# Configurative Service Engineering – A Rule-Based Configuration Approach for Versatile Service Processes in Corrective Maintenance

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## Abstract

*Recently, service orientation has increasingly been debated both in research and practice. While researchers postulate a paradigm shift towards services as the basic unit of exchange in economies, companies strive to efficiently provide a wide array of business services to their customers.*

*To accomplish this, companies (a) are required to consciously design the services in their portfolio with respect to a structured engineering approach and (b) also have to flexibly adapt the engineered service processes to individual customer needs, wants, and demands. Hence, services shall be supplied efficiently and in consistent quality without sacrificing customization for customers.*

*Supporting this mass-customization strategy for business services, we present a configurative service engineering approach. After engineering a configurable process model for business services, customized service processes can efficiently be derived from the model by applying configuration mechanisms. The process of configuration is aided by the software tool Adapt(X). We present the concept and tool support by applying them on business services for corrective maintenance in the mechanical engineering sector.*

## 1. Service Engineering for versatile business processes

Based on well-established product engineering concepts, the discipline of Service Engineering [1] strives to design and implement services with respect to systematically applied engineering principles. A central part of the approach is to describe service processes and requirements on supporting information systems by means of (semi-) formal conceptual models. Conceptual models provide an important coordination function as they account for a common understanding of the service processes, the resources to be used and the organizational units to be involved among all participants in the development, implementation and provision of services.

During the development phase the conceptual model of a business service is created. This model acts as a master design (or service blueprint) for a business service to be provided to customers. Amongst others, it constitutes the basis for computer-aided simulation and business calculations of the service process. Subsequently the service process is transferred and implemented into the organizational and IT infrastructure of the service provider or the service value network. After this implementation, the service can be offered as a value proposition to customers and eventually is delivered by utilizing the realized infrastructure as specified in the conceptual model.

If providing highly standardized services, a unique conceptual model of the service processes can be developed and a specially tailored organizational and IT infrastructure can be implemented. Based on that infrastructure, a large number of service process instances can then be executed irrespective of individual customer demand in a rather standardized way and with low variety. This would enable companies to reap economies of scale and apply sophisticated resource planning and optimization for their service processes, as proposed by [2].

In contrast, it has to be noted that service processes necessarily are to be carried out in cooperation with customers [3][4][5]. Therefore, service processes often have to be fine-tuned to individual needs, wants and demands [6] of particular customers, and in many industry sectors an increasing individualization of business services can be observed. If services have to be provided with respect to multiple customer-specific variants, a specific model and a specific infrastructure would have to be provided for each customer or customer group. In a worst case scenario, the same effort as for setting up a unique infrastructure for each service instance would have to be spent on each customer request. Consequently, a methodologically accurate

Service Engineering approach would come under immense cost pressure. Additionally, customers may not be tolerating the increased preparation time a service providers might need to get ready for service delivery.

In the context of conceptual modeling, the concept of configurative modeling strives to increase the reusability of existing models. In this paper we apply the concept of configurative modeling to the discipline of Service Engineering. We propose a procedure model that is subsequently applied in selected parts to corrective maintenance service processes in the mechanical engineering industry.

We argue that configurative conceptual models can help reducing time and cost efforts for developing variant-specific organizational and IT infrastructures. Therefore, firstly we reflect on approaches and instruments for model configuration discussed in the existing business process management body of literature (Section 2). Secondly, those approaches are applied in the Service Engineering discipline. Based on a comparison of various traditional approaches from 'New Service Development' (NSD) and the 'Service Engineering' discipline we therefore introduce a phase model for a configurative service engineering approach (Section 3). The proposed approach has been applied in first case studies taking place in the course of a governmentally funded research project. Taking the corrective maintenance process for the mechanical engineering industry as an example, we identified various configuration rules to tailor the organizational and IT infrastructure to the customized service process. The configuration itself is aided by the software tool Adapt(X) (Section 4). Concluding our findings we provide an outlook section to foster further research in the contemplated research areas.

## 2. Configuration mechanisms for conceptual models

The aim to support systems development processes by reuseable artifacts, which can be adapted to special conditions of use with less effort and time consumption, is addressed by many scholars. Their approaches differ by the way they support the user during the adaptation process. Conventional reference models for example deliver monolithic information systems models, which can be specialized and modified by the model user without any special guidance beyond the rules of the used modeling language. ROSEMANN and VAN DER AALST [7] propose configurable reference models which are extended by patterns describing semantic dependencies between model elements. If model users adapt the reference model (for example by erasing some of the selected parts), he or she is supported by a hint to also erase the dependent parts of the model.

The approach of SOFFER, GOLANY and DORI [8] differs by predefining the configuration of models in much more detail. Therefore they enhance the models by attributes which describe the relationship of the attributed model elements and scenarios of reference model application. The user is supported as follows: Firstly, he or she has to describe the application context. Secondly, the attributes are interpreted regarding this specified context and the model gets modified accordingly.

BECKER, DELFMANN and KNACKSTEDT [9] propose a similar approach which integrates predefined model variants for different application scenariaos within one model. Configuration rules describe which variants can be considered to best suit a specific application scenario. For defining these configuration rules, configuration terms are annotated to the model elements. Configuration terms describe conditions of the context of application. If the condition is fulfilled in the current context of application, the model element remains in the configurated model. If the condition fails, the model element is removed from the model. The current context of application is described by selecting appropriate values from a set of predefined configuration parameters. Logical combinations of this configuration parameter values are used to build more complex configuration terms.

