and design products and services individually, the total value is not considerably increased (see Operations 1 and 2). By designing a product-and-service set as an overall system, the total value can increase. As can be seen, products and services according to customer's value should be designed concurrently for success in the *PSS* business.

To realize such a concurrent design of *PSS*s, the design methods of a service take an important role. In conventional product design, a variety of engineering methods and tools have been developed for the design of highly functional products, and many of them have been utilized in actual product design processes. Though many methods dealing with services have been proposed, especially in the marketing research field (Ramaswamy 1996; Shostack 1981), engineering approaches to design services are scarce. Under these circumstances, Service Engineering research to design and improve services in the engineering manner started.

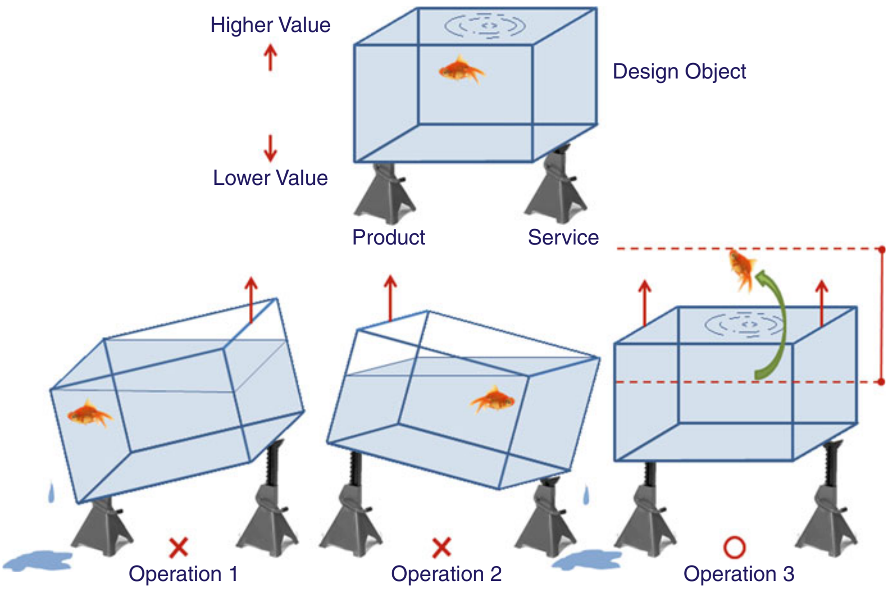

Fig. 36.1 Design operations with constraint between product and service

3 PSS and Service Research

Before focusing on the design methods, the authors explain the overview of PSS and service research. Research on services and PSSs ranges over numerous subjects. Meier et al. summarized the PSS and service research (Meier et al. 2010). Figure 36.2 shows the categories and concrete methods on PSSs according to their classification. In this chapter, the authors mainly introduce the concept and methods in the category "design and development," including service modeling, design methods, and a design process. Although the financial and management topics in the category "business models, risk evaluation, and management" are important to continue a service as business, they are not the target of this chapter. The analysis and control methods in the category "delivery and use" are also beyond the present focus. The utilization of design knowledge in the category "knowledge management and life cycle issues" is partially discussed in this chapter.

4 Service Design

Traditionally, *service design* often means just the determination of the behavior of service staff, even when some products are strongly related to service contents. In the traditional design process of a service, products and service activities are

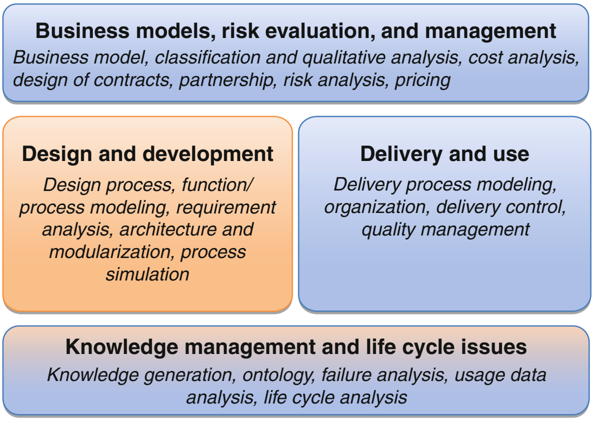

Fig. 36.2 Research categories on PSSs and services

separately designed, and the design actors of products and services are separated. This causes insufficient fulfillment of customer requirements and inefficiency of *PSS* design.

