Full Length Research Paper

Evaluation of the software architecture of the supply chain management system

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This paper describes an approach to the evaluation of supply chain management system based on architectural framework. The approach involves collection of a set of data on different supply chain management systems from different software evaluation centers. The methodology was an analysis of the supply chain management software architecture using the ALMA method. The evaluation was based on software integration for effective supply chain planning and ability to handle the return stage of the supply chain management. A proposed architecture to handle the return stage was developed and recommendations made on how to improve IT integration in the supply chain business model.

Key words: Supply chain management system, ALMA, software architecture.

INTRODUCTION

Though every organization aims at satisfying their customers, the primary goal is to maximize profit. Profit maximization with minimal resources enables the organization to exist in perpetuity. The series of activities involved in business processes are targeted towards achieving these goals among other objectives of the organization. In order to satisfy customers, their needs must be identified. It is the duty of the organization to identify the consumer’s needs, source for resources necessary to make the product or service needed by the consumers and deliver it to them. This process, though simple as it may sound is a big challenge to every organization. The way the organization finds the raw materials it needs to make a product or service available and deliver it to the right consumer at the right time is regarded as supply chain. Supply chain is a set of organizations directly linked by one or more of the upstream and downstream flows of products, services, finances, and information from a source to a customer (Mentzer et al., 2001). This means that supply chain is an integral part of every business organization, hence the reason for supply chain management as a unit in any organization.

Supply chain management simply means the process whereby organizations improve their supply chain to ensure efficiency and cost effectiveness in the system. It is actually a collection of steps that an organization takes to transform raw materials into final products or services and deliver same to consumers. Due to its necessity and the advent of information technology, supply chain management is simpler, efficient and effective with the use of business enterprise software known as Supply Chain Management System (SCMS). The supply chain management system refers to modules used in executing supply chain transactions, managing supplier relationship and controlling associated business processes using a computer system. This system which is meant to serve as a relief to organizations is faced with some challenges which have made it difficult for the software to be fully implemented in every organization.

Objectives

1. Identify existing supply chain management software and the features supported.
2. Evaluate the performance of the supply chain management software with reference to the architecture.
3. Develop software architecture for the supply chain management system.

**Contribution to knowledge**

The evaluation is aimed at primarily helping researchers and practitioners in implementing a successful IT system for achieving an effective supply chain management system.

**LITERATURE REVIEW**

Supply chain management has gained significance as one of the 21st century’s manufacturing technology and innovative paradigms for improving organizational competitiveness (Danish et al., 2008). Supply chain management is the management of a network of interconnected businesses involved in the ultimate provision of product and service packages required by end customers (Harland, 1996). More concisely, supply chain management integrates supply and demand management within and across companies. Supply chain management is an increasingly applied operations paradigm for enhancing overall organizational competitiveness. It includes all organizations and activities associated with the flow and transformation of goods from raw materials to the end user and the information flows associated with it (Gunasekaran et al., 2004).

Chandra and Grabis (2007) found that, supply chain is a network of suppliers, manufacturers, warehouses, distributors, and retailers who through coordinated plans and activities develop products by converting raw materials to finished goods.

A more customer focused definition of supply chain management by Hines (2004) stated that, supply chain strategies require a total systems view of the linkages in the chain that work together efficiently to create customer satisfaction at the end point of delivery to the consumer. As a consequence, costs must be lowered throughout the chain by driving out unnecessary costs and focusing attention on adding value. This means that organizations must ensure that their supply chain is efficient and cost effective.

**Supply chain management stages**

The supply chain management is basically made of five components or stages (Venus, 2010):

- **The planning stage**
  There must be a plan developed to address how a given product or service will meet the need of consumers. This stage is a process whereby a set of matrices is developed to monitor the supply chain so as to ensure efficiency, cost effectiveness, high quality and value to consumers. The focus in this stage is to device a profitable supply chain.

- **The source stage**
  This stage involves building a strong relationship with suppliers of the raw materials needed in making the product or service the company wants to deliver. The methods of shipping, delivery and payment are also considered in this stage.

- **The make stage**
  This is the point of utilizing the resources acquired to manufacture the end products. This stage includes testing, packaging and scheduling the product for delivery. It is the most metric-intensive portion of the supply chain because organizations are able to measure quality levels, production output and labor productivity.

