Architecture for Service Engineering – The Design and Development of Industrial Service Work

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1 Introduction

As indices of 'tertiarization' not only for Germany but also on a worldwide basis show, the service sector has become increasingly important compared to the agriculture and physical goods production sectors (European Commission 2002). Service companies contribute about 70% of the total GDP of Western Europe's economies.

Despite these figures of GDP share and the strategic intention to successfully run the service business, knowledge on how to develop service products and who should design them is marginal. This is in strong contrast to the profound knowledge and skills in the engineering of physical goods. Although some methods for designing and developing physical goods can also be used for services, recent surveys show a fundamental lack of knowledge and specialized skills in the use of procedures, methods and tools to design and develop professional services. This shortage of adequate procedures, methods and tools is mainly based on the immanent characteristics of services that strongly differ from those of products (Luczak et al. 2000).

In consequence of the lack of supporting methods and procedures, service operations frequently deliver ineffective and low quality services that do not meet the customer's needs. Furthermore, service processes, which have been inadequately planned and developed, are hard to reproduce with constant quality, requiring strong improvisation efforts by the service personnel. Combined with an insufficiently designed and developed working environment, profitability is negatively affected since only motivated personnel can deliver high quality services that satisfy the customers in the long term (Heskett et al. 1997; Liestmann and Meiren 2002).

Based on this balance of arguments this paper presents an architecture that comprises steps to be taken to successfully design and develop professional services.

2 Service Engineering as a New Research Discipline for Successful Service Design and Service Development

A new research discipline moving from scientific discourse into business is called 'Service Engineering'. Service Engineering mainly deals with the following aspects (Luczak et al. 2002):

1. Improving the procedures for designing and developing services more professionally
2. Establishing service design and development as a corporate function
3. Adapting a service specific human resource management

The term 'Service Engineering' implies a basis of engineering knowledge and originates from the assumption that services can be designed and redeveloped in a similar way to physical products (Bitran and Pedrosa 1998; Meyer and DeTore 1999; Luczak et al. 2000). Accordingly, engineering procedures, methods and tools form the core of this approach (VDI 1980, 1993). Service engineering encompasses what Ramaswamy (1996) established as 'Service Design', stretching its focus with regard to the extent of the innovation process and the addressed aspects as listed above.

This approach differs to some extent from the proximate research field of New Service Development (NSD), which also deals with the issues of how to develop new service products (Easingwood 1986; Bowers 1989; Scheuing and Johnson 1989; Edvardsson and Olsson 1996; Sundbo 1997; Edvardsson et al. 2000). NSD has its roots in service quality, because quality is said to strongly contribute to the understanding of the service logic and the drivers of customer satisfaction (Parasuraman et al. 1988). In contrast to Service Engineering, NSD mainly addresses consumer services rather than business-to-business (B2B) services and approaches the issues of service innovation from a marketing perspective (Johne and Storey 1998).

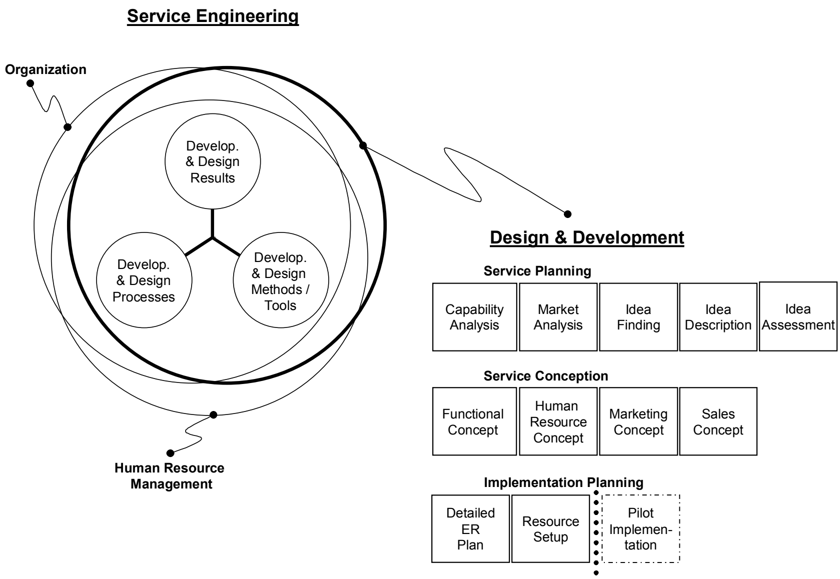


Fig. 1. Aspects of Service Engineering and phases of the design and development of services

Within Service Engineering the process of service design and development consists of three major phases, namely the service planning, service conception and service implementation, as shown in Fig. 1 (Luczak et al. 2003). The first phase, service planning, is centered on idea generation, forming and evaluation. The subsequent phase, service conception, leads to a more precise description of these ideas in terms of their content, eventually resulting in a service that is ready to be launched. The launch itself takes place in the implementation phase.

