Go with the Flow - Design of Cloud Logistics Service Blueprints

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***Abstract*—By adopting principles of cloud computing to the logistics domain the paradigm of Cloud Logistics is derived. It appears to be a promising paradigm in order to evolve logistics into being more flexible and collaborative. Yet, appropriate concepts that enable the cloud logistics paradigm are missing. In the paper, existing body of literature is reviewed and a definition and a framework of cloud logistics is given. Further, service blueprinting is combined with domain engineering and general morphological analysis in order to create a suitable method for designing cloud oriented service blueprints. Those are focusing on domain-specific flows and transformations enabling cloud oriented business collaboration. The method is applied to the logistics domain and a cloud logistics service blueprint is designed. Finally, the concept is evaluated with real use cases from logistics service providers.**

***Keywords*-Logistics, Service, Blueprinting, Cloud Logistics, Resource Virtualization, Service Encapsulation**

I. Motivation and Methodology

For years, logistics is facing the trends of outsourcing and concentration on core competencies [1], [2]. In order to fulfill complex customer demands in such an environment of specialized logistics service providers (LSP), selection of and collaboration between them is obligatory. For the selection of LSP, flexibility - in terms of ability of adaption to changing customer requirements, responsiveness to target market, handling of specific requirements and time response capability - is an important evaluation criteria [2], [3], [4]. Flexibility and performance of logistics services can be increased [5] by the adoption of a service oriented paradigm [6], [7], which is also the foundation for the principles of cloud computing (CC) ('...-as-a-Service') [8], [9]. This comprises on the one hand *encapsulation*, composability, loose coupling, and reusability (adapted from service orientation) and on the other hand *virtualization of resources*, ad-hoc reconfiguration and inter-connectability of resources (adapted from CC). The adoption of those principles to the logistics domain to the most possible extent leads to the idea of *Cloud Logistics* (CL) as discussed in [10]. Its core idea is the virtualization of both IT and *physical* logistics resources and their encapsulation in logistics services in order to provide flexible and customized logistics solutions.

It is pointed out, CL is still a topic in its infancy, just existing as an theoretical concept and potential fields of further research are discussed [10]. The most promising field is a comprehensive service model based on logistics resources and ensuring compatibility through coherent (data) interfaces, which is crucial in order to combine services and resources of different LSP. This conforms to the results of Gupta et al. [11] and Arnold et al. [12]. They found simple communication between stakeholders, ease of use and convenience (which are enabled through comprehensive models and compatibility) to be the topmost success factor of CC ([11] for small and medium enterprises in general and [12] for logistics enterprises in particular). Hence, those factors are assumed to enable the success of CL as well.

Ease of use through compatibility and a comprehensive model can be provided by a modular construction kit [13] that is based on generic compatible building blocks that represents the comprehensive service model. Thus, the idea of Cloud Logistics Service Blueprints (CLSB) arises that can be configured and specified to virtualize and represent the various logistics services in a network and their resources. By virtualizing and encapsulating with the help of the same CLSB, compatibility of services and their resources is granted and CL is enabled. Eventually, the engineering of such a blueprint is a challenging task that answers the leading research question: *'How can the logistics domain and its essential resources be analyzed, described, abstracted and categorized in order to create a logistics service blueprint that enables cloud logistics?'* that is solved with the following sub-questions:

- SQ_1: What is the leading definition of cloud logistics?
- SQ_2: What are suitable service engineering methods for creating cloud oriented service blueprints?
- SQ_3: What is an appropriate conceptualization of the logistics domain (description, flows, interfaces, transformations) in order to develop Cloud Logistics Service Blueprints for enabling cloud logistics?

As CL is a theoretical concept [10], an empirical observation is not possible. Hence, the design-science paradigm for information systems [14] is chosen and the design-oriented information systems research approach [15] is applied as the leading methodological framework. Its phases of analysis, design, evaluation and diffusion shape the structure of the paper by using specific methods, see Figure 1. The *analysis* is conducted in section II with a systematic literature review

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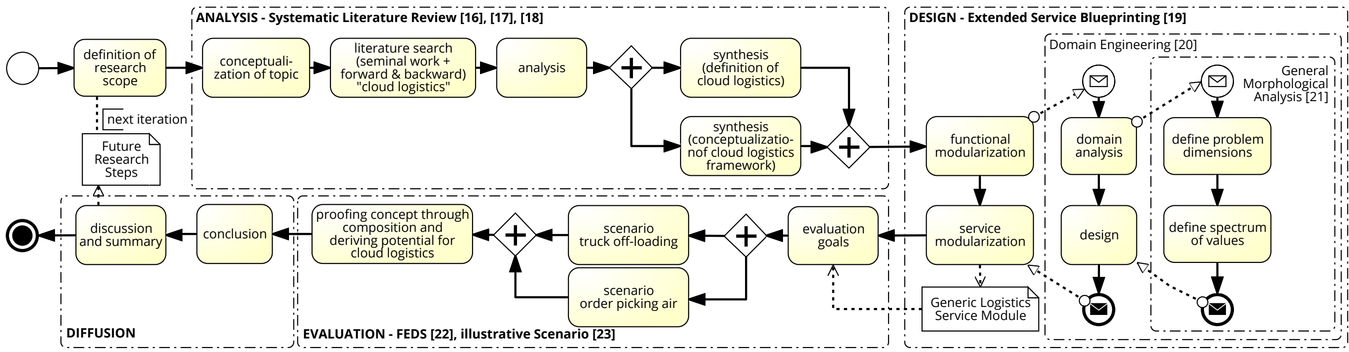

Figure 1: The design-science paradigm [14] as leads the design oriented research frame [15] with invoked methods.

that follows the approaches of [16], [17], [18]. It reveals the state of the art of current literature concerning the concept of 'cloud logistics' in order to develop a thorough theoretical basis. In times of ever increasing amount of scientific papers being published and being accessible in seconds via electronic databases and the internet, it gets more difficult to accomplish a comprehensive analysis and synthesis of literature due to limits of human perception and processing of information. Hence, Vom Brocke et al. [16] argue for the strategy of finding publications in a field with the most seminal character as the 'backbone' of the body of literature that is broaden by forward and backward search subsequently. The *design* phase in section III focuses on the development of a suitable method for designing cloud oriented service blueprints. The comprehensive method involves mainly the methods of 'extended service blueprinting' [19] as the leading approach, 'domain engineering' [20] in order to find common and varying points of a domain and to create a configurable architecture. The 'general morphological analysis' [21] is invoked in order to structure the multidimensional problem complex and to create a morphological field. After being described, the comprehensive method is applied to the logistics domain in order to develop the CLSB. For *evaluation*, in section IV the resulting CLSB concept is applied to services abstracted from real world processes of internationally operating LSP and evaluated with the 'Framework for Evaluation in Design Science Research' (FEDS) of [22] with an illustrative scenario [23] is used to. Finally, the *diffusion* of evaluated results is conducted by the paper itself. Section V concludes the paper with a summary and discussion of findings as well as an outlook on further research steps for the next iteration of the frame.

