B2B e-hubs and information integration in supply chain operations

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Abstract

Purpose – B2B e-hubs have been studied by IS researchers for close to a decade, and supply chain integration is a critical topic for supply chain management. However, the interface of the two topic areas has not received adequate attention from both researchers and practitioners. This paper aims to examine the impact of B2B e-hubs on supply chain integration, with particular emphasis on information integration, B2B e-hub architecture, and enabling technologies.

Design/methodology/approach – General system theory (GST) provides the theoretical framework. The main approach is theoretical analysis of information integration and development of e-hub architecture. The paper discusses how information integration can be achieved through B2B e-hubs and explores extensible markup language e-hub architecture and technologies.

Findings – GST could provide the theoretical framework of integration, whereas information integration is the foundation of broader supply chain integration. E-hubs open up communication and enlarge networking opportunities and thus tremendously affect information integration. By analyzing B2B e-hubs, this paper explores the mechanism of information integration and points out managerial and technical limitations. Although there are many challenges, e-hubs create value by aggregating and matching buyers and sellers, creating marketplace liquidity, and reducing transaction costs. E-hubs could be a crucial solution to supply chain integration.

Originality/value – The paper uses GST as the theoretical foundation to analyze information integration in supply chain operations. The paper explores how e-hubs can support supply chain integration, examines the design and development of B2B e-hub architecture, and compares some enabling technologies. The research provides an understanding of how data interchange solutions can be implemented in supply chain operations.

Keywords Business-to-business marketing, Supply chain management, Integration, Extensible Markup Language, General system theory

Paper type Research paper

1. Introduction

The widespread popularity of supply chain management (SCM) leads to numerous kinds of definitions by different industries and academics. There seems to be a convergence toward the central theme of SCM. The theme suggests that SCM is an integrative philosophy of managing flows of material, information, and finance from the earliest supplier of raw materials to the ultimate customer. SCM can thus be defined as the integration of key business processes from end user through original suppliers that provides products, services, and information and hence adds value for customers and other stakeholders. SCM is a systematic, strategic coordination of the traditional business functions within a particular company and across companies within the

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supply chain, for the purpose of improving the long-term performance of the individual companies and the supply chain as a whole (Menzter, 2001).

In general, SCM involves the flows of material, information, and finance in a network consisting of customers, suppliers, manufacturers, and distributors. Material flows include both physical product flows from suppliers to customers through the chain and reverse flows via product returns, servicing, recycling, and disposal. Information flows involve order transmission and delivery status. Financial flows include credit terms, payment schedules, and consignment and title ownership arrangements. These flows cut across multiple functions and areas both within a company and across companies. (Figure 1; Lambert *et al.*, 1998; Menzter, 2001). Numerous success stories imply that a tightly integrated supply chain can lead to superior chain performance and improved competitiveness for each of the involved channels. Integration of these flows within and across companies is critical to effective SCM.

A truly integrated supply chain does more than reduce costs. It also creates value for the company, its supply chain partners, and its shareholders (Lee, 2000). As mentioned earlier, the core of SCM is integration. Lee points out that supply chain integration constitutes the following three dimensions: information integration, coordination, and organizational linkage. Information integration exchanges information and knowledge through information sharing, collaborative planning, forecasting, and replenishment. Coordination and resource sharing exchanges decision and work through decision delegation, realignment, and outsourcing. Organizational relationship linkage exchange accountability, risks/costs/gain through extended communication and performance measurement, and realignment.

Information integration refers to the sharing of information and knowledge among members of a supply chain. They share demand information, inventory status, capacity plans, production schedules, promotion plans, demand forecasts, and shipment schedules (Lee, 2000). The members also coordinate forecasting and replenishment. Information integration is the foundation of broader supply chain integration. For companies to coordinate their material, information, and financial flows, they must have access to information reflecting their true supply chain picture at all times. Without information integration, few gains can be made in overall supply chain integration. The capability for all supply chain partners to have access to share information on a timely basis is therefore a key to improving supply chain performance.

However, management and integration of information between business partners continues to be a significant challenge for businesses. Despite the advancements in the emergence of data standards, companies are facing difficult decisions about how to integrate systems with external partners to gain competitive advantages. Over the past few years the B2B sector of e-business has grown exponentially. Technical compatibility

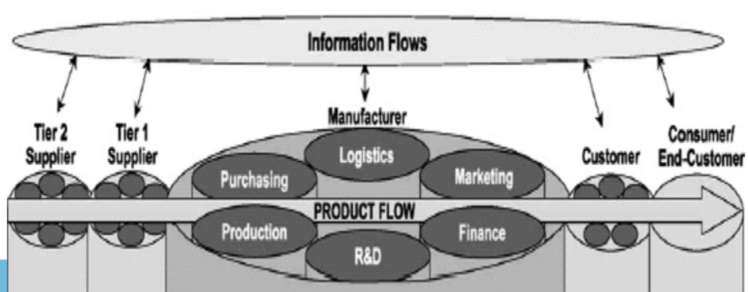

Figure 1.
A supply chain model

presents a great challenge in B2B e-hub and supply chain integration, which typically involves communication across a variety of hardware and software.

For organizations that exchange data via e-hubs, web commerce-server applications are useful for B2C, but they are not sufficient for B2B needs. In general, organizations need to exchange data and messages in more general and flexible ways than they can do with commerce servers. They need to exchange orders, order confirmations, requests for quotations, item inventory status data, accounts payable and accounts receivable data, and a myriad of other types of data and documents. System integration methodologies have evolved from a technical orientation to an effort that focuses on inter-organization perspectives that trend toward B2B integration.