This paper will focus on service planning and service conception and thus contributes to the first aspect within the framework of the discipline of Service Engineering as mentioned above.

3 Service Planning for Promising Service Ideas

The phase of service planning starts with a systematic idea generation. The use of the contradictory expressions 'systematic generation' and 'idea' might cause confusion. Obviously, the search for ideas can only be supported by systematic approaches, however it cannot be systematized in the sense of an automatic generation, as generating ideas will always remain a creative process.

Depending on the size and the strategic goals of a company, the idea generation might have different focuses. One can distinguish the resource-oriented and the market-oriented idea generation (Luczak et al. 2000). The starting point of a resource-oriented idea generation is a firm's set of capabilities and new possibilities to put them into effect. During the planning process this input focus moves to the needs of the market. In the B2B sector these needs are mainly determined by the customer problems in the sense of services being a solution to an existing problem. The market-oriented approach starts with the analysis of market opportunities and customer problems as source for ideas and subsequently takes necessary capabilities and resources into account (Luczak et al. 2000, 2003). An adequate method, which brings together both mentioned aspects, is the policy deployment (Akao 1991). In any case, both the company's core capabilities and customer problems serve as valuable resources for idea generation.

The main criterion for identifying and selecting core capabilities is their potential to redound to the company's sustainable competitive advantage. According to Barney (1991) this is the case if the resources are rare, valuable and can neither be imitated nor substituted. A Value Chain Analysis helps to gather this input data (Sontow 2000). Result of this analysis with respect to the Barney criteria is a catalogue of sustainable and superior core capabilities and underlying resources.

For gathering customer problems internal and external information sources can serve as input. Departments with a high degree of interaction with the customer, i.e. sales or after-sales services usually have a huge amount of information about customer problems and customer needs. Even if this knowledge is rarely documented, it can be processed by means of workshops. Of course, one can also directly ask key customers (e.g. in workshops) what their problems are and how they think one can solve them. This is especially useful for professional services, where business relations are close and intimate. The Purpose of this analysis of customer problems is to gain a better understanding of what the problems are, what effects they have and how services can be applied as a problem solution.

By bringing together sustainable competitive capabilities and problems with the help of Interdependence Analysis Method, the creation of ideas takes place systematically. Thus, combinations of sustainable competitive capabilities that highly contribute to the solution of a severe customer problem build an attractive basis for a service idea. The actual creation of an idea, again, is a matter of creativity suitably assisted by creativity techniques like BrainBlooming, Mind-Mapping or the 6-3-5 Method. The description of the addressed customer problems, the necessary capabilities / resources and a rough description of the solution process combine to form the service idea and conclude the phase of service planning.

4 An Architecture for Service Conception

Based on the formulated service ideas, the main focus of the service conception phase is to bring more substance and depth to the ideas. The architecture as shown in Fig. 2 consists of five essential components for designing and developing professional services:

The *Service Development Process Model (SDPM)* comprises development steps that are necessary to determine requirements and to form the functions and processes that fulfill these requirements. This model also contains steps to identify the skills and resources that are essential to perform these processes professionally. The steps included in the SDPM will be described in detail in the following sections.

The architecture component *Service Development Methods (SDMe)* comprises methods that enable a systematic approach to the development targets. The methods best suited to support the design and development will also be shown in depth in subsequent sections.

The architecture component *Service Development Tools (SDTo)* only contains tools that directly support distinct methods. In the understanding of this architecture, the tools of the SDTo operationalize the methods of the SDMe.

The *Service Development Result Description Model (SDRDM)* documents the respective outcomes of the design and development steps, as well as of the service work itself. Thereby, this model also builds a common understanding among the design and development team members. The SDRDM combines functional and graphical aspects of the representation of development results.

The *Service Development Management Model (SDMM)* integrates the four other components. The SDMM connects the development steps of the SDPM with the methods and tools of the SDMe and SDTo respectively in order to archive the development result represented in the SDRDM. Furthermore, the first practical experiences have shown that the SDMM can be used as a guideline for developing and designing professional services as well.