We cite a general model of retail companies as an example which can be reduced to an individual model for any specific retail company. One important configuration parameter therefore is the business model. Values of this parameter are "warehousing business" (retailers accomplish all functions of procurement, storing and distributing themselves) and "third-party delivery" (retailers do not accomplish logistic functions). The configuration term "business model (warehouse business)" is used for marking those parts of the model, which describe the picking process. This expresses that the picking process is only relevant in case the retail company conducts warehouse operations. If the retailer provides only the business model third-party delivery, the configuration term is evaluated as *false* and the corresponding model elements are removed from the configured model. For formulating complex conditions, configuration parameter values can be combined logically within configuration terms. For example, the configuration term "business type (warehousing business) AND trade level (wholesaling)" is *true* for all wholesalers with their own warehouses. For retailers with centralized clearing or third-party delivery the value will be *false*. In contrast, the configuration term "business type (warehousing) OR trade level (wholesaling)" will deliver e. g. a *true* value for wholesalers using a centralized clearing approach.

In this paper we propose to use such a configuration approach to reduce the effort and time for engineering service processes. We follow the latter approach due to three reasons: The approach of BECKER, DELFMANN and KNACKSTEDT provides a comparatively extensive and detailed set of configuration mechanisms; it has already been applied in variants management for a multitude of different objects; and finally, diverse software tools have been developed to support the configuration process:

*Mechanisms*: On the basis of an analysis of modeling projects and a questionnaire-based survey, five categories of adaptation mechanisms, so called configuration mechanisms, have been identified [10]: Model Type Selection (1) allows for providing only those modeling languages and their according model types to users that are relevant for them. Element Type Selection (2) considers the necessity to provide modeling language variants with different expressive power for distinct user groups. Element Selections (3) allow for selecting single instances of model element types, e.g. a single process model function. Synonym Management (4) considers that it can be necessary to change the label of model elements depending on different user groups. Finally, Representation Variation (5) allows for the assignment of different representational forms to model elements. Therefore, the symbols representing model elements can be changed.

*Configuration objects*: The use of the illustrated mechanisms in the general context of method engineering is discussed by [11]. The application of the approach for process modeling is outlined by [12]. Configurative approaches for multidimensional modeling of information needs in the context of data warehousing and business intelligence provide [13] and [14]. The configuration of process models and data models by dint of reference models for information systems is discussed by [15]. The application of the approach to align ERP-functionality and its documentation is discussed in [16].

*Software Tools*: The development of software tools to implement the approach of configurative modeling is described in [17]. Exemplary implementations comprise the H2-Toolset and Adapt(X). The H2-Toolset allows for the definition of hierachic modeling languages and the development of appropriate models. The models can be automatically configured by querying the current application context (described by configuration parameter values) and by analyzing the configuration terms annotated to the model elements.

The software tool Adapt(x) allows for the configuration of process models represented in the form of event-driven process chains (EPC). Process models are modeled by dint of the ARIS Toolset standard software. Adapt(x) is implemented as an extension of the ARIS Toolset. It is integrated into the user interface and supports the creation of configuration parameters and their values, and the annotation of configuration parameters to model elements. Before conducting configuration, any currently relevant configuration parameters are requested and the selected parameter values are highlighted. Then the configuration of the process models is conducted by importing the ARIS models and the configuration rules from Adapt(x). Subsequently, the terms annotated to the model elements are matched against the configuration parameter values. Model elements linked to configuration terms that are evaluated to *false* instead of *true* in this comparison are consistently excluded from the model. The resulting configured model is exported back into the ARIS Toolset as a model variant, allowing for further (manual) adaptations to be made by utilizing the build-in functionality of the ARIS Toolset. For a broader overview of existing tools to support configurative modeling see [10].

## 3. Configurative Service Engineering

Several approaches have been proposed to systematically design business services. Two main research streams constitute the 'New Services Development Approach' [18][19][20][21] as proposed from a service marketing point of view primarily in the U.S., and the 'Service Engineering' approach [1][23][24][25][26][27][28][29][30][31][32]. The latter approach is often focused in German Service Research [1] and explicitly strives to apply well-established product engineering approaches to the service sector. As one example for a Service Engineering Process the development steps proposed by LUCZAK ET AL. is depicted in Figure 1 [33].

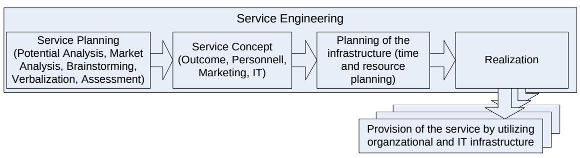


**Figure 1:** Exemplary Service Engineering Process

Despite their origin from different research disciplines, many approaches still apply similar development steps (cf. Table 1). For instance, most approaches propose a first brainstorming to take place to clarify the general idea, scope and targeted customer groups of the service (brainstorming, first specification, assessment). Subsequently, the work-steps in the service process are specified in a gradually increasing level of detail. Once service processes have been specified and operant and operand [4] resources have been acquired and implemented into the organization (often referred to as detailed specification and implementation), the generic service process blueprint is ready to be executed in cooperation with various customers. Thus, the business service can also be offered as a value proposition on the market. As services are intended to fit (specific) customer demands and require a co-creation with customers [3][4] the blueprint might have to be adapted to a specific customer demand before it can be executed (market launch).