II. Cloud Logistics

A clear context for the design of the CLSB is necessary, i.e. a distinct definition of cloud logistics (CL). As described, CL is a theoretical idea for a new paradigm of logistics. Hence, the currently available literature is searched, analyzed and synthesized. CL is conceptualized, a definition and a conceptual framework is given.

Table I: Amount of papers found and included with exact phrase 'cloud logstics' in title (per database and year).

databases	result	included	2010	2011	2012	2013	2014	2015	2016
google scholar www.scholar.google.com	59	9	1	-	-	-	5	2	1
Springerlink link.springer.com	19	2	-	-	1	1	-	-	-
Science Direct www.sciencedirect.com	6	1	-	-	-	1	-	-	-
IEEE Xplore ieeexplore.ieee.org	6	3	-	-	2	-	1	1	-
Web of Science apps.webofknowledge.com	1	0	-	-	-	-	-	-	-
Emerald Insight www.emeraldinsight.com	0	0	-	-	-	-	-	-	-
ACM dl.acm.org/	0	0	-	-	-	-	-	-	-
Foward and Backward	2	2	1	1	-	-	-	-	-
Total	93	15	2	1	3	2	6	3	1

A. Systematic Literature Review

In a very first step, google scholar presented an amount of 27,500 results searching for 'cloud logistics'. In order to achieve a reasonable quantity, we expect literature dealing meaningfully with it to use the term in the title of the publication as this is a very young field. Next to google scholar further databases were searched for the term 'cloud logistics' in title, which lead to a reasonable amount of papers as shown in Table I (access date: 19^{th} May 2016). Duplicates are excluded and removed (13 paper). Further exclusion criteria are either no recognition of CL as a new paradigm in logistics and/or no accessibility. Most of the excluded paper dealt with the implementation of CC in the logistics domain (without virtualization of physical resources), or e.g. regarded CL as the allocation and management of CC resources on server farms, see [39]. In total, 13 papers form the body of seminal work. Through forward and backward search another 2 paper were found to be relevant for the topic of CL. The concepts of CL in the related literature are discussed and presented.

The conceptualization of topic emerged into the fields of

Table II: Conceptualization of ’cloud logistics’ and the characteristics of the included paper.

		layer			virtualization			encapsulation			
publication	defintion	number	Iaas/PaaS/SaaS	physical/virtual/service	semantic-oriented	object-oriented	categorization concepts	service model	(data) interfaces	XML-based description	building blocks
[24]	-	3	x	-	x	-	-	-	x	x	x
[25]	-	6	-	x	-	-	-	-	-	-	-
[26]	-	3	x	-	-	-	-	x	x	x	x
[27]	[24]	3	-	x	x	-	x	-	-	x	-
[28]	[24]	-	-	-	-	-	-	-	-	-	-
[29]	[24]	-	-	-	-	-	-	-	-	-	-
[30]	-	4	-	x	-	-	x	-	-	-	-
[31]	[27]	-	-	-	-	-	-	-	-	-	-
[32]	-	3	-	x	-	x	-	-	x	x	x
[33]	-	3	-	x	x	x	x	-	-	-	-
[34]	[24]	3	-	x	-	-	-	-	-	-	-
[35]	[24]	-	-	-	-	-	-	-	-	-	-
[36]	[27]	3	-	-	-	-	-	x	-	-	-
[37]	-	4	x	-	x	-	-	-	-	-	-
[38]	x	4	x	x	-	-	x	x	x	x	-

definition of CL, layers, virtualization and encapsulation, see Table II. It is evident that there exists no proper *definition* of the term ’cloud logistics’ covering its entire and genuine characteristics. All papers eventually root their description of CL on Holtkamp et al. [24] that do not give a definition of CL but rather describe the general idea of adopting cloud principles to the logistics domain, like the other publication created by the Fraunhofer Institutes, i.e. [32]. Leukel et al. [38] establish the term ’supply chain as a service’ (SCaaS) and define the terms cloud, supply chain system, (composite) supply chain service and classification scheme. SCaaS is added as another layer to the standard layers of CC on top of SaaS. Summarizing, a definition of CL is required.

Concerning the regarded *layers* of CL two general perspectives exist, which are not mutually exclusive. On the one hand, there is the ’classic’ view adapted from CC with the layers of IaaS/PaaS/SaaS that could be extended with a layer on domain-specific logistics services (i.e. Business Process-aaS [26], Process-aaS [37], SCaaS [38]). This view comes with difficulties, as computational resources are getting less physical from IaaS to SaaS but the domain specific layer on top again builds on other physical resources. On the other hand, the majority of publications regard CL with the layers of (1) physical resources that are (2) virtualized into logical resources that afterward are (3) encapsulated into services. Goal is the accessibility and orchestration of physical resources through service interfaces. Additions to those 3 basic layers are conceptually not necessary for the essence of CL paradigm (like extra middleware layer for virtualization and application interface layer of [25] or operation mode layer (public/private/hybrid cloud mode) and user role centered layer of [30]).

The *virtualization* concepts’ objective is to establish the connection from physical resources to logical resources and thus, the synchronization between real world and IT-systems. While on the one hand, a business ontology [24] or semantic data mediators [37] are just mentioned, on the other hand ontologies based on resource classification [27] and conceptualization of physical resources [33] are presented. However, the both ontologies differ a lot and do not seem to rely on literature nor on proper ontology engineering. The object-oriented concept of [32] focuses on the essential objects of logistics. They aim at abstracting real-world objects (goods, handling units, transportation vehicles, facilities and documents (e.g. orders, invoices)) by business objects (BO) in order to synchronize physical and virtualized resources. [33] apply an object-oriented approach in order to achieve the unified description of cloud logistics physical resources. A useful categorization concept supports building up a catalog in order to increase the ease of use for a logistics planner or logistics integrator (retrieving services in order to compose them to complex services in order to meet its customers’ demand) as well as the ease of use for the LSP (subscription to provider list of existing services in the catalog). [27] distinguish between different types of resources: equipment, human, service, information and financial. [30] present a classification of basic services (transport, warehousing and transshipment) and value-added services. [33] accomplish resource categorization by integrating a taxonomy that is not further detailed. The categorization of [38] is based on the Supply-Chain Operations Reference Model (SCOR) [40] but already in their evaluation example they admit that SCOR is not able to model detailed logistics processes (e.g. ground handling operations at airports). Organization of the content of the services is an important issue in order to grant ease of use. Facilitated virtualization, categorization, finding, and composition of the resources are important requirements for cloud logistics. An ontology should contain information and knowledge about logistics objects (like the BOs of [32]) and logistics resources as well. This comprises also a categorization concepts for enhanced ease-of-use. The concept of the logistics service map [13] also emphasizes the importance of the categorization of logistics services and their resources. It comprises a catalog and a construction kit of modular logistics services in order to engineer and manage logistics services easily.

