MODEL STRUCTURE OF CLOUD COMPUTING BASED DECISION SUPPORT SYSTEM FOR LOGISTICS APPLICATION

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Abstract: *Firstly, the paper presents the use of mobile solutions in the supply chain and, afterwards is describes the models and forms of cloud computing. Based on these, the paper describes the IT technical approach of cloud supply chains, and it presents a SOA based model of optimization and decision supporting methods. Moreover, the paper contains the new challenges and opportunities of cloud supply chains.*

Keywords: CLOUD COMPUTING, SUPPLY CHAIN, CLOUD SUPPLY CHAIN, SOA, OPTIMIZATION, DSS

1. Introduction

On the Budapest University of Technology and Economics, Faculty of Transportation Engineering and Vehicle Engineering at the Department of Transport Technology there are several logistics related research in progress. These researches mostly connected to Supply Chain networks due to the system approach. To connect these researches and put them on a higher level of cooperation a concept of a new system was born. This concept integrates various number of methods used in logistics (and public transport) and it is called TSB (Transport System Bus).

The Department's research areas are the following:

- inventory control systems,
- advanced scheduling and forecasting systems,
- electronic freight and warehouse exchange,
- city logistics,
- supply chain planning,
- advanced warehouse planning.

The aim of this project is to develop a dynamic system model (TSB) which contains different services (SOA = Service-Oriented Architecture) and using the latest cloud based techniques it provides a global decision support for the user. The basic research is about to develop various algorithms based on the cloud computing technologies such as parallelization or new heuristics.

The main goal is to develop a complete system model. Dividing the project into subprojects is crucial with the correct circumstances. According to this principle the system model can be divided into the following layers shown on Fig. 1.

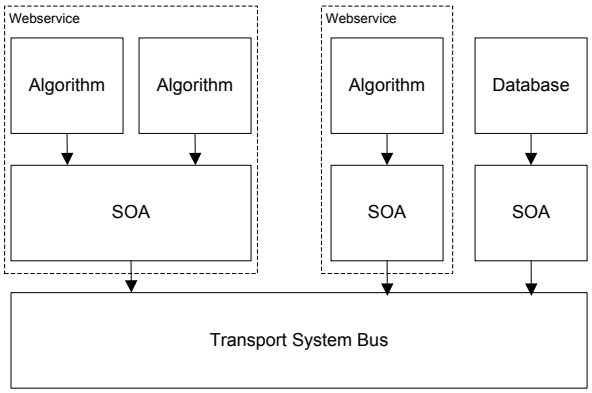

Fig. 1 *TSB model layers*

This TSB can be created by creating multiple tasks (modules) and join them into a system. The tasks are reusable webservices therefore the developed algorithms and databases (and database structures) are reusable to another logistics related problems.
It is clear that the main concept is to bring correct decision support Supply Chain solutions to the cloud. Therefore examination of the Supply Chain is needed.

2. The future of Supply Chain

As everybody knows that the Supply Chain (SC) or the net of connections is an expanded system where each link (enterprise) contains a very complex, separated subsystem. It is understandable, since the enterprises do not exist in isolation from the environment in which they function: the organizations do not act in isolation and their survival is often dependent upon effective interactions with the environment [1]. This integration should be based on close and partner cooperation [2].
The systemic understanding of the enterprises operating in the Supply Chain is also the starting point and the basis for designing effective Supply Chain which would be characterized by more effective competitiveness and meeting of recipients' and consumers' expectations. The systemic approach is the skill to see the problem as a whole as well as the relations that connect individual elements (enterprises) thereof and the permanence of changes that take place over time [3].

Nowadays we can distinguish three specific stages of Supply Chain development from the functional, through the reactive to the adaptive nature. Key characteristics and relationships in the Supply Chain are shown on Table 1.