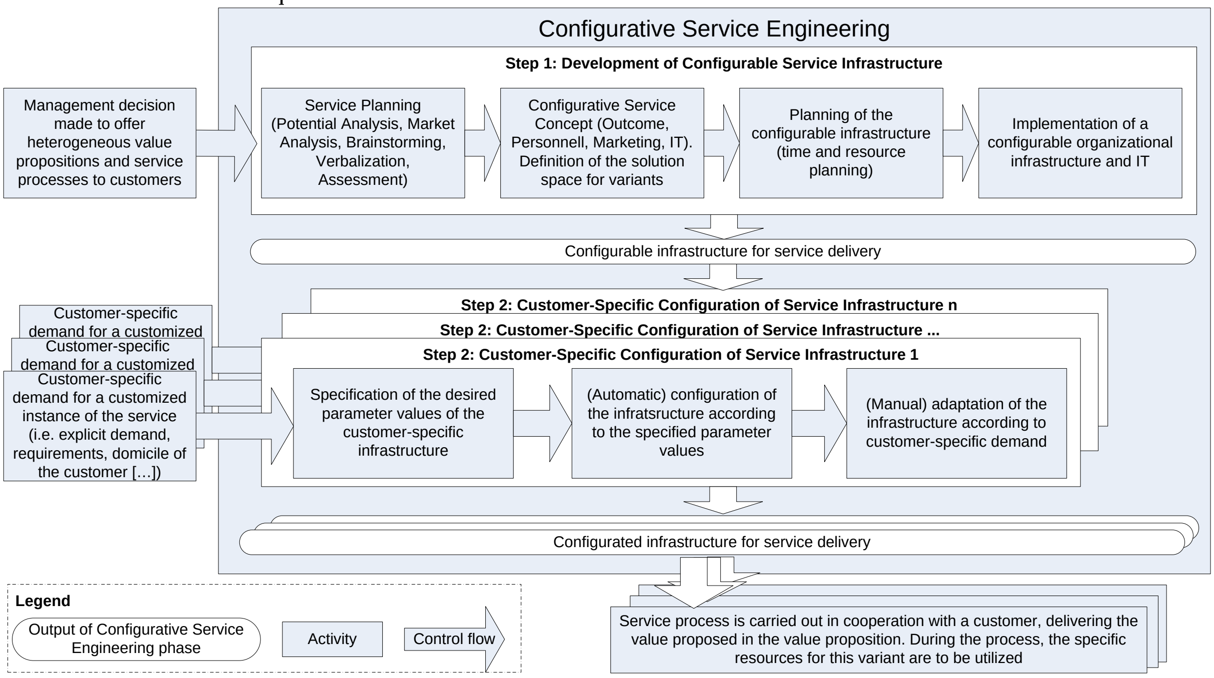


**Figure 2.** Proposed procedure model of a configurative service engineering approach

Even though services might have to be adapted according to the needs, wants and demands [6] of particular customers, all instances should be derived from the original service blueprint. This might lead to higher quality and consistency of the service instances to be provided, and may make a resource planning for services [2] easier.

The configuration mechanisms introduced in Section 2 can be built into an existing service engineering approach to simultaneously account for both perspectives. Following a mass-customization approach for providing services [34][35], the challenge of providing individual value propositions for customers can be arranged with spending the effort to systematically engineer a suitable service process blueprint.

The configuration mechanisms can be used to configure the engineered service process model, the value proposition and the organizational and technological resources to be applied during the service process. Configuration terms representing configuration rules are assigned to each element represented in the model. The terms explicitly determine the elements to be used in certain customer-specific variants. These variants might differ e.g. in terms of the underlying business context. Once having described the configuration rules and having annotated configuration terms to the model, configuration mechanisms reduce the effort and time to tailor the engineered service process to individual customer demands. Frequently, with a sufficient tool-support at hand, those adaptations and modifications can be conducted even automatically. In this paper, we refer to such an approach, which provides a configurative model and also a configurative infrastructure basis to subsequently make use of these artifacts during service delivery, as a *Configurative Service Engineering* approach (cf. Figure 2).

Initially, the management decision to provide business services in a mass-customization approach must be made, e.g. as a means to cope with the aforementioned heterogeneous customer demands. Customers' expectations and business parameters constitute the definition of the relevant variants space to be incorporated into the configurable service process model. By defining the allowed solution space for variants, the configurative organizational settings and IT infrastructures to be provided for the service process can be planned and implemented.

Applying the described configuration mechanisms, a context specific service infrastructure can be derived to deliver each particular service instance (middle row in Figure 2). Starting with the service request, attributes to be provided by the variant are defined. Subsequently, those attributes are applied by (automatically) configuring a suitable subset of the previously specified generic service infrastructures. The resulting configured infrastructure might also require final manual adaptations and implementations. Subsequently (bottom row in Figure 2), services can be delivered to customers by making use of the context-specific service infrastructure.

This paper seeks to investigate the methodological feasibility of the Configurative Service Engineering approach by explorative research. The investigation is focused on service processes for corrective maintenance, which we identified in multiple enterprise value networks focusing on optimizing the process of corrective maintenance. Subsequently, insights pointing at specific configuration requirements have been abstracted from the cases. Then, we analyzed how the derived configuration rules can be mapped by software tools for supporting the configuration of organizational and IT infrastructures for the service processes under study. Regarding the infrastructure design, our analysis focused on process models (organization) but might also be applied to configure Service Oriented Architectures (IT), as is lined out in the outlook section.