The presented *encapsulation* of CL are manifold. The hierarchical structure of classic service models (I/P/SaaS) is broken up by Papazoglou [26] in order to modularize and enable free combinations of e.g. SaaS from one provider on a PaaS from another provider run on the physical IaaS from another third provider. This is pointed out as an important requirement for effective implementation of BPaaS. This model comprises functional characteristics, KPIs, resources, policies as well as structured interaction and flow represenation. Leukel et al. [38] build their service model of SCaaS on a flow-oriented perspective of logistics with parameters for products, mode of transport, source and sink. Further, they define input/output/inner data elements for the services and their interfaces. Weißenberg and Springer [32] distinguish between control, data and material flow in logistics. As basic types they introduce GUIs as interfaces for human resources and APIs for machine resources. Sensors are linked in order to retrieve current state parameters of physical resources. Zhang et al. [36] emphasize the combined characteristics of logistics of physical and non-physical objects and thus, argue for a product service system view on logistics. (Logistics) services are encapsulated and accessible via XML-based description and interface. Different purpose-specific languages are described in detail by [26], [32], whereas the other authors only mention their existence. Commonly, an easy-to-understand language for end users is conceptualized, i.e. Blueprint Request Language (BRL) [26] and domain-specific language of industry [32]. Further, a common exchange language of the involved IT-systems is described, i.e. XML-based communication via bus or process engine [32] or more detailed blueprint languages (BxL) of [26] for description (BDL), constraints (BCL) and manipulation (BML). Interestingly, the metaphor of combinable 'lego bricks' for services is explicitly used by [26], [32] and implicated by emphasizing the need for standardized building blocks by [24] in order to enable the idea of CL. This idea avoids pairwise adapters (between LSP and/or their IT-Systems) and data mappings [32]. Further, the creation of newly available services in a logistics network is drastically facilitated. On the one hand, Papazoglou's cloud blueprints [26] aim at creating building blocks for cloud services. On the other hand, [32] aim to abstract real-world objects (goods, handling units, transportation vehicles, facilities and documents (e.g. orders, invoices)) by business objects (BO) in order to synchronize physical and virtualized resources. Hence, the BOs only take the first step of resource virtualization but logistics services are not encapsulated. BOs abstract the logistics objects but not the logistics services whereas the created cloud blueprints are not focusing on logistics.

Summarizing, the idea of *Lego Bricks of Logistics* emerges as pre-built, pre-configured and pre-optimized building blocks focusing on reusable modular capabilities in the logistics domain. Hence, they are filling the gap between cloud blueprints for CC services of [26] and BO of [32]. Main shortcoming of [32] is the need of code generation by domain experts when they want to offer and provide their services via the described 'logistics mall'. The current goal is to create blueprints of logistics services in a language (or graphical notation) that a logistics domain expert could easily understand in order to use them to built collaborative logistics services. Retrieval and access to descriptions must be easy. Existing technical service specifications (e.g. service operations, their input/output parameters and the data types) are to be pre-linked with the business level. This kind of strategy is described in the concept of *look-ahead* [41]. Main input for the lego bricks should be the flows and transformations of logistics domain as the essence of every logistics service.

B. Definition of cloud logistics

As it stems from CC, the definition of CL is based on the CC-defintion of [8] which should be taken into account in order to get the whole picture of CL:

Cloud Logistics is a model, based on and inspired by the paradigm of cloud computing, for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable and virtualized logistics resources (e.g. means of transportation from different modes of transport, warehouses, domain-specific knowledge, logistics applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction. This cloud model is composed of the five *essential characteristics* of cloud computing (on-demand self-service, broad network access, resource pooling, rapid elasticity, measured service) but is adjusted in consequence of logistics' more physical character. This comprises: a location dependency of services, the need of knowledge about that current location as well as a lower elasticity due to slower allocation of physical resource. The domain-specific layer *Logistics as a Service (LaaS)* is added to the CC service models. The capability provided to the consumer is to provision transport, storage, handling, knowledge and other fundamental logistics resources where the consumer is able to ship and convey and transform logistics entities, which can be of physical or non-physical character. The logistics resources are purchasable through interfaces combining GUI and/or API. The consumer does not manage or control the underlying logistics infrastructure but has control over the source and sink location and the transformation of the entities shipped as well as control over the configuration settings for the transformation-enabling environment. The *deployment mode* of LaaS results in different business models of logistics service provider (LSP): public cloud (for networks), private cloud (for big LSP with a comprehensive service portfolio) and hybrid (for a participation of big LSP in networks or as the basis of the business model for big LSP to become a Lead Logistics Provider (LLP)).

C. Cloud Logistics Framework

Is CL just old wine in new skins? Of course outsourcing and insourcing of capabilities, processes and resources is nothing new to logistics. However, with the help of CL and the concept of service blueprints, LSP are provided with the possibility to collaborate digital and more flexible within a network. This is possible even without good mutual internal IT systems when the approach is provided by a logistics integrator. CL is not only the application of CC in the

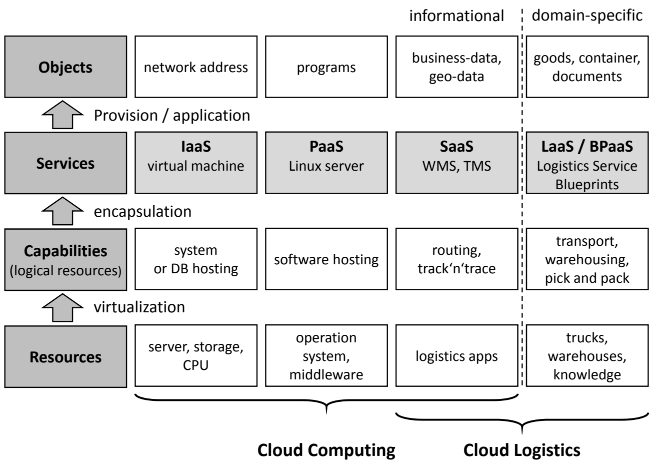

Figure 2: Framework of Cloud Logistics, adapted and extended from Leukel and Scheuermann [42]. Examples are given by small printed text.

