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Kyrill Meyer, Michael Thieme (Eds.)

Theory and Practice for System Services Providers in Complex Value and Service Systems

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Klaus-Peter Fähnrich (Series Editor)

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Theory and Practice for System Services Providers in Complex Value Chains and Service Systems

Proceedings of the 5th International Symposium on Service Science
Leipzig (Germany), September 24, 2013

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More information about the International Symposium on Services Science and the online version of several papers and presentations are available at the website: http://isss.uni-leipzig.de/.

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Preface by the Series Editor

The book-series „Leipziger Beiträge zur Informatik“ (Leipziger Contributions to Computer Science) publishes reports from research projects, edited volumes from innovative and emerging research areas, dissertations and post-doctoral lecture qualifications as well as conference proceedings and outstanding students works. The value of the series that has been brought into life in the year 2003 is that it offers a prompt and comprehensive look at running or recently finished scientific work or current scientific discussions. The series brings an innovative variety of topics alongside a high scientific penetration. Also, scientifically relevant areas are enriched through practice-oriented technical papers and documentations.

The different contributions are presented from a background of an applied computer science and with an information systems view. Key aspects of activity are business information systems, content- and knowledge-management as well as cooperation in intra- and internet-settings. Also, with close relation to the location and network background, special attention is given to the service sector, especially with respect to IT-enabled services and solutions.

Institute for Applied Informatics (InfAI) publishes lectures and fosters the further development of the book series. The InfAI is an affiliated institute of the University of Leipzig with the non-profit goal of boosting science and research in the area of computer science and information systems.

This present 41. volume of the series documents the “International Symposium on Service Science” that took place in Leipzig as part of the SABRE-multiconference / Leipzig Day of Applied Informatics on September 24, 2013. As series editor I would like to express my gratitude to the organizers of the conference and the different presenters and attendants for their participation.

Klaus-Peter Fähnrich — Leipzig, September 2013

Series Editor
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Preface by the Symposium Chairs

Service Science is a new research discipline that has received, over the last years, a growing attention from academia and practice. It combines research from various fields which have evolved more or less independently and is concerned with the development and management of service products. Whereas theories from organizational and marketing science usually capture the nature of these products, engineering disciplines focus on shaping and developing these information goods, and the information systems field on integrating services as encapsulated application functionalities by using standardized (XML) interfaces. All these research streams converge in the new interdisciplinary area of Services Science which integrates the principles, design, and management of economic and technical services.

In September 2013, the "International Symposium on Service Science (ISSS)" offered various participants a unique platform for advancing research and discussions in service science for the fifth consecutive year. Being held as part of the "Leipzig Days of Applied Informatics/Leipziger Tage der Angewandten Informatik", researchers and practitioners alike joined in their effort to better understand the emergence of system services providers in complex value chains and service systems. The proceedings book documents some of their insights and wants to serve as reference for the advancing discussion.

The symposium was organized by the Institute for Applied Informatics (InfAI) in cooperation with the Department of Computer Science at the University of Leipzig and the Fraunhofer IAO in Stuttgart. As reflected in the conference proceedings, the sessions of the symposium dealt with system services providers from different perspectives: Besides research and demonstration papers reviewed by the program committee, invited keynote talks and presentations and a panel discussion contributed to this year's event. The organizers would like to thank the different authors, presenters and the program committee for their valuable work.

The Symposium Chairs, Leipzig, September 2013

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5th International Symposium on Service Science

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Research Paper Session

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Towards a Research Framework for Multiagent Organizations

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Abstract: The increasing number and variety of electronic services offered by heterogeneous cloud service providers in value chains faces new challenges of transferring the real world business strategies to software. We address the problem of defining a set of specifications for the design of a software system that exhibits the requirements and characteristics of the service networks' underlying organizations. This research adopts the theory of multiagent organizations to study and conceptualize a software system that acts on behalf of a cloud service provider to facilitate decision-support for complex organizational tasks. Organizational concepts from social theories of organizations have been applied to multiagent systems in order to capture the organizational features and components of an enterprise. The contribution of our research is a set of requirements for software systems that integrates precise mappings of appropriate terminologies and concepts.

1 Introduction

The increasing number and variety of electronic services offered by heterogeneous cloud service providers in complex value chains has stimulated the identification and characterization of innovative business models for the commercialization of these services [Boe09, Wid13]. In dynamic service environments as such, service providers face new challenges as they must gain and manage specific market knowledge and strategic resources or expertise. To this end, it appears significantly important for service providers to understand the connection between the business strategy and the innovation management of a successful business model [Tee10, Krc11]. According to resource-based theory [Bar91], however, service providers are organizations that can be viewed as a bundle of resources and capabilities. In particular, the heterogeneous types of customers, the geographic dispersion of the service provider and its interaction requirements significantly influence the configuration of the organization as a whole and specifies its resource requirements [Mor05], i.e., the types and specifications of electronic services constituting the portfolio. Hence, the increasing number of such complex organizational tasks and challenges confronts the management of a service provider enterprise with difficult and often unmanageable decision-making processes.

We address the problem of defining a set of specifications for the design of a software system that exhibits the heterogeneous requirements and characteristics of the service provider organization. The conceptualization and realization of such software systems have to consider the individual settings, goals, and preferences of the service provider and reflect the relations of its organizational structures. In particular, since the software system represents and acts on behalf of the service provider, it must be capable of pursuing the delegated objectives of its user.

This research adopts the theory of multiagent organizations to study and conceptualize a software system that acts on behalf of the service provider to facilitate decision-support for complex organizational tasks. A multiagent system from the field of artificial intelligence (AI) is a software paradigm that suits well in settings where individual actors are represented by intelligent software agents. These agents are able to perform autonomous actions in order to pursue their individual delegated objectives [Woo09]. Organizational concepts drawing from social theories of organizations have been applied to intelligent agents and multiagent systems in order to capture the organizational features and components of an enterprise [Kir96, Fer04]. The application of models from organizational theory to technical systems such as multiagent systems must, however, consider precise mappings of appropriate terminologies and concepts. For instance, while management literature considers organizations as social systems in its original sense (just humans as members), DAI/MAS literature defines organizations as social systems comprised just of technical artefacts (software agents). Further, the role concept of the Contract Net provides for flexibility in distributed problem solvers, while the social sciences role concept aims to support the organizational stability in social systems. It is thus necessary to carry out a detailed analysis about similarities and differences between these two areas of organizational research. Hence, the emerging design of a multiagent organization is capable of emulating the heterogeneous requirements of a service provider such as exceptional market knowledge, access to unique strategic resources or expertise, and openness to new technologies.

The remainder of this paper is structured as follows: In section 2, we describe the basic terms of our research. We then introduce the different conceptualizations of "organizations" in management science (section 3) and distributed artificial intelligence (section 4). Section 5 concludes the paper and gives an outlook of future work.

2 Basic terms

This section introduces basic organizational terms. The definitions are deduced from general linguistic definitions taken from the Oxford dictionary [Oxf05]. The oxford dictionary defines an organization as "*an organized group of people with a particular purpose*" [Oxf05] and a *group* as "*a number of people or things that are located, gathered, or classed together*". The term *member* respectively the *membership* of a person or any other instance is a central factor to define the boundaries of an organization. The oxford dictionary defines a member as "*a person, country, or organization that has joined a group, society, or team*" [Oxf05]. This definition shows that even organizations may be members of other organizations, but it leaves the definition of criteria that specify when the term *join* is satisfied open. This specification is a central problem in definitions of membership in organization theoretic literature and the range of drawing this circle is wide. While Luhmann [Luh00] even dedicates the employees of an organization to its environment Cyert and March [Cye63] include the customers of an organization in the organization itself [KiWa10]. With blurring delimitations of different contract types, e.g. employees and freelancers, we follow the broader definition of an organization and require a member to have a contract with the organization that obliges him to provide its resources.

The term *resource(s)* defines "*a stock or supply of money, materials, staff, and other assets that can be drawn on by a person or organization in order to function effectively*" [Oxf05]. Consequently, each member of the organization provides a part of its resources to the resource pool of the organization. In the notion of the resource-based organizational approach, a resource is "*anything which could be thought of as a strength or weakness of a given firm*" [Wer84], including assets, capabilities, processes, knowledge, capital, and trade contacts [Wer84, Bar91]. Organization may exhibit formal organizational structures based upon general rules as well as the allocation of roles to each single member. Organizational *rules* are "*a set of explicit or understood regulations or principles governing conduct or procedure within a particular area of activity*" [Oxf05] and intentionally limit the scope of action of each member [Sch08]. All these instruments aim at organizing the responsibilities, the allocation of resources, and division of labour within the organization. The organizational rules set the basis for *roles* – a set of normative expectations to the owner of the role – that are occupied with members of the organization. The role itself, however, is an anonymous part of the organization that can be associated with different members [Fre92].

While the Oxford dictionary definitions are based upon a general understanding of organizations as open social systems of any kind (soccer team, enterprises, families, etc.), the management-related literature applies *organizations* to economic actors, e.g., enterprises and administrative institutions. To this purpose, this literature generally uses more restrictive definitions and especially specifies the relation between the people forming the organization or between these and the organization itself. Organization theory further distinguishes between different views on organizations: the *institutional view* considers different types of organizations (institutions), e.g. hospitals, manufacturers, universities, or governmental bodies. The *instrumental view* is concerned with the development and implementation of organizational rules, and structures in order to organize the social system (enterprises "have" an organization). The *social system view* considers organizations as open social systems with common goals, and (organizational) information processing systems. The *intelligent organizations view* builds upon a conceptualization of an organization that integrate human and machine-based intelligence.

3 Management science perspectives on organizations

3.1 The System Theory Perspective

The system approach combines socio-economic aspects with a structural approach. The structure of an organization is broken down from a macro perspective into interdependent subsystems. The basic model assumes an open system. Consequently, the goal is not to find an absolute explanation of the organization, but rather to gain causal connections for specific situational conditions. The system approach applies technical heuristics (e.g. cybernetic systems) to explain the dynamic behavior of organizations. The validity of this interpretation is controversial discussed in literature. Furthermore, the macro perspective neglects the subjective intentions of single decision-makers. However, in the context of the projection of economic aspects onto an information system, the system approach is a suitable paradigm.

3.2 The Decision Theory-Perspective

From the decision theoretical perspective, management in an organization mainly focuses on making decisions. Decision theory in organizations can divided into two distinct fields of research: Behavioral descriptive and decision-logical approaches [Hil98]. The research problem of the decision-logical approach is to develop formal decision methods and models to find the optimal behavior on different types of problems facing incomplete information [Hil98]. The majority of work in this research area is inspired by the prescriptive decision theory and focus on fitting the organizational design decisions into the decision-logical structure [Sch08]. The following list describes three representative approaches in this area:

1. Organizations are systems where autonomous actors aim to satisfy their objectives efficiently and effectively while taking into account the expected behavior of possible opponents. *Game theory* offers models and constructs that can be used to analyze typical situations in such games [Hil98]. Especially in the presence of conflicting goals or competing individuals, game theoretic methods suit well to analyze the underlying decision making processes. In the context of such a decision-logical organization theory, Laux [Fre92] emphasizes the need for an appropriate incentive system from an economic perspective. The provision of incentives within the organization causes the decision making individual to reach his personal goals if and only if the decision was a good decision. Further, Laux discusses the choice of an appropriate metric within a decision making problem. In particular, two different ways to incentivize members are presented: Provide side payments to each member that (i) are directly bound to the organization's profit, and (ii) depend on the contribution of each member to the success of the organization as a whole. The choice of the appropriate side payment function is a decision problem in itself which depends on the attitude of each individual member regarding its risk. In case of a risk neutral member, the individual bears the whole responsibility of the organization's success and usually models its utility using a quasi-linear function. In contrast, a risk averse member bears the responsibility only if it receives a specific side payment that correlates with the underlying risk.

2. The *theory of teams* [Mar72] aims at optimizing decision-, communication- as well as information-rules to maximize the outcome of the organization. The theory assumes that teams are organizations in which members have only common interests and follow the behavioral rules. Hence, there is no need for an incentive or control system. Members of a team can share information, what causes communication costs but enables the communi-

cation partner to improve its ability to make decisions. The main problem is to decide which information is gained by each organization member and to whom the information will be communicated. [Fre92]

3. The *delegation value concept* is an advancement of the theory of teams for solving delegation problems. The problem is to decide whether a utilitarian instance should make an object decision, e.g. the acceptance of a proposal, itself or delegate it to another instance with potentially more relevant information and if so, to whom. It is possible to delegate the decision to a single instance, a decision panel with multiple members or to divide the problem and delegate these sub-problems. Similar to other prescriptive decision theories, the alternative with the highest expected outcome is chosen [LaLi05].

The behavioral descriptive approach studies human behavior in organizations. This behavioral decision theory looks at the decision processes not as decision logic, but as empirical observable decision behavior. The problem is how organizations with incomplete information can ensure their existence in a changing stochastic environment. The proposed solution is a formal structure that reduces the complexity and uncertainty in the environment of the organization for the individual decision maker [KiWa10].

3.3 The Resource-based Approach to Organizational Theory

The resource based approach is an internal analysis of an organization focusing on strength and weaknesses related to resources. The theory states that the advantage of an organization compared to their competitors is based on the available resources. These resources can be tangible, but also intangible, e.g. competences and skills [Sch08, p. 299]. Hence, as the resources of a firm are heterogeneous in type and each of them may result in a different level of payoff, the resource-based approach to organizational theory analyzes the circumstances under what a resource will lead to a high return over longer periods of time [Wer84]. In particular, the authors differ between resource-oriented and product-oriented acquisition strategies of prospective buyers. Instead of searching for bundles of resources that make up the product, potential buyers limit their search to targets (products) which satisfy certain simple criteria. Hence, the discussion on resource bundles is raised while it is assumed that the different combinations of these resources yield a higher profitability to the firm.

In contrast to the well-studied field of markets and corresponding empirical knowledge about market structures, the notion of resources remained amorphous for quite some time [Wer95]. However, the resource-based view to organizational theory opened a door to better understand the effect resources have on the success of a firm. In particular, strategic management research investigates one of the main issues that arise in the context of the resource-based view: the competition for resources. Wernerfelt [Wer95] highlights the necessity to exploit differences among the heterogeneity of the firm by analyzing and estimating the opponents' possible strategies. Hence, the application of methods from game theory provides insight into the best way to achieve competitive goals. In addition to understanding the opponents' strategic behavior, the resource-based view to organizational theory also utilizes the differences in firms' resource endowments. Insofar, open research questions in this field will focus on how to exploit the differences of (i) a firm's competitors and (ii) a firm's heterogeneous resource endowments from a game-theoretic perspective.

3.4 New Institutional Economics

There are several more approaches regarding organizational theories. Some of them are summarized under the term “new institutions economy” including “Principal Agent Theory”, “Property rights theory” and “Transaction cost theory”. The following list briefly introduces these theories [Sch08]:

- The *principal agent theory* treads organizational problems with unequally distributed information between the client (principal) and the contractor (agent). Research aspects are the hidden information- and expertise advance of the agent, and the following opportunistic utilization of this aspect by the agent ("moral hazard").
- In the *property righty theory*, property rights means the competence of subjects in economy on goods or resources. The research aspects in this theory regard the effect of these different kinds of rights and the various degrees of property rights, which can come up.
- The *transaction cost theory* states that the coordination of transactions by the market also causes costs. Examples for transaction costs are costs which arise while negotiating a contract for a product or service or costs for monetary transactions.

All theories of the new institutions economy share the central statement that institutions are important for the economic process. In contrast to other preceding theories institutional constraints and transaction costs are no longer neglected. [RiFu99]

4 DAI / MAS perspectives on multiagent organizations

4.1 Basic assumptions of MAS Theory

Deliberative agents are autonomous, and permanently alive. They exhibit some "technical" intelligence, are able to identify each other and to communicate with each other. They have intentions, objectives, and goals. They are able (and supposed) to plan and execute their actions to achieve their goals (bounded rationality). Agents are situated: they sense their environments, and they act tactically to achieve their goals. All agents together form the set of agents. An agent may know any other agents of this set. These agents are then called its acquaintances.

Based upon its own decision, an agent may communicate with others, may form groups (see literature on group formation), etc.

Agents may access external resources. In such cases resource access conflicts may arise, the plans of these agents are thus not mutually independent. MA coordination methods have been developed to resolve such conflicts. Agents may also decide to cooperate (co-operate) with each another. In this case, the agents process their mutually independent individual plans, and they try to increase the efficiency and/or the effectiveness of their actions trough "intelligent coordination".

If agents join a MAS, they become a 100% member of this particular MAS. So far, literature does not consider the case (and its consequences) that an agent may join more than one MAS. It is generally assumed that an agent having joined a MAS still has full control over its individual resources. This is however (mostly implicitly) restricted to the fact that the agent is allowed to decide on its own whether to contribute or not to contribute its resources to the MAS. There is no chance for the agent to employ its resources still (or additionally) outside of the MAS.

MAS are open systems. Burkhard [Bur89], however, has provided formal proofs that this is a risky idea as with each change within a multiagent system its formal semantic changes without any realistic chance to predict the impacts resulting from these changes. MAS do just exist to get one singular task done. If this aim has been achieved they dissolve immediately. Thus, and so far in contrast to the agents as their "constituent members", MAS are not permanently alive.

4.2 Early work: the organizational concept of the C-Net system

The C-Net, developed by Smith and Davis in the late 1970s [Smi80], maintained a map of vehicle traffic controlled by distributed sensors.

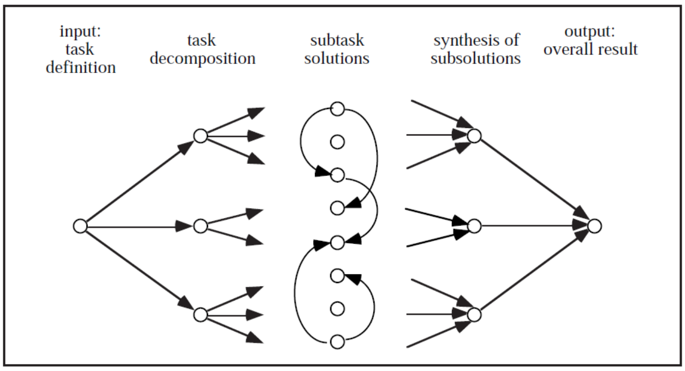

Figure 1: DPS - Task decomposition and synthesis of sub results in the C-Net [Kir96].

The aim has been to count every observed car exactly one time, starting when cars entered the controlled area, and stopping when they left it again - and neither loosing the information about a particular car nor counting it twice when seen by more than one sensor at the same time. In order to solve this challenge Smith & Davis developed a role concept for so-called task managers and contractors. The manager M of a task T may decompose it and allocate each subtask T_i to a contractor C. If C decides to decompose a subtask T_i further into a set of sub-subtasks T_{ij}, she becomes a manager for T_i, and it may also happen that the manager M of T becomes a subcontractor to C.

The C-net role concept guarantees high organizational flexibility for task sharing and distributed coordination, but – in contrast to role models in (human) social systems – does not support organizational stability.

4.3 Towards a Theory of Multiagent Organizations

Several theories have been suggested upon which the design of multi-agent systems can build. However, none of them helps to understand the relationships between software agents and an enterprise in general which may own or embed them. In such cases, the organizational structure of an embedding enterprise can bind agents by providing aims and goals, competencies, resources, etc. This is quite a relevant question because, in general, agents are owned by somebody (e.g., by an enterprise, or by a person). I.e., any agent acts on behalf of its owner, and is supposed to contribute to its owner's aims and objectives. Different agents may have different owners. In general, these control the behaviour of their agents in such a way that the agents respect the individual situation of their owners, and their local aims and goals, as well as their constraints. This view opens up a lot of still unanswered questions.

As a first approach, Kirn & Gasser [KiGa98] assume that software agents are owned by enterprises, and that these agents are linked to concrete organizational positions within the respective enterprise. They aim to develop the foundations of an organizational theory for software systems composed of (semi-)autonomous agents, and they provide a set of tools by which the behaviour of agents which join a multi-agent system can be controlled.

The specification of our multi-agent organizational theory comprises a static, and a dynamic organizational structure. The latter introduces a set of organizational inference processes, distinguishing between primary constitutional processes (to establish and resolve a multi-agent organization), and secondary constitutional processes. Secondary constitutional processes are necessary whenever an organized multi-agent system needs to be changed (e.g., in order to adapt it to changes in its environment). Changes can be performed bottom up (from agent to agent system), or top down (from the agent system onto the single agent).

4.4 Organization of Distributed Problem Solvers: Decomposition of the global search space into local (individual) search spaces

Distributed problem solving as coordinated distributed search: Having a search problem in DPS the global search space is decomposed into several individual local search spaces for the individual nodes. “Distributed problem solving can be viewed as distributed research” [Gas92], where the paper states that following applies: (i) The space of alternative problem states can be seen as a large search space investigated by a number of problem-solvers. (ii) Each problem solver has to make local control decisions about its search area. (iii)The local search decisions have impact on the overall effort expended by the collection of problems-solvers.

The concept of cooperative problem solving takes the concept of the integration of already existing single problem solving experts (intelligent agents) into an overall framework [Dur89]. The object is to make synergetic use of their individual abilities that, otherwise, could only be used locally. This is a top-down perspective on coordinating global processes of problem solving. This approach can straightforwardly be compared with the perspective of management science, in which organizations are systems which gather individual resources together in order to gain extra benefits for all of their members [Kir98].

Changing the perspective from DPS to MAS: Distributed problem solving realizes the concept of dividing labour among a group of individuals each possessing a particular capabilities profile [Kir98]. The difference from MAS to DPS is that in the MAS approach the global space is not given in the beginning and then split up into the divisions, but rather there is a given set of agents that already have their *pre-existing search spaces*. Two interesting questions then are: How will the global search space form up, and why should an agent join a MAS?

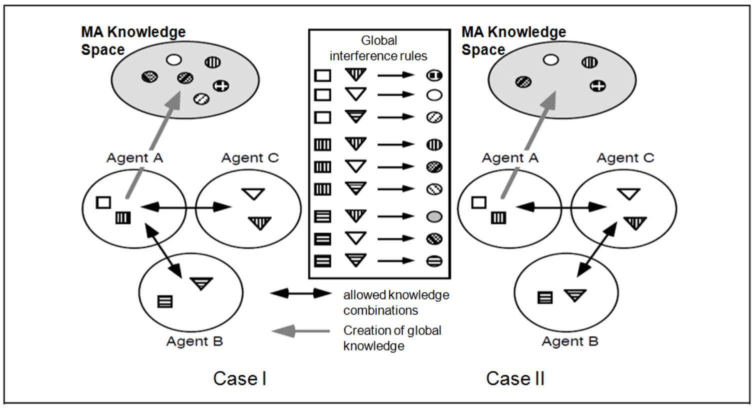

Figure 2: MA knowledge spaces depend upon communication structures in MAS [Kir96]

Now focusing on the formation of this composite network (MAS) the question of the organizational structure of the MAS arises. As Figure 2 depicts, different communication structures may lead to different joint knowledge and skills of the MAS. From this in turn diverse, dissimilar solutions and outcomes can emerge. The agents bring in their own knowledge spaces and skills represented as different shaped squares and triangles. The box with the global interference rules explain how new knowledge is created. In both cases there are the same agents with the same knowledge space, the only difference is in the combination of the organizational connection.

Agent-based software systems are thus a resource pool in which the knowledge, skills, and resources of the agents involved are put together. In addition to the domain-specific and social skills of the members of the system, the performance of agent-based software systems therefore depends on the properties of the communication and coordination principles used. Accordingly, the specific design of the micro-macro link is primarily determined by the acting of these coordination principles interrelations between firstly the global level and secondly the individual agents involved in the network. As already mentioned, the constitutive characteristic of MAS is that the overall system behavior is not determined by a central design, but just 'emerges' by decentralized coordinated interactions among the involved agents.

5 Open Questions and Research Issues

The discussion of this paper reveals that there are different organizational basic concepts and perspectives in organization science. To not limit the functional design space in Multiagent system organizations we propose for further research to compare the DAI concepts with the different organizational business as well as the organizational social concepts. The concrete methods in the context of MAS currently do not apply one explicit organization theory; at the most the applied organizational concepts can be mapped to concepts from an organization theory. Some MAS methods without using social norms rather tend to the group of classical organization theories, while MAS methods using social norms can be assigned by trend to neoclassic and modern organization theories. However, to represent all facets of an operational organization in a software system such as a MAS the concepts of the applied organization theory has to be transferred in a top-down approach to the MAS. From the perspective of functions and tasks, as well as of intention and persistence, MAS begin to exhibit more and more useful characteristics, so that the residual differences to human subjects possibly will be less important in a significant number of cases [Kir98].

This is especially interesting in the context of the provision of composite services that are provided by several members of an organization. Transferring the real world competences, structures, behaviour, norms etc. that are defined by the organization to the software system guarantees an unobstructed process and fosters a higher technology acceptance of real world actors.

The usage and new challenge for intelligent agents is to induce them in helping organizational designers to construct or maintain new organizational forms such as human computer cooperative work or virtual enterprises [Ste90]. Here emerge persistence questions between the business view, where the organization must for example be auditable and on the other hand the view from a organization as a social system, which focuses on issues e.g. the intention to survive as an social system and tailored incentives to contribution from members.

6 Conclusion

This work presents a set of requirements for the design of a software system that exhibits the disparate characteristics of a cloud service provider organization. Relevant organizational concepts from social theories were identified and mapped to appropriate concepts found in extant DAI/MAS literature. The resulting conceptualization of the software system emulates the heterogeneous requirements of a cloud service provider such as exceptional market knowledge, access to unique strategic resources or expertise, and openness to new technologies.

The conceptualization of our software system is limited to identifying and mapping relevant terminologies from social sciences to concepts from DAI/MAS research. An extension to a concrete software architecture that integrates the identified components will be considered in future research.

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Simulation- and Optimization-based Development of Proposals for Service and Engineering Projects

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Abstract: The preparation of proposals for knowledge intensive services is a critical success factor for companies. Where such quotes are incorrect or generate only a small contribution to the objectives of a company, resources are wasted and opportunities are missed. To respond to this challenge, a Multi-Objective Evolutionary Heuristic for planning services was developed in order to support managers to create optimal proposals. The issues of calculating a proposal will be illustrated on the basis of a stochastic simulation model and a Multi-Objective Evolutionary Algorithm. According to the high impact of human work in service projects, a person-centered simulation approach is introduced to take the effects of personal factors on a service provision into account in detail. The results of a validation study confirm that the approach is capable to calculate and optimize the planning objectives of managers when developing a plan and a proposal for a complex engineering project. Therefore, our paper will make a contribution to improve the quality and productivity assessment of engineering companies and their customers in the phase of project planning. Due to an appropriate planning support prior to as well as during a service a reduction of risk and an improvement of profit are quite likely.

1 Introduction

Complex engineering services, such as factory design and architecture services are a popular example of operations that are particularly prone to disruption or failure. The high levels of time and resource dependencies make such complex service provisions susceptible to unforeseen events and delays. Therefore, developing and calculating proposals for complex service projects are a challenging task. The dependencies between tasks have to be considered for a specific service scenario, and decisions must be often made within short time. Managers of services who are responsible for the planning and calculating make their decisions based on the current situation and according to their individual experience regarding the service. Therefore, the quantity and the quality of available information for planning a service provision and the ability of a manager to analyze and to use the given information are crucial for the quality of a service provision. Subsequently a metaheuristic for a situation specific planning has to be introduced if the quality of decisions is to be improved.