**Table 1:** A comparison of approaches from 'New Service Development' and 'Service Engineering'

| Source | Brainstorming, First specification and Assessment | | Detailed specification, organizational and IT implementation | Market launch |
|---|---|---|---|---|
| [23] | Brainstorming and assessment (ideas from customer feedback an down ideas) | Requirements analysis (matching of ideas with customer requirements) | Design process (potential, process, outcome), organizational implementation | [implicit] Later: Provision of service, displacement |
| [24] | Definition (generate idea, assess benefit for customers, visualize, organizational primary treatment) | Conceptualization (specify components, functions, customer interface, and infrastructure) | Implementation (finalize service, plan process organization, technical implementation, piloting, market launch | |
| [25] | Definition | Requirements analysis | Conceptualization and implementation | Market launch |
| [18] | Repeat definition, analysis and synthesis until a blueprint (master design) for the service exists | | Implementation , documentation | Introduction, audit, market launch, final design |
| [19] | Service concept (develop concept in cooperation with customers, evaluate, analyze services of competitors, SWOT Analysis) | | Service system (specify resources), Service Process, Pricing | Market launch |
| [20] | Direction (Service strategy, screening for ideas, development of concept and assessment) | | Design (detailed description, market analysis, feasibility, models, marketing concept, employee training) | Testing (with customers), Introduction |
| [21] | Defining design attributes, setting design performance standards, generating and evaluating design concepts | | Developing design details, implementing the Design (organizationally) | Implementing the design (market launch), measuring performance/ satisfaction, improving performance |
| [26] | Define and analyze problem statement, identify and describe functions, and their structure, find solution, specify modules realistically | | Specify major modules, specify product, specify detailed parameters | [not covered] |
| [27] | Requirements analysis, product specification | | Construction, work scheduling, test scheduling, NC-Programming | [not covered] |
| [31] [32] | Extending product engineering approaches tot he scope of product-service systems, integrating their lifecycle models, „extraction“ | | Integration of products and services into bundles only for the operation stage of the physical product | Assembly, transport, sale, installation, use, maintenance, disposal |
| [28] [29] [30] | The design of product-service systems is done in an iterative design process, analyzing and synthesizing components | | No detailed concept, no implementation, focus on development until the product model is created | [not covered] |

# 4. Partial Application on Maintenance Services

## 4.1 Definition of the Variants Space

We applied the Configurative Service Engineering approach to two cases in the domain of corrective maintenance in the mechanical engineering industry sector. In each case, a value network of suppliers, original equipment manufacturers (OEM) and customers existed. As machine downtime in manufacturing might lead to significant costs, corrective maintenance processes in each value network have been designed to speed-up the repair processes. To identify the distinctive configuration parameters from these cases and to apply our approach, we investigated alternative process variants, which result from providing corrective maintenance services in different repair scenarios of machinery and equipment engineering goods.

Within the analysis of diverse corrective maintenance service processes, we identified constitutive parameters, which demand an adaptation of process models and the required infrastructure. Those parameters are listed in Figure 3. They have to be known up-front to make the underlying model configurable by annotating the parameters to model elements, such that customer-specific variants of the service process can be derived from the configurable model later on.

| Configuration terms | Parameter Values of the Configuration Terms | | | | | |
|---|---|---|---|---|---|---|
| Business Model Focus | Function | | Technical Availability | | Outcome | |
| Domicile of OEM | Germany | Switzerland | USA | Russia | China | ... |
| Domicile of User | Germany | Switzerland | USA | Russia | China | ... |
| Domicile of Supplier | Germany | Switzerland | USA | Russia | China | ... |
| 3rd Party delivery | possible | | | not possible | | |
| Maintenance by customer | possible | | | not possible | | |
| Spare part procurement | Supplier | | OEM | | User | |
| Current view of the model | Supplier | | OEM | | User | |
| Rank | Decision | | | Excecution | | |

**Figure 3:** Configuration parameters

The configuration parameter *business model focus* has a particular significant influence on the service process. Today, the machinery and equipment engineering industry is dominated by rather function oriented business models. Those business models focus on selling physical goods to their customers according to previously defined sets of features. After the machinery or equipment has been sold to a customer, the customers themselves or a mandated service provider conducts maintenance activities independently from the OEM and systems suppliers. Business models focusing on the function are common and highly important for technical maintenance services.

Though, suppliers increasingly rely on differentiating from competitors by providing solutions in terms of integrated value bundles consisting of physical goods and related services [36]. A multitude of empirical surveys back an increasing relevance of services provided along with physical goods. Major reasons for combining goods with services comprise (but are not limited to) the differentiation from competitors and a more customer-individual array of solutions. This leads to the provision of machinery and equipment in business models focusing on the technical availability of the machinery or even on the outcome of applying the machinery as operand resource in customers' manufacturing processes. In this case the customer is relieved of identifying causes of malfunctions on his own, because the operational availability is guaranteed by the OEM or supplier, as e.g. specified in a service-level agreement.

