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**USING CLOUD COMPUTING TO INTEGRATE PROCESSES
IN THE SUPPLY CHAIN**

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ABSTRACT

Usually, to obtain the most benefits provided by Supply Chain Management an appropriate integration of processes between companies along the supply chain is required. For such, the contemporary development in Information and Communication Technologies (ICT) can provide some alternatives to deal with most of the issue. But a series of relevant hurdles still remain, such as a better and effective managerial systems integration (and exchange of information) between the tiers in the supply chain. Thus, more recently the adoption of a new technological paradigm called as Cloud Computing

has emerged as a potential solution to the exposed challenge. In this sense, this article discuss the main pros and cons in using Clouding Computing as a way of integrating processes in the supply chain, as well as proposes a manner to conduct it. The research was conducted through a bibliographical review and a study together to one large ICT company.

Keywords: Supply Chain Management, Cloud Computing, Process Integration

Introduction

When analyzing a company as an open system, it becomes clear that every organization needs to be involved with the internal and external environment and with their respective resources in order to fulfill its role. Usually, while the components of the internal environment must be managed in order to coexist in harmony, the external environment affects the development of the company. So the company must adapt to these external factors in each new market situation (REZENDE & ABREU, 2009). Especially due to constant technological evolution that has been witnessed in recent years, companies have to rely on new elements in this business environment. Factors such the consolidation of globalization offered by Information and Communication Technologies (ICT) and shorter distances require that the business adapt itself to these new realities, and use all available resources in the pursuit of competitive advantage. Added to these issues the increase of costumer requirements, especially regarding the quality of services, companies have realized the importance of managing adequately their supply chains to generate a

sustainable competitive advantage over the competitors. According to Cooper et al. (1997), there is a clear need for some level of coordination of activities and processes within and between organizations in the supply chain to meet the goals of the supply chain management (SCM). The tiers need to constantly exchange information, especially about the demand generated by costumers and also to integrate their business processes quickly and easily so that the gains provided by the model are effectively achieved. This relationship focusing on collaborative management came up with the improvements in the processes of communication and information, being the greatest examples the ECR (Efficient Consumer Response), VMI (Vendor Managed Inventory) and CPFR (Collaborative Planning, Forecasting, and Replenishment) (PIRES, 2009). But what happens in practice is that, despite strong support from ICT to integration and joint management, we still witnessed some difficulties related to information systems used by companies for this purpose. The lack of standardization of systems, the need to use several types of software or the strong dependence of B2B portals (Business to Business) portals means that not all the benefits of an efficient management of the supply chain can still be achieved. In the other hand, an emerging technology known as cloud computing might be the answer to these concerns, since it is related to share computing resources between companies, providing a common interface to all users. In this article we will discuss the possible reasons for the adoption of this technology by companies in a supply chain, and propose a way to use this new concept of ICT to maximize the benefits arising from the process integration and collaborative management.

The importance of process integration in supply chain

Currently in the more competitive industrial fields, it is no longer enough the integration of operations, structures and internal infrastructure with the company's competitive strategy. Organizations that better integrated their key internal processes with suppliers and customers and, in this way, built supply chains with clear aims and well-defined procedures, tend to get a better competitive performance (PIRES, 2009). With this focus, Simatupang & Sridharan (2002) argue that a collaborative supply chain is that one which two or more businesses work together to plan and execute supply operations. In this process the goals are achieved with greater effectiveness than if they acted alone. Of course to achieve this level of collaboration is extremely necessary trust between the parties and a relationship of partnership designed to achieve the common goals of supply chain. Partnerships perform an important role in SCM, which is to facilitate the achievement of the typical benefits of vertical integration without the burden of asset ownership (PIRES, 2009). So it is clear that an effective management of supply chain necessarily entails the integration of business processes among partners, as well as effective information sharing, both in the upstream (suppliers) and upstream (dealers) directions. In this sense, Lambert (2004) argues that a business process is the structured set of activities designed to achieve business results aimed at costumers, and lists eight very useful processes: Customer Relationship Management, Supplier Relationship Management, Customer Service Management, Order Fulfillment, Demand Management, Manufacturing Flow Management, Product Development and Commercialization, and Returns Management.

