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Decision Making in Logistics Processes Supported by Cloud Computing

Summary

Logistics processes in a globalized economy are increasingly complex, dynamic, and distributed. These characteristics pose major challenges for logistics management. Planning, organizing, leading and coordinating processes have become progressively more complex activities that are carried out by an increasing number of internal actors. Information inputs and outputs of these processes are more diverse and complex, with a greater number of users. Decision making is distributed in a way that all actors within these processes make decisions locally and autonomously. Development of a unified and open logistics information platform aimed at integrating various (heterogeneous) logistics sources and data would facilitate improvement of the logistics operation efficiency and also reduce costs, enhance competitiveness, and enable advance of the logistics system. Logistics information platform is the core and key development factor of the modern logistics system. Construction of this electronic platform can greatly promote the information oriented (can greatly improve the information necessary) for modern logistics development. In addition to that, it would provide essential support in making strategic and operational decisions in logistics processes.

This paper analyzes decision-making activities at different levels of logistics process management and explores the possibility of using cloud computing technology based on their key characteristics. In addition to that, the authors identify the different types of cloud computing architectures and cloud deployments models that are most frequently utilized for decision making in logistics. Research results include identified benefits and limitations of application of cloud computing technologies in supporting decision making in logistics processes.

Keywords

logistics processes, cloud computing, decision making

1. Introduction

The environment where managers make decisions has changed significantly these years. Organizations design their products in one country, purchase materials and raw materials in another, production is carried out in a third country, and finished products are marketed in numerous countries around the world. At the same time, logistics processes were the first processes to be outsourced. New logistics service providers, whose particular focus is on their core competencies, have emerged. Specialization has become the goal for logistics providers as well. Hence, they differentiated their operations based on the different logistics resources and processes managed. Under such circumstances, a great number of logistics operators appeared: main business owners, fourth party logistics service providers, third party logistics service providers, second party logistics service providers and first party logistics providers. Logistics processes, as transaction intensive, are abundant with various data used by numerous parties in logistics processes for effective and efficient management

and decision making in a changing environment. Intensive utilization of information technology that provides timely transaction processing and support in decision-making processes has an especially important role in the execution of complex management activities.

In supporting complex, dynamic and distributed logistics processes, organizations increasingly use information technologies. Logistic process management became inconceivable without the support of ICT technology. Therefore, the choice of mode of transport, stock quantities, mode of storage, locations and number of distribution warehouses, decisions regarding new market penetration, determining the profitability of some consumers and levels of services represent examples of activities in strategic decision-making where computer systems are utilized. Of course, the application of computers is even more intensive in planning, execution and control of operational activities. Certain parties of the logistic system use specific applications within their enterprise information systems for management of operational activities and decision making at an organizational level. These are rarely widespread

software solutions; most often these are completely different applications that are hard to connect, and enabling data exchange among them poses a challenging task.

Cloud computing is relatively new paradigm in the computing world, quickly developing and attracting a number of users. Cloud computing represents a new way to outsource. Cloud computing services provide consistent global platforms, shared real-time data, faster decision-making, improved customer service, greater automation and efficiency. In the domain of strategic and operations management of logistic activities, cloud logistics, as an innovated concept, should enable effective and efficient management of distributed logistics resources, especially in volatile, uncertain and complex environments.

The second section of this paper presents the applied research methodology, based on systematic analysis of selected literature and its expert interpretation. The subsequent chapter, literature review, contains a brief elaboration on the concept of cloud computing technologies, types of cloud computing architecture, cloud deployment models and their characteristics, followed by an overview of decision-making activities and processes in logistic processes at an enterprise level and the logistics system as a whole. The fourth section elaborates on decision making activities in logistics processes and potential application of cloud computing in these activities. Finally, the last chapter identifies prospective benefits of applying clouds logistics to support decision making processes, along with possible courses for its further development and use.

2. Research Methodology

Systematic review of cloud logistics - A systematic review of the existing literature on cloud computing logistics was carried out for the research on the selected topic, not only in order to summarize the existing studies related to the application of cloud computing technologies in logistics processes, but also to identify and analyze the current state and the most notable possibilities for applying cloud computing to support decision making in the domain of logistics.

Question formalization - The purpose of this paper is to determine whether decision-making processes in logistics would benefit from use of cloud computing at the enterprise level, and also at the logistics system level. Specifically, what advantages and disadvantages may logistics enterprises and all other actors in logistics systems experience from a logistics information platform deployed in the cloud?