The service-centered design approach is a holistic approach to determine the specification of service activities and products required for providing PSSs and even pure services. For example, Aurich et al. propose integrated product-and-service design processes (Aurich et al. 2004). The authors also have been developing the integrated design methodology of service activities and products based on the service-centered design approach, so that a single actor can carry out the core processes of *service design*. In the context of the service-centered design approach, "service" means not only intangible human activities to provide value to customers but also the total performance of PSSs including products. In addition, "service design" in the service-centered design approach is a designing activity to create such expanded services. In this context, the authors explain required engineering methods for service design, including service modeling methods, service design phases, and related design methods.

5 Modeling Method

5.1 Definition of a Service

In recent research on services, service is commonly considered as an activity to provide certain value (Goedkoop et al. 1999; Spohrer et al. 2008; Shimomura and Tomiyama 2002). For example, the authors defined a service as an activity by a service provider to change the state of a service receiver (Shimomura and Tomiyama 2002). In this definition, a service is delivered by means of service contents and service channels. Service contents such as materials, energy, and information directly change the receiver's state. A service channel transfers, amplifies, and

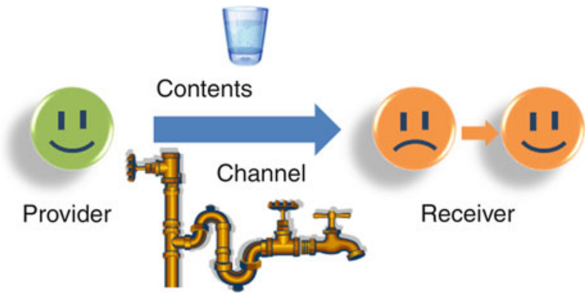

Fig. 36.3 Definition of service

controls service contents and indirectly influences the state change of a service receiver (see Fig. 36.3). Service contents and channels configure the realization structure of a service.

Based on the abovementioned definition, the representation scheme of the state change of a service receiver, contents, and a channel has been proposed (Shimomura and Tomiyama 2002). This method expresses a service as the combination of parameters and their relationships, and it provides three kinds of parameters, namely, receiver state parameters (RSPs), content parameters (CoPs), and channel parameters (ChPs). A set of RSPs represents a receiver's state. Any RSP can be defined if it describes a receiver's state. However, for meaningful service design, RSPs must be observable and related to the needs of a service receiver. The adequate representation of a service receiver's demands with RSPs is one of the most important processes in service design. CoPs express contents, and ChPs which express a channel affect CoPs and indirectly influence RSPs.

5.2 Service Models

Developing models is an important step to understand and develop a target object or system. Especially in the early phase of the PSS research, developing business models suitable for PSSs was an important topic (Tucker and Tischner 2005). Some researchers tried to analyze the ecological and economic aspects of PSS by means of their models (Tukker 2004).

On the other hand, a service contains various aspects. When designing services, the viewpoints to describe those aspects are important. As an example of the design models of services, the authors explain the model consisting of the following three types of models that describe such viewpoints.