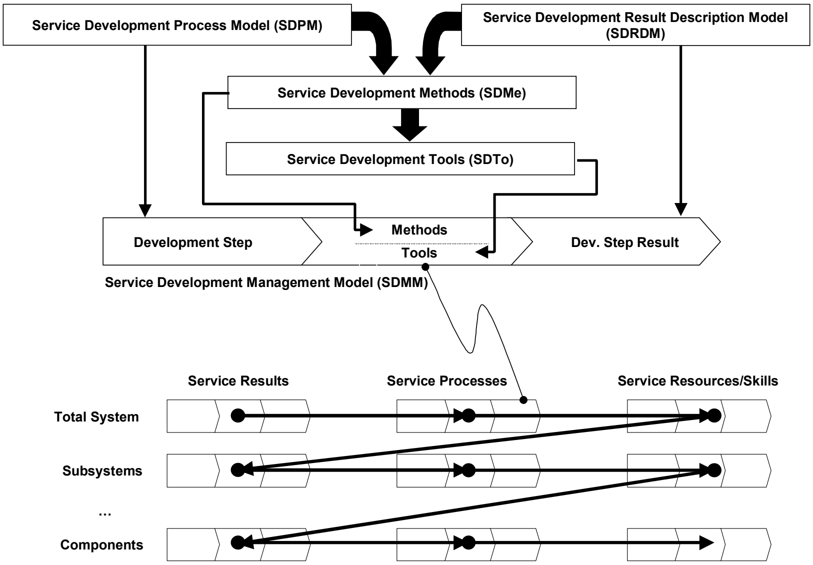


Fig. 2. Essential components of the architecture

To minimize the complexity of a development project, one should not attempt to outline every detail of the service from the very beginning. Instead, the development can be commenced in such a way, that the identified requirements for the service system are implemented first in a general concept. Afterwards, the general concept can be divided into components. The determined characteristics of the general concept result in requirements for those components. Each component can then be considered independently. This procedure of specifying concepts into partial concepts and their subsequent configuration can be continued at all levels of detail in the same way. An appropriate method to detail a service system is the Function Tree Analysis under consideration of Sun's axiomatic design (Akiyama 1991; Suh 1990). Among other things, Suh states that one can only detail a function tree with the embodying concept in mind.

Based on the essential characteristics of professional services, the architecture itself is divided into three partial models with regard to the constituent elements of services: results, processes and resources. The partial models are closely connected in the sense of means-end relationships. Since results are generated by a set of processes, which still have to be specified, a certain service result for its part implies requirements for the service processes. Hence, service processes are means, which generate predetermined results. The processes in turn necessitate resources for their implementation. For this reason processes and resources represent a means-end relationship. Therefore, a complete service concept always contains a result concept, a process concept and a resources/skills concept.

4.1 The Service Result Branch of the Architecture

This partial model of the architecture comprises activities to incorporate the external requirements of customers, as well as the internal requirements on behalf of the company, to check their plausibility, to prioritize and to substantiate them.

The first step on this level is the investigation of customer and company requirements (Fig. 3). One recommended method for this is the Advanced Sequential Incident Method (Parasuraman et al. 1988; Kamiske 1997).

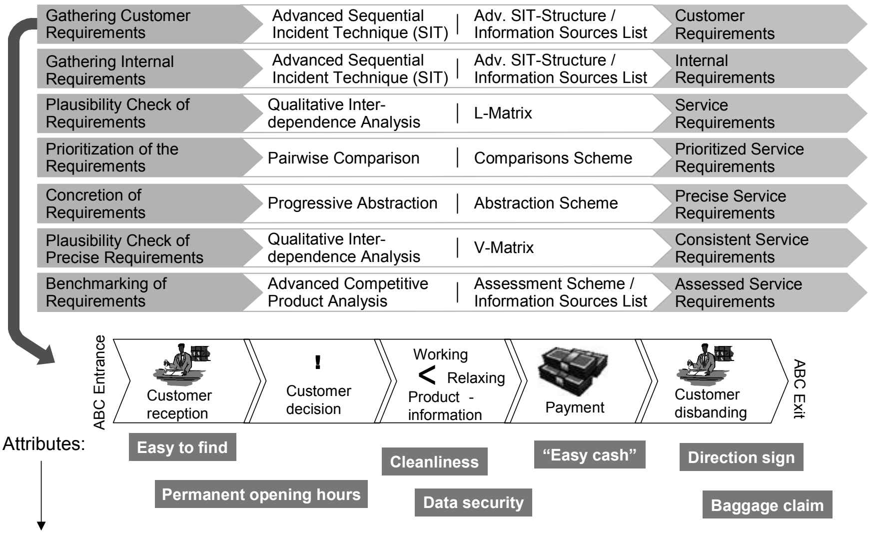


Fig. 3. The Service Result Branch of the Architecture for Service Conception - Gathering Customer Requirements

