A CONSTRUCTION KIT OF FLEXIBLE IT-SERVICES FOR SUPPLY CHAIN PLANNING AND OPERATIONS

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ABSTRACT

Current logistic IT systems tend to be monolithic applications with low flexibility and low awareness of interoperability. Modern IT trends like Service Oriented Architectures and Cloud Computing are key factors to provide convenient access to customized IT-Services on demand and as a service. Hence, the idea of the concept "Logistics as a Service" is to provide domain specific IT services to support the planning and operations in supply chains which are supported by infrastructural technologies. In this paper, the general concepts behind "Logistics as a Service" as well as exemplary IT services are presented and proven to be applicable by demonstration of several use cases. "Logistics as a Service" is one leading topic in the EffizienzCluster LogistikRuhr (EfficiencyCluster LogisticsRuhr) and therefore part of the German High Tech Strategy.

Keywords: Logistics as a Service, Supply Chain Management, Cloud Computing, Service Oriented Architecture, Unified Service Description Language

1. INTRODUCTION

Complex supply networks are the business of Supply Chain Management (SCM). SCM deals with the integrated and process-oriented planning of operations in supply chains from the raw-material supplier to the customer (Kuhn and Hellingrath 2002). The corresponding task model (ten Hompel and Hellingrath 2007) describes the three underlying fundamental business areas of SCM (Klingebiel 2009, p. 40, Hegmanns 2010):

- Supply Chain Design (SCD) covers those strategic and long-term oriented tasks which design and configure the structure, processes and information systems of a logistic system.
- Supply Chain Planning (SCP) covers those long-, mid- and short-term planning activities concerned with anticipation of material requirements, required inventories and resource capacities in a given logistic network
- Supply Chain Execution (SCE) finally covers all operational tasks focussed on order management and order-related operations.

It is common knowledge that IT systems empower logistics managers and planners to deal with supply chain complexity and dynamics in supply chain planning and operations. Yet, available IT systems are just as diverse as their respective tasks: Advanced Planning and Scheduling Systems (APS) and Enterprise Resource Planning (ERP) systems focus on supporting interorganisational and intraorganisational planning tasks, while Warehouse Management Systems (WMS), Transport Management Systems (TMS) and Manufacturing Execution Systems (MES) manage supply chain operations (see for example ten Hompel 2012). Nevertheless, these systems are mostly designed monolithically, thus implying high effort in individual deployment and configuration (Klingebiel and Wagenitz 2012). In addition, the compatibility of these software solutions and the ability to be integrated easily into existing IT infrastructures is still inadequate (Delfmann and Jaekel 2012, page 14).

Against this background, there exists an increasing demand for adaptable and modular (IT) systems which can be quickly and cost-effectively harmonized with other supply chain systems. In this context, the term "Logistics as a service" stands for a new generation of service-based instruments for the management of supply chains which provide flexible decision support through appropriate IT functionalities (Leukel et al. 2011). Following this idea, innovative decentralised and interoperable IT services and infrastructural elements are being developed based on concepts like service-oriented architectures (SOA, Dostal et al. 2009) and cloud computing (Buyya 2009) within the projects of the EffizienzCluster LogistikRuhr (www.effizienzcluster.de).

This paper presents the first deliverables: A construction kit of flexible IT services for supply chain planning and operations. After discussion of the current state of the art in chapter 2, the architectural concept is presented in chapter 3. Chapter 4 describes and reviews the prototypical application of exemplary services in industrial practice. Chapter 5 concludes with a short summary and an outlook on further work.

2. STATE OF THE ART

Today's IT systems are designed by cost-efficiency-principles (Christopher & Beck 2004). Whereas these systems operate efficiently under stable environments, performance declines significantly under volatile and dynamic conditions (Tang and Tomlin 2008). Furthermore, a recent survey conducted by the German Logistics Association confirms that operational Supply Chain Management requires more IT-functions

