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Advancements in Cloud Computing for Logistics

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***Abstract*—Adequate integrated ICT infrastructure and services are a prerequisite for keeping pace with the rapid rise of complexity and service levels in logistics. Recent studies indicate a high attractiveness and impact perspective of cloud computing for logistics service providers within few years in order to cope with the growing IT capacity demands. Within this paper, a comprehensive overview is given on R&D with relation to CC for logistics. Among these, the EU-project LOGICAL is presented in detail since it combines different aspects and benefits of CC for the logistics sector. A generic system of CC use cases in logistics and the corresponding needs for a logistics cloud architecture are discussed and compared with the implementation status of the LOGICAL cloud. Special attention is given to the problem of incompatible data and service interfaces. Instead of following the single-window, single-document concept, a semi-automated on demand interface creation service is presented as an intermediate alternative for the practitioning logistics sector.**

I. Introduction

A. Market Background

THE emergence of new cloud computing services is steadily increasing. More and more companies realize the benefits and opportunities of using IT-resources with unlimited scalability and on-demand services at pay per use conditions over the Internet, as opposed to "classical" on-premise installation and operation. A recent survey of web-hosting and cloud computing specialist *Parallels* [1] indicated that especially small and medium sized enterprises (SME) are drivers of extraordinary growth rates above 20% per year in this market domain worldwide.

The full potential of collaborative business processes, especially for logistics companies, is still not exhausted. The benefits for design and organization of heterogeneously fragmented logistics processes based on new logistics software that is available within minutes and allows an easy integration of customers, suppliers and partners, are about to be appreciated by logistics service providers (LSP). The latest *Logistics Trend Radar* report, published by DHL, ranked cloud computing and supergrid logistics among the trends of highest mid and long term impact perspective [2] due to the expectation that these innovative trends will foster completely new process models and service provider types in logistics of the future.

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The trends mentioned above may be seen as a partial facet of a larger trend: *bottom-up economics*, a paradigm change which may lead to a total economic reconfiguration in the 21th century, driven by the Internet. The planning, organization and implementation of complex logistics processes is currently carried out by large logistics companies with complex software systems. Cloud computing fosters the cooperation and collaboration of numerous small and medium-sized logistics enterprises without major capital expenditure in IT hardware and software. An open research question is how to cope with heterogeneous data models and interfaces on one side and how to organize and control these cloud-based collaborative business processes.

B. State of R&D in Cloud Computing for Logistics

The development of cloud computing platforms, services and solutions for various business purposes is driven by different institutions, academic and commercial, both on national and international levels. The project "Future Business Clouds" (FBC) alone lists about sixty different cloud computing R&D-projects which are funded by the EU and its member states [3]. Most of these projects, however, are dealing with general technological aspects of cloud computing for business. Just about. 5% of these business clouds, however, explicitly address the application domain of logistics and supply chain management. In addition to these cloud developments, an impressive number of R&D activities and institutional capacities have been initiated internationally in the EU under the 6th and 7th Framework Programme during the last decade upon the field of information and communication systems in transport and logistics. This R&D-domain is relevant for cloud computing in logistics due to a significant focus on interoperability and standardization of data structures in support of collaborative and smart supply-chain management and resource efficient co-modal transport management, especially for SME. An overview on related EU-projects is given by [4].

The joint efforts to solve the problem of incompatible interfaces and data structures as main obstacles of interoperability in the transport and logistics sector lead to a conceptual *Common Framework for Information and Communication Systems in Transport and Logistics* which follows the single-window, single-document approach to create interoperability by standardization. Finally, a unified single transport document shall be established that can be used for

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all modes of transportation. The framework consists of a definition of different "roles" (stakeholders with unique set of responsibilities), "business processes", related standardized "messages" and common ontology based "data elements". Current plans to connect the common framework community with SMEs and proprietary systems aim at the creation of standard web forms and so-called "connectors" (like "translators between differing formats and data models"). As a part of the EU *Freight Transport Logistics Action Plan* the common framework was developed with a holistic perspective by means of integrating the concepts and results of several EU-projects (e.g. FREIGHTWISE, e-Freight, INTEGRITY, Smart-CM, SMARTFREIGHT, EURIDICE and RISING) in the EU-project DiSCwise [4].

