Towards Real-Time Data Acquisition for Simulation of Logistics Service Systems

Stefan Mutke[1], Martin Roth[1], André Ludwig[1], and Bogdan Franczyk[1,2]

[1] University of Leipzig, Information Systems Institute, Grimmaische Straße 12, 04109 Leipzig, Germany
{mutke,roth,ludwig,franczyk}@wifa.uni-leipzig.de
[2] University of Economics, Institute for Business Informatics, Komandorska 118/120, 53-345 Wrocław, Poland
{bogdan.franczyk}@ue.wroc.pl

Abstract. Driven by rising competition pressure companies began to outsource at least parts of their logistics functions to specialized logistics providers in order to concentrate on the core competences. Hence, new business models emerged like the fourth party logistics provider who acts like a coordinator of arising logistics networks. One of the main tasks of the provider is the planning of such logistics networks, which have a very collaborative and dynamic character. In this paper an efficient way to integrate process modeling and simulation as part of the planning phase is introduced. Furthermore, an integrated approach is introduced for supporting the planning by a better data acquisition in order to provide reliable results at an affordable effort using simulation techniques. Therefore, complex event processing is used to gather real-time data and provides the data as service profiles for simulation.

Keywords: Fourth Party Logistics Provider, Simulation, CEP, Data Acquisition.

1 Introduction

Logistics is defined as the management of the flow of goods and information between point of origin and point of destination meeting the requirements of shippers and recipients. The main objective of logistics is the delivery of the right goods, at the right point of time, to the right place, with the right quality and quantity and to the right costs (6Rs, [1] and see [2, 3] for a general overview).

In recent years, the logistics industry remarkably changed such that the planning and monitoring of logistics functions is no longer a task performed by customers of logistics providers (e.g. vendors, manufacturers) but by a number of so-called value-added logistics or fourth party logistics service providers (4PL) [4, 5]. Outsourced logistics functions encompass basic services such as transportation, handling and storage of goods but also services like packaging, finishing or clearing of goods. Due to specific requirements of each company (amount of demanded services or integration level) and due to industry-specific requirements (security or tracking issues) each requested logistics service is individual in scope. Thus, value-added

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logistics service providers need to provide highly individual service offerings to their clients. Within a network of affiliated logistics providers a 4PL selects matching providers to the needed services and integrates them to meet customer's requirements. Moreover, a 4PL governs the overall process, optimize it, and acts as prime contractor for the customer. They are the main contact person, coordinators of the involved logistics providers, and have the responsibility for the overall process and its quality of service. To determine the quality of service, the 4PL has to monitor and to measure the performance of each participating partner. Fig. 1 illustrates a 4PL's service lifecycle which consists of the phases: analysis, design, implementation, operation and retirement [6]. The lifecycle is outlined in more detail in Section 6.

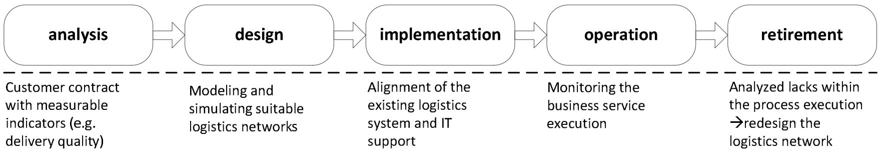

Fig. 1. 4PL service lifecycle

In this contribution we focus at first on the design phase and, thus, one of the main activities of a 4PL to be competitive – the multi-step planning process for its customers. Depending on specific requirements this planning process includes e.g. process modeling, selecting providers, defining the needed services or building long-term forecasts in order to assure a viable and robust logistics systems (see Fig. 1). Although we can accommodate several steps of planning a complete logistics system, the results of the various steps are still isolated (i.e. we still have to provide same information in multiple systems). Hence, high costs and an error-prone overall planning process are the results. Therefore, it is shown in [7] that the integration of planning steps, especially the further use of process models for developing simulation models, is essential to avoid this and to reduce the overall time and effort.

Another problem we focus in this paper concerns the data acquisition. Nowadays, companies are overwhelmed with data. On the one hand, this can lead to a more robust, and thus, more precise simulation because the available database is bigger than ever. On the other hand, it is more difficult to select the needed data in the right quality, quantity and granularity. This flood of data must be processed in a suitable manner to meet the requirements of the presented 4PL simulation approach.

