CLOUD ARCHITECTURE FOR LOGISTIC SERVICES

Korczak J., Lipiński P.*

Abstract: This paper concerns organization of the local cloud computing environment at the Wroclaw University of Economics, developed in the framework of the LOGICAL research project. In particular the architecture of the environment, the implementation of main components of the environment are described as well as their references to the global cloud computing environment and the general architecture of the VMWare platform.

Key words: cloud computing, logistic services, cloud portal, data security

Introduction

One of the key trends in modern ICT business applications is the virtualization of computation resources and services through cloud computing [8], [11], [14], [15]. The virtualization of resources enables management and operation of so-called "*virtual machines*" that can be used to provide services activated inside the cloud system. The idea of cloud computing is to replace locally installed hardware and software resources, local databases and processes by web-interconnected servers, data storage devices and applications accessible on-demand through web-based user interface.

Recently numerous studies and research project have shown the advantages for logistics enterprises of migration of applications and services on the cloud servers (e.g. [2], [4], [7], [12], [17], [13], [18]).

This paper concerns architectural issues of a cloud computing platform for logistic services. It proposes an optimal architecture of a cloud computing platform for logistic services to enhance the interoperability of logistics businesses. Presented in the paper LOGICAL project was started in 2011 within the Central Europe programme of the European Regional Development Fund. Its general objective is to enhance the interoperability of logistics businesses of different sizes, to improve the competitiveness of Central European logistics hubs through a decrease of transaction costs (better access to systems of logistics partners and global players), and to promote collective (sustainable) modes of transport (multi-modal cooperation) [4].

This paper is structured in the following manner: Section 2 presents a short introduction to the cloud computing. Section 3 refers to some prototype applications and the environment. Section 4 discusses data protection and service cost estimation. Section 5 presents the development status of the project and concludes the paper.

* **Prof. Jerzy Korczak,** Wroclaw University of Economics, **Piotr Lipiński, PhD.,** University of Wroclaw
✉ corresponding author: jerzy.korczak@ue.wroc.pl, lipinski@ii.uni.wroc.pl

Architecture of the cloud computing platform

The research team of the Wroclaw University of Economic, as a partner of LOGICAL project, has developed the local cloud computing environment based on the architecture of the global cloud computing environment of the LOGICAL project, described in details in [4]. The architecture of the general cloud computing environment in the LOGICAL project is schematically illustrated in Figure 1 The first layer of the system is the web user interface implemented by the LOGICAL solution portal. The second layer of the system includes cloud computing components, which realize the general cloud computing tasks, such as the user authentication, the process management, the data security, as well as tasks related to interoperability, data migration or service integration. The last layer of the system is composed of a number of integrated external systems.

