Engineering and Evaluation of Process Alternatives in Tactical Logistics Planning

Michael Glöckner, Stefan Mutke and André Ludwig
Information Systems Institute, Leipzig University, Grimmaischestraße 12, 04109 Leipzig, Germany

Keywords: Logistics, Planning, Model-driven, Process Alternatives, Evaluation.

Abstract: The objective of tactical planning in logistics is the engineering and evaluation of processes within a given set of possible alternatives. Due to outsourcing and a division of labor, a high number of participants, available services and thus possible process alternatives arises within logistics networks. The additional wide range of service description and annotation methods result in a complex planning process. In order to support planning, a semi-automated approach is presented in this paper that is based on a combined catalog and construction system (for engineering) and a generic simulation approach (for evaluation) that are able to handle the variety of description and annotation methods. The basic concepts are presented and afterward associated by a model-driven approach in order to connect them and make them compatible to work with each other. Finally, a method is developed to foster a semi-automated engineering and evaluation of process alternatives.

1 INTRODUCTION

Logistics focuses on planning, operating and monitoring systems that comprise material flow as well as the related information flow (Gudehus and Kotzab, 2012). Resulting from the common paradigms of division of labor and outsourcing, a high number of participants within logistics systems arises. Each of them maintains a wide range of IT-systems as well as a wide range of services with differing provider-specific descriptions (Arnold et al., 2012). This complexity is difficult to be handled, e.g. see (Faber et al., 2002), (Stevenson and Spring, 2007) in order to negotiate and fulfill specific and individual logistics contracts. Especially, the fact that the planning phase of a logistics system forms the basis of all future operations and system's results implicates a challenging issue that arises from the high amount of services, their descriptions and possible combinations.

Planning is generally differentiated into the commonly accepted classification of strategic (long-term), tactical (mid-term) and operational (short-term) planning (Stadtler et al., 2011). Tactical planning in logistics is typically situated in the competence area of central logistics departments (Stadtler et al., 2011), which could also be outsourced to and represented by a central logistics integrator (e.g. fourth party logistics service provider (4flow AG, 2014), (4PL Central Station Deutschland GmbH, 2014) or lead logistics provider), while actual operation and physical movement of goods is carried out by subsidiary logistics service providers (LSP) (Handfield et al., 2013), (Langley and Terry, 2014). Tactical planning in logistics addresses the flexibility of processes (volume, delivery and preconditions of operation) as well as supply chain design, relationships and inter-organizational information systems (Stevenson and Spring, 2007), (Esmaeilikia et al., 2014), (Schütz and Tomasgard, 2011). The term flexibility means the ability to be easily modified by maintaining and analyzing a variety of alternatives in order to choose the best for a specific task under current conditions (Bibhushan et al., 2014). In summary, tactical planning in logistics focuses on the *engineering* of available process alternatives and their *evaluation* (Esmaeilikia et al., 2014).

When analyzing the applied methods of tactical planning in logistics, literature provides a wide range of publications addressing that specific topic, see e.g. (Gudehus and Kotzab, 2012), (Esmaeilikia et al., 2014), (Rushton et al., 2014), (Hompel et al., 2007). Consensus of all approaches is a planning procedure subdivided into several distinct phases, whereas there are different numbers of phases and aspects to be considered in each approach. Further consensus could be found in a non-linear phase-sequence as iterative loops are allowed and encouraged in order to develop appropriate solutions. Another important similarity – as already pointed out – is the development of distinct

Glöckner M., Mutke S. and Ludwig A..
Engineering and Evaluation of Process Alternatives in Tactical Logistics Planning.
DOI: 10.5220/0005377801660176
In *Proceedings of the 17th International Conference on Enterprise Information Systems* (ICEIS-2015), pages 166-176
ISBN: 978-989-758-097-0

planning alternatives and the subsequently evaluation of each in order to either approximate the current solution towards an optimum or to find the best solution to a given task. However, a common shortcoming of planning methods is an inadequacy in a specific description on how to create and evaluate process alternatives.

Especially tactical planning - as the foundation of flexibility - in the field of transport and distribution is underrepresented in research (Esmaeilikia et al., 2014). Further, the related adaptable IT is important for inter-organizational information linkage (Stevenson and Spring, 2007), (Bibhushan et al., 2014). This leads to additional difficulties as a variety of annotations and modelling methods exists next to the variety of IT-systems of the LSP. Hence, the paper focuses on fostering tactical planning issues on IT-level. Since tactical planning lacks in a concrete method for developing different alternatives and this issue is an essential aspect for flexibility, an approach is needed that supports the finding and subsequent evaluation of alternatives. A comprehensive overview of currently available alternatives of services and processes in logistics networks is needed to develop a wide range of potential solutions. Due to a high number of participants and their diverse approaches for service description within an open logistics network (Arnold et al., 2012), (Langley and Terry, 2014), a suitable solution for engineering and evaluation of services and processes within the heterogeneous LSP-landscape (and their related service descriptions and IT-systems) could be found in a *model-driven* approach.

The paper's contribution is a method for linking engineering and evaluation of process alternatives to support logistics integrators. After presenting the basic concepts in section 2, a model-driven approach is introduced in section 3 that focuses on their combination using a common metamodel. The derived method for engineering and evaluation in section 4 and a summary with future research prospects in section 5 conclude the paper.

2 BASIC CONCEPTS AND RELATED WORK

With the issues in mind (engineering of alternatives and their evaluation), the following section introduces at first an approach for a combined catalog and construction system (the logistics service map) for engineering and afterward focuses on simulation in logistics as an approach for the evaluation of service and process alternatives.

2.1 Logistics Service Map

The challenge of retrieving appropriate services with inhomogeneous descriptions from different IT-systems (Arnold et al., 2012) that arise from a complex logistics network with numerous participants demands a solution that is commonly accepted by all network participants. Those challenges create the requirement of presenting the services of a network in a common way (catalog function) and combining them to composite services (modular service construction system function). This issue can be solved by the concept of the service map (SM).