In this contribution we, therefore, present an approach for integrating simulation in the overall planning process of a 4PL. Firstly, we discuss the prerequisites and requirements our planning approach is designed for, followed by an overview of adjacent approaches and fields of study. Then we show how to build a simulation model from an already modeled process and service profiles which contain information concerning the performance of each provider and their offered services. After that, we present a method on how to deal with the increasing velocity, variety, value and volume of data and how to analyze and process this data for further use. Afterwards, we show how to apply this method in order to use the acquired data for simulation in form of service profiles. And finally we end with a conclusion and future work of the approach.

2 Planning Prerequisites and Requirements

A core competence and an important task of a 4PL is the planning, orchestration and choreography of complex logistics services integrating various subsidiary logistics service providers [8]. Therefore, different IT-systems are used. Within the design phase, relevant services have to be identified and liable providers have to be chosen and coordinated in the overall process. Moreover, the entire structure of the logistics network with regard to their temporal dependencies has to be validated. Appropriate instruments for this purpose are, for instance, process modeling languages (e.g. Business Process Model and Notation (BPMN), Event-driven Process Chain (EPC)). Davenport defines a process as "*a specific ordering of work activities across time and place, with a beginning, an end, and clearly identifies input and outputs: a structure for action*" [9] Processes can be also described as follows: a process is defined as a coherent, self-contained sequence of activities required to fulfill an operational task in order to produce a specific service or product [10]. Similar to this is the description in [11] in which a process is described as a collaboration between process roles which perform tasks on concrete artifacts. Though processes have been widely used within a company, the definition above also allows making use of processes in an inter-company context with the same purpose. Thus, process modeling as an activity for the definition and description of a process combines executive (organizational units), design objects (information objects) and tasks (activities) and connects them via different control flows regardless of organizational boundaries. Fields of application and purpose of process modeling are, for example, the documentation, preparing for automation or optimization. As processes are described as a structure for action, process modeling languages represent the static structure of business processes but the dynamic aspects are not considered. This leads to a growing use of simulation in logistics [12]. Therefore, process models are in many cases the basis for building simulation models [13].

Simulation allows the current behavior of a system to be analyzed and understood. *"Simulation is the imitation of the operation of a real-world process or system over time. […] Simulation is an indispensable problem-solving methodology for the solution of many real-world problems. Simulation is used to describe and analyze the behavior of a system, ask what-if questions about the real system, and aid in the design of real systems. Both existing and conceptual systems can be modeled with simulation."* [14] In logistics, simulation methodology is becoming increasingly important for securing the planning, management and monitoring of material, personnel and information flows [12]. As complex logistics services are established for a long period of time radical changes during the operation phase are very expensive and often consume an enormous amount of time [15]. Thus, it is necessary to anticipate the future behavior of a logistics system prior to its implementation. Hence, simulation models of logistics networks can be used to improve the decision-making process in the planning phase. Especially discrete-event simulation (DES) is appropriate to enhance decision support by analyzing several system configurations, which differ in structure and behavior [16].

The use of simulation also leads to a number of problems. Building simulation models requires special training and experience to avoid errors, because it is a methodology that is learned over time. Furthermore, building simulation models and their analysis is expensive and consume an enormous amount of time. This can lead to a non-profitable use of simulation [14]. The use of different models within the planning process (process model, simulation model) leads to another problem. Each time a model is slightly modified, any of the other models must also be revised. This also increases the modeling effort. One of the main problems with the use of simulation is the availability of valid input data in the right quality, quantity and granularity [17]. These are an essential precondition for high-value results [18]. In addition, the used data must be available and visible as fast as possible. Conventional approaches using data stored in data warehouses and are request-driven [19]. Thereby a simulation works on retrospective data.

For these problems, the following requirements are derived. The effort for the development of simulation models must be reduced. Especially as in the planning of logistics systems several models come to use. These models build upon one another and have dependencies among each other. A change in a model also leads to changes in subsequent models. Therefore, the use of simulation techniques has to be integrated in the planning process [7]. It must be ensured that the created process models within the planning process, based on a separate description of each logistics service, can be transferred automatically into a simulation model. However, the different fluctuations (e.g. fluctuations in demand, sales trend and seasonal fluctuations) of the entire logistics system, which can potentially arise, should be considered. On the one hand, this requirement aims to minimize the planning effort of a 4PL. On the other hand, manual errors in the creation of a simulation model should be avoided. Furthermore, the need for special training and special experience in simulation model building is reduced. Another requirement concerns the information acquisition. As a result of the information overload the investment in simulation projects for information acquisition is almost 50 % of the total project time. This leads to the need of an efficient approach for gathering information to support the logistics planner in all planning activities. To gain a robust simulation result the used data have to describe the current state of all logistics networks.