These business processes are integrated through the use of ICT resources which provides the necessary infrastructure for sharing information with the speed and reliability that the

supply chain demands. The sharing of such data is strategic for achieving the cohesion of all functions between the supply chain members in order to provide adequate visibility, and thereby improve the profitability of the total chain. The advantages derived from this practice depend on information systems that can help the chain members to acquire, store and process private information and make them available to a broader set of users in an appropriate way and in a timely manner (SIMATUPANG & SRIDHARAN, 2001). According to AMR Research estimation, the world market of supply chain management software's exceeded US\$ 6.68 billion in 2008 and had the expectation to reach or exceed US\$ 8 billion by 2010. However, due to the current global economic crisis, the forecast was changed to a decline of 6% in 2009 and the need for at least five years to the market recover itself and reach the original goal for 2010 (MODERN MATERIALS HANDLING, 2009). The SCM software are the more modular information systems existing, and can include systems for Supply Chain Planning (SCP) and applications as Transportation Management System (TMS), Warehouse Management System (WMS) and Manufacturing Execution Systems (MES). Although some products available on the market are able to efficiently managing internal and external SCM business processes and sharing their data efficiently (such as SAP Advanced Planner and Optimizer - APO), many companies decide to work with simpler products. This is because each supply chain has a unique set of challenges and different ways to be managed. Thus the preferred option is for software that meets the needs of the corporation, even knowing the integration of the systems is an inevitable consequence. Another option is to use web tools for effecting transactions along the supply chain, also known as B2B portals whose

brings sometimes to the company the advantages of not require a proprietary system neither the interaction by EDI (Electronic Data Interchange) systems.

Challenges to processes integration

Regardless of which ICT is used and the kind of software available in each organization, Barratt (2003) have noted that the supply chain integration is just a great promise for most companies. His perception is that this phenomenon tends to occur because the behavior developed in most of the supply chains does not favor collaborative actions, making limited and individualized the focus of each company. The deployment of an effective collaboration is by its nature somewhat complicated because involves the sharing of cultures, business placements and strategic objectives that do not always go to the same direction. Cooperation in the supply chain is exceptionally hard because its complexity extends beyond the walls of the company. Only the largest and most powerful manufacturers or retailers can force such radical changes to its partners. Moreover, the goals of a company can be a threat to their suppliers. For example, collaboration between Wal-Mart and Procter & Gamble (P&G) meant that the supplier would assume more responsibility for managing the products inventory, something traditionally done by the retailers. Wal-Mart had power to demand this from P&G, but also gave it something in return, which was better information about the demand at its sales point. This kind of information helped P&G manufacture its products more efficiently. In order to business partners of a company agree on this kind of collaboration, supplier relationship managers must be willing to compromise and help these partners to achieve their own goals (WAILGUM, 2008). Once the collaboration between the participating companies in the

chain is achieved, through the formalization of partnerships and unique objectives, another issue that came up is that the ICT resources currently available in these companies do not contribute to the effective exchange of information quickly and cheaply. While the concepts of SCM are moving fast for a new business model of multiple networks, the available technology delivered by traditional providers of SCM software (such as SAP, Oracle and i2) have failed to support this proposal for a model of collaborative community. The reality is that supply chain partners have different SCM systems, ERP (Enterprise Resource Planning) systems and CRM (Customer Relationship Management) systems. Due to this heterogeneity, collaborative mechanisms currently used are mainly Excel spreadsheets, phone, fax and e-mail (AMITIVE, 2009). It is clear the partners would prefer a better way to work together and reach the SCM goals. For a perfect integration, all data of business processes need to flow between manufacturers, logistics providers and costumers. Thus the needs of chain members related to exchange of information and compatibility of information systems should be defined as (AMITIVE, 2009):

- A **common platform** or a **common application** to all participants in the chain, capable to support multiple business processes;
- An **integration of different levels** to this unique platform, to meet the communication of each system, enabling each member of the supply network communicate and work on a common business language;
- **Scalability, uptime, security and failover** of computing resources to support mission-critical nature of operations in supply chains;

- **Simple, flexible processes and agile practices** to support the constant changes of shape and size of a supply chain.