The concept of the SM addresses the challenges by combining these two functions (Glöckner and Ludwig, 2013). On the one hand a catalog of all available services and process activities is provided. Every network participant has to subscribe its services to this catalog in order to have a commonly used single point of truth. With these characteristics the SM covers the conceptual functionality of a service repository. Though, to increase usability, the overview could be categorized by the user’s needs in different abstraction layers. As shown in Fig. 1, a graphical representation with two spatial dimensions for the user-chosen categories simplifies the interaction for the users when searching for services or process activities. In that way, service retrieval is enhanced and can be done in an intuitive way. Besides the intuitive manual usage, the catalog function also fosters a systematic categorization for (semi-) automated usage and engineering. On the other hand, the concept includes a modular service construction system in order to combine atomic services to composite services. Through combination, service descriptions of the composite services are also derived so that they could be transformed into process models later on, e.g. for mediation and collaborative planning in networks. With this approach, the network participants are supported in retrieving services in different use cases. (1) Adding a new service provider to the network and match its offered services to the existing set of services in a logistics network by adding the new service provider to the provider list of the particular services. (2) Developing a new composite service to meet a specific customer’s need by selecting and composing services from the SM. Service-specific information and attributes can be displayed when changing the selected granularity

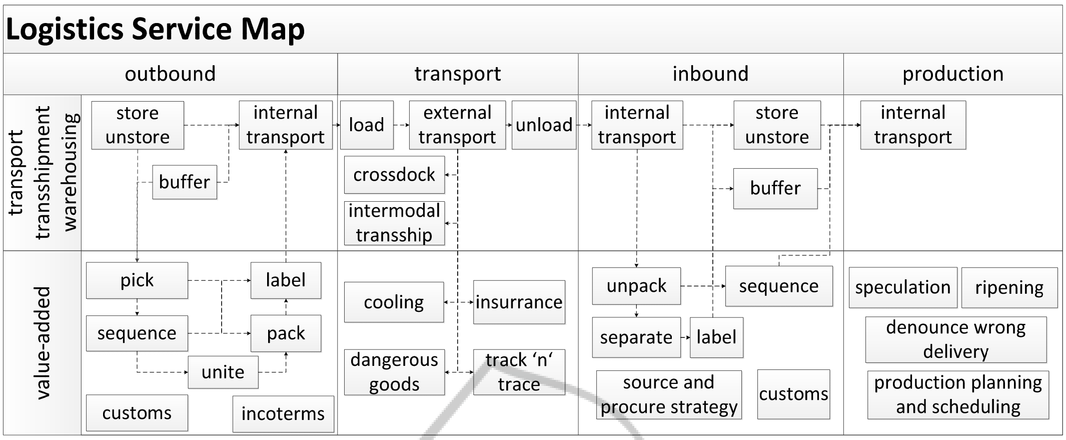

Figure 1: Exemplary service catalog with two dimensions: 'classic logistics function vs. value-added' and 'stage-specific'.

to a more detailed level to foster engineering and management. Moreover, the unique standard of the used set of services within a network and the visualization foster a precise mediation and communication between all stakeholders during the whole service life-cycle. (3) Finding compensational service or provider when realizing the urgency for re-planning or elimination of errors because of unpredictable disturbances in the network or an insufficiency in solving a given task. Consequently, the SM is capable of representing and creating planning alternatives.

Literature provides a wide variety concerning the SM concept. Either (a) the term 'service map' is used and also the functionality meets partly the requirements mentioned above, e.g. (Kohlmann and Alt, 2009), (Kim et al., 2013), (Vaddi et al., 2012), (Kutscher and Ott, 2006), or (b) the term is used but a different substantial functionality is addressed, e.g. (Mi Sun Ryu et al., 2006) or (c) the term is not used but the described concept partly includes functionality for the mentioned purpose, e.g. (Kohlborn et al., 2009), (Fleischer et al., 2005). Collectively, none of the approaches comprise both functionalities of catalog and construction system. As the SM concept comprises both, its functionality enables the engineering of services for a later combination to more complex processes. Hence, the creation of process alternatives could be realized with the use of this concept.

2.2 Simulation in Logistics

The planning of value-added logistics services is performed using several different models (e.g. process model, service profile, and simulation model). A rough plan, including each sub-service and their temporal dependencies, is represented by a process model. Based on this, dynamic aspects of logistics systems can by analyzed using simulation. The main task of simulation in logistics is to study the behavior of complex logistics services (e.g. lead times, transport volumes and capacities) to ensure that customers' requirements can be met. Thus, it is possible to analyze the flow of goods through the logistics system with regard to the capacity to identify bottlenecks at an early stage. As a result, simulation models of logistics networks can be used to *evaluate* different process alternatives and consequently improve the decision-making process in the tactical planning. Especially discrete-event simulation (DES) is appropriate to enhance decision support in the planning process by analyzing several system configurations, which differ in structure and behavior (VDI-Richtlinie, 2010). However, the use of simulation also leads to a number of problems.

As mentioned previously, different models (process model, provider models and simulation model) are used within the planning process. This is a major problem because each time a model is slightly modified any of the other related models must also be revised. As already outlined in the introduction, the modeled information itself could also differ from one provider to another whereby a wide range of descriptions and used annotations arises within a network with a high number of participants. This increases the modeling effort. Further, building simulation models requires special training and experience to avoid errors. It is a methodology that is learned over time. Consequently, the creation and analysis of simulation models could be expensive while consuming an enormous amount of time. This can lead to a non-profitable use of simulation (Banks, 1998). As a consequence, the effort for the development of simulation models has to be reduced. In terms of planning logistics systems several models are used. These models build upon one another and show dependencies among each other. A change in a model also implicates and claims changes in subsequent models. To ensure the interaction between simulation and other models, simulation techniques have to be well-integrated in the planning process (Mutke et al., 2012). It is necessary that the created process models within the planning process, based on a separate description of each logistics service, can be transformed automatically into a simulation model. Accordingly, an approach to combine different heterogeneous planning models in order to force the reuse of already modeled information is needed. This requirement aims to minimize the planning effort of a logistics Integrator by reusing already modeled information. In addition, manual errors in the creation of a simulation model are avoided. Furthermore, the need for special training and special experience in simulation model building is reduced.