3 Related Work

Simulation: Simulation approaches are widely used in logistics in order to plan logistics systems. Ingalls discusses the benefits of simulation as a method to study the behavior of logistics networks [20]. Additionally, advantages and disadvantages are presented for analyzing supply chains with the use of simulation models in general. A concrete simulation approach is not provided. In [21] a commonly applicable simulation framework for modeling supply chains is presented. Instead of [20] 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 is presented by Longo and Mirabelli in [22]. In addition, they provide a decision making tool for supply chain management and, therefore, develop a discrete event simulation tool for a supply chain simulation using Plant Simulation[1] including a modeling approach. All these approaches are relevant for developing an

[1] (based on eM-Plant) `http://www.siemens.com/plm/PlantSimulation`

integrated planning and simulation approach. However, all these approaches satisfy the 4PL's specific requirements (Section 2) only partially. The development of simulation models based on process models is insufficiently considered.

Model Transformations: For integrating simulation in the planning the use of transformation approaches for defining transformation models as a mediator between process and simulation models is interesting for our approach. In both approaches of [23, 24] 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 a specific modeling language (EPC).

Data Acquisition for Simulation: Bernhard et al. gives at first a theoretical overview of research results including theoretical definitions of terms like information, data, and knowledge. Based on this a process-oriented procedure model for information acquisition in a superordinate procedure model for simulation according to VDI 3633 [16] is presented. Furthermore, different taxonomies of methods from data acquisition, statistics and visualization and their utilization were analyzed and classified. In contrast, [25] propose the separation of the steps of information and acquisition from the modeling process. Therefore, the procedure model for simulation was extended by a separate handling of the model and the data. So a continuous and iterative verification and validation process should be provided. Kuhn et al. argue that a distinguished consideration of data collection and preparation is missing and fill this gap by another procedure model extended by a chain of sub-processes within information acquisition [26]. The paper proposes a procedure model of information acquisition which is more a task- and user-oriented approach. All these contributions have one thing in common: they assume that simulation projects are isolated from an overall integrated planning procedure and the development and analysis of simulation models is a project for its own. In our approach, simulation is part of an integrated planning process and an overall approach for a 4PL.

Complex Event Processing: Roth and Donath point out the use and advantages of complex event processing (CEP) for the 4PL business model for monitoring business processes and collecting real-time data [6]. Yao et al. analyze the application of CEP in hospitals by using RFID. They introduce a framework and provide a possible solution to improve patient safety, whereby the power of CEP is shown. Some parts of the approach can be partly adopted, but the framework is too abstract and not suitable for the presented application area [27]. Buchmann et al. investigate event processing in production, logistics and transportation. It is described how service-orientation and event processing can be combined and how the application area can benefit from real-time data. This paper covers the logistics area and discusses CEP as a powerful approach without going into detail [17]. Because of the high level consideration the paper only provides partial input for the work presented in this paper, but the discussion underpins the thoughts of the authors. Anymore these approaches do not meet the requirements of a 4PL business model, more precisely for the simulation. In this contribution we present how CEP can be used for gathering and processing real-time data for simulation.

4 Simulation Approach

In Section 2 it is described that different models (e.g. process models, simulation models) are used for planning logistics processes. This section specifies how the transformation of process models into simulation models is implemented prototypically as part of an integrated planning process for a 4PL.

Process models describe functional or structural aspects relevant for a process. In the scope of a 4PL's planning process these components represent the different partial logistics services as part of the overall process. Within this research BPMN is used as modeling language for creating process models. Therefore, we presume that tasks of BPMN represent logistics services. In [28] 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 logistics services 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 from BPMN tasks to the description of specific logistics services. Thus, each BPMN task is assigned to a specific logistics service type. So, the result is a BPMN process model including all logistics services necessary to meet customer's requirements. Fig. 2 illustrates the prototypical implementation of logistics annotations (e.g. service types) within a BPMN-Modeller.