In this research, based on general system theory (GST), we discuss supply chain integration and how B2B e-hubs can help information integration in supply chain operations. We analyze how information integration in SCM can be achieved through new trend of e-hubs. Understanding how these electronic hubs work is crucial to creating a successful e-business strategy and supply chain integration. Although there are potential managerial and technical challenges, we identify that e-hubs greatly facilitate the communication and collaboration among some of the key trading partners. We present a framework for integrating the existing e-hubs into SCM so that future e-hubs could provide better solutions to SCM. We hope that the framework helps both researchers and practitioners identify promising e-hub business models – ones that are both profitable and defensible.

This paper is organized as follows. In section 2, we present GST as a theoretical foundation to examine the relationships of integration and supply chain operations, with a particular emphasis on information integration. Section 3 contains a discussion on how information integration can be achieved through B2B e-hubs. In section 4, we propose an architecture that integrates information in supply chain operations and compare enabling technologies. Section 5 addresses the managerial and technical challenges and suggests future directions.

2. GST and information integration in supply chain operations

To stay competitive, enlightened companies have strived to achieve greater coordination and collaboration among supply chain partners in an approach called supply chain integration (Lee and Whang, 2000).

The companies must expand their integrated behavior to incorporate customers and suppliers. An integrated supply chain is more comprehensive than traditional systems, such as enterprise resource planning (ERP) or decision support system (DSS).

However, integration of business functions and supply chain operations has long been criticized by the lack of guiding theories. Very little research describes and examines the theoretical groundwork for the integration of business functions. By analyzing the features of an integrated supply chain, we propose GST as the referenced theoretical framework, which can introduce various definitions and mechanisms to reveal the nature of supply chain integration.

GST and integration

System thinking can be traced back very early in human history. A system can be defined as a group of interacting, interrelated, or interdependent elements that function together as a whole to accomplish a goal. However, the term GST had not been invented until the 1950s. Biologist von Bertlanffy (1972) integrated earlier system thinking and proposed the GST. GST as a meta-theory can be used to bridge many models with different assumptions. The major concern of GST is to provide a superstructure, which can be applied to various scientific fields. In other words, GST is concerned with developing a systematic, theoretical framework for describing general relationships of the empirical world. The contribution of living/organic/open systems to organization study is that it excluded the nonliving systems from GST and addressed organization related issues such as structure, function, subsystem, information, control, adaptation, system boundary, environment growth, and integration. All these concepts are related to supply chain integration (Zhao *et al.*, 2006).

GST was proposed to transcend discipline boundaries. As a meta-theory, it differs totally from the conventional theories. Conventional theories are usually tied to a set of assumptions. However, GST does not preclude any assumptions before it is applied to a particular context. Therefore, GST can be used to integrate existing theories or invent new theories to fit the needs of different situations. Nonetheless, GST has one universal assumption – non-summative assumption: the whole is greater than sum of its parts. It points out that things emerge when two or more parts act together that are not seen in those parts alone. GST implies that organization as a system must have purpose and goals. The aim of system theory for business is to develop an objective, understandable environment for decision making. This lays the theoretical foundation and basic reason of supply chain integration.

SCM takes a systematic approach to viewing the channel as a single entity, rather than as a set of fragmented parts, each performing its own function. It focuses on managing the total flow of goods to the ultimate customer. Each partner in the supply chain directly and indirectly affects the performance of all the other supply chain members and overall channel performance. The whole performance is greater than the sum of those of its partners. The objective of SCM should be the synchronization of all channel activities to create customer values.

Actually, Siau (2004) observed that a supply chain should have the following features. These features differentiate supply chain integration from expedient measures such as making traditional ERP web-based or combing ERP with analytical supply chain applications:.

- These systems, as a whole, will cover all stages of the supply chain.
- These systems exist as separate components, thus offer more flexible choices to meet the special needs of a company.
- For a targeted supply chain such systems can independently provide not only operation management functions, but also strategic, analytical, and decision support functions.
- Such systems are interoperable and can be integrated seamlessly with each other, and with other company's IT system and consumers along the supply chain through e-business components.
- The integration is dynamic, which means a company is able to choose and integrate with those partner supply chains that best suit its needs. This dynamic integration transforms the supply chain from a traditional fixed sequence into an adaptive network, which helps the company achieve both internal and external efficiencies.

Thus, a system approach is necessary to view the channel as a whole and to manage the total goods inventory from the supplier to the ultimate customer. A strategic orientation toward cooperative efforts is required to synchronize and converge intra-firm and inter-firm operational and strategic capability into a unified whole. Based on GST, we consider supply chain as a complex system in whole, which consists of parts (supply chain partners), all having the same goal and the same focus of serving customers.

Establishing the same goal and the same focus is a form of policy integration (Menzter, 2001). Successful relationships aim to integrate channel policy to avoid redundancy and overlap while seeking a level of corporation that allows partners to be more effective at low cost levels. Policy integration is possible if there are compatible cultural and management techniques among the supply chain members.

The implementation of SCM needs the integration of processes from sourcing to manufacturing and to distribution across the supply chain (Lambert *et al.*, 1998). As one subsystem of supply chain integration (information integration, coordination, and organizational linkage), information systems that links customers directly to suppliers enable the suppliers to react in real time to change in the market places, thereby enabling supply and demand to be quickly matched. Lee (2000) analyzed the three dimensions (actually subsystems) of supply chain integration and concluded that information integration lays the foundation of supply chain integration.