With regard to planning and calculating a service based on available information — Evolutionary Metaheuristics provides promising opportunities. Such heuristics can be used to analyze valid and probable service scenarios and to propose (ideally optimal) service provisions to the manager of a service. This information regarding tasks and activities for a service provision and the assignment of tasks to the available internal and external employees and resources allows the precise arrangement of the proposal, and thus the conditions for an effective and efficient implementation of services. However, although recent efforts to increase the modeling and optimization of Resource Constrained Project Scheduling Problem (RCPSP) have led to new more realistic variants of the problem, and despite the fact that increases in computational power and algorithmic efficiency continue to support the development of scheduling tools, current Decision Support Systems often suffer from a lack of an inadequate modeling of the decision making and the behavior of humans during a service provision. This is mainly due to the fact that there is currently no approach available, which takes the individual behavior of humans during a service provision as well as the weakly structured predecessor constraints between tasks and the dynamic process execution into account in cases of an iterative activity execution due to unforeseen events.

Our work presented in this paper intends to overcome this lack by proposing a person-centered approach for a detailed modeling of a service provision. Furthermore, a Multi Objective Evolutionary Algorithm is presented that can identify optimal solutions for a multi-criteria target system in a short period of time. Our work was motivated by the insights and findings of a study conducted with several large architecture offices in Germany. While evaluating the potential of the approach to create technically-correct proposals for complex services, the elementary requirements of decision support systems were analyzed in a practical context.

The paper is structured as follows. In Section 2 the management of proposals for complex services is defined and an overview on related work is provided. In Section 3, a short overview of the relevant variants of the RCPSP is given and a framework for the comprehensive description of a person-centered simulation and optimization approach is presented. By extending the well established RCPSP with the individual behavior of humans and the notion of an iterative execution of activities, it is possible to formulate a wide variety of service scenarios. In Section 4, we illustrate how the modeling framework can be used by a Multi-Objective Evolutionary Algorithm. The evolutionary representation of a planning problem is used to evaluate the structural validity and the performance of the metaheuristic in Section 5. This enables us to provide a statement regarding the expected benefit of a simulation based planning of a complex service provision. Section 6 summarizes the contributions of this paper.

2 Development of proposals for service provision

In this section the terms "*proposal*" and "*proposal management*" for service projects are informally defined and a brief overview of current approaches is given.

Definition 1 (proposal for complex services): A proposal for complex services contains information regarding the conditions under which the service provider would accept to provide the service for a specific customer. Content of a proposal may be: the targets of the service and the way to achieving these goals, the period of the provision with milestones, costs of providing the service, involved employees and method of payment etc.

Such proposals for complex services are associated with risk due to the uncertainties pertaining to information on the availability of employees and the prospective evaluation of the effectiveness and efficiency of task processing. In many practical situations, manifold unforeseen events make a deviation from the planned service provision necessary. But, in practical situations it is often difficult, to dynamically adapt the proposal to the modified situation and to repair an invalid proposal.

Definition 2 (proposal management): Proposal management is the process of creating and selecting an appropriate set of information to prospectively describe the service scenario and to derive the service goals to be achieved.

Typically, the central goal of proposal management is to define and describe the cost, duration and the content (product) of a service provision. Thereby, the target is to optimize the relation between the guaranteed service and the price for the service.

Definition 3 (proposal management problem): A proposal management problem consists of 1) a service product to be produced, 2) a work schedule for the service provision, 3) limited resources, and 4) objectives for the service provision. It is solved through the process of proposal management.

Due to the customer specific service provision, the pricing of proposal management is analytical and the description of the service provision and the corresponding product is often incomplete and not explicit. Starting point for the development of a proposal is the cost estimation for the service provision. Cost estimation modeling techniques can be fundamentally divided into parametric models based on statistic, individual knowledge of the managers, or machine learning [BES+98].

The HOAI - German Fee Regulations for Object Planners and Engineers is an example for the analytical development of a proposal for factory planning projects. Thereby, the scope of services for all service phases is described in the HOAI and the computation of fees is based on the construction costs that are determined based on the design development. The content of a proposal is mainly caused by the result of the service provision. Since the European Commission has instructed the national competition authorities to proceed against the ordinances on fees of associations and special-interest groups new approaches for calculating service proposals are necessary [SWS12].

Within the project "Price information on services" Kappler et al. carried out an empirical study which contains the evaluation of 896 planning projects [KSL07]. The investigated main factors influencing a proposal are: 1) building costs, 2) gross floor space in square meters, 3) building volume and 4) complexity of planning. Historical data of building projects were used for a regression analysis. Thereby, the authors identified a positive correlation between gross floor space and the planning expenses and costs. The disadvantage of this method is the fact that project specific characteristics are not thoroughly taken into account because the work processes are not considered. To conclude, to the best of our knowledge there is currently no approach available for a proposal development which is based on a prospective description of the dynamics of general workflows for services which could be adapted to a specific service project.

3 Framework for service provision

3.1 Variants of the RCPSP

Over the past 10 years the RCPSP became a standard for planning problems with sequence relationships and boundary condition [BDM+99]; [HB10]; [ADN08]. The RCPSP is defined as follows: The problem is described by a project which consists of a set of activities $i = \{1,...,n\}$ to be processed. The duration of an activity i is denoted by p_i. The precedence relations between activities are defined by the set of immediate predecessors of an activity $j \in P_i$. Only if the predecessors are fully processed, i can be started without time lag. Each activity i requires r_{ik} units of renewable resource k during each period of processing. The availability of each resource type k in each period is R_k units, $k = 1,...,K$. All parameters are assumed to be non-negative integer valued. The objective of the RCPSP is to find a schedule S, which consists of a set of starting times S_1, S_2, ..., S_n for the activities, where the precedence and resource-constraints are satisfied, in such a way that the schedule length $T(S) = S_n$ is minimized. Heuristic algorithms for the RCPSP can be essentially classified into two categories, the priority based heuristics [AT89]; [KD96] and metaheuristic approaches such as simulated annealing, genetic algorithms and tabu search algorithm [Har97]; [CK97]; [Tho98]. For developing proposals for services based on the service process the model of the RCPSP makes a substantial contribution to describe the predecessor/successor relationships between activities of the service provision. This ensures that the chronological order of tasks corresponds to the function-logic requirements of the service. But, the representation of the production factors of a service is too abstract and unrealistic for the development of realistic proposals. Thus, for example, the abilities and capabilities of humans on processing a task as well as the temporal availability of these persons have not been sufficiently taken into account by the RCPSP.

An extension of the RCPSP is the Multi-Skill Project Scheduling Problem (*MSPSP*) which was originally published by Néron and Baptista [NB02]. The model was expanded through the introduction of workers with heterogeneous skills. The requirements of an activity are given by the required abilities and capabilities of workers for processing an activity. Therefore, all subsets of workers have to be identified that are capable of carrying out the activity with regard to the required skill levels [FH10]. The depicted extension with heterogeneous skills of workers and their influence on the duration p_i of an activity i leads to a more realistic reproduction of a service provision. Especially the modeled need of heterogeneous skill requirements and the effects of a skill level on processing an activity meet the characteristic that a service is determined by the persons involved.

All introduced approaches up to this point assume that the availability of the resources is constant in each period. Due to restricted working hours of employees Franck et al. introduce a calendar concept for the RCPSP with activities which can be interrupted [FNS01]. They use a break calendar which is described by a binary function $b\colon \mathbb{R}_{\geq 0} \rightarrow \{0,1\}$. Buddhakulsomsiri and Kim follow a similar problem setting and propose a calendar concept for the Multi-Mode-RCPSP. The concept permits activity splitting due to a pre-defined vacation schedule for resources [BK06]. For modeling a service provision the calendar concept of Franck et al.; Schwindt and Buddhakulsomsiri should be adopted [FNS01]; [ST00]; [BK06].

If a weighting of the planning objectives is not suitable for an efficient solving, the concept of Pareto-optimal solutions is a way to deal with optimal objectives. Doerner et al. investigate the time-cost trade-off problem and use three metaheuristics (PACO, PSA and NSGA) to evaluate and select the generated solutions [DGH+08]. A multi-mode RCPSP with the objectives 1) makespan, 2) mean weighted lateness, 3) total number of tardy activities, 4) smoothness of the resource profile, 5) total and weighted resource consumption, and 6) net present value is proposed by Slowiński et al. [SSW94]. Wang et al. adapt a multi-objective evolutionary algorithm (NSGA-II) to solve the multi-mode RCPSP with the objective to minimize project makespan and resource utilization smoothness [WLM05].

3.2 Modeling the dynamic of service processes

The provision of a service is determined by the assignment of tasks to employees. Therefore, we limit ourselves here to the formal description of the assignment of tasks to employees and the selection of tasks by the simulated behavior of employees. Each employee has degrees of freedom for action-taking and decision-making. Processing a task is therefore the result of the situation and individual qualifications and competencies and represents an observable activity. The consideration of the individual effect of employees on a service provision is one of the fundamental principles of an industrial engineering oriented service science. Thereby, the model of a human covers all persons participating in a service provision such as the employees of the service provider and the subcontractors (internal factor of production) as well as the consumer of a service (external factor of production).

$$\xi_{w,q} := \begin{cases} 1, & if\colon \quad employee\ w \in \boldsymbol{W}\ has\ the\ qualification\ q \in \boldsymbol{Q} \\ 0, & else \end{cases} \tag{1}$$

$$QM^{(w,q)} := \begin{Bmatrix} \xi_{11} & \cdots & \xi_{1Q} \\ \vdots & \vdots & \vdots \\ \xi_{W1} & \cdots & \xi_{WQ} \end{Bmatrix}, \quad \xi_{w,q} \in \{0,1\} \quad \forall\, w \in \boldsymbol{W}, q \in \boldsymbol{Q} \tag{2}$$

$$\sum_{q \in \boldsymbol{Q}} \xi_{w,q} \geq 1,\ \forall\, w \in \boldsymbol{W} \tag{3}$$

$$KV_w^{(1,k)} \in \{0, 1, \dots, |\boldsymbol{L}|\},\ \forall\, w \in \boldsymbol{W} \tag{4}$$

$$KM_w^{(l,k)} := \begin{cases} 1, & if: \quad l \leq KV_w^{(1,k)} \\ 0, & else \end{cases},\ \forall\, k \in \boldsymbol{K}, l \in \boldsymbol{L}, w \in W \tag{5}$$

$$KM_w^{(l,k)} := \begin{Bmatrix} \nu_{11} & \cdots & \nu_{1k} \\ \vdots & \vdots & \vdots \\ \nu_{l1} & \cdots & \nu_{lk} \end{Bmatrix},\ \nu_{l,k} \in \{0,1\}, \forall\, k \in \boldsymbol{K}, l \in \boldsymbol{L}, w \in \boldsymbol{W} \tag{6}$$

$$\sum_{l \in L} \sum_{k \in K} \nu_{l,k} \geq 1,\ \ \forall\, w \in \boldsymbol{W} \tag{7}$$

Each employee w has at least one qualification $q \in \boldsymbol{Q}$ and one competence $k \in \boldsymbol{K}$ (3), (7). The qualifications and the competences of an employee are given by a qualification matrix (2) and a competence vector (4) as well as a competence matrix (5), (6). The entries of the vector $KV_w^{(1,k)}$ for an employee *w* describe the level for the competences $k \in \boldsymbol{K}$. The values of $KV_w^{(1,k)}$ are mapped to the matrix $KM_w^{(l,k)}$ to simplify a statement which levels of heterogeneous competences are fulfilled or even exceeded by assigning tasks to one or a team of employees.

For processing a service, tasks have to be assigned to the individual task pools of the employees. We assume that an assignment is valid if the conditions of a sufficient execution of the predecessor tasks are fully met and the qualification and the competence requirements are fulfilled. Such an event leads to an appearance of the task in the task pool of the employees the task is assigned to. A task pool may contain several tasks with varying processing statuses due to a pre-emptive task processing and uncoupled activities. We assume that an employee can process only one task at a time so that the employee has to organize his or her individual task pool.

A human does not always make rational decisions during processing a service. Empirical studies indicate that humans are prone to seeing short-term tasks as more important than long-term ones due to the operational day-to-day business in an organization. A higher priority results when the time frame until desired task completion continues to greatly decrease. This behavior is referred to in literature as bounded rational behavior. In order to take this behavior into consideration, the time factor must be included in a prioritization algorithm for selecting tasks from the individual task pool. The Temporal Motivational Theory (TMT) of Steel and König manages to do so [SK06]. The prioritization algorithm of the service model is based on the findings of TMT. Organizing the individual task pool by a simulated human is based on evaluating the positive and negative aspects of processing a specific task at time *t*. Positive aspects are determined by the importance I_i and the urgency of task *i*. The latter is determined by the period between the deadline t_{i_dead} of *i* and the current time *t* as well as the already reached degree of processing δ_i of the calculated time exposure a_{im}. The negative aspects are measured by the familiarization of the worker with task *i* δ_{STpi} and the preparation time a_{STi}. To consider the influence of the decision behavior of an individual person, the factors K_w and K_{STw} and $\Gamma^{+}$are part of the formula. The priority of a task is expressed as follows [DTS11]:

$$Priority(t) = \frac{I_i \cdot K_w}{1 + \Gamma^+ \left(\frac{t_{i_{dead}} - t}{a_{im}(1 - \delta_i)} \right)} - \left((1 - \delta_{STi}) a_{STi} K_{STw} \right) \tag{8}$$

Processing a service has a chronological and a chronometric dimension. The former specifies the starting times and the distribution of activities over the planning horizon and the latter describes the time period of processing an activity. Thereby, the starting time of an activity is determined by the working hours and the availability of an employee. To describe the working and non-working periods of a worker the calendar concept is introduced:

$$\varsigma_{w,t} = \begin{cases} 1, & if: \ \tau_{w,AA} + t_{day} \leq t < \tau_{w,PA} + t_{day} \lor \tau_{w,PE} + \tau_{day} \leq t < \tau_{w,AE} + t_{day} \\ 0, & else \end{cases} \tag{9}$$

The daily working hours of an employee $w \in \boldsymbol{W}$ are given by the period between the start $\tau_{w,AA}$ and lunchtime $\tau_{w,PA}$ as well as between the end of the break $\tau_{w,PE}$ and the start of the leisure-time $\tau_{w,AE}$ (9). Thereby, the variable t_{day} defines the beginning of the current day.

The concept of modes is used to describe different valid combinations for assigning a task to the task pool of employees based on qualification and competence requirements. Each task has at least one qualification (10) and one level of competence requirement (11).

$$|\boldsymbol{M_i}| \geq 1, \ \forall \ i \in \boldsymbol{A} \tag{10}$$

$$|\widetilde{\boldsymbol{M}}_{\boldsymbol{i}}| \geq 1, \ \forall \ i \in \boldsymbol{A} \tag{11}$$

$$AQ_i^{(\mathfrak{m},q)} = \begin{Bmatrix} ap_{1,1} & \cdots & ap_{1,q} \\ \vdots & \vdots & \vdots \\ ap_{m,1} & \cdots & ap_{m,q} \end{Bmatrix}, \ ap_{\mathfrak{m},q} \in \{0,1,\dots,|\boldsymbol{W}|\}, \ \forall \ i \in \boldsymbol{A}, \ \mathfrak{m} \in \boldsymbol{M_i}, \ \ q \in \boldsymbol{Q} \tag{12}$$

$$\sum_{q \in \boldsymbol{Q}} ap_{\mathfrak{m},q} \geq 1, \ \forall \ AQ_i^{(\mathfrak{m},q)}, \ \mathfrak{m} \in \boldsymbol{M_i} \tag{13}$$

$$AK_{i,\widetilde{\mathfrak{m}}}^{(l,k)} = \begin{Bmatrix} ak_{1,1} & \cdots & ak_{1,k} \\ \vdots & \vdots & \vdots \\ ak_{l,1} & \cdots & ak_{l,k} \end{Bmatrix}, \ ak_{l,k} \in \{0,\dots,1\}, \ \forall \ i \in \boldsymbol{A}, \ \widetilde{\mathfrak{m}} \in \widetilde{\boldsymbol{M}}_{\boldsymbol{i}}, \ \ l \in \boldsymbol{L}, \ k \in \boldsymbol{K} \tag{14}$$

$$\sum_{k\in \boldsymbol{K}}\sum_{l\in \boldsymbol{L}} ak_{l,k} \geq 1,\ \forall\ AK_{i,\tilde{\mathfrak{m}}}^{(l,k)} \tag{15}$$

$$\sum_{w\in \boldsymbol{W}} QM^{(w,q)}\alpha_{i,\mathfrak{m}_i,\tilde{\mathfrak{m}}_i,w} \geq AQ_i^{(\mathfrak{m},q)},\ \forall\ i\in \boldsymbol{A}^+,\ \mathfrak{m}\in \boldsymbol{M_i};\ \tilde{\mathfrak{m}}\in \widetilde{\boldsymbol{M}}_{\boldsymbol{i}}, q\in \boldsymbol{Q} \tag{16}$$

$$W_i^{min} \leq \sum_{t\in T}\sum_{m\in \boldsymbol{M_i}}\sum_{w\in \boldsymbol{W}} \alpha_{i,\mathfrak{m}_i,\tilde{\mathfrak{m}}_i,w} \leq W_i^{max},\ \forall i\in \boldsymbol{A}^+, \tilde{\mathfrak{m}}\in \widetilde{\boldsymbol{M}}_{\boldsymbol{i}} \tag{17}$$

$$l_{i,\tilde{\mathfrak{m}}_i,k}^{(min)} := \begin{cases} min\left\{l \mid AK_{i,\tilde{\mathfrak{m}}_i}^{(l,k)} = 1\right\} \\ 0 \end{cases},\ \forall\ k\in \boldsymbol{K},\ i\in \boldsymbol{A}^+,\ \tilde{\mathfrak{m}}\in \widetilde{\boldsymbol{M}}_{\boldsymbol{i}} \tag{18}$$

$$KM_{W_i}^{\left(l_{i,\tilde{\mathfrak{m}}_i,k}^{(min)},k\right)} \geq AK_{i,\tilde{\mathfrak{m}}_i}^{(l_{i,\tilde{\mathfrak{m}}_i,k}^{(min)},k)},\ \forall\ \left(l_{i,\tilde{\mathfrak{m}}_i,k}^{(min)},k\right),\ i\in \boldsymbol{A}^+,\ \mathfrak{m}\in \boldsymbol{M_i} \tag{19}$$

The requirements of qualifications and competence levels of a task are given by a matrix of qualification $AQ_i^{(\mathfrak{m},q)}$ (12) and a matrix $AK_{i,\tilde{\mathfrak{m}}}^{(l,k)}$ (14) for the competence requirements. Entries $AQ_i^{(\mathfrak{m},q)} \neq 0$ determine the required number of workers with the specific qualification $q\in \boldsymbol{Q}$ to process the task i in mode $\mathfrak{m}$. The selected mode $\mathfrak{m}$ determines which combination of heterogeneous qualifications and number of workers is used to process the task i. The binary variable $\alpha_{i,\mathfrak{m},\tilde{\mathfrak{m}},w} = 1$ indicates if a task i is assigned to worker w based on the modes $\mathfrak{m}$ and $\tilde{\mathfrak{m}}$.

An entry of $AK_{i,\tilde{\mathfrak{m}}}^{(l,k)} \in [0,1]$ represents the minimum required level $l_{i,\tilde{\mathfrak{m}},k}^{(min)}$ of a competence $k\in \boldsymbol{K}$ if the task i is processed in mode $\tilde{\mathfrak{m}}$ (18). The constraint (17) ensures that the qualification requirements of a task are met without violating the minimum and maximum number of employees. Furthermore, it is evaluated, if the employees assigned to task i, $p\in W_{\boldsymbol{i}}$ fulfill the required level l of each competence k (19).

4 Evolutionary metaheuristic

A Multi-objective Evolutionary Algorithm (MOEA) uses techniques and procedures inspired by evolutionary biology and serves as a heuristic meta strategy to solve complex optimization problems. For an introduction into MOEA we refer to [AJG05]. In this paper a MOEA with a multi-objective selection, based on SPEA2 [ZLT01] has been extended to identify optimal solutions for the person-centered service model.

The MOEA makes use of a population divided in islands and a global archive for non-dominated individuals. The procedure starts by computing an initial population POP of individuals. Based on objectives, the individuals are evaluated according to dominance relations. The quality of a solution is further refined by techniques to evaluate the density relations of the identified solutions in order to distribute the non-dominated solutions uniformly along the Pareto-front. Until the quality of the solutions is insufficient and the stopping criterion is not met, genetic operations like the recombination and mutation modifies selected individuals. To create new individuals for the next generation $t + 1$, simulated binary crossover (SBX) operator [DA95] and polynomial mutation operator [DG96] are used. The newly evolved population is combined with the best individuals preserved from the previous generation t. A global archive is used which keeps best solutions over the generations. The combined population is evaluated according to dominance relations. If the pre-defined population and the archive size is exceeded by the number of non-dominated individuals, solutions are discarded which are in crowded areas of the Pareto-front. This allows a distribution of the individuals uniformly along the discovered front. Otherwise, non-dominated solutions are transferred to the population of $t + 1$ according to their strength. All other solutions are deleted. The remaining non-dominated and dominated solutions form the new population of generation $t + 1$ and the evolutionary cycle is repeated until the stopping criterion is met.

In the following we will concentrate on the representation of an individual because it contains all decision variables of the introduced service model and is crucial for the performance of MOEAs. Kolisch and Hartmann distinguish different schedule representations for coding a RCPSP and noting the frequent use of the activity-list (AL) and random key (RK) representation [KH06]. The substantial differences between the activity-list (AL) and the random key (RK) representation and our person-centered service model is that the priority in which the activities are scheduled depends on the simulated bounded rational decision making of the humans involved in the service process. Consequently, the start time of an activity S_i is determined by the fulfillment of precedence constraints P_i and the individually assigned priority of a task by a simulated employee. A scheduling order of tasks cannot be indicated before the predecessors of a task are processed and the task is placed in a task pool of a worker. Therefore, the indication of relative relations between tasks is necessary. In this paper we use a vector λ of independent random variables (configuration bank) for the representation of the decision vector of the optimization problem. The length and the structure of the vector (quantity and position of entries) are the same across all individuals:

$$\lambda = (s_i \quad e_i \quad \mathfrak{m}_i \quad \widetilde{\mathfrak{m}}_i \quad I_i \quad l_i \quad \overline{\mathfrak{m}}_i \quad \ldots \quad s_N \quad e_N \quad v_N \quad \mathfrak{m}_i \quad I_N \quad \overline{\mathfrak{m}}_N \quad D_A \quad D_Z \quad I_A \quad I_Z)$$

The vector λ includes three classes of configurations with different random variables:

- Activity configuration for 1,..., N tasks of the problem:
    - The relative start time s_i defines the time of assigning task *i* to the task pool of the corresponding task pools of the employees in relation to the degree of

completion of the predecessors of i, P_i. The random value is restricted to a permitted range or fixed values.

- The random value e_i is used to model uncertainty involved in time and effort estimation for processing an activity i. If a triangular distribution is used e_i references to a time value for the correction of a_{imb}.
- The random value $\mathfrak{m}_i$ refers to the number of employees for task i and is restricted to a given range.
- The random value $\tilde{\mathfrak{m}}_i$ refers to a unique set of workers $\boldsymbol{W_i}$. $\boldsymbol{W_i}$ is a subset of all feasible combinations of workers for a given $\mathfrak{m}_i$ to work on the task i. $|\boldsymbol{W_i}|$ corresponds to the value of $\mathfrak{m}_i$.
- The random value I_i can accommodate values between 0 and 1 and represents the importance of the task and the service process communicated to $\boldsymbol{W_i}$.
- The entry l_i determines the deviation from a date - dictated by the planning task. The outcome is the stated deadline t_{i_dead} for task i.
- The random variable $\overline{\mathfrak{m}}_N$ corresponds to a mode of an activity execution and describes a specific consumption of non-renewable and renewable resources. The occurrence of the variable is restricted to a given set of modes $\boldsymbol{\overline{M}_i}$ for task i.

- Decision configuration: A configuration D consists of a random value and represents a XOR branch node. D_A is the outcome of a decision regarding branch node A and refers to at least one path of tasks (direct successors of the node) which have to be processed. The specification of the value can depend on rules or a random distribution.
- Iteration configuration: The random value I_A determines the occurrence of an iterative execution of tasks and the characteristic of the iteration loop. Each iteration node is represented by one entry of λ.

During the optimization process all entries of λ may be modified by the evolutionary operators. To evaluate the quality of λ it is necessary to develop a detailed plan by mapping λ under consideration of restrictions. To ensure the comparability of λ the mapping of a specific vector must always lead to the same plan and therefore guarantee reproducibility.

5 Use Case

In the following, we discuss the results of a use case that shows that the proposed MOEA quickly converges on good-quality solutions. We describe the experimental setup and the use case before summarizing the obtained results. Note that the intention of this evaluation was to show the general applicability of the presented metaheuristic rather than to evaluate the performance of the specific evolutionary operators. Thus, the problem representation, the MOEA and the corresponding evaluation results should be considered as a starting point for a further development of MOEAs for person-centered models of service processes.

5.1 Scheduling Problem

The investigated scheduling problem is derived from a service process for factory planning. To better understand the particularities of the person-centered model of a service provision, we explore only a very small segment of the whole service project. This segment comprises 15 tasks of the HOAI phase No. 6: Preparation, placing and arranging of service specifications. In the case study, two conflicting objective functions were chosen: duration and costs of the service provision.

In the process model of the service provision shown in Figure 1 the rectangles of the graph correspond to tasks. The round nodes represent operators to characterize the logical relationship between tasks and the directed arcs between these elements visualize the precedence constraints. The planning problem corresponds to a Multi-skill project scheduling problem. Therefore, the skills (competence levels) of an employee as well as the number of employees a task is assigned to, have an impact on the duration of the task. Stochastic factors which determine the duration of a task processing were not considered. The extension of the scheduling problem leads to a diversity of activity processing modes. Each mode requires a minimum and maximum capacity of employees (e.g. [2,2]) with certain level *l* of competence *k* (e.g. skill 1 with the level: “medium”: K1[m]). The requirements for processing a task can be obtained from Figure 1. Furthermore, the graph describes the alternative routing of different task sequences (A9 to A12 OR A13 AND A14) as well as the possibility of an iterative processing of tasks (A: A2 and A3; B: A10; C: A10 and A12). The occurrence of an iterative task processing is determined by the competence levels of the employees and a probability distribution.

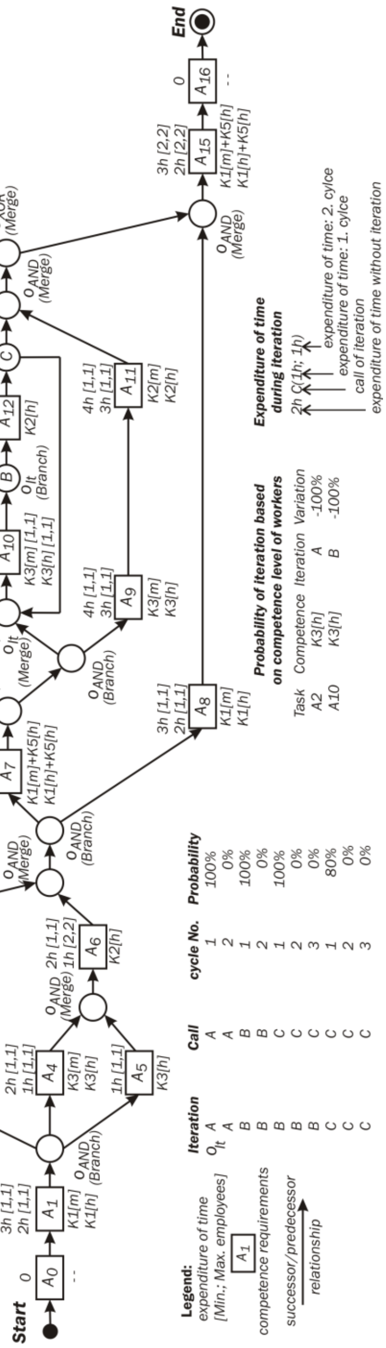

Figure 1: Graphical representation of the scheduling problem

Table 1 describes the internal and external staff for processing the service. The extension of the planning problem to a MSPSP leads to additional information regarding the competence level provided by an employee. The working hours of the employees were set for the case study to 8:00-12:00 and 13:00 to 17:00.

