A KNOWLEDGE MANAGEMENT ARCHITECTURE IN COLLABORATIVE SUPPLY CHAIN

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ABSTRACT

Recent advances in the field of computer networks and Internet have increased the significance of electronic commerce. Through electronic networks, companies can achieve integration by tightly coupling processes at the interfaces between each stage of the value chain. Electronic linkages in the value chain have been fundamentally changing the nature of inter-organizational relationships. Organizations are redesigning their internal structure and their external relationships, creating knowledge networks to facilitate communication of data, information, and knowledge, while improving coordination, decision making, and planning. This study is devoted to examining the types of knowledge flow in collaborative supply chain, and proposing a knowledge management architecture to facilitate knowledge management in collaborative supply chain. Three cases are presented to outline how different industries build their e-business model under different architectures. Also, knowledge flows are discussed in these e-business models. These case studies reveal the benefits that organizations can achieve through the implementation of electronic commerce technologies in collaborative supply chain. The results also show that different network type of supply chain, the amount of transaction, and the main collaborative function in the supply chain will lead to different type of knowledge flow and the tools adopted, and ultimately different knowledge management system.

Keywords: knowledge management, electronic commerce, collaborative supply chain, knowledge management system architecture.

INTRODUCTION

Competitive pressures are forcing companies to take available actions to reduce costs and compress time between each stage of the value chain (24). Recent developments in the field of computer networks and Internet have increased the significance of electronic commerce. Electronic commerce (e-commerce) refers to conducting business electronically. Benjamin et al. (6) have argued that electronic commerce can reduce the costs of integrating customers and their suppliers. Through electronic networks, companies can achieve integration by tightly coupling processes at the interfaces between each stage of the value chain. The customers get benefits through EC networks due to lowering of search cost, while the manufacturers get the benefit of the economy of production by attracting more business from the customers by providing their products at a lower cost. Also, electronic linkages in the value chain have been fundamentally changing the nature of inter-organizational relationships (24). To support the inter-organizational sharing of resources and competencies in a network structure, communication and coordination need to be maintained. Organizations are redesigning their internal structure and their external relationships, creating knowledge networks to facilitate improved communication of data, information and knowledge, while improving coordination, decision making and planning (41). Knowledge networks allow their participants to create, share, and use strategic knowledge to improve operational and strategic efficiency and effectiveness. This study is devoted to examining the types of knowledge flow in collaborative supply chain and proposing a knowledge management architecture to facilitate knowledge management in a collaborative supply chain.

COLLABORATIVE SUPPLY CHAIN

To position our study, we use the standard classification of electronic commerce. Consumer-oriented commerce comprises business to customer application such as shopping and banking. Business-to-business commerce is the typical application domain of electronic data interchange (EDI) where business partners join forces to enact inter-organizational business processes. Intra-organizational business facilitates the sharing of business information, maintaining business relations, and conducting business transactions within the company. As we just stated above, electronic commerce refers to conducting business electronically. There is a revolution transforming the global economy. The rate of technological change is so rapid that emerging e-commerce already is making fundamental changes in the economic landscape, affecting every aspect of how business is and will be conducted. E-commerce technologies enable more collaborative relationships by changing the multi-functional interactions between customers and their suppliers. Companies are now pursuing more intensive and interactive relationships with their suppliers, collaborating in new product development, integrating key business processes and cross-functional information sharing on a range of issues, and exchanging strategic knowledge in order to achieve mutually beneficial objectives. This electronic commerce knowledge can be termed "e-knowledge" (14). Among all these e-commerce issues, business-to-business e-commerce is projected to constitute the largest portion of the whole e-commerce market. Some estimates put B2B to be close to 78% of the overall EC market (36).

There are two types of B2B EC markets. One is related to the management of material flows in production-oriented supply chain networks. The other is related to the procurement of maintenance, repair, and operation (MRO) items, sometimes referred to as the indirect items. For the procurement processes, electronic data interchange has been used to forge automated linkages between the buyers and suppliers to transmit orders, receipts, and payments electronically. According to Warkentin et al. (41), the primary objective of traditional supply chain management was the minimization of "the total cost of transportation, warehousing, inventory, order processing and information systems" (39). Progressive supply chain management encompasses the planning, directing, and controlling of the flow of products, services, and information from a firm's supplies' suppliers to its customers' customers, through intermediaries such as distributors and retailers (2). The purpose is to coordinate activities "across the supply chain to create value for customers, while increasing the profitability of every link in the chain. This coordination aspect addresses the role of shared knowledge that enables the analysis and management of all supply chain activities. The nature of information exchange between supply chain partners has evolved from limited information sharing environments to sharing of rich knowledge between partners (41).