In this method, individual process steps are identified along the chronological course of the service creation. It is then analyzed on the level where customers and suppliers are in direct contact.

In the following development step 'plausibility analysis of the service requirements' the requirements that have been identified from the perspective of customers and the company are brought together and analyzed with respect to their plausibility. The Qualitative Interdependence Analysis is employed to show the mutual dependence between requirements (which are regarded as coequal), by analyzing the response of elements to changes in another element (Clausing 1994; Schütze 2001). For this purpose, the requirements for the service from the customers´ perspective are confronted and compared with those from the company's perspective in a matrix. Criteria for the Qualitative Interdependence Analysis are 'target-neutrality', 'target-harmony' and 'target-conflict'. The results of this development step are consistent service requirements from the perspective of customers and the company. As a next step, the service requirements are prioritized from the customer perspective with respect to their impact on the success of the service (Fig.

4). The Pairwise Comparison has been identified as a suitable method for this prioritization (REFA 1990; Eversheim et al. 2002).

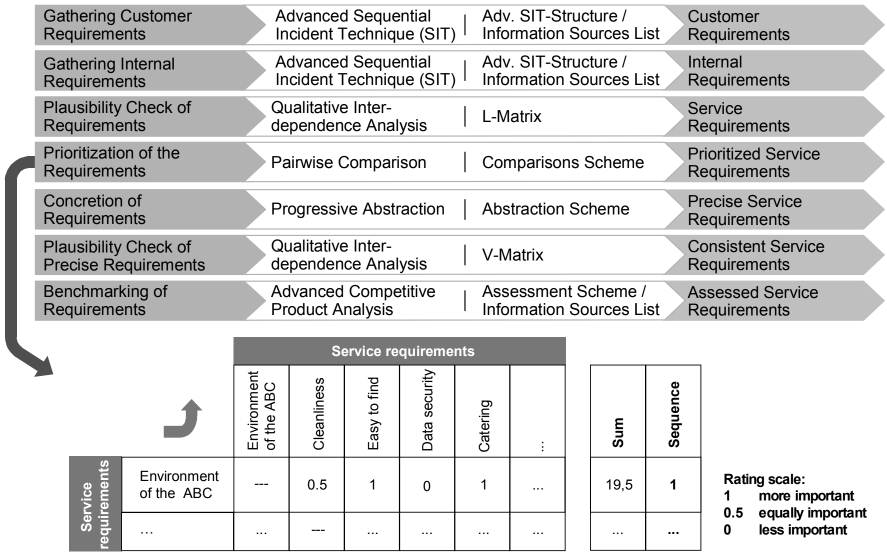


Fig. 4. The Service Result Branch of the Architecture for Service Conception - Prioritization of Requirements

For this purpose, the service requirements are compared head-to-head. Criteria of comparison are the ordinal rating scale ‘more important’, ‘less important’ and ‘equally important’. After that the ordinal rating scale has to be transformed into a metric scale as e.g. 1 = more important, 0 = less important and 0.5 = equally important. Finally, a ranking order of the service requirements can be drawn up based on the sum of the rows in the matrix.

In the development step ‘concretion of the service requirements’ the method of Progressive Abstraction is used in the architecture. With the Progressive Abstraction the requirements in terms of their benefit of use are edited and the levels of measures which contribute to a large extent to the achieved objectives of the development are revealed (Botschen and Mühlbacher 1998). The results are requirement-solution combinations, which are more exact and more precise than the originally formulated service requirements. Since the processed service requirements could have changed while implementing the Progressive Abstraction, a new Plausibility Analysis has to be conducted.