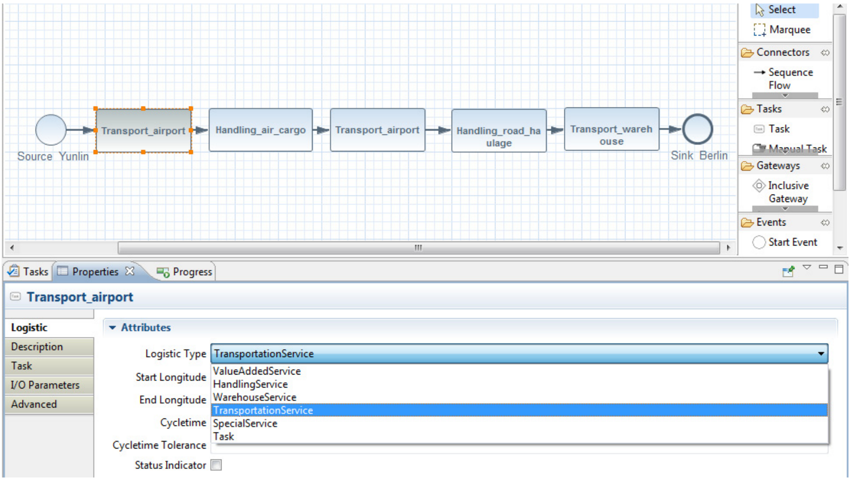

Fig. 2. BPMN-Task assigned to logistics service type

Despite having a process model and using this model as the basis for creating a simulation model, additional information such as the visualization of the processes, is necessary. Therefore, it was analyzed what information are additionally required to create a simulation model. The following elements are the basic concepts of simulation models in general and, therefore, also the basic concepts of DES environments [14]:

Table 1. Essential simulation concepts

Entities	An entity represents real-world objects. Entities that move through the system (e.g. products, customers) are dynamic and entities that serve other entities (e.g. conveyors, machines, warehouse) are static.
Events	An event is an occurrence that changes the state of the simulation system and is the beginning and ending of an activity or delay (e.g. freight is loaded).
Attributes	An attribute describes the characteristics of an entity (e.g. time of arrival, due date priority, color). A set of entities may have the same attribute slots but different values for different entities, so the attribute value is tied to a specific entity.
Activities	An activity represents a specific period of time. The duration of this time period is known prior and can be a constant, a random value from a statistical distribution or input from a file, etc. (e.g. processing time of a machine).
Delays	A delay is an indefinite period of time. The duration is caused by some combination of system conditions (e.g. the freight is waiting for loading).

The fundamental goal of simulation in logistics is the study of transport volumes and capacities of the partial logistics services over time to ensure that customers' demand can be met. So it is possible to analyze the flows of goods through the logistics system with regard to the capacity in order to identify bottlenecks early on. To create simulation models of a specific domain (e.g. logistics) primarily application-oriented modeling concepts are used [14]. Typical in logistics is the use of "modular concepts". These provide topological, organizational and / or informational elements - appropriately aggregated, predefined and parameterized from an application perspective - for a specific application domain [29]. Two simulation tools which are widely used in the logistics domain, which realize more or less the application-oriented modeling concept (Enterprise Dynamics (ED)[2] and Arena[3]), have been used to create different examples of simulation models to study transport volumes and capacities [30]. These tool-dependent models have been analyzed and compared in terms of the used modeling concepts and the required data. The common basic concepts were consolidated and used to create the metamodel shown in Fig. 6.

A simulation model basically consists of the following concepts. A *source* generates goods at predefined time periods. A *sink* is the concept where goods leave a model. The purpose of an *activity* is to handle goods. Therefore, *goods* enter an activity and remain there for a certain time. Moreover, an activity is assigned to a *service* type. All *time* periods can be described by a set of *distribution* functions. Regarding the service 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. The connecting elements between the activities are represented by two different *relations*. On the one hand, relations can be simple, i.e., without specific characteristics. On the other hand, a

[2] `http://www.incontrolsim.com/`
[3] `http://www.arenasimulation.com`

connection between activities can be represented by *conditional relations* with specific characteristics. Depending on certain conditions or probabilities one or the other path is used. The model itself is marked as a *ServiceAspect* and the elements representing characteristics are marked as *ServiceDescriptionElements*. So these marked elements represent the connection to other models [31].

Now, the question arises of where to get the information for building a simulation model. As already mentioned, modeling business processes including different partial logistics services using BPMN is part of the 4PL's planning process. These process models can be regarded as given in a service repository [31]. So we can use the structure (start, end, tasks, relations, gateways) of the process to derive the structure (source, sink, activities and relations) for the simulation model. Gateways, for example, in process models are represented by conditional relations. Further information is available in service profiles (see Section 6). So these profiles contain the specific information required to characterize the activities in the simulation model, e.g. time, quality or capacities. The method of collecting this information is described in Section 5 in more detail.

