Using Cloud Computing in Supply Chain Management: Third-Party Logistics on the Cloud

1Eirini Aivazidou, 2Antonios Antoniou, 3Konstantinos Arvanitopoulos
4Agorasti Toka

1,2,3,4Department of Mechanical Engineering, Aristotle University of Thessaloniki, Greece
1aveirini@auth.gr, 2apantoni@auth.gr, 3arvanito@auth.gr, 4atoka@auth.gr

Abstract

In the modern world companies are investigating ways to optimize both cost and operational efficiency of each phase of their supply chain, such as planning and forecasting, sourcing and procurement, logistics and service and spare parts management. Cloud computing emerges as a useful technology that contributes to this optimization by providing infrastructure, platform and software solutions for the whole supply chain via internet. The utilization of cloud-based services in supply chain management leads to both financial and operational benefits. Lower cost in contrast to on-premises infrastructure cost, supply chain visibility, platform scalability and flexibility through supply chain partners’ collaboration are some notable examples. Nonetheless, there are aspects that should be taken into account when using cloud-based applications such as data privacy, process customization and trust among collaborators. In this paper, the use of cloud computing is presented in supply chain management and more specifically in the case of third-party logistics service providers. At a first level, the paper demonstrates what cloud technology is, how it can be used in supply chain management as well as its benefits compared with other systems. Furthermore, the paper outlines the implementation of cloud computing in the case of third-party logistics companies, especially from the perspectives of cost effectiveness and real-time visibility of shipment and inventory between companies and their customers.

Keywords: cloud computing, supply chain management, third-party logistics.

1. Introduction

Cloud computing is a rapidly evolving technology that more and more companies are adopting in order to improve their efficiency. According to a recent study of IBM, a top multinational IT (Information Technology) consulting corporation, the use of cloud computing will be more than double until 2014 (Berman et al., 2012). Through the survey, they discovered that 72% of the participants had already piloted, adopted or substantially implemented cloud technologies and 90% of the respondents expected to have done so in three years. More specifically, the number of respondents whose companies have substantially implemented cloud is expected to grow from 13% today to 41% in three years.
Motivated by the above research, the objective of this paper is to plainly present how cloud computing can be implemented by companies in supply chain management as well as demonstrate the profits that this application has to offer in this field. Activities like planning and forecasting, sourcing and procurement, logistics and service and spare parts management are the first to move to the cloud (Schramm et al., 2011). Employing cloud-based technology in supply chains can generate numerous advantages such as capital investment savings, simplification, scalability as well as real-time visibility. However, risks such as information security and lack of customization and as a result lack of competitive advantage should be taken into consideration. After all, the paper specifically showcases how known 3PL (Third-Party Logistics) companies utilize cloud computing firstly in private and then in public level in order to obtain the whole benefits of cloud networking.

The following sections of the paper are structured as follows. Section 2 defines cloud computing technology as well as present the cloud service models. In Section 3, the paper describes all the supply chain activities that have the potential to move to the cloud. Thereafter, Section 4 looks at the benefits that cloud computing has to offer in supply chain management but also the possible challenges that a company will have to confront when employing cloud-based systems. In Section 5, the paper presents the effect of cloud computing utilization in third-party logistics providers. Finally, Section 6 includes the conclusions and an outlook of future research.

2. An overview of cloud computing

Before embodying the concept of cloud computing in supply chain management, the paper illustrates in general an outline about cloud computing technology. In the following paragraphs, a short definition of cloud computing as well as its categorization and later on the three different cloud service models are presented.
2.1 Cloud computing definition

Cloud computing is an IT service model where computing services (both hardware and software) are delivered on-demand to customers over a self-service fashion, independent of device and location (Marston et al., 2011). Customers access cloud-based applications through a web browser while the software and data are stored either on in-house servers or on servers at a remote location. Most commonly, cloud computing is divided into two forms: public and private cloud.

Public cloud infrastructure is provisioned for open use by general public. It may be managed and operated by a business and their multiple partners and it exists externally on the premises of the cloud provider (Mell and Grance, 2011). Using public cloud, the end-user can achieve an inexpensive set-up, as the application costs are covered by the third-party provider. Moreover, the cost of using this service is being kept at the lowest as the users pay for what they use (Zhou et al., 2012).

In contrast, private cloud is an on-premises cloud infrastructure accessed by users of different business units within a company (Pires and Camargo, 2010). Since the main motivation for cloud services is independence from having to operate internal computing resources, the term of private cloud is an oxymoron (Kim et al., 2009). However, the need of lower risk and high security levels makes private cloud an intriguing concept. Actually, the choice between private and public cloud depicts a trade-off between security and flexibility respectively (Schramm et al., 2010).