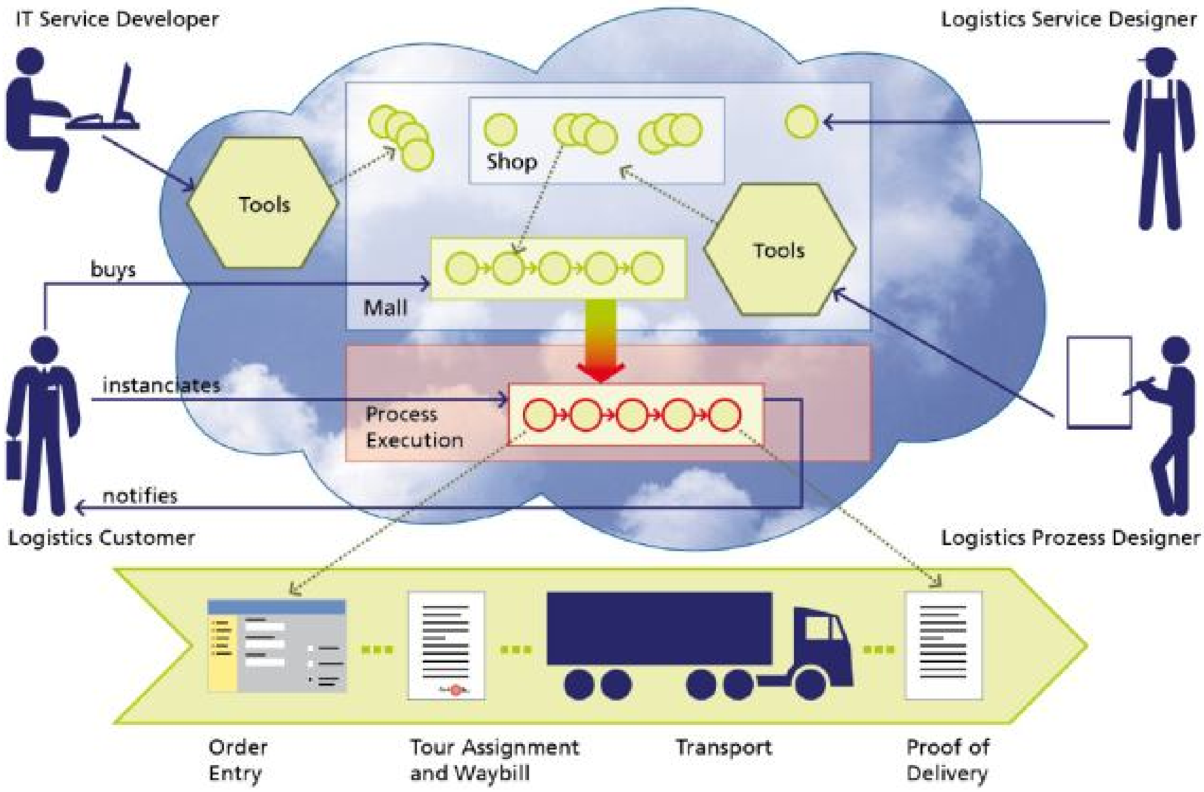

Figure 1. Logistics Mall business architecture

than currently available SCM-IT solutions offer (BVL 2012). Hence, increasing the interoperability of the systems and creating flexible IT architectures, which interlink functions of various systems and allow for an easy integration of new functionalities, seems to be a promising path to follow.

Technologies that capture process information from supply chain operations have improved significantly in the last decades. Advances in RFID and AutoID technologies have led to opportunities for new informational transparency in supply chains (Hellingrath and Alberti 2009; Hegmanns and Toth 2011). Nevertheless, the challenge for SCM-IT is to integrate, filter and draw conclusions from the flood of information available from both process event capturing and other Enterprise-IT systems.

Autonomous systems, SOA and cloud computing are on the rise and establish a new generation of decentralized and interoperable systems, so-called Logistics Assistance Systems (LAS). LAS supplement WMS-, TMS-, ERP- and SCM-systems with individual functionalities and combine the performance of modern decision support technologies with the expertise and judgement of the logistics planner (Klingebiel et al. 2011). However, the availability of individual LAS functionalities which allow an integrated logistics IT support by combinability and individual configurability is still non-existent (Klingebiel and Wagenitz 2012).

The technological scaffolding for scalability, flexibility and a strong alignment to business is service-oriented computing or service-oriented architectures with loose coupled services for the flexible configuration of the required set of services and a high cohesion to achieve interoperability. The Organization for the Advancement of Structured Information Standards (OASIS) defines the term SOA as ‘A paradigm for organizing and utilizing distributed capabilities that may be under the control of different ownership domains. It provides uniform means to offer, discover, interact with and use capabilities to produce desired effects consistent with measurable preconditions and expectations.’ (OASIS 2011). SOA technologies have reached a high maturity. Consistent orientation on SOA principles allows stepping from monolithic systems to configurable sets of standardized logistics functionalities, i.e. to achieve the development of interoperable logistics applications and provide them as a service, ideally via a cloud platform.