Selection of sources – Selection criteria through which we evaluated sources was based on research experience of the authors of this paper. The following sources have been taken into consideration: Science Direct, Wiley Interscience, Emerald Publishing, AIS digital library and Scholar Google. The following journals were particularly singled out: Journal of Operation Management, Journal of Supply Management, Journal of Logistics Information Management, International Journal of Physical Distribution and Logistics Management, Journal of Business Logistics, and International Journal of Logistics Management. These journals were specifically selected for review, as they represent significant research in logistics.

Once the sources were defined, it was necessary to describe the process and the criteria for study selection and evaluation. The inclusion and exclusion criteria of this research were based on the research question. Therefore, we established that the studies must contain issues and topics which consider cloud computing in logistics, and that these studies must also describe strategic and operational decision-making process activities in logistics.

Review execution - During this phase, the search in the defined sources was executed and the obtained studies were evaluated according to the established criteria. After executing the search chain on the selected sources, we obtained a set of about 90 results which were filtered in accordance with inclusion criteria which resulted in a set of about 60 relevant studies. This set of relevant studies was once again filtered with the exclusion criteria to produce a set of studies which corresponds with about 40 primary proposals listed under references.

3. Literature review

3.1. Overview of Cloud Computing

A large number of distinguished authors have made efforts to define the concept of cloud computing and specify technologies associated with this term in academic and professional literature. The list of proposed definitions of cloud computing is extensive. It is especially difficult to formulate a single clear definition of cloud computing, due to a vast variety of elements associated with this concept (Youseff, Butrico & Da Silva, 2008). The most often cited definition, however, is the one by the National Institute of Standards and Technology (NIST): "Cloud

computing is a model for enabling ubiquitous, 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." (Mell & Grance, 2011). In other words, "cloud computing is a large-scale distributed computing paradigm that is driven by economies of scale, in which a pool of abstracted, virtualized, dynamically-scalable, managed computing power, storage, platforms, and services are delivered on demand to external customers over the Internet" (Foster, Zhao, Raicu & Lu, 2008).

NIST definition primarily reflects the providers' perspective of cloud computing. From the consumers' perspective, the phenomenon of cloud computing is described as described as a new cost-efficient computing paradigm in which applications, platforms, networks and ICT resources power can be accessed by consumers thru a Web browser, without any knowledge or concern about the location of these resources, while all these resources/services are available on a pay-per-use basis. Research on consumer preferences of cloud service attributes resulted in the following list of attributes that were most frequently stated as important by the respondents (Koehler, Anandasivam & Ma, 2010): security and reliability, provider reputation, required skills, migration process, pricing tariff, cost compared to intern solution, and consumer support. Security and reliability are attributes that consumers consider to be knock-out criteria, while the most important among other attributes are the reputation of the cloud service provider and the use of standard data formats. These two attributes are indicated by consumers as more important than those related to financial aspects, such as cost reduction or pricing tariff choice.

Among various definitions of cloud computing, a particular one that looks at this concept holistically, from the perspective of application and infrastructure, should particularly be highlighted. According to this definition, "Cloud computing is an IT deployment model, based on virtualization, where resources, in terms of infrastructure, applications and data are deployed via the internet as a distributed service by one or several service providers. These services are scalable on demand and can be priced on a pay-per-use basis." (Leimeister, Böhm, Riedl, & Krcmar, 2010).

According to the NIST, cloud computing has five fundamental characteristics, involves three service models and four deployment models. The five essential characteristics of cloud computing are:

- On-demand self-services: A user can obtain computing capabilities as needed, automatically, without requiring human interaction with providers of each service.
- Broad network access: Cloud capabilities are available over the network and accessed through standard mechanisms that promote use by heterogeneous thin or thick client platforms.
- Resource pooling: The provider's computing resources are pooled together to serve multiple consumers using multiple-tenant model, with different physical and virtual resources dynamically assigned and reassigned according to consumer demand.
- Rapid elasticity: The cloud is flexible and scalable to suit consumer immediate business needs. Cloud services can be rapidly and elastically obtained, in some cases automatically, to quickly scale up and rapidly released to quickly scale down. To the consumer, the capabilities available for hire often appear to be unlimited and can be purchased in any quantity at any time.
- Measured service: Use of cloud computing resources can be measured, controlled, and reported on, providing transparency for both the provider and the consumer of the utilized service. Cloud computing services often possess metering capabilities, which enables control and optimization of resource utilization. This implies that IT services are charged per usage metrics – pay per use.