logistics domain, but rather the adaption of its principles to the domain-specific (physical) logistics services in order to increase flexibility and collaboration. Furthermore, it helps especially small LSP to take first steps towards digitalization. By extending the existing definition of CC for CL purpose, the definition of CL is formed and builds up the basis of the CL framework presented in Fig. 2 that combines both layer perspectives. The *virtualization* of computing resources is adapted to (mostly physical) logistics resources. By *encapsulating* them, logistics services are shaped, that can be freely combined. Foundation for such a flexible modular collaboration is the design of Logistics Lego Bricks, or the CLSB, respectively, that describe the essential flows and transformations of the logistics domain in order to design compatible virtualized resources from different providers. Objective of services is always the transformation or manipulation of certain objects. Following [36] an integrated view is supported by following a product service system approach for engineering cloud logistics service blueprints, i.e. service blueprinting. Those service blueprints for a cloud-inspired approach and environment are engineered in the next section.

III. Designing a Cloud Logistics Service Blueprint

The above described idea of cloud oriented service blueprints bears potential for other domains as well. Hence, the method of their design will be firstly developed without domain-specific aspects of logistics. Afterward, the method is applied to the logistics domain.

A. Involved Engineering Methods

1) Extended Service Blueprinting: The method of service blueprinting [43], especially the modified version extended service blueprinting by [19], offers suitable aspects to describe services that are based on both business services and electronic services, see Fig. 3. The essential aspects of services [7], i.e. interaction between consumer and provider, value creation, input and output (physical or non-physical, e.g. information, skills, knowledge or costumer requirements) can be modeled with the help of extended service blueprinting. Hara et al. [19] distinguish between a *behavior blueprint* that represents the 'hardware' and their related software involved in a service (= electronic services) as well as an *activity blueprint* that represents the 'humanware' and their related supporting software (= business services). General depiction method is the business process management notation (BPMN) in order to ensure a common and easily understandable communication standard. Services in general are seen as a set of functions that have a possible value for customers in terms of changing one or more receiver state parameters (RSP) [44], [45]. Those RSP could be structured down to the lowest level where they represent basic functions and are mapped afterward to specific process steps of services in order to highlight their importance in the context of interaction with the customer. The change of the RSP is the goal of business activities and thus they form the customers' requirements. Further, two important lines are introduced: the line of interaction (separating service consumers and service providers) and the line of visibility (separating 'onstage (visible)' and 'backstage (invisible)' of activities performed by the provider). An inter-relation between the activity blueprint (humanware + related software) and the behavior blueprint (hardware + related software) is obligatory for the extended service blueprinting. A further connection is established between the functions of the RSP (customer requirements) and the appropriate process steps.

2) Domain Engineering: Domain Engineering [20] is used to find common and varying points of a domain in order to determine configurable requirements. The created domain model serves as a generic architecture for a con-

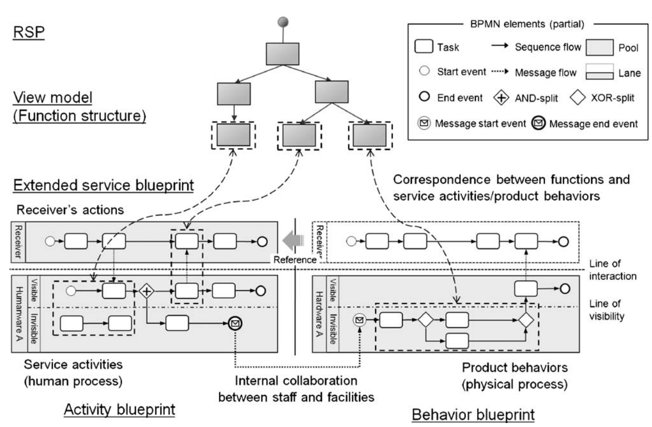

Figure 3: Notation of the extended service blueprint taken from Hara et al. [19].

figurable and standardized solution for a family of systems. An advantage is the creative character. Not only existing systems of a domain are to be collected and formalized, but also additional domain knowledge can be added in order to improve the result. With a domain categorization similarities and differences are the core of re-configurability. Goal is to enable functional and architectural reuse of software.

As the automated exchange of software and interaction with logistics systems is the goal of cloud oriented service blueprints, domain engineering appears to be suitable to be integrated into the whole design method.

3) General Morphological Analysis: The General Morphological Analysis (GMA) [21] can analyze and formalize organizational and stakeholder structures as well as planning issues and present them in a morphological field format. The objective is to identify all dimensions of a problem as well as the possible spectrum of values within the dimensions. The method is suitable to structure and investigate the total set of relationships of mutli-dimensional, non-quantifiable problem complexes.

B. Method for Designing Cloud Oriented Service Blueprints

Services in general are relying mainly on a specific input of physical and/or non-physical elements that are changed in a certain kind of way during the service provision. Non-physical elements are obligatory as e.g. information of the customer sets the requirements and objectives of service provision. Further, this implies an interaction between consumer and provider and a certain value creation for the customer, which means a change of certain parameters is the customer's motivation and defines the output of a service [7]. Alternatively speaking, a service can be characterized by (1) a *flow of entities* (physical or non-physical) and (2) a certain *transformation* of those entities. Hence, a Cloud Oriented Service Blueprint has to describe the essential flows and transformations of the target domain.

Having this and the aforementioned methods in mind, the resulting objective is to design, a specific domain's essential flows and transformations and the human and machine related interfaces. The objective of the service is the transformation of customer's RSP. Hence, the idea arises that the typical RSP of a specific domain is always built upon a certain set of possible domain-specific transformations. The possible values of the flow and transformation dimensions can be figured out with the GMA. Consequently, those common points can be pre-configured in a cloud Oriented Service Blueprint with interfaces for input and output data elements and an inner data element [38] and an interface to invoke further (sub-)services. Inspired by the blueprint of [26] KPIs, resource utilization and policies (Figure 4) and the according languages (Figure 5) are taken into account. The *look-ahead* strategy by Bauer et al. [41] for improving quality and cost-effectiveness of process-oriented, service-driven applications focuses on the description of reusable services with graphical notations or with a language that is understandable to a domain expert with just low or even without IT-Skills at all. This conforms with the ideas of Papazoglou's BRL [26] and Weißenberg et al.'s domain-specific language of industry [32]. Additionally, the orchestration and automation in the background requires the description to be understandable by machines as well, e.g. BxL blueprint languages of [26].