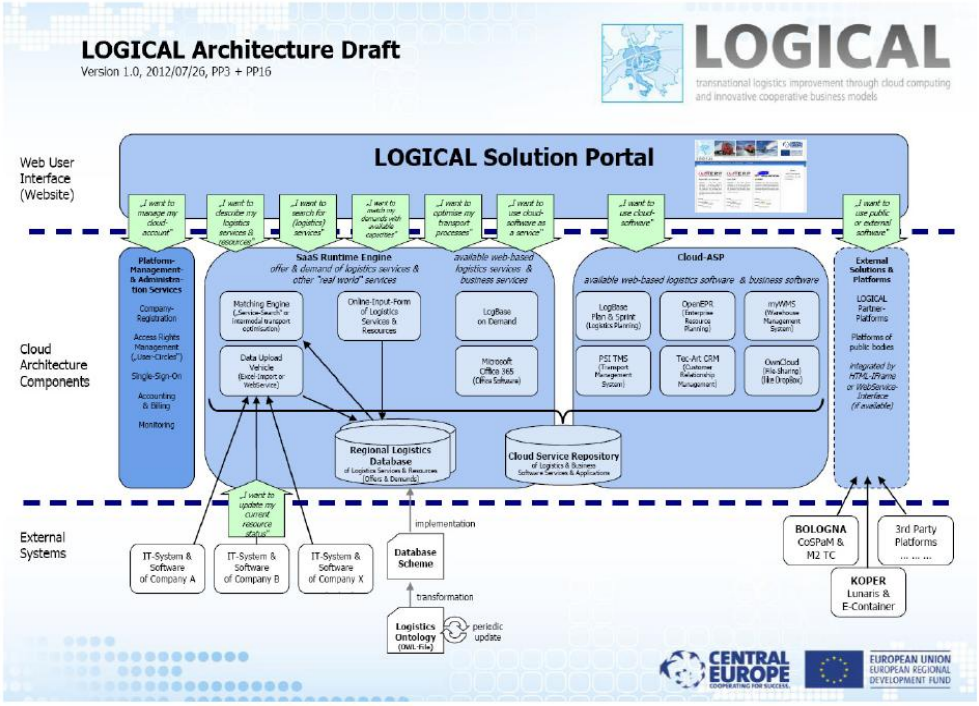

Figure 1. The general architecture of the cloud computing environment
Source: [4]

The main components of the entire cloud computing system include:
- the web user interface (the LOGICAL portal),
- the internal functions and components of the cloud architecture,
- the connected external systems.

The internal functions refer to the basic cloud computing operations:
- platform management and administration services,
- SaaS runtime engine and related services,

– cloud application service provider and related applications,
– exchange gateway to externally hosted services and platforms.

Figure 2 presents the components of the second layer of the system in more details.

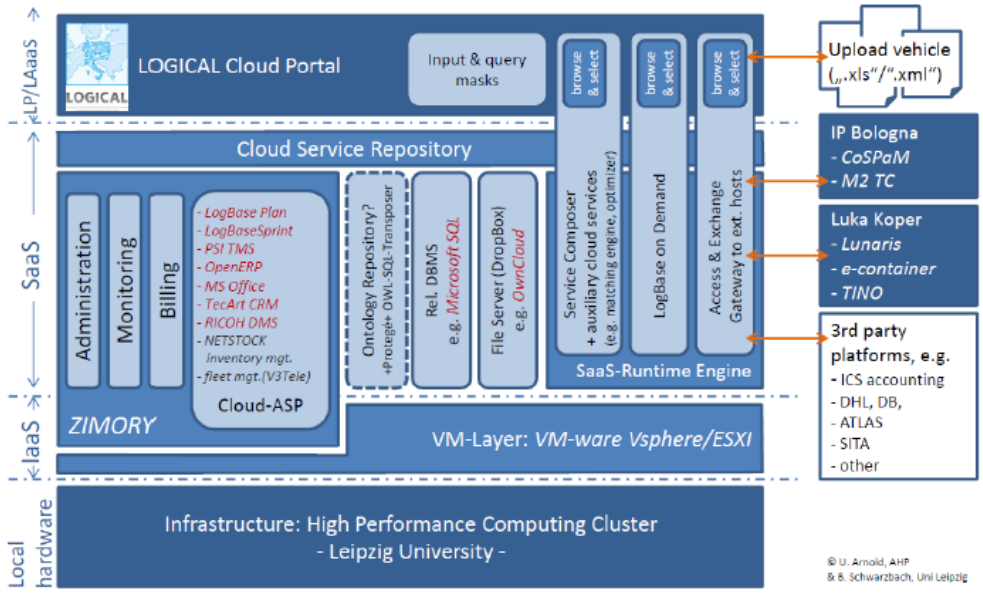

Figure 2. The technical architecture of the cloud computing environment
Source: [4]

The local cloud computing environment at the Wroclaw University of Economics is based on the general schema proposed in [4] for cloud computing environments in the LOGICAL project. However, a part of the architecture, especially the services of the second layer of the system, are dependent on the integrated external systems, which constitute the last layer of the system. Further, these external systems depend on particular preferences and requirements of the local partners and the local logistic enterprises, especially on particular software packages and applications they use and need to integrate with the cloud computing environment. Therefore, the detailed architecture of the second layer of the system may vary depending on requirements of the local logistic enterprises and the software they need.

The prototype version of the cloud computing environment at the Wroclaw University of Economics is built on the VMWare platform [3], which is one of the most popular and reliable commercial cloud computing platforms available.

