

# Logistics Mall—A Cloud Platform for Logistics

Damian Daniluk and Bernhard Holtkamp

**Abstract** Common characteristics of all logistics processes are individuality and dynamically changing requirements of the customers' business. Cloud computing enables new business models to provide highly individual IT services that fit the needs of logistics customers. After outlining logistics specific cloud service requirements and the results of a study about the acceptance of cloud computing in logistics domain this paper presents the Logistics Mall, an approach for a domain specific cloud platform for the trading and usage of logistics IT services and logistics processes.

**Keywords** Logistics mall • Cloud computing • Cloud platform • Business process as a service

## 1 Introduction

In 2011, the overall global logistics market represented a total volume of approximately 981 Billion € [1]. According to BVL (recognized german logistics institution), in Germany logistics is the third largest economy branch with an market volume of approximately 235 Billion € in 2014 and a work force of 2.9 Million. The German logistics market, as typical for the logistics domain, is characterized through small and medium size enterprises with little or no IT capacities and competences besides operating their own IT resources.

---

D. Daniluk (✉)

Fraunhofer Institute for Material Flow and Logistics IML,  
Joseph-Von-Fraunhofer-Str. 2-4, 44227 Dortmund, Germany  
e-mail: Damian.Daniluk@iml.fraunhofer.de

B. Holtkamp

Fraunhofer Institute for Software and Systems Engineering ISST,  
Emil-Figge-Str. 91, 44227 Dortmund, Germany  
e-mail: Bernhard.Holtkamp@isst.fraunhofer.de

Trade and industry consider logistics as a cost factor and as a factor of competitiveness at the same time. As a consequence there is a growing trend for outsourcing and contract logistics to benefit from scale effects and from synergies. This way the market for logistics services has developed from classical transport—transshipment—warehousing services towards a growing market of more individual services which are offered by specialized logistics service providers. There is also a trend this services become more complex increasingly. One of the reasons for this is the development in the e-commerce sector. In Germany, purchases over the internet result in more than 100 million additional packages per year. Each of these packages is ordered individually and on demand, picked, packed, transported, distributed and delivered. At the same time, the number of items increases exponentially. This means that customers of logistics service providers today require individualized logistics services with:

- a flexible and broad service spectrum,
- individual logistics processes and value-added services,
- transparency of costs and performance,
- short-term contracts.

These requirements increase the following problems, evident for many logistics service providers:

- It usually lacks sufficient investment funds (or the willingness to invest) for the expansion of IT.
- Often it lacks IT expertise and availability of human capacity to operate the necessary IT infrastructure adequately.
- The development of new IT components and their integration into the existing IT landscape is time-consuming.

Many logistics companies neither have adequate IT skills and capabilities, nor the capital needed to close the gap between requirements and the status quo in the logistics IT. In addition, there is growing pressure on the logistics sector through legislative changes. Moreover, street charges and the need for electronic customs clearance imply the use of new IT services, e. g. for control of driving and rest times. The same applies to the introduction of tracking and tracing for continuous condition monitoring of goods.

In this context cloud computing is a very interesting technology to face the outlined challenges. The rest of the paper is organized as follows. In this chapter the requirements of logistics on application domain specific cloud services are discussed. Section 2 summarizes the results of a study about the acceptance of cloud computing within the logistics domain in Germany carried out by the Fraunhofer Institute for Material Flow and Logistics IML. Section 3 provides an overview of the Logistics Mall development. The paper closes with a summary of results and an outlook to future work.

## 2 Cloud Computing in the Logistics Domain

Cloud computing is considered as a megatrend which will have an impact on the usage of information technology in all application domains. Forrester forecasts that the global market for cloud computing will grow from \$40.7 billion in 2011 to more than \$241 billion in 2020. The total size of the public cloud market will grow from \$25.5 billion in 2011 to \$159.3 billion in 2020 [2].

For a common understanding we adopt the working definition of NIST [3] that defines cloud computing as “a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction. This cloud model promotes availability and is composed of five essential characteristics, three service models, and four deployment models.” The basic characteristics are on-demand self-service for consumers, broad network access, resource pooling to serve multiple consumers using a multi-tenant model, rapid elasticity of resources and metering capabilities for service provision. The identified service delivery models are software-as-a-service (SaaS) where consumers use a provider’s application running on a cloud infrastructure, platform-as-a-service (PaaS) where a consumer can deploy an application on a cloud infrastructure using a provider’s tools and platform, and infrastructure-as-a-service (IaaS) where a consumer can run arbitrary software on a provided cloud infrastructure.