To combine the process model with the provider information, the process editor is extended by a provider selection. Based on the process model for each partial logistics services represented as BPMN tasks a suitable provider and the required information are selected. With this information and the underlying simulation metamodel (see Fig. 6), a 4PL can automatically generate a simulation model for a specific simulation tool. This requires that for each simulation tool transformation rules have to be defined only once. This approach enables a 4PL to make use of the advantages of simulation for securing the planning process and to improve decision-making without any special training and special experience in the creation of simulation models. Simulation models can be created in an easy and efficient way and the effort for comparing a set of different logistics network configurations is reduced. Furthermore, the simulation results serve to improve the planned process in form of a planning cycle (see Fig. 3).

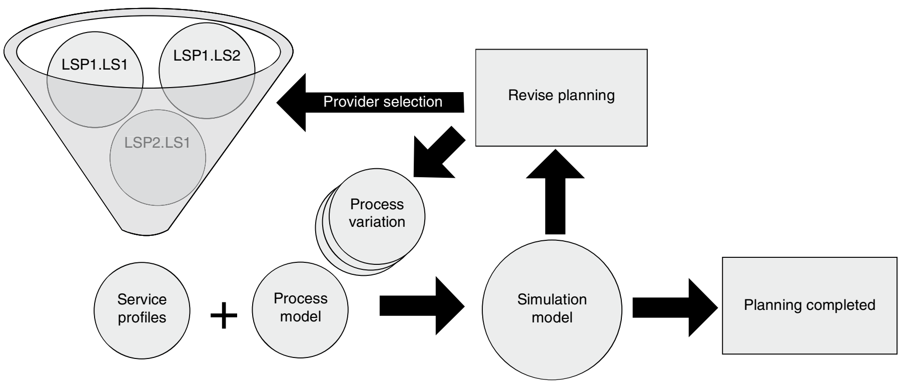

Fig. 3. Automated planning cycle within the design phase

5 Data Acquisition Using CEP

In this section the data acquisition for simulation using CEP is introduced, whereby the consideration is on an abstract level without going into detail of a particular tool or technique.

Complex event processing (CEP) is designed to deal with the increasing velocity, variety, value and volume of data, known as Big Data. CEP is defined as a set of tools and techniques for analyzing and controlling the complex series of interrelated events. Thereby the events are processed as they happen, thus, continuously and in a timely manner [19, 32]. An event is the central aspect of CEP and is defined as "*anything that happens, or is contemplated as happening (change of state)*" [33], e.g. a RFID-enabled good is recognized by a RFID reader. If an event summarizes, represents or denotes a set of other events, it is a so-called "complex event", e.g. a good left the issuing area [33]. In this paper it is assumed that CEP is already used to monitor an instantiated logistics network [6]. The next paragraph exemplifies this and emphasizes the adequacy of applying CEP in the area of a 4PL.

The outsourced service between the 4PL and the customer as well as between the 4PL and the service providers is contractually secured. A contract records the agreed upon obligations and responsibilities of contractual parties in terms of business process conditions [34]. These conditions are often expressed as goals which must be achieved by each party. The goals can be extracted from the customer needs or from legal regulations and are known as Service Level Objectives (SLOs), which define measurable indicators like delivery quality, delivery reliability or delivery flexibility. The contract must exist in a formalized form, whereby the CEP engine is capable to work with. This contract describes the target state of each logistics service (LS) realized by the participants of the network and acts like a pattern. As soon as the process execution is started (and thus instantiated) the 4PL has to ensure the fulfillment of the defined SLOs. To achieve this, internal (e.g. good left the issuing area) and external (e.g. traffic jam) data regarding to the good will be pushed to the 4PL. By doing this the 4PL can ensure that possible penalties (e.g. delayed or damaged good) will be hand out to the "faulty" participant of the network. If it is not traceable which participant of the network is the flaw, a logistics network would not be robust and sustainable over a longer period. Furthermore, the use of CEP allows to forecast, whether an instantiated process will meet the SLOs in the future or not [6]. The incoming data which describe the actual state is squared with the SLOs which describe the target state. This comparison takes place within the CEP engine. All data will be processed to evaluate the process execution of every logistics network partner and build up service profiles. The service profiles include key performance indicators which benchmark the logistics service providers (LSP) and their services. In contrast to current instruments, this evaluation takes place during the process run-time and not at the expiration (retirement, see Fig. 1) of a process. If delays are identified, an alarm will be triggered and data about the failure will be raised, e.g. the duration or reasons of a delivery delay. The following example and explanation should briefly describe the suitability of CEP in the area of the 4PL business model at a more detailed level.