Along the supply chain, the flows of products/services and funds generate a large amount of information that can be used in SCM decision making. To ensure that the information is accurate, accessible in a timely manner, and of the current type, good supply chain information technology architecture, acting as an information enabler, must be constructed. Therefore, an important question arises: how information integration can be achieved in SCM?

B2B and information integration

Technological developments in information systems have the potential to facilitate information integration and this, in turn, should enhance the possibility of virtually integrating the entire supply chain. IT has a pivotal role to play in improving communication and co-ordination by acting as an enabler.

The rising of the internet has made it possible to virtually integrate various channel members and functions of a supply chain. To support the inter-organizational sharing of resources and competencies in network structure, communication and co-ordination needs to be maintained. The internet helps to manage supply chain activities by offering information about what kind of product is demanded, what is available in the warehouse, what is in the manufacturing process, and what is entering and exiting the physical facilities and customer sites. The internet offers a unique opportunity for supply chain operations to take a central stage in the fast online economy. Because it is open, standards-based and virtually ubiquitous, business can use the internet to gain global visibility across their extended network of trading partners and help them respond quickly to changing business conditions such as customer demand and resource availability.

While the most visible manifestation of the internet has been in the emergence of electronic commerce as a new retail channel, it is likely that the internet will have an even more profound impact on B2B interaction, especially in the area of supply chain integration. The internet can redefine how back-end operations, product design and development, procurement, production, inventory, distribution, after sales service support, and even marketing, are conducted. B2B far exceeds B2C both in the volume of transactions and rate of growth. B2B has been used by companies to communicate with business customers, suppliers, trading partners, and numerous other audiences who contribute to operating efficiency and effectiveness.

An important challenge in B2B is interaction (Medjahed *et al.*, 2003). This has been a central concern because B2B applications are composed of autonomous, heterogonous, and distributed components. Although B2B has already had a significant impact on supply chain integration, but it is safe to say that we have only scratched the surface. By adopting B2B approaches for supply chain integration, companies can realize dramatic returns through efficiency improvements, better asset utilization, faster time to market, reduction in total order fulfillment times, enhanced customer service and responsiveness, penetrating new markets, higher return on assets, and ultimately, higher shareholder value (Lee and Whang, 2000).

Over the past 20 years, interactions among loosely coupled and tightly coupled systems had been an active research topic in areas such as database, knowledge-based system, and digital library. B2B requires the interaction and interoperation of both application and data because of issues such as scalability, volatility, autonomy, heterogeneity, and legacy system.

In order to build an integrated B2B supply chain network, there must be an exchange and market place that understand all document structures to facilitate business data interchange services. While the need of the supply chain integration has been recognized there was not a single supportive technology that could integrate the varying demands of the channels for smooth flows of information, one important approach to B2B supply chain integration is e-hubs that instantly process and forward all relevant information to all appropriate partners along the supply chain, so that the entire supply chain can work as a whole. From a general systems theory viewpoint, e-hubs have great potential to link all supply chain partners to function as a whole.

3. E-hubs and information integration

The need for e-hubs is encouraged by the practice of B2B e-business. Unlike B2C e-business, B2B yields direct benefits for companies in the way of reducing transaction time, broadening access to customers and suppliers, and reducing search costs.

There have been speculations about how e-hubs will develop and groom. In this section, we retrospect e-hubs evolution, analyze how e-hubs facilitate information integration, and examine some examples of the impact of e-hubs on supply chain integration. We propose that the next generation e-hubs could act as a control center so that at functional level, supply chain partners will be able to integrate their own operations with other functions, and at channel level all transactions are managed, monitored, and executed in real time by all trading partners.

The e-hub evolution

There are various e-hubs for different industries and various functions, providing unique and overlapping features. The industrial e-hubs basically facilitate buying and selling processes, whereas functional e-hubs provide exchange information on transportation, logistics, or selling facilities. Berryman and Heck have identified three phases of e-hub evolution. The mushroom of the dot.com exchange on the web represents the first generation e-hub. During this phase, companies such as e-Steel and Paperexchange opened up their exchanges on the web and provided a basic portal for consumers to view information and perform basic ordering activities. These all independent start-ups failed in recognizing the role of large enterprises and their financial power in terms of their transaction volume and value.

During the second phase of B2B exchanges, essentially beginning in year 2000, the large enterprises initiated their own exchanges by starting or strengthening their consortia with trading partners. Since the second wave started by large companies, they are ineffective incorporating the needs of small players and are not perceived to be neutral. These exchanges were focused on cutting costs and providing wide choices associated with electronic matching of buyers and sellers.

For the third phase, the authors describe and support four forms of models. The first one follows a hub-and spoke network, in which electronic marketplace will work as a hub for sharing information among various business entities. The second is knowledge based, where industry participants will share knowledge, thereby making it possible to standardize the products and processes. The third one suggests that each model be used for each kind of transaction, thus providing tailored solutions for each participant. The last model is based on an e-distributor concept, in which e-hubs can work as online distributors and take the title of goods they sell. In summary, this research suggests that different types of e-hubs will coexist providing specialized services for various needs and must focus on information sharing among all partners.

How e-hubs work

E-hubs are defined as neutral internet-based intermediaries that focus on specific industry verticals or specific business processes, host electronic marketplaces, and use various market-making mechanisms to mediate any-to-any transactions among businesses (Kaplan and Sawhney, 2000). E-hubs instantly process and forward all relevant information to all appropriate partners. These hubs create value by aggregating and matching buyers and sellers, creating marketplace liquidity, and reducing transaction costs.