Apart from the essential ones, there are some other significant features of cloud computing (Petkovics, Tumbas, Matkovic & Baracskai, 2014); (Seres, Horvat, & Horvat, 2011):

- Security of services - implementation of the most rigorous cutting-edge security measures for service provision;
- Multitenancy - a single instance of an application serves multiple consumers (tenants) with the possibility (for the tenants) to customize some details of the software applications;
- Increased reliability - because errors are constantly removed and repaired;
- Identity management and access control - application of advanced techniques in identity

checks and access control in order to provide legitimate data use;

- Diverse platform support, where cloud providers often provide services with built-in support for an abundant compilation of client platforms to reach a broader base of users;
- Centralization of infrastructure and lower expenses of operation and maintenance;
- Faster development - cloud computing platforms with a large number of services and preset templates for application development considerably facilitate the development process.

Cloud computing services are categorized according to the type of capability provided to the consumer into three service models: Infrastructure as a Service, Platform as a Service, and Software as a Service (Weinhardt et al., 2009).

- Infrastructure as a Service (IaaS) - It is the lowest layer of cloud computing. At this level, the service includes lease of hardware resources to the consumer. Resources are normally provided using virtualized hardware, and the consumer is responsible for managing these resources and installing software onto them. The provider owns the equipment and is responsible for housing, running and maintaining it. Consumers can generally access resources on-demand, paying only for what they use. The key advantages of IaaS for the consumer are: scalability, portability, unlimited hardware capabilities, predictable and guaranteed usability and beneficial costs, expert guidance, system acquisition bypass, enhanced agility and innovative business racing.
- Platform as a Service (PaaS) – It is the middle layer of cloud computing. At this level, providers offer consumers a development platform as a service, which they can use to build their own software solutions and deploy them on the cloud infrastructure. PaaS provider is responsible for managing operative systems, network resources, servers and storage, whereas the PaaS consumer manages the deployed application and customizes the application-hosting environment. PaaS covers a wide range of service types, from general value-added services on top of cloud infrastructure to highly advanced, domain-specific platforms. The main benefits of PaaS for the consumer are: prepared platform for fine tuning and use, consumers do not have to maintain hardware, operative system, network infrastructure, development platforms, servers, reduced costs, lower

development failure risk, increased security and faster time to market.

- Software as a Service (SaaS) - It is the highest level of cloud computing service. This layer covers service-enabled remotely-accessible software packages. Providers deliver a single application through the browser to thousands of consumers using a multi-tenant architecture. The consumer uses the services for business purposes via Internet, as a communication medium. By using SaaS services, consumers get complete and functional solutions, with the only necessity to customize and use it, whereas providers retain all other obligations. Benefits of SaaS for the consumer include: pay-per-use software, infrastructure maintenance and software updates, global accessibility, easier collaboration, compatibility, and easier administration.

Four deployment models have been defined for cloud computing; the distinctive feature being who is entitled to consume underlying cloud infrastructure resource. These are: Private cloud, Community cloud, Public cloud and Hybrid cloud.

- Private cloud: The cloud infrastructure is dedicated to exclusive use of a single organization with a large number of staff/end users. Private clouds are set up within a specific private community. This may be a single institution or a group of individuals in collaboration across multiple locations. Private cloud is preferred in the following case: for customized applications and service; in case of highly sensitive data; for extremely mission critical and high-load appliances; when high performance is necessary; full control is demanded (legal, privacy); and as a first step in cloud migration strategy.
- Community cloud: The type of cloud service that provides resources to a specific group of persons or organizations with a common interest. These may be organizations engaged in strategic partnerships or those that serve same communities. Community clouds are known to be more expensive than public clouds, but usually offer services tailored to the requirements of the community. Community cloud is mostly used in the following cases: when there is a well-identifiable community with clear common interest and specific demands; there is a need for collaboration between institutions and researchers; when sharing of resources leads to cost reduction;

when procurement of cloud services in shared context is easier.