Recently, big IT companies have invested many million dollars in the development of cloud technology and in the provisioning of commercial cloud offers. The span reaches from IaaS solutions like Amazon’s Elastic Compute Cloud [4] to PaaS offers like Microsoft Windows Azure [5] and SaaS offers like Salesforce CRM [6]. A common characteristic of these offers is their generic nature. They all concentrate on broad usage scenarios but do not provide business relevant features. These cloud offers are called “horizontal clouds”. In their report on the future of cloud computing [7] a European expert group identifies the provisioning of application area specific cloud services, also called “vertical clouds”, as a significant business opportunity. The German excellence cluster EfficiencyCluster LogisticsRuhr ([www.effizienzcluster.de](http://www.effizienzcluster.de)) shares this view and has declared the development of a domain specific logistics cloud a strategic target.

### 2.1 Requirements on Logistics Services Out of the Cloud

Logistic applications often have specific characteristics that are implied by the requirements of the industry. By shifting logistics applications to the cloud, these characteristics have to be considered in order to provide a proper replacement for the existing customizable software solutions. The essential requirements that must be considered in the context of logistics specific cloud services include:

- Integration of customer-specific peripherals
- Realization of short response times of logistics software
- Ensuring data security and transparency
- Timely implementation of highly-customized business processes at low cost

Many of these requirements are not just technical in nature. However, they lead to technical requirements on cloud computing on closer inspection.

### **2.1.1 Integration of Customer-Specific Peripherals**

Typical software systems used in intralogistics include warehouse management systems (WMS). In addition to the basic functions including the management of quantities, bin locations and transport orders a warehouse management systems also includes extensive means of controlling the system states and implements a variety of operating and optimization strategies. Typical peripherals that have to be interfaced with a WMS include [8]:

- Forklift and handheld terminals: These components are wireless computers for mobile applications such as for forklifts or for manual operation. They are used for timely and easy collection of data, for example as part of the picking of products.
- Barcode reader (infrared scanners) and transponder reader (RFID scanner): Scanners are wired (e.g. USB) or connected wirelessly to a PC. The captured data is processed by the WMS.
- (Label) printers: Printers serve in the context of WMS as a medium for the creation of goods receipt documents, picking lists or goods issue papers. Special label printers can write adhesive labels which are attached as forwarding labels on pallets.

## **2.2 Realization of Short Response Times**

In logistic applications, compliance with upper limits of the response time of the software is very important. For example, if it takes too much time to update a user dialogue in applications like high performance picking, the employee cannot continue with his work (e.g. scanning of products) and is hindered in his work routine. This results in a reduction of productivity. To prevent such occurrences, cloud applications should be high-performant, i.e., the response time of the application for user input must be as low as possible so that user productivity is not affected. Particularly, the use of cloud computing may not lead to an obvious reduction in the performance of the user-frontend.

A particular challenge is the control of real time material flow systems. In the field of continuous conveyor systems guaranteed response times of less than 10 ms

are standard. This can only be realized through the use of a material flow control systems on site, which may be coupled with applications in the cloud that are less time-critical. On the other hand autonomous designed conveyor modules increasingly allow a decoupling of real-time operations and thus the direct combination of cloud and material flow control.

### **2.2.1 Information and Data Security**

Information and material flow in the logistics domain have reached a very high level of complexity. On the one hand this results from the variety of involved entities (suppliers, customers, means of transport, machinery, goods, IT systems, etc.). Another reason for this are multiple dependencies between the involved entities. Logistics is responsible for the planning, control and optimization of material and information flow that goes beyond company boundaries. As part of the cooperation between companies more and more short-term co-operations are formed, which depend on the core competencies of the companies. The tendency of this development is increasing.