Another point that should not be neglected in this issue is the costs of establishing and maintaining a system for supply chain management. Due to the economic crisis that swept around the globe in 2008, many companies are rethinking the need for ICT investments, and are prioritizing the spending only in critical processes. In the implementation of a system devoted to the SCM, the expenses related to the acquisition of infrastructure and software packages normally are paid by the main company of the supply chain, which is the most interested in the advantages of the model. These costs generally are extremely high and require a detailed analysis about its payback.

Cloud Computing Technology

According to data from one of the largest search portals in the Internet, the cloud computing term has undergone a dramatic increase in demand since mid-2007 when was noticed the first records of its use (GOOGLE, 2009). Despite this growing interest, there is still no agreement about definition for the concept, being the target of many discussions and proposals. Buyya et al (2008) pointed out that cloud computing is a type of parallel and distributed system consisting of a collection of interconnected and virtualized computers that are dynamically provisioned and presented as one or more unified computing resources, based on service-level agreements established through negotiation between the service provider and costumers. FOSTER et al (2008) defines cloud computing as a 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. In a summary of the definitions given above it is possible to conceptualize the term cloud computing as an ICT service offered through the Internet according to customer's needs by a specialist provider. At this point it is highlighted one of the biggest advantages that the new computational paradigm proposes, i.e., package and offer resources in an economical, scalable and flexible way that is accessible and attractive to any company wishing to reduce their costs and restrict its focus only to the core business. The adoption of the cloud computing expression is assigned to a metaphor for the Internet, an abstraction for the complex infrastructure it conceals in order to properly work (LAMB, 2009). In fact, the hiring of casual labor on the Internet, paying only for the desired activity is not something new in the business environment. What is different in this concept is the intention of sharing and offering hardware resources as a service (such storage and processing) and advanced software for business management (such ERP and SCM systems), thus relieving companies in relation to expenditures deployment and maintenance of these computational structures. It is important to understand that this is a way to use cloud computing, but is not the only one. There are different types of deployment of the concept, which differ basically by who is responsible for the resources that will be shared. Initially there are the private clouds, where a particular company creates its own infrastructure to deliver resources in a smarter way. The company remains the computing resources owner, and can share it with who need, like business units or partners in the chain. This model was designed to minimize the high costs and poor utilization of equipment, which occurs when the corporation needs purchase equipment and infrastructure for all business units. The main disadvantage in using this type of cloud

is the high financial investment required to create the environment and provide the services that will be used. Another type is the public cloud, which is characterized by being available for use through a service provider based on Internet. The public word mentioned here does not mean free, although may be found some services at no cost or very cheap. This kind of cloud computing represents a major advantage offered by the paradigm, since companies will not have concerns about the construction of infrastructure or its maintenance. The company will only need a browser to access the Internet and also a subscription service for broadband, common requirements in business environment. On the other hand, the company that uses the service has a strong dependency on its service provider, since all data are held by the supplier. One of the biggest risks is this provider resolve to change its payment system arbitrarily or does not provide all the information back when the contract is canceled. This strong dependence is one of the most frightening aspects to the companies when thinking about change to this business model and it is the point that more defer the spread of this kind of service. Finally the third type is the hybrid cloud, which is a type of cloud implemented when the company uses the services of public clouds to deal with the burdens of its inner cloud. When the structure created by the company does not support the use because of workload peaks, the external service is contracted and stays available to users (IBM, 2009).

Using Cloud computing for process integration

Before the Internet advent the aspirations of systems aimed to managing the supply chain was limited to improving their ability to forecast customer demand and make the information flow more easily along the supply chain. However, due to the benefits of the