Table 1: Employees for the service provision

Name	Labor costs	Qualification	Competencies	Working hours
AP1	80€/h	Q1	K1[h]	8:00-12:00 13:00-17:00
AP2	50€/h	Q1	K1[m], K2[h]	8:00-12:00 13:00-17:00
AP3	30€/h	Q1	K2[m], K3[h]	8:00-12:00 13:00-17:00
AP4	10€/h	Q1	K2[h], K3[m]	8:00-12:00 13:00-17:00
AP5	30€/h	Q2	K4[h]	8:00-12:00 13:00-17:00
AP6	30€/h	Q3	K5[h]	8:00-12:00 13:00-17:00

Note that in a company it is advisable to use an appropriate graphical modeling tool which offers an easy modeling of the planning task. The definition of a formal specification for service specific planning tasks and a definition of the functions and the user interface for such a tool is however beyond the scope of this paper.

5.2 Results

To the best of our knowledge, no public benchmark data exist for a person-centered model of a service provision with iterative task execution. The only option would be to compare the MOEA with scheduling problems of RCPSP libraries [KS97] to consider predecessor constraints and resource allocation. Such a verification study for the developed MOEA is described in [TSD+12].

To generate the information necessary for developing a proposal for the service, the scheduling problem is solved by 100.000 stochastic independent simulation runs as well as an objective-based search by the MOEA (5 initial populations, 300 generations). The following findings can be derived based on an analysis of the Pareto-front and the distribution of the solutions in the range of results:

- The precedence constraints between tasks as well as the limited availability of the employees limit the range of results (Figure 3).
- The assignment of tasks to the employees with heterogeneous skills has a considerable impact on the duration and the cost of a service provision. Higher skills of an employee often lead to a shorter processing time of a single task but due to higher wages, the costs can be much higher. Therefore, due to predecessor and resource constraints it is neces-

sary to evaluate for each task if a higher qualified but more expensive employee generates a certain added value.

- Three iterations generate different possible service scenarios which are caused by accidental events or lower competencies of the workers (Figure 2). Therefore, the specific characteristic of the service provision is subject to considerable uncertainty. If no iteration occurs and an optimal processing without any deviation and disturbances is achieved, 14 Pareto optimal plans exist.

- Eight different service scenarios with different iterative characteristics exist. For each scenario the MOEA develops a Pareto-Front. Therefore, the service manager can select an optimal plan for the service scenario which is suitable for his or her individual risk attitude.

- The scatterplot in Figure 3 highlights the areas of the range of results which are more often identified by 100.000 simulation runs. If a vector (duration, cost) is developed more than 500 times the objective values of the corresponding plans have a high probability of occurrence.

Each vector within the objective space (Figure 3) represents a valid plan for the provision of the service and the achievement of the desired service product. Such a plan provides detailed information regarding the working process (cost and time, milestones, critical chain etc.), the responsibilities for tasks and the risk of implementing the plan. This information forms the basis for a detailed proposal of the intended service. In the case that the customer makes a concrete specification regarding the objectives, the service provider can use the scatter plot to evaluate the risk of a fulfillment of the given objective values and for further negotiations.

The non-dominated solutions have been completely solved by the MOEA. But, it must be noted that the MOEA did not identify the non-dominated solutions for all of the initial populations (seeds). Across all five seeds the Pareto solutions were identified. These values can be improved significantly if the parameter settings for the evolutionary operators are better adjusted to the scheduling problem. The stochastic simulation model significantly underperforms the MOEA. None of the non-dominated solution of the scenario without any iteration could be identified.

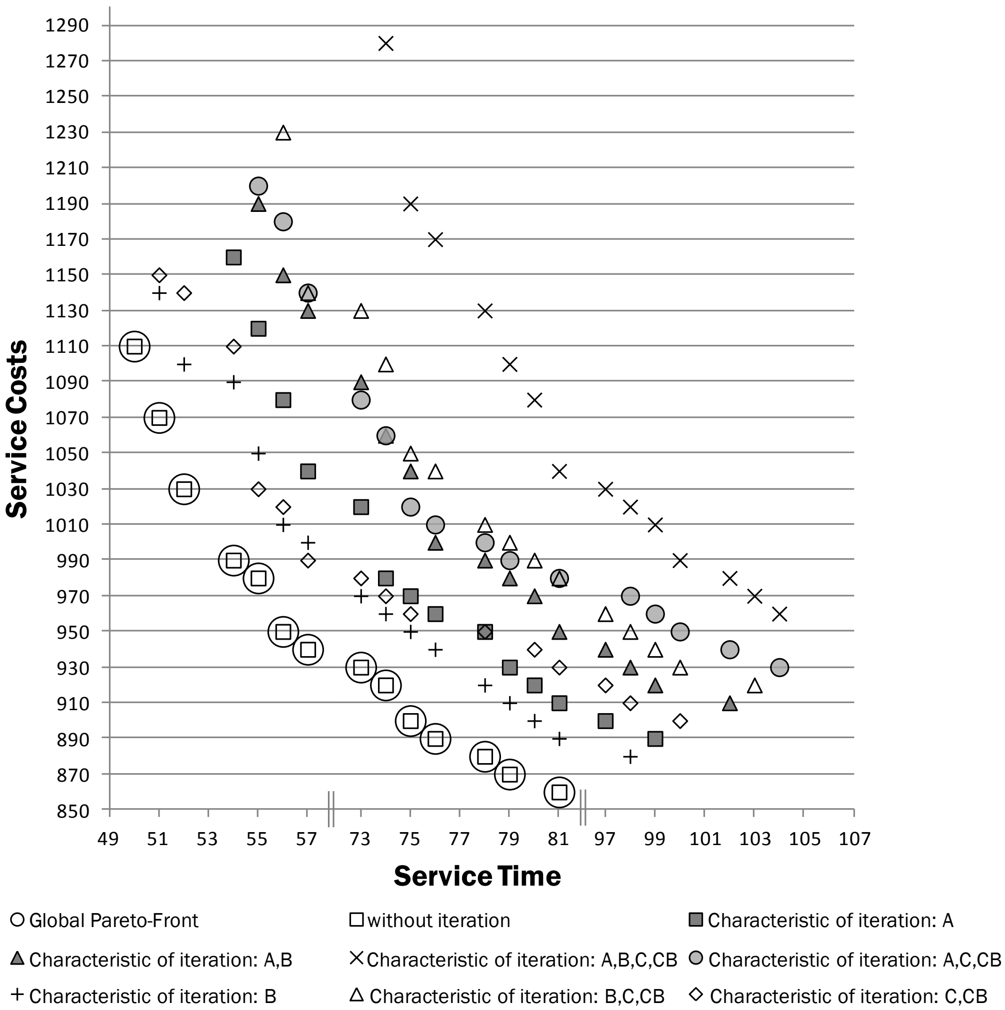

Figure 2: Pareto-Fronts for the different service scenarios

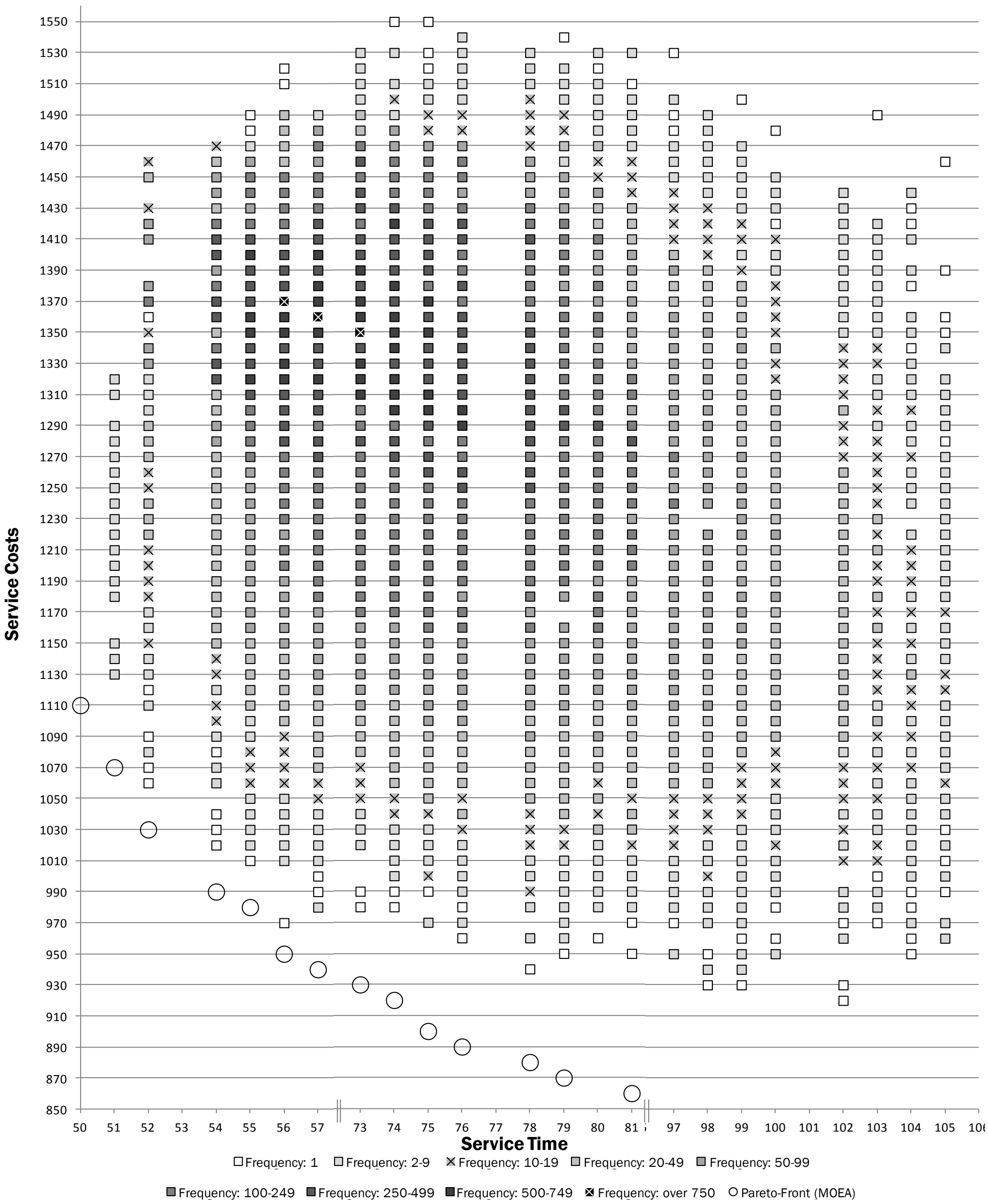

Figure 3: Range of results for the modeled service scenario

6 Summary and Conclusion

This paper proposes a comprehensive approach to modeling and solving service scheduling problems and to support managers to develop optimal proposals for a complex service provision. Based on a literature review of the variants of RCPSP it was shown that standard RCPSP approaches do not cope to describe a service process in detail and that it is also necessary to consider alternative service scenarios and an iterative task processing in order to develop proposals which are correct and generate an essential contribution to the objectives of the company.

Motivated by the lack of possibilities to describe the behavior of humans in existing approaches, the well-established RCPSP concept was extended to meet the demands. We subsequently introduced the concept of alternative and iterative task processing and defined decision variables for the person-centered model of a service provision. A MOEA was proposed for schedule optimization based on the fact that in many practical service planning problems managers have to deal with conflicting goals. The use case demonstrates that the MOEA converges on the Pareto-Front within only a few generations. This behavior of convergence indicates that the presented approach is suitable for developing plans for a complex service provision. Such plans form the basis for the development of proposals for different service scenarios. Therefore, we propose that the presented person-centered service model and the MOEA form an ideal starting point for further extensions and improvements.

One potential of our approach is to further develop the MOEA to a robust online scheduling algorithm. Finally, a comprehensive set of publicly available test cases and benchmark results for service management problems should be provided in near future which will stimulate further research in a simulation based service science.

Acknowledgment

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Potential of Service Engineering in the Field of Renewable Energies

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Abstract: Currently, a variety of services along the whole lifecycle of renewable energy systems are provided. These include services concerning the phases planning, building, commissioning, operating as well as maintaining energy systems. Technical innovations, the international competition and regular legal changes force the market players to continuously optimize and adjust their service portfolio. Concerning the topic of "Services for Renewable Energy Systems" only a few publications are available and relevant sources in the field of renewable energies discuss the aspect of services only insufficiently. The consideration of these services only happens, if at all, marginally in the context of environmental services. Due to this situation, this paper discusses services for renewable energy systems and focusses on the applicability and potential of Service Engineering in the field of renewable energies. The goal of this paper is to identify objectives of this industry sector on the basis of the research project EUMONIS and derive their future needs afterwards.

1 Introduction

Currently, a variety of services along the whole lifecycle of renewable energy systems are provided. These include services concerning the phases planning, building, commissioning and operating as well as maintain energy systems. Technical innovations, the international competition and regular legal changes force the market players to continuously optimize and adjust their service portfolio. This will be equally important for pure service providers as well as manufacturing companies in the sector of renewable energies. Due to increased competitiveness, it is not sufficient anymore to provide solely manufactured products. Therefore, manufacturing companies need to provide additional service to distinguish from their competitors. [BT10]. Furthermore, these services need to be tailored to the needs of customers [Pap04]. Manufacturing companies therefore have to change from pure products to offer costumer solutions including bundled services, e.g. by providing so-called product-service-systems [Mon02]. Concerning the topic of "Services for Renewable Energy Systems" only a few publications are available and most of the relevant sources in the field of renewable energies [BMU11; BW11; Gei10; HWK09; HW09; Pra10] discuss the aspect of services only insufficiently. Due to this situation, this paper discusses services for renewable energy systems and focusses on the applicability and potential of Service Engineering in the field of renewable energies.

The methodological approach regarding the development and delivery of services holds enormous potentials also in the renewable energy industry. In the course of the current industrialization of the service sector, added value can emerge through efficiency and possible quality improvements. Recent studies prove that methods for the description and individual configuration of services are not consistently put into practice [DIN11]. The evaluation of questionnaires, conversations with the EUMONIS industry partners and the analysis of service portfolios of corresponding providers also verify these findings concerning the field of renewable energies. However, it is necessary to develop and describe services in a structured way to offer transparent services with the possibility to be adapted to individual customer needs.

The Service Engineering approaches this request. It provides methods, models and tools to describe services in a structured manner and form a foundation for the methodological conception and delivery [BS09]. In detail, Service Engineering supports the componentization, the creation of service platforms or the customer oriented configuration of services.

The following illustration visualizes a few examples of benefits for the structured description of services. Orientated at the lifecycle of services, the internal point of view shows the possible benefit for the provider and the external point of view shows the possible benefit for the customer.

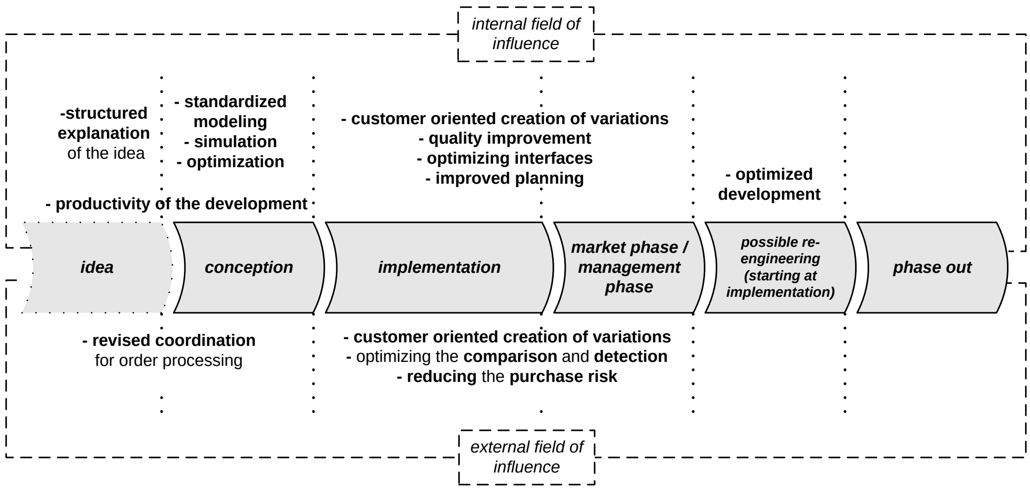

Figure 1: Internal and external benefits for the structured description of services [Böt08]

Therefore, Service Engineering provides a variety of possibilities to accomplish added value for the field of renewable energies. Together with the industry partners of EUMONIS, potentials were developed according to service engineering methods to analyze these possibilities. By means of a survey these potentials were then analyzed regarding their relevance and degree of realization.

Accordingly, this paper is structured as follows. First of all, the overall research approach is discussed in chapter 2. Chapter 3 then focusses on the definition of possible potentials/objectives which is followed by chapter 4, the analysis of the questionnaires. Chapter 5 finally gives an overview of the results and derives future needs.

2 Methodology

The methodological approach is divided into three parts. Firstly, possible objectives were worked out based on a comprehensive literature research covering relevant sources [BöK11; Böt08; BS09; BK11; DIN98; DIN11; FMMF08; HW09; MKS10; SEKL08; SG08; SK10]. Secondly, these objectives are analyzed by means of a survey with the EUMONIS industry partners. With the help of questionnaires, the relevance and the degree of realization of the objectives has been documented. Based on this data, the future needs were developed and identified in a third step.

The literature research conducted as the first step also allowed investigating the current state of utilization of Service Engineering in the field of renewable energies. Following the goal to acquire a wide range of objectives, 34 objectives were identified, which are then separated and listed according to the fields of influence. Based on this classification, it was possible to establish a clean and user-friendly questionnaire.

During survey, the industry partners discussed these objectives and analyzed them regarding their relevance. Their results have been collected in a total of 8 questionnaires. The four industry partners represent different areas (bio, wind, solar) of renewable energies. The range of companies encompasses small companies up to global players in the market. Therefore, the validity of the research is justified. The following table provides a short description of the companies by describing the different areas and the number of staff members.

Company	Area	Number of staff members
A	wind, solar	approx. 360.000
B	wind, solar	approx. 46.000
C	wind	approx. 100
D	bio	approx. 10

For an overview, questionnaires were handed out to the industry partners to identify a first rough relevance of the objectives. On the basis of this information, several workshops were held which discussed these objectives individually and separately for each company. With this detailed analysis it was possible to acquire well-founded knowledge on the relevance of objectives. The results are summarized in section 4. Furthermore, the degree of realization was identified with the help of an additional questionnaire. Besides the degree, another focus was set on the question on how to realize the highly relevant objectives. These results are summarized in section 4 as well.

Based on this data, future needs and recommendations for key activities were derived in a third step. Due to focusing on the key activities, the companies are able to realize the objectives efficiently and, therefore, strengthen their competitive position in the market. Furthermore, it is shortly discussed to what extent the service engineering can serve the identified needs.

3 Identifying Objectives

Based on the literature research, the objectives are separated into three fields of influence: internal, external and internal/external. Internal objectives describe all those objectives which address internal tasks. These appear mainly at the provider's level within the development or the structuring of services. Accordingly, external objectives address external tasks as part of the interaction between the provider and the customer. Internal/external objectives on the other hand are relevant for both fields of influence. In the following, some examples on the process of developing and identifying possible objectives are given.

The focus concerning the internal objectives is set on the structured development of services. This structured and systematical development of services is essential for providing services economically and efficiently with a desired quality [AJ12, BS09; SK10]. In addition, the reduction of the developing time is highly important due to the fast-paced market conditions [BS09; SEKL08]. Therefore, the first internal objective is identified as follows:

"Structured development and composition of novel services, reduction of Time-to-Market"

This fast-paced situation always leads to new market needs and, therefore, to the need of innovations, which is summarized in the next objective:

"Increased innovation capability"

In addition, the emergence of specialized and new market needs do require more complex services. This complexity makes it difficult to manage services. With structure and modularization it is possible to overcome this complexity. The separation into modules, which need to be independent and connected by standardized interfaces, on the one hand makes it possible to configure highly complex and standardized services which are on the other hand comprehensible and easy to manage [BA12, BK11; BöK11; BS09]. This is reflected in the following objectives:

"Simplified connection/configuration of services"

"Detailed/structured overview of all services/variations of a provider"

This aspect of modularization is also used to economically provide customer oriented services. Individuality is increasingly important to satisfy customers and to accomplish a competitive advantage and differentiation over competitors [See09, Gu10]. This is captured by the first internal/external objective:

"Customer oriented creation of variations"

The further focus of the internal/external field of influence lies within the consideration of the service delivery process and the needed resources. The in-depth examination of the service delivery process, e.g. with a simulation, provides many advantages. The continuous and critical review leads to general awareness of all relevant processes [Con10; SK10]. With regard to this awareness, it is possible to increase the quality, recognize weak points and finally increase the productivity. This potential for optimization is expressed in the following objectives:

"Increase the productivity of the service delivery"

"Increase/normalize the quality of the service delivery"

"Recognize weak points of the service delivery process"

"Simulate the service delivery process"

"Optimize the process of the service delivery"

The external field of influence mainly identifies objectives regarding the relationship between the customer and the enterprise. While it is important to develop services in a structured manner and steadily optimize all involved processes, the customer will decide whether a service succeeds or fails [BK11; BöK11; MKS10]. Therefore, it is mandatory to involve the customer wherever it is possible. This aspect can be found in the next objectives:

"Involve the customer in the choice and composition of individual services"

"Customer oriented/flexible formation/presentation of service offerings"

The other important aspect of the external objectives is the distribution of services and opening up of new markets. Both focus on the acquiring and caring of customers to build up a solid and preferably large customer base. In the long run, this is the foundation of every service company's revenue and a reliable source of high quality feedback [SG08; MKS10; Böt08; DIN11]. These aspects can be found in the following objectives:

"Simplify/optimize the service distribution process"

"Increase the market transparency for services in the field of renewable energies"

"Opening up of new markets"

4 Relevance and Degree of Realization

For the identification of the relevance of these objectives, questionnaires were handed out to the industry partners. After analyzing and evaluating, the results of these questionnaires were revised and summarized in new questionnaires. These questionnaires are now used to identify the degree of realization of each objective and field of influence.

For the analysis, the characteristics of relevance were preset with values (1=low, 2=middle, 3=high). A total of eight questionnaires were taken. Every objective can get a maximum of 24 points in the column "Total points of relevance" and a maximum average of 3 in the column "Average relevance" (if all industry partners valued the relevance of an objective as high). The results of these questionnaires regarding each field of influence are shown in the next figures.

To focus on high relevant objectives only those with a total relevance of 14 points or higher are listed.

Field of influence	**Objectives**	**Total points of relevance**	**Average relevance**
internal	Optimized illustration of services with the description of functionalities and characteristics (e.g. availability, quality characteristics)	20	2,5
	Optimization of internal workflows by means of managing services integrated in the internal company processing e.g. company processes, features	20	2,5
	Structured development and composition of novel services, reduction of Time-to-Market	20	2,5
	Detailed/structured overview of all services/variations of a provider	17	2,125

Regarding the internal field of influence, the optimized description of services and optimizing internal processes are highly relevant. Surprisingly, the relevance of the ability to innovate is rated low whereas the structured development and shortening the time-to-market is highly relevant for the industry partners. This shows that the sector is still aiming at being effective and efficient while developing new services. Being innovative is a further step for these companies.

Field of influence	**Objectives**	**Total points of relevance**	**Average relevance**
Internal/external	Supporting the service delivery process by means of optimizing the planning, selection and usage of resources	24	3
	Optimizing the process of the service delivery	23	2,875
	Process automation	21	2,625
	Customer oriented and cost-optimized generation of offers and contracts on the basis of services described in a structured manner	20	2,5
	Increase/normalize the quality of the service delivery	20	2,5

	Increase the productivity of the service delivery	20	2,5
	Precise/flexible accountability of services and resources	20	2,5
	Detailed assignment of resources to tasks	19	2,375
	Recognize weak points of the service delivery process	19	2,375
	Process oriented description of services – visualization of the service delivery process	17	2,125
	Development oriented description of services – technical and human resources and their characteristics (e.g. mobility, tangibility, capacity)	16	2
	Quality improvement and standardization of offers and contracts (creation of offer and contract templates)	16	2
	Customer oriented creation of variations	14	1,75

Regarding the internal/external field of influence, the aspects of the service delivery process are highly relevant. The assignment of resources to tasks is also important in this context but the integration of resources is rated low. Again, the description seems to be essential. Because of the intangibility of services, it is even more important to have an optimized description of the service itself and the process of delivering it. In addition, the automation is rated high to improve the quality and effectiveness of service processes.

Field of influence	**Objectives**	**Total points of relevance**	**Average relevance**
external	Offering services through one central platform: Customer's point of view: ● overview of all service offerings, ● configuration of services regarding inquiries, ● creation of invitations, ● buying services, ● finding and comparing offers of several providers, ● display services for a specified product/component, ● identify the availability of services, ● direct use of electronical services,	21	2,625

	● more		
	Offering services through one central platform: Provider's point of view: ● configuration of services, ● description of service characteristic e.g. quality characteristics, ● defining discount possibilities, ● selling services, ● connecting to the Workflow-Management-System, ● collaboration possibilities with other companies, ● more	20	2,5
	Involving the customer in the choice and composition of individual services	19	2,375
	Customer oriented/flexible formation/presentation of service offerings and their composition to product-service-systems	19	2,375
	Opening up of new markets	17	2,125
	Increase the market transparency for services in the field of renewable energies	16	2
	Simplify the distribution of services	15	1,875

Taking a look at the external field of influence, distributing services over a central platform is highly relevant. Furthermore, it is necessary to integrate the customer into the distribution and configuration of new services. Individuality is also an important factor in this context to provide customer oriented services.

Besides the now identified key areas which are crucial to the majority of industry partners, there are several other results which are not displayed by the figures. One of them is the circumstance that not all objectives are equally important to the different partners. This is mainly based on the situation of different industrial divisions (wind energy, bio energy, etc.) of the partners within the field of renewable energies but also on the fact that services are provided from different types of providers (manufacturers, specialized service providers, operators, etc.). Depending on the type of provider and their operating field, objectives are more or less important and, therefore, also their relevancies.

To consider the practical realization, the degree of realization of each objective was analyzed in the survey as well. The degree of realization was summarized in four characteristics (yes, partially, no, planned). Again, only the objectives with a total relevance of 14 or higher were analyzed. The questionnaires were answered by four industry partners. The following figures show the collected results separated for each field of influence.

Field of influence	**Objectives**	**Participant 1**	**Participant 2**	**Participant 3**	**Participant 4**
internal	Structured development and composition of novel services, reduction of Time-to-Market	no	planned	planned	no
	Detailed/structured overview of all services/variations of a provider	partially	partially	planned	partially
	Optimized illustration of services with the description of functionalities and characteristics (e.g. availability, quality characteristics)	partially	yes	planned	partially
	Optimization of internal workflows by means of managing services integrated in the internal company processing e.g. company processes, features	no	partially	partially	partially

In the internal field of influence, on the one hand one objective was realized by only one industry partner. On the other hand, the objective "Structured development and composition of novel services, reduction of Time-to-Market" was not realized at all and additionally is not planned to be realized by 2 out of 4 industry partners which can be based on less information and experience with service engineering. The other 3 objectives are mainly partially realized.