1. Stakeholder model

   For a service provider, the most important stakeholder is a service receiver. As explained above, the requirements and state change of service receivers are described with RSPs. For the extraction of the RSPs of service receivers, the stakeholder model employs the persona method, which is used primarily for software interface design to provide a simplified description of a customer and

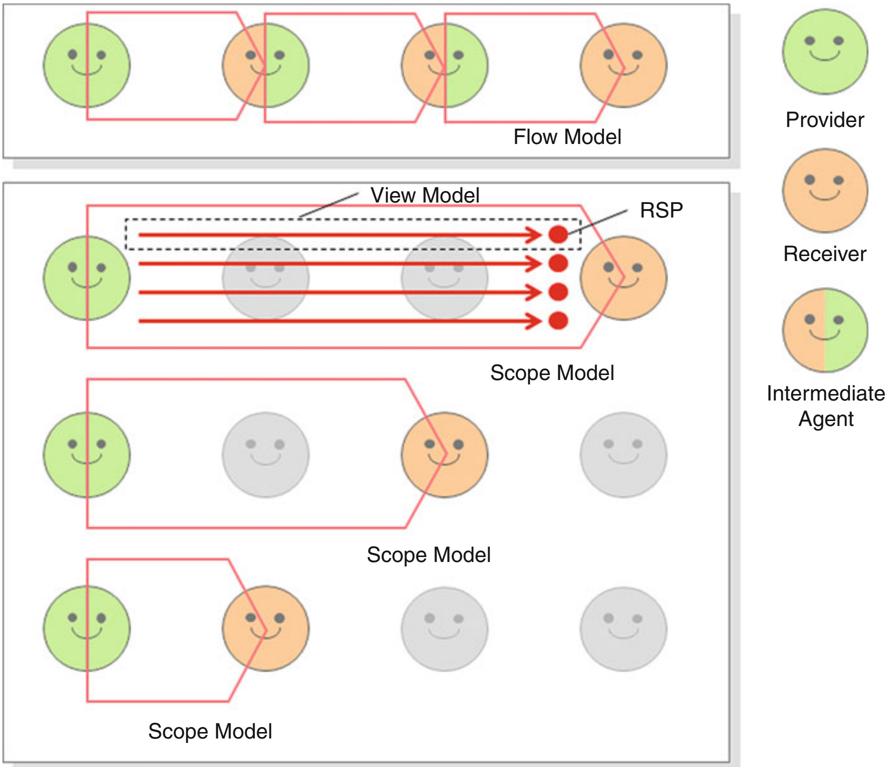

Fig. 36.4 Structure models

works as a compass in the design process (Cooper 1999). Meanwhile, a service receiver's activity should be also analyzed to identify his or her unstated needs. In addition to the persona method, various researchers have suggested a type of scenario analysis to clarify a customer's activities. For example, the authors have proposed a method to describe a scenario in a graph form to represent scene transitions (Shimomura et al. 2007). For each described scene, a service designer describes the receiver's state with RSPs based on the scenario information.

2. Service structure models
   Service structure models describe realization structures to provide services. Service structures can be described from various aspects and at various levels of abstraction. In this chapter, the authors introduce the service structure model consisting of three submodels (Shimomura and Tomiyama 2002). Figure 36.4 is the overview of this model.
   – View model
     A view model describes a functional structure that can be used to realize a change in an RSP. Here, the functional structure is described as functional relations among the RSP, CoP, and ChP. The view model expresses a part of

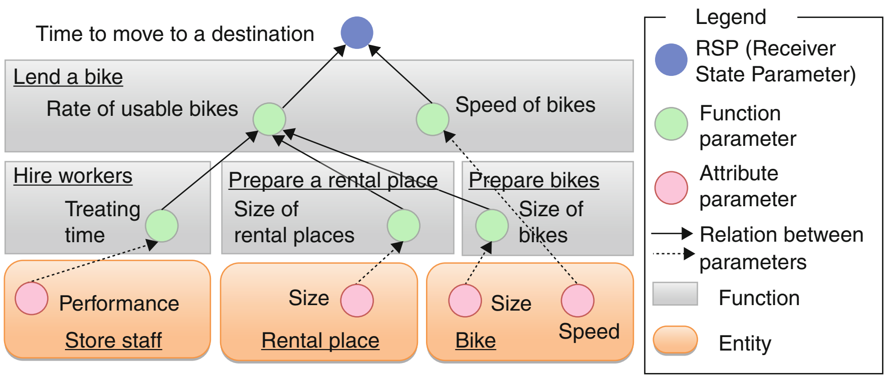

Fig. 36.5 An example of view model

the realization structure of a service through the relationship between the RSP and the functional structure. Figure 36.5 is a description of the view model.