Kaplan and Sawhney consider "electronic hubs (e-hubs) as third-party internet-based intermediaries that focus on specific industry verticals or specific business processes, host electronic marketplaces, and enable any-to-any transactions among businesses." The two major types of the e-hubs were envisaged: "vertical" hubs specialized along specific industry or market, and "horizontal" hubs specialized along specific function or business process.

To better understand how e-hub works, Shevchenko (2004), compared e-hubs to conventional supermarkets (see Figure 2). Like the supermarkets in conventional commerce, the e-hubs aggregate customers and producers, and create added value through proposing:

- one-stop shopping, low prices and better quality of products, and services for the consumers; and
- increased marketplace liquidity, reduced transaction costs, well-structured and organized market services, as well as high-quality standards and better competitive image, for the producers.

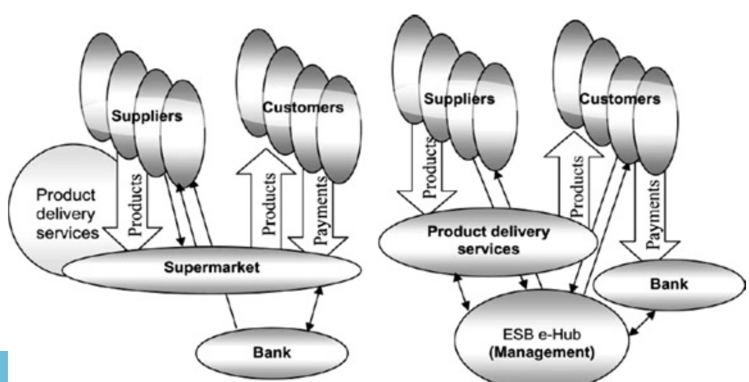

Figure 2.
Supermarket supply chain and e-hub

Thus, the e-hub can be regarded as a web-enabled platform system for multiple trading parties (subsystem) to find, exchange, and prioritize information related buying and selling. Also it automates all different transactions that needed to occur in customer fulfillment, both inbound and out bound.

To understand how e-hubs facilitate supply chain integration, it is useful to understand what businesses buy and how they buy. Businesses buy a diverse set of products and services, ranging from paper clips to computer systems, from steel to machinery. At the broadest level, the purchases can be classified into manufacturing inputs and operating inputs (Kaplan and Sawhney, 2000).

Manufacturing inputs are the raw materials and components that go directly into a product or a process, whereas operating inputs, by contrast, are not parts of finished products. Often called maintenance, repair, and operating (MRO) goods, they include things like office supplies, spare parts, airline tickets, and services.

The second distinction in business purchasing is how products and services are bought. Companies can either engage in systematic sourcing or in spot sourcing. Systematic sourcing involves negotiated contracts with qualified suppliers. Because the contracts tend to be long term, the buyers and sellers often develop close relationships. In spot sourcing, the buyer's goal is to fulfill an immediate need at the lowest possible cost. Commodity trading for things like oil, steel, and energy exemplifies this approach. Spot transactions rarely involve a long-term relationship with the supplier; in fact, buyers on the spot market often do not know from whom they are buying.

As we think about the differences between systematic and spot purchasing, it becomes obvious that the market-making mechanism that is appropriate for MRO and catalog hubs is quite different from the mechanism used by exchanges and yield managers. Kaplan and Sawhney indicate e-hubs create value by two fundamentally different mechanisms: aggregation and matching.

E-hubs that use the aggregation mechanism bring together a large number of buyers and sellers under one virtual roof. They reduce transaction costs by providing one-stop shopping. For instance, PlasticsNet.com allows plastics processors to issue a single purchase order for hundreds of plastics products sourced from a diverse set of suppliers. The aggregation mechanism is static in nature because prices are pre-negotiated. Since buyer and seller positions are fixed in an aggregation model, an important characteristic of this mechanism is that adding another buyer to the e-hub benefits only the sellers.

The matching mechanism is a trade mechanism that creates values by bringing buyers and sellers together to negotiate prices on a dynamic and real-time basis. Imark.com, for example, brings buyers and sellers together in the market for used capital equipment. In contact with the aggregation mechanism, buyers can be sellers in the matching mechanism, so adding a buyer to the hub benefits buyers as well as sellers. The source of value creation in the matching is improved matching due to improved marketplace liquidity. As a dynamic mechanism, matching is more powerful business model than aggregation, but the matching mechanism is far more complex and far more difficult to scale (Kaplan and Sawhney, 2000).

An analog to an e-hub in the physical logistics is "cross-docking," a process in which products from multiple supply sources arriving at a logistics hub are sorted in accordance to the destination points without being stored at a hub. In a small fashion, e-hubs allow critical supply to be cross-docked and seamlessly forward to the right partners at the right time (Lee and Whang, 2000).

An e-hub is indeed a system in the data network where multiple organizations (subsystems) interact in pursuit of supply chain integration as a whole. B2B e-hubs are exchanges and marketplaces, and the name signifies the potential that has been hidden underneath the concept. It is the kernel of the enterprise integration architecture and provides the functions required to execute B2B transaction agreement and manage B2B document exchange in the network. It has the capability of data storage, information processing, and push/pull publishing. The overall network forms a hub-and-spoke system with the participants' internal information system – such as ERP being the spokes. Next we discuss in detail how e-hubs can support information integration in specific supply chain operations.

Procurement

Procurement hubs are initially emerged e-hubs. They are inter-organizational information systems through which multiple buyers and sellers interact to accomplish market-making activities for corporate purchases (Gottschalk and Abrahamsen, 2002).