Fig. 4 illustrates a possible material and data flow of a specific logistics network. As seen in the material flow layer, three LSP take part in the logistics network to accomplish the contract between the 4PL and the customer. The squares emblematize the responsibilities for each LSP. Beside the actual transportation of the good, the data regarding to the good must be processed as well. The lower part of the data flow layer exemplifies the data sources within a logistics service (ERP, RFID, Barcode). These examples should clarify that there are a multitude of data sources with their own characteristics, which must be linked with the 4PL system. By using CEP it is possible to link nearly every data source in a short space of time, because CEP is loosely coupled. Thereby the 4PL gain situational awareness, because a high variety of data sources – internal and external (e.g. traffic systems) - can be linked rapidly. Moreover, CEP can handle the rising velocity of data while processing them in real-time, which will lead to a better availability and visibility of data. Using e.g. RFID leads directly to the challenge that a flood of data is generated. Moreover, companies are only interested in information with a high value. Therefore, it is necessary that a dispatcher does not receive messages such as “good_1 was read at reader_1 at 12:45 UTC”. According to that, CEP provides filtering mechanism so that all redundant messages will be percolated, which will reduce the volume of data. The result is that only one message is received by the dispatcher. Moreover, it can be stated that the message “good_1 was read at reader_1 at 12:45 UTC” does not have a high information value. CEP offers the opportunity to aggregate data to obtain a higher information value. By using these mechanisms it is possible to aggregate technical data (e.g. RFID reads) to business processes, whereby the message is transformed to “good_1 for Mr. X left the warehouse at gate 2. The delivery is delayed for 45 minutes”. This message is used to evaluate the performance of the logistics service (see e.g. LSP1.LS2 in Fig. 4) in form of service profiles. The profiles of each offered and operated logistics service are aggregated again to achieve an overall performance profile of every logistics service provider (provider profile). Furthermore, these benchmarks can be aggregated again to achieve a profile for the whole network (network profile). All of these profiles represent an essential input for other tasks like provider selection or simulation of newly planned logistics systems.

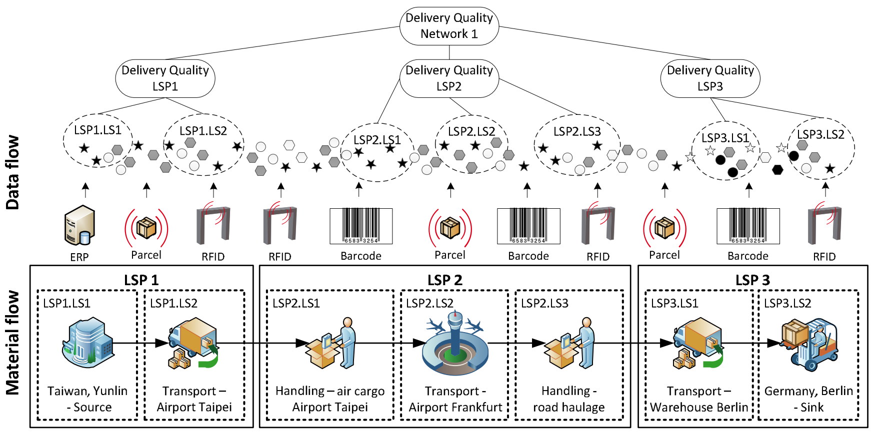

Fig. 4. Exemplified material and data flow of a logistics service instance

CEP provides powerful approaches to process data, transform them to information and link them to business processes. By doing so, CEP is a suitable technique to provide actual data at a desired granularity level in a timely manner. Hence, CEP is a suitable approach to monitor logistics networks and to support simulation with latest data constituted by service profiles. This leads to a better database, whereby simulations have not to rely on experience or outdated data. The available data includes current performance profile built up from internal and external data and can be combined as desired. This data can be used to simulate logistics networks at an early point of creation and generates more reliable predictions.

6 Service Profiles as Data Source for Simulation

The previous section explains how the logistics network including the different logistics services are monitored with the use of CEP during the operation phase.