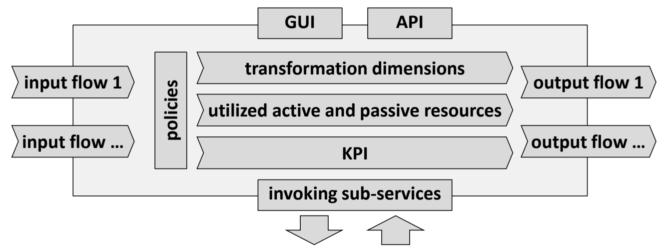

Figure 4: The Cloud Oriented Service Blueprint contains flow-related interfaces, transformations and interfaces for invoking other (sub-)services, as well as resource utilization, policies and KPI.

Language	Resources	Target
Convenient Blueprint Request Language	request and discovery	user and developer centric
Blueprint Defintion Language	utilization	transformation dimensions, active and passive resources, KPI, interfaces
Blueprint Compliance Language		SLA, privacy and security, law and customer constraints
Blueprint Manipulation Language		algebraic operators, e.g. match, merch, compose, delete, etc.

Figure 5: The blueprint framework and its blueprint languages.

This pre-configured blueprint represents a process-oriented service perspective like the extended service blueprint of Hara et al. [19] that is based on the BPMN language. Transformations always aim at specific values of a domain or domain-specific RSP, respectively. Hence, it is only useful to focus on the transformations of dimensions, which are transformable by the services of a specific domain. With this common understanding, a high flexibility, simple communication and ease of use in service networks can be achieved. The question *What should be done 'right' in order to provide the service in a customer satisfying way?* can be used as a guidance (e.g. 'the domain's objective is to transform the right *entity* from the right *input* into the right *output* with the right *costs* under the right *conditions*' etc.). The resulting method involves the following steps:

1) develop a convenient *request language* by finding representational questions a service costumer could have concerning service objectives (brainstorming with domain experts)

2) develop the *description language* with conceptually configured and domain-specific common points:
   a) essential transformation dimensions for both hardware and humanware (What has to be done *right*?)
   b) essential flows for the interfaces (input, output, request of sub-services (What are the *right* entities?)
3) extend the *description language* with conceptually configured and domain-specific varying points by identifying the morphological field that can be extended later on:
   a) possible 'active' domain-specific resources that enable transformations (e.g. staff, machines, infrastructures)
   b) possible 'passive' domain-specific resources that enable flows (e.g. business objects: container, documents)
   c) domain-specific SLA
4) develop the *compliance language* with conceptually configured privacy, security, mandatory and non-mandatory constraints
5) develop the *manipulation language* for opreations with other blueprints

C. Cloud Logistics Service Blueprint

The method above is applied to the logistics domain. As [36] emphasize logistics' characteristics of physical and non-physical objects and thus, argue for a product service system view on logistics, the method based on extended service blueprinting is suitable. When creating a basic cloud Logistics Service Blueprint (CLSB), which is based on the extended service blueprinting, the concept shown in Figure 3 has to be encapsulated and logistics characteristics have to be taken into account. From the basic logistics lego brick (the CLSB), specific logistics services can be derived that incorporate distinct logistics resources in order to fulfill logistics functions, i.e. transformations. Because of the services with common interfaces, those logistics functions can be combined and thus cloud logistics is enabled. The results of the several steps are shown in a conceptual way. Implementation is to be done in an XML-based language.

(1) The request should enable consumers to discover and request appropriate resource (e.g., 'I need this many trucks with a pallet capacity of x', or 'I need cooled storage capacity for x pallets') and higher-level application requests (e.g., 'I need enough capacity to perform this specific service') over standardized blueprint images that are stored in the logistics service map [13] that act like a catalog of cloud services and providers. Hence, the request language should be able to express kind and number of the resources, transformations based on the flows.

(2) The description of the logistics services should comprise all essential *transformations* of the logistics domain. Mentzer et al. [46] describe the 7R as the common points of a successful logistics that targets to deliver:

1) the right product
2) to the right location
3) in the right time
4) in the right quality
5) in the right quantity
6) for the right price
7) with the right information

Since these are target to be delivered by logistics, logistics must be able to manipulate or transform them, respectively. Thus they form the core transformation dimensions. Essential *flows* of logistics are the flow of information and the flow of goods [47]. [32] additionally take the flow of control into account for their approach of logistics BO. Sometimes the financial flow is also mentioned as essential for logistics but can be left out. On the one hand it is not in the main focus of logistics, and on the other hand it is implicitely contained as it can be regarded as a kind of informational flow in the context of online banking (even though, there may be higher formal and security requirements). Cloud logistics is information intensive and comprises also information-centric (sub-)services (e.g. customs clearance, identification or track and trace). Hence, the flow of physical goods is not always obligatory for every service but overall objective of logistics is still the re-allocation of physical goods. Summarizing, it has to be mentioned that the CLSB are not re-allocating the goods themselves but information about the physical re-allocation and transformation has to be passed on in order to trigger human or machines to fulfill the distinct transformation via an API or GUI.

(3) The possible resources of the logistics domain that are used in order to conduct the transformation are manifold. As they form the varying points, it is appropriate to just present a selection, that has to be customized (extended or reduced) according to the use case. *Active resources* of logistics are (with example transformations in parenthesis) e.g. trucks (location), warehouses (time, quality), picking systems (product, quantity), conveyors (location), sorter (product, quantity), warehouse management systems (WMS) and Transport Management Systems (TMS) (information), etc. Hence, those resources are able to actively transform the dimensions mentioned in the point before. The *passive resources* of logistics systems are either of physical character (according to the physical flow, e.g. packing, pallet, trailer, container) or of non-physical character (according to the informational flow, e.g. freight documents, pick lists, warehousing contract). The domain specific *SLA* are also part of the varying point and they are case-depended and determined in individual logistics contracts. A selection comprises lead time, delivery rate, reliability, picking accuracy.

(4) Privacy concerns in logistics are a further research topic for themselves, e.g. see [48], [49]. Mandatory con-

straints comprise legal regulation [30] on e.g. securing of cargo on means of transport [50], permission to handle dangerous goods [51], permission to handle transport entities that are alive. Non-mandatory constraints could be preferences or requirements of the customer, e.g. cold chain, CO_2 reduced logistics, express (fastest lead time possible).