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Knowledge Flows in Collaborative Supply Chain

In managerial issues, Knowledge Management (KM) is increasingly viewed as a crucial factor for competitive success. At the same time, the academic question of how knowledge should best be defined is still a subject in debate. On one hand, knowledge can be seen as a representation of the real world; on the other, it can be conceptualized as a product of the interaction between individual cognition and reality (18).

Many of us have an intuitive feel for what knowledge means. There has been an emerging shift in firms beginning with a focus on data, and further refining into information and information systems. From the perspective of a firm, data is a set of particular and objective facts about an event, the purchase of something at the grocery store or a change in the stock price, for example. Such figures are not meaningful until they are converted into some form of information. Information is regarded as an organized set of data. It is data endowed with relevance and purpose. On the other hand, knowledge is an organized combination of data, assimilated with a set of rules, procedures, and operations learned through experience and practice. In a sense, knowledge is a "meaning" made by the mind (20). Without meaning, knowledge is information or data. Thus, the distinction between information and knowledge depends on users' perspectives (7). Knowledge is context dependent since "meanings" are interpreted in reference to a particular paradigm (20).

According to Nonaka and Takeuchi (30), knowledge can be classified into two broad categories: tacit and explicit. Tacit knowledge consists of mental models, beliefs and is personal, context-specific which is difficult to formalize, record, or articulate; it is mainly developed through a process of trial and error encountered in practice. Every employee has a wealth of tacit knowledge deeply rooted in his or her actions, particular craft knowledge or product market. Explicit knowledge is knowledge that can be codified and transmitted in a systematic and formal language: documents, databases, webs, e-mail, charts, etc. Pakstas (31) suggests that there are two types of knowledge flows in typical inter-organizational media-based communications activities – informally and formally structured. Formally structured knowledge includes web publishing content, EDI transaction information and files transferred. Informally structured knowledge includes e-mail, dialogues on BBS and coordination process.

Miller, Demaid and Quintas (27) identify five categories of knowledge: catalogue knowledge (know-what), explanatory knowledge (know how), process knowledge (know how), social knowledge (know who), and experiential knowledge (what-was). Tiwana (40) categorizes knowledge into three types. Externalized knowledge is complex and initially tacit, and can be externalized and embedded in a company's products and process. Multi-locational knowledge might be resident both within the organization and outside it, and is mobile and convertible from tacit knowledge into a form of explicit knowledge. Migratory knowledge is knowledge that is independent of its owner or creator. As this kind of knowledge becomes more and more extensively codified, its capacity to more increases. Bhatt (7) argues that organizations possess foreground knowledge and background knowledge. Foreground knowledge is much easier to capture, codify, and imitate, while background knowledge is tacit and sticky, which makes it difficult to replicate and imitate.

Knowledge Flows in Collaborative Supply Chain

To discuss knowledge flows in collaborative supply chain, we categorize the source of knowledge into seven functional linkages of supply chain – design and development, pre-sales, sales, manufacturing, distribution, service and supply and finance, and further distinguish these knowledge flows into formally structured and informally structured knowledge. Formally structured knowledge is usually explicit and can be codified in a formal format. In collaborative supply chain, it is usually transmitted by technologies such as EDI, web pages, FTP, etc. Informally structured knowledge is difficult to formalize, record and is context-specific. It is usually embedded in processes or in the heads of people. In collaborative supply chain, this kind of informally structured knowledge flow is usually transmitted by technologies such as e-mail, video conferencing, bulletin boards, etc. Table 1 shows the knowledge flows in each linkage.

In design & development process, organizations in the value chain face the pressure of increased emphasis on customer satisfaction. In order to achieve these goals, manufacturers have to collect customer needs and market trends from their wholesalers, distributors, retailers, and even directly from their customers. Also, information such as CAD/CAM and engineering specification is helpful.

Unlike the supplier-customer relationship in B2C e-commerce, the buyer-supplier relationship in supply chain is more close and specific. So during the pre-sales and sales processes, information such as cycle-time, service level and available-to-promise (ATP) quantity is needed for the buyer-side, and request-for-quotation and detailed purchasing information is needed for the suppliers. Salesman's customer relationship and service proposal are also valuable knowledge, although they are hard to codify and transfer.