A second integrative initiative upon EU-level is the open innovation network platform ETP (*European Technology Platform on Logistics*) which is the output of the 7th FP EU-project WINN [5], [6] and was launched under the acronym ALICE with participation of global players in logistics and industry in June 2013. Among others, involved R&D institutions are the Dutch Institute of Advanced Logistics DINALOG, the Polish competence centre of logistics ILiM and the German Fraunhofer Institute IML. The major issue of ETP and ALICE is virtual collaboration in supply chains. A case study of a platform (T-Scale) based upon global communication standards, which supports virtual supply chains in real time, is described in [7].

A market-oriented approach to collaboration is matching transport demand and offer by means of virtual market places such as online spot exchange platforms and services. An example of this category is the web-based system for rail freight matching developed in the joint R&D-project CODE 24 of the Rotterdam-Genoa corridor [8], programmed by means of open source tools at Duisburg-Essen University. A second example is the project CloudLogistic [9] of Aachen University and industry partners which develops a cloud platform for matching part loads of trucks (capacities and demands) based upon geo-coordinates. Related issues of the business model, SLAs and billing mechanisms are included in this project.

One of the most prominent examples of establishing a virtual market place by means of cloud computing is the ,*"logistics mall"* of the *Fraunhofer innovation cluster for cloud computing in logistics*, developed by the Fraunhofer institutes IML and ISST and operated by Logata GmbH [10]. Basically, the logistics mall serves as a virtual IaaS and SaaS platform for matching demand and supply of logistics software and related IT services. It comprises both an ASP for running proprietary software and a SaaS engine and SOA-bus for combining atomic services with uniform data model and interfaces. Standardization is achieved by means of a uniform ontology and semantic modeling leading to standard *Business Objects* (BO). The mid-term development perspective is a repository of BOs and granular SaaS components which are selected, linked and orchestrated by means of a *Logistic Process Designer* and an interactive graphics user surface. The developers expect IT-cost reductions up to 50% especially for SME due to the mall and its on-demand services.

The example of the logistics mall illustrates that interoperability of IT services and SaaS components of logistics clouds and platforms are crucial for the capability of generating value added especially for the benefit of SME by means of combining available SaaS components to customized virtual process and supply chains. Numerous developments are characterized by standardization approaches like common ontology, semantic programming (e.g. using the language OWL), federated data management and linked open data concepts. Related projects are for instance CollabCloud [11] and COCKTAIL [12] to mention just a few.

A meanwhile finished R&D-project which among other results produced a uniform ontology (in OWL) for logistics was InterLogGrid [13]. Based upon InterLogGrid the joint R&D-project LOGICAL was initiated in the Central Europe programme in order to integrate several of the issues and benefits of the R&D-activities mentioned before: IT- and business process outsourcing, virtual market place for logistics services, integrative data and collaboration space and platform for the orchestration and optimization of collaborative business especially for the benefit of SME-size LSPs [14].

C. LOGICAL profile

LOGICAL's [14] objective is to enhance the interoperability of logistics businesses of different sizes, to improve the competitiveness of Central European logistics hubs through the development of a modern logistics cloud infrastructure. Beneficiaries of the project are especially small logistics companies that are enabled to use cloud-based logistics software to collaborate with other regional and global players. Cloud computing furthermore enhances the hubs' attractiveness for business activities in logistics.

LOGICAL will be simultaneously implemented at six major Central European logistics hubs: Leipzig (DE), Bologna (IT), Wroclaw (PL), Miskolc (HU), Koper (SI) and Ustí nad Labem (CZ). They represent multi-modal infrastructures such as the Airport of Leipzig/Halle, the freight village Interporto Bologna in Northern Italy, one of the most important sea harbours in the Adriatic Sea (Port of Koper) and the largest logistics centre in Hungary. In this way, cloud computing is used by different companies to organize intermodal transports using innovative cloud services.The project started in May 2011 and ends in October 2014.

The results of a survey in order to determine the initial as is situation among participating LSPs, their information demands, typical business processes and first architecture concepts were described in [15]. In the following the LOGICAL architecture and functionality will be presented in detail both from an application oriented view and in terms of the technical components used. Chapter V covers a special contribution to the issue of connecting data and systems with heterogeneous formats and data models.