(5) As logistics is characterized by specialization and outsourcing, the typical manipulation operators are needed, e.g. match, merch, compose, delete, extract, disjoint, etc.

The outlined results are summarized in Figure 6. With the final output of information, parameters of service quality as well as the control flow, the next logistics module (if existant) can be forwarded. The three mentioned flows are also involved in requesting and invoking further sub-services. Following the ideas of [24], [27] an ontology appears to be suitable to model and describe the particular varying points (active and passive resources) of an logistics network. It should be based on the morphological field but can be extended or reduced if necessary. The capabilities of services that are created on the base of the CLSB could be interpreted as a resource of the logistics network as well, hence it appears usefull to collect those capabilities in an ontology as well. As proper ontology engineering is a challenging task, this topic is beyond the scope of the current paper. With the CLSB flexibility can be improved as well as simple communication and ease of use.

IV. Evaluation of the Logistics Service Blueprint

For the evaluation the 'Framework for Evaluation in Design Science Research' (FEDS) of [22] is taken into account and a *quick & simple* strategy is chosen, as the

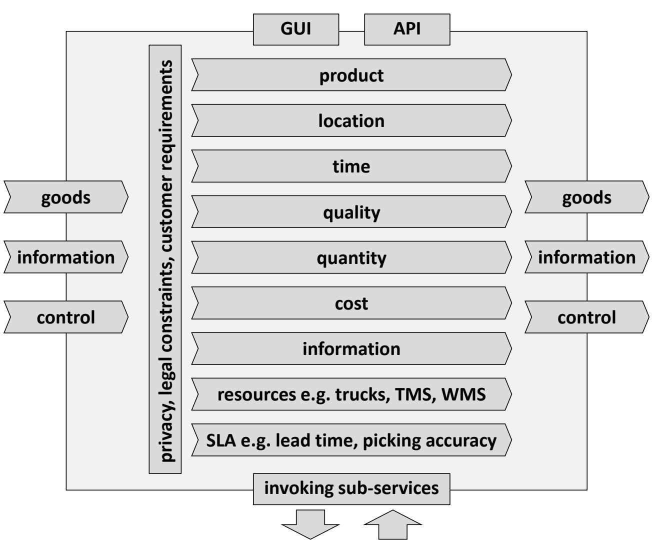

Figure 6: The cloud logistics service blueprint (CLSB) is developed by application of the cloud oriented service blueprint to the logistics domain.

designed artifact is of small and simple construction, with low social and technical risk and uncertainty. An illustrative scenario [23] is chosen to evaluate the developed artifact of CLSB. The evaluation is summative (judge the extent that the outcomes match expectations) and located in the middle between artificial and naturalistic: example processes of the logistics domain from two real internationally operating LSP are anonymized (due to privacy reasons) and they are modeled with the help of the CLSB proofing the feasibility. Goal is to create logistics services that could be easily connected even though they are offered by different LSP. This represents a realistic scenario in a logistics network characterized by specialization and division of labor. Such a network could be managed (planning, controlling, monitoring) by a central logistics integrator.

LSP 1 offers the service 'off-loading of long-distance truck transport' within the network. This comprises all physical entity movements from the truck and follows the steps of (1) getting freight documents from the driver, (2) identification, scanning and off-loading of package, (3) bringing package to pallet space and (4) scanning and forwarding protocol. The input flows are informational (freight document: goods identification, quantity, shipper, consignee) and physical (pallets containing goods). The control flow is then later on added, when the logistics service is composed with other services. The trigger signal would be the arriving of the truck at the warehouse. The transformations aim at the dimensions of location (truck to pallet space), time (the process takes a certain amount of time), costs (occuring for the provision of the service), information (state of the BO pallet containing a certain good changes from in transfer to in warehouse, and the location information is changed as well). The necessary resources for this comprise staff, forklifts, scanners, WMS (active), and pallet, freight documents (passive). Important KPI and SLA comprise the time consumed, the accuracy of identification of goods, identification of pallet space and the matching of the latter two. For the forwarding of the protocol that contains the transformations done, electronic web services could be used for information transmission to the logistics integrator.

LSP 2 offers the service 'order picking air' within the network. This comprises the steps of (1) pallet picking, (2) scanning, (3) transportation to air packing station, (4) loading aircraft container, (5) scanning, (6) transferring aircraft container to outbound, (7) scanning. The input flows are informational (electronic data on handheld: flight number, start time and end time (critical due to flight schedule), aircraft type, terminal, position (aircraft parking space), pallet space) and physical (aircraft containers carrying goods). The control flow is then later on added, the trigger signal would be of timely manner according to flight schedule. The transformations aim at the dimensions of product (the right products have to be collected), location (goods from warehouse to packing station to outbound), time, quantity (certain amount is picked), cost, information (state of the BO pallet from warehouse to packing, state of the BO goods from pallet to aircraft container, state of the BO aircraft container from packing to outbound). The necessary resources for this comprise staff, forklift, scanner, WMS, tractor unit (active), and pallet, loading document, aircraft container, trolley (passive). Important KPI and SLA comprise the time consumed, picking accuracy, throughput. Electronic services are invoked to transfer data, identification of required aircraft container type according to aircraft type.

The potential for *cloud logistics* comprises the following aspects: (1) those two example services can be added to the networks portfolio. Hence, both can be composed in order to form the complex service of transshipment between road and air transport when the pallet spaces of the both processes are merged. (2) Due to virtualization, it is possible to e.g. add another provider (LSP X) to the list of LSP able to fulfill the off-loading service. Now as more LSP offer their resources (staff, forklifts) a bottleneck in the inbound area could be dispatched by requesting resources from LSP X. A higher specialization is imaginable, e.g. LSP 1 focuses on standard goods, whereas LSP X could handle dangerous goods or offer its resources flexibly to either off-loading or the picking for the outbound for a higher price in order to break an upcoming bottleneck. (3) The resource list (e.g. ontology) contains forklifts at the transshipment site that could be provided by different LSP.

Summarizing with the connection of the both services and the utilization of the virtualized resources cloud logistics is enabled. To the customer of the central logistics integrator just the transshipment is offered as a service. The operations, resources and their providers remain transparent to the customer. The basic characteristics of the cloud paradigm are transferred to the logistics domain. Flexibility of resource usage is increased, communication can be simplified and the ease of use in planning is increased due to the logistics lego bricks, aka CLSB.