Figure 2. Trade-off between private and public cloud (Accenture, 2010)
Furthermore, another form of cloud computing is hybrid cloud which is a combination of both private and public cloud. In this type, two or more distinct cloud infrastructures, which remain unique entities, are bound together by standardized or proprietary technology that enables data and application portability (Mell and Grance, 2011). In a hybrid cloud, a company can maintain its own private cloud and then scale out to a public when local capacity is exhausted (Sujay, 2011). Of course, hybrid clouds balance the benefits and risks between private and public clouds as well as the total cost which consists of both operating cost of the in-house infrastructure as well as the usage-based cost of the cloud provider services.

2.2 Cloud service models

2.2.1 Infrastructure-as-a-service
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 (Mell and Grance, 2011). More specifically, the user buys these resources as a fully outsourced service instead of buying servers, software and network equipment (Conway, 2011).

2.2.2 Platform-as-a-service
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 (Sujay, 2011). 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 (Conway, 2011). In some cases, the underlying compute and storage resources scale automatically to catch application demand such that cloud user does not have to allocate resources manually.

2.2.3 Software-as-a-service
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 (Mell and Grance, 2011). This can be an attractive and low-cost solution to acquire demanding software capabilities without the need of applying and maintaining traditional software and hardware (McPherson, 2010).

Thereafter, Figure 3 shows how computing resources can be accessed from a variety of customers (from different devices and places) using one of the three different service models of cloud architecture (Marston et al., 2011).
3. Cloud-based supply chain activities

The application of supply chain concept in the context of cloud computing is innovative and generates a new field of research. A cloud supply chain is two or more parties linked by the provision of cloud services, related information and funds (Lindner et al., 2010). In the next paragraphs, the paper investigates the manner in which cloud computing can be applied in order to facilitate each supply chain step and create the previously mentioned cloud supply chain.

3.1 Forecasting and planning

Cloud-based platforms are going to help companies improve their service levels by coordinating the chain’s partners (retailers, suppliers and distributors) that are playing a major role in demand forecasting. These platforms can gather sales data via internet, perform basic analytics and consequently execute more accurate statistical demand forecasts for all the supply chain participants (Schramm et al., 2011). Such a process can lead to a significant decrease of the Bullwhip effect, which is information distortion among different stages of the supply chain, (Lee et al., 1997), allowing all chain partners to be aware of the real demand volatility they have to cope with. Actually, cloud solutions for demand and order planning combine EDI (Electronic Data Interchange) as well as forecast execution applications into
one single multi-party platform. As shown in Figure 3, when customers generate demand, distributors send the data to the public cloud making the information available in the same time to the entire supply chain (Pires and Camargo, 2010).

**Figure 4.** Integration of supply chain processes (Pires and Camargo, 2010)

3.2 Sourcing and procurement

Sourcing includes acquisition, receipt and inspection of incoming materials as well as procurement processes and selection of the appropriate suppliers (Schrödl and Turowski, 2011). In this case, cloud-based platforms can operate as a database, which contains multiple data about different suppliers, creating significant benefits for companies that deal routinely with thousands of them. Consequently, companies are able to select their suppliers depending if they can provide the appropriate materials according to the specifications and time limits. Moreover, cloud-based tools enable companies and suppliers to mutually develop contracts, drastically improving contract management (Schramm et al., 2011).

3.3 Logistics

Cloud computing is also useful for inventory, warehouse and transportation management, as it is able to offer logistics tracking to multiple supply chain partners. Processes such as replenishment planning, order processing, fleet management, transportation route planning as well as global trade compliance can migrate to the cloud (Schramm et al., 2011). More
specifically, a sole integrated cloud platform gives the advantage of streamlined transportation as well as reduced on-hand and pipeline inventory that can lead to annual freight cost savings for companies. Especially in the logistics sector, cloud services appear to be essential for 3PL companies’ necessity for itinerary and warehousing management for many different customers in one single system.

3.4 Service and spare parts management

Reverse logistics are the last supply chain stage that should be taken into consideration in order to increase profits. Cloud computing gives the opportunity for companies to integrate forward logistics with reverse logistics in the same closed-loop supply chain model (Guide et al., 2003). RFID (Radio-Frequency Identification), which is an intelligent technology that can be used in such models, is able to track inventory’s location and transmit it to a cloud application. As a result, inventory’s route can be visible to all supply chain partners, from the manufacturer to the customer and vice versa. In fact, warranty validation, returns processing, spare parts inventory and distribution or technician dispatch are processes that can be hosted efficiently in a single cloud-based platform (Schramm et al., 2011).