▪ Public cloud: The type of cloud deployment that provides services to any consumer over the public Internet. Public clouds are provided by commercial organizations who generally offer a certain range of cloud related services and resources, and bill consumers for their usage. Public cloud is available for personal and business use. Public cloud is used in case of incidental or ad-hoc need for resources; public sharing of research results; in case of need for commodity or standardized IT services; and when IT staff resources and knowledge is limited.

▪ Hybrid cloud: This design of cloud deployments present the mix or composition of two or three types of the above clouds. The clouds remain unique entities, but are tied together by standardized technology that allows a degree of data and application portability.

When choosing infrastructure deployment models, organizations must bear in mind the numerous limitations associated with particular cloud computing model, or can opt to combine several models to solve certain problems and facilitate their operations.

From the viewpoint of locality of implementation, cloud deployment models are internal and external (Petkovics, Trninic & Djurkovic, 2013).

▪ Internal cloud - where above mentioned basic services (IaaS, PaaS and SaaS) are offered as internal services, i.e. realized by an internal IT organization (in-house implementation) for internal usage (usually). In-house computer clouds are physically located within the organization's premises and protected by the organization's firewall. Access is provided through the intranet, and the cloud is intended for internal use only (in most cases);

▪ External cloud - where basic types of cloud computing services are not hosted in-house. An external cloud can be public or private, but must be implemented by an external IT organization.

The brief overview of the cloud computing concept presented in Fig. 1. particularly highlights its characteristics that render it applicable in decision making activities in logistics processes.

3.2. Decision Making in Logistics Overview

A characteristic trait of the modern enterprise is the growing importance of its relationships, interactions and interdependences with other entities from its business environment. Under circumstances such as increasing competitive pressure, companies develop their relationships, cooperation and collaboration with their partners in a way that provides substantial benefits for all parties. At the same time, companies constantly seek solutions to ease and improve their collaboration and cooperation with their partners.
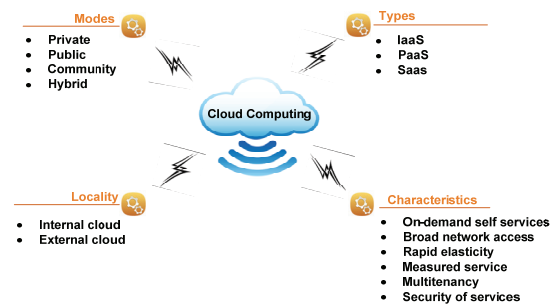

Figure 1 Core concepts of cloud computing

Logistics sector covers processes and activities of variously sized companies, and a multiplicity of services on a global level. It includes very large, but also small firms, offering a wide range of services. Services offered to their customers ranges from simple transport services, through forwarding, warehousing, palletizing, packaging, to full supply chains management services, all the way to virtual service integration. Their activities may be limited to a region, country, continent, or reach the whole world (Kawa & Ratajczak-Mrozek, 2013). In order to ensure successful execution of logistics processes and activities, as well as a fast and appropriate flow of information between individual actors in a logistic system, all categories of logistics operators (logistics service providers) must use appropriate information technology. Logistics service providers primarily apply IT in order to increase efficiency and automate their work. However, satisfaction of potential and existing customers' needs also poses itself as an important goal. Logistics operators are most commonly divided into the following categories:

▪ Main Business owner (MB) – the main business entity around which logistics processes and activities are built.

▪ Fourth Party Logistics Service Provider (4PL) – a general contractor; they manage the entire

logistics process, integrating different services offered to logistics service providers or to other actors. The 4PL assembles and manage resources, knowledge and technology of other logistics service providers. They are also defined as the Virtual Logistics Provider.

- Third Party Logistics Service Provider (3PL) – a service operator who manages the main part of the logistic process outsourced by the MB to 1PL or 2PL (or other 3PLs). They manage the flow of goods between different organizations in logistics processes.
- Second Party Logistics Service Provider (2PL) – manages a single activity (or subprocess) of the logistics process.
- First Party Logistics Provider (1PL) executes a single logistics activity.

Logistics operators most commonly use two types of information systems for managing their logistics processes and activities and decision-making - Enterprise Resource Planning (ERP) and Decision Support Systems (DSS). DSS, as interactive computer based information systems, have the following core (basic) characteristics (Eom & Lee, 1990):

- Support decision makers, not replacing them in decision-making;
- Use internal and external data and models;
- Solve problems of different complexity (unstructured, semi structured and structured problems), and
- Focus on the effectiveness, not efficiency in the process of decision-making.