According to the Definition of the National Institute for Standards and Technologies (NIST), the term cloud computing is characterised as a model for enabling access to a shared pool of configurable resources in an ubiquitous, convenient and on-demand manner over a broadband network (Mell and Grance 2011). Mell and Grance distinguish the three cloud models: “Infrastructure as a Service (IaaS)”, “Platform as a Service (PaaS)” and “Software as a Service (SaaS)”. The basic principle can be identified in the allocation of a requested resource on demand and as a service. For example, the top layer of SaaS allows for applications to be provided via a web browser. This principle is transferred to the logistics domain by the concept of “Logistics as a Service” (LaaS).

The Fraunhofer Innovation Cluster “Logistics Mall – Cloud Computing for Logistics” is a project associated with the EffizienzCluster LogistikRuhr. With the idea of “logistics on demand” it shares the vision of Logistics as a Service. The developed Logistics Mall is a virtual cloud platform for logistics IT applications processes and services which can be offered, hired, and then run in the cloud environment (see also

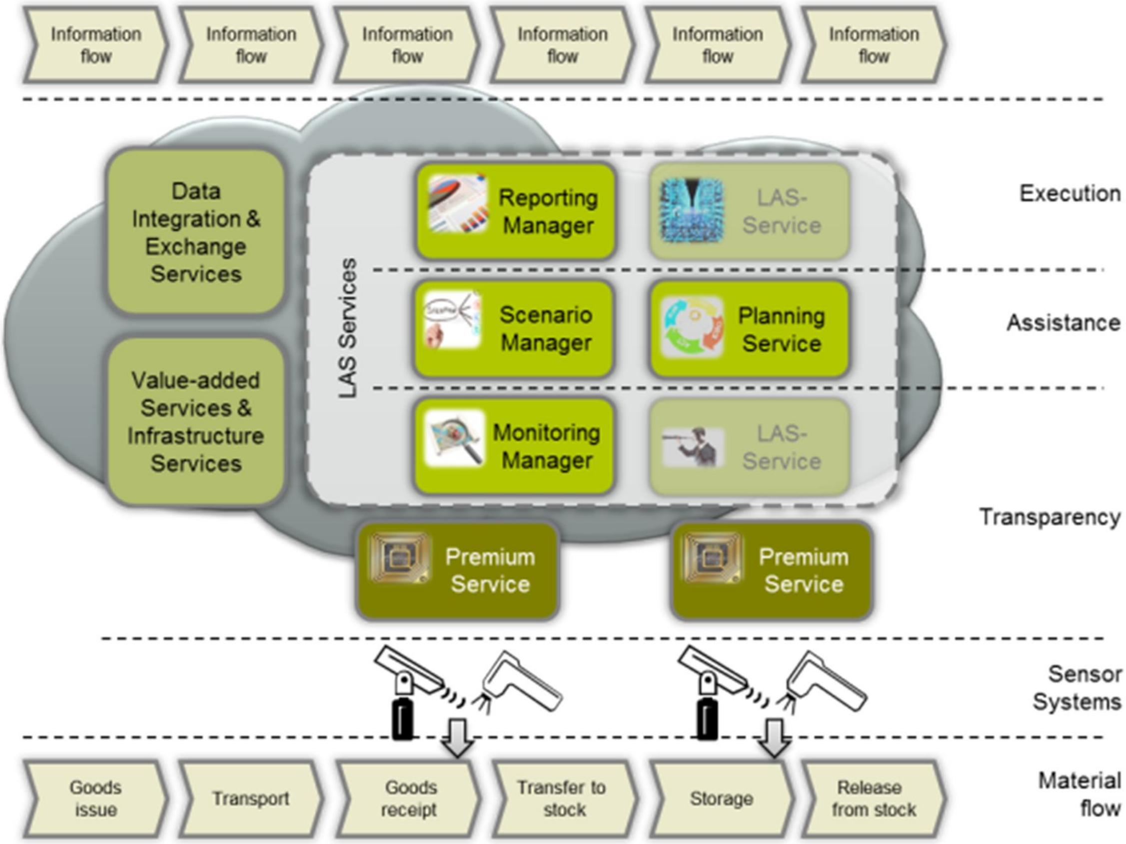

Figure 2. Architectural Framework for Logistics as a Service

http://www.logistics-mall.com). It consists of two main components:

Customers of the Logistics Mall benefit from cost and performance transparency by pay-per-use. Providers benefit from an infrastructure in which a multitude of cloud-based logistics-related services and software can be offered and even orchestrated using business process models (see figure 1). Current market studies prove that such a solution is appreciated by both logistics users and logistics application providers (Fraunhofer IML, 2010).