V. Conclusion

The paper systematically reviewed the existing literature and research gaps of 'cloud logistics'. The topic was conceptualized in order to develop a definition of the term (SQ_1 is answered) and framework in order to separate it from and simultaneously integrate it with cloud computing. The most promising field of research is the identification and conceptualization of standardized modules or 'lego bricks' of logistics in order to enable cloud logistics. Existing ideas are taken from the state of the art and integrated with the help of several service engineering methods (SQ_2 is answered) in order to develop Cloud Oriented Service Blueprints. Those Cloud Oriented Service Blueprints are applied to the logistics domain in order to create Cloud Logistics Service Blueprints (CLSB) as standardized modules, shaping the foundation of cloud logistics (SQ_3 is answered). Two services from process descriptions of internationally operating LSP are taken into account to evaluate the suitability of the CLSB with a illustrative scenario in a quick & simple strategy. The outcome - the CLSB - matches expectation of enabling CL in terms of virtualized resources encapsulated in services.

The systematic literature review reveals some threats to validity: completeness (selection of database, technical limitations of search functions) and reliability (bias is reduced due to literature analysis done by all authors, but could not be fully excluded).

Implications are rather existent for researchers by adding to current literature on CL and, as an outllok, opening research questions towards comprehensive virtualization of the varying points (resources). This is complicated, as logistics network are of dynamic character. Hence, ontology engineering (from literature and and practice) to offer a first starting point to LSP in order to use CL is one of the next steps.

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References

[1] J. Langley and M. Long, "2016 third-party logistics study: The state of logistics outsourcing: Results and findings of the 20th annual study," vol. 20, 2016.

[2] R. Wilding and R. Juriado, "Customer perceptions on logistics outsourcing in the european consumer goods industry," *International Journal of Physical Distribution & Logistics Management*, vol. 34, no. 8, pp. 628–644, 2004.

[3] A. Aguezzoul, "Third-party logistics selection problem: A literature review on criteria and methods," *Omega*, vol. 49, pp. 69–78, 2014.

[4] T. Solakivi, J. Töyli, and L. Ojala, "Logistics outsourcing, its motives and the level of logistics costs in manufacturing and trading companies operating in finland," *Production Planning & Control*, vol. 24, no. 4-5, pp. 388–398, 2013.

[5] S. Kumar, V. Dakshinamoorthy, and M. S. Krishnan, "Does soa improve the supply chain? an empirical analysis of the impact of soa adoption on electronic supply chain performance," in *40th Annual Hawaii International Conference on System Sciences (HICSS'07)*, 2007, 171b.

[6] A. Arsanjani, G. Booch, T. Boubez, P. Brown, D. Chappell, J. deVadoss, T. Erl, N. Josuttis, D. Krafzig, M. Little, B. Loesgen, A. T. Manes, J. McKendrick, S. Ross-Talbot, S. Tilkov, C. Utschig-Utschig, and H. Wilhelmsen. (2009). Soa manifesto, [Online]. Available: http://www.soa-manifesto.org/SOA_Manifesto.pdf.

[7] T. Erl, *SOA: Principles of service design*, 5. print, ser. The Prentice Hall service-oriented computing series from Thomas Erl. Upper Saddle River, NJ [u.a.]: Prentice Hall, 2009, ISBN: 9780132344821.

[8] P. Mell and T. Grance, "The nist definition of cloud computing," *Computer Security Division, Information Technology Laboratory, National Institute of Standards and Technology Gaithersburg*, 2011.

[9] L. M. Vaquero, L. Rodero-Merino, J. Caceres, and M. Lindner, "A break in the clouds," *ACM SIGCOMM Computer Communication Review*, vol. 39, no. 1, p. 50, 2008.

[10] W. Delfmann and F. Jaekel, *The cloud - logistics for the future? discussionpaper*, German Logistics Association - BVL International, Ed., 2012.

[11] P. Gupta, A. Seetharaman, and J. R. Raj, "The usage and adoption of cloud computing by small and medium businesses," *International Journal of Information Management*, vol. 33, no. 5, pp. 861–874, 2013.

[12] U. Arnold, J. Oberlander, and B. Schwarzbach, "Logical—development of cloud computing platforms and tools for logistics hubs and communities," in *Computer Science and Information Systems (FedCSIS), 2012 Federated Conference on*, 2012, pp. 1083–1090.

[13] M. Glöckner and A. Ludwig, "Towards a logistics service map: Support for logistics service engineering and management," in *Pioneering solutions in supply chain performance management: Proceedings of the Hamburg International Conference of Logistics (HICL) 2013*, ser. Supply chain, logistics and operations management, T. Blecker, W. Kersten, and C. Ringle, Eds., vol. 17, Eul, 2013, pp. 309–324, ISBN: 978-3844102673.

[14] A. Hevner, S. March, J. Park, and S. Ram, "Design science in information systems research," *MIS Quarterly*, vol. 28, no. 1, pp. 75–105, 2004.

[15] H. Österle, J. Becker, U. Frank, T. Hess, D. Karagiannis, H. Krcmar, P. Loos, P. Mertens, A. Oberweis, and E. J. Sinz, "Memorandum on design-oriented information systems research," *European Journal of Information Systems*, vol. 20, no. 1, pp. 7–10, 2010.

[16] J. Vom Brocke, A. Simons, K. Riemer, B. Niehaves, R. Plattfaut, and A. Cleven, "Standing on the shoulders of giants: Challenges and recommendations of literature search in information systems research," *Communications of the Association for Information Systems*, vol. 37, no. 9, pp. 205–224, 2015.

[17] B. Kitchenham and S. Charters, "Guidelines for performing systematic literature reviews in software engineering: Technical report, ver. 2.3 ebse technical report. ebse," PhD thesis, Keele University, UK and Lincoln University, NZ, 2007.

[18] J. Webster and R. T. Watson, "Analyzing the past to prepare for the future: Writing a literature review," *MIS Quarterly*, vol. Vol. 26, no. No. 2, pp. 13–23, 2002.

[19] T. Hara, T. Arai, Y. Shimomura, and T. Sakao, "Service cad system to integrate product and human activity for total value," *CIRP Journal of Manufacturing Science and Technology*, vol. 1, no. 4, pp. 262–271, 2009.

[20] K. Czarnecki and U. Eisenecker, *Generative programming: Methods, tools, and applications*. Boston: Addison Wesley, 2000, ISBN: 0-201-30977-7.

[21] T. Ritchey. (2013). General morphological analysis - a general method for non-quantified modelling, [Online]. Available: http://www.swemorph.com/pdf/gma.pdf.