- **The delivery stage**
  This stage often referred to as logistics is when the organization coordinates the receipt of orders from customers, develop network of warehouses, pick carriers or distributors, to get products to customers and set up an invoicing system to receive payments.

- **The return stage**
  During this last stage, customers may return defective products and the organization will also address customer questions. The supply chain managers have to create a responsive and flexible network for this stage. It is often seen as the problematic part of the supply chain. These components must be fully and effectively integrated in the supply chain management process in other for organizations to compete in the networked economy. Hence, the need for supply chain management in an organization cannot be over-emphasized. It remains a top priority for organizations eager to optimize operations.

**Supply chain management and the SCOR model**

Supply chain management is based on the supply chain
operations reference model (SCOR). Delia (2008) stated that, this model was introduced in 1996 by the supply chain council as a tool for measuring supply chain performance, the effectiveness of supply chain re-engineering, for testing and planning for future process improvements. The supply chain reference model encompasses a pyramid with four levels:

1. Establishes the competitive objectives, the key supply chain process type: plan, source, make, and deliver.
2. Definition of the 26 core supply chain process categories with which supply chain partners can jointly present their actual operational structure.
3. Planning and setting goals for improvement.
4. Implementation of supply chain process improvement efforts.

**Information technology in supply chain management**

In this era of globalization where location is a negligible factor in every process, information technology has enabled organizations to operate solid collaborative supply networks. This interorganizational supply network can be seen as a new form of organization. Powell (1990) found that with the complicated interactions among the players, the network structure fits neither “market” nor “hierarchy” categories. Zhang et al. (2004) stated that from a systems perspective, a complex network structure can be decomposed into individual component firms. This enables the organization to effectively manage the components. Changes in the business environment have led to the development of supply chain networks. Driven by intense competition and rapid development of information technology, businesses turn to sophisticated planning software for help. These systems are now a necessity for large and medium sized companies in other to meet the increasing customer demands, face global competition and minimize costs while making profit. There is need for organizations to share information such as forecasting data and production data among supply chain members. Complicated as it is, the evolution of information technology has enabled the integration of supply chains into value systems. Handfield and Nicholas (2002) already stated that, through collaboration and information sharing; companies create high performing value systems, providing member organizations an important competitive advantage. Value system is a connected series of organizations resources and knowledge streams involved in the creation and delivery of value to the end customer (Delia, 2008).

Gunasekaran and Ngai (2004) stated that, the concepts of supply chain design and management have become a popular operations paradigm. This has intensified with the development of information and communication technologies (ICT) that include electronic data interchange (EDI), the Internet and World Wide Web (WWW) to overcome the ever-increasing complexity of the systems driving buyer-supplier relationships. The complexity of SCM has also forced organizations to go for online communication systems. Supply chain management emphasizes the overall and long-term benefit of all parties on the chain through co-operation and information sharing. This signifies the importance of communication and the application of IT in SCM. This is largely caused by variability of ordering (Yu et al., 2001). Srinivasan et al. (1994) already stated that, Information sharing between members of a supply chain using EDI technology should be increased to reduce uncertainty and enhance shipment performance of suppliers and greatly improve the performance of the supply chain system.

Today, organizations use the internet to link their business information systems and to increase the efficiency of the decision-making process for their suppliers and customers. The supply chain management process is integrated into a system to improve its optimization efficiency. The supply chain management systems or software enable quality growth of products and services, information services and e-business links, inventory reduction, customer service improvement. The supply chain management software refers to the different software tools used in supply chain management and controlling associated business processes. The major function of the supply chain management software includes: customer requirement processing, purchase order processing, inventory management, goods receipt and warehouse management and supplier management or sourcing (Wikipedia, 2009). The major requirement of supply chain management software is forecasting. Gunasekaran and Ngai (2004) found that, the following are some of the problems often cited in the literature both by the researchers and practitioners when developing an IT-integrated SCM:

1. Lack of integration between IT and business model
2. Lack of proper strategic planning
3. Poor IT infrastructure
4. Insufficient application of IT in virtual enterprise
5. Inadequate implementation knowledge of IT in SCM.

