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A Cloud-based Business Analytics for Supply Chain Decision Support

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Abstract

Todays' businesses are required to have control over the big volume of data, transaction information and records that are rapidly generated through various sources, such as networked sensors, Internet sites, smart devices, and industrial machines. This 'big data' are significant to process, store, manipulate and communicate for its various strategic and operational purposes. The pattern, growth or declining facts/rates of the big data are important for developing business strategies, improving management and operational business decision making. Although through various individual interactions the big data are continuously created or re-created by offline and online activities, the actual solution design by offering power of analytics have not been discussed at a greater extent over the past in academic outlets. In this paper, we introduce a combined requirement of developing cloud-based analytics system to handle, retrieve and manipulate the big data for improving decision making in supply chain management. The main emphasis in the study goes after outlining a conceptual analytics approach for meeting the decision support needs in a hypothetical supply chain industry problem-domain, specially focusing on decision support application for various individual chain managers.

Keywords: Supply chain management; business analytics; business intelligence; decision support systems.

1. Introduction

Today's businesses are increasingly turning their attention to adopt data-centric and data-driven approaches for managerial decision making. Businesses are now keener to their effective use of soft assets such as multiple types of data collected from their customers, distributors, manufacturers and suppliers. This data are rapidly generated throughout various sources, such as Internet sites, smartphones, special tracking devices, RFID and other individual's digital devices, around the globe. This contributes to the amount of 'big data' available across businesses. The growing volume of big data has played a major role in the management of business strategic planning and performance (Knight, 2011). The situation is particularly true in supply chain performance in that when businesses deal with various systems, people, activities, information, and resources involved moving a product or service from supplier to customer (Trkman et al. 2010; Knight, 2011). However, over the past years although growing number of studies have discussed the requirements of developing analytics solution or data discoveries to handle the big data within business industries, the understanding around the newer form of business analytics design and requirements of its various provisions for decision support are still emerging to leverage new technologies. The paper outlines requirements of developing a cloud based business analytics solution to improve decision support of managers in the supply chain management.

Effective supply chain management (SCM) has now become a recognized method in order to ensure competitive advantages (Trkman et al. 2010). It is important to promote the understanding of how SCM can be improved through new emerging applications, especially for better leveraging the soft assets - day to day data, transaction logs, social media data, and information to achieve effective decision support. The effective decision support provides transformation of SCM strategies, which areas are, the important moderator in businesses. A multi-echelon supply chain housing suppliers, manufacturers, wholesalers and retailers is very often vulnerable to issues like 'full integration' when it comes to flow of products and information.

While the purpose of the integration is to smooth out the products flow from the far end suppliers to the end customers through a complex chain network; information flow also plays crucial role in delivery of products in this invisible thread of chain network. The consumers deem to be satisfied only when they are serviced with right products in right time. When a supply chain is competing against another chain (such as in a global competitive market), the transmission of the quality information (i.e. right information at right time to right decision makers in reliable way) over the Internet is considered as competitive advantage of that chain over others (Accenture, 2014). A chain powered by reliable network of IT backbone can provide a complete real time visibility of data and information flowing among the decision makers within the chain. Without the provision of IT backbone and supporting technologies, a chain will not be able to survive in today's fierce competition. This paper thus analyses the basic requirements of business analytics techniques and other emerging technologies for the applicability to various business users.

Supply chain managers or any business users who are responsible for chain activities require applications of analytics within the IT backbone to retrieve strategic and actionable insights in the chain network. For instance, it is important to have quality information flow and customizable reports for monitoring key indicators or key disorders across the entire supply chain. In the rest of the paper, the background section provides details of business analytics and its various provisions for supply chain. The section after that discusses conceptual solution approach for addressing various decision makers' information support, providing a conceptual framework of a cloud based business analytics. And finally the section of discussion and conclusion presents overall discussion and summary of the theoretical paper.

2. Background of study

According to *Supply Chain Insights Global Summit in September, 2013*

"We tackled the topics of talent, analytics and the many changes that are happening in the shifts of technology including the proliferation of social signals, increase in weather sensing, changes in corporate social responsibility, the shortage of talent, and the evolution of new forms of analytics" (Cecere, 2013,p.1).