Today, applications are already made available via the Logistics Mall. These applications communicate through customer-driven data and interface converters. Application integration into the Logistics Mall requires the adoption of the Logistics Mall infrastructure (for details see Gsell and Nagel 2012). This migration may involve steps for:

- Interoperation with other applications (Logistics-as-a-Service, combinable with other services)
- Process-based coordination of applications

Also with the Logistics Mall the authors identified the trend from simple and isolated SaaS-offers to freely configurable and interoperable LaaS-applications. Nevertheless, this new kind of flexibility also leads to new challenges for the logistics domain:

- Standardized IT-functionalities demand the identification of reference processes for logistics and the deduction of standardized planning and operational processes
- These IT-functionalities must provide adequate methods for planning and execution
- The functionalities must then be encapsulated into services which require the provision of standardized interfaces and parameters to guarantee interoperability and a sustainable technological infrastructure to be deployed to.

In the following chapter we provide the first results related to these issues. The next chapter presents a framework for Logistics as a Service. Chapter 4 transfers the presented approach to the specific needs of a use case that has been conducted with an automotive supplier. Chapter 5 concludes with a summary and an outlook on further work.

3. AN ARCHITECTUAL FRAMEWORK FOR LOGISTICS AS A SERVICE

The development of all components is based on the principle of service-oriented architectures. This presupposes a flexible system architecture, which loosely couples professional services and functionalities in the form of autonomous services. This framework comprises four types of services based on open infrastructure services (see figure 2 and following paragraphs for details):

1. Services for data integration and interchange
2. Services for supply chain transparency (Sensor-based premium services)

3. Services for robust logistics planning and operations (LAS Services):
4. Value-added Services and Infrastructural Services

Open interfaces of all services allow docking single functionalities to comprehensive Logistics Assistance Systems (LAS), as well as these LAS to other internal IT systems or those of external network partners.

The interoperability of these systems is facilitated by the development of appropriate data structures in the form of semantic models, known as business objects (BO). BOs characterize relevant objects in a given domain by structured sets of attributes. They are used for the orchestration of applications and services and for the communication between them (Böhmer et al., 2012). A detailed discussion of Business Objects in the context of the Logistics Mall is given in Steinbuss and Weissenberg (2012). In the following paragraphs a detailed insight into the building blocks of the framework shall be given.

3.1. Infrastructure and platforms

Cloud-oriented service-marketplaces like the Logistics Mall (www.logistics-mall.de) target the dynamic provisioning of services or applications with a pay per use cost model. Especially for the German logistics market, which basically consists of small and medium sized enterprises (SME) with a small number of IT-staff, the cloud-based provisioning leads to broad access to professional IT-services (Holtkamp, Steinbuss, Gsell, Loeffeler and Springer 2010). These services or applications are delivered as a Software as a Service (SaaS) offering.

Generally a cloud-oriented service-marketplace consists of an underlying cloud infrastructure. This can be an Infrastructure as a Service (IaaS) or a Platform as a Service (PaaS) offering (Mell and Grance 2011; Stemmer, Holtkamp and Koenigsmann 2011). On top of a cloud-oriented service marketplace is a so-called trading service, which consists of a shop frontend for human users and an enhanced service registry for machines. A trading service can look up services by their functionality and by non-functional aspects, like a price-model, implemented security features (e.g. token-based authentication or encryption) or warranted service level agreements (SLA). In addition, value-added services like security-services, billing services or helpdesk services realize the non-functional aspects and offer other basic services for cross-cutting concerns, e.g. logging. A role model for cloud-oriented service-marketplaces differ the four roles Mall operator, Cloud operator, service provider and service consumer. A Cloud Operator is responsible for the provisioning of a service platform and other technical concerns. The Mall Operator, on the other hand, cares for business concerns and has a contractual relationship to service providers and service consumers.