The functions of channels and contents are expressed by function names as lexical expressions and function parameters (FPs) as target parameters of functions. Each function is related to another. The FPs that are directly related to RSPs are recognized as CoPs, and those indirectly influencing RSPs are ChPs. The most important role of *service design* is to clarify the realization structure of a service represented through the relationships among the parameters reported above (RSP, ChP, and CoP). In addition, by relating the realization structure composed of CoPs and ChPs to artifacts, called entities, the roles of actual entities in a service, as a channel or contents, can be determined.

– Scope model
  Since an actual service is composed of complicated mutual relationships among providers and receivers, it is necessary to specify the active target range in the design of the service (Shimomura and Tomiyama 2002). A scope model expresses the target range of a service. A scope model is represented as a set of RSPs specified by a designer and view models that are related to them.
– Flow model
  As reported above, many services form complex structures consisting of many stakeholders. Between a final receiver and a provider, there may be many intermediate agents, since it is generally inefficient to provide a service without the support of these intermediate agents. Since intermediate agents also evaluate services as service receivers, values for intermediate agents must also be designed.

  The flow model describes stakeholder relationships (Shimomura and Tomiyama 2002). The flow model consists of stakeholders, called agents, and one-to-one relationships among them. The scope model depicts a one-to-one relationship between two agents in a flow model. A service designer needs to integrate the evaluation of multiple receivers to increase the value of a service.

3. Service process models

A service process can be considered as a sequence of activities to provide a service. Compared to the aforementioned structure models which describe components of a service and their functions, a service process model describes their actual activities, behaviors, and interactions among them. For example, the order of stakeholders' activities and the timing of their interactions can be described only with the service process model. To describe those activities, several modeling methods have been proposed.

The extended service blueprint is one of the modeling methods to describe a service process (Shimomura et al. 2009). The origin of its concept is the service blueprint, which is commonly used in the service marketing field to describe service activities undertaken by a customer and a service provider (Shostack 1981). However, a service blueprint is not available to describe the role of products in a service process. Thus, the extended service blueprint was developed to describe both human activities and product behaviors. The notation of an extended service blueprint is based on Business Process Modeling Notation (BPMN) for the description of business processes (Havey 2005). BPMN is one of common notations to describe business processes and suitable to describe both human activities and product behaviors. Figure 36.6 shows an example of the extended service blueprint. The extended service blueprint describes a service process which consists of sequences of human activities and product behaviors, and their interactions with nodes and arrows. Activities which can or cannot be seen from the customer and detailed behaviors of product parts can be described explicitly, also.

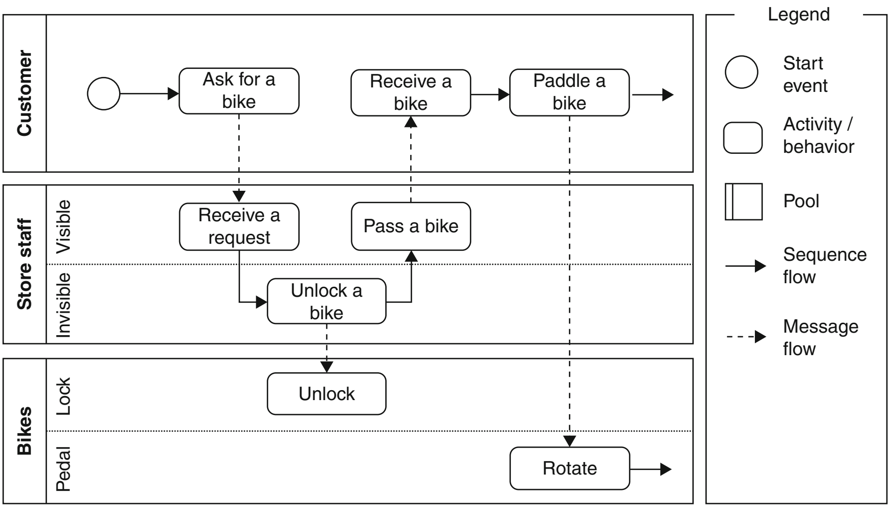

Fig. 36.6 An example of extended service blueprint

6 Service Design Phases and Methods

The design activities of services can be categorized into three design phases, i.e., value analysis, embodiment, and evaluation. A variety of design methods to realize and support the design activities is proposed in each phase.