In this section an approach is presented to transform process models into simulation models in order to reuse already modeled information and thus reduce modeling effort. Related work is presented by describing different simulation approaches that have influenced the development. Simulation is widely used in the field of logistics in order to plan logistics systems. Ingalls discusses the benefits of simulation as a method to study the behavior of logistics networks (Ingalls, 1998). Additionally, advantages and disadvantages are illustrated for the analysis of supply chains with the use of simulation. A concrete simulation approach is not provided. In (Cimino et al., 2010), a commonly applicable simulation framework for modeling supply chains is presented. Contrary to (Ingalls, 1998), they focus on a more technical perspective as they show an overview of event-discrete simulation environments in terms of domains of applicability, types of libraries, input-output functionalities, animation functionalities, etc. Cimino et al. also show how and when to use certain programming languages as a viable alternative for such environments. A modeling approach and a simulation model for supporting supply chain management are presented by Longo and Mirabelli in (Longo and Mirabelli, 2008). They also provide a decision making tool for supply chain management and, therefore, develop a discrete event simulation tool for a supply chain simulation. All these approaches are relevant for developing an integrated planning and simulation approach. However, all these approaches satisfy the logistics integrator's specific requirements (Mutke et al., 2012) only partially. The development of simulation models based on process models is insufficiently considered.

In addition, we make use of transformation approaches for defining transformation models as a mediator between process and simulation models. In both approaches of (Petsch et al., 2008) and (Kloos et al., 2010) a transformation model is used in an additional step in order to derive a simulation model from an already existing process model. Both approaches take the fact that process models are independently defined from simulation requirements. In practice, process models serve to foster transparency or documentation and to analyze the requirements for the introduction or implementation of new information systems. However, both approaches assume that a process model is defined using Event-driven Process Chain. Cetinkaya proposes a comprehensive theoretical framework for model driven development in the field of M&S for the efficient development of reliable, error-free and maintainable simulation models (MDD4MS framework) (Cetinkaya, 2013). In a case example it is shown, MDD4MS framework is applicable in the DEVSbased discrete event simulation domain. The transformation of the BPMN elements into DEVS components has provided an effective way to easily model and simulate business processes. However, the MDD4MS framework currently provides only model transformation method from BPMN process model (conceptual modeling language) to DEVS (platform-independent simulation model) and from DEVS to Java (platform-specific simulation models). Furthermore, the required parameters for simulation were added directly in the Java code and thus can be performed by simulation experts only. Huang describes another interesting approach for Automated Simulation Model Generation (Huang, 2013). The proposed method can use existing data to automatically generate simulation models. Therefore, a domain meta-model and the model component library have to be designed before the existing data can be used to provide the information about the model structure and parameterization. However, in contrast to our research the use of existing process models as source models are not considered. Nevertheless, the use of existing data for the parameterization of simulation models shows similarities to our research.

The added value of the simulation approach presented in this paper is the automatic transformation of existing process models to simulation models as described in the following. A process model, e.g. Business Process Model and Notation (BPMN) or Event-driven Process Chain (EPC), is simulation independent, i.e. the model does not contain any information regarding to the dynamic aspects such as arrival times, processing times or capacities. The process model is transferred into a transformation model and enriched with information required to run a simulation. However, the transformation model is platform independent and therefore cannot be executed in a specific simulation tool. The specific simulation models (e.g. Enterprise Dynamics (ED), Arena) are generated from the transformation model. The structure of the transformation model is described in more detail in (Mutke et al., 2013a). Fig. 2 illustrates this approach.

Even though simulation provides a possibility to evaluate process alternatives, the main problem in the current context is a dependency on existing process models in order to conduct their evaluation via simulation models. Accordingly, a combination with the former presented SM concept appears to be a suitable approach for an integrated engineering and evaluation of process alternatives. The connection of both concepts is presented in the following section.

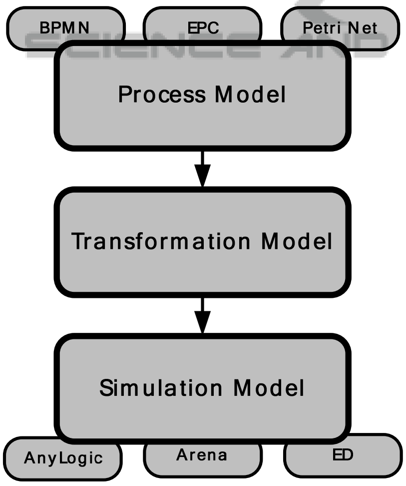

Figure 2: Transformation approach from process models to simulation models.

3 MODEL-DRIVEN CONNECTION OF CONCEPTS

The combination of the presented concepts for engineering and evaluation of process alternatives is realized with a model-driven approach. General information about and a foundation of model-driven development and metamodeling can be found in (Atkinson and Kuhne, 2003). The basic idea of this approach is to create metamodels for the several concepts that conform to a common metametamodel. As models are derived from those metamodels and thus conform to them as well, interconnection and data-consistency can be ensured between models with a (transitive) common metametamodel. In the beginning the distinct metamodels of both concepts are introduced and connected at the end of the section.