Table 1: *The evolution of Supply Chain [4].*

Attribute	Functional Supply Chain to the 1980s	Responsive Supply Chain the 1990s	Adaptive Supply Chain the 2000s
Integration focus	Over the wall Reactive/ quick fixes Monopoly suppliers	Transactional Responsive Competition is suppliers	Collaboration Decision/ proactive Joined-up networks of enterprises
Customer focus	Customer can wait 'you will get it when we can send it'	Customer wants it soon 'you will have it when you want it'	Customer wants it now you will get it'
Organisation focus	Departmental and ring fencing	Intra-enterprise 'internal' involvement	Extended enterprise involvement
Product positioning	Make to stock Decentralized stock holding Store then	Assemble to order Centralised stock holding	Make to order Minimal stock holding Whatever is

	deliver	Collect and cross dock	needed
Management approach	Hierarchical	Command and control	Collaborative
Technology focus	Point solution	ERP	Web connected
Time focus for the business	Weeks to months	Days to weeks	Real time
Performance focus	Cost	Cost and service	Revenue and profit
Collaboration	Low	Medium	High levels
Response time	Static	Medium	Dynamic

The reactivity of the links composing the Supply Chain is interpreted as a relatively constant intensity of reacting to external signals (resulting from the environment in which the Supply Chains functions) and internal signals which come from other links of the Supply Chain and from the enterprise itself. The enterprises thus function on the basis of action-reaction rule. They accommodate their own as well as mutual needs and expectations. These actions are both of reactive nature, forced by the business partner and adaptive, carried out at own initiative of the enterprise. As a result of reactivity of the Supply Chain, a relative synergy of joint actions of enterprises takes place. Considerable support and facility for maintaining the reactivity of a Supply Chain is implemented in ERP-class IT systems and in other telecommunication technologies. The available resources of cooperating enterprises are appointed to specific goals. Selection of both the resources and business partners is oriented on competitiveness goals set out [5].

Aiming a higher level of cooperation, enterprises started to make strategic plans together. To maintain the strategic cooperation on a proper level the IT systems had to follow the requirements.

In order to make Adaptive Supply Chain even more efficient and adaptive to market requirements, the authors propose a new solution based on Cloud Computing. In cloud computing, the user's computer may contain almost no software or data only an operating system and a thin client. The Cloud Computing providers offer services form the cloud. These services are provided via an Internet connection within one or more of the next layers: software, platform and infrastructure [6]. The application of the Supply Chain concept in the context of cloud computing is innovative and opens a new research field. Lindner et al. present definition of Cloud Supply Chain [7]. It is two or more parties linked by the provision of cloud services, related information and funds. The Cloud Supply Chain represents a network of interconnected businesses in the cloud computing area.

Fig. 2 is part of an exploration on moving from the old methods of running our businesses (in the 20th century) – including business models, processes, and technologies – to the new (the 21st century). Characteristics of Cloud Supply Chain:

- Primary goal: Cloud Supply Chain demand at the lowest level of costs and respond quickly to demand,
- Product design strategy: Create modularity to allow individual setting while maximizing the performance of services,
- Pricing strategy: Lower margins, as high competition an comparable products,
- Manufacturing strategy: High utilization while flexible reaction on demand,
- Inventory strategy: Optimize of buffer for unpredicted demand, and best utilization,
- Lead time strategy: Strong Service Level Agreement (SLA) for ad-hoc provision,
- Supplier strategy: Select on complex optimum speed, cost, and flexibility,
- Transportation strategy: Implement highly responsive and low cost modes.

Supply Chain	v.s.	Future Supply Chain
Classical business		Business agility
Web Site		Complex e-solutions
Centralized production		Distributed production
Client-Server architecture		Cloud architecture (webservices)

Fig. 2 *The changes in the concept of Supply Chain*

3. Migrating Supply Chains to the Cloud

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. According to NIST specification (National Institute of Standards and Technology, U.S. Department of Commerce) cloud model is composed of three service models (Software as a Service /SaaS/, Platform as a Service /PaaS/, Infrastructure as a Service /IaaS/), and four deployment models (Private-, Community-, Public- and Hybrid Cloud), [6]. Fig. 3 shows the overview of cloud computing.

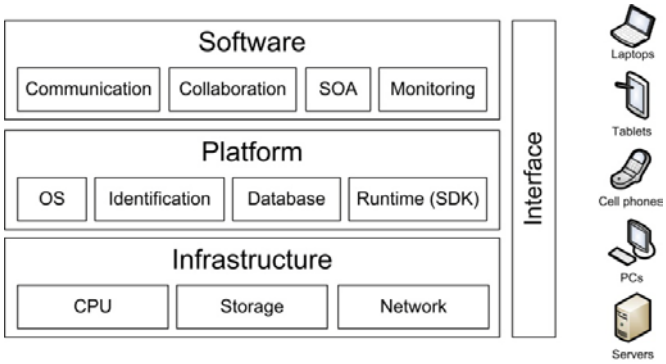

Fig. 3 *Diagram showing overview of cloud computing*

This migration needs a very high level IT solutions and infrastructure. As cloud computing is a new area of IT technologies preparation is needed in key areas such as standardization technology, virtualization technology, data management technology, platform management technology in supply chain information collaboration [8].