The logistics of today is not imaginable without modern IT, wireless data transmission and mobile devices. Decentralization and particularly networking play an increasingly important role in logistics. This development leads to new requirements for existing security concepts. Especially in the logistics domain, the customers of logistics service providers have a legitimate, strong interest to protect their data (e.g. throughput data, sales data, and master data). Also, the use of mobile devices (GPS, telematics, RFID readers, PDAs, smartphones and laptops) is ubiquitous in logistics. Especially here it is important to develop concepts that enable the safe use of such mobile hardware in the cloud.

### **2.2.2 Individual Business Processes, Implementation Timeframes and Costs**

In particular, the time factor blocks the development of flexible and innovative IT-based logistics solutions in several ways. The implementation time of today logistics systems is very long in proportion to the period of their utilization. Thus, business models and strategies in industry and commerce currently have a typical life cycle time of 2–3 years. The adequate modeling of (logistics) business processes often claims a realization time of 6–10 months. If additionally there has to be implemented a new, efficient IT solution for providing the required logistics services, then the implementation period extends to an average of 12 up to 24 months. The operating time of such strategic investments is an average of 3–5 years. After this time period normally the IT solution has to be adjusted because of new or changed requirements. This leads to an economically problematic relationship between planning and realization expenses and usage times [9].

This problem can be mitigated by IT components that can adapt to new requirements simply and quickly by dynamic combination to support more complex processes. For a cloud computing infrastructure this means that it must support the loose coupling of functional services in the form of autonomous IT services. A complete business process can be built up on this basis by choreography or orchestration of IT services [9].

### ***2.3 Acceptance of Cloud Computing in Logistics***

The acceptance of cloud computing in logistics was analyzed in the current market study “Cloud Computing for Logistics” of the Fraunhofer Institute for Material Flow and Logistics IML in Dortmund [9]. In this analysis providers of logistics IT services and potential users from the fields of logistics service providing, commerce and industry were interviewed. The goal was to find out the conditions under which the logistics and IT managers are willing to consider and use cloud computing approaches for critical logistics applications such as warehouse management systems (WMS).

The results of the study speak for themselves: the degree of acceptance of logistics solutions in the cloud is very high. Already today the majority (56 %) of corporate leaders can imagine to rent and run logistics software on external servers. This shows that the market is open-minded for the usage of logistics software from the internet and there exists a great potential for this form of software distribution.

The following section describes the “Logistics Mall”, a platform that allows the purchase and usage of logistics software from the internet based on cloud computing.

## **3 Logistics Mall**

### ***3.1 Vision***

Common characteristics of all logistics business processes are individuality and dynamically changing requirements of the customers’ business. A process has to be adapted to every new or changed requirement. Consequently, the underlying IT infrastructure is also subject to these frequently changing requirements.

Today a typical logistics process runs in a heterogeneous IT environment. Such systems are mostly standard software like SAP, Oracle, or more specialized logistics software systems like warehouse management systems (WMS) or production planning systems (PPS). All these systems do not entirely meet the requirements of logistics customers regarding short contract duration, pay-per-use accounting and the provisioning of individual IT services. The majority of the

features of standard software is rarely used or not used at all, but has to be paid for, due to a monolithic architecture. Customizing software to adapt to new or changed requirements involves high efforts, costs and risks. Nevertheless the solution's flexibility for upcoming adaptations is not increased.

The introduction of cloud computing is a new opportunity to deliver different IT services over the internet. The idea of this IT paradigm is the abstraction of the underlying software and hardware. Based on this, users do not have to manage and administrate the physical hardware or software they are using. An additional advantage is that software can be acquired on-demand and paid per use [10].

The concept of providing services over a cloud encompasses three different stakeholders. Basically these are the operator of the cloud computing environment (CCE) being responsible for its administration, providers offering their applications or IT services and customers purchasing and using the services [11].

Regarding the dynamically changing requirements cloud computing provides the opportunity for a logistics customer to rent IT services only as long as they are needed. Furthermore, using a CCE to provide and use services enables customers and logistic service providers to focus on their key business by outsourcing the IT infrastructure to the cloud. Both customers and logistic service providers do not have to establish and administrate an internal IT infrastructure and only require a connection to the internet for interacting with the cloud. Additionally, pay-per-use accounting is another advantage for the customers. For providers cloud computing is a new opportunity to gain greater market relevance and design new offers by connecting their products with services provided by other independent providers (according to the slogan “The whole thing is more than the sum of its components”) [12, 13].

