Cloud Computing Applications in Global Logistics Information System Infrastructure

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Abstract: Information and communication technology (ICT) and systems are essential for every business. They can be used in retail, manufacturing and other industries. Nevertheless, new and innovative ideas and solutions are constantly emerging and introducing new possibilities for the reorganization of traditional logistics processes. Particularly, attention is given to basic concept of CC (cloud computing) service models and opportunities in logistics. This paper provides comprehensive review and comparison of different ICT solutions and CC applications. As a new and cutting-edge technology, CC is changing the form and function of information technology infrastructures making supply chain information collaboration easy and feasible. It can also be 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 activities.

Key words: Cloud computing, information and communication technology, logistics, supply chain, service models.

1. Introduction

Information technology systems and applications are essential to businesses and enterprises. In the last two decades, ICT (information and communication technology) has strongly influenced organizational processes and logistics as well. IT (information technology) service is an interconnected set of hardware and software resources, and is conceptually similar to a manufacture or retail supply chain.

Supply chains generally have two functions: a physical function—the production of a particular product and transportation of all components to the right place at the right time; a market mediation function—to ensure that the product meets market needs.

In general, logistics involves a multitude of suppliers, manufacturers, carriers, 3PLs (third logistics partners), 4PLs (fourth logistics partners) and financial institutions that are essential to transporting

a product from place of origin into customer's hands. A study of cloud information technology suggests 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]. A supply chain must be classified according to its components and the end-product it supplies.

As a new business model, CC (cloud computing) has and will have a profound impact on the entire IT industry [2]. CC is offering competitive advantages to companies through flexible and scalable access to computing resources. For a business to successfully utilise the cloud, it needs to migrate some or all of its IT services to the cloud, and then manage the new environment. The undertaken research has shown that, by using a cloud lifecycle, both the migration and the on-going management of the cloud can be planned and controlled to ensure success [2].

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. ICT provides support for logistics processes and solves many logistics problems.

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Constant progress of ICT field brings different solutions for dealing with problems that are emerging in logistics, and for growing customer's demands. 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. In practice, CC enables the uploading, normalization and embedding of data from each participant into the network where they can be accessed if permitted [3].

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 within the network where every new user in the network expands the list of potential partners in virtual supply chain making its connections and data available to all.

The rest of the paper is organized in the following way: Section 2 provides related work in ICT and logistics. Section 3 presents advantages and disadvantages of ICT applications in logistics. In Section 4, concept of cloud computing is presented and followed by detail description of basic characteristics, service models and deployment models. Data quality in the cloud approach and benefits of CC in logistics are presented in Section 5. Finally, Section 6 gives concluding remarks.

2. Related Work

Implementing different kinds of ICT into logistics management can successfully improve and redesign logistics system as a whole, and it can also change customer's view on logistics [4]. ICT implementation and application require the great investment, thorough training sessions and constant learning. There are various ICT solutions for different logistics segments on the market, and the most often used solutions in logistics processes are: APS (advanced planning and scheduling), ERP (enterprises resources planning),

EDI (electronic data interchange), TMS (transportation management system), WMS (warehouse management system), RFID (radio frequency identification), GSM (global system for mobile) communications, GPS (global positioning system), GIS (geographic information system) and Wi-Fi (wireless fidelity).

RFID has strategic importance in empirical and conceptual insights in logistics activities [5]. The impact of RFID technologies on supply chain management is presented in detail in literature [6].

APS systems are improving the integration of materials and capacity planning using constraint-based planning and optimisation in SCM (supply chain management) which can be defined as a process for designing, developing, optimising and managing the internal and external components [7].

Additionally, the impacts of the integrated logistics systems on electronic commerce and enterprise resource planning systems are described in [8].

Intelligent transportation systems are discussed in the study of WMS (Tompkins Associates) which also proposes their applications in integrated information systems [9].

The distribution flow of aluminum alloy pipes, starting with the completion of the manufacturing process and final inspection, considers the use of bar-coded caps integrated in production, transport and customer data bases [10]. The observed process may be improved by cloud logistics system.