A typical company needs to procure thousand of products from hundreds of suppliers. E-hubs help to manage the complexity of procurement process. Numerous companies offer enterprise procurement solutions that dynamically link the buyers into real-time trading communities over the internet. They also automate the internal procurement process from requisition to order, as well as the supplier interactions from order to payment. The solutions enable companies to reduce operational costs and increase efficiency by automating the entire indirect goods and services supply chain.

E-hubs offer platforms for trading direct and indirect goods online. Suppliers can securely log into the site and the on-line server confirms their information. Suppliers can create their online catalog, give access privilege to different users and distributors, approve buyers' identities, and offer customized catalogs for buyers. On the other hand, buyers are allowed to see the availability of the goods and track the order status in real time. Additionally, buyers are able to do cross vendor comparison and multiple order processing.

For instance, E2open.com provides supply chain collaboration services and allows integration of suppliers, original equipment manufacturers, contract manufacturers, and distributors by suing global collaboration network. Buyer or manufactures can send their forecast in real time to suppliers. Suppliers can check the availability and production plans and report the exception by providing facilities to sell excess inventory. There is no automated real-time information transfer between buyer and seller, and the exchange is achieved by actual physical posting on the site. In general, the procurement hubs help in reducing transaction costs and search time. The easy access for the suppliers or buyers helps small companies enter into the market where they did not have place before. As a result, the choices for business transactions are greatly widened (Zeng and Pathak, 2003).

Sales forecasting

In the traditional supplier-buyer relationship, companies communicate demand exclusively in the forms of orders. If the suppliers depends solely on orders for future production planning, order data often distort the true dynamic of the market – the well-known "bullwhip effect" (Lee, 2000). Information distortion often rises when partners make use of local information to make demand forecasts and pass them to upstream partners; partners making ordering decisions based on local economic factors, local constraints or performance measures. These distortions are amplified from one level to another in a supply chain, and are considered to be one of the biggest causes of inefficiencies in a supply chain.

One way to counter the bullwhip effect is to have transparency of demand information. To avoid double or triple forecasting, actual sales and inventory data can be shared on e-hubs. For instance, P&G routinely receives sell through data from its major customers' distribution centers and point-of-sales data from some retails stores. It is widely known that Wal-Mart and P&G share information regarding the retails sales of P&G products at Wal-Mart stores. This information sharing enables P&G to do a better job of managing its production of these products and provides Wal-Mart with greater in store availabilities.

P&G and Wal-Mart indeed found a way to leverage on information technology by sharing data across their mutual supply chains. The resulting channel has become more efficient because channel activities are better integrated. There are reduced needs for inventories but greater returns by focusing on selling what the customers want. The e-hub between P&G and Wal-Mart has adopted a much better customer focus through the channel partnership. It is mutually beneficial. Both parties gain benefits that could not be obtained on their own. The whole is greater than the sum of its parts. This integration of the supply-chain information systems will become increasingly important for enhancing business-to-business electronic commerce.

Cisco has also embarked on a very ambitious project to create an e-hub linking multiple tiers of suppliers via the internet. It is intended to using to coordinate supply and demand planning across the supply chain. The e-hub will also help identify potential supply chain demand problems early, provide proper warning to the appropriate parties, and permit prompt resolution via the internet.

Inventory

Inventories provide a means to combat uncertainties in component/product supply and demand. At the same time, inventories can present a threat to cooperative profitability. Systematically sharing information reduces operational performance risk because it makes processes easier to monitor by substituting information for inventory.

One of the most frequently shared data sources between supply chain partners is inventory level. E-hubs can increases inventory visibility. Many research results show that inventory and communication are economic substitutes (Lee, 2000). Access to supply chain inventory status can contribute to lowering the total inventory level in the supply chain. Consider two companies in a supply chain in which a retail chain purchases products from a manufacturer. If the retailer and the manufacturer independently manage their respective inventories without sharing inventory status information, they must end up having duplicate safety inventories or stock-outs at both locations.

A solution to this inefficiency is to coordinate the management at two sides. Echelon-based inventory control is optimal under certain assumptions. The echelon inventory is the combined inventory at the site and at its downstream partner. To implement echelon-based inventory control, the upstream company should keep track of the inventory level at the downstream end of supply chain and start production only when the echelon inventory position is low enough. This way, the upstream company can better determine when and what to produce and downstream companies can improve the service level with fewer inventories (Lee and Whang, 2000).

In addition, goods can be tracked/monitored through the e-hub in real time from acquisition to delivery. The hierarchy of control and communication can generate a real-time report of system status at any desired levels of detail. For example, a company can establish a production plan according to the market demand and release purchase orders to the suppliers. When raw materials are required, the manufacturer procures the needed items from the suppliers of raw materials and components. Then, the supplier examines the supply and demand situation of the materials and prepares for delivery transportation by an e-hub. The e-hub prepares for the proper transport of goods, allocates goods to the designated place, and transports the goods to the destination. All the upstream and downstream partners use the web-based real-time tracking system to review the status of inventory.

Transportation

Transportation, as a spatial linkage for the physical flows of a supply chain, is associated with the physical movement of goods from one place to another. By its nature, transportation is a geographically diversified and fragmented industry. Time and cost are two most important factors differentiating the transportation service providers, and when both are reduced, the value delivered to the ultimate customers can be added (Menzter, 2001).