### **3.2 Concept**

The main idea of cloud computing—“Anything as a Service”—can be adapted to source complete logistics business processes, designed by connecting single IT services using an appropriate tool that is executed in the browser. Therefore, an adequate process modeling methodology is necessary to offer logistics customers an opportunity to model individual processes themselves. This service delivery model is defined as Business Process as a Services (BPaaS). There are contributions that use BPaaS as abbreviation to name models that have the general idea of outsourcing of existing processes into the cloud [14]. Here, more specifically, the unique feature of this model is that both modeling and process execution are part of the cloud platform. This idea is the basis of the Logistics Mall, a development of the Fraunhofer Innovation Cluster “Cloud Computing for Logistics” [15], that focusses on the modeling and execution of processes that are built out of several IT services and that can be offered using a cloud platform. Most of the today available approaches are too complex to be used by logistics customers that have minor software engineering skills. On the one hand the vision of the Logistics Mall is to

create a methodology that is capable to deliver business processes that can be deployed automatically for execution. On the other hand the logistician may not be overburdened by technical details.

The main idea of the Logistics Mall and the offering of BPaaS is visualized in Figs. 1 and 2. Today’s monolithic software solutions are replaced by small, dedicated IT services of different service providers which can be combined to superior services that support the individual business processes of the logistician.

In addition to the offering of BPaaS solutions the Logistics Mall is also able to provide classic IT services corresponding to the Software as a Service (SaaS) cloud model. The main reason for this is to address as many software providers as possible to be able to offer IT systems that support a broad range of logistics processes. For an IT service that is offered in conjunction with BPaaS the technical

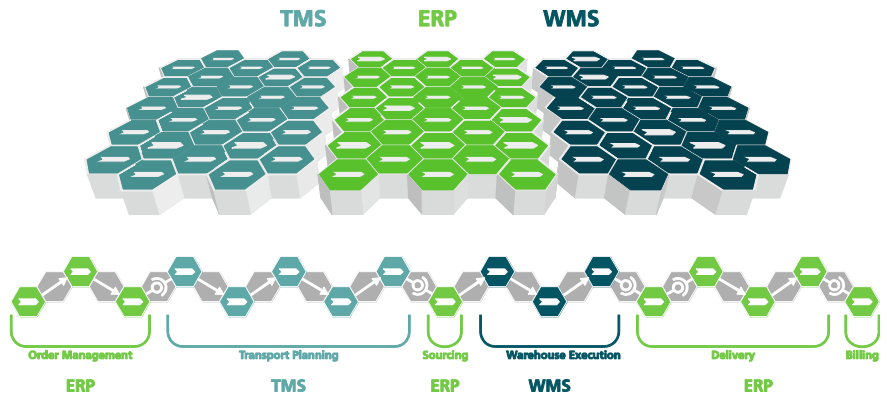


Fig. 1 Today’s monolithic software solutions and their interaction within a business process

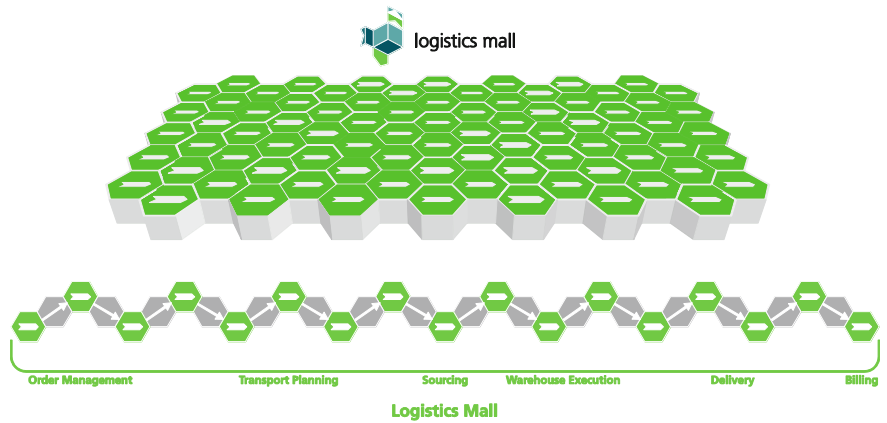
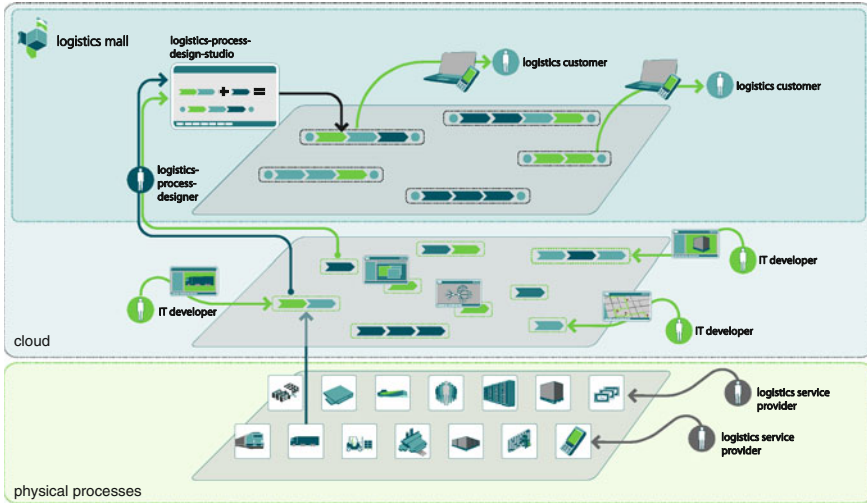