Field of influence	**Objectives**	**Participant 1**	**Participant 2**	**Participant 3**	**Participant 4**
internal/ external	Development oriented description of services – technical and human resources and their characteristics (e.g. mobility, tangibility, capacity)	no	partially	no	partially

	Supporting the service delivery process by means of optimizing the planning, selection and usage of resources	planned	partially	partially	partially
	Detailed assignment of resources to tasks	planned	partially	no	partially
	Process oriented description of services – visualization of the service delivery process	no	partially	planned	no
	Recognize weak points of the service delivery process	no	no	planned	partially
	Optimizing the process of the service delivery	no	partially	planned	partially
	Increasing/standardizing the quality of the service delivery	no	yes	planned	partially
	Increase the productivity of the service delivery	no	yes	planned	partially
	Process automation	no	partially	partially	no
	Customer oriented and cost-optimized generation of offers and contracts on the basis of services described in a structured manner	partially	partially	partially	partially
	Quality improvement and standardization of offers and contracts (creation of offer and contract templates)	no	yes	partially	partially
	Customer oriented creation of variations	partially	/	partially	partially
	Precise/flexible accountability of services	no	partially	partially	partially

	and resources				

The internal/external field of influence has a high percentage of non-realized objectives. While a lot of objectives are partially realized, 9 out of 12 objectives are not realized at all by one or more industry partners. Again, only a marginal number of 3 objectives were realized by the same industry partner as in the internal field of influence. The other three industry partners have not fully realized a single objective so far.

Field of influence	**Objectives**	**Participant 1**	**Participant 2**	**Participant 3**	**Partici-pant 4**
external	Opening up of new markets	partially	partially	partially	/
	Simplify the distribution of services	no	partially	partially	/
	Increasing the market trans-parency for services in the field of renewable energies	partially	no	no	partially
	Involving the customer in the choice and composition of individual services	no	partially	planned	/
	Customer oriented/flexible formation/presentation of service offerings and their composition to product-service-systems	no	partially	partially	partially
	Offering services through one central platform: Provider's point of view: ● configuration of services, ● description of service characteristic e.g. quality characteristics, ● defining discount possibil-ities, ● selling services, ● connecting to the Work-flow-Management-System, ● collaboration possibilities with other companies, ● more	no	partially	partially	partially

	Offering services through one central platform: Customer's point of view: ● overview of all service offerings, ● configuration of services regarding inquiries, ● creation of invitations, ● buying services, ● finding and comparing offers of several providers, ● display services for a specified prod-uct/component, ● identify the availability of services, ● direct use of electronical services, ● more	no	no	partially	partially

The last field of influence, the external, confirms the findings. No objective was fully realized by any partner and 6 out of 7 objectives were not realized by one or more industry partners.

A complete overview of all objectives shows that on the one hand the vast majority was not realized. On the other hand, all objectives are partially realized or planned to be realized by at least two industry partners. This underlines the relevance of the identified objectives.

5 Results

In summary, the structured development, composition and description of existing and new services are highly relevant. In this context, both resources (description, assignment, accounting) and delivering processes (optimization, standardization, quality improvement, automation) are in the focus of consideration. Another key area lies within the distribution of services, e.g. offering/delivering services via a central system. Thus, methods and tools are needed which provide the ability to offer services in a structured way and therefore simplify the distribution. This can also lead to a structured and flexible formation of the service portfolio and its composition into array of products. Furthermore, the majority of the highly relevant objectives are only partly or not at all realized. This shows a strong need for a structured and systematical approach for realization.

The Service Engineering can serve as a foundation in this context. It provides several methods and tools for a systematic development and optimization of services and, therefore, plays a significant role for the implementation of the identified objectives. This proves the high potential of Service Engineering in the field of renewable energies. It is now up to the market players to benefit from the various possibilities of Service Engineering and on the one hand finally transform the identified potential into added value which on the other hand strengthens the position of the industry sector at national and international markets.

The survey in this paper provides a qualitative inquiry and is, therefore, not easily transferable to the whole market. Identifying relevant potentials and evaluating them with selected companies of the renewable energy market was the goal. The results and potentials have to be examined in further research in the context of the whole market.

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Discussion Paper Session

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Process-Oriented Simulation of Complex Service Provision Based on the Design Structure Matrix

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Abstract: Providing innovative and complex services requires great detailed design. Thus, developing efficient and valid plans for service provision is often crucial for service companies. The design or planning of service activities must take due account of certain precedence and resource constraints. However, this is a complex task for human schedulers. Unmethodical scheduling of service activities does not always ensure optimal use of resources, customer satisfaction and the attainment of service targets in an acceptable period of time. In other words, estimating the expected duration of a service provision using network techniques is not very convenient, as these techniques do not allow modelling of complex dynamic interactions or frequently occurring iterations between service activities. Instead, innovative methods and tools like computer-aided simulation should be used to improve the design and scheduling of complex service provision processes. Dynamic simulation enables human schedulers to forecast the total period of a service provision as well as effects of changes to the design of a service provision. This paper introduces a simulation model for adequate planning of complex service provision and design of a nearly optimal plan for service provision. The paper concludes with an industrial application of the presented simulation model.

1 Introduction

Companies can capture a large fraction of their overall benefit with services [KD06]. For example, the costs for operation and upkeep of industrial machines often account for up to 90 percent of the machine purchase costs. To exploit this revenue and profit potential, companies have to systematically build and expand their services. But a great many companies are confronted with the problem that their implemented organisational structures and processes are not optimally designed for efficient development and provision of new services [Ros09]. In particular, they often lack clear definitions of the provided services as well as distinct descriptions of service specifications, inherent service processes and needed resources. Furthermore, there are only a few appropriate methodological tools to assist with strategic and operative planning of service processes and to develop competencies and skills for efficient service provision design. For a long time, services were not examined in academia, neither in the science of management nor in engineering science. Only recently have services begun to play a vital role in academic studies. The efficient design of a service provision is referred to here as the technical discipline of service engineering. Service engineering aims to extend engineering approaches and experiences as well as corresponding models, methods and tools developed for conventional product development to the area of services. Service engineering covers the systematic development and design of services and service products using adequate models, methods and tools (for an overview of the developments in service engineering, refer to [MGT12]). Therefore, service engineering provides an interface between conventional service science and engineering science. As the service sector becomes increasingly important, service engineering methods have the potential to support companies in the development of innovative and complex service models as well as stable and efficient service processes that are adequate and proportionate to minimise risks and the costs of service provision.

In the following, several references are made to engineering methods and the new product development (NPD) process for the purpose of service engineering. For that matter, the presented models and methods originally developed for NPD are extended so as to apply for the design and planning of service provisions and corresponding service processes. For example, addressing the challenges of the market, it is often necessary to minimise development time for new products; in other words, the time between when a product is initially conceived and when it becomes available for sale (time-to-market). Likewise, a service provider strives to design and schedule service processes so that the total period or duration of service provision will be minimised. Due to the assimilable planning approach, the engineering methods used for planning and scheduling NPD projects and processes are also suitable for designing service provisions and scheduling service processes. We attempt to discover such engineering methods and demonstrate best practices for service provision design.

The outline of this paper is as follows: In the first part the theoretical basics of the Concurrent Engineering methodology, the Design Structure Matrix (DSM) and DSM-based simulation models as well as the simulation model for the design and scheduling of service provision processes are introduced. In the second part of this paper the results of an explorative case study involving the construction of a large-scale chemical engineering plant are presented.

2 Background

2.1 Concurrent Engineering

Concurrent Engineering (CE) is a widely shared work methodology for reducing time-to-market [PW89]. Fundamentally, the work methodology is based on integrating and parallelising functions of product and process design (e.g. design engineering and manufacturing engineering functions). Requirements arising from the post-product lifecycle phase are considered at a very early stage. In this way, time and cost-intensive modifications of product and process design in late phases can be prevented. Due to the emphasised parallelisation in CE, mutual dependent activities start based on informational assumptions. If the assumptions subsequently prove to be incomplete, erroneous or incorrect, affected activities have to be performed again in iteration loops. Generally, this leads to a longer duration for the entire product development phase and extended time-to-market, which conflicts with the purpose of CE.

2.2 Design Structure Matrix

In connection with CE, matrix-based techniques are widely applied to analyse and manage complex systems in engineering. The Design Structure Matrix (DSM) supports engineers and project managers in modelling, visualising and analysing dependencies among the entities in their NPD projects [Ste81]. In a DSM, an NPD or service provision process is decomposed into n distinct activities, which are entered as labels in the rows and columns of an n-by-n matrix. The values in a given cell indicate informational dependencies or coupling between the corresponding activities, resulting in feed-forward control flows in the lower triangular matrix and feedback control flows in the upper triangular matrix. Hence, the strength of the DSM is its clear and compact representation, which allows it to consider iteration loops and mutual activity dependencies. Interactions, interdependencies and interfaces between entities in a complex system, like an NPD project or a service provision process, can be captured easily in a DSM.

Despite the methodological support of the DSM, NPD project planning and corresponding resource management is an extremely complex task for human schedulers [PC94]. Likewise, it is an equally complex task to find the optimal design of service provision and scheduling of service activities. The application of the DSM method in itself does not ensure appropriate consideration of certain precedence and resource constraints and optimal use of resources, customer satisfaction and the attainment of service targets in an acceptable period of time. Instead, innovative methods and tools like computer-aided simulation should be used to improve the design and scheduling of a complex service provision. Dynamic simulation approaches enable human schedulers to forecast the total period of a service provision as well as effects of changes to the design of a service provision. In combination with simulation approaches, DSM-based process modelling often results in better, more realistic design and planning for service provision.

2.3 Simulation Models Based on the Design Structure Matrix

Several simulation models can be found in the literature. [SE97] were the first to develop simulation models based on Marcov chains that used a DSM to model interdependencies and iteration probabilities (that is, the probability of iteration from a downstream activity to an upstream activity occurring during the execution of the downstream activity). Another simulation model was developed by [BE02]. Their DSM-based Monte Carlo simulation enables them to predict the probability density function of the process duration. In addition, [YWZ01] supplement this simulation model with a methodology for efficiently estimating iteration probabilities that are used as input data for the simulation. It made use of a multi-project environment that considered resource constraints. The approach in [CE05] is also based on the simulation model developed by [BE02]. It allowed the modelling of different workflow regimes, like overlapping activities, and indicated the rework fraction during an iteration loop and the reduction of iteration probabilities resulting from increasing quality. [KR07] used DSMs of different types to model intra- and inter-activity iterations and developed a Petri net simulation based on these matrices. Finally, [ZZL+12] model autonomous task scheduling behaviour based on information relation matrices and use it in an agent-based product development process simulation.

3 Simulation Model for the Design and Scheduling of Service Provision Processes

The approaches described above culminated in a discrete event simulation model for integrated project and change management on a process-oriented basis developed by [Gae11] and presented in [GRS08], [GRS09] and [GRS+09]. The simulation model is based on the DSM and allows the prediction of probability density functions (PDF) for the expected total period and costs of a service provision. It considers information dependencies between service activities, iteration probabilities, rework fractions due to iterations, and the reduction of iteration probabilities resulting from increasing quality. Furthermore, it can model changes and modifications to the design of a service provision and simulate the effects of changes and modifications based on interdependencies between service activities.

The procedure of designing and planning a service provision process usually starts by specifying the work breakdown structure or process structure with all necessary service activities. The work breakdown structure is organised in a task list. A three-point estimation technique is used to construct an approximate PDF of every activity's duration and costs based on the planners' experience or best-guesses. It differentiates between a best case estimate D_b (i.e. the minimum activity duration), a most likely estimate D_m (i.e. the average activity duration) and a worst case estimate D_w (i.e. the maximum activity duration). The PDFs for each activity's costs are constructed in the same way. Activity costs include all costs that are directly attributable to the execution of this activity, e.g. personnel and material costs.

The simulation model makes use of four activity-based DSMs, referred to as process DSMs. In the first process DSM, the Earliest Start Time (EST) of an activity has to be specified. Figure 1 shows a sample work process with activities A-H modelled in a DSM. Framed cells in the DSM indicate different processing strategies. For overview purposes, zeros are not displayed except in framed cells. Reading across row F, for example, we see that activity F is dependent on activity E. As the EST in row F and column E is 0.4, activity F starts as soon as 40 percent of activity E is executed (that is, 40 percent completion). The EST determines whether the activities are processed in parallel, sequentially, overlapped or coupled. Different processing strategies based on information dependencies modelled in the DSM are shown as bar graphs on a horizontal time scale as well as free graph notation (see figure 2). If any dependencies are absent, two activities can be processed in parallel if all necessary information, employees or teams, and resources are available. In the event of a unidirectional dependency between two activities, the process starts with the information-generating activity (upstream activity). As soon as the necessary information is generated, the dependent activity (downstream activity) begins; both activities are processed sequentially. If the information is generated during the execution of the upstream activity at a certain point in time t_i, both upstream and downstream activities can be processed overlapped. The ratio to which the upstream activity has to be completed before the downstream activity can start is modelled in the DSM as quotient t_i/Sn_i, where Sn_i is the total duration of the upstream activity. In the event of a mutual dependency, two activities are processed sequentially or overlapped in several feedback loops (iterations). This coupled process only terminates if a sufficient quality of information outputs is achieved for both activities. The different processing strategies described above enable the deduction and simulation of work processes based on the information dependencies modelled in the DSM.

	A	B	C	D	E	F	G	H	
A		0				0.1			parallel
B	0			0.3					
C		1		0					sequential
D			1					0.2	
E			1	1		0			overlapped
F					0.4				
G		1				1		1	coupled
H							1		

Figure 1: DSM representing an exemplary work process

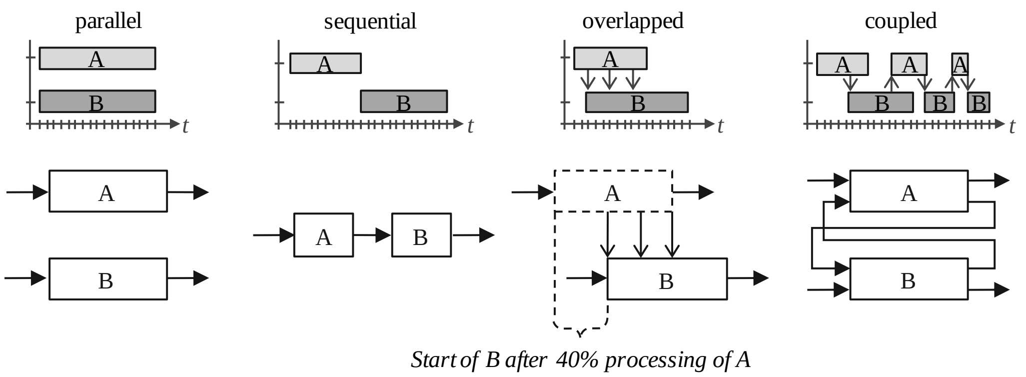

Figure 2: Different processing strategies

In the second process, DSM iteration probabilities are modelled. They express the probability of iteration from a downstream activity to an upstream activity occurring during the execution of the downstream activity. The amount of rework is modelled in the third process DSM and defines how much of the primary work has to be performed during an iteration loop. The fourth process DSM models the factor of decrease of the iteration probability due to increasing quality.

In addition to planned iterations, which ensure the quality of the process, and unplanned iterations resulting from necessary corrections of incomplete, erroneous or incorrect assumptions as described above, the simulation can also consider changes and modifications to the design of a service provision process. For example, these changes and modifications might stem from changing customer or client demands and requirements, changing legal regulations, or the need for process optimisation. If a change to the design of a service provision process is taken into account, a change vector has to be modelled. The change vector expresses the specific point in time within the service provision process at which the change to the design occurs. Furthermore, the change vector expresses which service activities carried out so far (upstream activities) will possibly be affected by the change, and it indicates to what degree a certain service activity is dependent on the change. The resulting rework due to a change in the process design is similar to the rework of upstream activities due to unplanned iteration loops.

The user determines the number of simulation runs that have to be evaluated; the default value is 1,000. During these simulation runs, the minimum, mean, modal and maximum value, standard deviation and variance as well as 5th and 95th percentile of the total period and costs of a service provision process are calculated. Frequency distribution of the simulated total period and costs of a service provision process (shown in the form of histograms as well as Gantt charts for the simulated service provision process with shortest, average and longest total period) allow detailed risk analyses and assessment in the run-up to important strategic and operative decisions. As a result, the simulation model can be used to iteratively improve and optimise the design of a service provision.

4 Industrial Application

To show the application of the simulation model and to determine how simulation helps with the prediction of the expected total period and costs of a service provision, a case study involving the construction of a large-scale chemical engineering plant was simulated and analysed. The company is a service provider of plant construction and site operations with a very wide-ranging service spectrum. Services offered range from operation-oriented maintenance of chemical production plants and the execution of individual maintenance projects to main contracting and full-service models. Furthermore, the company contributes to boosting the efficiency of chemical production plants by optimising maintenance processes in terms of costs and plant availability as well as developing customised maintenance strategies for the deployment of human resources, materials and spare parts.

The simulation was primarily based on data and information from the company’s project planning system, supplemented by interviews and workshops with project managers and engineers from the company. In this way, comprehensive information about the work breakdown structure, duration and costs estimates for each service activity, information dependencies between service activities, iteration probabilities, etc. of the service provision was gathered. The service provision process consisted of 47 activities. The simulation was conducted with near-sequential activities and partly overlapping activities. Without considering overlapping and iteration loops, the simulation resulted in an average total period of service provision of 209 time units (TU) with a standard deviation (SD) of 17 TU. The minimum total period of service provision was 156 TU and the maximum period was 264 TU. The simulation proved to correlate very well with the real service provision process. Unanticipated long total periods of service provision are likely because the modal value of the probability distribution is smaller than its mean value.

4.1 Simulation analysis of iteration loops

This section considers the sub-process for dimensioning the chemical engineering plant that was to be constructed. The sub-process starts with a calculation of the process parameters (13) after the mass balances have been generated (12). Then the following activities are executed in a feed-forward control flow (in this sequence): analysis of possibilities for implementing the block elements (15), evaluation of the alternatives (16), and dimensioning of the plant elements and machines (17). In particular, the activities of this sub-process have a high probability of being reworked in iteration loops. If the dimensioning of the plant elements and machines (17) fails or requires re-calculation, an iteration is performed either to evaluate the alternatives (16) or to calculate the process parameters (13). Conducting an iteration of the activity (13) is very time-consuming, because after changing the calculation of the process parameters, the activities (15) – (17) also have to be executed iteratively. In other words, the analysis of possibilities for implementing the block elements, the evaluation of the alternatives and the dimensioning of the plant elements and machines all have to be reworked again.

With the consideration of iteration loops in this sub-process, the simulation reveals an average total period of approximately 236 TU for the service provision process, even though the probability for the occurrence of an iteration loop decreases as the sub-process progresses. The maximum total period of the service provision process is 295 TU (see figure 3). In comparison, without considering iteration loops in this sub-process, the simulation yields an average total period of 209 TU and a maximum of 264 TU.

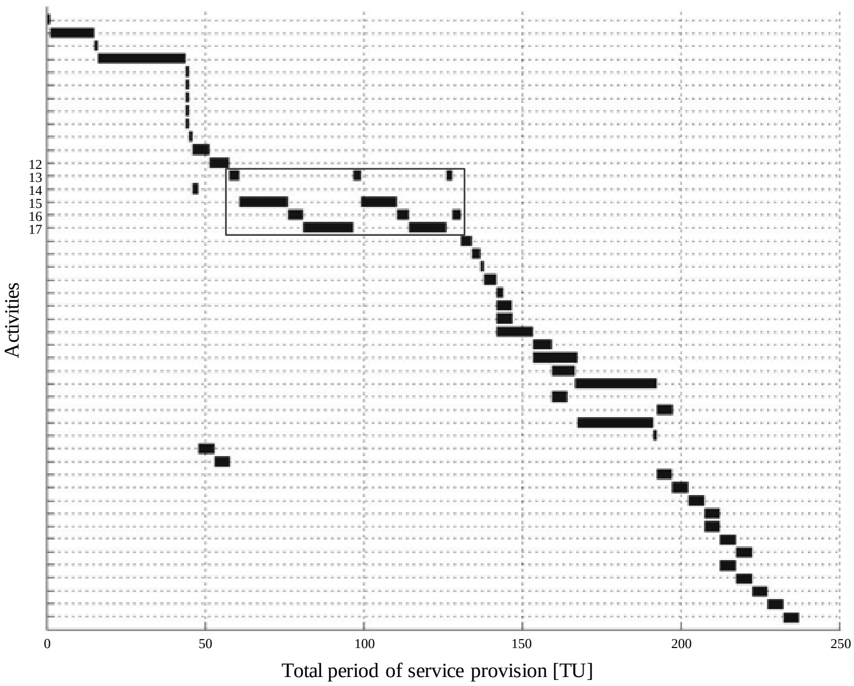

Figure 3: Gantt chart for the simulated service provision process with average total period

4.2 Simulation analysis of changes to the design of the process

In the following, changes to the design of the service provision process due to changing customer requirements are simulated (see figure 4). We consider three different scenarios for various points in time within the service provision process at which a change to the design is made. Regardless of the scenario chosen, changes always cause rework for the upstream activities, and this rework has to be conducted in an iteration loop. However, depending on the point in time within the service provision process at which the change to the design occurs, different numbers of upstream activities have to be reworked again. The amount of change and the impact on the processing of the activities were estimated by the service provider's project managers and engineers along with the process data. The analysis of these estimations indicates that, according to the coupling of the activities, iteration loops due to changes in the design of the process cause rework from 25 percent up to 100 percent of the initial duration of the upstream activities.

In the first scenario, the change occurs at a very early stage in the process. The customer requests modifications after awarding the contract and executing a few activities for initiating the service provision. The modifications and changes to the design of the process result in an average total period of service provision of 262 TU (SD = 30.0 TU). This equals an average additional time consumption of 48 TU (22.43 percent) compared to when the simulation had no modifications or changes to the design.

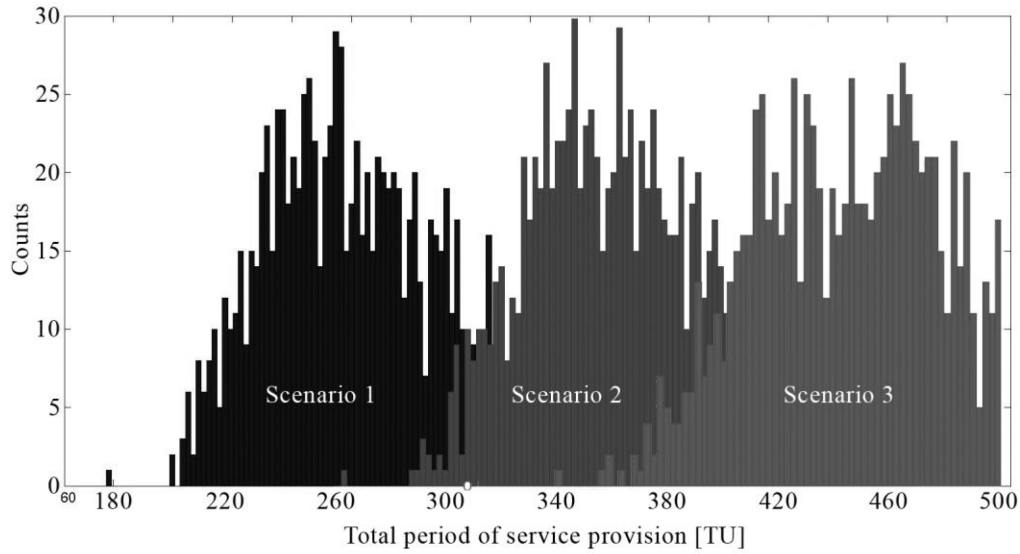

Figure 4: Frequency distributions of the simulated total period of the service provision process.

In the second scenario, the customer requests modifications after nearly half of the elements and machines in the chemical engineering plant have been fully constructed. The modifications and changes to the design of the process result in an average total period of service provision of 351 TU (SD = 31.0 TU). This equals an average additional time consumption of 137 TU (64.02 percent) compared to when the simulation had no modifications or changes to the design.

In the third scenario, the change occurs at a very late stage in the process, when construction of the chemical engineering plant is nearly complete. The modifications and changes to the process design result in an average total period of service provision of 450 TU (SD = 17.4 TU). This equals an average additional time consumption of 236 TU (110.28 percent) compared to when the simulation had no modifications or changes to the design.

The dispersion of the distribution increases from 301 TU^2 for the simulation without modifications or changes to the design to 965 TU^2 and 1754 TU^2 for the simulation with modifications or changes due to the rework of the activities and the increased probability of iterations, respectively. This means that aside from “stretching” the service provision process, a change to the design increases the risk of even more iterations and therefore entails a higher risk of time and cost overruns.

4.3 Simulation Benchmark

The simulation model described above was implemented in a Matlab® numerical computing environment. The simulation experiment ran on an Intel Core i5, 1.17 GHz CPU with a Windows XP operating system (version 2002). As standard, 1,000 simulation runs were executed per simulation experiment. The computing time for one simulation run averaged around 5 ms.

5 Conclusions

Developing efficient and valid plans for service provision is often crucial for service companies. But the design and planning of the service processes must take due account of certain precedence and resource constraints. However, this is a complex task for human schedulers. Therefore, we developed a simulation model for planning and scheduling service provision processes. The DSM-based simulation model allows the prediction of probability density functions for the total period of a service provision. It considers information dependencies between process activities, iteration probabilities and rework. In this way, the simulation enables project managers and human schedulers to identify the potential for reducing the total period of a service provision.

With respect to the industrial case study, the simulation we performed has so far produced a very good approximation of the total period of the service provision. The results show a high correlation with historical data and expert knowledge. Besides providing mean values for the total period of a service provision process, the simulation model offers important possibilities to managers. They can use it to determine the risk of time and cost overruns more precisely.

Although originally developed for the simulation of NPD projects, the simulation model is not limited to a particular field of application. As the case study demonstrated, the simulation model can also be applied very effectively to the simulation of service provision processes.

In the case study, the simulation model was validated by the project managers and experts from the company. It could been shown that there are no significant deviations between the researched model behaviour model and the real system behaviour. Therefore, the simulation results could be used as a valid basis for the evaluation of the company's complex service provision processes. Furthermore, the simulation model presented in this paper also provides plain simulation results and offers the oportunity to assess and coordinate different planning alternatives with the customer and the management.

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Simulation as a Decision-Making Support Tool for Full-Service E-Commerce Providers

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Abstract: In recent years, the business model of full-service e-commerce has rapidly emerged. It enables companies to sell their products and to provide their services over the internet without having specialized knowledge in e-commerce and without taking the risks of huge investments. These responsibilities are assigned to the full-service e-commerce provider, who sets up and maintains the technical shop system as well as fulfills the complete business operations and related processes in collaboration with numerous high specialized service partners. Because of the inherent complexity of these tasks the online shop managers require sophisticated decision support, e.g. cost-benefit estimations and investment calculations of several shop configurations. In this paper, we characterize full-service e-commerce providers as system services providers and present simulation as a powerful tool for decision support in order to improve the economic success of online shops. The simulation approach is compared with controlled experiments and web analytics, well established decision support tools for online shop managers. Moreover, the specific benefits of using simulation for full-service e-commerce providers are mentioned.

1 Introduction

The electronic commerce (e-commerce) is an important channel of distribution for many companies in order to offer their products and services. According to current studies, the electronic commerce is still a market with a high growth potential. For example, eMarketer predicts for Germany a sales growth of 9.4 % for the year 2014 [eMa13]. Forrester forecasts a sales growth from EUR 112 billion in 2012 up to EUR 191 billion in 2017 for the European online retail sales [Gil13]. The e-commerce will therefore continue to play an important role in the future. Especially companies with high-quality retail products are under a high competitive pressure. They have to increase sales and the brand's visibility and have to develop profitable long-term customer relationships by obtaining consumer's feedback. These requirements can only be met by a modern online shop which is fully integrated in the company's IT infrastructure and has a well-designed storefront layout addressing the needs of the target audience.

Nevertheless, the setup and also the successful operation of an online shop is a very challenging task for many companies. Especially the setup of a new shop system is characterized by high barriers to entry. In many cases the companies use standard e-commerce solutions which have to be customized according the individual needs. Furthermore, it is necessary to establish an infrastructure ensuring the availability and operability of the technical system. The design and implementation of an individual storefront layout and the integration with other application systems are additional blocks of costs [Qin09]. The operation of an online shop and the associated processes are another challenge for the companies. Additional service providers are necessary for the execution of payment and logistic processes, the customers expect attractive product presentations in the online shop and legal framework conditions have to be respected.