II. LOGICAL USE CASES

A. Logistics cloud computing architecture: generic use cases

Based upon the survey findings, the identified user demands and migration requirements, major use cases of cloud computing for logistics were developed from a rather practical point of view. This process, however, cannot be considered to be finished, since understanding the opportunities of cloud computing in the logistics application domain grows with usage experience. Therefore, a two-step methodology was put into practice: at first generic use cases (use case classes) were developed and described in order to cover the utilization potential of a logistics cloud as completely as possible. Afterwards, specific use case instances which originated from communications with the survey participants and project partners were presented. The collection of these specific use cases will never be complete due to the ongoing creative process of finding useful new applications of a logistics cloud by means of ongoing interaction and communication with the growing number of users. For the logistics cloud the following generic use cases were identified and are interrelated in multiple ways (see fig. 1):

1) *Outsourcing* of IT resources and related services, i.e. hardware, software applications, and data pools from local (on-premise) IT-systems into a cloud
2) *Integration, Synchronization and Sharing of data* created and utilized by multiple users
3) *Market Place* for product and service offers and demands, platform for adding e-commerce activities to the corporate business models
4) Platform for the *management and optimization of collaborative business* activities of multiple business partners.

1) Generic Use Case 1: IT-Outsourcing: A meanwhile standard application of web-based systems consists in providing and using web-hosted software applications, either by means of an application service provider or by SaaS.

Typical IT functions which are outsourced in general business environments are accounting software, enterprise resources planning software (ERP), customer relations management software (CRM), document management software (DMS) and project management software (PMS).

Outsourcing of logistics IT services for logistics service providers may include transport management software (TMS), route planning software, fleet management software, tracking & tracing software, warehouse management system (WMS), supply chain management software.

Outsourcing is a method which supports enterprises in concentration upon core competences and cutting down secondary or overhead costs. Consequently, following the step of merely outsourcing the IT services of secondary business processes a higher level of this strategy is reached by completely outsourcing the complete related business process, such as accounting processes e.g. financial accounting, personnel accounting, e-procurement & e-commerce fulfillment.

Usually, for outsourcing just one client (e.g. company) is using the web-hosted application provided by the cloud, even

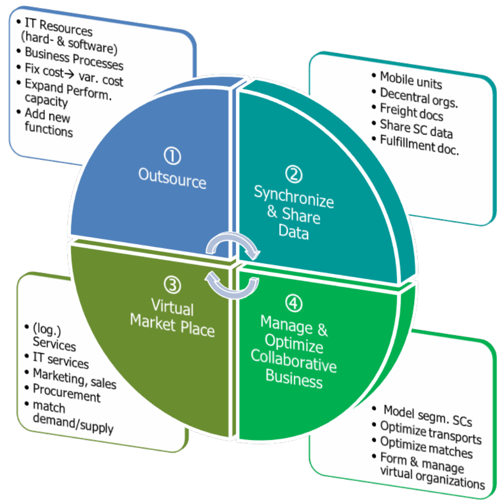

Fig. 1. System of generic use cases of a logistics cloud

if the client is represented by multiple persons (employees, team members). Legally, this relationship can be considered as a 1:1-relation. To find and select web-hosted application or public cloud service a public market place will be used. Another possibility for logistics companies is to develop and use own privte cloud services e.g. with locked data space and encapsulated VM.

The software applications which are offered for IT service outsourcing can be provided as a web-hosted application which instead of running on a local computer is running on a virtual machine. To use *separated instances* of the software, an application service provider (*ASP*) is used as a component of the cloud architecture. To use the *same instances of the software like other users*, the services in the *SaaS runtime engine* are usable.

2) Generic Use Case 2: Synchronize & Share Data: Using cloud computing for the integration, synchronization and sharing of data is one of the original drivers of establishing early cloud systems. A web-hosted managed data space is a basic solution for synchronizing files in simple file-sharing scenarios.

An already well-established representative of this cloud function is the meanwhile widespread DropBox® which offers web-hosted data storage capacity at pay-per-rent conditions (block tariff system based upon booked storage volume independent from actual consumption of the memory space). The Dropbox® is already established with data sharing and access right administration services.