Fig. 2 The Logistics Mall as a cloud platform offers IT-services that can be combined to support individual logistics business processes





**Fig. 3** Concept and stakeholders of the Logistics Mall

requirements are much higher than for an IT service that is offered only in as SaaS in the manner of ASP (application service providing). The reason for this is that BPaaS requires the IT service to use the same business object data model so that in the context of a modeled process IT services of different service providers have a common understanding of the data that is communicated between them. A detailed description of this data model and how it supports logistics business processes and reduces the business-IT gap is provided by [16]. Moreover the IT services in context of BPaaS should have a consistent look and feel of the GUI when they are used to support one business process. This requirements force service providers to undertake broad modifications on their existing IT services to be offered on the Logistics Mall. In contrast, providers have to do only slight modifications to their web-based IT services to offer them as SaaS products on the Logistics Mall platform (cf. Sect. 3.4).

Part of the concept of the Logistics Mall (Fig. 3) is that *IT developers* can offer and operate IT services in the cloud. Another target group is companies that have the function of integrators. As *logistics process designers* they combine IT services, which are compatible to be used in context of BPaaS, to more widespread IT solutions that support complete logistics business processes. The third group is the *logistics customers*, who order and consume the IT solutions offered by the Logistics Mall.

Conceptually the Logistics Mall also supports the integration of physical services. Such serviced could be offered on the Logistics Mall platform by *logistics service providers*. Examples of these include transport services, which encompass a transport of goods from a source to a destination.

Overall, the Logistics Mall is a comprehensive approach of an integrated platform that offers PaaS for IT developers and SaaS/BPaaS for logistics customers. The usage model behind the Logistics Mall for both is its operation as a public cloud or as a private cloud. Commercial operation of the Logistics Mall is available to the public at <http://www.logistics-mall.com>.

The design of the Logistics Mall is based on two pillars. The first pillar is the shopping frontend in the form of the mall marketplace (MMP). The MMP provides a publicly available online shop for the offered products. The second pillar of the Logistics Mall is a platform that allows the operation and usage of the IT solutions rented on the MMP by the logistics customer. After ordering a product in the MMP it is provided on the so called Customized Access Framework (CAF).

### ***3.3 Components of the Logistics Mall***

The following section describes some essential elements of the Logistics Mall from a functional viewpoint. An architecture overview about the Logistics Mall is presented in [17].

#### **3.3.1 User Management**

User management in the Logistics Mall is realized as a cross-component that is used at both the MMP and the CAF. Every user account of the Logistics Mall is assigned to an explicit company, in the wording of the Logistics Mall called client. A distinction is made between three types of clients, namely the operator, the providers and the customers. The operator has an integral access to the Logistics Mall through which he can access all the functions necessary for administration. Providers and customers get access to the Logistics Mall as part of a registration process. During this process, every company gets assigned a unique client number. Besides user name and password as user-specific identity information the unique client number is required for the MMP login. For the CAF login the client number is not necessary because the CAF is provided client-specific and is accessed via a unique ULR assigned to the client.