In today's business world, the practices around developing own dashboards for data monitoring or management or use the hundreds of predefined views and metrics to display information at a real time manner. The data must make meaningful sense to managers or decision makers, are based on common applications in businesses. In supply chain, software applications have been met such demand already for data sharing; alert functions, and producing reports across managers and trading partners. The technologies around scorecard functionality measures and continuously evaluates performance. Such functionalities are also common and well-known applications for decision support. As decision support applications, business analytics is the practice of iterative investigation on past databases in any target area such as business performance using statistical or mathematical models. In recent years,

"Business analytics has led to significant developments in business applications that analyze customer data. They've been used to reduce customer attrition, improve customer profitability, increase the value of e-commerce purchases, and increase the response of direct mail and email marketing campaigns" (Kohavi, Rothleder and Simoudis, 2002, p. 47)

Trkman et al. (2010) described potential use of analytics in various areas include: in planning, where analyzing data to predict market trends of products and services are of significance; in sourcing, where the use of an agent-based procurement system with a procurement model, search, negotiation and evaluation managers in order to improve practices around supplier selection, price negotiation and supplier evaluation; in making, where the correct production of each inventory item or product not only in terms of time, but also about each production belt and batch; in delivering, where various applications of analytics in logistics management have used in order to bring products to market.

SCM is one of the vital managements for businesses. The specific type of managements uses set of approaches utilized to integrate suppliers, manufacturers, warehouses, and retailers, so that merchandise is produced and distributed at the right quantities, to the right locations, and at the right time, in order to minimize system-wide costs while satisfying product and service level requirements (Simchi-Levi et al., 2008). In the chain, four echelons (such as retailers, distributors, manufacturers, and suppliers) make the chain's integration in order for ensuring product delivery from manufacturers to consumers. In the supply chain there are three types of flow from the supplier to the customer: Product Flow; Information flow; and Money flow. Information flow is nothing but the sharing of information from the customer as well as supplier. It is across both directions. In the information flow, various data exchange, sharing, processing and updating of data related to customer orders, sales orders, product requisitions, and information of transportations. Data transmit multiple or cross functional ways from one end to other end in the chain as per their decision making requirements. The decisions are new product information decisions; physical procurement decisions, manufacturing decisions; stock deployment decision and forecasting decisions. One of the vital challenges of data transmission across the four ends for these decisions making is, to maintain high-quality information and real-time support in the value adding process of SCM. These issues are resulted from incomplete data entry, multiple data format when it is global chain, poor network or Internet connectivity, data storage or data governance issues, and data reliability or integrity issues.

Ganeshan and Harrison (2002) suggested four vital aspects of decision making in SCM, such as: location; production; inventory and transportation. According to Ganeshan and Harrison (2002), although these four aspects are embedded both in strategic and operational processes, the effort in these are critical to effectively manage the product and information flow in SCM. The location decision involves decision making activities about placement of product in geographic locations, such as stocking points, size or quantity and possible path by which product flows through to this destination. This decision is important as such decision making related to basic strategy for accessing customer directly and therefore have significant impact on revenues, cost or service quality. This decision must be made by optimization routine that considers production costs, taxes, duties, tarffs, distribution costs and other management related budgets. The production decisions includes what product to produce and which plants to produce them in, allocation of suppliers to plants, or production plants to distribution center and distribution center to customers. This decision holds big impacts on the revenues, costs and customer services. These decisions assume the existence of the facilities, but determine the exact path through which a product flows to and from these facilities. Inventory decisions refer to how inventories are managed at every stage of supply chain, as it could be in-progress between locations. The transportation decision making is closely linked to inventory decisions, since the best choice of mode is often found by trading-off the cost of using the particular mode of transport or the shipments. The factors of decision support for this, can be on how fast, cheaper, lesser safety stocks, and/or reliability of transport systems.

Literature in the SCM suggests three modelling approaches (Ganeshan and Harrison, 2002) such as: network design, rough cut and simulation methods. The network design is for covering the four major aspects of decision support by focusing on network development across the chain. The rough cut method guides policies development for operational decisions, considering single site rather than the network. The simulation model provides comprehensive aspect for considering strategic and operational, but the limitations of such method are, it can only evaluate effectiveness. Going beyond the simulation method, in the paper we address the decision support issues in in two different ways; offering a SAAS (software as a service) based to enable effective and secure access to the supply chain data through a central repository approach for the retailers, distributors, manufacturers, and suppliers and developing an analytics system for the decision makers who are seating at the four aspects (in the SCM), in order to control, monitor and predict real-time data, special nature of data growth, demand forecasting, request logs, disorders, defects in the past business data or transactions. The advantage of cloud computing is that it is capable to offer a cloud-based (e.g. Internet or web-based provisioning) analytics service to meet chain decision needs. Other known benefit is that it can bring access and service flexibility both for service users and service

providers. With the benefit, it is important to understand and develop conceptual approach for designing the service technology for the big data management.

The newly rising cloud computing have also been used as a modern architecture of shared computing service in many areas for minimizing labor and implementation expenses (Santos, Gummadi and Rodrigues, 2009). However, the use of cloud based services for the effective decision making of multiple parties is still largely overlooked given the potential benefits. The services offered are mainly supported through computing utility rental by service providers. After the introduction of web-based utility services by Amazon.com, many web service providers became increasingly interested in the cloud-computing platform for launching new services to meet clients' demands as the cloud-based provision involves minimal labor and implementation expense (Santos et al. 2009).