In the manufacturing process, knowledge flows in the manufacturer side such as production plan, shop flow schedules, production capacity, inventory level and special processes are helpful for customers to make arrangement about their orders. Customer side's demand forecast is, however, an important source for the manufacturers to set their production plans.

TABLE 1
Knowledge Flows in Each Linkage of Collaborative Supply Chain

	Formally Structured	Informally Structured
Design & development	•CAD •Component specs •Estimated cost •Engineering change	•Market •Concept •Target for quality and cost
Pre-sales	•RFQ •Response and cycle time •Service level and order fill rate	•Bid process
Sales	•P.O./contract •Credit status •Sales proposals	•Relationship with customer
Manufacturing	•Production plan •Schedule •Capacity •Inventory level •Quality plan	•Demand forecast •5S, layout •Technique/special skill
Distribution	•Shipment plan •Delivery plan	•Logistic process
Service & support	•Customer complaint •Technical document	•After sale service •Technical support
Finance	•Invoice •AP/AR •FEDI •Finance report	•Credit

Customers are eager to know the status of their orders, especially when scheduled due date is hereby. So the shipment plan and delivery information during distribution period are important for both suppliers and customers.

After-sales service is always critical for the customers to perceive the quality delivered by manufacturers. Through service and support process, customers can get help about static technical document and interactive support, and manufacturers can collect important knowledge from customers' complaint.

Finally, financial supporting process handles invoices transaction. This kind of information mostly is formally structured and EDI based.

Knowledge Management Architecture for Collaborative Supply Chain

Information Technology Tools. A common base for both e-commerce and knowledge management system is information technology (IT). To support the inter-organizational sharing of resources and competencies in a network structure, communication and coordination need to be maintained. IT has a pivotal role to play in improving communication and coordination. Many of the technologies that support knowledge management in collaborative supply chain have been around for a period of time. These technologies can be classified into five categories according to their functions in the collaborative supply chain knowledge management system. These five functions stand for five different processes in the knowledge value chain – knowledge storage, data exchange, information messaging, process collaboration, and knowledge creating.

Knowledge storage related to any types of knowledge in each part of supply chain. Traditional databases, file systems and legacy systems are basic technologies for this stage. Almost every company has its own database for operation data and other sorts of information and knowledge. Data warehouse can combine and aggregate data from multiple sources, and make it possible to run queries simultaneously across several different databases. The ultimate objective for knowledge storage stage in collaborative supply chain is to set up a knowledge server. A knowledge server allows smooth integration across multiple enterprises that use the same knowledge server. It provides an extensible architecture unifying and organizing access to disparate corporate repositories and Internet data resources as a first affirmative step toward building content for the knowledge management system (40).

Data exchange, information messaging, and process collaboration represent the same function in knowledge management system – knowledge distribution. In data exchanging, formally structured data such as product data, technical data and engineering data are transmitted through EDI technology or through web pages. It is the usual way that traditional e-commerce communicates. Information messaging, however, transfers formally structured information such as documents, files and informally structured information such as e-mail and discussion. They are also common ways for the customers and manufacturers in collaborative supply chain to communicate and share knowledge, but usually they were treated as informal communication channels and abundant knowledge was overlooked. Process collaboration refers to the process of creating, sharing and applying knowledge. Knowledge-based activities related to innovation and responsiveness are intensively collaborative, involving people from different locations and different background. The basic technologies to support such collaboration include groupware, electronic meeting and videoconference. Sometimes companies in the supply chain build their own inter-organization collaboration platform for the security and efficiency.

TABLE 2
Knowledge Related Functions and Their Supporting IT Technologies

Functions	Knowledge Storage	Data Exchange	Information Messaging	Process Collaboration	Knowledge Creating
	•Databases	•EDI	•E-mail	•Groupware	•Data mining
	•File systems	•Web pages	•BBS	•Electronic meeting	•DSS
Supporting	•Legacy systems		•FTP	•Video conference	•Generic algorithm
Technologies	•Data warehousing			•Project management	•Intelligent agent
	•Knowledge server			•Workflow	

Knowledge creation relates to knowledge addition and the correction of existing knowledge (37). It emphasizes interactions between individuals and organizations. Technologies supporting knowledge creating in collaborative supply chain include data mining, decision support system, genetic algorithm, neural networks, export system and intelligent agents, etc. These technologies all serve one purpose – to find, summarize, interpret, and analyze large volumes of data and contextualize information efficiently and effectively.