The role of geographical information in logistics network management is all too evident. More than 80% of business data have a geographical element, and hence GISs (geographical information systems) are playing an increasingly important role in any area of business. New logistics network which consists of suppliers, warehouses, distribution centres, retail outlets, raw materials, work-in-process inventory, and finished goods that flow between the different facilities which are a part of the logistics network is proposed [11]. Logistics network in web-based GIS-T

system is proposed as well. It presents a basis for CC network adoption [11].

Furthermore, implementation of GSM communications, GPS and Wi-Fi as widely implemented up to date in logistics information systems are discussed in Refs. [12, 13].

3. ICT Applications in Logistics

The ideal production is considered to be the real machine of non-stop working at the maximum speed. The assembly process information flow in real time, enterprise wide, from assembly station sensors to the company policy maker's offices, is the true solution for improving productivity competence, reducing bottlenecks and optimizing the supply chain network. In such a way, missing operations in the floor process are identified and are reducing losses and making greater profits than ever. Business process reengineering and processes transformation are necessary to ride the expected tide of change in the current manufacturing environment, particularly in the information technology and automation landscape.

Benefits of ICT applications in logistics are:

• EDI—reduces bureaucracy, streamlining and logistics costs;

• E-commerce—reduces prices, increases investments, facilitates marketing decisions, enables safety rules;

• APS—reduces costs, improves product margins, lowers inventories and increases manufacturing throughput;

• ERP—improves productivity and transparency, integrates strategies and operations, reduces costs and risks, enables immediate access to enterprise information, improves financial management and corporate governance;

• TMS—facilitates tasks as transportation planning, performance measurement, control over vehicle loading and management of routes, distances and freight payments;

• WMS—manages and optimizes operational and administrative activities along the warehousing process, which involves receiving, inspecting, labelling, storing, sorting, packing, loading, shipping, issuing documents and managing inventory;

• Barcode and RFID—supports various logistics activities, such as picking, vehicle loading and unloading, orders tracking and optimization of distribution routes;

• GSM—supports maintenance of connections between subjects in logistics processes;

• GPS—supports routing and tracking;

• GIS—enables visualization of key processes, high level of interoperability and data sharing, and provides comprehensive approach regarding logistics system as whole;

• Wi-Fi—offers possibility to exchange data wirelessly across logistics complex and establish high speed internet, improve safety and security in logistics network.

ICT applications in logistics are investigated and sorted, as well as:

• 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 [2].

Multinational companies strive to reduce computing costs, to improve plant floor visibility and achieve more efficient business power of their IT hardware and software investments.

4. Concept of Cloud Computing

CC shifts the frontier of ICT possibilities in modern

business. Different complex software solutions and applications for business become available online and CC leads to this new trend. CC infrastructure accelerates and promotes these objectives by providing unparalleled flexible and dynamic IT resource collection.

4.1 Basic Characteristics

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 facilitates their business organization, because all the partners are constantly interconnected. What is important to stress is that time can be saved, efficiency increased and high quality data achieved. By adopting cloud solutions, an organization can focus on their core business, as cloud providers are under obligation to run ICT applications faster and more cost-efficiently.

CC characteristics are:
• on-demand self-service;
• broad network access;
• resource pooling;
• rapid elasticity;
• measured service [14].

Benefits of CC adoption as new business concept are:
• cost containment;

• innovation speed;
• availability;
• scalability;
• efficiency;
• elasticity [15].

