FROM TRADITIONAL ICT SOLUTIONS TOWARDS CLOUD COMPUTING IN LOGISTICS

Vladimir Ilin*
University of Novi Sad, Faculty of Technical Sciences, v.ilin@uns.ac.rs
Dragan Simić
University of Novi Sad, Faculty of Technical Sciences, dsimic@eunet.rs

Abstract: *During the last two decades Information and Communication Technologies (ICT) have strongly influenced organizational processes as well as logistics. Therefore, ICT provide many benefits in logistics sector, including time and cost reduction and improved efficiency and performance. However, new solutions and innovative ideas are constantly emerging which intrigues new possibilities for the reorganization of traditional logistics processes. The main idea of this paper is to provide comprehensive review and comparison of different ICT solutions and cloud computing (CC). Basic concept of CC, service models and opportunities of CC in logistics are particularly explained. As an emerging technology, CC is changing the form and function of information technology infrastructures making supply chain information collaboration easy and feasible. It can also be observed as an enabler of fully electronic logistics management systems. Adoption of CC concept involves strong hardware support, good Internet connectivity and implied reorganization of traditional business.*

Keywords: *ICT, cloud computing, logistics.*

* Corresponding author

1. INTRODUCTION

Nowadays logistics involves a multitude of suppliers, manufacturers, carriers, logistics providers, and financial institutions that are essential to getting a product from origin and into customer's hands. Each of these partners owns a portion of the data that drives the logistics process, and each has a stake in the successful delivery of goods to the final location [1]. Global view, transparency of each phase during realization of logistics processes and comprehensive control over the crucial data are imposed as a priority in contemporary logistics. Therefore, Information and Communication Technologies (ICT) provide support for logistics processes and solve many logistics problems [2]. Constant progress of ICT field brings different solutions for dealing with arising problems in logistics and growing customer's demands. Cloud computing (CC) is among the most-discussed new technologies, and the current reality is that approximately 20% of discrete, process, retail, and wholesale manufacturers are using it [3]. In practice, CC enables that the data of each participants be uploaded, normalized and then embedded into the network where can be accessed if permited.

Logistics resources and web services are two major aspects of cloud oriented logistics. Logistics resources have the characteristics of variability, geographical distribution, heterogeneity, morphological diversity and self-governing zone. Web services have the characteristics of distribution and heterogeneity in a cloud logistics platform [4]. Integrated into complexity of cloud network logistics resources present a platform for the virtualization of information and material flows. Therefore, reorganization of traditional logistics is imposed as a priority. CC allows scaling autonomous logistics applications flexibly based on the dynamically arising logistics demands [5]. The main goal is to facilitate smooth realization of individual and complex logistics services.

The traditional ICT approach provides solutions only for specific logistics jobs for which it is installed. In comparison with the CC approach the old way of doing business is costly, time-consuming and error-prone. Modern cloud-based logistics offers lower costs and collaboration in network where every new user that joins the network expands the list of potential partners in virtual supply chain making its connections and data available to all.

2. REVIEW OF ICT APPLICATIONS

Implementing different kind of ICT into logistics management can successfully improve and redesign logistics system, as whole, and also change customer's view on logistics [6]. ICT implementation and application requires great investment, thorough training sessions and constant learning [7]. There are various ICT solutions for different logistics segments on the market, and the most often used in logistics processes are: Advanced Planning and Scheduling (APS), Enterprises Resources Planning (ERP), Transportation Management System (TMS), Warehouse Management System (WMS), Radio Frequency IDentification (RFID), Global System for Mobile communications (GSM), Global Positioning System (GPS), Geographic Information System (GIS), Wireless Fidelity (Wi-Fi), etc. Detailed explanation of mentioned technologies is beyond the scope of this paper.

Benefits of ICT applications in logistics are:

- EDI - reduce bureaucracy, streamlining and logistics costs;
- E-commerce - reduce prices, increase investments, facilitate marketing decisions, enable safety rules;
- APS - reduce costs, improve product margins, lower inventories and increase manufacturing throughput;
- ERP - improve productivity and transparency, integrate strategies and operations, reduce costs and risks, enable immediate access to enterprise information, improve financial management and corporate governance;
- TMS - facilitate tasks as transportation planning, performance measurement, control over vehicle loading and management of routes, distances and freight payments;
- WMS - manage and optimize operational and administrative activities along the warehousing process, which involves receiving, inspecting, labelling, storing, sorting, packing, loading, shipping, issuing documents and managing inventory;
- Barcode, RFID - support various logistics activities, such as picking, vehicle loading and unloading, order tracking and optimization of distribution routes;
- GSM - support maintenance of connections between subjects in logistics processes;
- GPS - support routing and tracking;
- GIS - enable visualization of key processes, high level of interoperability and data sharing, and provide comprehensive approach regarding logistics system as whole;
- Wi-Fi - offer possibility to exchange data wirelessly across logistics complex and establish high speed Internet, improve safety and security in logistics network, and propose unique standardization which facilitates outsourcing.