For instance, Freightquote.com offers enhanced modal services by focusing on inter-modal transportation needs of shippers within confined geographical territory. Shippers can select a mode of transportation and provide detailed information about their load and requirements. They can save efforts by entering repetitive information in product log. Based on the various available options they can select and confirm the deal with the carrier online with additional facilities, like electronic payments and shipments tracking related tasks.

Apart from these basic facilities Freightquote.com offers enhanced services beyond basic transportation services. For those shippers who are exporting goods to North American Free Trade Association countries, detailed instructions and invoices are provided online. Claims reporting is provided between the shipper or consignee and the carrier and Freightquote.com is not involved in the actual claims process. Shippers can also buy insurance for their shipments at the end of confirmation for their shipping order. One major function that can facilitate supply chain integration by creating visibility among various entities is to authorize restricted or complete access to various persons and organizations (Zeng and Pathak, 2003).

E-hubs offer some general benefits to all partners. For both carriers and shippers, transportation e-hubs widen the choices available as any shippers/carriers can enter into the market easily. E-hubs reduce the search time associated with the process by providing easy criteria-based search function. The transportation and communication substantially reduce time of processing and managing transportation needs. Carriers improve business practices by utilizing their unused capacity and there by optimizing their capacity utilization.

4. B2B e-hub architecture and enabling technologies

With the rapid expansion seen in B2B e-hubs, there is a major need for infrastructures and frameworks that can be used to implement inter-organization integration. In this section, we describe B2B e-hub architecture and overview and compare some technologies, particularly extensible markup language (XML), which provides support for routing of information flow among trading partners for internet-based B2B transactions.

E-hub architecture

E-hubs are neutral internet-based intermediaries that focus on specific industry verticals or specific business processes, host electronic marketplaces, and use various market-making mechanisms to mediate any-to-any transactions among businesses. E-hubs provide not only an administration portal to first-tier suppliers; it also serves as a trading partner portal to manage the profiles of business partners. There are various e-hubs for different industries and various functions, providing unique and overlapping features.

B2B e-hubs cover a wide spectrum of interactions among business partners. The types of interactions depend on the usage scenarios, parties involved, and business requirements. Each framework makes specific tradeoffs with regard to the requirements of B2B interactions. It is therefore important to determine the relevant requirements and understand the related tradeoffs when evaluating models of interactions. Medjahed *et al.* (2003), from a technological viewpoint, presented three layers of B2B interaction frameworks: communication, content, and business process layers.

The communication layer provides protocols for exchange messages among remotely located partners (e.g. HTTP and SOAP). It is possible that partners will use different proprietary communication protocols. In this case, gateways should be used to translate messages between heterogeneous protocols. The objective of integration at this layer is to achieve a seamless integration of the communication protocol.

The content layer provides languages and models to describe and organize information in such a way that it can be understood and used. Content interactions require that the involved system understand the semantics of content and types of business documents. The objective of interaction at this layer is to achieve a seamless integration of data formats, data models, and languages.

The business process layer is concerned with the conversational interactions (i.e. joint business process) among services. The objective of interactions at this layer is to allow autonomous and heterogeneous partners to come online, advertise their terms and capabilities, and engage in pear-to-pear interactions with any other partners. Interoperability at this higher level is a challenging issue because it requires the understanding of the semantics of partner business processes.

In this research, we, from a system theory viewpoint, present a three-tier framework, which is consistent with widely used e-business application architecture. Figure 3 shows the layered B2B e-hub architecture for information integration.

The user layer consists of computers that have browsers that request and process web pages. A browser is a computer program on the client computer that processes the web page. For instance, for website walmart.com, the browser issues a request via HTTP for the web server at the domain name walmart.com to send users to its default web page.

The server layer consists of systems that run servers and process application programs. In order to build a system-to-system supply chain network, there must be an intermediary server (XML trade hub) that understands all document structures to facilitate business data interchange services.

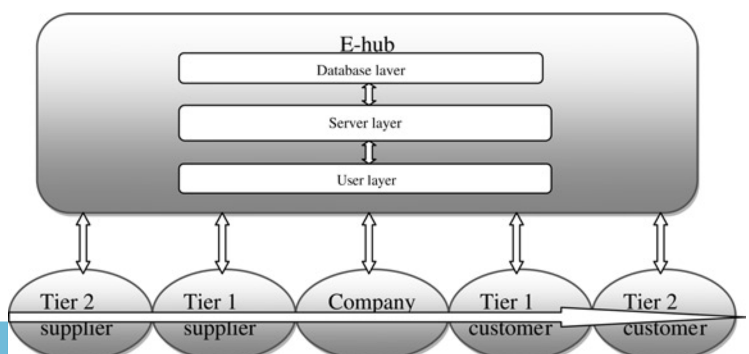

Figure 3.
E-hub architecture

Three kinds of service could be provided by server layer (Hou *et al.*, 2004):

(1) The B2B mapping service dynamically constructs business document mapping based on individual trading partner's business logic. B2B mapping service is the module for defining the B2B protocols and saving the protocols in the document exchange database. There are two components in this module: document types and document semantics.

(2) The exchange service is responsible for translating the document format using the XSLT template, controls the message queue receiving incoming XML documents, and replies to or triggers transmittal of documents to other trading partners. The exchange service manager is responsible for sending and receiving business documents while providing the correct translation template and transportation binding. Two components in this module are: document translation and exchange process manager.

(3) *Registry services*: each trading partners must register their company information and its business objects through the registry service before conducting transactions with other e-hub reading partners.