In business models focusing on the business outcome, the machinery or equipment even is not operated by customers. Instead, customers pay a fee for the output itself, without being involved in the production process. Realizing such business models requires manufacturers to complement their physical goods portfolio with e.g. maintenance services and operating services. If the machinery or equipment manufacturer possesses the required skills and resources, offering those such business models can be conducted independently. Elsewise, cooperating with external service providers, e.g. in a value network, might be a suitable strategy.

Faced with e.g. various different business models, providers of corrective maintenance services are challenged by the need to provide their services with a high variety. Service providers have to satisfy quite heterogeneous business demands of their customers. To meet them, firstly, they have to keep the machines and equipment in operation – regularly for a period of several years or even decades – at the construction site of the customer. Secondly, they may need to cooperate with several OEMs or suppliers during the sales phase of new machinery and equipment, to be able to provide business models with an availability or outcome focus.

The geographic location of the organizations participating in value networks also is important for designing service processes, e.g. due to assure compliance with tax regulations. Thus, in case of a cross-border supply of spare parts, current customs regulations have to be taken into account. The world-wide activities of the investigated value networks and a high divergence in those regulations (e g. in declaration, packaging and transport of the spare parts) results in multiple variants of the underlying business process. Furthermore, some spare parts might be also procured from third-party vendors. For other, especially for critical parts, this might not be permitted. If the defect part is repairable, additional processes for the preparation and execution of the repair process have to be conducted. Also, returns of unused spare parts have to be carried out. The accountability for spare part sourcing also is a major configuration parameter, which can vary with respect to the organization of value creation in the particular value network.

These configuration parameters were found in the cases to greatly effect the service process of corrective maintenance. Besides this effect, in our analysis we noticed that each company in a value network only requires information about specific subsets of the service process models. Thus, access to the process model may be restricted to only display the steps companies are involved in, while consciously blanking out other steps. Consistently, regarding our cases, we identified two views on the process model: The first view is dominated by the operational functions, the second view hightlightens the logistics functions for planning purposes. As shown before, these model adaptations can be accomplished by the mechanisms of configurative modeling.

## 4.2 Configurative Process Models

As stated above, the approach of Configurative Service Engineering addresses the entire organizational and IT infrastructure. Here, we demonstrate the implications of configuration mechanisms on business process models as one aspect of the organizational infrastructure.

From the cases, we constructed process models for the corrective maintenance process of technical equipment, representing the configuration of an enterprise's organizational infrastructure. Those models illustrate the control flow of the service process and outline, which organizational units are involved with each step of the service process. The process model comprises two levels of granularity: The first level contains elements of the value chain, which are then detailed on the second level by event-driven process chains (EPC).

We annotated configuration terms to each element of the value-chain model to outline that entire sub-processes only apply if specific configuration parameter values are met (cf. Figure 4). This allows e.g. for representing, that the "problem identification" process is contingent on the selected business model: In the case of a focus on the function, problem identification is initiated by the customer reporting a problem. In the case of the business model focusing on a defined outcome, the customer is not involved in problem identification, but the provider is responsible for keeping the machine in operation.

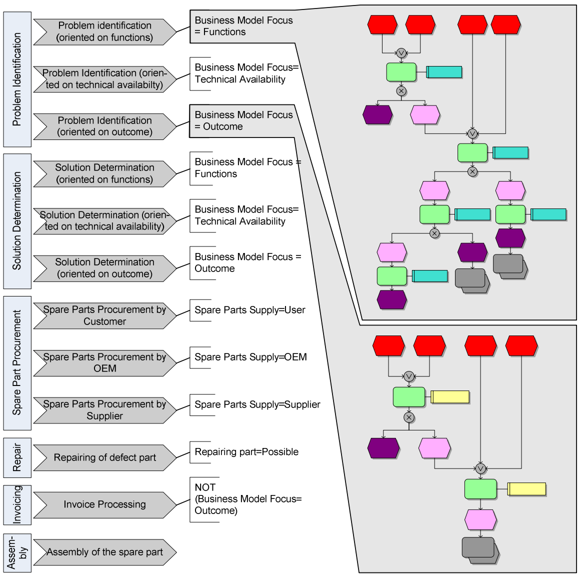


**Figure 4:** Elements and terms of a service process for corrective maintenance

Within the process chains for each of the clusters in Figure 4, further configuration rules have been defined. Therefore, we annotated configuration terms to all the model elements depicted in the event-driven process chains. E.g. the *spare part supply from third-party suppliers* activity has been labeled with the parameter "3$^{rd}$ Party delivery" and the value "possible" (cf. Figure 3). In case the value "possible" would later be replaced by the value "not possible" during configuration, the marked acitivity would automatically be excluded form the configurated process model, as the condition would be evaluated to be *false*.

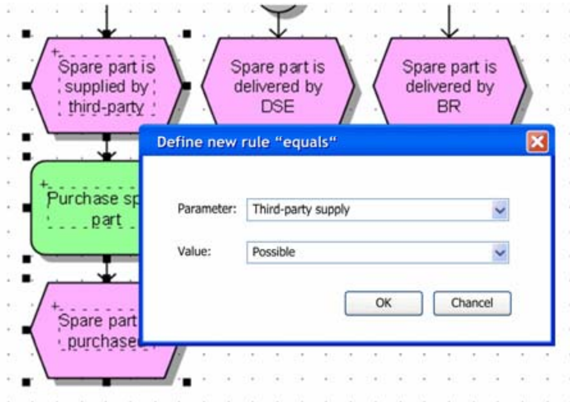


**Figure 5:** Assigning a configuration term to the service process model in Adapt(X)

The process models were modeled using the professional application "ARIS Toolset". The adaptation of the configurative process models was conducted utilizing the academic prototype Adapt(x) (cf. Figure 5), which is implemented as an extension of the ARIS Toolset. Figure 6 shows some service processes for corrective maintenance which have been configured from the originally engineered configurative process model. The top area shows the result on function cluster level, whereas the bottom illustrates implications on a process model level, dealing with spare parts supply in EPC notation. With this support at hand, process model variants of the corrective maintenance process can be generated rapidly, based on specific configuration parameter values.