The file synchronize & share function of the cloud can be applied to intra- as well as extra-organization uses of file synchronization and sharing. Typical intra-organizational uses are:

- File synchronization of mobile actors and business units, such as trucks and other vehicles, external service teams, smart devices of employees etc.
- Linkage of subsidiaries, regional or branch offices, ser-

vice posts etc. with the headquarter.
- Business data exchange and synchronization within decentralized organizations.

File Exchange across borderlines of single enterprises and organizations are:
- File exchange with clients
- File exchange among business partners
- File exchange with infrastructure operators such as seaports, airports, intermodal terminals and authorities such as customs authorities

Since data are usually shared among multiple users and the integration space should be a unique one, this relationship can be considered as a n:1-relation. The cloud can be used by clients to give business partners simple access to own files by using a web-hosted storage software suite e.g. DropBox® or OwnCloud.

3) Generic Use Case 3: Market Place: Using the internet as a channel for e-business is state-of-the-art for numerous market participants and traders. Although e-commerce in logistics is still a rather rare phenomenon, a logistics cloud may be the right instrument for adding an online-component to the commercial processes of members of the logistics community. The cloud market place in this context can be a limited access community market or platform open to the public. Since the members of logistics communities cover a wide spectrum of different services, the design of the market place should rather be like a shop of the shops (mall) than a uniform store. Since all functions of the cloud can be considered as a marketable service, the cloud market place can provide access to the whole service repository of the cloud as well as to the complete set of services offered by the logistics communities attached.

A user of the market is addressing to multiple recipients of his sales offer or procurement request. Thus the typical use configuration is a 1:m-relation.

The market place function of a cloud requires the following components of the cloud architecture: e-commerce platform and administration system (affiliate system with purchase monitoring, feed-back system and brokerage provision administration), data base management system, query masks, search & matching engine.

4) Generic Use Case 4: Management platform: The fourth generic use case class represents advanced uses of the cloud which aim at efficiency improvements and value added by means of additional cloud services. Matching demands and supplies in the market place does not automatically mean that a best fit is found. This requires optimization tools, i.e. instruments provided by operations research and systems analysis in order to find an optimum. This optimum may consist in the minimization of cost, carbon footprint, failure risk or a maximum of defined benefit functions. Applications in the logistics domain may be:
- Optimization of transports: best fit of demand and offer of transportation capacities according to predefined goal functions.
- In a generalized form: best fit of any kind of service demand and suitable supplies.

In sophisticated cases, the suitable supply for a service demand may not be offered by a single party but has to composed from the offered capacities of multiple providers as a fragmented sequence of several basic logistic processes, such as transport, storage, cross-docking, transport, intermodal transfer, transport, storage, commissioning, final delivery etc. In such a case, support services are needed for composing the whole process chain and for managing the cooperation of several (heterogeneous) partners. Possible functions of this functionality of collaborative business engineering and management are:
- Composition of suitable logistics process chains (from the online catalogue of single service capacities provided by single partners and covered by the logistics communities)
- Setting up of a “virtual organization” (a special purpose vehicle for logistics projects) of the partnering service providers
- Management and administration of the business processes of the virtual organization with devoted data work space, ERP-service, management tools, job management and billing services and allocation of cost and revenues to the contributing partners.

In these complex cases of multiple actor cooperation, *m* participants are addressed in the composition phase of the fragmented process chain and *n* participants access mutually applied data in the operation phase of the virtual organization. Thus, the use configuration is a m:n-relation.

The collaborative business function of a cloud requires the following components of the cloud architecture: optimization tools, simulation of fragmented logistics process chains, cloud hosted representations and management tools for virtual organizations.

B. Logistics cloud computing architecture: specific use cases

The specific use cases are ordered according to the generic use case classes system presented in the previous chapter.

1) Specific Use Case 1: Logistics software catalog: The logistics software catalog so far contains and provides typical business and logistics software applications. At current state the following applications are available: Standard office software (MS Office 365), ERP software (OpenERP), document management softeare (RICOH DMS), transport management software (PSItms), warehouse management software (*LogBase on Demand*®)

2) Specific Use Case 2: Synchronize & Share: All four use case categories of the LOGICAL cloud require data storage capacity. Thus, use case 2 will be integrated as cloud data space in other use cases.