4.2 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 in Fig. 1. There are:
(1) IaaS (infrastructure as a service);
(2) PaaS (platform as a service);
(3) SaaS (software as a service).
Nomenclatures of presented layers in Fig. 1 are:
• Infrastructure—a physical layer (servers, processors, storage devices, network);
• Hypervisor—a virtualization layer which provides the virtualized infrastructure resources;
• 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.
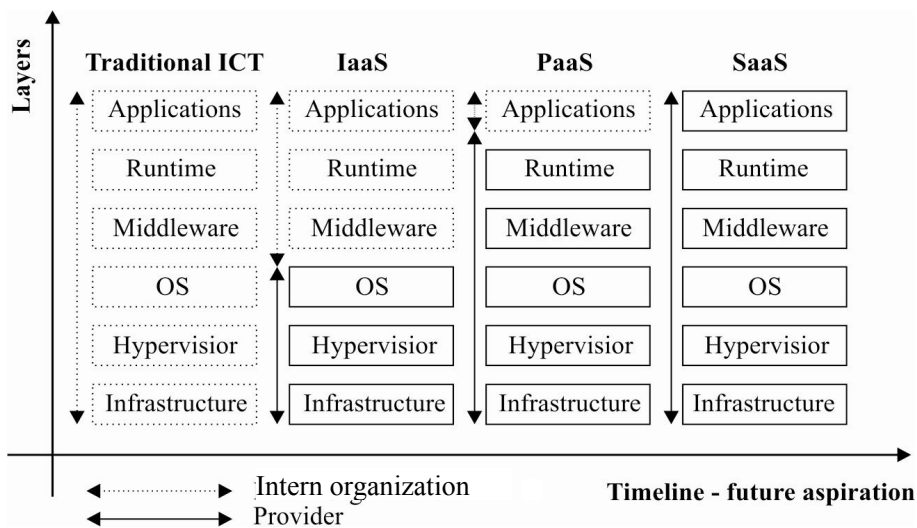

Fig. 1 Service models [14].

IaaS is a platform through which businesses can avail itself with equipment in the form of hardware, servers, storage space, etc. at pay-per-use service. In this service model, cloud providers offer everything from physical or virtual machines to raw storage, firewalls, load balancers and networks [14]. More specifically, the user buys these resources as a fully outsourced service instead of buying servers, software and network equipment as discussed in Ref. [16].

In PaaS, cloud providers host a computing environment typically including operating system, data base and programming language execution environment, where users develop and deploy applications. 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 [16].

In SaaS model, cloud providers install and operate application software in the cloud and users access the software through 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 [14].

The new service models with new IT paradigm are presented in Fig. 2. The former theoretical model is extended and reshaped [17].

New defined model ITaaS (IT-as-a-service) is sometimes called BPaaS (business process as a service). This service type combines the application elements of CC with human aspect. The main difference between this service and traditional IT outsourcing is the fact that the human resources providing the ITaaS are as well pooled between different clients.

Each of these service models can be used more than once in the cloud supply chain. And these not only provide single services but can also be combined to provide value-adding services that act as single objects in the cloud supply chain. These aggregated services can be made up of two or more services, e.g., infrastructure and platform can be combined as a service for software developers.

4.3 Deployment Models

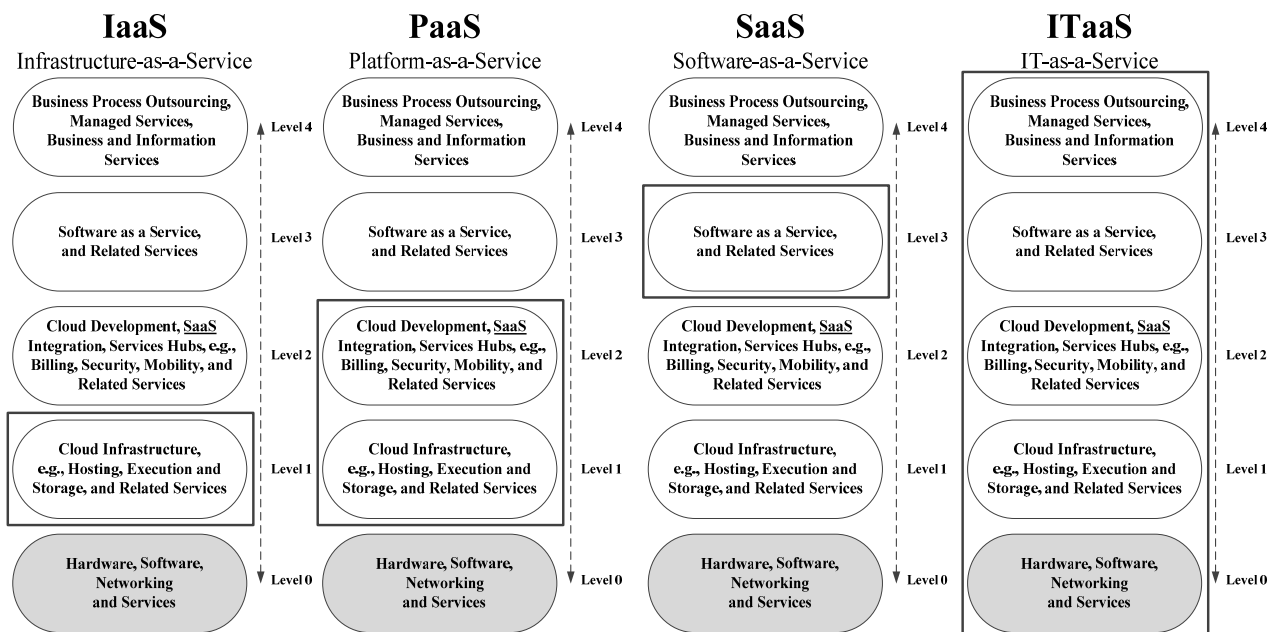CC can be run in various deployment models which