Regarding to the dynamic changing computational and storage demand the Cloud computing service providers (e.g. Amazon EC2, Microsoft Azure) or Private Clouds (e.g. forthcoming Microsoft Windows Server 2012) use virtualization technologies to maintain resources mainly for load balancing and management purposes. Hardware virtualization refers to the creation of virtual appliances such as computers, storage and network devices. In this case a hypervisor is installed on the physical hardware. The hypervisor runs the virtual entities and manages the hardware resources such as CPUs, memory, hard disks and I/O devices.

Cloud service providers provide classical data storage and database as virtual machine image (e.g. Oracle Database 11g Enterprise Edition) or as a service (e.g. Amazon Relational

Database Service or Microsoft SQL Azure) within the cloud. The advantages of these services are scalability, high availability, reliability compared to the traditional solutions. These factors are highly important as the key element of the Supply Chain Management is information. With high quality services and reliable data communication techniques this goal can be achieved.

One of the most challenging questions in Supply Chain Management is data exchange between service providers. The traditional ways of changing data is Electronic Data Interchange (EDI), which is a structured electronic data transmission standard between computer systems. This standard was developed in 1996 and it is capable of computer-to-computer communication over computer network (e.g. VAN, BBS). As it was developed for point-to-point communication the current state of EDI is not able to grant the present need of business-agile enterprises. Collaboration of companies nowadays is a key factor and the dynamic interchange of information is a need.

Along with the development of information technology, internet data transmission became secure, scalable and standard for data communication. Compared to the EDI internet transmission cost is far lower, the enterprise only need to open a SOA based web service without having to acquire additional equipment and increase the professional management staff. In the supply chain management the mode of information collaboration and information service object is also constantly changing, the supply chain members may quit and also new members may join at any time.

As mentioned before collaboration and data exchange between companies within the whole supply chain is a common need in logistics. Such as traditional point-to-point EDI is no more acceptable for the market. The existing ERP and CRM systems are capable for the communication through its standards (e.g. SOA), developed in early 2000s, but a centralized solution not exists on the market, which can reduce supply chain information distortion, accelerate information transmission speed and accuracy, and improve the overall competitiveness of supply chain's role. With an integrated cloud service application such as electronic freight and warehouse exchange a controlled collaboration can be achieved within the whole supply chain.

To use the available computation resources in an efficient way, the available resources should be dedicated to the needs. Using giant server parks to run only ERPs is wasteful. To avoid this, intelligent resource management is needed, like turning servers automatically off at night or running different tasks (e.g. big simulations) in those hours, when ERP systems are not highly loaded. With these solutions the power usage is always as low as it is possible. This is also a future benefit of the cloud.

4. Summary

As it is clear, with a well build up system the Transport System Bus can be developed. As it mentioned above the concept can be divided into three layers. On the first layer, algorithms are needed to operate the TSB. Algorithms like the A-star [9], solver for Traveling Salesman Problem (TSP) or Vehicle Routing Problem, Jándy-algorithm for center point seeking [10], various genetic algorithms for stock level optimization [11], Hungarian method for layout planning [12] can be implemented. Beside the algorithms there are the databases that are needed for some problems.

The second level is the SOA layer, which is basically a universal interface. With this interface the usage of an algorithm can be really wide. Also the different SOA sections grant for the user to use only those that are needed for them. In an economical approach the user pays only for those modules and services, which are needed and will not get confused with unexpected information.

The third level is the base framework of TSB where users can easily reach the modules and feed the system with the proper data. It is responsible for linking the webservices. It also provides a Graphical Interface for the user.

As it was indicated some problems need complex algorithms and dealing with huge amount of data. In general these problems are causing big calculating effort. Parallelization and good parameterized genetic algorithms are welcome to make the calculating faster and with this cloud based solution it can be also achieved.

Acknowledgement

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