Recent studies on improving healthcare with cloud computing provide examples of the proliferation of cloud computing through two main services: Software as a Service, Infrastructure as a Service and Platform as a Service. Nurmi, Wolski, and Grzegorczyk (2010) described an open-source software framework for cloud computing in which computing resources are considered as an Infrastructure as a Service. Santos et al. (2009) addressed requirements of confidentiality and integrity in data access and process, and deliberately proposed a trusted cloud computing platform for facilitating a closed box execution and storage in a virtual environment (p.2).

As the demand of business analytics to support effective decision making have increased, so have the terms used to describe them: data warehousing, knowledge management, data mining, collaborative systems, online analytical processing, with Business Intelligence tending to encompass all (Gibson et al., 2004). Business analytics can be considered as the combination of processes and technologies to assist in decision making for managers and end users. The business analytics systems have been well-recognized for enhancing the effectiveness of information management and decision making. It is suggested that business analytics system provides comprehensive decision support mechanism to meet all levels of demands for decision makers through applications as decision support systems, query and reporting, online analytical processing (OLAP), statistical analysis, forecasting, and data mining (Stasieńko, 2010).

3. Conceptual framework

In this paper, we focus on broader requirements of developing decision support provision through business analytics applications that can be delivered using cloud based platform. The solution view is a service-oriented mechanism that brings data-centric solution for managers. The requirements can be addressed through a demand-driven business intelligence development approach that is influenced by a "one-size-fits-all" method of De Meo et al. (2008), which has been of interest at the basis of many public healthcare services. We adopt the approach (Miah, 2014; and Miah, Kerr and von-Hellens, 2014) that focuses on extending a DSS approach into business intelligence design for the decision support aid of government professionals, domain experts and end users in the rural business context. An Ontology based knowledge repository has been employed for putting appropriate knowledge reasoning with better interpretations for individual's decision support. For well-defined domains, it is claimed that ontology, as a conceptual modelling technique, has the potential to improve the structuring of database management. Ontology refers to a particular view of the properties of data and how those properties relate to each other for data management (Gennari et al. 2003). The use of ontology to model big data specially for enhancing its search-ability through a meaningful vocabulary terminology that can lead the development of a solid as well as contextually relevant cognitive base that enables effective data representation from the big data repositories (Evermann, 2005).

The approach proposed by Miah (2014) can be adopted through implementing two layers of functional processes that allow users (managers and officer decision support) as it is important to recognise operational and strategic need of user in the supply chain. Whilst scientifically informed big data model will be built and maintained by managers, the choice and focus of these is depended on policy or other matter of management. The first (in Figure 1) is an authorization or control layer for users such as managers who are responsible to oversee greater data view to specific domain (e.g. production or transportation data logs). Managers also can allocate various data slots for monitoring or continuously dashboard purposes. The second layer allows access to the data acquisition component of the system where the officers or managers are responsible for monitoring data for decision-making at various stages in the chain.