The DSS applications in the field of logistics give the support to decision makers in a huge number of logistics processes and activities on strategic and/or operative decision-making level. An overview of most significant processes and activities is given in Table 1.

In order to fulfil current expectations, DSS applications in the field of logistics must adapt to completely changed conditions in the global economy, especially to the global market that has never been bigger. Market expansion and development of multinational corporations requires information, communication and distribution networks, facilitation of a free flow of goods and information that cross national borders. DSS become strategically important for improving service quality, competitiveness and utilizing positive effects of economies of scale in transnational logistics processes. DSS applications

provide managers in logistics processes with exact and timely information to react fast and make right decisions.

Two basic approaches to the development of DSS applications are used most commonly:

- Implementation of the integrated DSS at the company level (enterprise, organization), partly including the field of logistics as well, and
- Implementation of a specific and independent DSS applications restricted to the domain of logistics.

Table 1 Overview of activities within logistics processes and types of decisions made (Tumbas, Sedlak & Matkovic, 2007)

Logistics processes and activities	Decision type
In transport:	
Choice of transport model	s
Choice of transport way	s
Routing vehicles at land and sea	o
Delivery planning	o
Delivery routing and distribution	o
Choice of carriers	o
Vehicle distribution	o
Assessment and control of consignment notes	o
Administration claims	o
Performance measuring	o
In warehousing:	
Determination of storage number and location	s
Choice of storage way	s
Sorting and packing of storage goods	o
Transfer of storage goods	o
Warehousing	o
Storage planning and design	o
Choice of equipments for storage goods	o
Performance measuring	o
In order processing:	
Choice of volumes of automated support	s
Order tracking and evaluating	o
Indebtedness control	o
Invoice harmonization	o
Performance measuring	o
In stocks management:	
Choice of restocking systems	s
Stocks forecasting	o
Stocks evidence	o
Tracking of transferring	o
Tracking of stocks turnover	o
In rendering services:	
Determining the level of rendering service	s
Measuring the level of rendering services	o

s - strategic decisions   o - operative decisions

However, the development of new information and communication technologies enable DSS (decision support systems) to have new possibilities both at macro and micro levels. RFID technology, mobile data transfer systems, positioning systems, networking technology, network security systems,

machine learning using artificial intelligence methods, robotics, the data warehouse /multidimensional databases, data mining, big data, internet of things, intelligent agents, www technologies, are just some of technological prerequisites. With regard to growing numbers of partners within logistics networks and a simultaneous expansion of the quantity of software solutions used, compatibility of different systems is becoming increasingly important (Scholz-Reiter, Windt, & Freitag, 2004). Such circumstances have generated the need for standardization of interfaces, as to ensure their interoperability.

When it comes to decision making in a logistics system, it should be pointed out that the logistics services industry lacks solutions that would integrate services of different operators in one place. In addition, a great number of small and medium (SME) logistics service providers, who are generally more flexible, often lack the needed resources for growth and have limited or no IT-competences and investments. Finally, absence of formal data semantics prevents automated data integration.

Logistics platforms appear as a solution to the aforementioned problems. There is no consensus on what represents a logistics platform in the referred literature – authors use the term in a wide variety of contexts. In practice, the term logistics platform is used differently and in diverse cases. It is clear that the use of the term is not always appropriate. After considering a number of definitions, a definition that best suits the research was chosen. A logistics platform is any kind of resource base for the implementation of logistics processes in a predefined environment. It offers customized infrastructure, a well-developed information-communication system, logistics technology, specialized logistics service work force, friendly rules and favourable support on the highest level (Gajsek, Lipicnik, & Simenc, 2012). A platform that supports integrations, i.e. implementation of inter organizational logistics processes both within and between supply chains aimed at improving operational efficiency may be referred to as a logistics information platform.

4. Research Results

Cloud computing represents a shift from locally installed programs, servers and computers in the enterprise, to the Internet deployment software and computing capacity, helping reduce information technology operating costs, maintenance and updates costs (Aviles & Rutner

2012). Furthermore, in a different business environment shaped by globalization, cooperation and collaboration amongst a great number of logistics operators in the realization of logistics processes and activities, cloud computing imposed itself as an operational necessity. Cloud services are owned by multiple providers, co-located in a single data center. Data centers are located globally and provide access to any device that has Internet connectivity (e.g., mobile phone, a PDA or a laptop). Computing resources are obtained and awarded in line with users' needs (Zhang, Cheng, & Boutaba, 2010).