An attempt has been made in this paper to develop a framework on the application of IT for achieving effective SCM based on analysis of existing supply chain management software architecture. There are many supply chain management system on sale with each having characteristic features. Presented in Table 1 are some SCMS with their characteristic feature. The features are rated as (1)-fully supported, (2)-supported, (3)-partly supported and (4)-not supported based on Asia Forum
Table 1. Supply chain management systems and their characteristic features.

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for ERP Software and Business Strategies and the Technology Evaluation Center reports. The features include:

1. Sales and operation planning
2. Demand management
3. Supply management
4. Warehouse management
5. Transport management
6. Supplier relationship
7. Customer relationship

**Typical supply chain management system architecture**

The basic systems that make up the supply chain management architecture are ERP systems, WMS and TMS. These systems can be either standard software programs or customized to company specific needs. The basic systems in a supply chain provide specific functions for typical users:

**ERP, enterprise resource planning systems**

Functions: Purchase, materials management and sales; Users: Manufacturers and trading companies.

**WMS, warehouse management systems**

Functions: Receipts put-away, bin management and order picking; Users: Logistics service providers and wholesalers.

**TMS, transportation management systems**

Functions: transport booking, planning and monitoring; Users: forwarders and carriers.

The architecture in Figure 1-3 can further be broken down to show the software component of the supply chain management. The software component of the supply chain architecture is also known as the supply chain engine which consists of the following systems (Vewijmeren, 2003):

**Communication engines**

Function: Basic communication between the systems (and users) in the supply chain; Examples: Data communication, message conversion and flow control engines.
Information engines

Function: Transparent information over the systems (and users) in the supply chain; Examples: Stock visibility, track and trace and report query engines.

Management engines

Function: Advanced management across the systems (and users) in the supply chain; Examples: Inventory management, production management and distribution management engines.

The supply chain engine make up the system software dedicated to supply chain management. Though much has not been done in the area of supply chain management system architecture, it is observed that the typical architecture of the SCMS comprises only the 'source', 'make' and 'deliver' components of the SCM eliminating the 'plan' and 'return'. This makes the system ineffective according to the first level of the SCOR model. To accommodate the plan and return component, the enterprise software applications can lead to serious disruption in business activities. The SCMS software architecture shall be analyzed using the Architecture
system needs to be flexible and integrate easily into the organizations existing business information system. An SCMS which is not sufficiently integrated with the rest of Level Modifiability Analysis (ALMA).

The architecture-level modifiability analysis (ALMA) method

ALMA is a scenario based evaluation method for software architecture quality attributes, focusing on modifiability. It is tested and developed for Business Information Systems (BIS). The purpose of the modifiability analysis is to compare two or more alternative architectures using the four ALMA analysis stages (Ionita et al., 2002):

Step 1: Set the analysis goal
Step 2: Describe the software architecture
Step 3: Elicit change scenarios

Figure 3. Proposed software architecture of the supply chain management system.
Step 4: Evaluate the change scenarios
Step 5: Interpret results.

The supply chain management consists of five stages 1) Plan, 2) Source, 3) Make, 4) Deliver and 5) Plan. The existing software architecture of the supply chain management system handles the Source, Make and Deliver components with no emphasis on the Return and Plan Components which are equally important. Other methods currently available and supporting the analysis of software architecture quality attributes include (Ionita et al., 2002):

1. SAAM, Software Architecture Analysis Method,
2. ATAM, Architecture Trade-off Analysis Method,
3. CBAM, Cost Benefit Analysis Method,
4. FAAM, Family – Architecture Analysis Method,

The ALMA method is used for the purpose of this analysis because it is specially designed for Business Information Systems of which SCM is one.

METHODOLOGY

The research methodology employed for developing the framework for the successful application of IT in SCM is the survey of some supply chain management software. The data for the analysis was collected from technology evaluation center, Asia forum for ERP software and business strategies, and business software.com. A sample of thirty (30) different vendors and their supply chain management packages were selected to identify their supported features based on SCM features defined by the Asia forum for ERP software and business strategies. A typical software architecture of the supply chain management system was evaluated.