All of the mentioned aspects need specialized knowledge which is missing among companies starting with e-commerce, because this knowledge is not part of the core business of these companies. In the last view years the business model of full-service e-commerce has therefore established. Hereby, not only the complete setup of the online shop system is provided by an external service provider, called Full-Service E-Commerce Provider (FSEP), but also the complete operation and the associated processes. Consequently, the electronic commerce is outsourced to specialized service providers.

For FSEP the optimal configuration of an online shop is also a challenging task. The main reason for this is the necessary expertise about the interdependencies between different configuration parameters and the impact of these parameters within the e-commerce ecosystem. This interdependency is often multidimensional nature and includes dimensions such as technical, economics and social aspects [HKKD12a]. Thus, it is also difficult for the online shop managers[1] of a FSEP to estimate the economic success of several investments such as the planning and execution of marketing activities, updates of the storefront layout, or the integration of a new payment method. The online shop managers use therefore different approaches for their decision support.

[1] We use the term online shop manager to denote a person who is responsible for the management of a specific online shop.

Based on a detailed characterization of the business model full-service e-commerce and the resulting requirements for the support of the online shop manager's decision-making process, in this paper we analyze three decision support methods: controlled experiments, web analytics, and simulation.

The paper is structured as follows. In section 2 the business model of full-service e-commerce is described in detail. The FSEP is characterized as a system services provider. Moreover, the complex partner network and the involved stakeholders, service providers for marketing, product information, payment, credit assessment, fulfillment, and so on, are presented. In the next section online shops are characterized as complex systems in order to motivate the need for additional decision support tools. In Section 4 we introduce three different approaches that support the decision-making process of online shop managers: controlled experiments, web analytics, and simulation. Then, the advantages and disadvantages of these decision support tools are discussed. Finally, we summarize the main points in Section 6.

2 The Full-Service E-Commerce Provider

Full-service e-commerce is a business model which aims to outsource the electronic commerce. A full-service provider is not only responsible for the initial setup process of the online shop but also for the distribution and the related business processes. This includes all activities and processes in the online shop, starting with customer attraction by means of marketing activities, the product presentation, navigation and search options, the checkout process including payment, the shipment of products, the returns management, and support or other services for the offered products. The FSEP acts as a general contractor towards its clients, that is, the FSEP offers all services mentioned above from one single source. In many cases the FSEP is incapable of providing the complete process chain on its own and is therefore forced to outsource several services to specialized companies resulting in a complex network of sub service providers [HK12].

A typical full-service scenario is shown in figure 1. The key player is the FSEP which hosts the technical shop system and is responsible for its availability. The necessary product specifications including the price information are provided by the client. Since the business transactions are handled by the online shop, only the FSEP is in contact with the online shop customers. Another important actor is the fulfillment provider which is responsible for the shipping of the physical products ordered in the online shop. Furthermore, the fulfillment provider manages the returns. The necessary order data and advice notes are communicated by the FSEP. In many cases the fulfillment provider is also responsible for the warehouse management, the merchandise management, and the accounting. In addition to the fulfillment provider the FSEP appoints several other specialized providers. This includes agencies for the traditional online marketing such as search engine optimization, search engine advertising, and e-mail marketing as well as service providers for particular channels of distribution, for example call center ordering, mobile commerce, or social commerce. Sub service providers are also used for the handling of the payment processes, credit assessment and address validation. In conclusion, the FSEP is integrated in a complex network of partners and is responsible for both the technical integration of the external services and also for the related organizational processes.

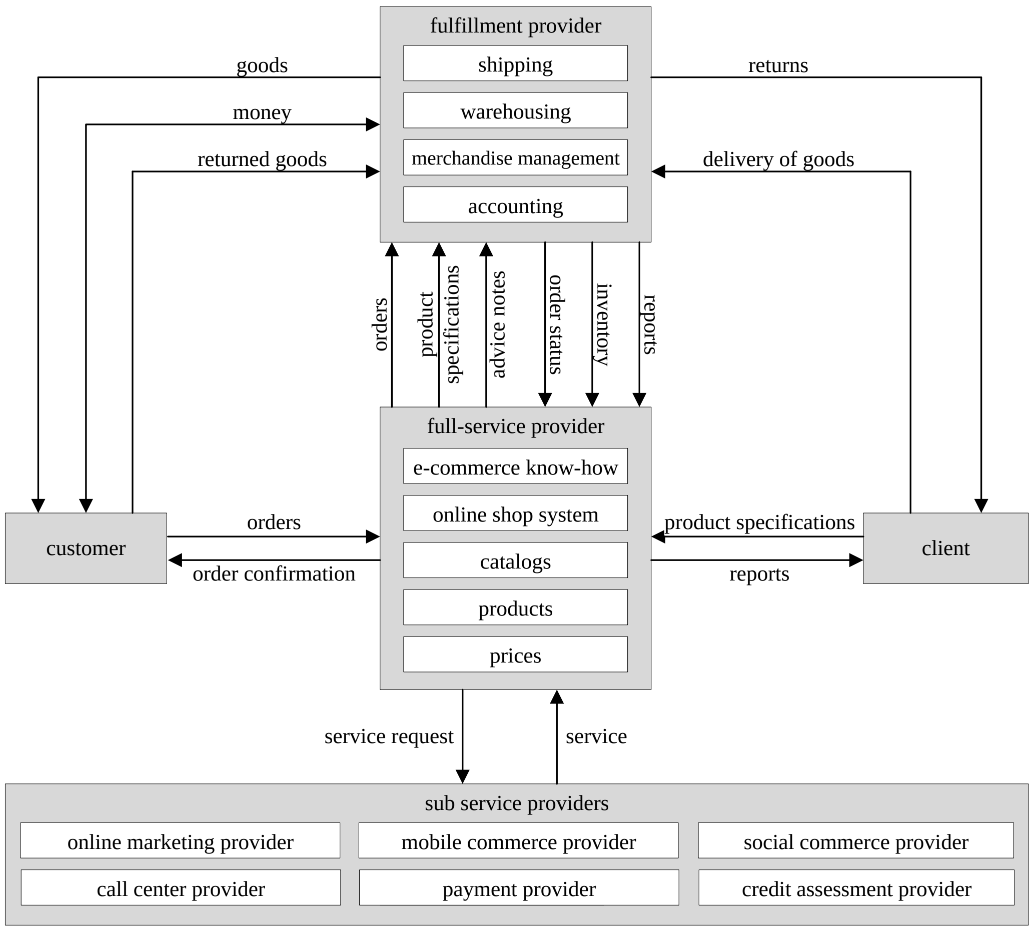

Figure 1: A typical full-service scenario for e-commerce, based on [HK12]

The close relationship between the client and the FSEP requires a remuneration model differentiating from the conventional software distribution. In contrast to a traditional software company, the FSEP generates no revenue by selling software licenses and consulting services. Instead, the remuneration is related to the economic success of the client's online shop. This means that the revenue often depends on the revenue of the client's online shop or the successfully carried out transactions. Efforts for the configuration and customization of the online shops, such as the implementation of an interface for the integration of a new payment method, modifications of the storefront layout, or the commissioning of the sub service providers are investments of the FSEP before the efforts are amortized by the additional revenues caused by the modifications.

The investment and business risk is therefore shift from the client of the FSEP to the FSEP itself. This results in a direct and permanent dependence of the FSEP from the economic success of the client. Therefore, the FSEP focuses on an increase in sales of the hosted online shops and cost-effective processes. For example, an increase of sales can be achieved through addressing the right marketing channels, the generation of high-quality content, or the integration of technologies and services stimulating the sales such as recommendation engines and intelligent search solutions. Effective processes ensure short delivery times, fewer returns, a high satisfaction of the end customers, and high repurchasing rates. The optimal composition of the payment portfolio and the integration of risk management measures (scoring, credit assessment) can minimize the costs and risks during the order handling process. It is therefore essential to estimate the effects of customization decisions as closely as possible for the responsible online shop managers of the FSEP in particular concerning the return on investment.

A successful example of establishing the full-service e-commerce business model is the German company Intershop Communications AG[2]. Originally started as a software company with its own online shop software, Intershop offers full-service e-commerce solutions for several years now and has considerable customers such as Mexx, Roadsign, Channel21, and Miele. Intershop has an extensive network of partners to provide all services from one single source. The network includes, for example, fulfillment provider (Fiege, DHL), payment provider (Computop, PayPal), credit assessment provider (Bürgel), as well as specialized providers for intelligent search solutions (Omikron) and product recommendations (Prudsys). In the following, we describe the Mexx case study in more detail. Since the beginning of 2009, Intershop is responsible for all technical processes of Mexx's online division including the development and design of the online shop, provision of hardware and software, the management and maintenance of the online shop, the development of technical add-ons, and also the content maintenance. The logistics processes and administrative services are handled by the fulfillment provider Fiege. The remuneration of Intershop is based on the sales revenues of the online shop [Int].

In conclusion, FSEPs have established themselves as the central coordinating authority of the complex e-commerce service network in order to act as a general contractor. The FSEPs are therefore responsible for the essential contribution of the offered services. They bring together specialized sub service providers and have therefore a detailed knowledge of the e-commerce market. Due to the dependence of the FSEPs from the economic success of the clients, the FSEPs have to optimize their processes continually and are open to new technologies. FSEPs are therefore major innovation drivers in the e-commerce domain. Hence, FSEPs can be characterized as so called system services providers that are a relevant starting point for service innovations.

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[2] http://www.intershop.com

3 The Need of Decision Support Methods in E-Commerce

Forecasting the effects of individual configurations and customizations of online shops is a challenging task. In this section, we will analyze typical characteristics of online shops in detail in order to motivate the need of decision support methods for online shop managers. Robinson introduces three properties of operation systems that require additional decision support methods. These properties are variability, interconnectedness, and complexity [Rob04]. These properties are also true for online shops.

- **Variability:** Online shops have a high variability, that is, there are a lot of configuration parameters that can be modified in order to improve the economic success of an online shop. For example, there are numerous marketing instruments to acquire new customers such as search engine advertising, e-mail marketing, the use of additional market places, or marketing in social networks. The online shop manager has to decide which marketing instruments are suitable and how much money has to be spend for the several channels.

- **Interconnectedness:** The several components of online shops are interconnected, that is, the modification of one component induces the change of other online shop components. For example, the provided payment methods mutually influence each other. If a new payment method is integrated in the online shop, then not only the abandonment rate in the checkout is reduced but also the utilization rates of the other payment methods decrease. The reason for this is that regular customers can also change to the new payment method. Similar interactions exist also between the different marketing channels. The setting up of advertisements on a search engine for example mostly has negative effects on the natural (organic) search, because the customers use the advertisements to enter the online shop and not the results of the organic search.

- **Complexity:** Online shops have both a high combinatorial and a high dynamic complexity. The combinatorial complexity is a direct result of the high variability. For example, if the online shop manager wants to integrate a new payment method in order to reduce the abandonment rate, over 50 different payment methods are available for integration in the German market. If the merchant operates in international markets, the number of possible payment methods increases multiple [LLS12]. The dynamic complexity rises by the interaction of system elements over time. This results over the short and long run in very different effects and leads to non-obvious consequences. Especially the long-term effects cannot be estimated adequately by online shop managers. Thus, intensive marketing that addresses a specific customer segment, leads over short-term to revenue growth and may, in particular cases, affect the structure of the customer segment over the time. This has implications on the product assortment and product pricing as well as upon the use of offered payment methods.

Due to these properties, the effects of configuration decisions cannot be adequately assessed, especially the need for FSEP of return on investment calculations can be done only in a very limited way.

Most online shops have a different range of products and address a specific customer segment. Thus, online shops do not only differ in store size, meaning number of products, sales volume or number of transactions, but also in seasonal variations and regional and country-specific characteristics. This individuality has the consequence that the experience of online shop managers regarding a specific online shop can be transferred to other online shops only in a very limited way. This complicates the assessment of decisions.

Furthermore, the high complexity and dependencies between different measures in e-commerce can lead to erroneous assumptions and finally to wrong decisions. If the online shop manager addresses online marketing channels in which the target group is not active, the marketing budget blows out without the desired effects. And a suboptimal payment portfolio will not only lead to higher costs but rather might result in higher payment frauds.

In addition to Robinson the velocity of decisions is an important factor of success in e-commerce. For the customer the next online shop is just a mouse click away. Merchants can no longer occur only as a price leader. To be successful in the long term they must offer their customers a pleasant shopping experience which dependents again and again on new trends, services and online shop technologies. Fast decision-making processes help the online shop manager soon to take advantage of these promising trends.

4 Decision Support Methods in E-Commerce

Due to the characteristics of online shops described in the previous section it is difficult to predict the system performance of online shops. Online shop managers use therefore specialized decision support methods for the optimization of online shops. Widespread approaches in the e-commerce domain are controlled experiments (A/B testing, multi-variable testing) and web analytics [Int11]. In contrast the use of simulation is a relatively new approach. In this section, the fundamental principles of the mentioned decision support methods are introduced in order to provide a common understanding.

4.1 Controlled Experiments

4.1.1 A/B Testing

The simplest form of a controlled experiment is an A/B test. In such experiments the original online shop, called the control system (A), and a new version of the online shop, called the treatment (B), are tested [MGH03]. For this the visitors of the online shop are randomly split in two groups. Group A is directed to the control system and group B is directed to the treatment.

Figure 2 visualizes the schematic process of an A/B test with a split rate of 50 percent. The behavior of the visitors is analyzed and by means of an Overall Evaluation Criterion (OEC) [Roy01], sometimes called fitness function, the success of both variants is measured. Typical examples of the OEC are the conversion rate, shopping cart value, units purchased, revenue, profit or weighted combinations of these key performance indicators. For A/B testing it is assumed that the two versions of the online shop are identical except the deliberately induced variation. Therefore, it can be concluded that the change of the consumer behavior is directly caused by the variation in the online shop.

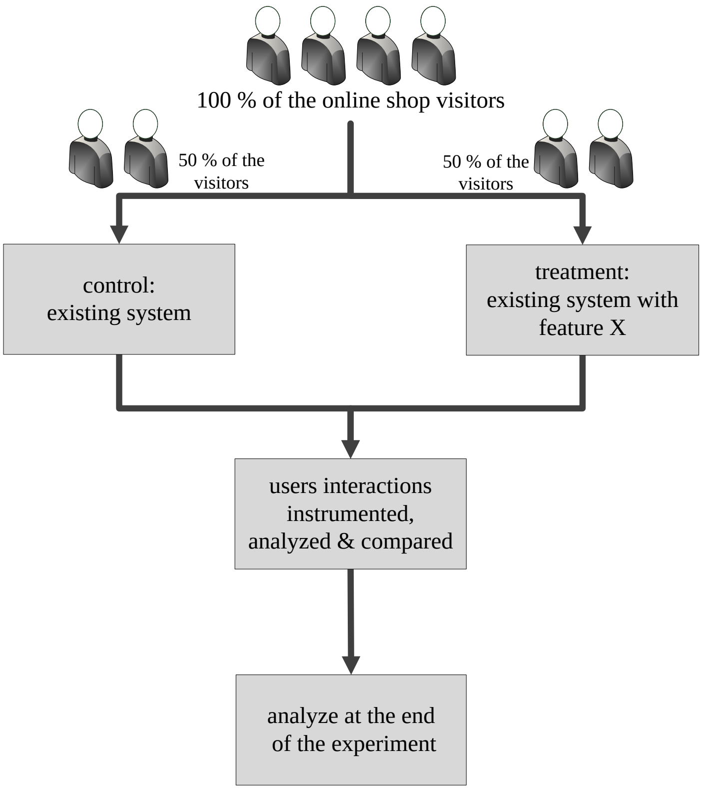

Figure 2: Schematic process of an A/B test with a split rate of 50 percent [KLSH09]

4.1.2 Multi-Variable Testing

By using A/B tests it is possible to test exactly one variation. If there are different variables or several variations of one variable it is necessary to run several A/B tests successively and this will take a lot of time. Multi-variable tests [KLSH09] allow the simultaneous testing of multiple variations and thus it is possible to test many changes in a short period of time. Moreover by using multi-variable tests it is possible to analyze the interaction between different factors. That is, it is possible to analyze if the sum of two or more factors of the individual effects is different from the combined effect of the factors.

To reduce the effort for creating the different online shop variants and to minimize the number of testing groups there are some approaches available that work well with a proper subset of all combinations, such as the Taguchi Method [Roy01]. These methods are necessary for a high number of features or a high number of values of one feature, because the number of variations increases exponentially.

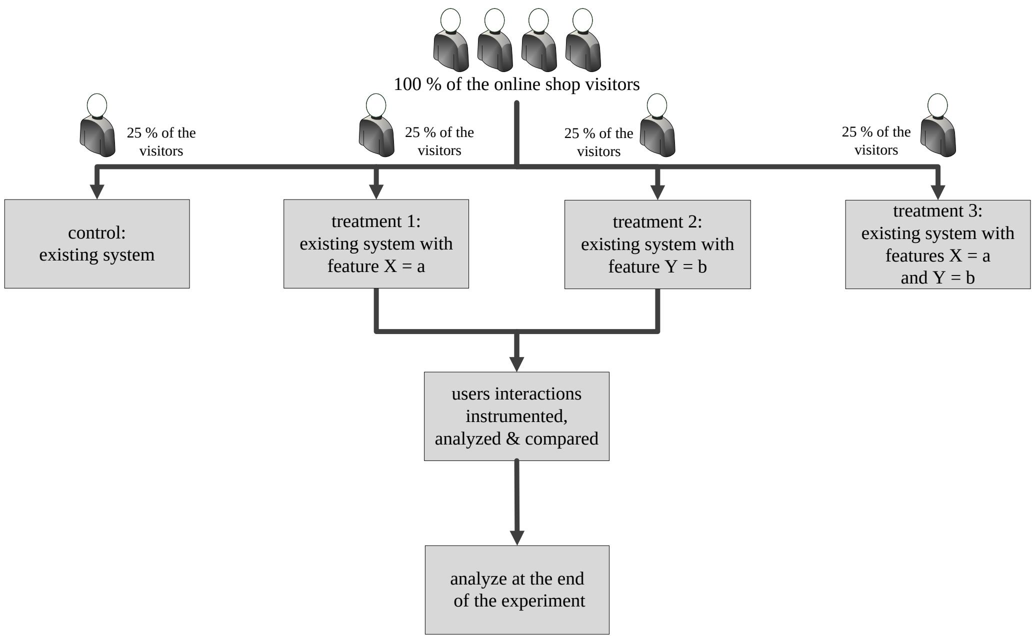

Figure 3: A multi-variable test with two different variables

The test procedure is analog to the A/B testing process. All variations (or the necessary subset) of the online shop have to be implemented and the visitors are randomly split in different groups whereby every test group is assigned to one of the test variations. A simple example of a multi-variable test is shown in figure 3. Here the effects of two different variables and their combination are tested. Since the stream of visitors is split in more than two groups it is necessary to have a high incoming traffic in order to obtain statistically correct results.

4.2 Web Analytics

The Web Analytics Association defines web analytics as the "measurement, collection, analysis and reporting of Internet data for the purposes of understanding and optimizing Web usage" [Web08, p. 3]. Kaushik [Kau07] describes three components which are included in modern web analytics. These are behavior analysis, outcomes analysis, and experience analysis. The components are shown in figure 4.

The component behavior analysis aims to infer the intends of the website visitors. Therefore the clickstream data, the data that describes which online shop pages are visited by the customers in which order, is analyzed. Click density analysis, the in-depth analysis of several pages and the analysis of the search queries are other typical methods of this component.

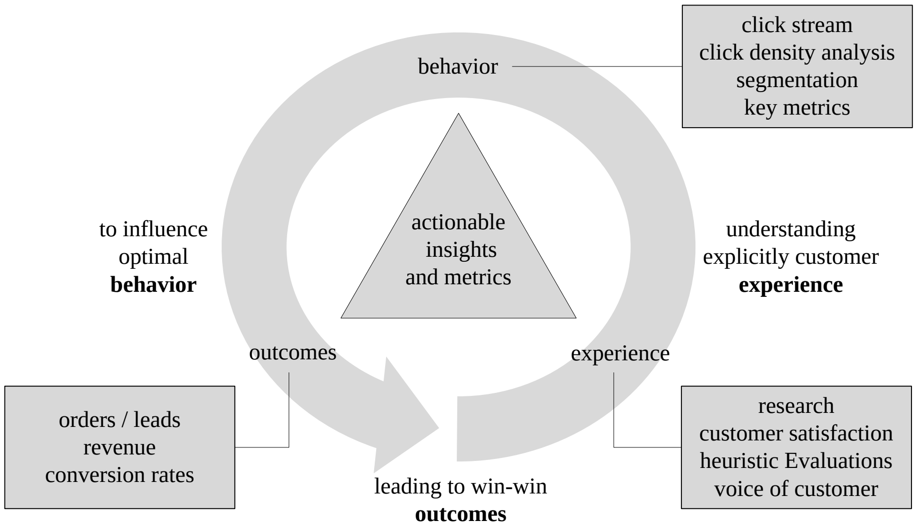

Figure 4: Fundamentals of web analytics [Kau07]

The outcomes analysis determines the real outcome. For online shops typical key performance indicators are the revenue, the number of orders, the global conversion rate, and so on. The analysis of these values serves as success control.

The third component is the experience analysis. This component addresses the why, that is, the experience analysis aims to explain why customers do the things they do. For this purpose statistical methodologies and customer surveys are used to measure the satisfaction of the visitors.

Based on these components it is possible to change the online shop in a way that influences the customer behavior to optimize the outcomes of an online shop.

4.3 Simulation

Banks et al. define simulation as “the imitation of the operation of a real-world process or system over time” [BCINN10, p 3]. The simulation generates an artificial history of the imitated system that can be analyzed in order to draw inferences about the behavior of the real system. To be able to run a simulation, a simulation model is necessary which is executed during the simulation experiment. A simulation model is a mathematical model that represents the real system, that is, the model describes the basic elements of the real system and the underlying relationships between these elements. The accuracy of the simulation results is consequently directly related on the quality of the model. The basic principles of the simulation approach, especially the relationship between the real system and the simulation model, are illustrated in figure 5.

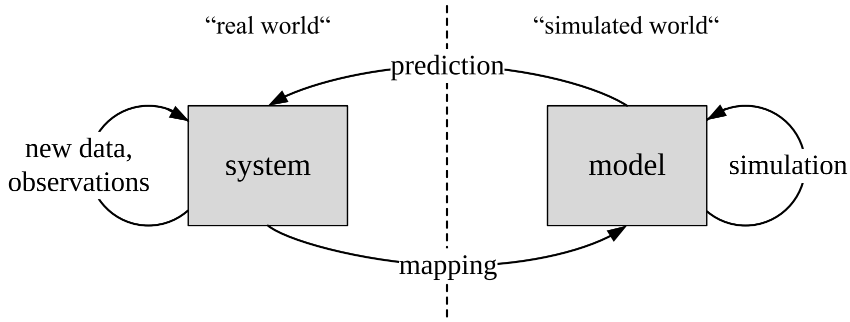

Figure 5: Basic principles of the simulation approach [Klü01]

Although simulation is one of the most frequently used quantitative approaches for solving business problems and supporting business decision making [Pow03], in the past simulation attracts only little attention in the e-commerce domain. Because of the current hype about predictive analytics [LF12] simulation is used in e-commerce more and more for predicting the customer behavior in order to improve advertising performance and return on investment. The first use cases of applying simulation in e-commerce are documented in the literature and demonstrate the power of this approach. Examples include the forecast of viral marketing effects in social networks [HKKD12b], the prediction of customer’s acceptance of different payment portfolios [HKD11, RPK06], or the simulation of online business models for news and music [SG04].

5 Discussion of the Different Approaches

5.1 Controlled Experiments

Controlled experiments are modifications to the existing online shop. Especially in the case of minor modifications controlled experiments can be quickly and simply implemented and provide precise results about the effects of the modifications. But controlled experiments also have some disadvantages restricting the applicability of this approach. The limitations are mentioned below.

- **High implementation costs and effort:** Controlled experiments are modifications of the existing online shop. The variants to be tested have to be implemented at first. This can be a very cost-intensive task, especially if additional online shop components such as new payment methods, recommendation engines, or search engines are tested and external service providers have to be involved in the test. Since the modifications are tested on a large customer base of the online shop, quality assurance measures are necessary which further increases both effort and costs [KLSH09].

- **Critical intervention in the online shop:** Every test variant is a modification of the existing online shop. Because of these interventions the probability of errors during the operational business increases. Moreover, it is possible that the changes cause unwanted side effects.

- **Lack of transferability:** Because of the high individuality of each online shop, the results of controlled experiments can be applied to other online shops only in a very limited way. The high efforts of controlled experiments can therefore not be amortized by multiple usages of the results.

- **Primarily short-term effects analyzable:** The test period of controlled experiments is mostly restricted to a few weeks. This period allows primarily the analysis of short-term effects. The investigation of long-term effects by controlled experiments is very difficult [Qv06].

- **Restrictions by legal regulations:** Because of legal regulations not all possible features can be tested in controlled experiments. In Germany for example it is prescribed that all customers visiting the online shop at the same time can buy the products with the same price. Therefore, it is not possible to test different pricing algorithms in a controlled experiment.

Because of these limitations controlled experiments are primarily used to optimize the storefront layout of online shops, that is, the online shop managers test different colors, positions, forms and sizes of the graphical user interface. Such modifications require only little implementation effort and do not change the core routines of the online shop. Moreover, the effects of such modifications can be measured very precisely by controlled experiments.

5.2 Web Analytics

By means of web analytics it is possible to carefully analyze the behavior of the online shop visitors. Typical questions which can be answered by web analytics are: Which are the most popular search queries? Which are the most visited products? Which are the critical steps during the overall checkout process in which a high number of customers cancel the process? Which payment method is used how often and by which customer group? Moreover, the success of a marketing campaign and the acceptance of the several entrance channels can be analyzed by the origin of the online shop visitors. Web analytics allows therefore a detailed analysis of the actual situation in order to identify weaknesses in the online shop.

However, web analytics allows predictions of future developments only in a very limited way. Based on historical transaction data it is possible to recognize and forecast periodic fluctuations such as seasonal revenue fluctuations. Moreover, long-term developments such as the development of the average shopping cart value or the average returns ratio can be analyzed and predicted if a sufficient amount of historical data is available. But web analytics is not suitable to identify the most appropriate and effective way to address the identified weaknesses. For example, if the online shop manager recognizes that an unusually high number of customers cancel the checkout process if they have to select their payment method, then it can be concluded that the offered payment methods are not accepted by the customers. But there are no indications which payment methods have to be added in order to reduce the abandon rate and how the customers will behave after integrating additional payment methods.

In conclusion, web analytics is a suitable tool for success control and the identification of weaknesses in order to find promising configuration parameters for the online shop optimization. Answering the question of the best solution to overcome the identified weaknesses however is supported by web analytics only in a very limited way.

5.3 Simulation

Simulation as a tool for decision-support has a number of significant benefits compared to the other approaches. In accordance with Robinson [Rob04], the most important advantages are the following.

- **Low costs:** For simulation it is necessary to develop a valid computer model of the real online shop. This is undoubtedly a challenging task involving a certain effort. Nevertheless, the costs are mostly much lower than the costs for the implementation of the test variants of the online shop.

- **No intervention in the real online shop system:** Simulations work on a model. Therefore, different variations can be tested without changing the real system. The availability of the online shop is thus not affected and unwanted side effects are avoided.

- **Forecast of long-term effects:** A simulation experiment enables to speed up the artificial timing. This makes it possible to analyze the effects of changes for weeks, month and years. Consequently, a detailed investigation of long-term effects could be carried out.

- **Replication of results:** With the simulation approach, it is possible to eliminate the influences of constantly changing environmental conditions. This allows testing of various alternatives under identical conditions. The simulation results of these action alternatives are therefore exactly comparable and the optimal solution can be identified.

- **No restrictions because of legal regulations:** The use of simulation is only subject to few legal regulations. Therefore, it is possible to simulate business scenarios which are prohibited in the real world.