1. Value analysis

   In the phase of value analysis, a service designer specifies the stakeholders of a service and analyzes their requirements and values. For that, the persona and scenario models are effective. To simplify the process of value analysis, the value analysis template has been proposed (Akasaka et al. 2009).

   The persona and scenario models use a form of representation based on natural language. Thus, it requires a certain amount of training, given the diversity of vocabulary selection and the difficulty of determining synonymy. Therefore, to describe these models simply, a design template has been proposed. This template is a set of five subtemplates used to describe personas, scenarios, and RSPs:

   – Persona template

     Persona template is to describe a persona with its demographic data and psychological data.

   – Character/intent template

     Character/intent template is to configure characters and intents of the designed persona with the prepared vocabulary list.

   – Script template

     Script template is to describe detailed activities of the designed persona to identify his or her needs.

   – Keyword template

     Keyword template is to convert the script to keywords which are unified lexical expressions.

   – RPS extraction template

     RSP extraction template is to determine RSPs by correlating them with the keywords.

     By filling these templates in order, a service designer can determine RSPs easily.

2. Embodiment

   According to the analyzed values of stakeholders, a service designer embodies a service process and its realization structure. To extract and determine their elements, the modeling methods reported above have been proposed.

   In addition, several design support methods have been suggested to embody a service. Applying the method for product design to service design has become one of the typical approaches. Here, the authors introduce the following two methods:

   – Abduction-based creative design

     Abduction is a reasoning method that generates the hypothetical knowledge needed to explain a certain fact and is realized by analogy in many cases (Takeda et al. 2003). Abduction by analogy has been applied to the creative design of not only products but also services by integrating knowledge from different domains (Oki et al. 2010). By using this technique, a service designer can extract possible design ideas for service design.

– Conflict detection and resolution

In the designed service models, there may be some conflicts. To avoid them, a conflict-detection method has been proposed by analyzing objects and predicates of functional expressions with a lexical expression database (Shimomura and Hara 2010). To resolve such conflicts, TRIZ is commonly used in product design (Mann 2002). TRIZ is a well-known methodology for the detection and resolution of conflicts by means of the principles and knowledge based on patent analysis. In several service studies, a part of the TRIZ methodology is applied for service design. For example, a list of inventive principles is used to solve the conflict (Shimomura and Hara 2010).

3. Evaluation

After embodying a service, a designer evaluates and verifies it. Several methods have been proposed to evaluate the efficiency and effectiveness of designed services.

– Simulation

To evaluate the designed services, various simulation methods have been proposed. For example, Komoto and Tomiyama applied a life cycle simulation method for the evaluation of service processes (Komoto and Tomiyama 2008) (see chapter ▸Life Cycle Simulation for Sustainable Product Service Systems). In addition, a simulation method with a scene transition net (STN) has been applied to service design (Tateyama et al. 2009). STN is a graphic modeling method for discrete-continuous hybrid systems. It is suitable for a service process simulation, since it can describe both the discrete-event transition and the state change of each stakeholder simultaneously.

– Structure analysis

For the improvement of a designed structure model, a structure analysis is also an effective approach. For example, a method to analyze the importance of a design structure and parameters by means of QFD and AHP is proposed (Shimomura et al. 2008). Quality function deployment (QFD) is a systematic analysis method to translate customer needs into the requirements and specifications of a design object (Akao 1990). Meanwhile, the Analytical Hierarchy Process (AHP) (Saaty 1980) is used to compute the importance of RSPs numerically according to bilateral comparisons among parameters. By creating an importance matrix of a designed service structure, essential points of the service structure can be identified for improvement.