[22] J. Venable, J. Pries-Heje, and R. Baskerville, "Feds: A framework for evaluation in design science research," *European Journal of Information Systems*, 2014.

[23] K. Peffers, M. Rothenberger, T. Tuunanen, and R. Vaezi, "Design science research evaluation," in *Design science research in information systems*, ser. Lecture Notes in Computer Science, K. Peffers, Ed., vol. 7286, Springer, 2012, pp. 398–410, ISBN: 978-3-642-29862-2.

[24] B. Holtkamp, S. Steinbuss, H. Gsell, T. Loeffeler, and U. Springer, "Towards a logistics cloud," in *2010 Sixth International Conference on Semantics Knowledge and Grid (SKG)*, 2010, pp. 305–308.

[25] X. Wang, W. Li, Y. Zhong, and W. Zhao, "Research on cloud logistics-based one-stop service platform for logistics center," in *2012 IEEE 16th International Conference on Computer Supported Cooperative Work in Design (CSCWD)*, 2012, pp. 558–563.

[26] M. P. Papazoglou, "Cloud blueprints for integrating and managing cloud federations," in *Software service and application engineering*, ser. Festschrift, M. Heisel, Ed., vol. 7365, Springer, 2012, pp. 102–119, ISBN: 978-3-642-30834-5.

[27] W. Li, Y. Zhong, X. Wang, and Y. Cao, "Resource virtualization and service selection in cloud logistics," *Journal of Network and Computer Applications*, vol. 36, no. 6, pp. 1696–1704, 2013.

[28] J. Wang, X. Zhang, X. Hu, and J. Zhao, "Survey on logistics service mode based on cloud computing," in *LISS 2013*, R. Zhang, Ed., Springer, 2015, pp. 321–327, ISBN: 978-3-642-40660-7.

[29] ——, "Cloud logistics service mode and its several key issues," *Journal of System and Management Sciences*, vol. 4, no. 2, pp. 34–44, 2014.

[30] C. Li, X. Zhang, and L. Li, "Research on comparative analysis of regional logistics information platform operation mode based on cloud computing," *International Journal of Future Generation Communication and Networking*, vol. 7, no. 2, pp. 73–80, 2014.

[31] Á. Bányai *et al.*, "Cloud logistics," *Polish Journal of Management Studies*, vol. 8, no. 1, pp. 11–16, 2014.

[32] N. Weißenberg and U. Springer, "Cloud process modeling for the logistics mall-object-aware bpm for domain experts," *Open Journal of Mobile Computing and Cloud Computing*, vol. 1, no. 2, pp. 31–49, 2014.

[33] Y. Zhong, W. Li, W. Guo, L. Gong, and G. Lodewijks, "A method of modeling and service encapsulation on cloud logistics resources," in *2015 IEEE 19th International Conference on Computer Supported Cooperative Work in Design (CSCWD)*, 2015, pp. 383–388.

[34] S. Zhang and X. Hu, "Game analysis on logistics cloud service discovery and combination," *International Journal of u- and e-Service, Science and Technology*, vol. 8, no. 10, pp. 193–202, 2015.

[35] X. He, J. Jiang, and G. Wei, "The cloud logistics modeling and validation based on pi calculus," in *First International Conference on Information Sciences, Machinery, Materials and Energy*, 2015.

[36] Y. Zhang, S. Liu, Y. Liu, and R. Li, "Smart box-enabled product–service system for cloud logistics," *International Journal of Production Research*, pp. 1–14, 2016.

[37] A. Schuldt, K. Hribernik, J. D. Gehrke, K.-D. Thoben, and O. Herzog, "Cloud computing for autonomous control in logistics," in *GI Jahrestagung (1)*, 2010, pp. 305–310.

[38] J. Leukel, S. Kirn, and T. Schlegel, "Supply chain as a service: A cloud perspective on supply chain systems," *IEEE Systems Journal*, vol. 5, no. 1, pp. 16–27, 2011.

[39] F.-C. Jiang, C.-T. Yang, Y.-H. Chen, W.-T. Huang, and H.-Y. Chao, "Decision support for cloud logistics by optimizing the quantities of standby servers in cloud environment," in *2015 International Conference on Cloud Computing and Big Data (CCBD)*, 2015, pp. 169–172.

[40] Supply Chain Operations Reference Model. (1996). Supply Chain Council, Ed., [Online]. Available: http://www.apics.org/sites/apics-supply-chain-council/frameworks/scor.

[41] T. Bauer, S. Buchwald, and M. Reichert, "Improving the quality and cost-effectiveness of process-oriented, service-driven applications: Techniques for enriching business process models," 2013.

[42] J. Leukel and A. Scheuermann, "Cloud logistics ist mehr als logistiksoftware aus der cloud," *Wirtschaftsinformatik & Management*, vol. 6, no. 1, pp. 38–45, 2014.

[43] L. G. Shostack, "How to design a service," *European Journal of Marketing*, vol. 16, no. 1, pp. 49–63, 1982.

[44] T. Sakao and Y. Shimomura, "Service engineering: A novel engineering discipline for producers to increase value combining service and product," *Journal of Cleaner Production*, vol. 15, no. 6, pp. 590–604, 2007.

[45] T. Arai and Y. Shimomura, "Proposal of service cad system - a tool for service engineering -," *CIRP Annals - Manufacturing Technology*, vol. 53, no. 1, pp. 397–400, 2004.

[46] J. T. Mentzer, D. J. Flint, and J. L. Kent, "Developing a logistics service quality scale," *Journal of Business Logistics*, vol. 20, no. 1, p. 9, 1999.

[47] T. Gudehus and H. Kotzab, *Comprehensive Logistics*. Berlin, Heidelberg: Springer Berlin Heidelberg, 2012, ISBN: 978-3-642-24366-0.

[48] A. Marucheck, N. Greis, C. Mena, and L. Cai, "Product safety and security in the global supply chain: Issues, challenges and research opportunities," *Journal of Operations Management*, vol. 29, no. 7-8, pp. 707–720, 2011.

[49] M. Zhou, R. Zhang, W. Xie, W. Qian, and A. Zhou, "Security and privacy in cloud computing: A survey," in *2010 Sixth International Conference on Semantics Knowledge and Grid (SKG)*, 2010, pp. 105–112.

[50] *Us patent 2,605,064 cargo securing system*, 1952.

[51] *ADR - European Agreement Concerning the International Carriage of Dangerous Goods by Road: Applicable as from 1 January 2013*. New York [etc.]: United Nations, 2012, ISBN: 978-92-1-139143-5.