A Knowledge Management Architecture. In our knowledge management model, we propose a four-layer architecture to describe knowledge flows in collaborative supply chain – infrastructure layer, backbone layer, tools layer, and knowledge flows layer. Figure 1 shows this four-layer architecture.

For the infrastructure layer, it is the basis of knowledge management system and the driver facilitating knowledge management activities. To describe elements of this layer, we adopt Meso and Smith's organizational knowledge infrastructure model (26). There are four kinds of infrastructure – technology infrastructure, organizational infrastructure, corporate culture infrastructure, and human resources infrastructure. Technological infrastructure comprises hardware, network, intranet and protocols that allow for the encoding and electronic exchange of knowledge. Organizational infrastructure refers to the set of roles and organizational teams whose members have skills to serve as resources for individual projects in each organization collaborative supply chain. It defines how the employees are organized into formal and informal teams; how these teams interact; and how these teams' goals relate to the overall strategy. Culture refers to the shared beliefs, norms, ethics and practices within an organization. Krogh (18) suggests that cultures with a quality of "care" facilitate organizational members' communication and sharing of knowledge. Effective knowledge sharing and management happens in companies that are characterized by greater openness and access to information and unobtrusive managerial structure. Human resource infrastructure refers to provide the maximization of productivity, quality of work life, and profits through better management of people to facilitate knowledge creation, distribution and application. The core of the knowledge management is the people. A high quality level of employee will prompt knowledge activities in collaborative supply chain.

Enterprise resource planning (ERP) has been rapidly developing in recent yeas. It allows companies to integrate various departmental information including logistics, cost accounting, human resource and other features relevant to production systems. ERP attempts to integrate the suppliers and customers with the manufacturing environment. These integrated interconnections ensure that information in one part of the business can be obtained by any other unit. Supply chain capabilities of ERP increase efficiency and productivity for their users. By linking supply chain application with other business systems, companies can reach beyond their own corporation to better connect with suppliers, distributors, and end users. So, ERP backbone provides information sources for the knowledge management system in collaborative supplier chain. In the backbone layer, product data management (PDM) as well as ISO 9000 is also included. The main purpose of a PDM system is to manage the design process and maintain the data of products during their life cycles. Many kinds of data used in PDM, such as bill of material (BOM), are also required by ERP during the design or production planning stage. On the other hand, the ISO 9000 series of standards was published in 1987 for its first publishing to provide the industry with guidelines on how to establish a system for managing product and service quality. The ISO 9000 standards attempt to build in quality through examination of the entire design, development and manufacturing, distribution and service and support processes. Kanji (15) argues that ISO 9000 gives a consistent set of procedures and requirements that can be universally applied. It provided an acceptable platform for documents and processes to communicate and collaborate.

The tools layer comprises of five kinds of tools facilitating knowledge flows – knowledge storage tools, data exchange tools, information management tools, process collaboration tools and knowledge creation tools. With help of these tools, all kinds of data, information and knowledge can be transmitted, communicated and distributed over the collaborative supply chain.

In order to leverage its competitive position in supply chain, a firm needs to adopt the knowledge management architecture. It should consider all four layers of infrastructure and choose suitable components pertinent to the implementation of its KM system in collaborative supply chain.

Based on our model of knowledge management architecture in collaborative supply chain, we conducted case studies to investigate what kinds of information and knowledge flows in collaborative supply chain and how they flow. We interviewed the directors and managers of the information management department for three firms. All these cases have been implementing e-business in B2B supply chain for a while. The result of case studies is described as follows.

CASE STUDIES

Case 1 – Chia Her Industrial Co., Ltd.

Chia Her Industrial Co.,.Ltd., renowned as the world's largest manufacturer of checked fabric, was established in 1972. To survive and thrive in accelerated economy and achieve the mission to be "The Global First Textile Supply Center," Chia Her decided to build an open supply system in order to remodel the business processes, respond customers' demands in time in this ultra-competitive environment. The supply chain network for Chia Her consists of many customers (garment factories as well as a few designers) and few suppliers (yarn factories) and subcontractors (dying factories). The original operation processes for Chia Her are shown in Figure 2.