In the last step of the result section of the service development architecture, the processed requirements are compared with the characteristics of services already available on the market. For this evaluation, the Advanced Competitive Product Analyses has been identified as a suitable method (Hildebrandt and Klapper 2000). For this purpose, it is first necessary to identify competitive services. Integrating aspects of customer expectation into the evaluation enlarges the perspective towards a rival service. The criteria used for this are the characteristics ‘must-be requirements’, ‘revealed requirements’ and ‘exiting requirements’, introduced by Kano (1984). As an evaluation criterion for the degree of performance by the rival product, the ordinal rating scale ‘better performance’ and ‘worse performance’ is used respectively. The objective is the design of marketable services. Therefore, requirements have to be further specified as long as the sum of the revealed and exiting requirements (which are already fulfilled by the competitive service) is smaller than that of the service to be developed. No further design should be considered in case this measure cannot be achieved. Otherwise this section of the architecture ‘determination of the service result’ is completed.

4.2 The Service Process Branch of the Architecture

Starting from the service requirements, the respective tasks are identified and defined by means of noun/verb-combinations in this partial model of the architecture. The main question for this task can be formulated as follows: ‘How can the individual service requirements are implemented?’ After having found implementation methods for each requirement, the requirements are summarized hierarchically with the help of Transfer Graphs as a tool of the Affinity Method (Schaude 1992). The results of using this method are hierarchically structured service tasks, which are deduced from the requirements.

In the next step, the service tasks have to be analyzed with respect to their type. By allocating the service tasks to the types ‘overall task’, ‘primary task’ and ‘secondary task’ distinctions can be made. The overall task shall be defined as: being able to meet the maximum amount of service requirements the customer is willing to pay for. The primary task fulfils at least one service requirement and can also be priced. Although a secondary task also functionally fulfills at least one requirement, the customer is often not willing to pay for this.

In order to benefit from synergies, service tasks, which are already implemented and the service to be developed need to be aligned. For this purpose, the Interdependence Analysis is again a suitable method. Therefore, an ordinal rating scale, which distinguishes ‘target is covered by existing task and target is not covered by existing task’, should be used to evaluate all primary service tasks respectively.

In the following development step ‘transfer of service tasks into service delivery processes’, a Process Modeling Method further details those primary service tasks, which are necessary to fulfill the customer requirements. Service Blueprinting by Shostack (1984) has been identified as a supporting tool for this step (Fig. 5).

Service Blueprinting is a method used for analyzing the service delivery process. Using a flow chart-like presentation, several types of customer interaction are distinguished and visually separated by so called lines-of-visibility. The customer section contains only processes the customer is directly involved in. The onstage processes are visible to the customers, but they do not take an active part in it. The third section of the process flow chart comprises the backstage activities that are entirely performed by the employees without any contact with the customer. With this differentiation the service delivery processes can be adjusted with respect to performance, robustness and reproducibility.

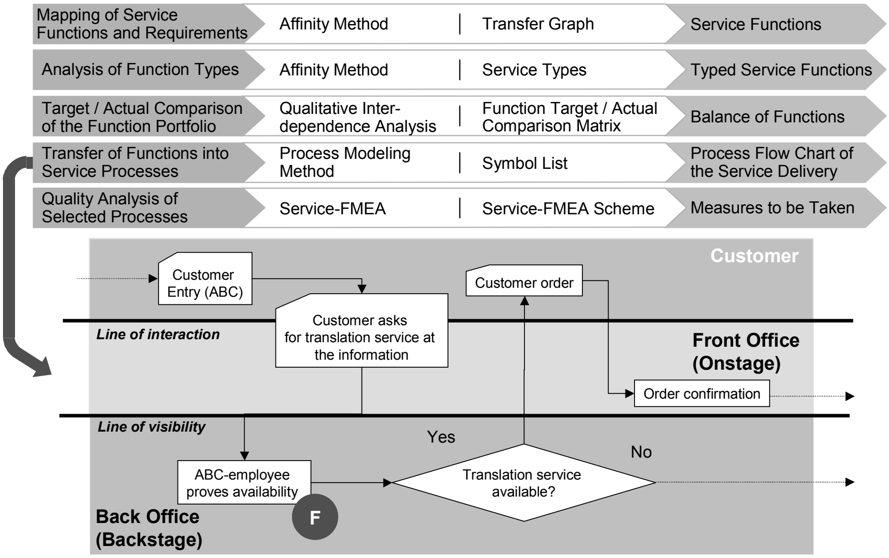
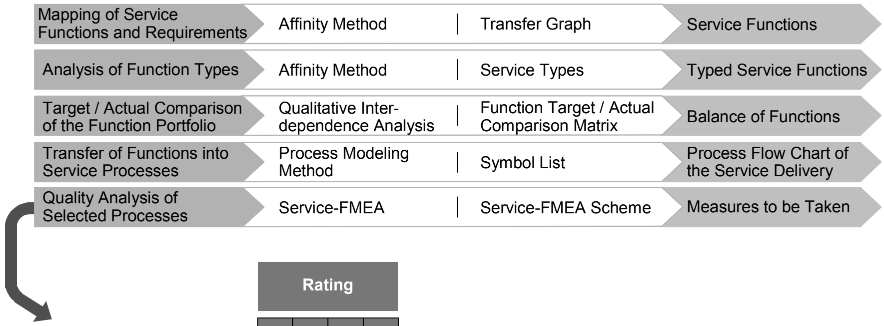