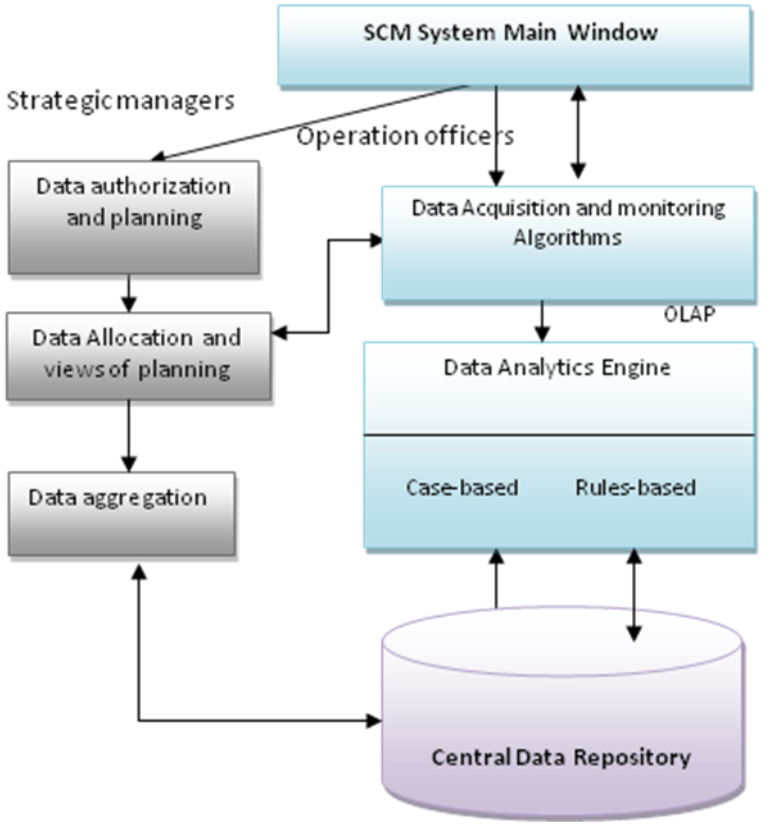

Figure 1: Business Analytics system for supply chain managers

Findings suggested that most of the data analytics simply use rules-based methodology although they may employ various statistical techniques (e.g. time series analysis, linear regression modeling) varying from the requirements special patterns or specific data investigation. However, a set of expert rules for decision making can be determined from the data patterns, which are then used to generate the target-relevant rules of decision support to the users' decision making requirements. This layer employs the rules for providing advisory and monitoring services. The data authorization layer is required to control data allocations.

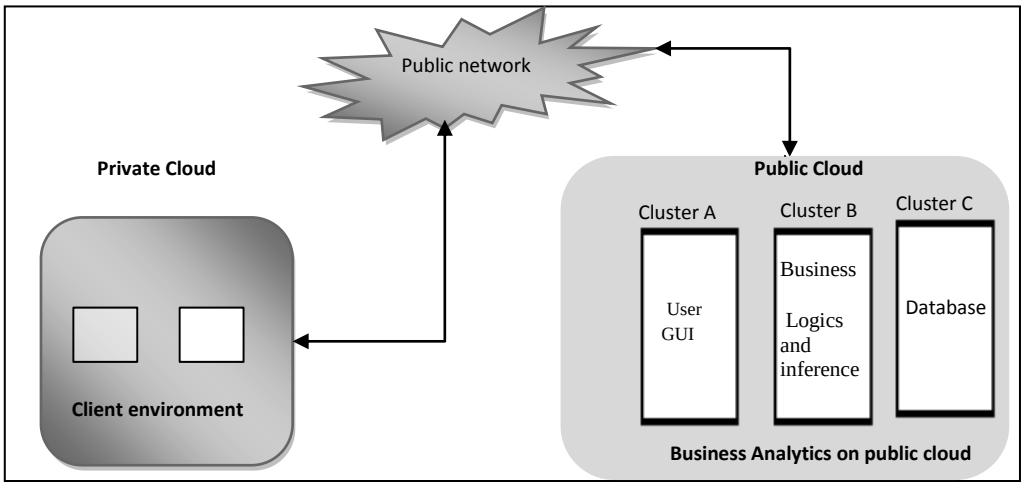

Figure 2: Proposed business analytics clusters on cloud computing

In the cloud based architectural design (presented in figure 2), the proposed business analytics design on cloud is based on private and public cloud using hybrid cloud deployment in that the strategy share technologies for application servers, however the storage server can still seat at their own premises. In the cloud based architectural design, the proposed business analytics is based on private and public cloud using hybrid cloud deployment in that the strategy is to share technologies for application servers; however the storage server can still seat at business's

own premises. Hybrid cloud deployment can offer an unprecedented opportunity to reduce the cost of IT, while improving functionalities of cloud services by employing DSS provisions to meet decision support requirements. In the aspect of the proposed business analytics on hybrid cloud, ontology based data repository is hosted on public cloud to provide vocabulary consistency specially to enhance search-ability among managers of SCM. Database or big data are located at private cloud connected through network, considering its sensitivity of privacy and security concerns. The proposed conceptual approach attempts to provide an initial decision support through cloud based business analytics for the target users.

4. Discussion and Conclusion

The paper introduced requirements of supply chain decision making and to address this, an emergent approach of cloud based business analytics solution is proposed. Organizations are increasingly involved in collaborative and virtual action-taking in the world especially for supply chain big-data management. Emerging technologies involving business analytics and cloud computing are becoming mainstream in developing real-time decision support for instance for managers in the supply chain management. We have shown a case demonstration using hybrid cloud deployment in the paper. This solution approach can be used for the four vital aspects of decision support in SCM such as: location; production; inventory and transportation, although the four aspects are embedded both in strategic and operational processes. The decision support provisions (for strategic managers and operation officers) are shown through two functional processes in the proposed conceptual framework in figure 1.

Many organizations therefore started to develop analytics tool to better leverage their soft assets – day to day data, transaction logs, social media data, and information to achieve effective decision support to transform their business strategies, operational processes, optimization of production and customer value propositions. Data-driven discovery and analytics around demand-oriented technologies for effective information support services change traditional system development practices, and as a result, newer forms of decision-support and analytics are on demand to leverage new technologies. Cloud computing offers cost-effective collaboration, agility, and availability of business data according to the demands of decision makers. Recent system development studies have discussed issues, approaches and methodologies around the use of these technologies, but few have identified requirements for combining them to meet decision support demand in the era of big data. This represented a new challenge: to develop information systems practice and relevant design theory for business analytics applications in dynamic digital ecosystems.

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