3.5 Manufacturing

Several companies consider the process of manufacturing as a phase of their broad supply chain. Nevertheless, it is worth mentioning that cloud computing may be proved unsuitable for manufacturing as it is in fact a complex core procedure that requires a high degree of customization which cloud-based services cannot offer yet (Schrödl and Turowski, 2011).

4. The impact of cloud computing on supply chain management

Before converting a traditional supply chain into a cloud supply chain, companies should first identify the technical requirements for migrating supply chain activities to the cloud. This transformation process can be executed by using the cloud lifecycle which is an improvement lifecycle with multiple steps permitting the process of transformation to be evaluated and improved recurrently (Lindner, 2011). However, before that, companies should weigh all the factors that can help them form an overall view of cloud implementation in the supply chain. Questions about the changes, the benefits as well as the challenges that have to face when using cloud computing should be answered before taking the critical decision of moving to the cloud (Schramm et al., 2010). In the ensuing paragraphs, the paper specifies some positive implications of cloud computing as well as the most common challenges that companies will have to face when using cloud-based technologies.

4.1 The positive aspects

4.1.1 Cost efficiency
Cloud computing systems can be used effectively as their financial benefits are evident to the companies that utilize them. Cloud services do not require any investment for software or computer power ownership, unlike common in-house ERP (Enterprise Resource Planning) systems, as they are offered by external providers (public clouds). As a consequence, capital costs for supply chain management software can be converted to operational costs, further enhancing one company’s cash flow. Indicatively, the only fees that companies have to pay in order to acquire cloud-based systems are an activation fee at first and usage fee which varies according to how much cloud service is used. Moreover, companies will be able to save money by reducing maintenance costs and keeping upgrade costs to minimum (Zhou et al., 2012).

4.1.2 Simplification
Another main advantage of cloud-based systems is their simplification. Every part of the supply chain is accessible through the same platform, eliminating compatibility problems as well as providing easy connection and enabling supply chain information collaboration (Chen and Mayan, 2011) between partners in one supply chain system. In this collaborative community, members can be added any time and then enter in the cloud only with a set of password and surname (Pires and Camargo, 2010). After that, all users have the opportunity to operate simple processes and applications in the same platform, reducing the response time of one partner to another’s decisions. Essentially, cloud-based services offer information control through one centralized storage system, so that information flow may be smooth between supply chain’s partners.

4.1.3 Flexibility
From demand forecasting to warehouse or transportation management, there is a variety of applications for the entire supply chain that can be hosted in one single cloud-based platform. In that way, supply chain partners could have access to such a platform from their own environment or company regardless the location by using common devices. In other words, running the cloud applications is location-independent (Zhou et al., 2012). This broad network access offers more agility to the whole supply chain, which leads companies to enter quickly in new markets with new products and services (Schramm et al., 2010).

4.1.4 Visibility
Visibility provides timely connectivity along multiple supply chain participants. Therefore, visibility is a key issue for 3PLs as it not only helps such companies to coordinate their operations and manage many different customers but also allows the customer network to have a transparent view of the entire system (Gillis, 2011). Cloud-based systems are able to provide real-time visibility of inventory and shipments and improve logistics tracking.

4.1.5 Scalability
By using cloud computing, companies can control their system capacity more accurately. In periods where demand is high, companies need enough capacity in order to be able to face this increasing demand. Consequently,
using common on-premises systems, they should own the necessary database for the whole year in order to respond to the excessive demand just for a short period. However, with the advent of cloud technology, companies where given the opportunity to adjust their capacity automatically according to their needs and scale their computing power depending on demand fluctuations (Zhou et al., 2012). Taking Figure 4 as an example, by using a hybrid cloud companies are able to deescalate their in-house capacity up to the limits of the forecasted low demand and employ cloud-based capacity for sudden demand spikes (M&E Team, 2009).

Figure 5. Traditional in-house model vs hybrid cloud model (Accenture, 2009)

4.2 The potential risks

The greatest risk companies have to encounter is data security and privacy. Cloud computing systems as software products cannot always ensure confidentiality and as a result run increasing risk of being infiltrated by hacking systems (Zhou et al., 2012). Additionally, possible data acquisition by competing companies would pose an imminent threat to the whole supply chain and as a result companies should consider which data should be sent to the cloud. Of course, data in the cloud must at all times be accessed only by authorized members, namely trustworthy supply chain’s partners. Nonetheless, this sharing of data and information in public implies a radical change on the traditional way of working and thinking which can be a significant cultural business issue (Zhou et al., 2012).