FIGURE 1
Knowledge Management System Architecture in Collaborative Supply Chain

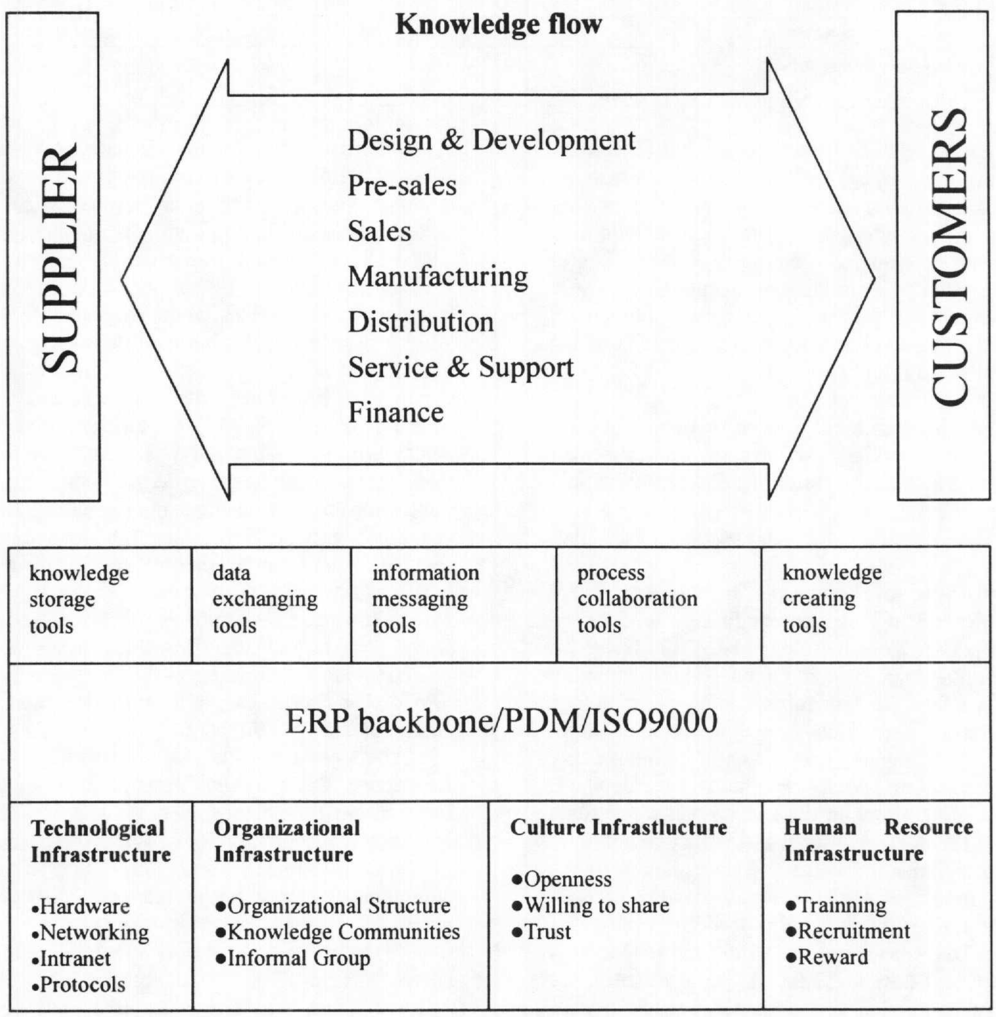
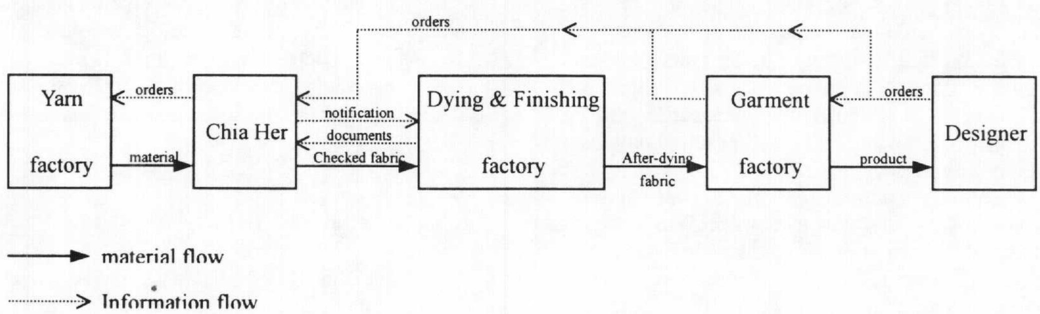