Figure 36.7 is an overview of the service design methods and processes described above. As is evident, Service Engineering and its methods are based on various existing approaches.

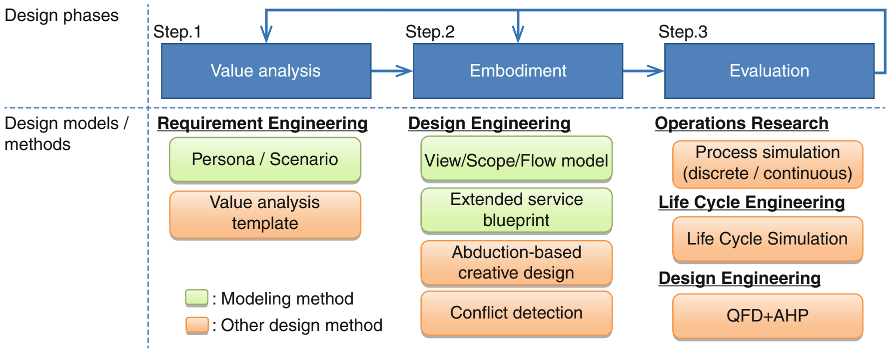

Fig. 36.7 Service design phases and methods

7 Service CAD

7.1 Components of a Service CAD

The solution space of service design tends to be much broader than that of the conventional product design. It makes the derivation of design solutions difficult. To provide computerized support for service design, the authors have been developing a CAD system for service design called a *Service CAD*.

The quality of design solutions and the efficiency of the design process depend largely on the designer's knowledge and design methods. Such issues on design management have been discussed in various fields, such as the research on knowledge-based CAD (Tomiyama et al. 1996). The existing design study regards design knowledge as an important element to derive a creative design solution. By providing design knowledge based on existing service cases and realizing a partially automated design operation, Service CAD can support the design of a new solution.

7.2 Structures and Functions of Service CAD

Figure 36.8 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. Persona database
   A database of personas and their detailed information
3. Function database
   A database to store function prototypes related to their realization structures
4. Design rule base
   A database of operational rules for service design
5. Reasoning engines