Fig. 5. The Service Process Branch of the Architecture for Service Conception - Transfer of Functions into Service Processes

The Service-FMEA (Failure Mode and Effects Analysis) is implemented into the architecture (Fig. 6) providing a detailed analysis of potential risks associated with service delivery processes.

When using the Service-FMEA, first, potential failures linked to the process steps are determined and rated on a 1-10 scale with respect to their severity (s) and their detectability (d) (DIN 1990; Eversheim 2000). For processes with direct customer interaction as ascertained in the Service Blueprinting, the detectability is irrelevant as there is no chance of preventing the customer from experiencing the failure. Following this, the causes of each potential failure need to be discovered and evaluated with regard to their probability of occurrence on a 1-10 scale. Subsequently, these three values of severity, occurrence and detectability (if applicable) are multiplied. The result is the so-called Risk Priority Number (RPN), which identifies the greatest areas of concern and indicates what kind of corrective actions should be taken. Preferable to this is the use of preventive measures, which helps to avoid cost-intensive failures before they occur.

Once the development steps for all identified primary service tasks have been undertaken, the development of the service delivery concept is complete.



Process description	Potential failure mode	Rating: Appearance	Rating: Relevance	Rating: Detection	Rating: Risk Priority Number	Failure causes	Effects	Actions
Appointment with customer	One Appointment is made twice	3	10	7	210	Appointments are made by more than one employee	Cancellation of the appointment by one of the customers	One person in charge
	...	...	...	...	...	...	...	...

Fig. 6. The Service Process Branch of the Architecture for Service Conception - Quality Analysis of Selected Processes

4.3 The Service Skills and Resources Branch of the Architecture

This partial model of the architecture helps to develop a concept for the essential service resources. The skills, which are necessary to perform the identified service tasks and service processes, are identified first with the help of the Affinity Method and hierarchically structured by means of a Transfer Graph. The result of this development step is a target skills profile, which should be understood as the sum of skills necessary for delivering the service.

Next, individual skills are analyzed with regard to their type: professional competence, social competence, personality competence and method competence. In addition to allocating the identified skills to the relevant types, a qualitative evaluation of the categories ‘no competence necessary’, ‘basic understanding necessary’, ‘first practical experience and advanced understanding necessary’ as well as ‘management, practical experience and distinct understanding necessary’ is undertaken (Fig. 7).

In order to benefit from synergies, a target/actual comparison should be conducted with the skills, which are already available within the company and the determined skill profile. The interdependence Analysis is again a suitable method for this.

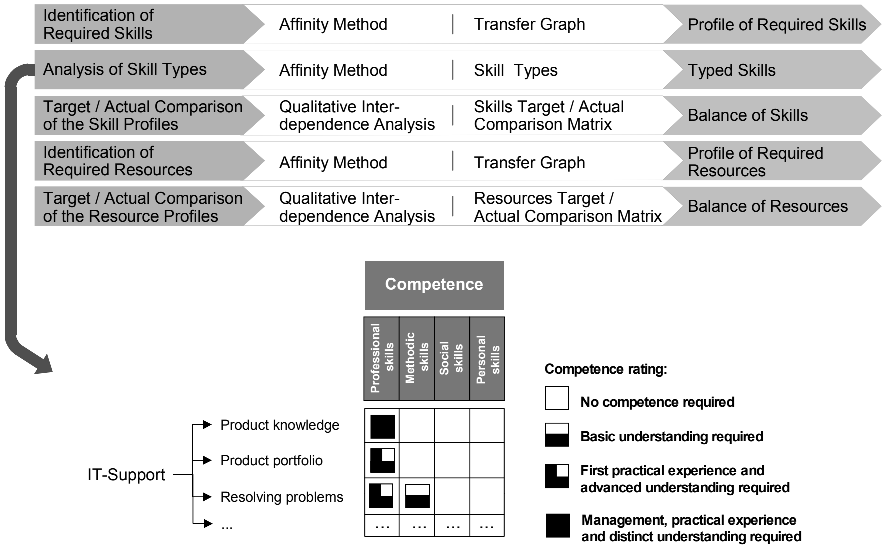


Fig. 7. The Service Skills and Resources Branch of the Architecture for Service Conception - Analysis of Skill Types