The architecture of the VMWare platform assumes a number of logical virtual machines, which are simulated on the physical cloud computing infrastructure. Each virtual machine is independent and isolated from the others, but may share some defined resources and exchange data through defined networks. The VMWare platform enables also to simulate a number of logical virtual networks,

which joint the virtual machines. Different hardware devices as well as software services may be emulated in the cloud computing environment.
Cloud computing provides an efficient platform for computational purposes and also enables to reduce management efforts and costs of maintenances. The numerous applications prove the efficiency of cloud computing in large areas of interests [1], [6], [8].
From the logical point of view, the VMWare platform assures a simultaneous running of a number of virtual machines, which uses virtual hardware items provided by the VMWare Virtualization Layer with the VMkernel and may offer services in global networks using the Virtual Networking Layer.
At the prototype version, the main components of the second layer of the cloud computing environment at the Wroclaw University of Economics include:

- platform management and administration services related to the VMWare platform,
- database management systems, such as MySQL, PostgreSQL available at public or Oracle Database Servers (licences are required),
- application servers, such as Apache Tomcat, JBoss available at public or Oracle WebLogic Server, IBM WebSphere (licences are required),
- additional services required by the integrated external systems.

The architecture of the cloud computing platform presented in this section was used to build a prototype cloud computing system for logistic services. The prototype system was used for the research presented further in this paper, especially for modeling and simulation of logistic processes, for some case studies with requirements gathered from partners of the LOGICAL project, for computational experiments and for the overall validation of the proposed approach.

Prototype LOGICAL Applications and the Environment

The prototype version of the cloud computing environment at the Wroclaw University of Economics enables installation and integration of external application systems depending on particular preferences and requirements of the local partners and the local logistic enterprises.
Currently, the basic applications and software packages include:

- the standard office software, such as OpenOffice available at public or Microsoft Office (licences are required),
- the enterprise resource planning systems (ERP), which integrate internal and external management of information across the enterprise, such as the OpenERP available at public,
- the customer relationship management systems (CRM), which manage the interactions of the enterprise with current and future customers (more details in [2]).

Moreover, some additional applications for specialized logistic purposes may be available after the integration of the local cloud computing environment with the rest of the LOGICAL network, as described in [4].

In the prototype version of the cloud computing environment at the Wroclaw University of Economics a number of default application services may be provided to the partners or the logistic enterprises involved in the project. The list of applications available is based on the general architecture of the cloud computing environment in the LOGICAL project [4] that contains:

- Microsoft IIS Runtime Engine. Microsoft Internet Information Server is an internet applications server for managing web content, including web pages, web applications and web services.
- Microsoft SQL Server. Microsoft SQL Server is a relational database server for managing data for internal and external applications.
- OwnCloud. OwnCloud is an open source system for managing the cloud computing environment, especially the data space and their availability to the users.
- Applications for being provided by ASP. These applications include popular office tools, such as Microsoft Office or Open Office, the popular enterprise tools, such as ERP or CRM systems, etc.
- OpenERP. OpenERP is an open source system for enterprise resource planning (ERP).
- SALT Solutions: LogBase. SALT Solutions is a member of the Leipzig-Halle logistics cluster providing some software products, such as LogBase Plan, LogBase Sprint and LogBase on Demand for R&D purposes, in the LOGICAL cloud computing environment [2].
- PSI: PSItms. PSI AG is a member of the Leipzig-Halle logistics cluster providing some front end products for the logistics applications in the LOGICAL cloud computing environment [2].
- Cloud Service Repository. These application services include popular tools for a cloud computing repository, its management, data access control, authentication and authorization.
- Ontology Repository. These application services include popular tools for an ontology repository management and data storage, as well as data access control, authentication and authorization.
- Additional SaaS Components. These application services include additional components necessary for connecting with external logistic systems provided by the project partners or other logistic enterprises involved in the LOGISTIC cloud computing environment.
- Supply Chain Optimizator for Multimodal Transport. These application services aims at multilevel cost optimizing, i.e. optimizing the costs of production, transport, distribution and environmental protection, under a number of

constraints taking into consideration timing, volume, capacity and various modes of transport.