Cloud computing services are suitable for application in logistics to provide consistent logistics global platforms, facilitate real-time data sharing, enable faster decision-making, improve customer service and achieve greater automation and efficiency. The logistics operators have access to three types of services: SaaS, PaaS and IaaS. SaaS allows them to run existing on-demand online applications accessed over the Internet (e.g. Warehouse Management Systems, Transportation Management Systems...). PaaS allows them to create their own applications using supplier-specific tools and languages (e.g., OMS Platform, eBuilder, Google App Engine, Microsoft Windows Azure and Salesforce.com). IaaS allows users to run applications of their own choice on cloud hardware (e.g. AmazonEC2, GoGrid and Flexiscale) (Zhang, et al., 2010).

Cloud computing applications can be deployed via public, community, private or hybrid clouds. The deployment model depends on the level of security, reliability, performance and cost a certain company requires. Firms select different types of deployment, depending on individual business needs (Aviles & Rutner 2012). In public clouds, the infrastructure and services are available for open use by the general public. In such way, companies are not required to invest in infrastructure, but on the other hand, firms lack control over data, network and security settings. Private clouds are designed exclusively for a single organization with multiple users and are not available to the general public (Armbrust et al., 2010). Private clouds offer the highest degree of control over performance, reliability and security, but they do not provide up-front capital savings. In hybrid clouds, one part of the service infrastructure runs in private clouds, and another part runs in public clouds, giving tighter control and security and also facilitating on-demand service expansion and reduction. (Zhang et al., 2010), (Aviles & Rutner 2012).

A well-designed cloud can be reliable, secure, and suitable for logistics processes and applications. Using a cloud to deliver decision support can reduce capital expenses and reduce operational costs. Proper deployment can provide significant savings, better IT services and a higher level of reliability. Some additional benefits of implementing cloud computing are: agility, greater reliability, accessibility to software and device, improved security, better suitability for distributed logistics operations, reduction in capital expenses, reduction in direct and indirect operating costs, availability on many diverse devices, scalability, expertise, and location independence.

Logistics information platform is especially significant to decision making in logistics processes. Generally speaking, the logistics information platform is a general information exchange platform, which applies information and communication technologies to collect, classify, store, analyse, evaluate, publish (release), manage and control relevant information on logistics operations, processes and management (Tang & Du, 2009). Logistics information platform provides applications for inter-organizational logistics operations. The platform involves multi-stakeholders such transporters, warehousing agents, distributors, suppliers, insurance companies, banks and other financial organizations, customs, regulatory bodies, educational and research organizations etc. The most important functionality of a logistics information platform is integration of various information resources to facilitate data exchange, implement data sharing and information transformation (Zhen, Gui-Cheng, & Bing-Wu, 2012). Numerous functionalities aimed at easing collaboration and cooperation of all participants within logistics process are suitable for implementation using cloud computing technologies. Identified functionalities of the logistics platform and expected benefits associated with them are presented in the following text.

The following generic use cases, interrelated in multiple ways, were identified and are the logistics cloud (Arnold, Oberländer & Schwarzbach, 2013):

- Outsourcing of IT resources and related services, i.e. hardware, software applications, and data pools from local (on-premise) IT-systems into a cloud;
- Integration, Synchronization and Sharing of data created and utilized by multiple users;

- Market Place for product and service offers and demands, platform for adding e-commerce activities to the corporate business models;
- Platform for the management and optimization of collaborative business activities of multiple business partners.

Analysis of the aforementioned use cases leads to a conclusion on their interrelation and interdependence. Outsourcing of IT resources and related services enables logistics enterprises, especially micro, small and medium-sized ones to access necessary resources at a desired level. By purchasing certain services, for example at the IaaS level, logistics companies gain readily available resources at the costs which are in line with their needs. The most popular IaaS partners for European SaaS vendors are Amazon, OVH, Hetzner, 1&1, Rackspace, Microsoft and Host Europe. When it comes to SaaS, logistics companies have the opportunity to use versatile software services in the cloud, such as Customer Relationship Management systems, Electronic Document Management systems, Enterprise Resource Planning systems, different collaboration suites, accounting software, Supply Chain Management systems, Workflow Management systems, route planning systems, as well as other software services offered in the market. Cloud computing has made these services available and affordable to logistics enterprises of various sizes.