3.1 Service Map Metamodel

Fig. 3 shows the current version of the SM metamodel (Glöckner et al., 2014). The SM supports the categorizing and development of services. Instances of the SM can be derived by the logistics integrator from the metamodel to describe specific service catalogs of a network. The advantage of a metamodeling approach is a high abstraction that provides a high reusability in a wide range of cases and a simple interaction between several instances. The SM metamodel follows the restrictions of the service modelling framework (SMF) (Augenstein and Ludwig, 2013), i.e. based on the EMOF (Essential Meta Object Facility) compatible Ecore metametamodel of the Eclipse Foundation.

Each instance of the SM metamodel consists of exactly one catalog containing services available within the network. This catalog is structured using categories that depend on a specific domain (i.e. logistics in our case). Thus, the catalog represents a structured overview of services, each capable of one or more capabilities. These capabilities belong to specific categories and are restricted by the concrete domain. For instance, on a high level capabilities represent the ability to transport, store or to fulfil more complex composite and value adding services. In order to provide capabilities in terms of services, a provider owns specific resources like trucks or warehouses which are consumed during service execution but typically are available again afterward. Each provider is also allowed to specify zero or more service level agreements (SLA) for its services in which it specifies service level constraints and service provisioning in terms of payment. Finally, services can either depend on other services or are restricted not to work with other services. Exemplary, restrictions for the transportation of dangerous goods could be mentioned, see (ADR, 2012). Therefore, each service contains references to others which are either available for the definition of a composite service (allowedSiblings) or not (deniedSiblings).

With the metamodel the contained information itself as well as the existing connections and attributes between several classes are structured and thus facilitate retrieval processes and allow an information based connection to other types of models or between different instances of SMs.

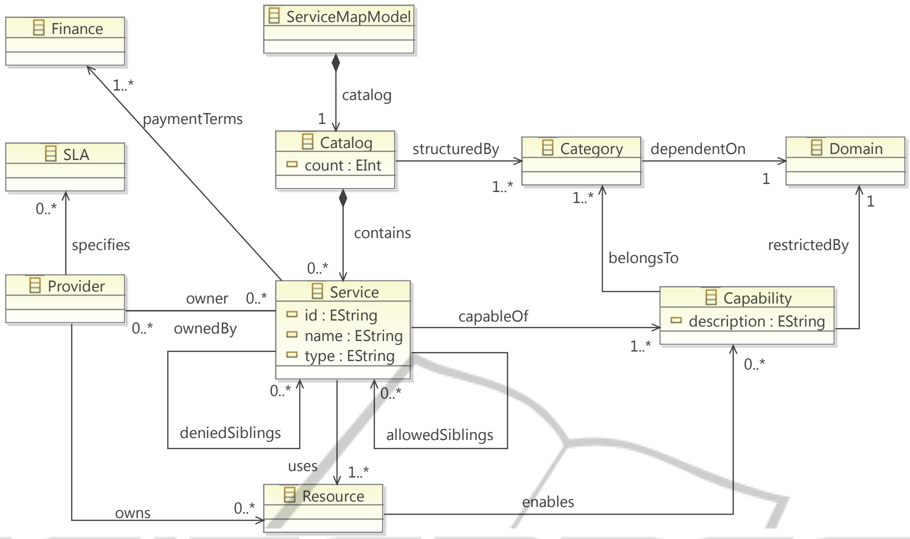

Figure 3: Service Map Metamodel.

3.2 Generic Simulation Metamodel

The generic simulation metamodel also follows the approach of the service modelling framework (SMF) (Augenstein and Ludwig, 2013), i.e. based on the EMOF compatible Ecore metametamodel of the Eclipse Foundation.

In the following, the approach is described in more detail and it is shown how the generic simulation metamodel (platform independent) was created considering the basic concepts of DES and the specific requirements from the perspective of a logistics integrator. Process models describe functional or structural aspects that are relevant for a process. Depending on the used process model notation, these functional aspects (e.g. Task in BPMN, Function in EPC, Transitions in Petri Net) represent the different partial logistics services (LSs) as part of the overall process in the scope of a logistics integrator's planning process. In (Hoxha et al., 2010) an approach for formal and semantic description of services in the logistics domain using concepts of service orientation and semantic web technologies is presented. The approach also categorizes and describes modular LSs such as transport, handling, storage, value-added services, etc. using a logistics ontology. Concepts of this ontology are used in this research paper to refer to the description of specific LSs from the functional aspects depending on the used process model language (Task, Function or Transition). Thus, each functional aspect is assigned to a specific logistics service type. Consequently, the result is a process model including all LSs necessary to meet customers' requirements. Despite having a process model and using this model as the basis for creating a simulation model, for simulation additional information as to the pure visualization of the processes is necessary. Therefore, literature was analyzed concerning information that is additionally required to create a simulation model and relating basic concepts were derived (Entities, Events, Attributes, Activities and Delays) (Mutke et al., 2013b). In addition to these basic concepts of DES, a simulation also has logistics-specific properties. Therefore, two simulation tools using an application-oriented modeling concept (ED and Arena) have been used to create different examples of simulation models in order to study transport volumes and capacities. These tool-dependent models have been analyzed and compared in terms of used modeling concepts and the required data. The common concepts of these tool-dependent models and the basic concepts of DES were used to create the metamodel shown in Fig. 4.