The Supply Chain Optimizator for Multimodal Transport is an unique and innovative solution to help logistic enterprises to optimize their operational costs. The solution, still being in a development version, uses new effective algorithms of computational intelligence, such as modern evolutionary algorithms for multi-objective optimization, in order to find optimal distributions of resources with multimodal transport. The key issues of the approach elaborated include:

- a solution is a n-tuple as in the original problem definition containing matrices, vectors and single numbers,
- advanced infeasibility analysis concerning the complex constraint system in the problem,
- improving individuals that violate constraints by resource allocations and random noising in order to avoid obtaining similar chromosomes and premature convergence,
- custom selection process: feasible solutions + promising infeasible solutions + random immigrants,
- matrix-based crossover operators for matrix components of the solution: exchanging row and column vectors,
- the two-point crossover operator for vector components of the solution.

The main bottlenecks in the approach include:

- in some problem instances, it is hard to obtain a feasible solution due to the complex constraint system in the problem,
- further research on improving infeasible solutions is needed,
- a tradeoff between (in)feasibility and the objective function value,
- the selection mechanism using both feasible and infeasible solutions may be improved.

The approach is in a development phase, but a prototype version was validated on some benchmark data with promising results.

Data Protection and Service Cost Estimation

One of the most important issues in commercial usage of a cloud computing environment is the data protection and security. It refers data storage, data transmission and data usage. Many recent scientific experiments suggest that cloud computing may assure most higher level of security than classic computing environments, [10], [9], [16], [17], due to facilitating the management of the environment and integrating many services into one secure platform.

The principle requirements of the data protection in the cloud computing environment at the Wroclaw University of Economics is described in the LOGICAL internal report [5].

As already pointed out the architecture of the cloud computing environment at the Wroclaw University of Economics is based on the VMWare platform. The

VMWare platform provides a number of data protection and security mechanisms guarantying a high level of data protection.
In the VMware platform, the data protection processes are managed by vSphere Data Protection, which is a software solution for data protection, especially disk-based backup and recovery processes, integrated with VMware vCenter Server. Further, the data security in the VMware platform is ensured by the vSphere Security, which provides information on securing the vSphere environment for VMware vCenter Server or VMware ESXi [3].
Estimation of the cost of logistic services may be based on a few factors, such as the cost-plus pricing, the competitors pricing or the perceived value to the customer. The cost-plus pricing is a standard method of pricing in logistics seeks to determine the cost of providing a service and then add an additional amount to represent the desired profit. In order to evaluate the cost, it is necessary to analyse the direct costs, indirect costs and fixed costs. In the competitors pricing, the estimation is based on an analysis of competitor websites, phone calls, opinions of associates having used the competitors services or available public reports.
Evaluating the cost of a service requires determining the labor cost, the material cost and the overhead cost.
In the cloud computing environment at the Wroclaw University of Economics, the preliminary cost evaluation may be also based on cost estimators analyzing commercial data collected in the databases or the data warehouses available in the environment. Such cost estimators, using data-mining techniques, may be more accurate than the classical methods, but they require reliable data referring to the time, money, resources and labor for the logistic services.

Summary

The local cloud architecture, its implementation and installation, is strongly based on the global architecture of the global LOGICAL cloud computing environment [2]. As most of the components of the global architecture is still in a prototype version and their implementation is still ongoing, the architecture of the local cloud computing environment may also change.
At this moment, the local cloud computing environment is in a prototype version with the components described in this report. It is ready to install additional services and to be integrated with the global LOGICAL cloud computing environment.
However, after the integration with the final version of the global architecture and its components, some experiments are necessary to validate the efficiency of the platform and test its components.