The database layer consists of systems that run DataBase Management System (DBMS) that process structured query language (SQL) requests to retrieve and store data. The supply chain database maintains information specific to the operations of the supply chain partners to customers. This information would most likely not be available to customers. This database stores internal supply chain information such as demand forecasts, sales data, inventory levels and location, production schedules, capacity availability and distribution data across the entire supply chain.

The B2B document exchange database: the database contains all data for the mapping models. All components retrieve and store data in this database. There are two modules in this tier. The security module provides the functionality for encryption, decryption, and IP locking methods. The transportation module provides the connectivity to the internet for data transmission.

Enabling technologies for supply chain integration

Technologies for B2B e-commerce have been studied for almost two decades providing business with a secure framework for sharing and exchanging data electronically. The technology used in B2B hubs is critical to the success of supply chain integration. In fact, the key inhibitor to supply chain integration has been technology. Technical compatibility presents a great challenge in supply chain architecture, which typically involves communication across a variety of hardware and software. Systems from different vendors and on different platforms may not be compatible. Siau (2004) described a list of enable technologies for supply chain integration: XML, CORBA, DCOM, Enterprise JavaBeans, SOAP, .NET, and Semantic Web. We will focus on XML and compare different existing technologies.

EDI vs XML

The most widely used and earliest framework is EDI standard that runs on dedicated computer networks. EDI standards provide a single homogeneous solution for content interoperability. They describe a set of types for describing business documents. EDI is commonly defined as the inter-organizational application-to-application transfer of business documents (e.g. purchase orders, invoices, shipping notices) between computers in a compact form. Its primary aim is to minimize the cost, effort, and time incurred by the paper-based transfer of business documents. EDI documents are structured according to a standard and machine-processing format.

EDI technology has been shown to facilitate accurate, frequent, and timely exchange of information to coordinate material movement between trading partners. Suppliers receiving just-in-time schedule information achieved better shipping performance. Similarly, suppliers with the ability to map incoming information to internal production control systems directly were found to enjoy even greater benefits.

Technically speaking, EDI is one well-known example of structured document content, to be changed between software applications that are working together to process a business transaction (Medjahed *et al.*, 2003). A practical problem that must be addressed when designing an EDI process is the lack of a globally recognized standard format for data storage and transfer. Because standards are lacking, organizations must agree upon the translation software and data format on a project by project basis. Without an agreement upon a standard the EDI process will not work. This is one of the reasons why there is a general movement away from these transaction-specific connections to more flexible methods of electronic information transfer. In addition, it would be difficult for trading partners to conduct transactions whose parameters are not included in an EDI document. In that regard, EDI is not very flexible in its ability to expand the set of supported document types.

EDI has been extended in many directions. The combination of EDI and the internet technologies seems to overcome several shortcomings of the traditional EDI. For instance, business documents in EDI standards have been mapped to XML documents. The use of XML-based e-business frameworks has increased more than the use of EDI-based e-business frameworks. XML-based e-business frameworks are more common in the industries for which there exists an XML-based but no EDI-based industry-specific e-business frameworks. XML, a standard markup language that offers advantages over EDI, will eventually replace EDI (Kroenke, 2007).

XML is a markup technology, much like hypertext markup language (HTML), that provides meaningful information – known as meta-data – about a data set through the use of tags. It describes structured data in one document or application, such as web page or a data repository, so that it can be used by another application or document. XML functions as a grammar or syntax for organization information and is interpreted by tools called parsers.

XML is a technology ideally suited to these requirements. It is a rich data format with a structure which can be validated. The semantics can be defined to meet the requirements of a particular industry.

It is an open standard, which brings many free extras. It is rich enough to transmit complex database information, and can convey information to keep in synch multiple databases even with very different schemata. For all that, it is easy for a machine to process.

It is also human readable, so that if we have not set up a system yet, we can still interact with the information on an *ad-hoc* basis, even if we are communicating with an automated system on the other end. The basic idea behind an XML interchange is to allow the definition of style sheets to transform one XML vocabulary into another. The any-to-any converter of XML formats in the supply chain enables many backend systems to interact with each other. Since XML's roots are as a document format, it can of course be used to automate business documents, but it can also serve as a rich messaging format, even for inter-process communication and can even be a low cost substitute for complex EDI technologies.

XML and EDI are two technologies for data exchange. While EDI is a well-known standard for data exchange, XML is not a standard in the same sense. Instead, it has the capability to define the contents of documents through a set of elements or tags. EDI is based on the notion of transaction sets, which are standard formatted documents such as a purchase order, delivery agreement, etc. Each transaction set defines the precise structure of the corresponding document and is used to exchange business information between partners. XML, on the other hand, is designed to be extensible by allowing users to define various entities on a form, such as name, address, price, quantity, etc. as tags or elements, thus creating user-defined forms (Medjahed *et al.*, 2003).

HTML vs XML

HTML, the current language of the web, is a presentation only language. It simply indicates how a web browser is to present/render the web page represented by the HTML code. However, HTML is a user interface standard for visual display and is insufficient for B2B integration. Thus, while HTML provides rich facilities for display, it cannot support the content and logic that are needed for today's web applications. There is a need for standard like XML that provide a universal data schema to represent information context.

In detail, HTML has the following shortcomings (Kroenke, 2007):

- HTML tags have no consistent meaning. The tags are used inconsistently. Unfortunately, there is no feature of HTML that forces consistent use. This limitation means that organizations cannot use HTML tags to reliable exchange documents.
- HTML has a fixed number of tags. It defines a fixed set of tags. If two businesses want to define a new tag, there is no way in HTML for them to define it. HTML documents are limited to the predefined tags.
- HTML mixes the structure, formatting, and content of a document. Ideally, the structure, format, and content should be separate.