The generic simulation metamodel basically consists of SimulationElements, SimulationParameters and Relations. A Source generates goods at predefined time periods and they leave the model at the Sink. The purpose of an Activity is to manipulate goods in some ways, e.g. to store or to transport them. Therefore, Goods enter an activity and remain there for a certain time period. Moreover, an activity is assigned to a certain ServiceType which defines the specific functionality of this activity. These three main concepts are subsumed under SimulationElements. All Time periods can also be specified more precisely with the help of Distribution functions. Regarding the service

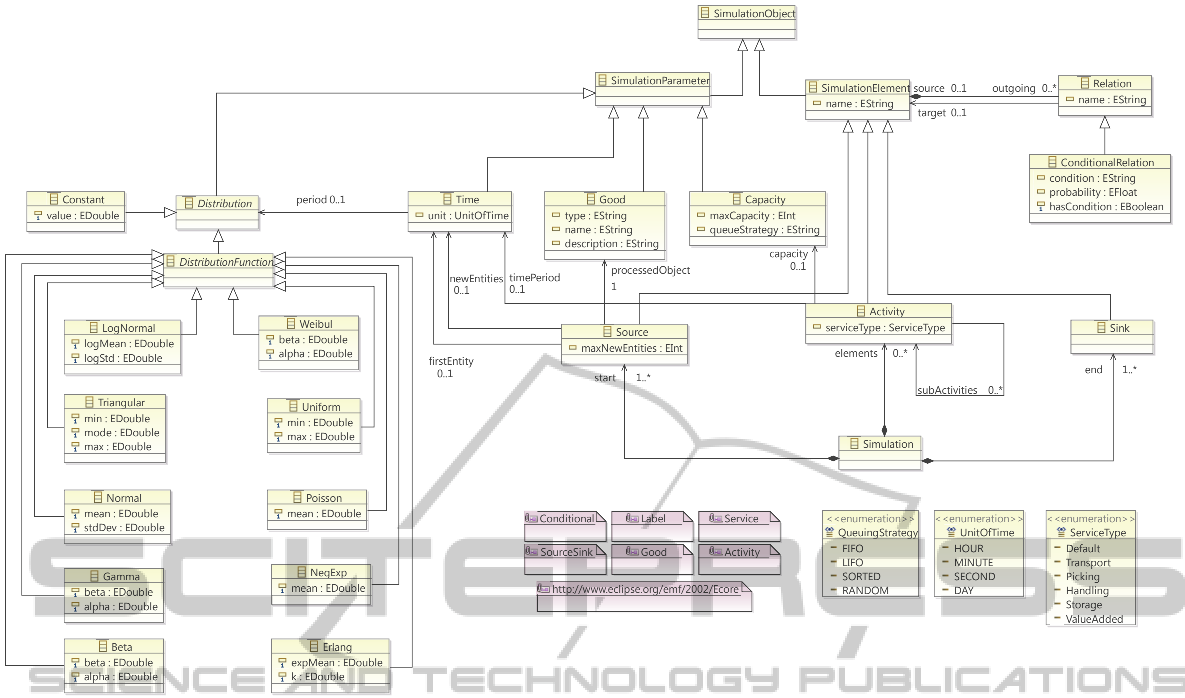

Figure 4: Generic Simulation Metamodel.

type, a Capacity is an additional characteristic of an activity. For instance, an activity with the service type “warehouse service” is restricted by a maximum capacity and has a certain queuing strategy. Time, capacity, goods and distribution are subsumed under SimulationParameters. The connecting elements between the activities are represented by two different kinds of Relations. On the one hand, relations can be simple, i.e. without specific characteristics. On the other hand, a connection between activities can be represented by ConditionalRelations with additional, specific characteristics (conditions, probabilities). Depending on values of these characteristics, in a simulation either one or the other path is used.

With this metamodel, it is possible to create simulation-tool-independent models, which contain all information necessary to perform a simulation. Further, a structure is built between several information aspects and thus fosters a parameter specific evaluation and improvement of processes.

3.3 Connection of Metamodels

The metamodels are kept simple and only consists of a few essential elements and their relationships. As both follow the SMF of (Augenstein and Ludwig, 2013) it is possible to interconnect models and model elements from different models, respectively with the common service model (CSM) (Augenstein et al., 2012). The CSM approach contains a metamodel for integration and transformation of differing models. Purpose of the CSM is to uniformly interweave distinct service models, each representing unique aspects of a service, and thus on model-level enables a generic and modular service model. Both models are defined through the same modeling language on metamodel-level, i.e. Ecore metametamodel. Hence, we are able to reuse information contained in these models and to easily interweave them. The metamodels are defined in Ecore but could be easily implemented in other frameworks as well.

The *Service* is the central element of the SM metamodel. As services implicate a kind of input and output connected to a certain capability and can contain sub-services, a connection to the *Activity* element of the generic simulation metamodel is suggested. Hence, an interchange of information and an automated workflow can be implemented to combine *engineering* and *evaluation* of process alternatives.

4 METHOD ENGINEERING

In this section a method for semi-automated engineering and evaluation is developed. The leading approach is a process model for method engineering. After connection of the basic approaches a brief flow chart illustrates the results and contribution of this paper.

The process model for method engineering presented by Ralyté and Roland outlines two different strategies for assembling so called 'method components', 'method chunk' or 'method fragments'. Depending on the characteristics, either an *association* strategy or an *integration* strategy is proposed for assembling method components (Ralyté and Rolland, 2001). The first strategy is recommended for method components without any common elements. This case occurs e.g. when basic components are working in a serial manner, i.e. the output of one component is used as the input for another component. Thus, by associating the two initial components a method can be created that provides a larger coverage than any of the basic ones. Hence, the objective of this assembling process strategy is to retrieve connection points and building a bridge between them. In contrary, the latter strategy concentrates on merging overlapping elements in two components that focus on similar tasks but with e.g. different solving strategies. The range of possible results remains similar but functionality is enhanced. The focus of this assembling process strategy is the retrieval of overlapping elements in order to merge them. Consequently, the *association strategy* is suitable for the purpose of this paper. *Engineering* and *evaluation* are two different 'method components' that focus each on solving different tasks. Further, the output of the engineering, i.e. one or more process alternatives, constitutes the input for the subsequent evaluation. The non-existence of common elements, which is to be recognized when comparing the given metamodels, underlines the decision for the *association* strategy as well as the serial characteristic of the designated final functionality of the two initial components.