Internet, especially regarding to their simple communication and universally accepted, this reality is being altered. Nowadays the companies have the possibility of connecting its processes with its suppliers and customers into the supply chain, optimizing costs and opportunities for everyone involved. This was the main reason for the increase of use of B2B portals, i.e., the idea that every partner which a company does business could be connected for effective cooperation and information sharing (WAILGUM, 2008). But these business models bring the difficulties discussed previously in this article, which makes them interesting but with important limitations. Thus the concept of being able to use and manage hardware and software as a service over the Internet that cloud computing brings to the business becomes an attractive, because it has the potential to reduce the trade offs and enhance collaboration between the chain companies. The new computing paradigm application in a supply chain goes beyond the finite end-to-end EDI connectivity, and brings a promise of greater ease of implementation and maintenance than any existing data exchange system or corporate portal. Typically these B2B portals are focused on just expose information securely, instead of really managing an inter-operation of the company. For such, an implementation of SCM through cloud computing could allow companies to define a unique business style and a dynamic partners set, and for the first time could facilitate the exchange of data and business processes in a non-compulsory way to the weakest links in the chain (AMITIVE , 2009). Therefore there are several ways to a SCM be implemented through software running in the clouds, ranging from partial integration and fragmented models until fully integrated supply chains. Figure 1 presents a proposal for the cloud computing use applied to SCM, which is based on the theoretical and the possible benefits of the paradigm.

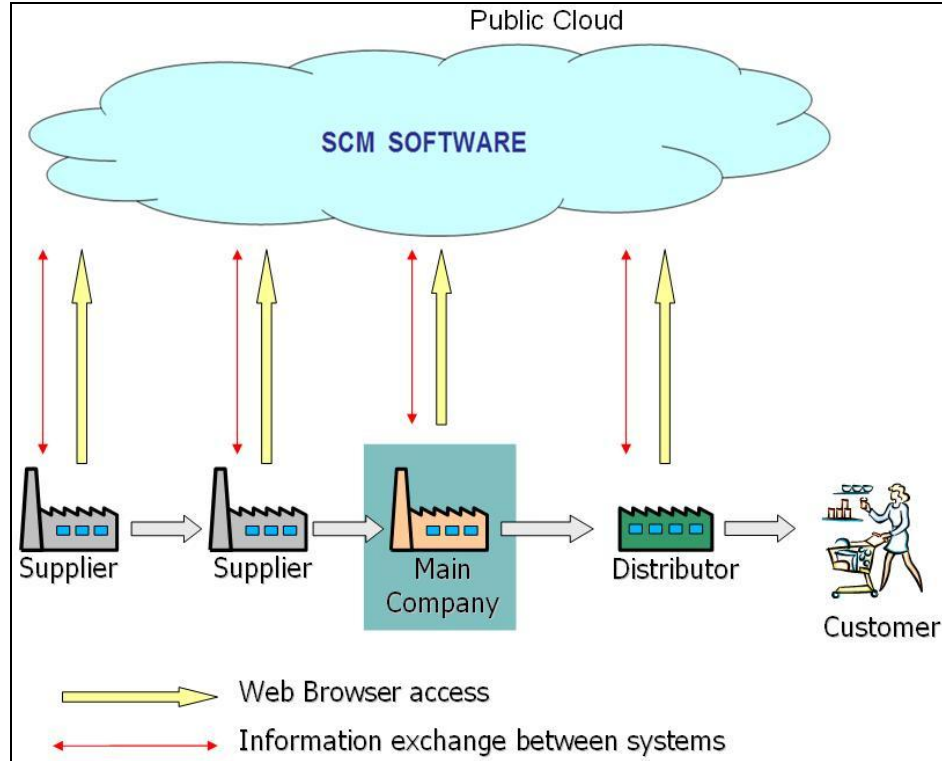


Figure 1: Proposed use of cloud computing to integrate processes in the supply chain

The model main idea is to have a software for managing the supply chain installed “in the clouds”, being this a public cloud. According to the concept of public cloud, the system would be offered as a service through a specialist provider, which will have the responsibility for the system management and maintenance. This supplier does not need to be a business partner of the supply chain, but only a service provider. The supply chain members would hold access to the system simply through a web browser and will have the possibility to exchange the data from this software to their existing management systems. Taking the Figure 1 as example, when the demand is generated by the customer, the distributor will send a data package to SCM system, making the information available in the same time to the entire supply chain. In the same way, the model provides a