Disadvantages and challenges of ICT applications in logistics are [3]:

- ICT systems and business process incompatibility;
- Collaboration problems with partners, customers, and consumers;
- The high fixed cost of ICT;
- Limited resources available to solve problems
- Lack of data quality and consistency;
- Lack of access to systems and information;
- Lack of speed of implementation;
- Lack of transparency;
- Lack of a comprehensive view of the business;
- Inability to easily and quickly acquire new capabilities.

3. CONCEPT OF CLOUD COMPUTING

3.1 Basic Characteristics

CC shifts the frontier of ICT possibilities in modern business. Different complex software solutions and applications for business become available online and CC leads in that new trend. CC experts and administrators maintain, update and upgrade all the applications that each client requires. All the clients are simultaneously a part of a complex virtual network, which facilitate their business organization, because all the partners are interconnected constantly. Importantly, high quality of the data can be achieved, along with time savings and increased efficiency. By adopting cloud solutions an organization can focus on their core business, as cloud providers are obligatory to run ICT applications faster and more cost-efficiently.

Cloud computing characteristics are [8]:

- On-demand self-service;
- Broad network access;
- Resource pooling;
- Rapid elasticity;

- Measured Service.

Benefits of cloud computing adoption as new business concept are [9]:

- Cost containment;
- Innovation speed;
- Availability;
- Scalability;
- Efficiency;
- Elasticity.

3.2 Service models

Service models define what kind of services can be provided from the cloud. Depending on the chosen model, the provider offers and delivers different services. Three main service models are illustrated:

1) IaaS (Infrastructure as a Service),
2) PaaS (Platform as a Service), and
3) SaaS (Software as a Service) (Figure 1).

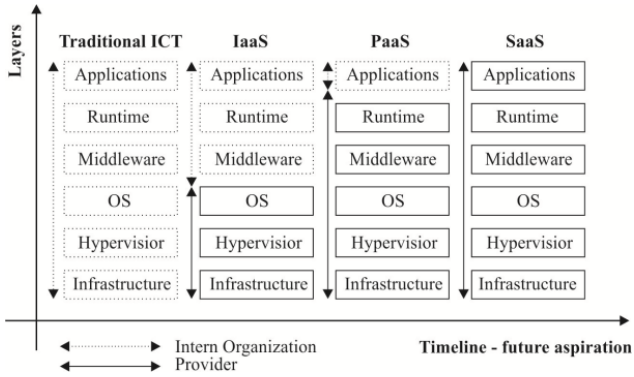

Figure 1. Service models ([8], edited by authors)

Nomenclature of presented layers:

- Infrastructure – a physical layer (servers, processors, storage devices, network);
- Hypervisor – a virtualization layer which provides the virtualized infrastructure resources;
- Operating System (OS) – the operating system which provides the system resources;
- Middleware – supporting software for communication between upper and lower layers;
- Runtime – special environment in which the chosen application is executed;
- Applications – different applications offered to clients.

IaaS (Infrastructure-as-a-Service) is a platform through which businesses can avail equipment in the form of hardware, servers, storage space etc. at pay-per-use service. In this service model, cloud providers offer from physical or virtual machines to raw storage, firewalls, load balancers and networks [8]. More specifically, the user buys these resources as a fully outsourced service instead of buying servers, software and network equipment [10].

In PaaS (Platform-as-a-service), cloud providers host a computing environment typically including operating system, data base and programming language execution environment, where users develop and deploy applications [11]. Users can rent virtualized servers for running existing applications or developing new ones without the cost and complexity of buying and managing the relating hardware and software [10].

In SaaS (Software-as-a-service) model, cloud providers install and operate application software in the cloud and users access the software various client devices through either a thin client interface, such as web browser or a program interface. The cloud users do not manage the cloud infrastructure and platform on which the application is running but have control over the deployed applications and possibly configuration settings for the application-hosting environment [8].

3.3 Deployment models

CC can be run in various deployment models. Which deployment model is used depends on the user requirements and on market availability [9]. There are various divisions, but according to authors five deployment models can be differed (Figure 2).