Description of the software architecture of the supply chain management system

In the ‘communication layer’, the message communication engines, for example, support the exchange of messages between systems using either SMTP (e-mail), FTP (file transfer) of HTTP (web protocol). A message communication engine is installed on each of the computers to be connected. Then, the local systems can exchange messages through the local engines, which pack, send, transfer, receive and unpack the messages. At the ‘information level’, the stock visibility engines, for example, can present stock data from different local systems. External users can specify their information request via a Web browser. The engines retrieve the stock levels from the local systems and integrate the information in a stock overview. This overview can be displayed to an external user or can be imported in another system in the supply chain. The ‘management layer’ includes engines for advanced management of the supply chain. They have intelligent rules for fully automatic decision making and semi-automatic decision support. For example, distribution management engines can be used for the integral management of distribution services which are provided by independent organizations in a physical distribution network (Verwijmeren, 2003).

A change scenario

In the analysis of this architecture, two scenarios were considered to test the systems flexibility and ability to integrate into the business model for SCM. Considering a case where a defective product delivered to a customer needs to be returned to the manufacturer. The customer may decide to go through intermediaries or directly to the manufacturer. Secondly, other business information system used by the organization may have information necessary for the supply chain management such as market research information from the marketing information system.

Evaluation of the change scenario

When customers for any reason are not satisfied with the product or service delivered to them, they can return same to the manufacturer either directly or via the distributors. This process known as the ‘Return stage’ which poses a problem to the entire supply chain (Venus, 2010). This stage need not be neglected in the chain management and data concerning the return needs to be properly documented. Again, other information necessary for the ‘Planning stage’ of the supply chain management may be within other business information system in the organization. Recall that the ‘Plan stage’ addresses how a given product or service will meet the need of consumers. This means that information such as market research information from the marketing information system is required. Marketing research is the objective gathering, recording, and analysis of all facts about problems relating to the transfer and sale of goods and services from producer to consumer or user (Oladele, 2001). For an effective planning in any organization, different matrices are employed and information from the different units of the organization both internal and external is important.

RESULT INTERPRETATION

From the analysis, 70% of the vendor’s SCMS did not support customer relationship management, 83.3% did not support supplier relationship management whereas 80, 70 and 76.6% supported transportation management, supply management and warehouse management respectively. 66.6% did not support demand management and 53.3% supported sales and operation planning. It was discovered that most supply chain management systems are deficient in the area of ‘Return’ and ‘Plan’ handling. Most of the vendor’s products did not support customer relations management, supplier relations management, and demand management. This means that customer and supplier information is not assessable in the system. This deficiency makes the supply chain unable to handle the following challenges:

1. Customer service
2. Planning and risk management
3. Supplier or partner relationship management.

A careful study of the supply chain management software architecture diagram showed that, the system had no component to handle ‘plan’ and ‘return’ stages of supply chain management.
DISCUSSION

The software component of the supply chain management system should be able to monitor returns from customers and keep record of its source, purpose of return, and quantity, in order to efficiently check and analyze it, to meet customer requirements. There is need for a feedback management engine to manage return services made by customers. The supply chain management system should be easily integrated into other business information systems and application packages used by the organization for good information transfer. The proposed software architecture of the supply chain management includes the following engines in the management and information engine.

Feedback management

This is in the management engine and is used to monitor and manage returned products or services from customers. It is found within the ‘return component’ of the system.

Return confirmation

This is embedded in the information engine and is used to record the necessary information about a returned product such as return source, quantity and purpose of the return. It is also found in the ‘return component’ of the system.

CONCLUSION AND RECOMMENDATIONS

Despite the architectural problem, supply chain management is still a priority for a majority of business executives. SCMS should not be stand alone for easy communication with other departments in the organization. Since supply chain management makes use of forecast, research information from other units in the organization should be accessible by the supply chain management system. The system should be flexible and well integrated into other applications used by the organization. This enables good information dissemination to make the supply chain management effective. The supply chain system architecture should include other business system components such as Customer Relations System (CRM), Supplier Management System (SMS), Order Management, etc in addition to ERP, WMS, and TMS. The system should conform to the supply chain operation reference model while meeting specific business requirements.

For the development of an effective supply chain management system, there is need for the information technology, operations research, supply chain management, and project management units of the organizations to work collaboratively. Supply chain system vendors should offer real time support and maintenance services. Further research on the impact of this architectural change on the cost, benefit, and risks of the supply chain management system is necessary.

Limitations

Inability to access any of the vendor’s architecture for evaluation and some of the vendors submitted no report on certain features to the evaluation centers.

REFERENCES