After having been configured with Adapt(X), the resulting model variant is exported back into the ARIS Toolset. Subsequently, it can be further modified using the build-in process modeling functionality of ARIS. As elements not fitting the context to which the model has been configured have been blanked out during configuration, service engineers are faced with a model that is significantly easier to comprehend and to apply. Even so, this service process variant still is consistent with the previously engineered model, i.e. the service process blueprint.

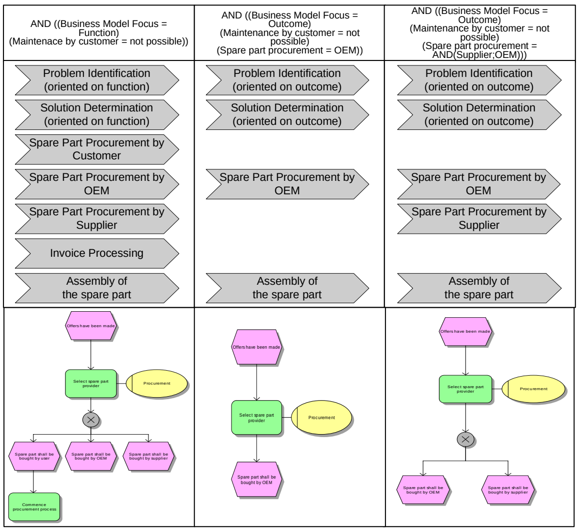

**Figure 6:** Configured service process variants

## 4.3 Lessons learned from applying Configurative Process Models

Our exploration of corrective maintenance processes in the mechanical engineering industry illustrated that configuration parameters can be identified to derive meaningful process variants. Having identified that set of configuration parameters is a prerequisite for formulating rules that explicitly describe the business models of service providers. Explicating those technical dependencies allows for a stronger intellectual grasp of the business and therefore is a valuable outcome for the investigated enterprises as well as from an academic point of view.

As illustrated, the business rules have been subsequently applied for designing configurative process models. We observed that the generic service models could be reduced substantially (though not all relevant parameters and values were regarded within our explorative case studies). The extent of configuration automatically conducted by the Adapt(X) tool was promising even in its present state of prototypical implementation. From a *user perspective* Configurative Service Engineering is expected to be a valuable instrument, which can be explored in further research steps.

The presented cases illustrated that constructing configurative models cause efforts for identifying rules and modeling them consistently, as this is the prerequisite to make the model eligible for configuration. Even so, this effort can be reduced in several ways:

(1) The model system (and also the related configuration rules) can be split up into value chain elements, detailed by EPCs. Thus, using configuration for large process blocks can save the effort of finding and annotating configuration terms to all the elements in the more detailed EPCs. Moreover, large process blocks can be modified with a limited set of rules, instead of modifying each unique block in the specified EPCs. This makes updating configuration rules more efficient and easier to handle.

(2) We consciously refrained from integrating all possible configuration parameter values into the models. Instead, we focused on parameter values with a high impact on the service process, as derived from our cases. Conducting all necessary model configurations automatically by intepreting configuration parameters turned out to be unrealistic. Therefore, we integrated the phase of a final manual adaptation into our proposed process model for Configurative Service Engineering.

(3) Particularly the rule-based definition of sequence variants turned out to be quite time-consuming. Therefore, we integrated an aggregation approach that allows for annotating sequence dependencies into model blocks (value chain level), although this does not map all sequence variants to EPCs and related configuration rules.

Taking these modifications into account, from a *service provider perspective* Configurative Service Engineering is expected to be an applicable and valuable instrument to handle their service processes consistently and yet satisfy heterogeneous customer expectations.

## 5. Conclusion and Outlook

We argued that configurative modeling can support variants management in generating (a) adapted organizational infrastructures and (b) adapted IT infrastructures with less effort and time expense. Therefore, we applied the technique of configurative modeling to the Service Engineering discipline and proposed an approach for a Configurative Service Engineering. We presented a procedure model to outline that Configurative Service Engineering takes place in two steps:

First, the configurable infrastructure has to be set up, defining the solution space that a supplier is capable of providing. Second, by conducting customer-specific configuration, which regards the demands of each specific customer, a configured infrastructure can be derived. Utilizing the configured infrastructure, services can be delivered in cooperation with customers. In consecutive research steps, a thorough validation of the concept is necessary to further underline its applicability and value in real-life scenarios.

So far, we illustrated the applicability of our concept on process configuration, focusing on a sub-aspect of the adaptation of the organizational infrastructure. Accordingly, configuration methods might also be applied to IT infrastructures. For example, the specification of a Service-Oriented Architecture supporting joined activities of service providers and physical goods manufacturers is one subject of our ongoing research activities and shall be presented here as a brief outlook.