Fig. 2   Service models with new IT paradigm [17].

will be used depending on the user requirements and on market availability [15]. There are various divisions, but according to authors, five deployment models can be differed (Fig. 3).

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 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.

5. Opportunities of Cloud Computing in Logistics

Logistics resources and web services are two major aspects of cloud oriented logistics. Logistics resources are characterized by variability, geographical distribution, heterogeneity, morphological diversity and self-governing zone. Web services are proposed as characterized by distribution and heterogeneity in a

cloud logistics platform [19].

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 [20]. CC allows scaling autonomous logistics applications flexibly based on the dynamically arising logistics demands. The main goal is to facilitate smooth realization of individual and complex logistics services.

5.1 Data Quality in the Cloud Approach

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

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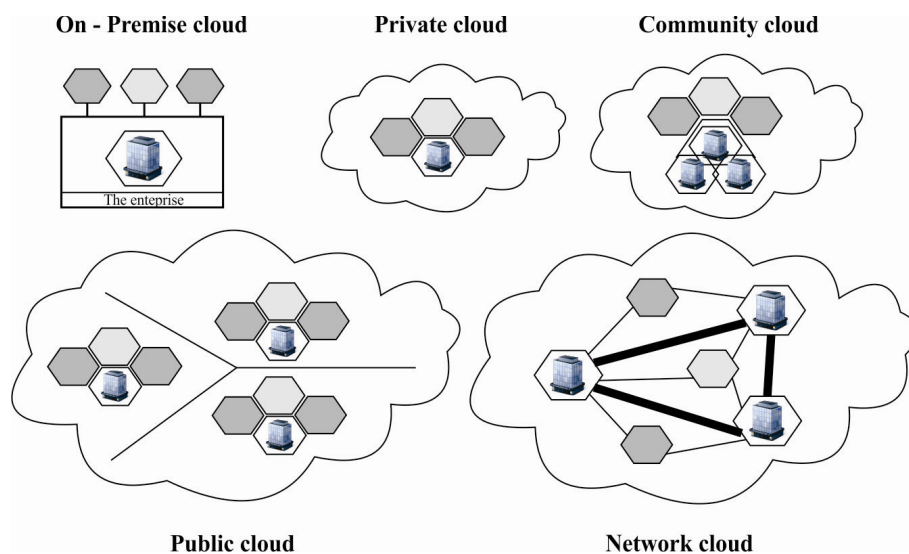

Fig. 3 Deployment models [18].

(1) Connecting with partners: (a) building an ICT infrastructure, (b) determining communication protocols (EDI) (Fig. 3);

(2) Normalizing the data they provide: (a) monitoring data flow—dedicated ICT staff, (b) ensuring that the data are normalized (locations, currencies, equipment types, organization names, reference codes, charge codes)—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 [21].