What is more, concerns exist about what is going to happen if the provider is unable to deliver the company’s services due to a system crash down. Supply chain operations are crucial for one company’s financial welfare and as a result any delays due to cloud system’s malfunction can be proved fatal. At the same time, the issue of availability is also crucial (Zhou et al., 2012). Users worry that they may not have always access to the cloud, for example due to poor internet connection in different geographic regions.

Finally, companies concern about lack of customization. Most of the times cloud computing offers standardized services that do not fit exactly to their specific supply chain operations. For example, manufacturing, which
consists of unique processes, is difficult to be boosted with cloud services. More specifically, the fear is that lacking customization will lead to slow market response or even worse loss of competitive advantage (Schramm et al., 2010).

5. Cloud computing in Third-Party Logistics services

After discussing broadly about the new potentials that cloud computing offers in supply chain management, a more specific issue is the manner in which this state-of-the-art technology can affect 3PL companies. Visibility of shipments and inventory, either within the company’s borders or among all the supply chain stakeholders, is of utmost importance to every 3PL. Cloud computing as private, public or hybrid cloud structure is able to enhance internal or external visibility with consequent benefits mentioned below.

5.1 The case of private cloud

The introduction of cloud computing as a new technology could not have been so abrupt. It started being utilized at first within the walls of companies, enhancing their internal infrastructure and processes. Private clouds enabled computing resources sharing among different business units, all powered by one single infrastructure. In the case of 3PL companies, FedEx is a pioneer in cloud computing. It introduced such a technology in 2011 at a private level in collaboration with CloudX (Watkins, 2011). CloudX enabled the company to focus on its customer relationship management and obtain a single interface for many of its sales processes.

Before using private cloud, the company faced several problems concerning large sets of data, which needed a lot of computing power to be analyzed. Furthermore, response time had been deteriorated due to large integrated batch processes (Cearley and Phifer, 2009). After turning to cloud computing, FedEx achieved to reduce response time by 60%, further allowing the parallel execution of batch processes. The company also managed to develop a new analytical application for processing data, something that was not affordable using previous infrastructure models.

Apart from the collaboration with CloudX, the company used other three cloud services such as FedEx® CLI (Critical Inventory Logistics), ROADS (Route Planning and Optimization System) and Salesforce Automation (Dack, 2011).

FedEx enabled a thorough control of its activities all over the world by providing global order-to-delivery status and global inventory visibility. The company manages FedEx® CLI for over 60 regional and multi-regional customers in over 200 order fulfillment locations around the world. That indicates an average of 160,000 orders per month consisting of 200,000 packages which means 4,500,000 pieces.

Furthermore, the company is able to optimize courier delivery routes and measure route efficiency through ROADS. This system runs in 500 locations and manages 20,000 daily service plans. It also helps the company to reroute deliveries and better predict delivery times.

FedEx has used its internal cloud structure at its best utilization. But it became clear that cloud computing had to run public in order company to take
advantage of its full spectrum. For this reason, FedEx turned to the hybrid cloud (Salesforce.com), which utilizes features of both private and public cloud. This hybrid cloud system provided company’s sales teams with a full featured mobile solution increasing their effectiveness and improving service level for the customers.

5.2 The case of public cloud

As a consequence, private cloud cannot be enough for large 3PL providers with numerous partners and customers. What should actually lead these companies to public cloud is the absolute need of real-time visibility of their shipments, carried out by information collaboration between all the supply chain partners.

Regarding to supply chain tracking, most of the traditional 3PL companies used emails or phone calls in order to collect the necessary data. However, these ways are not able to offer timely shipment visibility and certainly do not offer network connection between all the stakeholders. As a consequence, the inability of an efficient monitoring of vast supply chain flows, which large 3PL companies have to deal with, makes them to suffer. Moreover, common ERP systems used for organizing collected data or perhaps private cloud infrastructures, which both are deployed within the company, are unable to suggest the dimension of connectivity between the 3PL and its collaborators (Gillis, 2011).

On the contrary, by using a cloud-based public platform which offers an EDI system, 3PL providers are capable of connecting all their carriers and customers in the same network and getting in-time information of their cargo in transit. It is generally known that the variability of lead time is a real enemy for 3PL companies. For example, shipments lingering in ports because of ship sailing timetable’ mismatches, or even worse due to port strikes, could dramatically prolong lead times (Gillis, 2011). In addition, possible natural disasters can set back many company’s transportation schedules. However, cloud technology can assist 3PL providers to avoid such obstacles as their carriers will be able to alert them about the situation of the location that shipments are. Consequently, having the right information in the right time will facilitate 3PLs to rearrange their routes and deliver the orders to their customers while satisfying lead times.