In addition, the cloud will provide a managed file workspace function for pooling, synchronization and sharing of files in analogy to *Dropbox*®. The related software suite which is going to be used for this function is *OwnCloud*.

Several LOGICAL partners already develop or operate cloud-based systems for the common use and exchange of freight, customs or other official documents and files. These systems and data share functions can be linked to or integrated into the LOGICAL cloud. Systems to mention in this context are for example:

Logistics Cluster Leipzig-Halle (PP3) and its member SALT Solutions developed a simple software tool for smartphones linked with a web-based data space (e.g. LOGICAL cloud workspace) which helps freight forwarders and other transport service providers to cope with new legal requirements of safety inspection, supervision and documentation. The traffic-manger app of SALT is a direct example of new service products which are developed due to the communication of the R&D projects InterLogGrid and LOGICAL between IT companies and experts and the application community, in our case the logistics service providers organized in the logistics cluster Leipzig-Halle.

Luka Koper (Port of Koper, Slowenia, PP14) developed a planning and scheduling system (TINO) for trucks unloading and loading on the seaport grounds in order to equalize traffic, increase throughput capacity and support freight forwarders as well as the port authorities in planning the logistics processes. In addition, Luka Koper operates a web-hosted information and service platform LUNARIS. Luka Koper now plans to develop a web service and a new module in the cloud platform LUNARIS that would allow registered shipping agents to extract all data from the cloud-solution TINO that are needed to satisfy the customs requirements for the Export Customs manifest.

Another example of using a cloud workspace for the integration of data is the container-information-service provided by port of Koper's platform LUNARIS. The e-zabojnik (e-container) application provides tracking information about containers delivered to, stored within and departing from the seaport grounds.

3) Specific Use Case 3: Market Place: In addition to the logistics IT applications as presented before, the LOGICAL cloud will contain a market place for marketing and matching common logistics services such as transports, warehousing, freight commissioning, and value added services.

As a first step, the offline-partner manual, which was developed in the logistics cluster Leipzig-Halle will be transformed into an online available web solution and extended to all other logistics communities of LOGICAL. This online catalogue of service providers, their available resources (vehicles, technical equipment, warehouses, permits and licenses), logistics competences and frequently served relations as well as features required for international cooperation (language skills, country experiences etc.) can be considered as the online catalogue of the comprehensive logistics service capacities of the LOGICAL community. Parts of the online representation of the web-catalog of partners, competences and capacities shall be publicly accessible for marketing purposes and can be used by shippers for finding appropriate logistics service providers.

The related user and service capacity data are to be stored and managed within the LOGICAL cloud database. In addition to the database itself the LOGICAL cloud surface has to be established with suitable entry- and query masks.

Once the general features of the cloud users are available, the following step will consist in the establishment of the market place open to the public (or only to registered members of the logistics community) where logistics service providers can sell standardized logistics services online via the logistics service market.

The opposite to sales offers, i.e. the placement of logistics service demands by shippers, 4PL-providers and other logistics clients in order to carry out online-tenders for required services has to be introduced as an inverted version (service demand) of the data objects representing offered services (service offers).

The final development level of the logistics service market place will offer a semi-automatic matching service for suitable pairs of matching demand and supply items. This service of the cloud will require a (fuzzy) matching engine.

4) Specific Use Case 4: Management Platform: One of the objectives of logistics communities is to foster cooperation among community members and to develop new forms of collaborative business. The fourth use case of the LOGICAL cloud is meant to combine the functions of the preceding three and to provide supporting cloud services for collaborative business engineering.

Based on atomic logistics services (such as loading, transport, customs handling, storage, packing/unpacking, quality check, labeling, commissioning, cross-docking, final delivery, additional value added activities), the composition of these basic and partial logistics services to complex, fragmented compound logistics services is necessary in order to cover the complete supply chain of preceding, hub-specific and consequent processes. The final objective consists in simulating, monitoring and management of complex logistics processes.