The user management of the Logistics Mall allows a client to create arbitrary other user accounts for users of his company and to assign permissions to each of these accounts. The permissions relate to functions of both MMP and CAF. For example, a user of type customer that has all possible permissions can access both MMP and CAF and use all available functions and rented IT services with their full functional range.

The assignment of permissions to users is done via roles. Each role aggregates a set of permissions. On the one hand roles may have been created in the user management of the Logistics Mall and then refer to functions that are provided in MMP and CAF. On the other hand roles may have been exported by the IT services

the customer has rented and refer to permissions within the specific IT service. The user information and the roles of a logged in client can be requested by the IT services using a specific Logistics Mall interface. This concept called single sign on is realized across the entire Logistics Mall. A user only needs to login once and then can use all the features and IT services that he is allowed for by the permissions of his user account.

Thus, the user management built into the basic infrastructure of the Logistics Mall is a central element, which simplifies the usability of the Logistics Mall and reduces the organizational overhead.

### 3.3.2 Product Management

To capture new IT services in the Logistics Mall, there is a dialogue-based wizard, which queries all necessary product information from the IT service provider in a structured form. The registered provider can access the wizard on the MMP.

In the first step of the wizard, the general product information such as product name, version, classification and text, logos and flyers for product description are queried. In the second step the specification of the accounting model is done for the product. A distinction is made here between three accounting types: one-off costs, flat-rate costs (in regular intervals recurring costs) and transaction-based costs which support pay per use accounting. Transactions can be seen as clearly identifiable events that written by an IT service using a given logging interface of the Logistics Mall. Through the analysis of these logs a transaction-based billing is possible. A combination of these three accounting types is called pricing model. A pricing model may be assigned to the product itself or to any associated product option separately.

The specification of product options and associated pricing models is the third step of the dialog based wizard. Product options describe additional services that can be ordered by the customer together with the product. An example for such additional services is functional add-ons for the product. The product options can be aggregated into so called option groups. In addition, it can be specified whether a customer may choose only one option or several options from an option group as part of the ordering process.

In the fourth step of the wizard information about contractual design and accounting of the product is queried. These details include the minimum contract period and cancellation period. In the final fifth step, a preview of the product is presented. The provider can see how its product will be presented in the public MMP product catalog. The Logistics Mall workflow requires a product to be certified and released by the operator before it is presented in the MMP product catalog and can be rented by customers.

Generally, the product management of the Logistics Mall provides a comprehensive instrument with which the product and its associated accounting model can be described individually by the provider of an IT service.

### 3.3.3 Logistics Process Designer

The logistics process designer (LPD) is the central tool of the Logistics Mall that allows the modeling of IT solutions that support the individual business processes of a logistician. To be ready for business, the LPD supports a modeling methodology with the following characteristics:

- The LPD can be used by a logistics expert without detailed IT knowledge.
- A process consists of available IT services only. Modeling an arbitrary process just to notice it cannot be run by the IT services available is not practical.
- The LPD supports in its modeling process different functional granularity of IT services and the CCE. Forcing IT service providers to only implement services with specified, fixed granularity limits the distinction of IT services and hampers the growth of a broadly diversified range of IT services covering all ranges of functionality demanded by customers.
- The IT services within the modeled logistics process are exchangeable.
- On premise IT systems that are not operated in the cloud can be integrated into modeling by specific interfaces. By this, customers have the opportunity to migrate to the cloud step by step, still using existing IT systems and connecting them with IT services provided by the cloud.

A detailed description of the approach of the LPD is discussed in [18].

### 3.3.4 Reporting

Each client of the Logistics Mall gets access to a client-specific documents area. At adjustable, regular intervals, reports are stored that contain diverse dynamic data:

- Tickets: statistics about tickets, that have been sent using the helpdesk of the Logistics Mall
- Hardware utilization: details about utilized CPU time and memory utilization originated from IT service operation in the CAF
- Transactions: Data of the transactions the IT services in the CAF have written for pay per use accounting

Reports are customized specifically for the client types operator, provider and customer. For example, the transactions report for end customers contains the number of transactions logged for each rented product. For the provider the same report contains transaction numbers for each of his products and for each of his customers.