FIGURE 2
The Original Operation Processes for Chia Her



Chia Her places orders to yarn factory by phone or fax. After getting an order, the factory fulfills the order and shipment. The designer or garment factory places orders to Chia Her by phone or fax. Chia Her then sends a notification to the dyeing and finishing factory with e-mail for greige dying. Upon the completion of dyeing, the factory ships the finished cloth to garment factories directly for production. Meanwhile, the dyeing and finishing factory sends the documents (such as packing list, test report, etc.) to Chia Her. After that, Chia Her forwards those documents to garment factory by express. The major shortcomings of the operational processes are as follow:

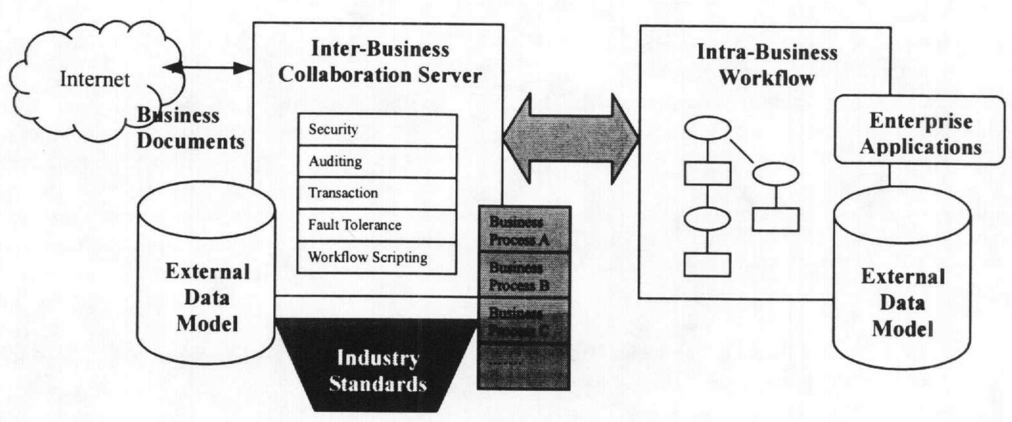
1. The collaborative business partners in supply chain are unable to share product related information and knowledge with each other.
2. Each trading partner develops product R&D information individually and delivers to each other by paper. To coordinate these design processes is time-consuming and tedious.
3. Due to the different document formats among collaborative partners, documentation repetition and conversion rate is high. Operations are inefficient and maintenance is costly.

In order to improve supply chain efficiency, inter-business collaboration between Chia Her and the dyeing and finishing factories was proposed. In the infrastructure layer, the Intranet has been built for the web-based application system for a while. In order to promote the electronic supply chain, the IT department is upgraded to a higher level in the whole cooperation and the position of chief information officer is set up. More than half of the project members are new recruits. They are trained to advance the electronic supply chain network project. Also, promise has been made that once this project is completed and prove to be successful, the whole IT department will be separated from the organization and running independently.

In the backbone layer, ERP system built by the IT department has been set up and functioning for a long time and is now transferred into web-based application system gradually. ISO 9000 system has been also working smoothly and is going to be upgraded to the 2000 version.

In the tools layer, a B2B integration platform called eBizarch has been developed based on the principle of RosettaNet Implementation Platform (RNIF) with CA's Jasmine. Figure 3 shows the runtime model for eBizarch. The model is composed of two major parts: (1) Inter-business Collaboration Server (IBC Server) and (2) Intra-business Workflow System. IBC Server collaborates the predefined business processes with partners via the Internet. It is structured as three layers (from low-end to high-end): messaging, data transformation and process collaboration. The messaging layer simply defines the method of message delivery in a secure and reliable way. The data transformation specifies the data schema, guidelines (i.e., external data model or XML DTD) and rules in business document exchange. The process collaboration layer is essentially an inter-business process flow engine. The external data model definition includes the XML schema and dictionaries used in the business document exchange. The current internal data model supports RDB, LDAP and applications such as ERP, e-mail and WFMC-compliant workflow systems.