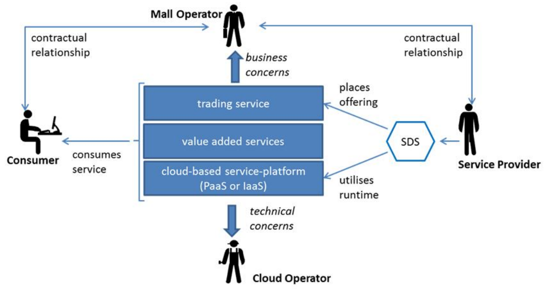

Figure 3. Roles and architecture of cloud-oriented service marketplaces

The project Service Design Studio (SDS) of the EffizienzCluster LogistikRuhr supplies a tool for service providers to place offerings on different marketplaces by utilizing a cloud runtime. Therefore, the functional service description, e.g. a WSDL, and the non-functional aspects are summarized in a semantic service description. A domain part contains a description of the service and its functionality in natural language. The SDS approach doesn't change the implementation of the service. The non-functional aspects encapsulate the service (see fig nn). The main focus of the SDS are the non-functional aspects: Security, Pricing and Service Level Agreements, which are identified as necessary aspects for the logistics domain (Iscan, Flake, Tacken, Ley and Schmülling 2012).

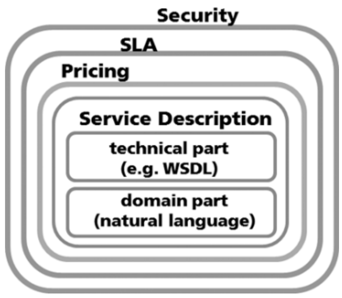

Figure 4. Service encapsulated with non-functional aspects as envelopes

The semantic service description and the executable part of the service get deployed to the marketplace, configure the runtime and get displayed on the trading service. A common format for a semantic service description is the Unified Service Description Language (USDL) (Barros and Oberle 2011). The Service Design Studio develops a logistic profile for the USDL.

A cloud-oriented service-marketplace offers value-added services to service providers. A basic set of value-added services consists of a billing service, security services for authentication, authorization, ciphering and data-integrity, helpdesk-services and a logging service for the traceability of business and technical transactions. A prototypic implementation of these value-added services for a cloud-oriented marketplace is presented by Iscan, Flake, Tacken, Ley and Schmueling (2012). This infrastructure is a solid platform that enables domain-specific building blocks to become a construction kit for flexible IT-services.

3.2. Domain-specific building blocks

The EffizienzCluster LogistikRuhr comprises projects which deal with the development of IT-services with regard to the different planning horizons of logistical tasks: strategic planning (Supply Chain Design), tactical planning (Supply Chain Planning) and operations (Supply Chain Execution).

Each of these projects is founded on industry cases of application, in order to validate the solutions in realistic scenarios. The services developed in the two projects, Supply Chain Planning and Supply Chain Execution, shall be presented in the following.

3.2.1. Supply Chain Planning

The project Supply Chain Planning deals with exemplary cases of application within the field oftactical planning. Supply chain planning activities anticipate, calculate and define demand requirements and resource capacities of the logistic network for the mid- to long-term future. Most of the factors influencing planning are uncertain. Therefore, IT-services for supply chain planning should offer the necessary functionalities for the configuration and evaluation of decision alternatives during the planning phase under uncertain knowledge about future demand requirements, market developments or other vague influence factors.

For this reason the building blocks for the described flexible construction kit for supply chain planning IT are defined as follows:

Building blocks for planning scenario configuration assist the planner in developing and configuring planning scenarios. Scenarios may result, for example, from different assumptions about future demand or service-level requirements, or may represent alternative plans, whose performance with respect to the business objectives have to be evaluated. Building blocks in this category are services enabling the user to design decision alternatives based on a data- and model-based representation of the real logistic network. The scope of the services comprises scenario design tools operated by the user based on his problem-specific knowledge and experience, but also more complex planning services which incorporate optimization, simulation or heuristic methods to derive possible solution alternatives to the planning task or sub-tasks.

Building blocks for plan evaluation allow the planner to analyse and study the effects of measures and plans on the logistic performance before deciding on plan realization. Ideally, the evaluation of the decision alternative covers the complete area of influence within the logistic network as well as the impact of dynamic effects. For this reason, simulation services are a substantial component of the planning services in this category. Simulation allows the analysis of complex interdependencies and dynamics of the logistic network and enables the planner to compare decisions in different scenario-based what-if analyses.

Building blocks for the short- to mid-term monitoring of planning performance allow continuous monitoring of the operations and the identification of necessary plan adaptations. These building blocks assist the planner in analysing the short- to mid-term development of the current operational situation given the defined plans and other decisions taken in prior planning steps. Building blocks in this category offer functionalities for identifying current or anticipated future performance gaps. In order to achieve this, information about the current state of operations must be retrieved from the network. This may require interfaces to various operational backbone IT-systems or event data repositories. To extrapolate the current operational situation into the short- to mid-term future, simulation techniques are again useful.