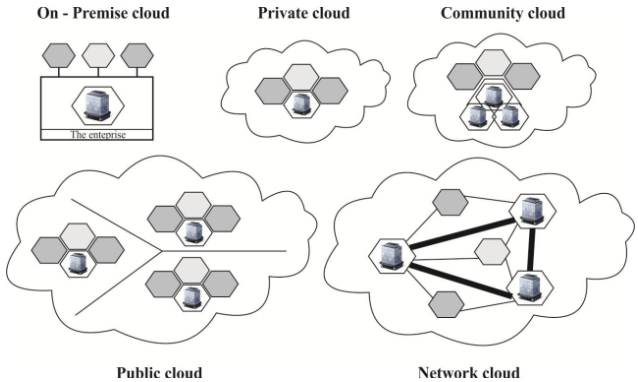

Figure 2. Deployment models ([12], edited by authors)

On-Premise cloud - All services are provided to the client's premises usually by a third-party provider.

Private cloud - The service is used by private clients. A private cloud can be run internally or by a provider.

Community Cloud - The service is used by several members of a defined group. The services may be offered by several providers who are either internal or external to the community.

Public Cloud - The service is available to the public, and in general provided by a single provider.

Network Cloud - Offers a combination of various organization forms, combining their respective advantages and disadvantages.

4. OPPORTUNITIES OF CLOUD COMPUTING IN LOGISTICS

4.1 Data quality in the traditional ICT approach and the cloud approach

In logistics, the right information is essential in order to efficiently realize any process. When introducing modern technologies and various software solutions into logistics branch, significance of the right information becomes priority. High quality data is crucial because every software solution (especially CC) requires quality input values in order to provide quality output values. If data is incomplete or incorrect the most of advanced software systems are useless for decision-making. High quality data must be complete, accurate and time precisiosly.

Figure 3. The traditional ICT data network [13]

There are three steps for getting quality logistics data in traditional ICT network [13]:

1) Connecting with partners: (a) build ICT infrastructure, (b) determine communication protocols (EDI) (Figure 3).
2) Normalizing the data they provide: (a) monitor data flow – dedicated ICT staff, (b) ensure that the data is normalized (locations, currencies, equipment types, organization names, reference codes, charge codes, etc.) – the goal is to avoid confusion.
3) Managing data quality: (a) monitoring for accuracy, completeness, and timeliness, (b) efficient ICT team of experts that are able to manage the relationships with partners and to provide missing information.

In opposite, CC offers easier way to establish efficient and effective logistics process which significantly lowers costs and enables time savings. Cloud platform facilitates an on-demand data network. The basic principle of functioning of such network is the following rule: the more clients join the network, the lower costs are achieved. The administrators create and maintain the cloud network and update all the information and crucial data across the network which always offers only actual and topical data to clients. Also, cloud network provides data that is already normalized, reduces time-to-benefit and shifts the hassle and technology risk from client-side to the on-demand network provider (Figure 3) [13].

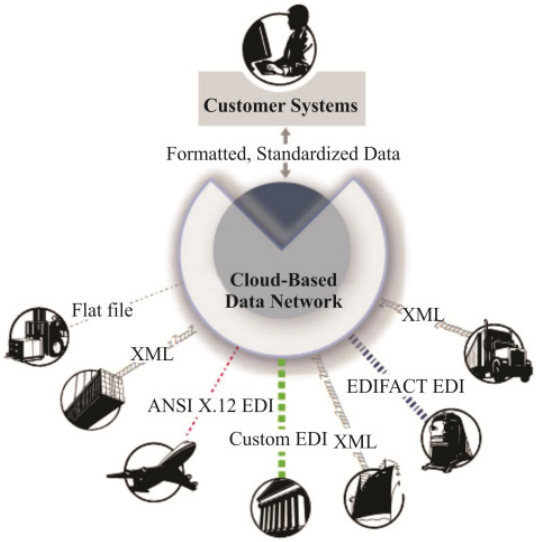

Figure 4. The cloud data network [13]

4.2 Benefits of cloud computing in logistics

The impact of CC in logistics is visible in the three important segments:

1) Collaboration – In each logistics process there are large and variable number of participants which is why the collaboration between all entities can be inefficient and even poor. Lack of cooperation between participants and barriers between different ICT solutions in each company are the main reason for emphasizing CC as new form of doing business in logistics. CC offers a common platform for all entities in logistics processes making them interconnected in the network.
2) Modernization – Volatility and the unpredictable nature of modern logistics processes encourage the transformation of the traditional logistics organization. The current trend in business is that the most of

logistics processes have variable rather than fixed costs. Therefore, CC provides modernization and enhancement of logistics organization and makes logistics processes more transparent and subject to data quality forecast which later facilitates decision-making process.

3) Implementation speed – The most important prerequisite for the CC adoption is wide bandwidth and reliable internet connection. Then, the implementation speed of CC is very high. The most important factor is to form a coherent team of experts from logistics and software fields and to suffuse their cooperation.