The figuring out of connection points for the association of the basic components is also based on the approach of Ralyté and Roland, taking (Castano and Antonellis, 1993) and (Jilani et al., 1997) into account. Mainly, the original approach focuses on detecting semantical and structural similarities between the elements of the two components that are to be connected. By evaluating their common properties and links, several similarity measures are calculated to conduct the assembly later on. However, an adapted and for the purpose of this paper simplified argumentative-deductive version is used. As already outlined, the *Activity* element of the simulation metamodel comprises an input-output relation for a specific object. Further, there exists the possibility to divide activities into sub-activities and they are always restricted by a certain capacity. This complies with the *Service* element of the SM metamodel. A service also focuses on taking an input object in order to releasing a modified output object. The division into subservices or combination to composite services also complies with the activity-pendant. Finally, as a service always depends on a certain resource and those resources have inherent distinct capacities, a similarity can be postulated between those aspects. As the original purposes of the two metamodels strongly differ, no other similarities can be figured out. In summary, the analysis of the metamodels shows that the suggested possible connection point from the former section, which was stating a possible association between the *Activity* and the *Service* element, can be confirmed.

Following (Ralyté and Rolland, 2001), the 'specification of method requirements' is outlined in the introduction in section 1 and the 'construction of the basic method components' is conducted through the cited literature of section 2 and 3. Subsequently, the paper now proceeds with the 'assembly' by determining the order of the components, identifying the connection point, i.e. the product of the first component that constitutes the source for the second one, and merging both. The final result is shown in Fig. 5. The engineering of an alternative before evaluating it implies the order of the components. Moreover, an iterative loop is obligatory until all possible alternatives are calculated. Connection point between the two components is the process model of the composite service that is the output of the construction system, as it is simultaneously the input for the transformation model for the later simulation.

The final method starts with the determination of customer requirements and the selection of the process or composite service from the repository that is to be (re-)planned. After selecting the process steps or sub-services that are to be alternated and analyzed the loop iteration starts. When no alternatives are available, an empty list of alternatives is presented to the user. As long as alternatives are still available, for every chosen (sub-) service all available alternatives from its category in the catalog are selected to create a new composite service in the construction system. With the derived description of the composite service, the *engineering of the process alternative* is conducted and a process model is created as the output of the first method component. The process model as the source of the generic simulation approach, is transformed into the transformation model, enriched with necessary simulation parameters, which could be analyzed and inserted e.g. from former operation statistics (like service profiles

(Roth et al., 2014)) to fully automate the method, to subsequently run the simulation in order to conduct *the evaluation of the process alternative*. If the customer's requirements are met by the current alternative, it is added to the list that will be shown to the user later on. If not, the procedure continues without saving. If all available possibilities within one category for a specific sub-service are evaluated, the next sub-service is chosen to be alternated. After all sub-services have been alternated and all possible process alternatives have been evaluated, the final list with all alternatives, which meet the given customer's requirements, is presented to the user. Sorted by its preferences, e.g. SLA, lead time, costs, the user could choose its favored alternative that is to be implemented afterward.

A simple use case could be a customer that is unsatisfied with the current performance of its supply chain that was planned by the logistics integrator. By analyzing the current performance parameters the lack in a certain transportation and a packing services is revealed. Hence, the integrator selects those services within the supply chain to be alternated and the resulting alternatives to be evaluated regarding the customer's required performance parameters. Another use case could be a disturbance within a supply chain through an insolvency of one LSP within the network. Hence, cheap or reliable alternative LSP are to be found for the affected supply chain processes.

5 CONCLUSIONS

As current planning approaches in literature lack in a specific description on how to create process alternatives that are evaluated afterward, this paper presented a new method for engineering and evaluation of process alternatives in tactical logistics planning. The method consists of two basic concepts, the service map as a combined catalog and construction approach for service engineering and a generic simulation approach for evaluation. Both concepts are especially designed for working in an environment of heterogeneous service descriptions and process models. By combining both concepts through a model-driven approach, the basis for interweaving the contained information is ensured. With the process model for assembling methods from sub-components, an associated method for combined planning and evaluation is finally developed.

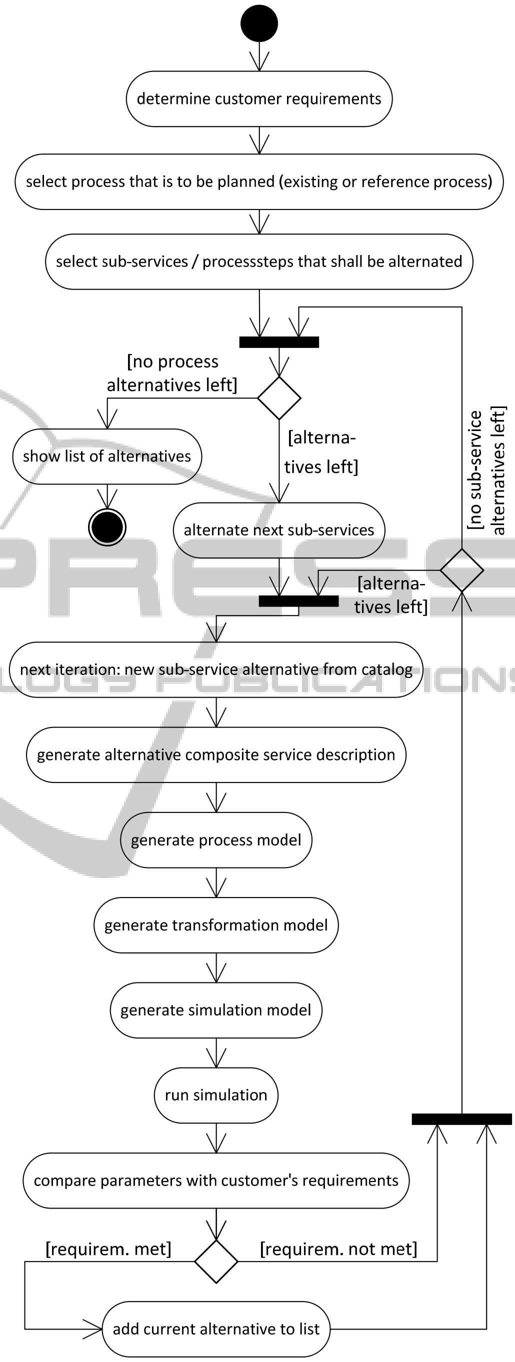

Figure 5: Activity diagram of resulting method.