Building blocks for collaborative decision-making represent services for the coordination and harmonization of distributed planning processes between functional units of an organization or between companies. These services offer functionalities for the exchange of (local) planning results for negotiation and coordination within distributed decision-making processes.

3.2.2. Supply Chain Execution

Within the scope of the project Supply Chain Execution different service components are developed; services for the operational capturing (Premium Services) of material flow events and sensor data as well as control services (LAS Services) for the operational control on the materials flow level. The services are web-based and can be used by mobile devices or other systems on the network.

The use case taken from the project contract represents the quality control process in the manufacturing of pieces of furniture. Sensors are used to capture information about the quality of the boards used for cupboard doors. The captured data is provided in near real-time to the decision maker (for example, in production). If the actual quality deviates from the expected quality, the decision maker could use the control services as decision support to control and monitor the entire material flow. By means of the control services, the decision maker is given the opportunity to intervene in the manufacturing process to rework or exchange an inferior part. The following sections describe the design and prototypical implementation of the services for integration, interchange and LAS to explain what control task they support.

Premium Service (Decision preparation) is a collection of individual services, used for the identification and data capture of multiple sensors, that are aggregated by the Premium Service into, for example, a quality score.

Premium Services are responsible for the platform-independent communication with the sensors and provide the LAS Services with a standardized interface using web services. The quality parameters can be easily modified in the Premium Service. The capture of sensor data is performed completely transparent for the LAS Service.

The LAS Service "Monitoring Manager"(Decision preparation) performs the near real-time IT capture and monitoring of the quality information from the Premium Service. This information is transformed into business objects when it is retrieved by the control service and thereby linked with a specific item of wood or production order. Predefined plan values can be used to compare the captured and identified quality score of a board.

The LAS Service "Scenario Manager" (Decision making) provides, in the case of deviating quality in a test process, the decision maker with a list of all control options. Depending on the severity of the quality defect, it might be possible to forego any rework. It is also possible to rework the identified defect directly in the production line or, if it is a very severe quality deviation, take it out of production and rework it outside of the line. If rework is not possible, an alternative part can be allocated for use. The defective part can be assigned to another order and used in another spot. Once a scenario has been selected, a simulation of the selected control measure can be performed to see the future impact of the decision (see Simulation Manager).

The LAS Service "Simulation Manager" (Decision making) uses historical data or proposed decision alternatives from the Scenario Manager to simulate decisions and visualize their impact. A new production schedule is generated based on the selected decision as well as the current existing and forecasted orders. The current and future requirements for parts are presented in the form of Bills of Materials or parts lists. These can be used to simulate the future conditions in the supply chain.

The LAS Service "Optimization Manager" (Decision making) optimizes the restructuring of existing orders. In accordance with the plan sequence, predefined plan values for requested delivery dates or production runs can be adapted to and optimized for unforeseen changes (for example, a lengthy rework of a piece of furniture or a last-minute cancellation of an order that is already being processed).

The LAS Service "Execution Manager" (Decision implementation) facilitates the self-control of the supply chain by invoking one or more services in a specific sequence. Beginning with a quality test by the Premium Service, the Monitoring Manager determines if a quality defect is present. If this is the case, the Scenario Manager is automatically invoked and creates a list of all possible decisions based on predefined plan values. These control options are taken by the Simulation Manager and are simulated. The Reporting Manager checks the results of the simulations. The Execution Manager makes a decision from the generated results based on predefined and prioritized Key Performance Indicators and implements the selected control alternative through the connected management system. This service implements the self-control of the decision implementation.

The LAS Service "Reporting Manager" (Decision implementation and monitoring) can be used to retrieve order-related reports. First, the desired report type is selected (for example, throughput time of orders or stock overviews) and then other options can be specified such as item, orders, time period, and report display options. Restrictions and threshold values, for identifying areas, can be specified for some report types.

The LAS Service "Decision History Manager" (Decision implementation and monitoring) service documents the decisions that were made. All relevant information used to make a decision, including order-related data, is saved from the Scenario und Simulation Manager. The goal is to provide traceability for the decisions that were made because of defective quality for other instances. This information can also be used as a reference for future decisions. All decisions that represent an unscheduled intervention in the material flow can be documented. These documented interventions can be used as reference information and aid in future decision making.

LAS Service "Revision Manager" (Decision implementation and monitoring) links decisions that were made and documented with the Decision History Manager with incoming complaints. This type of information from downstream supply chain stages allows for reflections on the impact as well as the monitoring of decisions that were made.