The supply chain process model contains different and multiple process steps (activities) which are executed by different logistics service providers. 4PL-Providers are the main target group of this use case which represents a strategic development direction of logistics clusters (e.g. the logistics cluster Leipzig-Halle). In this way logistics clusters can provide a modern communiction platform for their logistics service providers in order to enable and support cross-company cooperation and collaboration. In particular, the simulation of different combinations and variants for the implementation of complex logistics contracts is interesting to find out the most suitable variant for customers and service providers. Once a suitable chain of basic logistics services is identified and represented as a digital model of the comprehensive logistics process including the description of transport flows, freight quantities, resource volumes, times, cost and other parameters, this model can be used for the management of the process in forward (push-process) or reverse (pull-process) direction.

For the management and optimization of multimodal corridors and transports, Interporto Bologna developed cloud-based platforms and embedded applications CoSPaM and M2 TC.

One of the consequences of composing single logistics services to compound, fragmented service chains by means of collaborative business engineering will be the creation of purpose or project specific consortia of the contributing service

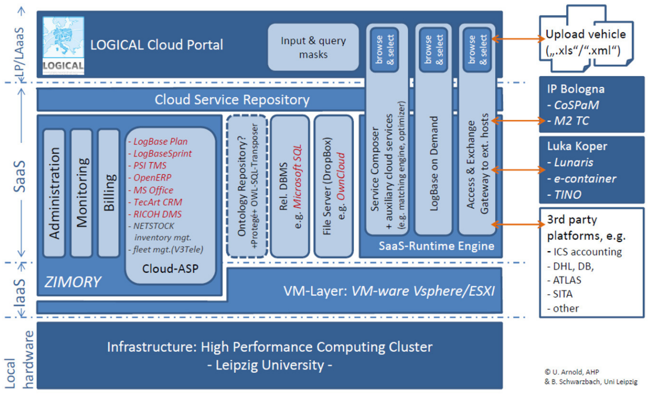

Fig. 2. LOGICAL cloud architecture, technical view

providers. Business administration of these organizations will need additional support like the technical support services of planning, optimizing and controlling the service chains as indicated before.

Thus, the management platform needs to be established with business administration services for the management of "virtual organizations". Like for a single company, the platform will have to provide access and configuration functions in order to apply the IT services of use case 1 to the virtual organization representing the cooperation consortium.

III. LOGICAL Architecture

The following sections describe the technical components and so far selected software products of LOGICAL cloud architecture at current development status in Leipzig.

Fig. 2 displays the technical view of the LOGICAL cloud as presented recently. This architecture consists of the Hardware layer and different software layers:

- IaaS-layer (Infrastructure as a Service),
- SaaS-layer (Software as a Service), with specialisation to logistics software, called “logistics applications as a service” (LAaaS)
- and BPaaS-layer (Busines Process as a Service) with specialisation to logistics processes in sense of “logistics processes as a service” (LPaaS)

So far the applications mentioned in chapter II-B1 are planned to be provided by means of ASP.

The cloud service repository (software catalog) will be used to store, administrate, select and manage the SaaS-offers of the system. The service repository needs to be developed yet. Apart from the software the repository will contain addressing data for the selection and activation of single SaaS applications.

The logistics cloud as outlined in the use case section will need additional SaaS applications to reach full functionality. Eventually required and yet to be specified or developed applications are for instance a search engine, a (fuzzy) matching engine, supply chain simulation tools, transport optimization tools, service composition tools to build complex supply chains, software services for the management of virtual organizations and interfaces to external exchange gateway services.

Logistics applications and logistics processes are specified, addressed, and activated by the cloud user on the top layer of the cloud architecture. The cloud portal serves as entry gate, orientation, service browsing, service selection and control instrument.

The LAaaS-layer and LPaaS-layer consists of the logistics-specific embedded applications and IT-services. In cases of existing web-based user-interfaces of single embedded applications and SaaS applications, these pages very likely need modifications for the integration into the cloud environment, e.g. in order to go back to the preceding cloud portal pages and to link with cloud workspace and composition service components. For the externally hosted platforms which are to be linked with the LOGICAL cloud via data exchange gateway, suitable cross-addressing and linkage tools need to be developed and implemented. The user interface is developed using ASP.NET.