Subsequently, the key resources related to the skills for the service delivery have to be identified with the help of the Affinity Method. It is important to find as many resources as possible, which embody the required skills (Fig. 8). A Transfer Graph is again an adequate tool for the structuring.

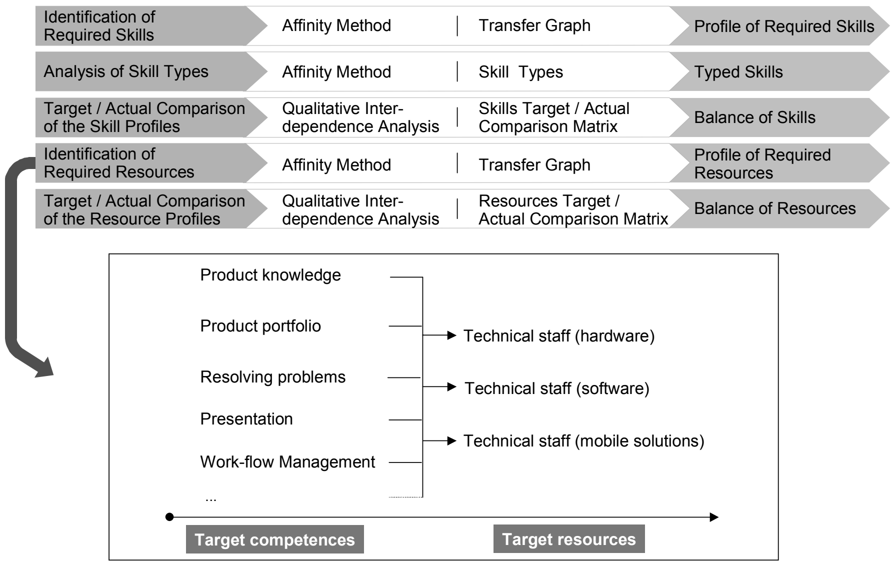


Fig. 8. The Service Skills and Resources Branch of the Architecture for Service Conception - Identification of Required Resources

Next, a target/actual comparison is conducted between those resources that are necessary for the service delivery and those that are already available throughout the company. Again, an adequate method is the Interdependency Analysis with an ordinal rating scale of 'target is covered by existing resources' and 'target is not covered by existing resources' respectively. In case of resource coverage or resource excess, the service which should be developed can be generated with the already available resources of the company. In case of resource deficit, the corresponding resources have to be obtained.

When the development steps for the identified competencies and resources are finished, the development of a potential conforming service provision concept is completed.

5 Application of the Architecture – Lessons Learned

So far, a telecommunications service provider has used the architecture for service conception in two cases. The company's revenues amounted to 40 billion euros in 2001 and, by the end of 2001, the company employed around 250,000 employees. The company offers a spectrum of around 4000 products and services in nearly all sectors.

At the beginning of the project there were only generic development steps on a non-practicable level and no corresponding support of tools or use of established methods. Until then, the average effort for the development of a new service product was 45 man-days with a team of 10 people and a time frame of 6-12 months.

The major goal of the project was to provide the development team with an architecture, which included the necessary components for developing professional services on a practical level as well as improving the information content about the developed service e.g. as a starting point for further cost effectiveness studies.

Two ideas, which had been generated, formulated and prioritized in a pool of ideas, served as starting points for the development process. In particular, these were an 'airport business centre' and a 'web portal for failure logging, dispatching and progress tracking'.

The major idea of the airport business centre is to offer 'frequent flyers' adequate accommodation for their stay between two flights without having to leave the customs area of the airport. Making use of this offer, business travelers are able to work in a professional working environment with IT-Support etc., as well as being able to relax during their stay at the airport.