The approach allows to process data and transforms them to information. This way of data acquisition is performed over all running processes in all logistics networks including their logistics services provided by the different service providers. With the use of CEP it is possible to create and update service profiles dynamically and at run-time. These profiles are provided in real-time at an appropriate granularity level and, thus, meet the requirements of simulation in the 4PL business model. Because CEP facilitates situational awareness by using external data and, thus, observes the environment, it is feasible to prioritize profile parameters far easier. There can be a multitude of reasons why a LSP does not comply with the delivery period, e.g. traffic jam or just driving too slow, which are interesting for creating profiles and causes different ratings. The profiles also include the positive and negative deviation from the agreed conditions. All these aspects are attached to the corresponding events and allow a detailed evaluation of a specific logistics service and its provider. So for each single logistics service a profile with parameter like service level, lead time, etc. is created and is updated continuously. The services provided by a single logistics provider can be aggregated to provider profiles. This evaluation is used for the provider selection and for simulation (see Fig. 1). In summary, a closer look at the service lifecycle in conjunction with the presented approaches is given (see Fig. 5).

In the *analysis* phase the 4PL establish a pool of LSP with a description of their capabilities. Furthermore, a contract between the customer and the 4PL with some SLOs (e.g. delivery time) is drawn up.

The 4PL models a logistics network regarding to the above mentioned constraints. This model is illustrated in a formalized way in form of a process model. The process model describes the static structure of a business process. To analyze the dynamic behavior of a system a simulation model of the logistics network based on the process model is used. In order to minimize the modeling effort and the manual errors creating a simulation model, the simulation approach is integrated in the planning process [7]. The *design* phase ends with this step.

In the *implementation* phase the 4PL has to encompass the designed process by integrating the LSPs and the alignment of the existing logistics information systems and IT support.

During the *operation* phase, the 4PL monitors the logistics service execution (process instance) realized by the LSPs. On that account, the 4PL processes internal (e.g. temperature) and external (e.g. traffic information) data regarding to the good by using CEP. The fulfillment of a logistics service and the resulting service profiles are created and updated continuously (see Section 5). If it is predictable that an ongoing contract and the regarding SLOs cannot be fulfilled, the 4PL will be timely informed to adopt compensating measures. In this case, the service lifecycle will be restarted. The gathered real-time data is an important input for the analysis and design phase for new logistics services, because the gap between physical and virtual can be bridged.

At the end of the service lifecycle the contract expires and the service terminates (*retirement*). The process execution is analyzed and possible lacks will be eradicated.

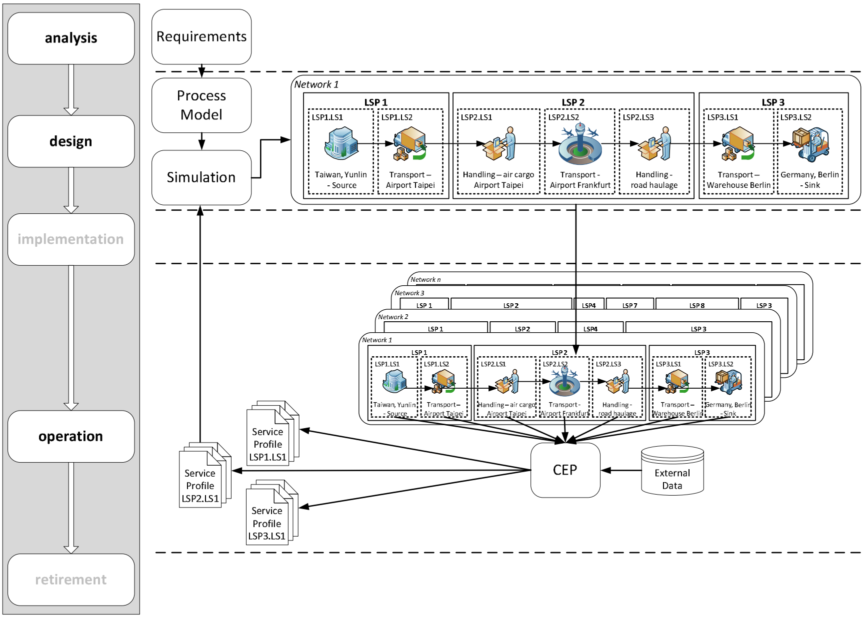

Fig. 5. Service lifecycle focused on using CEP for acquiring real-time data for simulation

7 Conclusion and Future Work

From the 4PL point of view a major issue is an integrated planning process with which a multitude of service providers are orchestrated in order to realize a customer's logistics network. Therefore, we clarified the requirements of our approach in general, in that we presented under which circumstances our approach can be applied. In this context, we presented an integrated planning approach based on a process transformation into a simulation in order to make sure, that the modeled process is robust, cost efficient and meets the customer's requirements. If the result of the simulation is satisfying and we can determine a valid combination of services and service providers respectively, the planning process can be closed at this point. Essential to this approach is the acquisition of real-time data for simulation. In [6] it is shown, that CEP is suitable to monitor an instantiated logistics network within the area of the 4PL business model. In contrast to that paper, we developed the approach further in that we discuss the use of CEP to acquire data for planning new complex logistics services, especially for simulating them. To prepare these data we propose the development of service profiles which can be aggregated to provider profiles. Finally, we illustrated the overall approach and the interaction between simulation, CEP and service profiles focused on the service lifecycle.