FIGURE 3
The Runtime Model for eBizarch



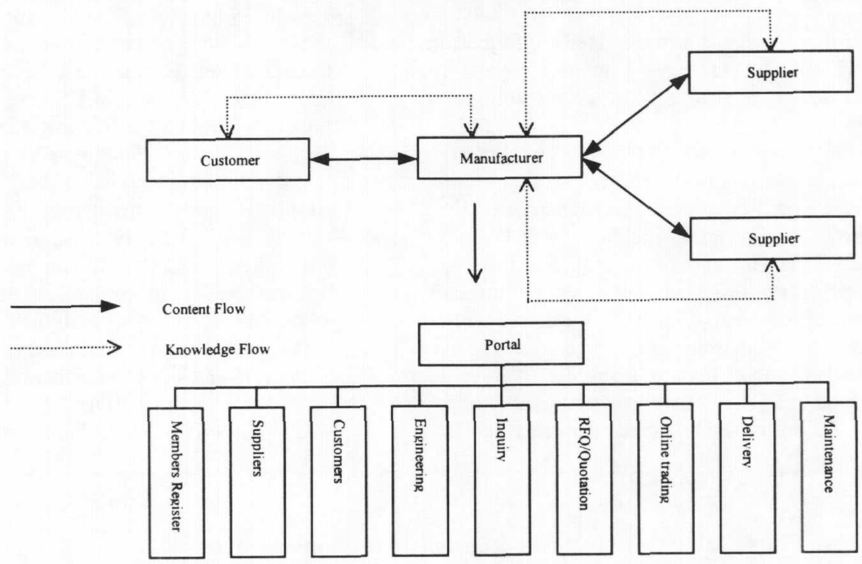
In the knowledge flow layer, formally structured and large-volume information is transferred between Chia Her and the dying factories, information including dyeing and finishing instruction, greige delivery, shipping, packing list, inventory, and invoice.

The deployment of electronic supply chain network has resulted in a 40%-100% reduction in material shortage cost, inventory cost, administration cost and inspection cost. Substantial cost reduction improves the capital requirement for business operation. It also improves the operation efficiency including lower turnaround cycle for purchasing, manufacturing, and delivery. The total fulfillment time has been improved from the original 35 days down to 29 days. The six-days improvement is critical to Chia Her to strengthen their competitive position in the textile industry and enhance the value of the company.

Case 2 – Yung Mao Industrial Corporation

The traditional manufacturing industry in Taiwan mainly produces general industrial product. Most companies are original equipment manufacturing (OEM). But some companies are original design manufacturer or even own their own brands. They enter the after-sales of DIY field of the world market through the help of international trade and logistic system. Yung Mao Industrial Corporation, with about 50 employees and $400,000 sales volume monthly, is a typical traditional manufacturer of mold and die whose customer ranges from vehicle parts to computer parts. Being a small sized enterprise, Yung Mao is constrained to quantity and quality of its employees and hard to keep pace with international market and technique. Because customer orders change from time to time, it's very difficult to plan and control production capacity. Sometimes the company must even cooperate with other companies for a big order. Consequently, Yung Mao constructs cooperation supply chain electronically with its suppliers and customers, forming a seamless cooperation and integration system. The framework of Yung Mao's electronic business model is based on real-time shop floor production data feedback and combines industrial automation and electronic techniques to build the B2B network with capabilities such as production information providing quick response, remote R&D collaboration and engineering support. Figure 4 shows this framework.

FIGURE 4
Yung Mao's E-business Model Framework



In the infrastructure layer, Yung Mao communicates with its customers and suppliers with browsers through the Internet because of the size of its customers, suppliers, and even itself is small to medium. It is the most convenient way to build the communication channels. The communication way and its supporting protocols are listed below:

Communication way: Web EDI/XML, Web form

Supporting protocols: HTTP, HTTP-S, FTP, SMTP, VPN

In the backbone layer, Yung Mao's MIS consists of production, sales and finance subsystems. It has also been certified to ISO 9002 for five years. In the tools layer, information is communicated mainly through web forms. But in the design and development stage, e-mail and BBS are used to transfer informally structured information such as drawing files and design features.