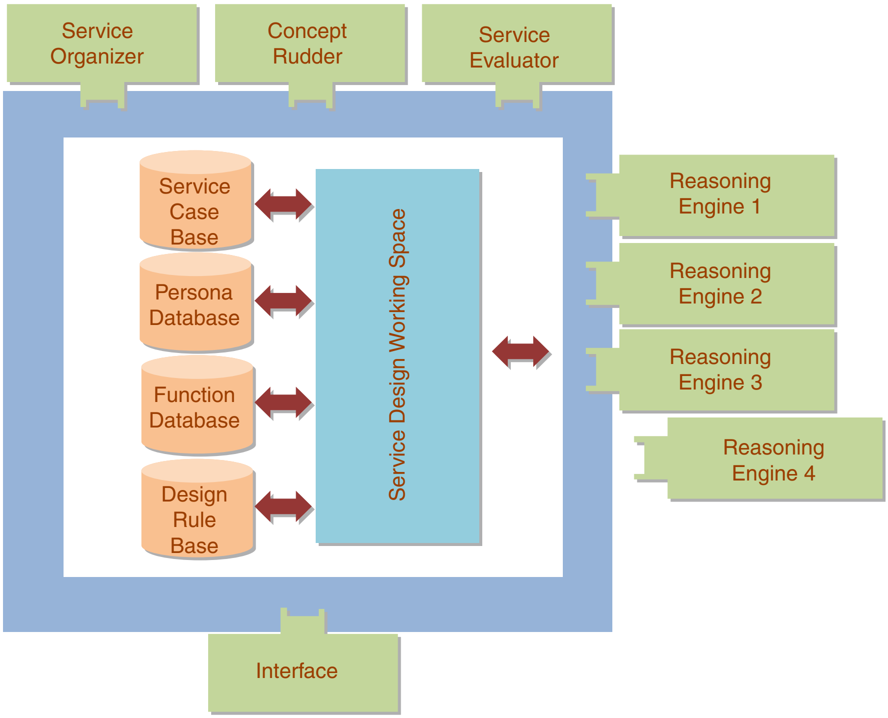

Fig. 36.8 Conceptual scheme of Service CAD

Modules to derive new solutions by correlating a service in design to other service cases from various aspects, such as their similarity. The pluggable mechanism that allows service designers to select the effective reasoning engine to derive new service ideas based on the designer's request is adopted.

6. Service organizer
   A module to support service design processes based on a specific design methodology by means of other components
7. Concept rudder
   A module to manage the stored knowledge in the abovementioned databases
8. Service evaluator
   A module to evaluate a service design solution

The *Service CAD* is designed to collect existing service cases. In addition, the *Service CAD* provides service designers with a reusable form of knowledge, such as function prototypes, personas, and design rules derived from the design procedures of existing service design cases. Those prototypes and rules can be utilized to embody other services. By applying them to service design in a partially automated manner, the efficiency of service design can be improved. For that purpose, a reasoning mechanism using service case databases and several reasoning engines

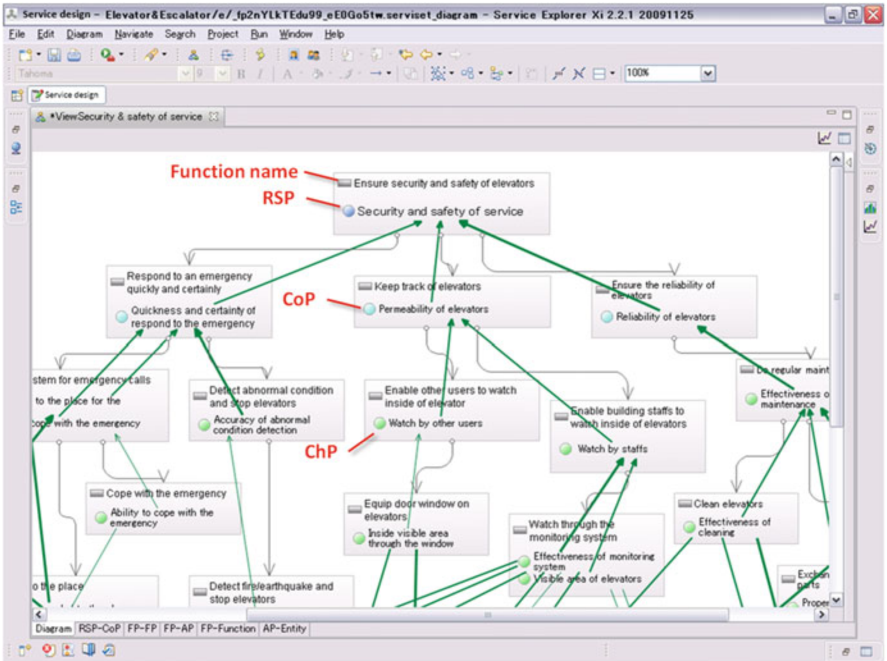

Fig. 36.9 Designed service in Service Explorer

to realize various design operations is implemented as a fundamental element of the Service CAD.

The authors have developed a prototype system of the Service CAD, called *Service Explorer*. Figure 36.9 shows a screen image of Service Explorer, currently under development.

This system has the following five functions:

1. To provide a design environment to input and edit a service model
   This is the most fundamental function of Service Explorer. In order to input information for efficient service design, an easy-to-use graphical interface to describe a service model is prepared.
2. To display focused components of a designed service
   Service Explorer can display the components of a service in design according to the designer's operation. Even a service designer who is new to the target service can understand the structure of the service by browsing its service components.
3. To register service cases in the service database
   Designed service models can be stored in the service database attached to Service Explorer. Whole design data can be stored in the service case base, and extracted components, such as functions and personas, are stored in the function case base or the persona database.
4. To search for a useful design knowledge in the service database

In Service Explorer, a search function is implemented to look up the service database according to the designer's requests. Service designers can search for service models as reference information by inputting related keywords.