Academic implication of the current article is a first method towards automated and integrated engineering and evaluation of process alternatives in the heterogeneous field of logistics. Current literature about planning in logistics does only propose to create several alternatives and to evaluate them, but does not provide explicit methods on how to do so.

Hence, the current paper also aims at motivating further research by the community in the field of IT-supported fostering of planning.

Managerial implications cover the development of interest in (semi-)automated planning support. Further, cited references could be used to gain deeper understanding in particular fields of interest.

Limitations of our approach can be found in the focus on one specific modelling framework, i.e. the Ecore metametamodel. However, it is based on the EMOF constraints and thus, it is transferable to other frameworks as well.

With this in mind, future work could cover a transfer to other platforms. Further, a refinement and the development of differing approaches of the automated engineering of process alternatives seems interesting. An evaluation with sample data from case studies is an urgent topic for upcoming research.

ACKNOWLEDGEMENTS

The work presented in this paper was funded by the German Federal Ministry of Education and Research in the project Logistik Service Engineering und Management (LSEM) under the reference BMBF 03IPT504X (www.lsem.de).

REFERENCES

4flow AG, 2014. 4flow Supply Chain Services.

4PL Central Station Deutschland GmbH, 2014. 4PL Central Station Deutschland - leading provider in Europe for Fourth Party Logistics services.

ADR, 2012. *European Agreement Concerning the International Carriage of Dangerous Goods by Road: Applicable as from 1 January 2013.* United Nations, New York [etc.].

Arnold, U., Oberländer, J., Schwarzbach, B., 2012. LOGICAL - Development of Cloud Computing Platforms and Tools for Logistics Hubs and Communities FedCSIS 2012, Wroclaw, Poland, 9-12 September 2012, Proceedings, in . *Federated Conference on Computer Science and Information Systems (FedCSIS), 2012,* pp. 1083–1090.

Atkinson, C., Kuhne, T., 2003. Model-driven development: a metamodeling foundation. *IEEE Software.* 20, 36–41.

Augenstein, C., Ludwig, A., Franczyk, B., 2012. Integration of Service Models - Preliminary Results for Consistent Logistics Service Management, in . *2012 Annual SRII Global Conference.* IEEE Computer Society, Los Alamitos, Calif, pp. 100–109.

Augenstein, C., Ludwig, A., 2013. The Service Meta Modeling Editor - Bottom-Up Integration of Service Models, in . *Design Science at the Intersection of Physical and Virtual Design.* Springer-Verlag, Berlin Heidelberg, pp. 386–393.

Banks, J., 1998. *Handbook of simulation principles, methodology, advances, applications, and practice.* Wiley Co-published by Engineering & Management Press, New York.

Bibhushan, Prakash, A., Wadhwa, B., 2014. Supply Chain Flexibility: Some Perceptions, in . *The Flexible Enterprise.* Springer India, New Delhi, pp. 321–331.

Castano, S., Antonellis, V. d., 1993. *A constructive approach to reuse of conceptual components*.

Cetinkaya, D., 2013. *Model Driven Development of Simulation Models: Defining and transforming Conceptual Models into Simulation Models by Using Metamodels and Model Transformation*.

Cimino, A., Longo, F., Mirabelli, G., 2010. A general simulation framework for supply chain modeling: state of the art and case study. *International Journal of Computer Science Issues.* 7, 1–9.

Esmaeilikia, M., Fahimnia, B., Sarkis, J., Govindan, K., Kumar, A., Mo, J., 2014. Tactical supply chain planning models with inherent flexibility: definition and review. *Annals of Operations Research*.

Faber, N., Koster, René B.M. de, Velde, Steef L. van de, 2002. Linking warehouse complexity to warehouse planning and control structure: An exploratory study of the use of warehouse management information systems. *International Journal of Physical Distribution & Logistics Management.* 32, 381–395.

Fleischer, J., Herm, M., Homann, U., Peter, K., Sternemann, K.-H., 2005. Business Capabilities als Basis fähigkeitsorientierte1 Konfigurationen. *ZWF - Zeitschrift für wirtschaftlichen Fabrikbetrieb.* 100, 553–557.

Glöckner, M., Augenstein, C., Ludwig, A., 2014. Metamodel of a Logistics Service Map, in W. Abramowicz and A. Kokkinaki, eds. *Proceedings of the 17th International Conference on Business Information Systems.* Springer-Verlag, Berlin Heidelberg, pp. 185–196.

Glöckner, M., Ludwig, A., 2013. Towards a Logistics Service Map: Support for Logistics Service Engineering and Management, in T. Blecker, W. Kersten and C. Ringle, eds. *Pioneering solutions in supply chain performance management: Proceedings of the Hamburg International Conference of Logistics (HICL) 2013.* Eul, Lohmar, Köln, pp. 309–324.

Gudehus, T., Kotzab, H., 2012. *Comprehensive logistics.* Springer-Verlag, Berlin Heidelberg.

Handfield, R., Straube, F., Pfohl, H.-C., Wieland, A., 2013. *Trends and Strategies in Logistics and Supply Chain Management: Embracing global logistics complexity to drive market advantage.* Bundesvereinigung Logistik, Hamburg.