However, despite these advantages, simulation is no panacea for all problems of online shop managers. There are some risks that should be taken into account, if simulation is used for decision support. The most important thing is that the results of a simulation study primarily depend on the simulation model. Only with valid models it is possible to obtain valid results that allow correct conclusions. But especially the development of valid simulation models is no easy task. The model development is connected to certain effort, requires sufficient experience, and need a lot of real transaction data for identifying the underlying cause-and-effect relationships as well as for the validation of the simulation model. It is therefore relevant to check whether simulation is a suitable tool to address the given problem [BG97].

Simulations should therefore be used when controlled experiments are not appropriate for the given problem. This is in particular the case if the implementation of the test cases is too expensive or the modifications of the online shop are too critical for the stability of the online shop system. For the analysis of long-term effects simulations are also recommended.

Due to the fact that FSEPs manage much more than one single online shop, there are two additional aspects that will further encourage the use of simulations by FSEPs.

- **Rapid amortization of the development costs:** An existing simulation model can be adapted to another online shop and its specific characteristics by recalibration. In contrast to special simulation studies the development costs of the simulation model can be amortized within a relatively short time, because of the model reuse.

- **Precise simulation models:** A major challenge for every simulation project is the acquisition of suitable data for identifying the underlying cause-and-effect relationships that have to be implemented in the simulation model as well as to validate the model. The high number of managed online shops, that mostly address different customer groups and countries, allows the development of very precise simulation models.

6 Conclusions

Due to the high complexity of online shop systems and the multidimensional dependencies between the configuration parameters of online shops and the corresponding e-commerce ecosystem, configuring an online shop in an optimal way is a challenging task. This requires additional tools to support the decision-making process of online shop managers, especially for full-service e-commerce providers which have to bear any modification costs on their own, before the efforts can be amortized by the additional revenues caused by the modifications.

In addition to classic approaches such as controlled experiments and web analytics, simulation provides a promising way to forecast the effects of online shop modifications and estimate the return on investment for these measures. A simulation works on the mathematical model of the corresponding online shop, so that cost-intensive and critical modifications of the real online shop system can be avoided.

Because of the high number of online shops which are managed by one full-service e-commerce provider and the resulting significant amount of data, it is possible to develop detailed and precise simulation models. Consequently, it is necessary to develop new methods in order to simplify the adoption of such models for the individual online shop instances and the replication of the specific business processes.

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Enhancing dependability through simulations: The example of the German toll system

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Abstract: Users and clients depend on the service provided by a system service provider. Considerable effort can be expended to document the contractual service level and to engineer the service system. Taking the notion of "dependability" [ALRL04] we propose to add simulation models to the service engineering toolset supporting both the ongoing service operations and the software development process. Taking the example of the German toll system and an existing simulation model of its automatic toll collection process we highlight the use and the benefit of simulations.

1 Introduction

Users of software-intensive systems depend on the service providers' ability of running the system continuously and keeping the service offering up-to-date. The service provider is the point where all contributions from the value chain are integrated into a single, working service offering. The challenges are manifold and well-known:

- The system service provider typically specifies and commissions the components required for rendering the service. Yet industry-wide experience shows that a large proportion of IT projects are either cancelled before completion or end up behind schedule and over budget (e.g. starting with the first Chaos report [Stan94]) – the exact figures vary and are disputed (e.g. [Gla06, Ev08]).
- The integration of the various parts into a complete, operational system is the final challenge in developing components for the service system. Many factors impede the integration [Has00]: inter-organizational processes, distributed systems, the heterogeneity of the technology stack and the autonomy of sub-contractors (e.g. with respect to their design decisions and tool selection).

- System operations needs to provide the service continuously – the users and clients depend on it. The dependability ("*the ability to avoid service failures that are more frequent and more severe than is acceptable*", [ALRL04]) of a computing system in the sense of [ALRL04] is composed of the factors availability, reliability, safety, integrity and maintainability (and confidentiality from the point of view of security). These factors have to be addressed by the service provider adequately over the whole lifetime of the service system.

The article takes these three challenges of developing, integrating and operating a service system and puts them into the perspective of existing software engineering practices. Using the V-Modell XT [V-Modell] we explain in section 2 the generation of executable specifications as a possible means of enhancing service quality. Section 3 discusses the particular challenge of operating a service system – typically responsible for the majority of the cost and yet not as well understood as the software engineering discipline. Section 4 briefly looks at the example of the German automatic toll system where a simulation model is used both as executable specification and to predict the day-to-day dynamic behavior of the real-world system.

2 Software Engineering: Building Service Systems

Creating new service systems (or more common: changing existing ones) is inevitably confronted with the challenges known from software engineering – software-intensive systems continue to grow in size (software evolution [Leh80]) and encompass ever more endpoints [CDKB11].

Starting with the emergence of the "software crisis" many software development process models have been suggested, starting with the (now infamous) waterfall model [Roy70]. All models try to organize the creative work necessary to deliver a software(-intensive) system fitting the customers' requirements. We take the "V-Modell XT" (XT as "extreme tailoring", [V-Modell]) as a starting point to highlight the difficulties of building a distributed service system that adheres to a defined quality level.

Looking at fig. 1 the basic idea of the system development is a series of steps (each ending with a decision gate) first to specify and partition the development work (fig. 1. left hand side) and then to implement and integrate the system (fig. 1 right hand side). In addition to older models at every design level verification and validation is explicitly ensured (horizontal arrows, fig. 1). However, the connection between the various phases is typically made through documentation [RBTK05] – exposing the model in principle to the same criticism as the original waterfall model [Pom06]. The typical reaction is allowing to reduce the time spent between the first phase (e.g. requirements definition) and the product delivery e.g. by introducing iterations (spiral model [Boe88]) or even short "sprints" (in "agile" models [TN86]).

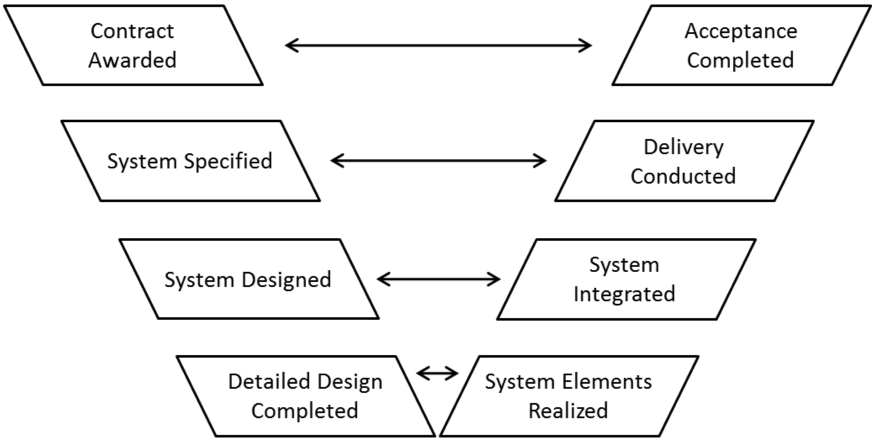

Figure 1: Verification and validation in the V-Modell XT system development structure (based on fig. 16 in [V-Modell]).

However, there remain two important questions from the point of view of the system service provider:

- Which tasks cannot be transferred to a second party? The providers' core competency during the system development is to select the right development model and to identify those steps that cannot be transferred to a second party.
- How to ensure the service quality upon completion? All development processes are prone to deliver the 'wrong' system: Requirements changed in the meantime, were incomplete (or not understood correctly) and the any software contains the occasional error.

2.1 The role of the system service provider

Although the waterfall approach is still visible in the "V" of the V-Modell (fig. 1) the development approach is much more evolved: There are many additional steps surrounding the system development starting with project approval and ending with a completed project. Looking at these decision gates (fig. 2), system development starts with a project approval and subsequent project definition followed by the definition of requirements. The system development may take place in a different organization (necessitating the acquisition and management of a supplier). Obviously, the setup of the system development process needs to be defined (i.e. broken up into partitions and iterations), scheduled, monitored and revised during the projects' lifetime.

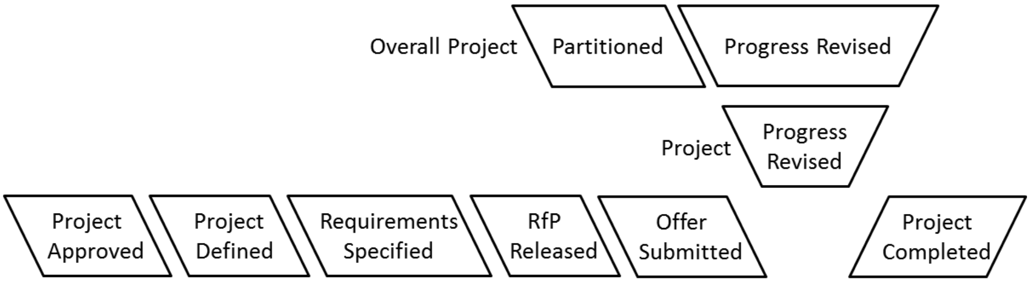

Figure 2: Decision points of the V-Modell XT (based on fig. 8 in [V-Modell]) beyond the system development iteration (which occurs in iterations after the decision gate "offer submitted" and before "project completed").

Using the V-Modell decision gates, the core tasks of the system service provider is the management of the system development process: Even if the development is done in a different organization (or several ones) the responsibility for the project (i.e. approval, definition and completion) rests with the system service provider as well as the partitioning and tracking of the overall project (upper layers in fig. 2).

A particular challenge is the specification of the requirements. Using the words of B. Boehm [Boe81], the success of the system development is measured according to the question "Are we building the product right?" (i.e. verification), yet the service system must answer to the question "Are we building the right product?" (i.e. validation). In that sense the responsibility to validate the system and to verify the implementation resides with the system service provider. Validating the service system is non-trivial since many requirements are not documented well, change during the project lifetime or concern non-functional or emergent properties of the system.

2.2 Improving the system development process through simulations

The system service providers' challenge is to know and to channel the requirements – functional requirements (defining the systems' tasks and behavior) and non-functional ones. Yet we do not have an unambiguous definition of the term 'non-functional requirements' [Gli07] and the dynamic behavior of distributed systems often emerges only at runtime (i.e. involving the real-world system and its users).

Figure 3: Process Improvement as integral part of the V-Modell XT (based on fig. 8 in [V-Modell]).

To improve the system development we introduce modeling and simulation technologies during the whole product lifecycle: At any given time an executable model exists and captures the current knowledge of the whole system. Looking at fig. 2 the requirements are immediately expressed as a model sufficiently concise to be executable – the projects' success can at any time measured in terms of the simulation results. In fact the solution architecture (e.g. the partitioning of the system into subsystems) is included in the executable and the developers of subsystems use the simulation model as a specification of the interface and the non-functional requirements (e.g. availability, processing speed but also system limitations).

With simulation driven development (SDD, whose foundation we defined in [BPJ12]) the erstwhile document-centric verification and validation steps in the development process (fig. 1) can be fully automated using the proposed executable specification. During the system development the simulation model serves as integrating component, i.e. subsystems are tested against the simulation model of the whole system – or even integrated into the simulation model (software/hardware in the loop, [SZ13]).

The executable specification used in the SDD approach is not limited to the technical system. It can (and should) encompass a model of the user interaction (a necessity in socio-technical systems) and can also include the development process itself. Looking again at the V-Modell we see that the typical stand-alone improvement loop (fig. 3) is also included as an ongoing process: Analyzing the process model, defining and implementing improvements. In the same manner the complete development process can be part of the executable specification allowing to automate many of the design steps ([Bau09], in a formal, consistent way, automatically validated by the simulation model).

3 Operating Service Systems: Dependability

Operating service systems is the challenge that remains on software engineering delivered the service system. As argued in section 2, the requirements are by no means obvious, especially the non-functional ones and the ones depending on the user interaction. In many respects a good starting point is the definition of dependability [ALRL04]: "*the ability to deliver service that can justifiably be trusted*". This contrasts with a typical characterization of a distributed system: "*A distributed system is one in which the failure of a computer you didn't even know existed can render your own computer unusable.*" [Lam87]. The core competency of the system service provider beyond implementing a system service is the day-to-day service operations: Users and clients depend on the service.

Following [ALRL04] dependability encompasses the factors availability, reliability, safety, integrity and maintainability (and confidentiality from the point of view of security). While these factors are generic terms the consequences for a service system can be technical or organizational: The organizational capabilities e.g. the management system (e.g. ISO 9001, ITIL, Cobit, and ISO 27000) and their maturity contribute (e.g. to ensure the security of the system). Of course, the technical implementation of the service system dominates many of the factors typically as a non-functional requirement. These are also captured by the simulation model detailed in section 2:

- The availability ("*readiness for correct service*", [ALRL04]) and reliability ("*continuity of correct service*", [ALRL04]) depends on the system architecture chosen. Especially in a situation with very high system load the dynamic behavior is very difficult to predict (and expensive to test and operate). Simulation models allow probing the system behavior close to the design specification.
- Safety ("*absence of catastrophic consequences on the user and the environment*", [ALRL04]) can be ensured by hardware-in-the-loop and software-in-the-loop tests at any time.
- The integrity ("*absence of improper system alterations*", [ALRL04]) can be interpreted both as technical alterations (e.g. due to different interpretations of a given system interface by the subsystems implementing it) or intentional (e.g. people interfering with the system). In the first case, the executable specification allows both sides of a given system interface to test and integrate against the simulation model – one-sided misinterpretations no longer occur.
- Most notably, maintainability ("*ability to undergo modifications, and repairs*", [ALRL04]) is a factor contributing to the dependability of a system: Software evolution is a fact of life. Of course, once SDD is established, changing the system is at any time validated against the real-world dynamic system behavior.

4 A simulation model of the German automatic toll system

Looking at the German toll system for heavy goods vehicles, the operator Toll Collect GmbH can be seen as the system service provider: As the operator of the system Toll Collect offers the tolling service and coordinates the value chain necessary to run and change the technical system.

Taking the ideas presented in section 2 and three we proceeded to introduce SDD techniques to the system development process of the operator of the German toll system. In previous work [PBJ12, PBJ13] we have implemented a high-performance realistic discrete event simulation model of the automatic German toll system. The simulation includes the vehicle fleet (of 750 000 on-board units) and their driving patterns, the mobile data networks and the terminating systems in the data center collecting the tolls and providing updates to the software, geo and tariff data.

The simulation model includes all major technical processes running at time scales of one second and above and some at considerably shorter time scale (e.g. connection authentication). A typical simulation run is performed to simulate several months and up to a year (taking less than 12 hours on a single CPU, [BPJ12]) and is calibrated with the real-world data observed in 2012. This calibrated simulation model is in turn used to predict the dynamic behavior of the system (either for future planned operating conditions or to scope "What-if"-scenarios). In that way some aspects of availability and reliability (cf. section 3) are addressed.

Having developed and validated the simulation model we can apply it to ensure the systems' maintainability ("*ability to undergo modifications, and repairs*", [ALRL04]) – i.e. using it as an executable specification in the system development. We first introduced SDD in the early design of an upcoming change to the system architecture: Changing from an open-loop controller (the focus of control typically resides with the OBU) to a closed-loop controller (the central system is the focus of control).

In the example 4 different application-level protocols between OBU and data center were suggested (initially as a mixture of UML diagrams and a textual description). The main task resolved through SDD was to measure the impact of the different protocols on the overall system behavior (e.g. the time needed to deploy fleet-wide updates or the load generated in the data center or the mobile data network). Making the specification executable lifted the precision of the specification document and allowed a direct comparison of the alternatives – using a model at a scale of 1:1 with realistic user interaction. In the end this allowed the selection of one particular protocol and a prediction of the network and server load generated. However, so far the solution has not yet proceeded to the implementation stage (where the simulation model would at least need to implement the correct sub-system interfaces).

5 Conclusions and Outlook

Today, users and clients depend upon many software-intensive services. Using the term dependability we have argued that the success is determined by the system service providers' "*ability to deliver service that can justifiably be trusted*" [ALRL04] – necessitating that some core tasks remain with the system service provider (e.g. specifying the requirements, setting up projects and managing suppliers). In its current form, software engineering and system operations are not yet up to the challenge posed by distributed service systems. Using the Toll Collect example we showed that executable specifications (i.e. simulation models at the appropriate level of detail) are a way forward to improve system development and operations.

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Towards a maturity assessment of service business development by manufacturers. A framework

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Abstract: Previous research and anecdotal evidence suggest that manufacturers undertaking the path towards service business development (also named as "servitization" or "solution offering") face several challenges, that may generate inconsistencies, e.g. among strategic intentions and internal organizational arrangements and even more with external elements. However, it is quite common that companies approach the transformation into service providers with no formalized and systematic perspective. Therefore, Maturity Models can be helpful tools to companies in assessing their move towards service business development, to provide guidelines and identifying inconsistencies. A preliminary study led to development of maturity model for New Service development for product-centric companies: the main findings are reported in this paper.

1 Service business development by manufacturers

Several manufacturing companies are shifting from being pure manufacturers to offering solutions and services, often delivered through their products or in association with them (Neely, 2008). The transition entails the breadth and complexity of the product and service offer to expand. The shift towards providing solutions is linked to moving downstream in the value chain via various customer activities (Wise & Baumgartner, 1999). Service offerings development follows a typical cumulative evolution, where manufacturers progressively add services to their product offerings (Oliva and Kallenberg, 2003):

1. First, manufacturers add **services supporting the sales phase.** These are meant to augment the product offering, through additional information, documentation, and to allow simplified forms of payment (financial services). Financial services can also enable non-ownership ways of transferring the product to customers, e.g. through rental or pay-per-use agreements

2. Then, **after-sales services** are introduced, aimed to support the installed base. Basic services such as reactive maintenance or spare parts supply allow to re-establish the product functionality, are reactive and can be provided in a transactional way to customers. Advanced after-sales services, such as product support contracts, preventive maintenance, remote and condition-

based monitoring are instead proactive, aimed to avoid product breakdowns, and relational in nature, relying on medium-long term agreements.

3, Next, **design and construction services** support the pre-sales activities, and consist in customizing the product and the service offer to match individual customer needs. They may also involve customer activities, through e.g. consultancy services that improve the customer's production processes.

4. Finally, **outsourcing services** correspond to the step in which the manufacturer takes over customer-related activities, such as operating and maintaining the product. This can be linked to result-oriented contractual agreements, such as pay-per-output or pay-per-performance.

1.1 Challenges in service business development

Moving from products to solutions extends the existing set of operational capabilities through which companies earn their living by providing products, services or solutions (Fischer et al., 2010). In order to be successful, companies have to develop capabilities in order to develop, sell and deliver services (service-oriented capabilities) and then integrate these services into customer-specific solutions (integration capabilities). The former includes establishing a service culture (Bowen, Siehl & Schneider, 1989) which, in turn, lays the foundation for increasing the degree of service orientation in the management of human resources and, more specifically, in the recruitment, development and assessment/compensation of personnel (Homburg, Günther & Fassnacht, 2003). Necessary competence in human resources includes the technical expertise to deliver repairing, inspection and maintenance services as well as to provide design & construction services. Technical expertise needs to be supplemented with a customer-orientated attitude. This involves listening and communication skills, which are essential when, for example, adapting maintenance services to the specific operational needs of customers (Neu & Brown, 2005).

Besides the development of capabilities (Paiola et al., 2013), the literature has highlighted a several challenges related to the service business development (Braax, 2005; Gebauer et al, 2005). Through a literature review (Alghisi and Saccani, 2013), we pointed out 16 major challenges for successful service business development, as reported in Figure 1.

Categories of challenges	*(Salonen, 2011)*	*(Johansson et al., 2003)*	*(Mattsson, 1973)*	*(Page & Siemplenski, 1983)*	*(Fang et al. 2008)*	*(Turunen and Neely, 2012)*	*(Baines et al. 2010)*	*(Neely, 2009)*	*(Gebauer et al. 2005)*	*(Martinez et al. 2009)*	*(Slack, 2005)*	*(Mathieu, 2001)*	*(Davies, 2006)*	*(Kindstrom, 2010)*	*(Lei et al. 2004)*	*(Baines et al. 2009)*	*(Brax, 2005)*	*(Lakemond & Windahl, 2006)*	*(Oliva & Kallenberg, 2003)*	*(Oliva et al. 2012)*	*(Paiola et al. 2012)*
Cultural readiness	✓	✓			✓			✓	✓	✓		✓	✓						✓		
Commitment & Leadership									✓												
Customer/Supplier interface capabilities		✓																			
Scalability			✓	✓																	
Risks					✓		✓				✓								✓		
Strategic vision					✓																
Critical mass					✓																
Integration practices						✓				✓							✓	✓	✓		
Capabilities and formalisation of New Service Development Process						✓		✓		✓	✓						✓				
Timescale								✓													
Organizational readiness (hierarchy, interfunctional cooperation)								✓						✓		✓		✓	✓	✓	
Coproduction									✓								✓				
Service and integration capabilities										✓											
Communication & training												✓				✓	✓				
Good-intensive brand															✓						
Supplier competition																					✓

Figure 1: Summary of main challenges for manufacturers (from Alghisi and Saccani, 2013)

They have been further grouped into five dimensions: strategy, offering, company (internal dimensions), service network and customers (external dimensions), as reported in Table 1.

Dimension	**Challenge**	**Description**
Strategy	Commitment & Leadership	An increased managerial service awareness and commitment at the top management level is needed to lead a change in the service awareness of employees
	Strategic vision	Adopting a service transition strategy may involve sacrificing the level of resource inputs to the core product and manufacturing competencies of manufacturer
	Product-relatedness of the firm’s brand	A very strong goods-intensive brand might become an obstacle in introducing successful brand extensions moving toward the service area

Dimension	Challenge	Description
Offering	Scalability	Through product modularization and standardization solution providers must learn to build solutions that are scalable
	Critical mass	Service transition strategies typically require building a critical mass in sales, estimated to be 20%–30%, before they can expect positive effects on firm value
	Capabilities and formalisation of New Service Development Process	The design of services is significantly different to the design products. New (service development) capabilities in are needed to successfully implement a service transition strategy
	Timescale	Multi-year partnerships and long-term risk and exposure have to be managed
Company	Cultural readiness	A cultural change for a product-centred organization is needed to become service-oriented
	Risk management	If not adequately managed, offering of product-service systems leads to increasing (financial) risks for the manufacturer
	Organizational readiness (hierarchy, inter-functional cooperation)	Due to differences between products and services shifting from traditional to servitized manufacturer requires significant organizational changes in language, values, design process, and organization design
	Communication & training	Due to the nature of services, proper communication and learning practices are needed to clearly describe to customers and service network partners the advantages of servitized offers
Customers / customer interface	Cultural readiness	Even customers need to change their mindsets, asking for (and willing to pay) services rather than looking for products
	Customer interface capabilities	Capabilities at the customer interface are needed in order to understand the customer's broader business needs and operating environment

Dimension	Challenge	Description
	Integration practices	Adopting a service transition strategy require a higher degree of integration among the actors of the value chain. The provision of an integrat-ed offering requires information and know-how intensive exchange with the customer
	Coproduction	Services require motivating the customer to the service co-production
Service network	Cultural readiness	Suppliers (e.g. delivering service components of the offering to the customer) should follow the cultural evolution of the manufacturer
	Integration practices	A greater degree of cooperation between a provider and its supporting network is required to provide advanced services
	Supplier interface capabilities	Capabilities at the supplier interface are needed to allow for greater integration, and to support the organizational change of supplier
	Supplier competition	Extending the service offering may lead manu-facturers to enter in competition with service network partners that already offer services to customers

Table 2: Classification of challenges in service business development (from Alghisi and Saccani, 2013)

2 Towards a maturity assessment of service business development

2.1 Maturity models

Maturity models can be viewed as staged roadmaps for assessing the capabilities of a firm/organization with respect to a definite management domain, in order to set out directions for improvement (Becker, Knackstedt, & Pöppelbuß, 2009). The basic idea behind maturity models is that higher levels of maturity testify increased capabilities in managing the specific do-main/process. One of the most influential maturity models is the Capability-Maturity Model (CMM), proposed by SEI (Software Engineering Institute) at Carnegie Mellon (Paulk, Curtis, Chrissis, & Weber, 1993). Maturity models have been applied to several management domains such as: business process management, inventory management, supply chain management, New Product Development, R&D projects, project management and quality management. However, to the best of our knowledge no model to assess the maturity of the service business development of manufacturers has been developed yet. The only partial exception is a maturity model for New Service Development (NSD) by "product centric firms", proposed by Rapaccini et al. (2013). It will be briefly described hereafter.

2.2 Maturity levels for New service development (NSD)

The maturity of a firm in managing NSD processes can be associated to five levels (Rapccini et al, 2013).

Level 1 (Initial state). NSD projects are run as ad-hoc and chaotic initiatives. The organization does not have a stable environment to support NSD projects, neither tools nor specific resources. The outcomes of NSD projects depend on the individual competences and heroics of people, rather than on proven management practices. The implications of new ser-vices are poorly addressed.

Level 2 (Repeatable). In this stage, the NSD processes are not carried out according to established guidelines, neither there is a common understanding of how a service should be designed and engineered. NSD projects are poorly managed and may lack robustness in the execution of some phases. By intuition and lessons-learned from past experiences, few key-elements (e.g. data collection from market analysis, involvement of stakeholders) are identified and repeated project after project. Nevertheless, a systematic perspective is lacking.

Level 3 (Defined). In this stage, NSD projects are planned and run according to documented and approved schema. Exceptions are necessarily justified. Nevertheless, neither good practices nor adequate resources or tools are adopted, in comparison to other innovation do-main (such as New Product Development or process technologies). Key-competences for successful NSD are not totally exploited, and the understanding of contextual internal or external variables is still limited. As a consequence, processes are not totally under control, and the outcomes of NSD projects are not predictable.

Level 4 (Managed). In this stage, NSD projects are managed with the use of specific competences and best practices. Each project is planned according to a standard framework that has been tailored to embrace the specific needs of the firm. Commitment by senior management supports NSD projects, as well as investments for introducing Service Engineering methods. Resources are trained to improve NSD skills. This way, the NSD process is systematically managed and controlled. Unfortunately, even if predictable results can be produced, they may be insufficient to achieve the established objectives, especially if markets continuously require an improvement in the service performance of the firm.

Level 5 (Optimized). In this stage, the organization is able to continually improve its NSD processes, through the full understanding of the relationships among the elements constituting the process. There is an explicit strategy to improve NSD performances through incremental and/or radical innovation of processes, technologies and resources.

2.3 An application

The company object of the study is a leading multinational firm operating in the professional printing sector (e.g. printers, wide format printers, professional plotters, etc). The company sells also accessorial products/services, such as media that can be printed on, packaged and custom software for production printing processes and document management, consulting services, maintenance services and financial services.

The company operates through its own direct sales and service organizations in more than 30 countries and employs more than 22,000 people worldwide. Its total revenue in 2010 amounted to over € 2,500 million. In particular, our unit of analysis is the subsidiary that is responsible for the business over the Italian market. Two ongoing NSD projects were analyzed. The first one concerned the reduction of on-site visits by technicians. The project was at an advanced stage, with already defined call handling procedures and performance measures. The second project was broader and ill-defined, and at a very early stage: the objective was to increase the service revenue of the company by "servitization" initiatives. Although not a specific NSD project, it entailed a discussion on how to translate strategic objectives into specific new service ideas and development plans. An evaluation of the maturity level of the NSD processes in the case company B is illustrated in Table 2 (see also Rapaccini et al., 2013).