Integration, Synchronization and Sharing of data created and utilized by multiple users is the next use case to become available, affordable and suitable form an increasing number of logistics companies, once again owing to Cloud Computing. Data management has become a major business, and among the most prominent Cloud Data Management services providers are Microsoft One Drive, DropBox and Google Drive. This type of services is used for data exchange both within organizations and among different ones, which is presented in Table 2.

Market Place for product, service offers and demands is the third use case that offers new possibilities to logistics enterprises. Implementation of this use case is realized thru e-commerce software solutions in the cloud. In this sense, this use case could be considered as Outsourcing of software, i.e. use of SaaS.

The fourth use case is the Management platform, which is intended for managing and optimizing logistics operations. All of the listed use cases and possibilities identified within each of

them are available thru different, independent services. Placing all those capabilities under one umbrella and implementing them in an environment suitable for logistics enterprises is the course for developing a logistics platform based on Cloud Computing.

Table 2 Examples of Integration, Synchronization and Sharing of data (Arnold, Oberländer & Schwarzbach, 2013)

Typical intra-organizational uses	File exchange across borderlines of single enterprises and organizations
File synchronization of mobile actors and business units, such as trucks and other vehicles, external service teams, smart devices of employees etc;	File exchange with clients;
File synchronization of mobile actors and business units, such as trucks and other vehicles, external service teams, smart devices of employees etc;	File exchange among business partners;
Business data exchange and synchronization within decentralized organizations.	File exchange with infrastructure operators such as seaports, airports, intermodal terminals and authorities such as customs authorities.

5. Conclusion

The paper explores the issue of applying cloud computing technologies to support decision making activities in logistics processes. Activities related strategic and operational decision-making at the level of individual logistics operators, as well at the level of a common logistics information platform were analysed within the research. Regardless of the level of observation, it can be concluded that activities, i.e. operations of logistics processes are very complex and that decision making process is carried out in conditions of uncertainty. Hard data and information from different types of computer based information systems form the basis for decision making, although soft skills, such as knowledge, intuition and experience, also play a very significant role.

Cloud computing is a promising approach to implementation of a contemporary concept of logistics systems. Use of cloud computing technologies yields many benefits, but also bears certain risks. Detailed analyses must be carried out before its implementation, as to ensure that the total cost of ownership, security, confidentiality, functionality, integration and process consistency requirements have been met. Application of cloud computing technologies offers several technical and financial advantages, which are listed below (Aymerich, Fenu, & Surcis, 2008).

Technical and architectural advantages are:

- Cloud computing easily handles peak load situations without the need for additional hardware infrastructures that would remain largely underutilized. Hardware and communication resources can be virtualized and provided to customers as virtual servers, which they manage themselves.
- It is possible to use the processing power of the cloud to do things that traditional productivity applications cannot do.
- The system delivers greater scalability as it is possible to add "on demand" computational resources.
- Cloud computing infrastructure accelerates and fosters the adoption of innovations. It alleviates the need of innovators to find resources to develop, test, and make their innovations available to the user community.
- Cloud computing infrastructure allows enterprises to achieve more efficient use of their IT hardware and software investments. It increases profitability by improving resource utilization.

Advantages for the logistics operators - single users and enterprises:

- The user is no longer tied to a traditional computer to use an application, or has to buy a version specifically configured for a phone, PDA or other device. Every device that can access the Internet will be able to run a cloud-based application.
- Users will not have to concern themselves with storage capacity, compatibility and similar issues.
- The user always uses the latest version of the software when accessing an application on the cloud.
- Cloud computing is particularly beneficial for small and medium businesses, where effective and affordable IT tools are critical for boosting productivity without excess spending on in-house resources and technical equipment.
- Also large businesses are moving to the cloud as well, for a variety of reasons, such as cost cutting, remote access, ease of availability and real-time collaboration capabilities.

The logistics information platform is of particular significance for ensuring suitable data for decision making at the global level, by facilitating collection, classification, storage, cross-referencing, exchange, use, evaluation, publication and control of data from multiple sources. In addition to that, information platform presents a unified solution for network data processing and connecting domestic and foreign business systems and platforms, thus making domestic logistics enterprises interconnected with foreign logistics platforms; realizing data exchange; providing accurate, rapid and comprehensive domestic and international logistics information and other related value added business services. In view of that, the logistic information platform improves decision making at the level of the whole logistics system.