Hompel, M. ten, Schmidt, T., Nagel, L., 2007. *Materialflusssysteme: Förder- und Lagertechnik.* Springer-Verlag, Berlin Heidelberg.

Hoxha, J., Scheuermann, A., Bloehdorn, S., 2010. An Approach to Formal and Semantic Representation of Logistics Services, in K. Schill, B. Scholz-Reiter and L.

Frommberger, eds. *Workshop on Artificial Intelligence and Logistics (AILog),* pp. 73–78.
Huang, Y., 2013. *Automated Simulation Model Generation*.
Ingalls, R. G., 1998. The value of simulation in modeling supply chains, in D. J. Medeiros, E. F. Watson, J. S. Carson and M. Manivannan, eds. *Proceedings of the 30th Conference on Winter Simulation.* IEEE Computer Society Press, pp. 1371–1376.
Jilani, L. L., Mili, R., Mili, A., 1997. Approximate component retrieval: An academic exercise or a practical concern, in . *Proceedings of the 8th Workshop on Istitutionalising Software Reuse, Columbus, Ohio*.
Kim, J., Lee, S., Park, Y., 2013. User-Centric Service Map for Identifying New Service Opportunities from Potential Needs: A Case of App Store Applications. *Creativity and Innovation Management.* 22, 241–264.
Kloos, O., Schorcht, H., Petsch, M., Nissen, V., 2010. Dienstleistungsmodellierung als Grundlage für eine Simulation. 5, in O. Thomas and M. Nüttgens, eds. *Dienstleistungsmodellierung 2010.* Physica-Verlag HD, pp. 86–106.
Kohlborn, T., Fielt, E., Korthaus, A., Rosemann, M., 2009. Towards a Service Portfolio Management Framework, in . *ACIS2009 - Australian Conference on Information Systems,* pp. 861–870.
Kohlmann, F., Alt, R., 2009. Aligning Service Maps - A Methodological Approach from the Financial Industry, in R. H. Sprague, ed. *Proceedings of the 42nd Annual Hawaii International Conference on System Sciences.* IEEE Computer Society Press, pp. 1–10.
Kutscher, D., Ott, J., 2006. Service Maps for Heterogeneous Network Environments, in . *MDM 2006 Japan.* IEEE Computer Society, Los Alamitos, Calif.
Langley, J., Terry, L., 2014. 2014 Third-Party Logistics Study. The State of Logistics Outsourcing.
Longo, F., Mirabelli, G., 2008. An advanced supply chain management tool based on modeling and simulation. *Computers & Industrial Engineering.* 54, 570–588.
Mi Sun Ryu, Hong-Shik Park, Sang-Chul Shin, 2006. QoS class mapping over heterogeneous networks using Application Service Map, in . *Networking, International Conference on Systems and International Conference on Mobile Communications and Learning Technologies, 2006. ICN.*
Mutke, S., Augenstein, C., Ludwig, A., 2013a. Model-based integrated planning for logistics service contracts, in E. Bagheri, D. Gasevic, M. Hatala, Motahari Nezhad, H. R. and M. Reichert, eds. *17th IEEE International Enterprise Distributed Object Computing Conference.* IEEE Computer Society, pp. 219–228.
Mutke, S., Klinkmüller, C., Ludwig, A., Franczyk, B., 2012. Towards an Integrated Simulation Approach for Planning Logistics Service Systems, in F. Daniel, K. Barkaoui and S. Dustdar, eds. *Business Process Management Workshops.* Springer-Verlag, Berlin Heidelberg, pp. 306–317.
Mutke, S., Roth, M., Ludwig, A., Franczyk, B., 2013b. Towards Real-Time Data Acquisition for Simulation of Logistics Service Systems, in D. Pacino, S. Voß and R. Jensen, eds. *Proceedings of the International Conference on Computational Logistics 2013.* Springer-Verlag, Berlin Heidelberg, pp. 242–256.
Petsch, M., Schorcht, H., Nissen, V., Himmelreich, K., 2008. Ein Transformationsmodell zur Überführung von Prozessmodellen in eine Simulationsumgebung, in P. Loos, M. Nüttgens, K. Turowski and D. Werth, eds. *Modellierung betrieblicher Informationssysteme - Modellierung zwischen SOA und Compliance Management,* pp. 209–219.
Ralyté, J., Rolland, C., 2001. An Assembly Process Model for Method Engineering, in . *Advanced Information Systems Engineering.* Springer-Verlag, Berlin Heidelberg, pp. 267–283.
Roth, M., Mutke, S., Klarmann, A., Franczyk, B., Ludwig, A., 2014. Continuous Quality Improvement in Logistics Service Provisioning, in W. Abramowicz and A. Kokkinaki, eds. *Proceedings of the 17th International Conference on Business Information Systems.* Springer-Verlag, Berlin Heidelberg, pp. 253–264.
Rushton, A., Croucher, P., Baker, P., 2014. *The handbook of logistics and distribution management: Understanding the supply chain.* Kogan Page, London.
Schütz, P., Tomasgard, A., 2011. The impact of flexibility on operational supply chain planning. *International Journal of Production Economics.* 134, 300–311.
Stadtler, H., Fleischmann, B., Grunow, M., Meyr, H., Sèurie, C., 2011. *Advanced Planning in Supply Chains: Illustrating the Concepts Using an SAPa APO Case Study.* Springer, New York.
Stevenson, M., Spring, M., 2007. Flexibility from a supply chain perspective: definition and review. *International Journal of Operations & Production Management.* 27, 685–713.
Vaddi, S., Mohanty, H., Shyamasundar, R., 2012. Service Maps in XML, in V. Potdar, ed. *Proceedings of the CUBE International Information Technology Conference.* ACM, [S.l.], pp. 635–640.
VDI-Richtlinie, 2010. 3633, Blatt 1: Simulation von Logistik-, Materialfluß- und Produktionssystemen.