As opposed to that, 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 a network is the following rules: the more clients join the network, the lower it costs. 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 are already normalized, reduces time-to-benefit and shifts the hassle and technology risk from client-side to the on-demand network provider (Figs. 4 and 5).

5.2 Benefits of Cloud Computing in Logistics

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

(1) Collaboration—in each logistics process there is a large and variable number of participants which is why the collaboration between all the 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
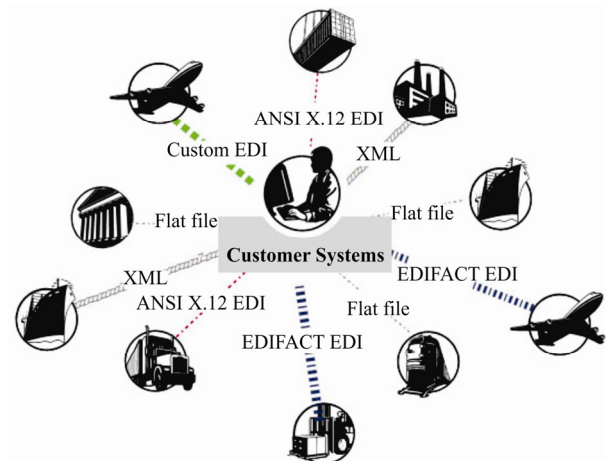

Fig. 4   The traditional ICT data network [21].
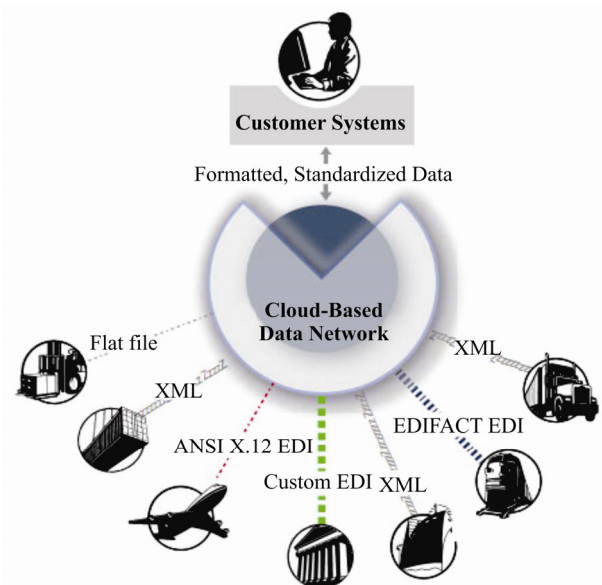

Fig. 5   The cloud data network [21].

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. Unique database and centralized ICT system decrease errors in business,

increase operations efficiency and enhance realization of complete business tasks. Consequently, the need for repeated operations is decreased, customer's satisfaction is improved and financial flows are more balanced and transparent;

(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:
- significant 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;
- tutorials availability—ease of use of applications;
- different analysis of the high quality data;
- time savings when searching the right information and adequate solution;
- visualization of the entire workflow;
- clarity of key functionality;
- various solutions for the same problem;
- updated and upgraded applications;
- constant new emerging capabilities;
- data security.

6. Conclusions

ICT unambiguously provides strategic advantages in business enterprises. Logistics processes without ICT would be insufficient, even impossible, for logistics sector operation. Nevertheless, the constant improvement of ICT sector frequently offers better solutions, but, at the same time it offers new adoption and reorganization of current business politics.

At this moment, cloud computing presents a peak of the ICT impact on logistics. Material flows cannot be transformed significantly by this system, but cloud approach facilitates and improves its realization. Starting with the electronic logistics, an ICT supported logistics, the aim is a new concept which integrates modern technologies, latest software solutions, and high-quality data within a single network.

It also reshapes traditional information flows in which the quality data become available within few seconds.

Cloud computing applications in global logistics information system infrastructure are the most important research and implementation approaches in contemporary enterprise development.

Acknowledgments

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