References

Armbrust, M., Fox, A., Griffith, R., Joseph, A. D., Katz, R., Konwinski, A., et al. (2010). A View of Cloud Computing. *Communications of the ACM, 53* (4), 50-58.

Arnold, U., Oberlander, J., & Schwarzbach, B. (2013). Advancements in cloud computing for logistics. *In Federated Conference on Computer Science and Information Systems (FedCSIS)* (pp. 1055-1062)). IEEE.

Aviles, M. E., & Rutner, P. (2012). Logistics Management: Opportunities in the Cloud. *Southern Association for Information Systems Conference SAIS*, (pp. 12-17). Atlanta.

Aymerich, F. M., Fenu, G., & Surcis, S. (2008). An approach to a Cloud Computing network. *First International Conference on the Applications of Digital Information and Web Technologies, ICADIWT 2008* (pp. 113-118). IEEE.

Eom, H., & Lee, S. M. (1990). A Survey of Decision Support System Applications. *Interfaces, 20* (3), 65-79.

Fechner, I. (2010). Role of logistics centres in national logistics system. *LogForum, 6* (2), 9-18.

Foster, I., Zhao, Y., Raicu, I., & Lu, S. (2008). Cloud Computing and Grid Computing 360-Degree Compared. *Grid Computing Environments Workshop. GCE'08* (pp. 1-10). IEEE.

Gajsek, B., Lipicnik, M., & Simenc, M. (2012). The Logistics Platform Disambiguation. *Research in Logistics & Production, 2* (1), 69-80.

Kawa, A., & Ratajczak-Mrozek, M. (2013). Cooperation between logistics service providers based on cloud computing. *In Intelligent Information and Database Systems* (pp. 458-467). Berlin: Springer.

Köhler, P., Anandasivam, A., & Ma, D. (2010). Cloud Services from a Consumer Perspective. *16th Americas Conference on Information Systems.* AMCIS.

Leimeister, S., Böhm, M., Riedl, C., & Krcmar, H. (2010). The business perspective of cloud computing: actors, roles and value networks.Paper 56. *ECIS 2010 Proceedings.*

Mell, P., & Grance, T. (2011). *The NIST Definition of Cloud Computing, NIST Special Publication 800-145.* Gaithersburg: U.S. Department of Commerce.

Petkovics, I., Trninic, J., & Đurkovic, J. (2013). The Role of Information Technology Support in Sustainable Development. *International Journal of Strategic Management and Decision Support Systems in Strategic Management, 18* (4), 3-13.

Petkovics, I., Tumbas, P., Matkovic, P., & Baracskai, Z. (2014). Cloud Computing Support to University Business Processes in External Collaboration. *Acta Polytechnica Hungarica, 11* (3), 181-200.

Scholz-Reiter, B., Windt, K., & Freitag, M. (2004). Autonomous logistic processes: New demands and first approaches. *37th CIRP international seminar on manufacturing systems*, (pp. 357-362).

Seres, L., Horvat, L., & Horvat, I. (2011). A Thunder in the Cloud. *International Scientific Journal of Management Information Systems, 6* (1), 16-19.

Tang, Y., & Du, W. (2009). Logistics Information Platform Development Based Knowledge Management. *Second International Conference on Transportation Engineering* (pp. 753-758). ASCE.

Tumbas, P., Sedlak, O., & Matkovic, P. (2007). Decision Support Systems for Logistics Management. *The International Scientific Journal of Management Information Systems, 2* (2), 32-39.

Weinhardt, C., Anandasivam, A., Blau, B., Borissov, N., Meinl, T., Michalk, W., et al. (2009). Cloud computing–a classification, business models, and research directions. *Business & Information Systems Engineering, 1* (5), 391-399.

Youseff, L., Butrico, M., & Da Silva, D. (2008). Toward a Unified Ontology of Cloud Computing. *Grid Computing Environments Workshop, 2008. GCE'08* (pp. 1-10). IEEE.

Zhang, Q., Cheng, L., & Boutaba, R. (2010). Cloud computing: State-of-the-art and research challenges. *Journal of Internet Services and Applications, 1* (1), 7-18.

Zhen, Y., Gui-Cheng, S., & Bing-Wu, L. (2012). Research on Architecture of Logistics Public Information Platform. *Intelligent Information Management, 4* (6), 396-400.

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