Within our concept, the architecture's constituting Web Services can be integrated into the configuration process to gain a configurable IT infrastructure, supporting multiple specific service variants. The specified infrastructure supports service providers and goods manufacturers in several ways: (a) by describing data centered Web Services, supporting the information flow between information systems of service providers and goods manufacturers (b) by specifying Web Services providing additional business functions that coordinate the cooperation and allow for a global planning and analysis of the overall business model. In the context of the corrective maintenance process such functionality comprises:

- A cooperate *definition* of the integrated bundels consisting of physical goods and related services in a joined effort by service providers and manufacturers.
- A cooperate *resource planning and scheduling*, regarding technician manpower as well as duties of the goods manufacturer (e.g. the production and delivery of spare parts).
- A cooperate *information infrastructure* for supporting the operational corrective maintenance provision, with the goods manufacturer contributing information on the machine and parts, and the service provider contributing information on the service process (e.g. to foster innovation processes for physical goods manufacturers).
- A cooperate *financial clearing* process that allows for setting incentives for business partners cooperating in a value network. This might increase efficiency in handling operative financial flows and also allows for monitoring the overall efficiency in value networks.
- And finally, cooperate *controlling*, providing a Balanced Scorecard that assesses and illustrates the efficiency of the cooperation, focusing on measuring the cooperation with a set of key performance indicators. Indicators may comprise e.g. cooperation intensity, or the willingness and capability of the business partners to cooperate efficiently in a value network.

If generating a specific process variant, adaptation parameters (cf. Figure 3) can be interpreted for identifying which of those Web Services should be used to support a configured process instance. Both, adaptation parameters and selected additional business functionality can be used for deriving required information flows between service providers and goods manufacturers, which might also be business units of one company. Finally, those information flows might be implemented by data centered Web Services.

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## References

[1] Ganz, W., "Germany: Service Engineering", Communications of the ACM, July 2006, Vol. 49, No. 7, p. 79.

[2] Dietrich, B., "Resource Planning for Business Services", Communications of the ACM, July 2006, Vol. 49, No. 7, pp. 62–64.

[3] Sampson, S.E.; Froehle, C.M., "Foundations and Implications of a Proposed Unified Services Theory", Production & Operations Management, Summer 2006, Vol. 15, No. 2, pp. 329–343.

[4] Vargo, S.L. and Lusch, R.F., "The Four Service Marketing Myths. Remnants of a Goods-Based, Manufacturing Model", Journal of Service Research, Vol. 6, No. 4, May 2004, pp. 324–335.

[5] Grace, A.; Finnegan, P.; Butler, T., "Service Co-Creation with the Customer: the Role of Information Systems", Proceedings of the 16th European Conference on Information Systems (ECIS), Galway, Ireland, 2008.

[6] De Kinderen, S.; Gordijn, J., "E3-Service – A Model-Based Approach for Generating Needs-Driven E-Services Bundles in a Networked Enterprise", Proceedings of the 16th European Conference on Information Systems (ECIS), Galway, Ireland, 2008.

[7] Rosemann, M., and van der Aalst, W.M.P., "A Configurable Reference Modelling Language", Information Systems 23 (1), 2007, pp. 1-23.

[8] Soffer, P., Golany, B., and Dori, D. "ERP modeling: a comprehensive approach", Information Systems 28 (9), 2003, pp. 673-690.

[9] Becker, J., Delfmann, P., and Knackstedt, R. "Adaptive Reference Modeling. Integrating Configurative and Generic Adaptation Techniques for Information Models" In: Reference Modeling. Efficient Information Systems Design Through Reuse of Information Models. Editors: Becker, J.; Delfmann, P., Berlin et al., 2007, pp. 23-49.

[10] Delfmann, P., and Knackstedt, R. "Towards Tool Support for Information Model Variant Management. A Design Science Approach" In: Proceedings of the 15th European Conference on Information Systems (ECIS 2007). St. Gallen, Switzerland. 2007.

[11] Becker, J., Knackstedt, R., Pfeiffer, D., and Janiesch, C. "Configurative Method Engineering. On the Applicability of Reference Modeling Mechanisms in Method Engineering" In: Proceedings of the 13th Americas Conference on Information Systems (AMCIS 2007). Keystone, CO, USA. 2007.