The emergence of XML has attracted much attention from both technical and business aspects. The simplicity of the XML format and its natural extension to commonly used HTML makes it easy to quickly integrate new applications with legacy systems. Thus, an XML specification can serve as an interface among business partners and their backend system for B2B integration automatically. XML solves the problems of HTML by requiring that content, structure, and format be placed into separate documents. Further, document designers can create their own tags and specify the precise arrangement of those tags in a document called an XML schema.

An XML document consists of nested data items called elements which can have sub-elements and attributes. It is associated with a type generally defined as a DTD or XML schema. The type describes the structure of the document and the relationships between the various elements that from the document. Encoding business information in an XML document with a common XML schema eliminates the need for one-to-one information transaction. An organization would create and publish XML documents that describe its offers, requirements, assumptions, and terms for doing business. Partners would then interact with each other after inspecting and understanding each other's descriptions.

In general, a complete XML-based integration requires standardized domain-specific ontology (such as an agreed upon DTD or XML schema), mapping between different ontology descriptions, and means for processing XML documents and invoking appropriate services to handle requests (Medjahed *et al.*, 2003).

The extensibility of XML makes it ideal for B2B e-business applications. Unlike traditional B2B technologies, which are oppressively rigid and expensive (thus making it impossible to add new partners to the system without disrupting all the order partners), XML lets one dynamically add partners, content, products, etc., to one's B2B applications without requiring any modifications to the application itself. The democracy of data exchange provided by XML benefits all computers. Large companies can integrate small manufacturers into their supply chains and reduce cost and complexities in inventory management between trading partners. Because of this ease of using XML as the standard means of exchanging data, it is becoming the preferred way to make legacy data available to users via the internet. Also, because XML is extensible by design, web designers of the future could create custom documents while developers write programs to interact with them.

There are a large number of XML-based frameworks for B2B interactions. BizTalk, cXML, eCO, RosettaNet, and ebXML are a representative set of XML-based interaction frameworks. An exhaustive list of XML-based B2B standardization can be found in Bussler (2001) and Medjahed *et al.* (2003). Existing frameworks mostly deal with enabling B2B interactions at the content and business process layers. However, these frameworks sometimes overlap or even compete with each other. The issue of interoperability has thus shifted from the level of applications to the level of standards. A traditional partner has to deal with several standards at the same time. In case one trading partner exchanges messages across industries, the variety of standards is likely to increase even more. One solution to deal with such problems has been described in through the use B2B protocol and integration engines. These execute actual message exchanges according to various standards.

5. Managerial and technical challenges and future directions

There are several managerial challenges that exist for those wanting to use e-hubs. First, sharing information with a supplier on e-hubs can jeopardize confidentiality. Many managers are not ready to share information with other supply chain members. Second, in many firms, management has not achieved internal integration of information systems and business processes. Internal integration is needed for achieving external integration on e-hubs. Third, competition for traffic leads to competition for setting data format standards. E-hubs provide connectivity to supply chain partners, but how will interfaces with other information hubs be implemented? Once a public information hub has gained critical mass by attracting the key players in an industry, standards could be used as a competitive weapon (Lambert *et al.*, 1998).

Kaplan and Sawhney (2000) similarly indicate that important characteristic of an e-hub is its bias. Most of the e-hubs are neutral-they're operated by independent third parties and do not favor buyers over sellers or vice versa. Neutral e-hubs are the true market makers because they are equally attractive to buyers and sellers. But neutral e-hubs face some daunting challenges. At first, they confront a "chicken and egg" problem: buyers do not want to participate unless there are a sufficient number of sellers, and sellers do not want to participate unless there are a sufficient number of buyers. To succeed, these e-hubs must attract both buyers and sellers quickly, creating liquidity at both ends. Neutral e-hubs also have to overcome the sellers' channel conflict. In addition, neutral e-hubs need to be careful when taking equity investments from large buyers as well as from large suppliers; such investments can create a perception of bias.

There are also technical challenges. Since the demand for high speed internet services for processing voluminous data, there is a need for high speed internet portals. There are many internet portals offer services to companies to have their products on e-marketplace. However, the system is slow during peak hours. They may lose their patience in buying products online. Hence, there is a need to trade-off between the quantity and quality of information that should be made available on their web site and the speed of access.

Developing e-hubs infrastructure requires investment in internet services, web development and updating. Companies should decide the type of e-hubs that would be suitable for their business. IT migration is required from time to time based on the changes to the business process and organizational objectives and strategies. This highlights the importance of being learning organization that obviously supports agility in internet-enabled supply chain integration.

Although XML is faster and cheaper to implement, it is not perfect. XML in comparison with other potential technology choices may make fewer machines efficient. For systems that are more permanent, and must have better performance requirements, CORBA, COM, or EJB are potential next steps. One of the weaknesses of XML is the possibility of variant interpretation, because different companies may each parse the XML content in their own and different ways. Building a vertical vocabulary is one way to overcome this (Siau, 2004).

As for challenges ahead, XML constraint checking technologies need to keep up with the voluminous research that has been performed on relational and object-oriented DBMS. Some of the issues include the investigation of active triggers, a feature commonly support in many DBMS, and seeing how they can be applied to XML schema/database. With a potentially huge amount of data being transmitted by B2B, how can the constraints be validated efficiently? Many research issues remain for this exciting area of XML-based information integration in supply chain operations in the years to come.

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