LAS Service "Quality Assurance" (Decision implementation and monitoring) is the quality-related equivalent of the Reporting Manager. This means that the retrievable reports focus on the quality defects that occurred. The type, number, and length of the rework carried out in the past in a specific process step serve as a reference for future decision making about the control of the material flow when the same or a similar quality defect occurs.

4. USE CASE

The presented framework for a construction kit for flexible supply chain IT is developed and tested in applicational cases with small as well large industrial partners. As an example for the resulting IT tools, the case of Continental tire logistics is lined out in the following.

The use case comprises the production and distribution network for the Continental aftersales and replacement business for passenger and light truck tires. The logistic network contains 9 plants in Europe with 52 Mio. passengers car and light truck tires per year (European replacement market), 23 European markets with regional and central warehouses and more than 700 different articles

Supply chain planning is a challenging task in this case, since the tire business is affected by strong seasonal effects. During the year frequent plan adaptations are necessary to react to seasonal demand developments in the various markets. There is also a strong interdependency of the production planning decisions and the supply chain planning decisions especially concerning the inventory management in the distribution network. Lot-sizing decision and banking measures due to limited production capacities during the peak season influence inventory optimization and product availability in the markets.

For tactical supply chain planning in this use case in total four typical building blocks have been identified and developed. Together these building blocks form a supply chain planning IT-system to be used on-top of the operational backbone ERP systems at Continental. The interaction and information flow between these building blocks is depicted in Figure 3.

stocking strategy decisions can vary during peak-season and off-season. To assist with this planning task, the building block "Stock Strategy Planner" was developed. Using the building block "Stock Strategy Planner" the planner determines optimized stocking points. For each article these decisions are derived under consideration of article characteristics (e.g. value, product segment, customer expectations, service targets) and demand information using heuristic methods and clustering strategies offered by the tool. To define clusters, the tool also analyses sales data (historical data as well as forecasts) in order to determine decision-relevant measures such as volatility of demand and accuracy of forecasts.

The building block „Target Stock Calculator" is a tool the planner makes use of to determine relevant disposition parameters, e.g. target stock levels, safety stocks, days of inventory coverage, reorder points.