[12] Becker; J., Delfmann, P., Dreiling, A., Knackstedt, R., and Kuropka, D. "Configurative Process Modeling. Outlining an Approach to Increased Business Process Model Usability" In: Information Through Information Technology. Editor: Khosrow-Pour, M., Information Resources Management Association. International Conference. New Orleans, Louisiana, USA. Hershey et al. 2004, pp. 615-619.
[13] Goeken, M., Knackstedt, R. "Multidimensional Reference Models for Data Warehouse Development" In: Proceedings of the 9th International Conference on Enterprise Information Systems (ICEIS 2007). Funchal, Portugal. 2007.
[14] Knackstedt, R., and Klose, K. "Configurative Reference Model-Based Development of Data Warehouse Systems" In: Managing Modern Organizations With Information Technology. Editor: Khosrow-Pour, M., Information Resources Management Association International Conference, San Diego, California, USA. Hershey et al. 2005, pp. 32-39.
[15] Becker, J., Janiesch, C., Knackstedt, R.; Rieke, T. "Facilitating change management with configurative reference modelling" Int. J. Information Systems and Change Management, 2 (2007) 1, pp. 81-99.
[16] Knackstedt, R., Winkelmann, A., Becker, J. "Dynamic Alignment of ERP Systems and their Documentations - An Approach for Documentation Quality Improvement" In: Proceedings of the 13th Americas Conference on Information Systems (AMCIS 2007). Keystone, CO, USA. 2007.
[17] Delfmann, P.; Janiesch, C.; Knackstedt, R.; Rieke, T.; Seidel, S.: Towards Tool Support for Configurative Reference Modeling – Experiences from a Meta Modeling Teaching Case. In: Proceedings of the 2nd Workshop on Meta-Modelling and Ontologies (WoMM 2006). Lecture Notes in Informatics. Karlsruhe, Germany. 2006. S. 61-83.
[18] Kingman-Brundage, J.; Shostack, L.G., "How to design a service", (Congram, C.A.; Friedman, M.L. Ed.): The AMA Handbook of Marketing for the Service Industries. AMA-COM, New York, 1991; pp. 243–261.
[19] Erdvardsson, B.; Olsson, J., "Key Concepts for New Service Development",The Service Industries Journal, 16 (1996) 2; pp. 140–164.
[20] Scheuing, E.E.; Johnson, E.M., "A proposed model for new service development", The Journal of Services Marketing, 3 (1989) 2, pp. 25–34.
[21] Ramaswamy, R., "Design and Management of Service Processes", Addison-Wesley, Reading 1996.
[22] Beverungen, D.; Kaiser, U.; Knackstedt, R.; Krings, R.; Stein, A.: Konfigurative Prozessmodellierung der hybriden Leistungserstellung in Unternehmensnetzwerken des Maschinen- und Anlagenbaus. In: Proceedings of the Multikonferenz Wirtschaftsinformatik. Munich. 2008.
[23] DIN Deutsches Institut für Normung e.V. (Ed.), „DIN-Fachbericht 75", Beuth Verlag, Berlin, 1998.
[24] Jaschinski, C., „Qualitätsorientiertes Redesign von Dienstleistungen", Shaker Verlag, Aachen, 1998.
[25] Meiren, T., „Entwicklung von Dienstleistungen unter besonderer Berücksichtigung von Human Ressources". In (Bullinger, H.-J. Ed.): Entwicklung und Gestaltung innovativer Dienstleistungen, Tagungsband zur Service Engineering 2001. Stuttgart 2001.
[26] VDI (Ed.), „VDI-Richtlinie 2221. Methodik zum Entwickeln und Konstruieren technischer Systeme und Produkte", Beuth Verlag, Berlin, 1993.
[27] Scheer, A.-W., „CIM Computer Integrated Manufacturing – Der computergesteuerte Industriebetrieb", Springer Verlag, Berlin, 1990.
[28] Weber, C.; Steinbach, M.; Botta, C.; Deubel, T., "Modelling of Product-Service Systems (PSS) – Based on the PDD Approach", In (Marjanovic, D. Ed.) Proceedings of the 8th International Design Conference, Dubrovnik/Croatia, 18.-21.05.2004. Zagreb 2004; pp. 547–554.
[29] Steinbach, M., „Systematische Gestaltung von Product Service Systems: Integrierte Entwicklung von Product Service Systems auf Basis der Lehre von Merkmalen und Eigenschaften", Saarbrücken : LKT, Lehrstuhl für Konstruktionstechnik/CAD, Univ. des Saarlandes, 2005 (Schriftenreihe Produktionstechnik; Bd. 35).
[30] Botta, C., „Rahmenkonzept zur Entwicklung von Product-Service Systems: Product-Service Systems Engineering", EUL Verlag, Lohmar, 2007.
[31] McAloone, T. C., "Teaching and Implementation Models for Sustainable PSS Development: Motivations, Activities and Experiences", Sustainable Consumption and Production: Opportunities and Threats, 23-25 November 2006, Wuppertal, Germany: Launch conference of the Sustainable Consumption Research Exchange (SCORE!) Network, 2006; pp. 119–130.
[32] Tan, A.; McAloone, T.C.; Andreasen, M.M., "What Happens to Integrated Product Development Models with Product/Service-System Approaches", Proceedings of the 6th Integrated Product Development Workshop, IPD2006, October 18–20, Otto-von-Guericke-Universität Magdeburg, Schönebeck/Bad Salzelmen, Magdeburg, 2006.
[33] Luczak, H.; Sontow, K.; Kuster, J,; Reddemann, A, and Scherrer, U. "Der systematische Weg von der Idee zum Leistungsangebot", Transfer-Centrum-Verlag, München, 2000.
[34] Baldwin, C.Y. and Clark, K.B., "Managing in an Age of Modularity", Harvard Business Review, September-October 1997, pp. 84–93.
[35] Garud, R. and Kumaraswamy, A., "Technological and organizational designs for realizing economies of substitution", In: Garud, R. Kumaraswamy, A., and Langlois, N. (Eds.) Managing in the Modular Age, Architectures, Networks, and Organizations, Blackwell Publishing, Malden et al., 2003, pp. 45–77.
[36] Tuli, K.R.; Kohli, A.K.; Bharadwaj, S.G., "Rethinking Customer Solutions: From Product Bundles to Relational Processes, Journal of Marketing, Vol. 71, No. 3, 2007, pp. 1-17.