	ELEMENT	**Case company**
ORGANISATIONAL APPROACH	Internal relevance of NSD	Company B learned to act as a solution provider: products are bundled with services or sold as part of an integrated solution. Nevertheless, innovation is mostly driven by product technological developments: *"Even if services are an important part of the overall business, each subsidiary differs in terms of commitment, deeds and efforts related to new service development"*(Service Director).
	Roles	NSD is approached through project-based cross-functional teams that collaborate in order to achieve the project objectives: *"People from product marketing work together with the product manager that is responsible of a given solution or market, in order to accomplish (the project related to) the development of a new solution. But locally the skills for developing new services are actually provided by people from product services."*
	Management practices	Basic project management techniques. Projects are planned on a case-by-case basis, according to complexity, organizational impacts and specific needs.
RESOURCES	Budget	Resources for NSD are budgeted within the overall budget of the Service Unit, and negotiated with the country manager. According to the service director *"in the last years, the budget granted for NSD activities has been sufficient to cover our needs".*
	Tools and methods	Neither specific methods nor tools are used for Service Development, "*each project manager develops its own spreadsheets and tools to perform scenario analysis and cost assessment, and to blueprint and communicate the ways new services should be delivered*".

	ELEMENT	Case company
	Skills	Attention is devoted to procure resources and deploy a training program in service marketing at a corporate level. *"Since two years, in the wide-format headquarter staff we appointed a service marketing manager and started a training program. I believe that this will be extended to other product segments in the near future".*
STAKEHOLDERS	Customers	Important customers are partners in the design of new solutions: *"We work in close partnership with our large account customers, our sales force and product managers continually visit them and they get involved in the design of tailored solutions to their emergent needs".*
	Other stakeholders (internal and external)	Suppliers of critical technologies are involved: *"Few strategic suppliers of critical parts - such as a leading multinational companies producing finishing solutions for digital printing - participate to the development of new services and support our projects with their expertise".*
PERFORMANCE MANAGE-MENT	Feedback systems (satisfaction, ac-ceptance and impact of new services)	Structured feedbacks are collected: *"We gather a lot of information about quality and customer satisfaction of our services".*
	KPIs	KPIs are measured at an aggregate level: *"We use a very complex KPIs dashboard to assess our performances, but it is quite difficult to identify the impact of new services in the short time".*

Table 2: Maturity assessment for the case company (from Rapaccini et al., 2013)

The case company has a structured approaches to NSD, although several gaps with respect to the most advanced maturity levels were identified. The company, in summary, has with an established Defined Stage in the organizational and stakeholders related factors. Tools and methods are, instead, the most neglected areas of intervention.

3 Conclusions

Previous research and anecdotal evidence suggest that manufacturers undertaking the path towards service business development (also named as "servitization" or "solution offering") face several challenges, that may generate inconsistencies, e.g among strategic intentions and internal organizational arrangements and even more with external elements, concerning both customers and service network. However, it is quite common that companies approach the transformation into service providers with no formalized and systematic perspective. Therefore, Maturity Models can be helpful tools to companies in assessing their move towards service business development, to provide guidelines and identifying inconsistencies.

A preliminary study led to development of maturity model for New Service development for product-centric companies (Rapaccini et al., 2013). The research findings suggest that such a model can be a powerful tool to assess the as-is situation in each of the four dimensions included in the model. Therefore, the model can support internal or external evaluation of NSD practices for descriptive purposes. Even if the model has little normative power, it can favor the identification and prioritization of the improvement actions, as emerged in the ex-post interviews. Moreover, the model can be helpful for benchmarking different companies.

Next steps of the research will extend the perspective towards the whole service business development by manufacturers, from single service development.

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A Use Case-driven Approach to the Design of Service Support Systems: Making Use of Semantic Technologies

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Abstract: A technical customer service technician has to fulfill a wide range of tasks at the point of service in a short time. Mobile devices can be used to support the everyday work while increasing the productivity and the empowerment of the Technical Customer Service (TCS). To increase the productivity appropriate information technology (IT) support is needed. Unfortunately, the development of such systems underlies complicated and complex conditions since diverse requirements need to be considered. Towards this, we provide an ontology to represent the domain of mobile TCS and supporting IT-systems. Use cases build the cornerstone of our attempt to reduce the complexity in order to design adequate TCS support systems. The prototypical implementation of the results in an integration platform provides flexible support for the service technician.

1 Introduction

A technical customer service technician is partially at the operating station or console of the machine or at the machinery itself and needs locally current information about the state of the system at the point of service, documentation and order data for his work [BNST08][Walt09]. He needs to be able to act in an autonomous way. Compared to other areas of a company the support service is the most time-consuming activity in the (TCS) [Harm99]. In addition, the TCS is considered as an interface between manufacturer and customer so that the information base must also include customer data [DeWB09, p. 156]. Product-related information is needed as well as customer information. Therefore, information can be declared as a fundamental component for the performance of a service process. For this reason, the usage of information systems (IS) is a critical success factor to provide the TCS employees with the required information for high-quality service delivery [RaMB05, p. 626]. The activities of the employees require in-depth knowledge, skills and sufficient IT-support to cope with the wide range of tasks. Information needs of the TCS causes that there is the necessity to integrate appropriate IS to support the operation and the staff efficiently. Proactive information provision is especially in TCS processes important as a large variety of information and data exist that are either needed for a service process or that result from them. For ensuring the competitiveness and quality of the service, it is important to structure and process the existing data. Knowledge and information as a key competitive factor need appropriate IS. Mobile devices are the key to increase productivity and empowerment of TCS.

One issue that arises in this context is the complexity of the systems. The complexity emerges by a wide range of solution components. Mobile technologies as well as enterprise data and measurement procedures need to be available in a single supporting system to improve the service technician's work. The more systems are involved and used for one task the more interdependencies occur between the components that have to be considered. Hence, an appropriate IT infrastructure is necessary to meet the demands of the growing data.

To solve the complexity problem, we attempt to define a mobile technical customer support system by identifying key concepts of the TCS and provide a structure to describe them in an integrated way. The main objective of this work is to constitute how to make the complexity of TCS processes manageable by providing a systematic structure for restricting the solution space and to handle the complexity.

In this contribution we present results of a joint research project with the aim to improve the efficiency of service technicians by intelligent mobile assistant systems. Therefore, we give an integrated overview how a concept of mobile TCS support system need to be designed and specified to increase productivity and empowerment in the TCS. In section 2 the concept of ontologies is presented and we classify an ontology scheme for mobile TCS support systems exemplified by the research project with focus on the information integration of the TCS. Section 3 introduces use cases as focal point of TCS support systems. Here, use cases are specified that are representative for activities in TCS processes. Subsequently, the evaluation of ontology-based use cases is discussed in section 4. A prototypical implementation of the specified use cases gives an overview on practical application. The last section 5 concludes our approach.

2 Ontology Design and Population

2.1 Ontology Schema

The most quoted definition by the ontology community states that an *ontology* is a formal, explicit specification of a conceptualization [Grub93, p. 199]. By conceptualization an abstract view of the world, that should be represented with the ontology, is meant [Grub93, p. 199]. As a consequence, ontologies can be used to describe a certain domain. Referred to the current case, ontology intends to represent the domain of the mobile TCS and supporting IT-systems for improving the productivity and empowerment. Newer definitions of the term ontology include the aspect of a shared conceptualization, i. e. the usage of an ontology originated from vocabulary of various individuals through a group [GoCF03, p. 8][StBF98, p. 184]. According to this point of view, the developed ontology should be used as a communication basis for the involved actors like the TCS departments and the people responsible for the IT implementation. Therefore, a communication medium (Semantic Media Wiki) was set up, which will be further discussed in section 2.2. By developing the *Mobile TCS Support Ontology* the six steps (identify purpose, capture, coding, integrating, evaluation and documentation) suggested by Uschold and King [UsKi95, p. 2] were followed, resulting in a complex ontology with plenty of elements. During the project work it turned out that the ontology was too extensive, particularly for implementing the IT-systems. Hence, the ontology was simplified and resulted as shown in Figure 1.

The *Use Case* is the nexus of the Mobile TCS Support Ontology, i. e. the central concept. Referring to Cockburn [Cock01, p. 15], a *Use Case* is understood as a batch for various *System Functions* which is accomplished from an actor in a specific sequence, related to a particular goal (compare section 3). To reach this goal, the *Subfunctions* of a *Use Case* have to be executed with the help of IT such as mobile devices with particular *Features* like a particular user-interface or sensor techniques. Regarding the data flow, input data, used by the *System Function*, as well as output data, produced after having executed a *Use Case*, is considered. This *Data* is stored in an *Application System*. *Use Cases* support *Activities* which are performed by *Organizational Units*. In fact that the *Activities* might have *Subactivities* or trigger the next *Activity*, a hierarchy is considered. The *Activities* are linked with *Productivity Metrics* that are calculated with certain *Measuring Methods*. Those metrics include productivity indicators to verify specified productivity goals.

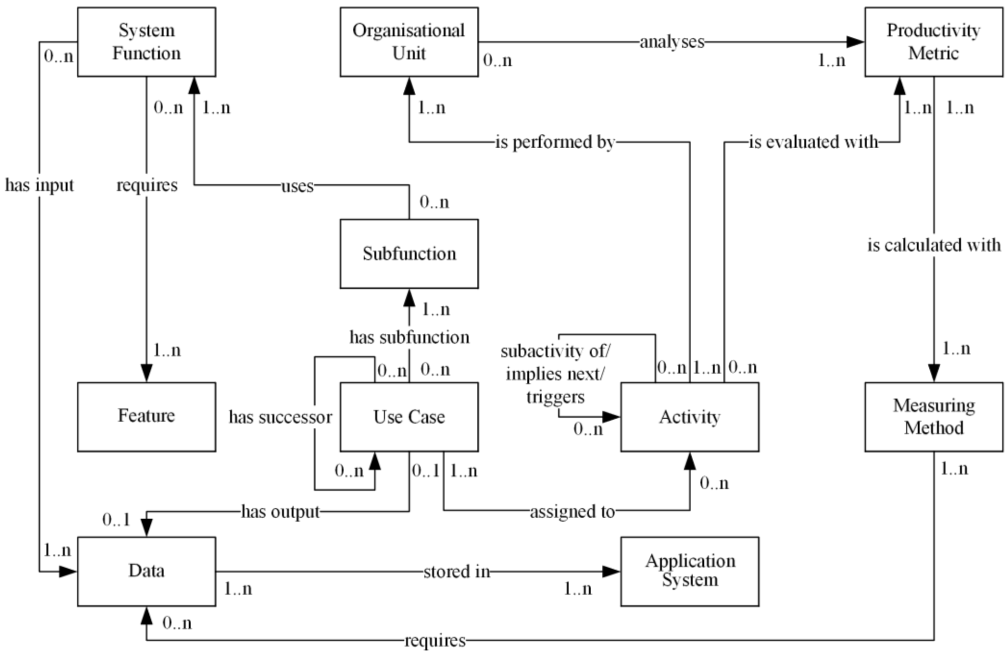

Figure 1: Mobile TCS Support Ontology

2.2 Population of the Ontology

To instantiate the TCS Support Ontology as described above, a Semantic Media Wiki (SMW) was set up. The widespread Semantic Media Wiki (semantic-mediawiki.org) is built upon the wiki-engine which gained popularity by Wikipedia [KrVV06, p. 935]. Semantic Wikis expand the flexibility of editing data of a normal Wiki on structured data, providing meta data for annotating semantic information and linking pages [SBBK09, p. 246].

For realizing an ontology as a shared conceptualization, the SMW was implemented because of its possibility to discuss the ontology components with all involved actors. Due to semantically specified links and categories, the covered knowledge in the Wiki can be effectively managed and accessed via embedded page requests (inline queries). These links, so called attributes in the Wiki, were established to represent the *Relations* of the ontology. They can be used to switch easily between the Wiki pages. These Wiki pages represent the *instances* of the ontology which are assigned to particular categories. The *Concepts* were implemented as Category Pages. An extract of the resulted Semantic Media Wiki is given in Figure 2.

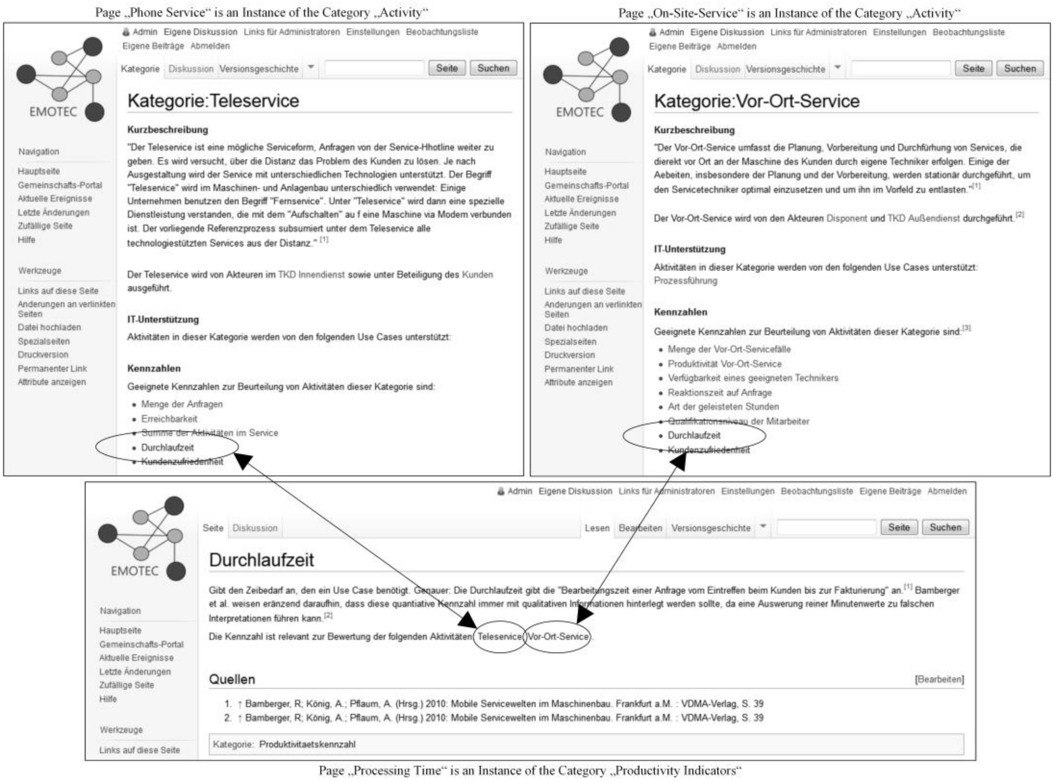

Figure 2: Project-specific SMW for the TCS

Implementing the linkage, a bidirectional concept was chosen, i. e. one link was explicitly coded and the other one was generated via query. For example, the page *On-Site-Service* (X) and the page *Phone Support* (Y) of the category *Activity* (A) were implemented as well as the page *Response Time* (Z) of the category *Productivity Indicators* (B). The linkage on page *On-Site-Service* and *Telephone Support* were set manually to [[A-to-B::Z]]. On page *Response Time* the inline query {{#ask:[[A-to-B::Y]]}} is used to automatically print out a list of all instances of the *Activities*, who are linked to this page, such as *On-Site-Service* and *Telephone Support*. Thus, the semantic consistency is guaranteed. For more structured information such as the template we used to describe use cases (compare section 3), we embedded *info boxes* inside the pages which we generated in conjunction with the template mechanism (due to space limitations, we cannot go into detail here).

Finally, a project-specific instantiation of the ontology was implemented. Hence, a source of reference and a documentation tool are provided for designing a TCS Support System. Basically all of the stated components of the ontology are important; however, it became apparent that the *Use Case* plays a central role in the ontology since they are intertwined with the other concepts of the ontology.

3 Use Cases as the Focal Point of TCS Support Systems

Use cases as essential element of the defined ontology, are a common technique for describing functional requirements of systems [Cock00, p. 16]. For this purpose the considered system is decomposed into different interaction scenarios that combined resemble the systems functionality [Lübk06]. Through use cases a complete course of interaction between an actor and the appropriate system can be constituted [CoLo01, p. 246]. Their design provides furthermore a basis for precise requirement documents [FeHa97, p. 121]. To achieve the aim the actor triggers an interaction with a system that responds to the request of the actor. Depending on what special kind of request occurs and under which conditions this happens, different scenarios arise. Though, a use case describes how a system interacts, it doesn't show how the result is achieved but how the actors achieve sub-goals. For a structured description of use cases a template can be helpful [Cock00, p. 14]. Through the design of use cases various situations can be bundled that emerge if an actor tries to reach his aim with the considered system. In this context all options are mentioned that might appear while pursuing the objective.

3.1 Identification of the Use Cases

In order to design a service support system for the TCS system-specific various requirements need to be considered that emerge during a TCS process [FKRM12, p. 126]. Therefor we identified 16 use cases (Table 1).

Nr.	*Title*
1	Contact management
2	Work scheduling
3	Mobile order entry
4	Place orders and offers
5	Process guidance
6	Proactive information provision
7	Scanning data
8	Information retrieval
9	Retrieve information object
10	Provide feedback
11	Create documentation
12	Management of the knowledge database
13	Management of warranty claims
14	Management complaints and returns
15	productivity management
16	Data analysis

Table 1: Identified Use Cases

The presented use cases have been identified in two different research methods. In a first step service technicians have been observed in their daily work and their usage of mobile TCS support systems. The result of the observation during service process executions is complemented by a literature study on requirements for mobile systems and the application of those in the TCS. Integral part here was a reference model for technical support published by the German Engineering Federation ("Verband Deutscher Maschinen- und Anlagenbau" (VDMA)) [Vdma08, p. 8]. The identified requirements of the two resources combined present a selection of different TCS use cases that can be supported by mobile information technology. They are not subject to a chronological sequence but some can depend on each other [Jaco03, p. 11]. *Contact management* is the first use case and provides communication media to communicate the necessity of a service activity. Within the *Work scheduling* service orders are integrated into work plans for the service technicians. The use case *Mobile order entry* allows the service technicians to create service requests with the mobile system while the *Place orders and offers* enables the creation of orders and offers with the mobile system. The *Process guidance* supports the operating service technician during the service process by providing additional information. An automatically data provision with material for the task execution by a mobile system can be found in the *Proactive information provision*. The activities of the use case *Scanning data* contain the automated detection of signals and data the service technician has access to. With the *Information retrieval* information search is systemized by additional instruments such as feature hierarchies. The return of the representation of information objects is identified in the use case *Retrieve information object*. Collected comments and notes during service activities are given back to the service center within the use case *Provide feedback*. *Create documentation* provides patterns in the mobile system for the documentation of the work and to bring it to close a bill can be created directly after the service order has been completed. *Management of the knowledge database* keeps the user-generated content up to date by summarizing or aggregating the data of the service activities. The use cases *Management of warranty* claims as well as *Management of complaints and returns* comprises the handling of warranties and complaints. The *Productivity management* provides methods and measures to check productivity of the service processes. With the last use case *Data analysis* operative data is analyzed by the system of the TCS.

3.2 Structured Use Case Description

Use cases underlie no specific rules in their appearance. They are written in free text [Lübk06, S. 138]. The use cases here are documented using the template provided by Cockburn [Cock00, p. 65]. The introduced template is often quoted and is widespread in the use case topic [CoLo01, p. 245]. Our template is adapted according to the context of the considered research project (Table 2).

Field name	*Description*
Number	Sequential number of the use case
Name	Designation of the use case
Brief description	Concise description
Phase in the service	Status of the project
Primary actor	Operator / target subject
Participant	Other participants
Pre-condition	Condition
Trigger	Trigger function
Post-condition	Ex-post condition
Activities	Contained functions
Input data	Required data
Output data	Generated data
Data source	Origin of the data

Table 2: Use Case Template

A practical form with less abstract variables is chosen to ensure a fast application. It contains beside identifiers such as *Number*, *Name* and a *Brief description*, an assignment to the *Phase in the service process*. This enables to draw a conclusion in a wider sense (of the entire service process disposed in its phases). *Primary actor* and *Participant* as well as *Pre-condition*, *Trigger* and *Post-condition*, follow the lead of Cockburn [Cock00, p. 23]. Activities describe the contained functions that appear within the use case. By classifying *In*- and *Output data* interdependencies can be identified at an early stage. Concluding data source shows the required data systems that are necessary for the operation of the use cases. As an example we apply the specified template for the use case *Create documentation* (Table 3).

Field name	*Description*
Number	11
Name	Create documentation
Brief description	Provision of building blocks and patterns for workflows for creation of documentation
Phase in the service	Execution
Primary actor	Service technician
Participant	-
Pre-condition	Building blocks and patterns exist
Trigger	Service order is going to be finished
Post-condition	Documentation occurred
Activities	Creation of bills and receipts
Input data	Service order, structured data
Output data	Documentation
Data source	Solution- and knowledge database, ERP

Table 3: Use Case Create Documentation

The presented concept provides the specification of functional requirements of a system in consideration of the user interaction. The user centric-orientation, which allows the view of an end-user of a system and its readability through using normal language, make use cases to an important object in the requirements analysis [Lübk06, p. 139].

4 Towards the Evaluation of the Ontology-based Use Cases

4.1 Project-relevant Evaluation Methods

The IS as well as the organization that are supported by these are characterized by a complex and purposeful design. For an effective interplay between the organizational units and the IS infrastructure an extensive design strategy is required. With the introduced ontology-based use cases a first step towards understanding of a specific domain is made. To improve the quality of our results an evaluation can be conducted to provide essential feedback information [HMPR04, p. 78]. In the construction-oriented Information System Research of Hevner et al. (2004) different methods are recommended for the evaluation of a designed IT artifact [HMPR04, p. 85]. The selection comprises *observational*, *analytical*, *experimental*, *testing* and *descriptive* evaluation methods [HMPR04, p. 86]. An *observation* can be conducted within the scope of a case study, where the results are analyzed in an intended operative context or in a field study with various projects. Due to novelty of the developed concepts and the circumstance of a prototypical implementation as a final outcome and not as initial point of the underlying research project, an observation under realistic conditions haven't been conducted so far. The evaluation method *analysis* can be done by a static examination of structural properties, analysis of the architecture, optimization concepts or the investigation of dynamic characteristics such as performance [HMPR04, p. 86]. The results have been analyzed and presented in several studies with focus on both, the conceptual level as well as the prototypical implementation [FKRM12][FÖMD13]. Additional to the technical views the evaluation method *experiment* is planned via an eye-tracking system. The prototypical implementation of the use cases in a TCS support system is going to be evaluated with service technicians as subject group. The individuals of the subject group have to handle a given service process with use of the considered service support system to analyze and evaluate the usability. The *testing* method can be conducted by a structural analysis (white box) or a functional analysis. Since the prototypical implementation started based on the results, this method is already used due to the fact that the user interface is constantly tested and refined by the developers. Likewise, the *description* occurred in our research process. This method is applied by established argumentation or a description of detailed scenarios [HMPR04]. The utility is presented through a systematic derivation of requirements and the specification of use cases.

The described methods by Hevner (2004) present only a small range of evaluation approaches to improve the quality of the research results. As a next step of evaluation standardization activities with the German Institute for Standardization (DIN) are in progress. In doing so, a wide range of practitioners can be reached and informed how to address information-related tasks.

4.2 Use Case Implementation

A prototypical implementation of the specified use cases in a TCS support system is shown in Figure 3. The service center can assign service orders to a specific service technician or the technician himself can create a new request. After the registration in the service support system the assigned technician can access the order. According to the use case *proactive information provision*, relevant information for the service process is displayed on the mobile client of the service technician. If the service technician accepts or rejects the assigned service order, feedback is transferred to the service center. Generated information during the service process concerning the service activities, service object or the customer are interfered corresponding to the use case *provide feedback*. Concluding, a service report can be created after the work of the service technician is finished. The use case *create documentation* provides for this activity a context-sensitive fill-out assistant (cf. Figure 3 bottom right mobile application screen) [FÖMD13]. The presented prototypical implementation of the use cases and the service support platform for the TCS is hitherto work in progress.

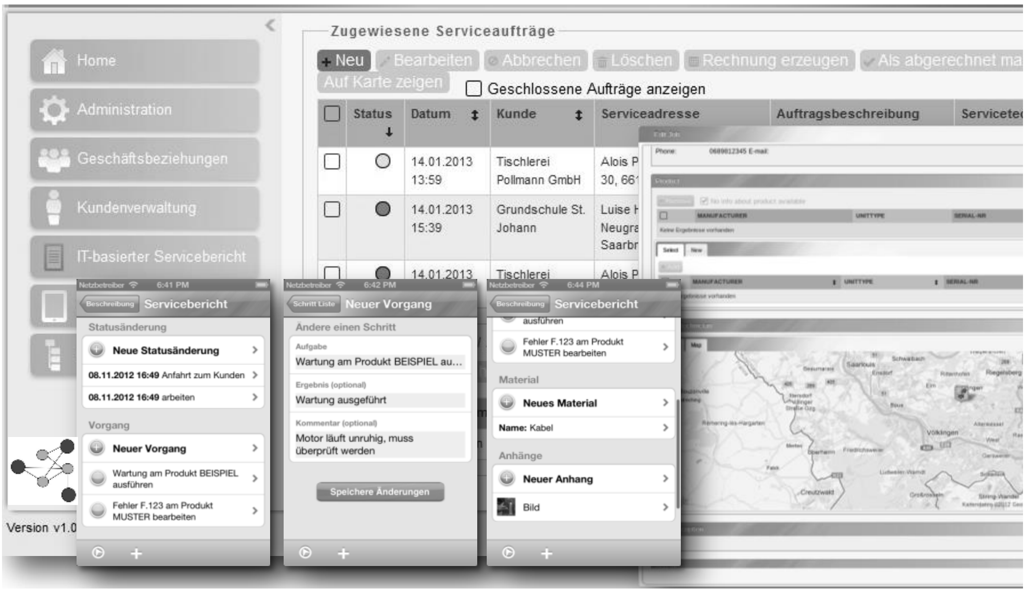

Figure 3. Stationary Web-based Client (Backend) and Mobile Application Screens (Frontend)

5 Conclusion

The complexity of systems is a challenge for mobile technologies that need to be available incorporating a wide range of solution components. Especially in the field of the TCS flexibility it is a criterion that should not be neglected. In this contribution we identified key concepts of the TCS. Therefore we devised an ontology to integrate relevant components of a mobile TCS support system. We presented a project-specific SMW as one field of application of the ontology and showed the relevance of information provision in this context. The use case is the central concept of the ontology so that 16 use cases have been specified and presented in an ontology-based template which provides a view of a system component in combination with navigation links to other contextually relevant concepts in the ontology. A selection of evaluation methods underlines the project's proposition with regard to the design-oriented research paradigm. The prototypical implementation constitutes the transfer from the conceptual to the technical level and demonstrates the usability of the use cases.

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The path to a computer-aided design system for services

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Abstract: With the increasing significance of services for manufacturing companies, interest has also increased in the question of how services can be developed and tested systematically and efficiently. Since the initial approaches of the 1990s (Ramaswamy, 1996; Bullinger, 1995), a whole range of approaches have been developed with terms such as new service development, service engineering or service design, which not only have a high profile in the world of research but also within companies. However, this does not mean that they are generally used in practice (Burger et al, 2011). In our opinion, this reticence on the part of companies is based on the fact that the suggested innovation models only cover a small segment of actual development projects and so are of limited use. In addition, there is a lack of effective technological support to simplify the use of these methods. This would be of particular relevance to system services whose development is complex and associated with not insignificant financial risks. In this regard, the ROUTIS project has set itself very ambitious goals. The development of a practice-based innovation model is intended to make a contribution to the faster development of system services so that they can be brought to market more quickly and form the basis for a computer-aided design system for services (ServCAD). This paper presents the project's initial results.

1 Challenges in the development of system service

We see a system service as a complex bundle of services to a customer as a complete service. System services can comprise several stand-alone services, or may involve a combination of products and services. They are often provided in conjunction with other service providers. The task of the system service provider is therefore to dovetail the services of various partners/suppliers into a consistent and financially optimised value chain. The main challenges associated with developing practice-based system services are the complexity of the service, the heterogeneity of the innovation processes, as well as the lack of technical support for the development process.

1.1 Mastering complexity via system services

With increasing cost pressure and decreasing profit margins, it has become ever more important for manufacturing companies over the past 20 years to complement their technical products with a relevant ranges of services. Manufacturing companies have become and are continuing to become providers of product service systems. This development is generally discussed in terms of servitisation (Van der Merwe & Rada, 1988), service-dominant logic (Vargo & Lusch, 2004) and hybrid added-value and its significance is reflected in the steadily increasing number of relevant projects and publications (see, for example, Korte et al. 2012).