The reporting component of the Logistics Mall allows clients to trace data that occurs in operation and is relevant for business and accounting.

### 3.3.5 Helpdesk

The Logistics Mall incorporates an integrated ticketing system, which enables the processing of support requests. The 1st level support for end users is carried out by the operator of the Logistics Mall. With this the operator represents the first instance to which customers direct their support requests. If the processing of a request is not possible by the operator because the problem-solving requires a deeper understanding of an application, the operator forwards the request to the provider of the application. The provider thus takes the 2nd level support and can reply to requests of customers using the integrated ticketing system of the Logistics Mall.

Since the ticketing system belongs to the basic infrastructure of the Logistics Mall, users can access it from both MMP and CAF. This provides a platform that can be used to discuss and solve customer's problems.

## 3.4 *Interfaces for Application Integration*

To make applications available in the Logistics Mall, interfaces are provided for the application integration that must be implemented by the provider. The application integration is largely based on Web service interfaces, as this will ensure that the interfaces can be addressed through almost all modern programming languages. Subsequently the main interfaces of the Logistics Mall are shortly described. These are related to classic IT services corresponding to the Software as a Service (SaaS) cloud model. Interfaces of IT services, which are used in the context of BPaaS in the Logistics Mall, are described in [19].

- IT service GUI integration: two different interfaces are provided for the integration of IT service GUIs. Supported are already web-enabled applications. A simple integration is provided with the help of so-called inline frames. They allow that a browser window containing the IT service GUI can be shown as component of another browser window. In addition, application GUI can be integrated via portlet technology.
- Transaction-based accounting: to implement the transaction-based accounting for each application the relevant business transactions are queried within the product management wizard (cf. Sect. 3.3). During operation the application then reports its transactions through an interface to the Logistics Mall. The transactions are logged for accounting purposes.
- Connection of external peripherals: for reliable connection of the typical peripherals in logistics environment a special interface is provided by the Logistics Mall. This interface allows an application to establish a secure connection to the periphery.
- File storage: applications often write log files, reports or exchange data using a shared file. These files also must be stored in a cloud environment like the Logistics Mall. For this reason, Logistics Mall provides an interface through

which IT services can read, write and delete files and folders that are stored in the cloud.

- **Error Handling:** because applications and services are not operated locally or in the company-internal infrastructure, it is important that they can report errors. To integrate the error handling with support the Logistics Mall provides an interface to the ticketing system. Using this interface an IT service can report errors using a Web service or sending a simple e-mail to the ticketing system. In both cases error handling is integrated with the ticketing workflow.
- **User and role management:** a key requirement for the provisioning of services and applications from the Logistics Mall is that after a one-time authentication a user can call all its associated services and applications without repeated login procedure (Single Sign On). The Logistics Mall therefore provides an interface that can be used by IT services to be query for user and role information.

## 4 Conclusion

The Logistics Mall platform aims at providing a market place for logistics services and business processes together with a cloud-based access and execution environment. The currently Logistics Mall platform that is accessible under [www.logistics-mall.com](http://www.logistics-mall.com) for the public supports the offering of IT services using the SaaS delivery model.

In the next step this platform will be extended towards support for the design and execution of workflows that combine logistics IT services and physical logistics activities using the BPaaS delivery model. With regard to the process execution a proof of concept implementation is being realized in form of a reference scenario. This reference scenario includes the execution of different types of business processes for warehousing within the intralogistics domain. The activities range from support for the incoming goods, the storage and picking to the shipping process and the outgoing goods. Part of the implementation is the integration of peripherals typically used in logistics, such as label printers and handheld scanners. The modeling and design methodology using the LPD is also demonstrated and validated by the reference scenario. The results obtained so far suggest that the proposed methodologies a viable, meaning that the proposed concept is suitable to be used in industrial applications.