5. To reuse service model data stored in the service database
Service Explorer provides not only a function just to search for a service model with a keyword but also one to reuse the structure of service models stored in the service database. For example, the function "clean floors" and its realization structure in a restaurant service can be used for the design of a hotel service. Various reasoning engines can be used for that purpose.

7.3 Application Cases

Service Explorer and service design methods have been applied to various service cases. Figure 36.9 shows the result of the functional design of an elevator maintenance service in the Service CAD. By decomposing a specific requirement of a service receiver into detailed functions, the concrete realization structure to embody a service can be described. Designed functions and their realization structures can be used for the design of other services.

After describing the service structure, a service designer can evaluate the service model in the Service CAD. Figure 36.10 shows the result of the importance analysis method of a service model. The set of numbers in the left-hand area in Fig. 36.10

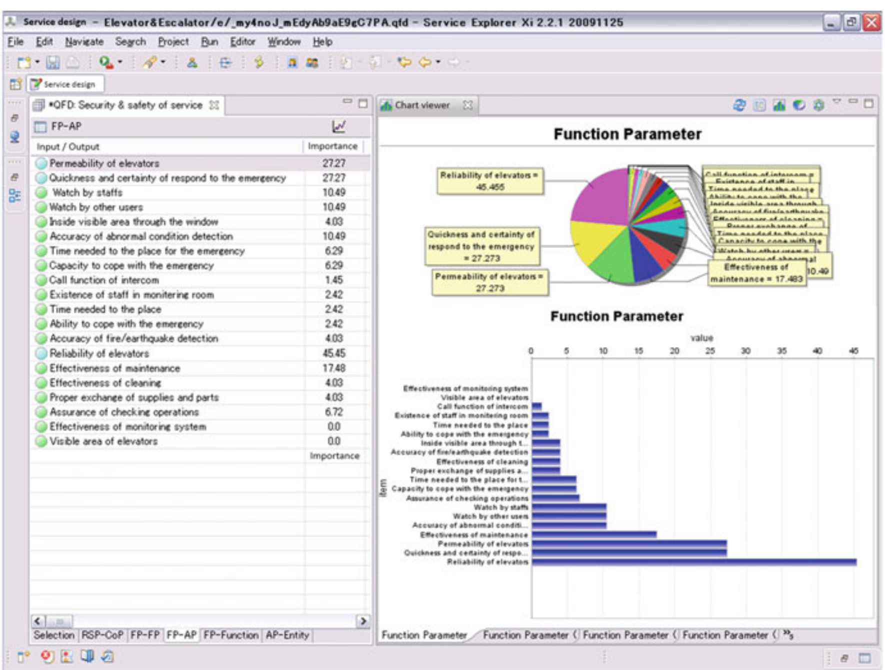

Fig. 36.10 Service evaluation in Service Explorer

shows the importance values of function parameters. They have been derived by means of the abovementioned importance analysis method. By visualizing the result of evaluation in the form of graphs in Service Explorer, a service designer can determine which part of a service structure should be modified.

Including the abovementioned design case, several projects of service design have been performed. One of the projects is Project ReCSeEn (Research Consortium on Service Engineering). This project was carried out by the Research Consortium on Service Engineering, which is comprised of four companies and three universities, in Japan in 2007/2008. In this project, the value analysis template was developed and applied to four case studies.

8 Summary

In this chapter, the authors explained the service-centered design approach and its effectiveness. To realize service-centered design, the authors introduced various design methods for each service design phase: value analysis, embodiment, and evaluation. In addition, the concept of Service CAD for creative and efficient service design and its prototype were explained.

9 Cross-References

►Life Cycle Simulation for Sustainable Product Service Systems

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