common graphical user interface to all companies, which normalizes the business language and facilitates the joint operation since all of them access the same system. In this sense, any supply chain could use the system, even if they are opponents on the market. Of course the company which provides the service must have ways to limit access to information for each supply chain, not allowing competing chains visualize the same data. In short, the advantage is that a partner participating of several different supply chains can access data from each of them through the same system, without the need of different access methods. Another potential advantage is the possibility to add members any time in the collaborative community, due to the current dynamics of many supply chains. When the system is installed in the clouds, to each participant entering in the supply chain would only be necessary to provide a set of username and password, so it can enjoy the model benefits. If this company is already a participant in a supply chain that uses the model, is just necessary allow it access to other relevant data to its new operation. Concerning the issue of information exchange between already existing systems and cloud system, this might be an option offered by the public cloud provider. Hiring or not this facility would depend on the disposal of each member to pay for the service. Here is another possible benefit of cloud computing, that is, who would pay to use the system would be each participant in the supply chain, according to a package of services previously available. In this sense, the main link of the supply chain (usually the focal company) is financially relieved, since it only would pay for what is used, dividing the operating costs with the other participants. In turn, they find themselves not obliged to install new systems and invest in ICT in order to participate in the supply chain. Current investments in system purchasing, its maintenance and all the hardware resources

required are dependent on the service provider, which owns the system. At this point is important to differentiate the proposed model from B2B portals already mentioned. In these portals is not possible to conduct all business processes required for an effective SCM, because they are not constructed and implemented as SCM systems. They serve an important part of business integration, which is to enable the exchange of some relevant information, but do not have all the tools and neither always have the possibility to exchange interfaces between the systems already installed and functioning. Table 1 provides other potential advantages of using cloud computing to integration process over the traditional form of integration, as well as its disadvantages:

Advantages	Disadvantages
<p>Lack of need for sophisticated computational resources.</p> <p>Investment economy of hardware and software.</p> <p>Control spending with the application in a more flexible way.</p> <p>Have the resources ready when the workload increases.</p> <p>Economy in ICT team in the applications maintenance and configuration.</p> <p>Decreased use of electricity (green operation).</p>	<p>Possible lack of service availability.</p> <p>Lack of clear safety procedures for information exchange over the Internet.</p> <p>Lack of procedures to ensure data confidentiality and auditability.</p> <p>Possible congestion in the transfer of data depending on the supply chain size.</p> <p>Precarious internet infrastructure in some parts of the world.</p> <p>Lack of cloud computing service providers.</p>

Table 1 - Possible advantages and disadvantages of the proposed model.

An information system for managing the supply chain being used through the cloud would enable this business model in a more simple way and especially with greater flexibility. The gains related to the speed of information transmission concerning customer demand and other key processes of SCM are added to the benefits of cost reduction and possibility of "green operations". This would make possible the spread out of the supply chain management at relatively attractive costs. Furthermore, would be possible to companies that do not have financial and/or technical conditions for proper integration (in the current integration model), to be prepared to join in more complex supply chains.

Final Considerations

Nowadays, supply chain managers have the perception that ICT is one of the main sources of improvements in productivity and competitiveness to its companies. This resource is used differently from the others, because it allows an increase in speed of information and data capacity, and simultaneously is capable to reduce costs (BOWERSOX & CLOSS, 1999). Since its emergence, several computational resources have supported the supply chain management, with different formats and purposes. This management concept evolution has frequently been permeated by the use of the most advanced software and hardware available. Important initiatives and practices of SCM as VMI (Vendor Managed Inventory), the ECR (Efficient Consumer Response) and ESI (Early Supplier Involvement), has strong dependence on EDI practice. It is not so different of this present period, when the cloud computing paradigm brings the ability to lower costs and easier processes integration in the supply chain. For such, the option of

using computer resources as a service, paying only for what is used, holds the promise of decrease investments, as well as brings more opportunities for smaller companies to become members of already structured supply chains.

In this sense, this article presents a cloud computing usage model that supports the processes integration and sharing information among supply chain partners. In the current global market, usually a fast and effective information exchange and/or achievement should provide better outcomes in relation to the competitors. The current ways to provide this data sharing rely heavily on supply chain management systems, but have several disadvantages, especially regarding the costs to participants. Through the proposed model is expected that the benefits of cloud computing is achieved, reducing investment, increasing the flow of information and creating business models common to all involved companies. Nevertheless, this new paradigm has major shortcomings and limitations that require further discussions and corrections, especially regarding to effective deployment and use. In this context, there is still a lack of proposals dealing with the use of cloud computing to support the supply chain management, even by large ICT service providers. However, the exploration of the subject in both academic and industrial environment is just beginning.

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