The origin of the web portal idea resulted from the fact, that the telecommunications service provider offers only specific hotlines for repair services with no further customer involvement at any point of the procedure. In order to improve the information quality, which should lead to higher customer satisfaction and reduce internal processing efforts, a web portal should support the whole process of failure logging, dispatching and progress tracking. Approximately 250,000 mid-size companies with contracted service level agreements constitute the target customer segment for the web portal.

The exemplary results obtained by application of the described architecture for the development of services have shown that this is a workable approach for the development of services and for the design phase as an early phase within service design. Overall development effort was reduced by 30% compared to similar projects. The development efficiency has been regarded as adequate by the project team and the project management. Due to the overall manageable development effort, the architecture also exhibits the possibility to generate service ideas, which at first glance seem outside the company's scope.

On an operational basis, experience has shown, that participatory workshops are the most suitable way to apply the architecture. This way knowledge of the development of services as well as the handling of the architecture for Service Engineering can be passed on.

6 Outlook

The architecture presented in this paper contributes to a general framework not only for the successful development of services on a practical level, but also as part of the new research discipline of Service Engineering, which is currently being established.

Looking to the future, there are three main trends within the research discipline of Service Engineering:

First of all and similar to advances made in product development, the development of services will be increasingly supported by systems for Computer Aided Service Engineering. Such systems require further specification of their components and interrelations, as current understanding of such systems is still rather vague. In regard to the presented architecture, supporting systems will have to include a configuration of the components of the architecture depending on the type of service, which is being focused on Nüttgens et al. 1998. This is due to the different characteristics of services (e.g. industrial and consumer-oriented services or stand-alone services and service bundles) and the subsequent differences in the complexity of the development process (Fähnrich 1999, Jaschinski 1998).

Possible evolution in the area of Service Development is depicted in Fig. 9.

A second avenue for future research is the development of so-called hybrid products i.e. a combination of material goods and services. In particular, the integration of the two (up to now separate) development processes poses an innovative research area. Furthermore, taking into account the different life cycles of products and services, future research should lead to an integrated complexity management. This, combined with the afore mentioned IT-based systems, would lead to the 'virtual development of hybrid products'. Using efficient simulation tools, rapid prototyping strategies and the integration of processes should lead to an overall reduction in development time and due to the possibility of early failure analysis, to higher product and process quality (Radtke 1995).

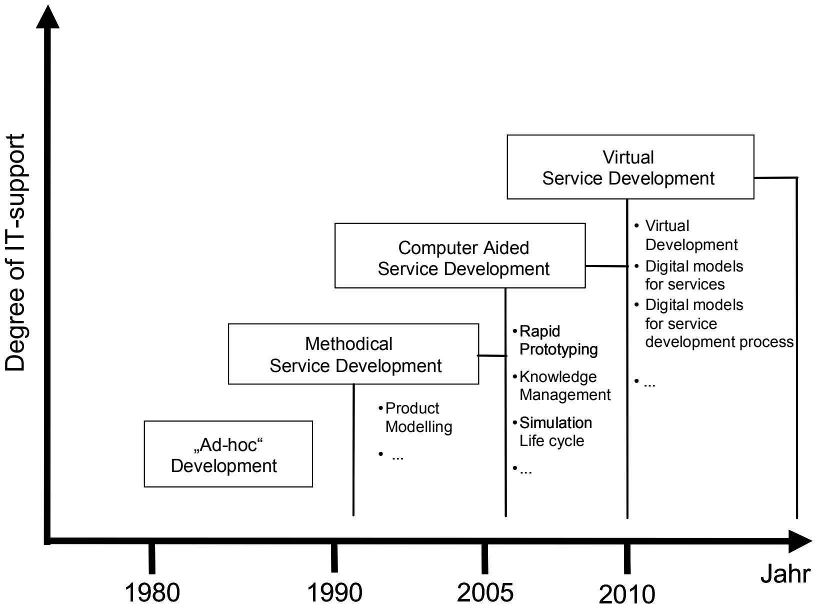


Fig. 9. Trends in Service Development

Last but not least, a third major possibility for future research lies in the organizational integration of the development process (Luczak et al. 2000). Service development seen as a process embedded in the company's innovation management has to be examined regarding the relevant factors influencing service development and their impact on service performance. Subsequently, this would lead to standardized evaluation and measurement models for the service development process.

Acknowledgements

Funding for the research leading to these findings was provided by the Federal Ministry of Education and Research (Bundesministerium für Bildung und Forschung, BMBF), grant number 01HR0019.

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