Subject of the future work is the development of service profile patterns. Depending on the service type (e.g. transportation, storage) a service profile consists of different KPI's. In addition, a set of indicators have to be worked out to create expressive provider profiles for further planning steps (e.g. provider selection). Furthermore, the prioritization of delays must be investigated.

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Appendix

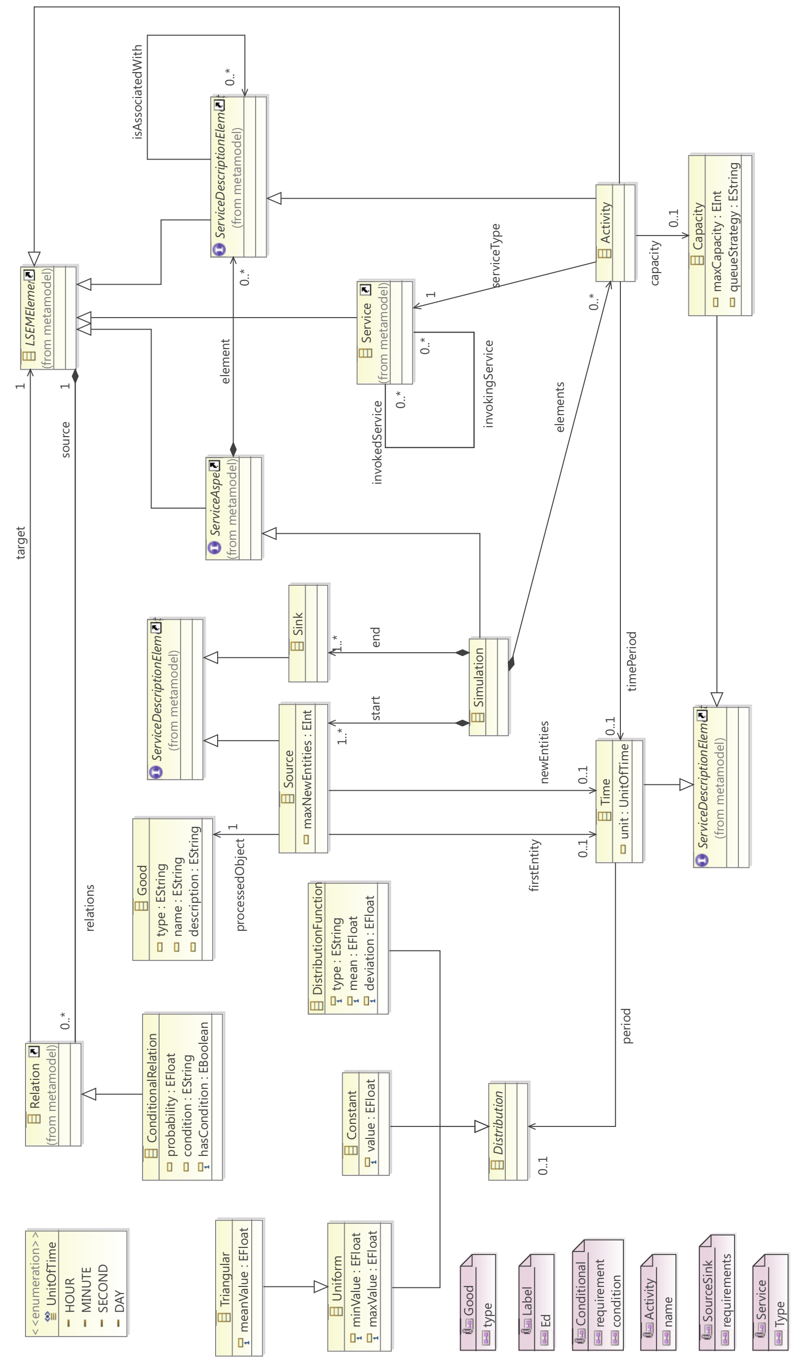

Fig. 6. Generic simulation metamodel