The fact that manufacturing companies offer services is hardly new. However, what is new is the complexity of the range of services and the level of professionalism with which they have to be provided. Baines & Lightfoot (2013) distinguish between three types of services offered by manufacturing companies: The core is made up of basic services that have direct relevance to the product itself, such as the delivery and start-up of machines, provision of spare parts, etc. The second level is made up of services that serve the system availability of a product. Regular maintenance and repairs of machines and systems, user training, condition monitoring and field services all belong to these medium-complexity services [intermediate services]. The highest level comprises advanced services (customer support agreements, risk and revenue-sharing models, hiring or operating complete systems). These aim to provide the customer with a defined capacity or service availability. While the basic services complement the product, the product itself is no longer the main focus of higher-level services; they are a means to an end.

According to Barnes and Lightfoot, complex product service solutions are in demand from customers for two main reasons: They contribute towards reducing investment risks and fixed costs, and allow customers to concentrate on their core business. These services offer the service providers the opportunity to make a bigger contribution towards the success of the customer's company. This is associated with the opportunity for more long-term customer relationships and a reliable flow of income for a longer period of time. However, these services also represent a higher risk. If the services cannot be provided at the quality level and speed agreed, high contractual penalties may be incurred, or the complete loss of its own advance deliveries or payments. The question of mastering complexity is not only a question of success for the service provider, but also sometimes a question of business survival.

1.2 Approving heterogeneous innovation processes

If we assume that it is of increasing importance to companies from a wide range of industries to offer system services, the issue arises of what the suitable approaches are to developing these system services as efficiently as possible.

Sakao et al., 2009 emphasise that products and services should be developed in close cooperation with, and at the same time as, the development of hybrid service bundles. Sakao et al. list two reasons for this: 1) Customer benefit is only partially derived from the functionality of the product. As a result, product functions and service activities should be defined from the start and adjusted in accordance with customer expectations. 2) Product and service components are developed by different groups of people, which means that constant negotiation is required in order to avoid any mistakes in development on either side. We share this opinion, however, it is actually fairly rare for complex services to have to be developed from scratch in practice. It is more often the case that existing services have to be modified, reconfigured or be supplemented by new components. This was also borne out by the company surveys we conducted. Among these companies, the starting point for the development of system services is generally successful customer projects that are later developed further into standardised and modularised services.

Innovative approaches such as service engineering do not take this into account. New first-generation service development approaches, including service engineering, aim to create an initial generic framework for the development of services. For matters of simplification, it is assumed that development projects are activities with a fixed deadline, within which time all stages must be completed from brainstorming to market launch. Re-engineering of existing services is not explicitly planned. In addition, these initial innovation approaches are largely guided by classic internal innovation paradigms (Meyer & Böttcher, 2011). However, this is not enough when it comes to system services that frequently involve customers and partners for their development and provision. This is one of the reasons why these innovation approaches are rarely used in practice.

In this regard, the participants in the ROUTIS project propose a new innovation approach, round-trip service engineering, which will better correspond to the methods of day-to-day business practice.

The term 'round-trip engineering' originally comes from software technology and describes a development process where a combination of top-down and bottom-up processes ensures consistency between class diagrams and source codes. In forward engineering, the system to be developed is first described at a highly abstract level (modelled), gradually refined and then translated into a program code. Reverse engineering starts with the program code and extracts the diagrams from it that correspond to the current software design. With the right software support, it can be ensured that changes made on an abstract level can be followed up automatically on another. This means that it is irrelevant on which abstract level the work takes place. Both display modes are always synchronous.

This is also the basic principle behind round-trip service engineering, which also combines forward and reverse engineering in one iteration method. Changes to the service model result in changes to the test scenario, or in practice. Conversely, changes to the practical aspects of the service are traced back to the model (see Figure 1).

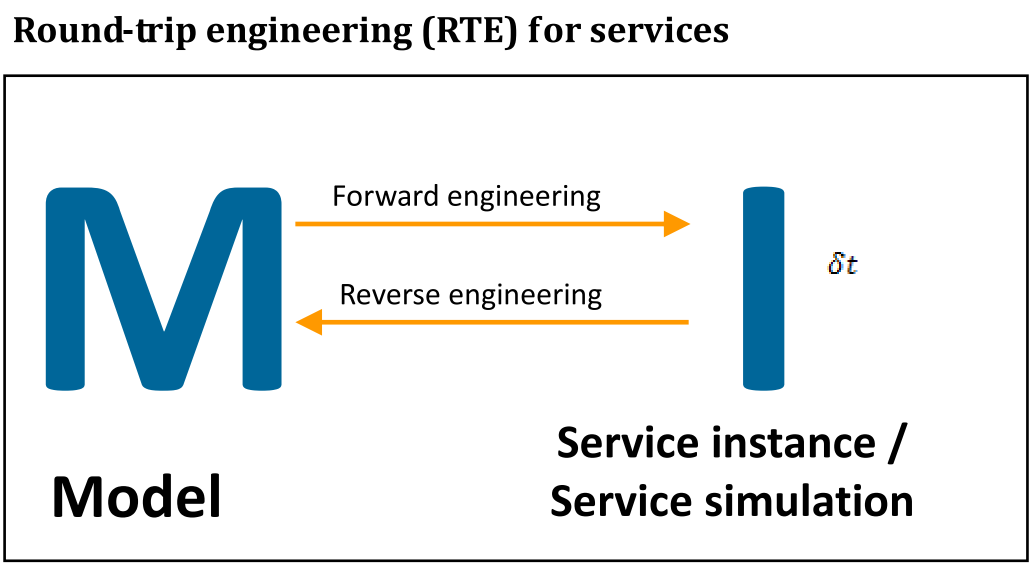

Figure 1 Principle of round-trip engineering for services (Source: University of Leipzig)

This means that round-trip service engineering also takes into account the fact that innovation impulses not only come from the system service provider but also from customers and partners. Open-service innovation (Chesbrough, 2010) or lead user approaches (v. Hippl, 1986, Olivera & v. Hippl., 2010) can thus be integrated seamlessly.

1.3 Using more powerful tools

The classic service engineering approach distinguishes five different stages (see Meiren & Barth, 2002): brainstorming and idea analysis, analysis of the market and company requirements, development of the service concept (product model, process model, resource model, marketing concept), service implementation and market launch (test, roll-out, start-up monitoring). There are already methods available for all these phases, which have been taken from various specialist disciplines (marketing, engineering, design, user experience design, etc.). These include the Business Model Canvas to describe business models, service blueprinting to visualise processes and customer touchpoints, service experience mapping or service FMEA to determine relevant quality aspects, etc. These generally consist of 'paper and pencil' solutions, or proprietary software tools. This means that the results cannot be processed automatically but always need to be documented manually and prepared for processing. This is a major contrast to the situation in product development, where most analogue tools were replaced years ago via digital solutions (CAD, simulation tools, rapid prototyping tools, etc.). It therefore makes sense to try to develop similar tools for service development.

2 Computer-aided service design

Initial ideas and a prototype solution for a computer-aided design system for services (ServCAD) were presented by Ari and Shimormura in 2004. The aim of the Ari und Shimormura research group is to create a tool that can be used to increase the value (customer benefit) of artefacts and also reduce the impact on the environment at the same time. According to the authors, the aim of service engineering is to create service product systems that provide the optimum relationship between product functions and service activities.

Ari and Shimormura define services as activities that change the status of the recipient. This change is created by the content of the service (material, energy, information) and the service channel by which the content is transferred, strengthened and/or controlled. In this system, artefacts (products) can be content or service channels. The authors argue that services can thus be designed in a similar way to artefacts. Like artefacts, they also have their own functions, processes and statuses.

The starting point for the ServCAD solution proposed by Ari and Shimormura is a service model that is based on these concepts. In its original form, it includes three components: the flow model, the view model and the scope model (see Figure 2). The flow model describes the sequence of content and channels that links the service provider (potentially via other persons in the value chain) with the receiver of the service. The view model defines the changes to the content and channels that produce a change in a given state parameter for the receiver (receiver state parameter, RSP), i.e. how a result can be achieved that leads to customer satisfaction. Because the value of a service can have various aspects, the service model consists of various view models. These are clearly summarised in the scope model. The scope model therefore provides information about changes to all relevant receiver state parameters.

With the service explorer, Ari and Shimormura presented a software tool in their 2004 paper that enables developers to edit service models, evaluate them and to search for similar models in a database. The evaluation components of the service explorer were tested using the example of a hotel service (Ari and Shimormura, 2005). To do this, they initially determined and weighted the functions that hotel services have for their customers via a customer and employee survey. A quality function deployment matrix was then created and design solutions sought that corresponded to these requirements. With the aid of the service explorer, it was possible to describe the structure of this service and to generate statements about the relative significance of various service elements to customer satisfaction.

In the development of the approach (see Sakao and Shimomura, 2007; Hara et al., 2009), the service model was complemented by a fourth component – the scenario model. The scenario model describes the characteristics and behaviour of the receiver. The characteristics are determined using the personas method (Cooper, 1999), while the behaviour is described in the form of service blueprints (Shostack, 1984).

The modelling process then starts using a description of archetype customers (personas), as well as the relevant scenarios for providing the service. Parameters are then determined for the customer segments identified, which describe the desired end point (receiver state parameter, RSP). Finally, the view model is created. Because the view model only contains a little information about the process of providing the service, the relationship between the defined functions and the entities involved (hardware, 'humanware', software) can now be depicted in advanced service blueprints. Activity blueprints describe the service processes carried out by humans. The automatised processes, on the other hand, are depicted in behaviour blueprints. Both types of blueprints and their interactions are specified in business process modelling notation (BPMN) and can be visualised in the service explorer using the same graphical user interface.

The modelling approach and software tool used by the Ari and Shimormura research group represent a major step in the development of a CAD system for system services. In contrast to product development or classic service development approaches, the complete service product system is the focus here. From the very start, functions are described not just for the product components but also for the service components. Both types of functions are seen as being of equal importance and the advanced service blueprinting ensures that the service functions are not overlooked in the development process. By using BPMN to create the blueprints, executable process models are created that also enable computer-aided simulations. This therefore creates a nucleus for a CAD system. However, in our opinion, this development needs to go further.

One major advantage of a ServCAD system is that the development process develops, visualises, selects and optimises design variations with little effort. The depiction of processes plays a major role in this regard. Experience from various service engineering projects show, however, that formal process models are extremely complex and intricate. Creating formal process models thus requires a high degree of imagination, concentration and modelling expertise. If customers, employees or decision-makers are to be integrated into the service development at early stages, clearer visualisation methods are required. In addition, process models are not suitable for depicting customer interactions. Process models such as the advanced service blueprints described above only show one particular type of customer interaction as an outcome. They do not provide information about how the customer interaction should look in detail. In addition, pure process modelling also does not take into account the fact that customer interaction process can be greatly influenced by the environment in which the service activity takes place (Bitner, 1999). Available space, noise, odours, lighting and furnishing all play a major role in human behaviour and should be taken into account when designing the service. ROUTIS therefore takes the system described above one step further. As the central element of a CAD system for service development, ROUTIS aims to develop a solution that supplements the abstract process models with an additional graphical user interface.

2.1 Designing the 2-D/3-D modelling tool in ROUTIS

Formalised process models have the advantage that they can reduce complexity through abstraction and can simplify communication by specialists (business process analysts, IT specialists). 3-D visualisations, however, present an intuitively comprehensible and tangible depiction of service situations and processes for people who may not be as well versed in the theory side (customers, employees, decision-makers). The ROUTIS project therefore aims to develop a visualisation tool as the core of a ServCAD system, which will enable a straightforward switch-over between both forms of visualisation (see Figure 2).

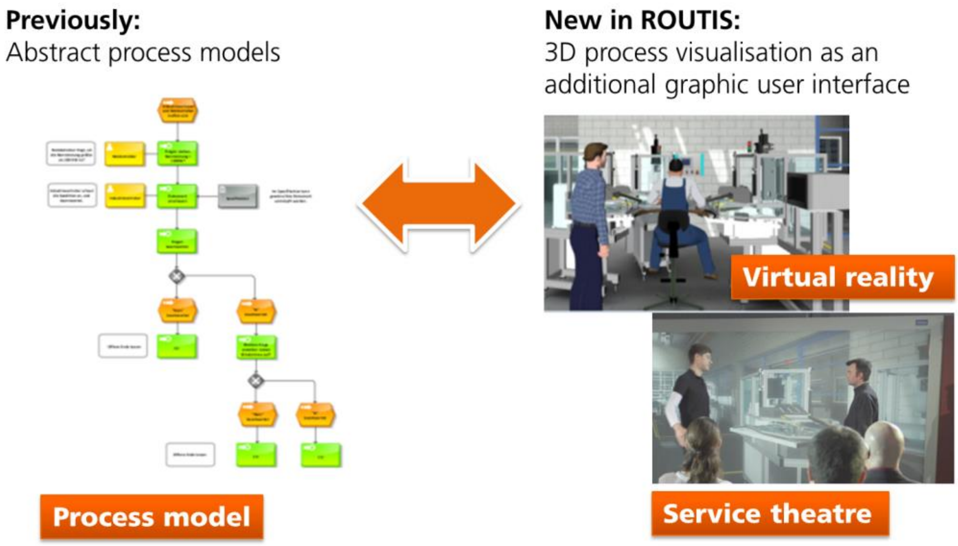

Figure 2: Designing the 2-D/3-D modelling tool

The ROUTIS project will initially investigate the feasibility of combining the 2-D and 3-D process visualisation and, using the results of this, will establish what research and development work is necessary in order to create a comprehensive ServCAD solution. In the first step, an application scenario (maintaining a system) was selected and described as an event-driven process chain (EPC model). The basic communication between the process moel and 3-D application is then set up in such a way that one mouse-click on a section of the process model creates the relevant scene in the virtual reality projection (VR). In future, the scene displayed should change automatically if modifications are carried out in the process model. Changes will also be able to be updated in the VR version of the process model.

One of the biggest challenges here is that information is required for the 3-D visualisation that cannot currently be depicted in formal process models. The correct visualisation of a 3-D scene thus requires, for example, information about the 3-D model, the objects contained in it and their position within the space, information about human models (positioning, orientation, gestures or expressions of avatars), about dialogue content and about timing (duration of a task, waiting times, etc.). For large projects, however, not all information that is required for 3-D modelling can be stored. The next step in the project consists of defining mechanisms that will be required by the process models and by the 3-D visualisation in order to save and update the necessary information.

3 Conclusion

The in-depth interviews during the ROUTIS project showed that companies are well acquainted with the results of service research. However, the development projects stick to established product and software development methods (stage/gate models, SCRUM). Service-specific innovation approaches do not play a role in these methods. In addition to a few industry-specific tools, other tools include standard word processing systems, spreadsheet programs and presentation software. Whether these statements can be made categorically must be evaluated by ROUTIS in a broader empirical study. The results so far, however, indicate a significant lack of methodological and technological support.

In our opinion, in addition to practice-based innovation approaches, the following areas also need to be addressed:

- Service models that depict all aspects of system services (product model, process model, resource model, ServiceScape, etc.).
- Simple visualisations that can be understood by all concerned.
- Tools that are not just suitable for use by specialists but also by skilled workers.
- A platform that continually supports the overall development process without changes in media format.

With the development of a 2-D/3-D modelling tool that is just as much based on the principle of round-trip engineering as the new innovation approach, we hope to make a major contribution to the development of a CAD system for system service development. The practical benefits and functionality of the system will be assessed throughout the project in partnership with companies from both fields of application. The first results appear to be highly promising.

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For more information about the project, please visit www.routis.de.

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Round-Trip Engineering for System Services

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Abstract: More and more companies consider themselves as system services providers. They offer complex services but suffer from difficulties to keep their service models in sync to the service in reality. We suggest a solution based on the concept of round-trip engineering applied in software engineering. Therefore, we discuss the state of the art of round-trip engineering and propose a theoretical framework for the adaption for complex services. This framework is extended by the concept of mediators like innovation laboratories to reduce the gap between service model and the service in reality.

1 Introduction

In this paper, we will outline some efforts made to develop a new framework for innovation in complex service systems based on the idea of round-trip engineering (RTE). More and more companies consider themselves as system services providers and acknowledge the importance of innovation management for complex services. As part of our research we have conducted interviews with such system services providers [Th13]. In those, they point especially to their problems to keep the service model in sync with the service offered. A similar problem of synchronization in the area of software development is dealt with by the use of the round-trip engineering method. An adoption of the round-trip engineering method to services is proposed here.

This paper is divided in four sections. After this short introduction, we outline the concept of round-trip engineering and the term system services provider in the second section. The third section introduces the concept of round-trip engineering for service systems as a solution for the innovation and synchronization need in the area of service system providers. Finally we draw some conclusions in the last section and give an outlook on further necessary research work.

2 Basics – System Services Providers and Round-Trip Engineering

2.1 Introduction of the term System Services Providers

We observed a shift in the public presentation of companies in Germany. More and more companies consider themselves as system services providers and acknowledge the importance of innovation management for complex services. In [Th13] we presented the findings of an explorative study on providers of complex services in the business fields of energy and ICT (information and communication technology). Personal semi-structured interviews with 11 experts were conducted and the findings summarized.

The definition for the term is given as follows:

A System Service Provider is an entity that provides complex service bundles that are offered as integrated solutions to one or more customer. In order to be able to provide such an offering, the system service provider coordinates and integrates different partners and their individual input within a value chain, structures the service provisioning systematically and promotes an integrated service portfolio.

2.2 RTE - State of the Art in Computer Science

RTE is a well-known term that is mainly used in the domain of software development and engineering. Initially, Aßmann describes RTE as “an instance of the method of domain transformations” [Aß03]. Many models and modeling languages are used in order to describe a software system on different abstraction layers and from different perspectives [HLR08]. Hence, the scientific discussion is primarily oriented on using the RTE concept for model transformation and model synchronization. Most studies are devoted to the synchronization of source code and UML [HL03], [KR00], [DDT99].

On that account it is hardly surprising that the results and definitions of terms are particularly shaped in this context. Nevertheless, Henriksson and Larsson [HL03] provide a general definition for the fundamental understanding of RTE. This definition describes RTE as a system of product, design and corresponding transformation procedures. Hereby, forward engineering characterizes a procedure intended for the creation of a product by a given design. Respectively, reverse engineering characterizes a procedure intended for the extraction of a design given a product. If it is possible to extract a design and based on this create an identical product (compared to the initial product used for extraction), then product, design and the transformation procedures form a RTE system (see figure 1).

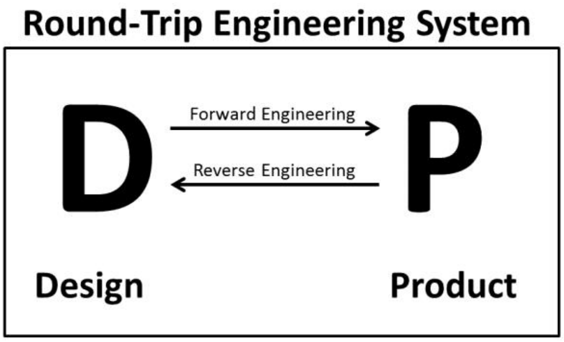

Figure 1: A RTE System consists of forward and reverse engineering procedures connecting design and product.

Although this definition seems intuitive, it is too strict to be useful in practice as it assumes that the source and the target are isomorphic to each other. By definition, scientific modeling involves abstraction and simplification of reality. Hence, the difficulty faced is that in practice transformations are neither total nor injective, all the more not bijective [HLR08]. Application in reality mostly has not to fulfill these requirements. For example, in practice it is not essential to extract a design from a product, as the initial design is created prior and is therefore available. But it is essential to update the design according to changes made to the product over time.

Hettel et al. [HLR08] propose an adopted definition of RTE taking partial, non-injective transformations into account. Hettel et al. argue, that

"RTE does not aim at recovering lost or otherwise unavailable source models, but is rather concerned with propagating changes from target to the source model. Therefore it assumes the availability of the source and target model, the forward transformation and the change to the target model, which are all input to the roundtrip transformation. The goal is to provide a new source model that when transformed produces the changed target model again."

This definition is more of a practical value and fits our thoughts of the following section 3.

3 RTE for Services

As stated in [Th13], keeping a service model in sync with the service offered in practice is a major challenge for service system providers. In real live it seems to be especially difficult to propagate changes in the service offered to the service model. The high complexity of the services offered could be one reason.

As synchronization of models is the main point in RTE we outline some ideas for a possible round-trip engineering system for services.

3.1 Basic Concept

Although almost all work conducted on RTE is concentrated in specific on software model transformations, the underlying idea can be applied in other application fields. Besides software modeling, first work has been conducted in the area of business process management [HLR08], [BDD07]. Salvendy et al. [SK10] briefly discuss the application of RTE in service engineering as a method for determining the correctness of implementation. Up till now, no further work is known to us that addresses the concept of RTE in the context of service engineering. In this chapter, we will briefly outline the application of RTE in service engineering based on the definition of Hettel [HLR08].

In this application scenario the source model is the service model and the target model represents the executed service as an instance of the source model applied in reality. Thus the diagram from figure 1 needs to be updated as shown in figure 2.

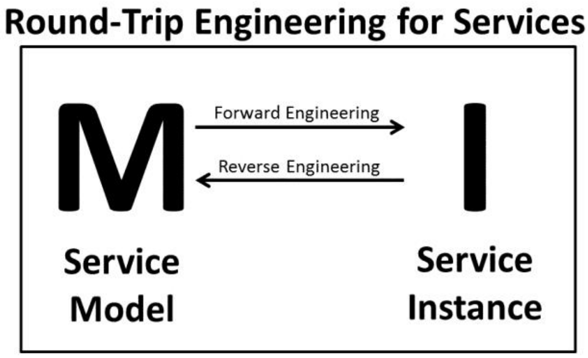

Figure 2: RTE for Services. The conversion is done between service model and instance. The service model could consist of product model, resource model and process model [Bö09]. The service instance is the service as it is actually offered and executed.

3.2 Forward and Reverse Engineering Procedures

In service science, management and engineering (SSME) and service modeling, forward engineering procedures and managing services is a well explored research area [BS03], [MKS10]. Based on the work of Böttcher [Bö09] a complete service description consists of three basic models:

- product model – covers modularization of service components, configuration information and constraints.
- resource model – describes all resources available and needed for the services
- process model – contains process descriptions for the execution of the services

The literature on SSME provides numerous procedures, methods and models covering the area of new service development (see [Me11] for an overview), forward engineering procedures as well as the management of services and service instances, e.g. software-service co-design [Me09] or service level management [SMJ00]. So far, there has been no work conducted dedicated to reverse transformation procedures.

This brief outline shows that service research provides a solid basis for the creation of RTE-systems. Nevertheless, the gap in the literature on reverse engineering procedures needs to be filled in order to be able to create complete RTE-systems for services and increase efficiency in service delivery and innovation. Future research has to address these procedures and examine to what extend they can be automated.

3.3 Introduction of Mediators

As experienced by the service system providers according to the explorative study of Thieme et al [Th13], the synchronization between service model and service instance is a major challenge. In order to reduce this gap, we propose the integration of mediators to the concept described above and outlined in figure 2. Possible mediators could be for example one or a combination of the following:

- *Innovation laboratories*:
  Innovation Laboratories offer an dedicated physical space for innovation [GMT13]. An innovation laboratory can make tools and expertise including the ones listed here affordable for small and medium sized enterprises (SME) [Sc09].
- Trained Facilitator:
  Persons that have special qualification in moderation and innovation techniques [Sc94] can improve the interaction between different involved stakeholders.
- Management software:
  One can imagine software tools that help with synchronization. Possible tools could for example manage the update notification message flow in both directions, improve the forward and reverse engineering with good user interfaces to the service model [HAS09], or just help with the collection of key performance indicators.
- Test and visualization tools:
  Early tests can improve the innovation result [MB10] and can, like service visualization, support the forward engineering. Examples could be:
    - the *service theater method* [BH], [MB10]
    - *screen mock ups and similar visualizations*
    - *rapid prototyping* tools similar to the ones offered in fab labs [Wa13].

The proposed concept of a round-trip engineering system with a mediator is shown as a summary in figure 3.

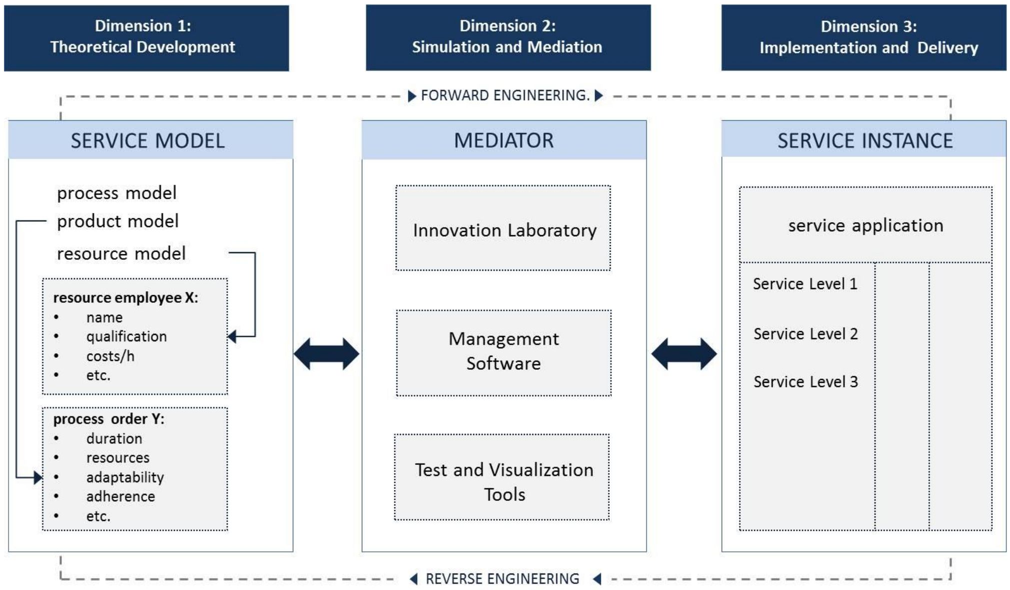

Figure 3: Draft of a RTE system for services including mediators. The service model is synchronized with the service instance by the use of forward and reverse engineering procedures. The service instance is the service as it is offered and executed. The service model can consist of the process model, product model and the resource model [Bö09]. The gap between service model and service instance is reduced by the introduction of mediators.

3.4 Innovation Laboratories as Mediators

To assess the potential of innovation laboratories in the area of service innovation further investigation still seems necessary. First work is done already by for example Meiren [MB10] and Burger [BH]. But for complex services new problems arise due to the higher number of pieces that have to get combined. Still we believe in the adoptability of the innovation laboratory concept to the management of complex services. They can offer special expertise and tools. Examples of possible support areas are:

- Idea generating
- Decision making
- Knowledge management
- Process management
- Service theater
- 2D/3D visualization.

4 Conclusion, Limitations and Further Work

In this article we introduce the concept of round-trip engineering in the field of service engineering to the scientific discussion. Round-trip engineering is state of the art in software development and here we described the basic concept of a round-trip engineering for services. Although this seems to be a promising solution to the synchronization problem reported by system services providers there are still important gaps to fill by future work. The main ones are:

- The existing forward engineering procedures have to be evaluated and perhaps new ones have to be defined.
- There is a big lack of known suitable reverse engineering procedures. Most service engineering approaches concentrate on the service model itself or just the direction from the model to reality.
- The list of possible mediators needs better evaluation and can possibly get extended. Especially the concept of innovation laboratories needs some work on a methodology adapted to the handling of complex services to tap its full potential.
- The service model itself has to get checked if it matches optimal with the other results.

Some of the work mentioned above is already in the making, but there is still a lot of effort to be done for this promising concept.

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