IV. Implementation Status

The implementation of the LOGICAL cloud architecture startet in 2012. The implementation is separated into four main implementation project: data management, end user portal, administative portal and service management including user identification.

This section gives an overview of the current state of each of the four subprojects.

A. *Model-view-controller*

The whole LOGICAL project architecture is following the model-view-controller (MVC)-software architecture pattern that separates data (model), functionality (controller) and end user frontend (view). This approach increases modularity and code reusability. [16]

A model is a POCO (Plain Old CLR Object [17]) that is used to describe the data that is representing a domain specific entity that carries no business logic.

The visual representation of a model is provided by a view that contains information on how the data of the model need to be arranged. Different visual representations, e.g. a print and an onscreen version of the same entity, are generated by multiple views for the same model.

Each view has a corresponding controller that comprises all the functional logic needed by the view, i.e. there is one public method for every single action of the view.

B. *Data management*

The basis of the cloud is data. There are different kinds of data like data of the cloud users, data of the user’s companies and data about alle the services provided by the user’s. These data are provided by the data management subproject. It consists of a model of approximately 80 classes, two views for every model and for every view one controller. The first view is the end user’s interface to create and edit his data entries into the LOGICAL database.

The more important view in terms of clouding is the API-view of the data. There is one REST-API-view for every model class that provides the methods to access the cloud data by other services inside and outside the cloud. This access is secured by the use of Oauth2.0. This ensures that only authorized services can access this API. The Oauth2.0-server forwards the login information to the OpenId 2 based user identification system.

If there are changes to the model, the adoption of those changes will be done to keep the full coverage of the API

C. Service management and user identification

The user identification is based on OpenId 2 [18] that provides a method to identify a end user without requiring the relying party, i.e. the cloud service, to request the end user's credentials, e.g. username and password. OpenID 2 is using a decentralized system consisting of an OpenID provider and multiple relying parties. The implementation of the OpenID 2 authentication system of the LOGICAL cloud is completed and fully functional.

The same subproject of the logical cloud is responsible for managing all the different available services. Service Providers need to specify some information about their services, i.e. name, description, URL to the logo and a class in a DLL offering state dependent information of the service. This class offers methods for:

- Pricing information returns a string that is shown to the end user to show the current pricing model of the service.
- Service state returns a value out of usable, notbooked, stopped, processing and usable that is representing the current state of the service for a particular user.
- Actions available to the end user that basically are a URL the end user is directed to and a name of the action.

This DLL is dynamically loaded into the service management engine. Since there are a multitude of possible services a webservice for all of this information would not be feasible in terms of timing.

D. Administrative portal

The third subproject is the administrative portal that provides services to the LOGICAL cloud provider to keep the cloud operating. Some of these services are:

- User management: Provides functionality to manage end users of the cloud, especially activation and suspension of an end user.
- Accounting: Provides functionality to charge the end users for their service consumption and to support the cloud service provider by monitoring payments.
- Exception handling: Provides functionality to recover misfuntional services, e.g. reset virtual machines, recovery of wrong data.

E. End user portal

The LOGICAL cloud end user portal is the entry point for end users. It provides information on all the different services that are available via the cloud. The services are assigned to different categories the end users can choose from. After selecting a category the end user receives a list that shows all the information necessary to decide which service is the best fitting for the user and offers the actions defined by the service management layer.

F. Summary

The implementation of the LOGICAL cloud architecture is almost finished. The only major part left is the accounting system which will be implemented in the next months.

Another task for the next months is to identify services that will bring a great benefit to the end users and to incooperate them into the cloud. Since there are always new services this will be an ongoing, task for the whole lifetime of the cloud.

V. SEMI-AUTOMATED INTERFACE CREATION

Compatibility of data structures and interoperability of SaaS components resp. IT-systems of collaborating partners still are prerequisites for achieving the targeted main benefit of the LOGICAL cloud: easy collaboration among different partners along heterogeneous fragmented supply chains. The survey carried out in the initial phase of the LOGICAL project revealed that more than 50% of the existing inhouse-interfaces of software applied by the interviewed LSPs are not at all functioning or insufficient.