Benefits and opportunities from the cloud computing adoption in logistics are:

- signifficant improvements in efficiency;
- increased benefits from faster time-to-value realization;
- single source of a logistics process;
- transparency in communication of all participants in the logistics cloud;
- comprehensive oversight of all processes;
- wide range of solutions;
- different analysis of the high quality data;
- tutorials availability;
- time savings when searching the right information and adequate solution;
- visualization of the entire workflow;
- clarity of the key functionality;
- various solutions for the same problem;
- updated and upgraded applications;
- constantly emerging capabilities;
- data security, etc.

5. STATE OF THE ART – WORLD-WIDE CLOUD

The following conceptualization shows in which direction the transformation of future logistics business will be focussed (Figure 5). Although this is just a prediction based on current trend, it is highly feasible in practice. Figure 5 also presents a framework for a world-wide cloud in which quality information flows become the most important.

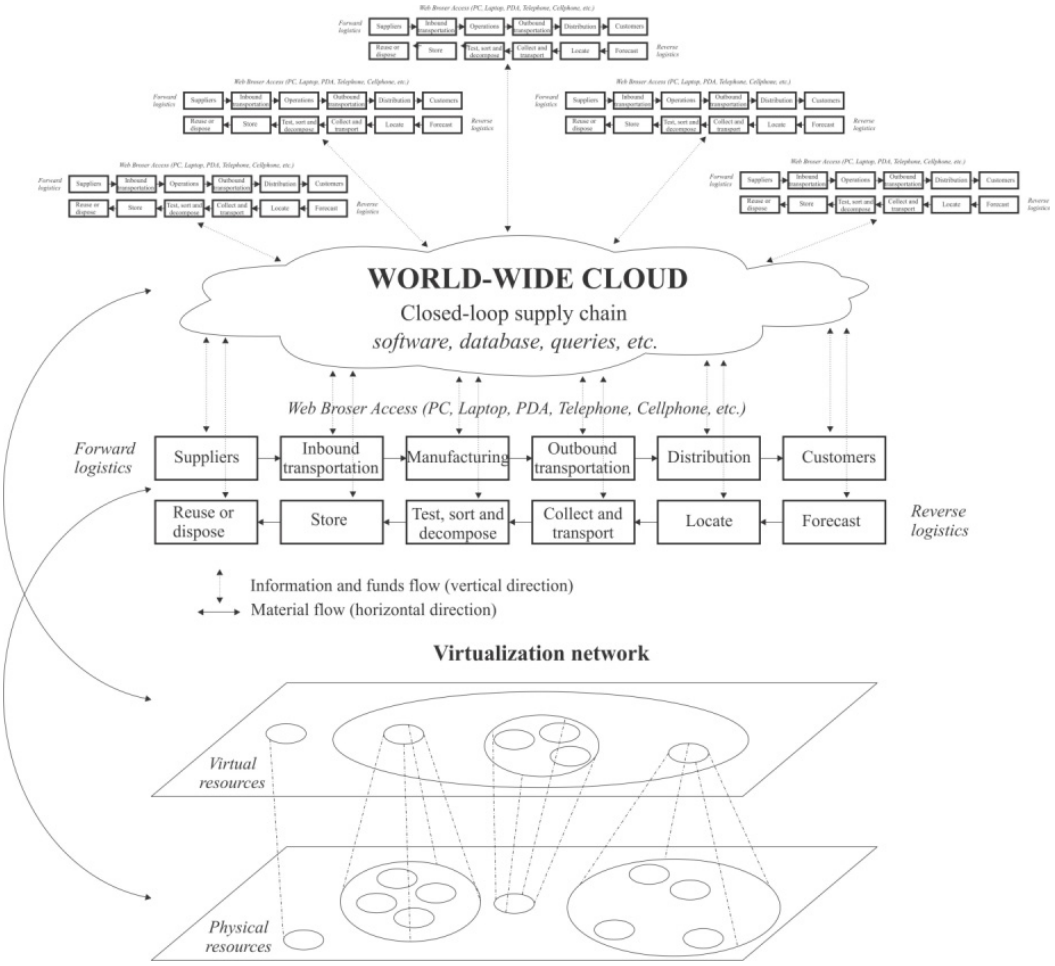

Figure 5. World-wide cloud

6. CONCLUSION

ICT unambiguously provides strategic advantages in business for logistics companies. Functioning of logistics processes without ICT support would be insufficient, even impossible. Nevertheless, the constant revolution of ICT sector frequently offers new improved solutions, but also stimulates new conditions for the adoption and reorganization of current business politics.

Cloud computing presents a peak of the ICT impact on logistics. New concept integrates modern technologies, latest software solutions and high quality data into one network. It also reshapes traditionally information flows in which the quality data becomes accessible within few seconds. Material flows cannot be transformed significantly by this system, but cloud approach facilitates and improves its realization. Nobody can for sure say how logistics process will look like for a few years or in which direction it will stream, but for now the future is in the cloud.

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