## References

1. Doll, A., Friebe, D., Rückriegel, M., Schwarzmüller, C.: Global logistics markets. [http://www.rolandberger.at/media/pdf/Roland\\_Berger\\_Studie\\_Global\\_Logistics\\_Markets\\_fin\\_20140820.pdf](http://www.rolandberger.at/media/pdf/Roland_Berger_Studie_Global_Logistics_Markets_fin_20140820.pdf) (2014). Accessed 24 Nov 2014
2. Forrester Research: Sizing the cloud—a BT futures report. Understanding and quantifying the future of cloud computing. <http://www.forrester.com/Sizing+The+Cloud/fulltext/-/E-RES58161> (2011). Accessed 08 April 2013

3. Mell, P., Grance, T.: The NIST definition of cloud computing. Working paper National Institute of Standards and Technology. <http://www.nist.gov/itl/cloud/upload/cloud-def-v15.pdf> (2009). Accessed 08 April 2013
4. Amazon Elastic Compute Cloud (Amazon EC2). <http://aws.amazon.com/ec2/> (2013). Accessed 08 April 2013
5. Microsoft Windows Azure. <http://www.microsoft.com/windowsazure> (2013). Accessed 08 April 2013
6. Salesforce CRM. <http://www.salesforce.com> (2013). Accessed 08 April 2013
7. Jeffrey, K., Neidecker-Lutz, B. (eds.): The future of cloud computing—opportunities for European cloud computing beyond 2010. Expert group report, European Commission, DG INFSO (2010)
8. ten Hompel, M., Schmidt, T.: Warehouse Management: Automation and Organisation of Warehouse and Order Picking Systems. Springer, New York (2007)
9. Meinhardt, M.B., Rahn, J.: Empirical qualitative analysis of the current market situation in the context of cloud computing for logistics. In: ten Hompel, M., Rehof, J., Wolf, O. (eds.) Cloud Computing for Logistics, Lecture Notes in Logistics, Springer (2015)
10. Schuldt, A., Hribernik, K.A., Gehrke, J.D., Thoben, K.D., Herzog, O.: Cloud computing for autonomous control in logistics. In: Fähnrich, K.P., Franczyk, B. (eds.) 40th Annual Conference of the German Society for Computer Science (GI 2010), LNI 175, Gesellschaft für Informatik, pp. 305–310. Leipzig, Germany, 27 Sept–1 Oct (2010)
11. Kaisler, S., Money, W.H.: Service migration in a cloud architecture. In: 44th Hawaii International Conference on System Sciences (2011)
12. Goyal, P., Mikkilineni, R.: Policy-based event-driven services-oriented architecture for cloud services operation and management. In: IEEE International Conference on Cloud Computing (2011)
13. Scholz-Reiter, B., Rippel, D., Sowade, S.: Limitations in modeling autonomous logistic processes—challenges and solutions in business process modeling. In: IEEE International Symposium on Assembly and Manufacturing (ISAM), pp. 1–6, 25–27 (2011)
14. Bentounsi, M., Benbernou, S., Atallah, M.J.: Privacy-preserving business process outsourcing. In: IEEE 19th International Conference on Web Services (2012)
15. Fraunhofer Innovation Cluster “Cloud computing for logistics”. <http://www.ccl.fraunhofer.de/en.html> (2013). Accessed 08 April 2013
16. Böhmer, M., Schmidt, M., Weißenberg, N.: Seamless interoperability in logistics: narrowing the business-it gap by logistics business objects. In: ten Hompel, M., Rehof, J., Wolf, O. (eds.) Cloud Computing for Logistics, Lecture Notes in Logistics, Springer (2015)
17. Holtkamp, B.: The logistics mall—an it-architecture for logistisc-as-a-product. In: ten Hompel, M., Rehof, J., Wolf, O. (eds.) Cloud Computing for Logistics, Lecture Notes in Logistics, Springer (2015)
18. Bochon, I., Ivens, V., Nagel, R.: Challenges of cloud business process management. In: ten Hompel, M., Rehof, J., Wolf, O. (eds.) Cloud Computing for Logistics, Lecture Notes in Logistics, Springer (2015)
19. Eggemann, J., Leveling, J., Weiß, N.: Business apps meet the challenge of covering continually changing logistics requirements. In: ten Hompel, M., Rehof, J., Wolf, O. (eds.) Cloud Computing for Logistics, Lecture Notes in Logistics, Springer (2015)

Cloud Computing for Logistics

ten Hompel, M.; Rehof, J.; Wolf, O. (Eds.)

2015, VII, 139 p. 68 illus., 58 illus. in color., Hardcover

ISBN: 978-3-319-13403-1