References

[1]. Abramson D., Buyya R., Giddy J., *A computational economy for grid computing and its implementation in the Nimrod-G resource broker*. Future Generation Computer Systems 18, 8 (2002), pp. 1061–1074.
[2]. Agarwal S., *Semantics and Ontology of Logistic Cloud Services*; © KIT Karlsruhe Institute of Technology, Presentation at LOGICAL Intl. partner meeting in Usti (CZ), 04 July 2012
[3]. *vSphere Security*, ESXi 5.1, vCenter Server 5.1
[4]. Arnold U., Oberländer J., Schwarzbach B., *LOGICAL - Development of Cloud Computing Platforms and Tools for Logistics Hubs and Communities*"[in] Proc. FEDCSIS conference, 9-12 Sept, 2012 Wroclaw
[5]. *Approach to Information Requirements Analysis*, LOGICAL Internal Report, Wrocław 2012.
[6]. Barroso L. A., Holzle U., *The Case for Energy-Proportional Computing*. IEEE Computer 40, 12 (December 2007).
[7]. Bughin J., Chui M., Manyika J., *Clouds, big data, and smart assets: Ten tech-enabled business trends to watch* [in] McKinsey Quarterly, August 2010, pp.1-14
[8]. Chen P.M., Noble B.D., *When virtual is better than real,* [in] Proc. of the 2001 Workshop on Hot Topics in Operating Systems (HotOS), pp. 133–138, 2001.
[9]. Flinn J., Narayanan D., Satyanarayanan M., *Self-tuned remote execution for pervasive computing* [in] Proc. of the 8th Workshop on Hot Topics in Operating Systems (HotOS-VIII), pp. 61–66, Schloss Elmau, May 2001.
[10]. Fox A., Gribble S.D., Brewer E.A., Amir E., *Adapting to network and client variability via on-demand dynamic distillation.* ACM SIGPLAN Notices, 31(9), pp. 160–170, 1996.
[11]. Fraunhofer IML, *Marktstudie Cloud Computing für die Logistik*; brochure, Fraunhofer IML, www.logistics-mall.de, Dortmund 2011
[12]. Holtkamp, B.; Steinbuss, S. ; Gsell, H. ; Loeffeler, T., *Towards a Logistic Cloud*, [in] Proc. of Conf. on Semantics Knowledge and Grid, Beijing, 2010, pp. 305-308.
[13]. Jeffrey, K., Neidecker-Lutz, B. (eds.) (2010). *The Future of Cloud Computing – Opportunities For European Cloud Computing Beyond 2010*, Expert Group Report, European Commission, DG INFSO.
[14]. Kunz T., Omar S.,. *A mobile code toolkit for adaptive mobile applications*. [in] Proc. of the 3rd IEEE Workshop on Mobile Computing Systems and Applications, pp. 51–59, Monterey, CA, December 2000.
[15]. Nurmi, D., Wolski, R., Grzegorczyk, C., Obertelli, G., Soman, S., Youseff, L., Zagrodonov D., *Eucalyptus*, Technical Report on an Elastic Utility Computing Architecture Linking Your Programs to Useful Systems, Tech. Rep. 2008-10, University of California, October 2008.
[16]. Oberheide J., Cooke E., Jahanian F., *Rethinking antivirus: Executable analysis in the network cloud*. [in] Proc. of the 2nd USENIX Workshop on Hot Topics in Security (HotSec 2007), August 2007.
[17]. Ogness J., *Dazuko: An open solution to facilitate on-access scanning*. Virus Bulletin, 2003.
[18]. 18. Steinbuß S., Weißenberg N., *Service Design and Process Design for the Logistics Mall Cloud*, [in] Principles, Methodologies, and Service-Oriented Approaches for Cloud Computing, eds. Yang X., Liu L., 2013, pp. 186-206

ARCHITEKTURA CHMURY OBLICZENIOWEJ DLA APLIKACJI I SERWISÓW LOGISTYCZNYCH

Streszczenie: Artykuł przedstawia organizację chmury obliczeniowej zaprojektowanej w ramach projektu LOGICAL (program Central Europe) i wdrożonej na Uniwersytecie Ekonomicznym we Wrocławiu. W szczególności opisano architekturę platformy, jej główne komponenty i usługi oraz platformę VMWare. Przedstawiona chmura obliczeniowa jest zorientowana na usługi i aplikacje dla małych i średnich przedsiębiorstw logistycznych w Europie Centralnej. Projekt LOGICAL jest w trakcie realizacji, jego zakończenie planuje sie na koniec 2014 roku.
Słowa kluczowe: chmura obliczeniowa, serwisy logistyczne, portale aplikacji, bezpieczeństwo i poufność danych

雲架構 - 物流服務

摘要：本文關注當地的雲計算環境，經濟的弗羅茨瓦夫大學，在邏輯研究項目的框架內發展的組織。在特定的環境中的體系結構，對環境的主要組成部分的實施進行說明，以及它們對全球的雲計算環境和 VMWare 的平台的一般架構的引用。
鍵詞：雲計算，物流服務，雲門戶網站，數據的安全性