Thus, in the beginning of the development a standardized data model concept based upon uniform ontology (InterLog-Grid ontology in OWL, transferred into SQL by means of a specific converter) was selected as a solution to the task of creating IT-interoperability. Workshops and discussions with representatives of the final user group, however, indicated that there is considerable reluctance among practitioners to adopt a standard ontology and to adapt the data models of existent data bases and proprietary software. Therefore, from a practical point of view for intermediate cloud operation an indirect path of linking existing documents and IT-systems with differing data formats and data structures was chosen: like in the Common Framework[4] customized "connectors" (here "upload vehicles", see fig. 2) are introduced for data im- and export.

Now the creation of customized "connectors" turned out to be a new bottleneck of system usability. Assuming an unlimited number of possible source-target-couples of data formats and underlying data models to be mapped, the idea of developing a sufficient repository of preconfigured "connectors" rapidly exceeds feasibility constraints. Thus, in cooperation with Leipzig-Halle cluster-member RICOH, a method of semi-automated creation of data interfaces (connectors) was developed and applied to the problem of mapping differently formatted freight documents (waybills) into each other. With respect to the as-is-situation in the field, the operative cloud concept deliberately refrains from requiring successful establishment of single-window/single-document standards as a mandatory condition. Instead, the system provides a separate tool for the on-demand creation of "connectors" (mapping procedures) which are associated to a specific pair of data

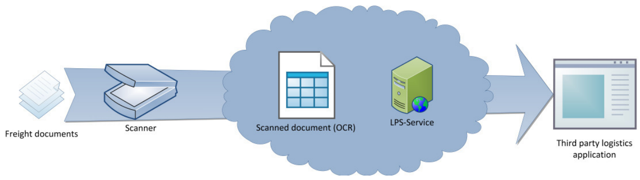

Fig. 3. Workflow of semi-automated interface creation

formats and stored in a mapping repository. Thus, the system is gradually learning during the course of being used and gradually increasing the number of already covered mapping tasks (data/document-format pairings). Once a mapping task occurs which already was tackled before, the mapping procedure does not have to be redeveloped again. Instead a pattern recognition service provides the matching mapping procedure which is applied.

Fig. 3 shows the main parts of the workflow of the semi-automated interface creation use case. Most of documents that need to be processed are paper based, therefore they need to be scanned prior they can be worked on by the software service. The scanning process can be done by existing scanners or a rented scanner that is preconfigured for sending scanned documents directly to the cloud.

Documents that are digitized will be processed directly by the cloud service. To upload such documents, and documents scanned with existing scanners as well, to the cloud a web service with a web interface is provided, that takes files of different formats, e.g. pdf, jpeg and tiff.

After the documents are stored in the cloud they are analyized by a pattern regocnition service to determine the type of the documents. If the type of the document is known and a mapping is available in the repository the mapping of the data of the document to the LOGICAL database is done by the LPS-service.

Otherwise, a new mapping procedure is created by means of manul linkage of data fields of the original document and the entry mask of the LOGICAL data base. This procedure is supported by the interactive graphics linking features of the LSP and stored as a new mapping procedure in the mapping-repository.

The user of this service can configure a set of third party systems for every document type where these documents should be forwarded to. This process step is done by a Extract, Transform, Load job that extracts the data from the LOGICAL database and loads them to the third party software. If the ETL job requires some data that are not available due to problems with quality (paper based documents and OCR) or input field left blank in the original document, the problem is reported to the user and the user can choose whether to add the missing data or to delete the document.

If the user is operating a third pary software that is not known by the cloud, the user can request a ETL-job for his software. This new job will be available to all cloud users, once it is created.

VI. Conclusion

Cloud computing, with it's service on demand philosophy, enables even small logistics service providers to cooperate with each other. The challenges for the logistics service providers are even more complex if they want to cooperate transnational. The paper has shown the use cases of the LOGICAL cloud in general and detail, that have been developed to enable transnational cooperation. One of these use cases is the semi-automated interface creation that helps logistics service providers with converting documents of one type into another without the need of a comprehensive ontology. The whole set of use cases that are covered by the LOGICAL cloud are resulting in a multitude of new possibilities for logistics service providers to create new added value services with international partners and to be one step ahead compared to the competition.

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