Apparently, moving to the public cloud also implies essential financial benefits for 3PL providers. The direct cost reduction derives from the absence of ownership cost of an EDI system as well as other consequent maintenance and upgrade costs. Nevertheless, the most significant profit is gained from the timely fulfillment of customer’s orders and as a result the lack of cost of delays and even worse cost of unsatisfied demand.

A noteworthy example of 3PL provider that recently moved to public cloud is COSCO Logistics, the largest 3PL company of China and the world’s second largest ocean shipping company. In 2009, the company started to reestablish its supply chain management system upon a cloud computing architecture. Their goal was to provide a SaaS service to their customers, subsidiaries and distributors in order all of them to use the same logistics management software (Harris and Alter, 2010). Of course, COSCO contracts contained confidentiality agreements so as to secure information that was
shared among all supply chain partners. Although this cloud network collaboration was still in trial stage, the company managed to offer real-time visibility across shipments worldwide.

6. Conclusions

As thoroughly discussed in this paper, the concept of cloud computing can be effectively used in the field of supply chain management facilitating mainly the collaboration among the supply chain stakeholders through the integration of supply chain activities. More specifically, forecasting on the cloud can reduce the distortion of demand when moving away from the real customer’s demand. Furthermore, cloud-based procurement enables companies to manage different suppliers in one integrated database. Last but not least, cloud systems can provide tracking in forward and reverse logistics in one closed-loop supply chain model. Therefore, companies that are willing to improve their supply chain activities are recommended to adopt cloud technology with consequent positive aspects. Cost efficiency, simplicity, flexibility, system scalability as well as timely visibility are the main benefits for businesses that choose to apply cloud computing on their operations.

At the same time, implementing cloud computing in supply chain management also implies some challenges. Uncertain data security, unfair data acquisition from competitors, system’s crash down or poor internet connection appear to be the most common. Especially in core processes such as manufacturing, the lack of customization that characterizes cloud systems, which are designed to be used by several customers, could lead to loss of competitive advantage. For this reason, cloud providers should strive to mitigate cloud disadvantages either by strengthening the system’s protection or by offering customization options for their customers in order to persuade them to buy and apply the cloud services. Nevertheless, one of the major obstacles that companies need to overcome when applying cloud technology is the transition from the traditional non-functional working concepts and methods to new innovative modern practices. Thus, companies that intend to apply cloud technology should radically change this myopic attitude by adopting a new one which entails real-time sharing of information as well as collaboration with all the supply chain stakeholders.

In practice, cloud-based models have already been implemented by leading international 3PL companies with great success so far, firstly at private and later on at public cloud structure. These real-world cases, as presented in the paper, indicate that these companies have succeeded in adopting the new collaborative thinking in supply chain management and enjoy the benefits of cloud computing, especially real-time visibility throughout their customer network.

The field of cloud computing appears to be vast yet relatively new. For this reason, many of its aspects have not been thoroughly studied and its full potentials have not yet been adequately discovered especially in the context of supply chain management. Quantitative models as well as cost analyses of companies, which have already implemented cloud technology, could document more accurately the cost benefits of cloud comparatively to traditional ERP systems or other on-premises infrastructure. Finally, subsequent academic research could possibly develop new advanced
integrated cloud models for supply chain management which will encourage
the majority of companies, including 3PLs, to innovate and drive forward their
enterprises by moving to the cloud.

Acknowledgements

This research has been co-financed by the European Union (European Social
Fund – ESF) and Greek national funds through the Operational Program "Education
and Lifelong Learning" of the National Strategic Reference Framework (NSRF) - Research
Funding Program: Heracleitus II. Investing in knowledge society through the European
Social Fund.

References

- Driving business model innovation”, IBM Institute for Business Value.

http://www.gartner.com/it/content/1286700/1286717/march_4_case_studies_in
_cloud_computing_dcearley_gphifer.pdf.

Collaboration Based on Cloud Computing”, Procedia Environmental Sciences,


C%20Dec%202011.pdf

Issue 12, pp. 8-15.

loop Supply Chains”, Interfaces: The INFORMS Journal of Operations
Research, Vol. 33, No. 6, pp. 3-6.

Computing”, Accenture.


Lindner M., Galan F., Chapman C., Clayman S., Henriksson D., and Elmroth E.
(2010), “The Cloud Supply Chain: A Framework for Information, Monitoring and
Billing”, 2nd International ICST Conference on Cloud Computing (CloudComp
2010), Barcelona, Spain.