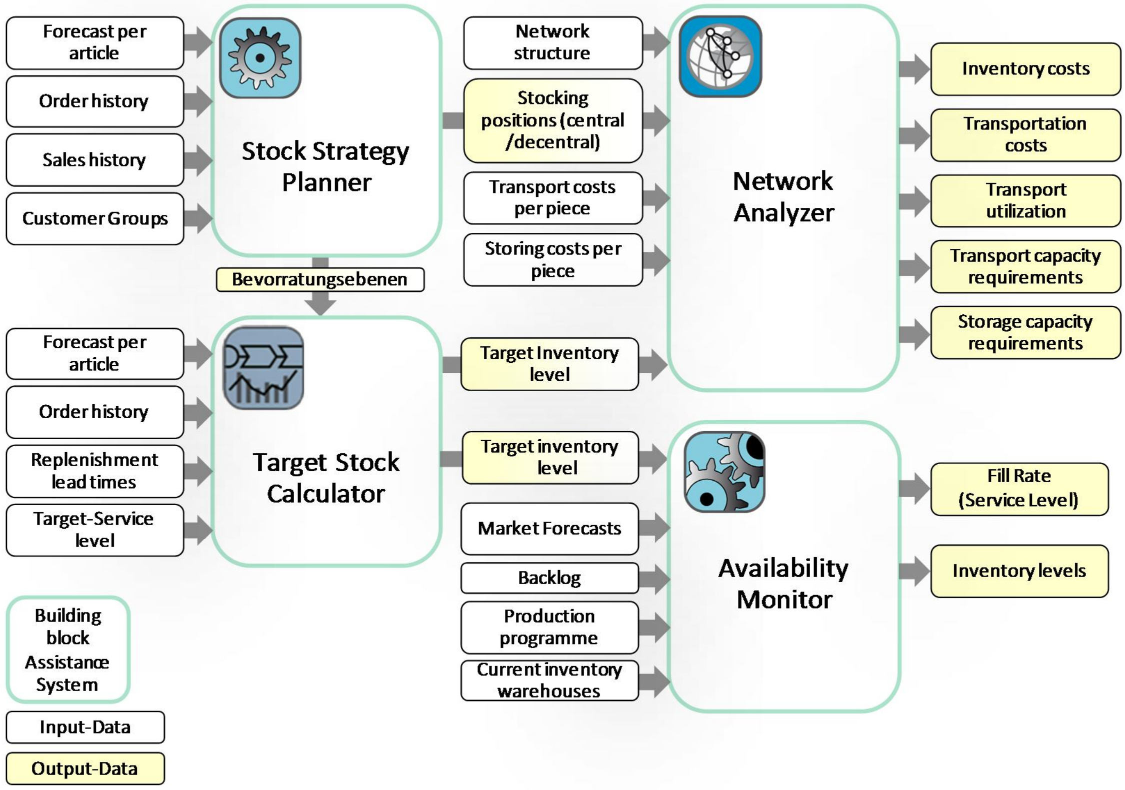

Figure 5. Information flow between building blocks

As a first step on the tactical level, it is necessary to decide on the stocking strategy for each article, i.e. which article is held at which stage of the distribution system (central warehouses vs. regional warehouses) at which point in time. Due to seasonal demand patterns,

Among others, the tool has adopted innovative methods for the determination of optimal reorder point strategies in multi-stage distribution. As data input the building block makes use of article sales data as well as historic and forecasted sales volumes of the markets.

Referring to the categorization given above, both building blocks, the „Stock Strategy Planner" and the „Target Stock Calculator", are examples of the category of building blocks required to configure planning scenarios. The planner uses their respective functionalities to specify a planning scenario defining which article is stocked where in what quantity in the network.

The effect of these decisions on the logistic costs and performance of the distribution network can then be analysed using the building block “Network Analyzer”. This building block offers a model-based representation of the real network as a basis for simulative evaluation of the network. The planning scenario defined by the results of the other two building blocks can be imported into the “Network Analyzer”. A simulation component then evaluates the planning scenario under different demand assumptions.

Last, the building block „Availability Monitor“ represents a tool for the rather short-term-oriented operative distribution planning. This building block evaluates the effect of production programme decisions on the demand fill rate of articles in the various markets. Again a simulation-based approach is used to determine the impact of planned production quantities per articles on inventory levels and service-levels per article, warehouse and market. By this, necessary adaptations to the production programme can be identified and their expected effect can be validated via simulation prior to realisation. For this analysis the building block integrates real orders from the current order book, forecasted orders and data from production planning system as well as the current As-Is inventory levels as reported from the warehouses.

In cooperation with Continental Tire Division the described building blocks for a supply chain planning system have been prototypically implemented and tested with real operative data. The building blocks and the planning system they constitute help connect and harmonize distinct activities in demand planning, production planning and inventory and distribution planning. All steps of the planning process receive assistance by model-based quantitative methods and make use of up-to-date supply chain and backbone ERP-information. Also, the time necessary to determine planning results is shortened: Simulation of one planning scenario comprising 9 production plants, several regional and central warehouses, more than 20 European markets and an order volume of 50 million pieces requires less than one hour.

5. OUTLOOK

In this paper the idea of “Logistics as a Service” as seen in the EffizienzCluster LogistikRuhr has been presented. After presentation of the state of the art in relevant research, a framework for Logistics as a Service has been developed. Domain-specific building blocks are the components of a construction kit of flexible IT Services for supply chain planning and operations. Exemplary services have been developed and demonstrated within this paper. Their practical application has been tested in realistic use cases, one of which is the described case of inventory management in the multi-stage production-distribution system of Continental tire logistics. An individual logistics assistant system has been assembled using building blocks from the general building block categories presented in chapter 3. Furthermore, the projects Service Design Studio and Logistics Mall contribute to this framework by providing the necessary sustainable technological cloud infrastructure and infrastructural services. One of the first significant results is the need for a holistic service description language. It could be identified that USDL fits the requirements of such a language, but is far too complex to be applied in industry scenarios. Therefore a logistics profile for USDL has been developed. Further research should analyse the suitability of USDL in other domains and develop similar profiles. Another approach is the decomposition of the USDL to a small core and optional, maybe domain-driven, modules. The research project “Linked USDL” (http://linked-usdl.org) starts with such an approach by application of linked data (Bizer, Heath and Berners-Lee2009).

To further support interoperability additional research is needed in the definition of logistics reference processes and standardized business objects. The presented projects cover specific supply chain management scenarios; nevertheless, other scenarios like warehouse logistics, transport logistics or the special requirements of urban regions are still open work. Here, reference processes need to be developed as the starting point. Only with these references processes, support by modern IT services, as depicted in this paper, may be given.

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