In the knowledge flow layer, customers can make inquiry about Yung Mao's capabilities such as facility, CAD/CAM, engineering, product types, etc. through its portal. By online RFQ/Quotation and online trading, Yung Mao has also reduced its time for quotation to within 24 hours. The accuracy of cost and delivery time estimation is above 90%. Furthermore, Yung Mao has cooperated with other mold companies to set up a virtual inventory database. Such a database lets Yung Mao access any parts and materials inventory data of its subcontractors and other cooperative companies, and process the automatic order placing capability. By using this technology, it cut down inventory cost more than 20%.

There are two kinds of knowledge flows in the B2B networking collaborative processes for Yung Mao. One is the knowledge flow between Yung Mao and its customers; the other is the knowledge flow between Yung Mao and its suppliers. First, it constructs a community of engineering support with the customer's bulletin board and engineering technique board. Secondly, the virtual inventory database shares the parts and material data with its subcontractors and other mold companies. It also provides special equipment capacity information. By doing this, facilities utilization is improved, and total inventory cost and design and development cost are reduced.

The information and knowledge flows between Yung Mao and its customers as well as its suppliers are shown in Tables 3 through 6.

Case 3 – FuYu Industrial Co.

The machinery industry is one of the ten rising industries with high added value and high technology in Taiwan. The competence of machinery industry in Taiwan comes from its complete supply chain system. FuYu, a grinder manufacturing company, is a leading company for its complete product line, technology innovation and market share. Its sales volume is about $3.5 million a month, and its employees are more than 500. FuYu's collaborative supply chain consists of several major customers and about 40 suppliers. Figure 5 shows the total solution framework FuYu adopted in its electronic business model.

TABLE 3
Information Between Yung Mao and Its Customers

System	Information Flows
On-line RFQ/Quotation	• Customers on-line inquiry, order placing, and uploading or downloading drawing files of mold
Engineering/Technique	• Engineering capabilities information such as facilities capacity, CAD/CAM information, process capability and product types • Pre-casting database • Mold design database
Customers' Board	• Customer complaint processing
Delivery	• Mold pre-testing schedule status check • Product delivery schedule status check

TABLE 4
Information Between Yung Mao and Its Suppliers

System	Information Flows
Suppliers Board	• Purchase orders announcement on the web pages and notification through e-mail

TABLE 5
Knowledge Between Yung Mao and Its Customers

System	Knowledge Flows
Engineering/Technique	• Engineering support and development community to focus on knowledge such as material, processing, development, and simulation

TABLE 6
Knowledge Between Yung Mao and Its Customers

System	Knowledge Flows
Suppliers Board	• Inventory level in virtual inventory database • Facility capacity and special technique

In the whole system, CHEVALIER.NET (oval in the center) are used as service center mechanism to carry out information exchange in the electronic business processes. This business model, based on the Internet, integrates money flows, customer's clearance (oval from the Internet), suppliers and subcontractors (oval in the right-hand side), and customers (oval below the Internet) to processed exchange of every transaction information.

In the infrastructure layer, the functions and features of FuYu's electronic businesses model are:

1. Because there are differences among suppliers and customers in the level of automation and information application, FuYu proposes an intermediary called "CHEAVALIER.NET" to solve problems of transforming and communicating data in different format. This mechanism can improve data transmitting speed and reduce labor operation cost. It also provides channels to communicate with different industries such as banking and customer systems.
2. CHEAVLIER.NET provides different ASP (Application Service Pack) modules such as "Web forms" and "EC Integration" for both large-scale and small-sized members.
3. Web Forms are designed for companies that do not own their own ERP systems and use the Web form given on the net such as order, RFQ, quotation, and production progress to conduct activities electronically.
4. EC Integration is provided for companies that have ERP, SCM systems in place, so as to achieve AP to AP automation and integration. Companies with systems such as SAP, ORACLE or AS/400 export their data to the mapping tables, transmitted to EC Integration, then translated to standard EDI/XML format. All the procedures are automatic.

In the backbone layer, FuYu has developed an ERP system partly by its own IT department and partly by buying outside solutions. Its EasyFlow™ workflow system can integrate with customer complaints in its ISO 9000 processes to accelerate the speed of response to customer complaints processing.

In the tool layer, data exchange tools such as order and RFQ web forms transfer formally structured information for sales related function. Knowledge creating tools like data mining are used in design and development stage to find the customer's preference. E-mail and BBS are employed to collect customer complaints and solve technique problems from customers.

The information and knowledge flows between FuYu and its customers as well as its suppliers are shown in Tables 7 through 10.

FIGURE 5
The Total Solution Framework of FuYu's E-Business Model

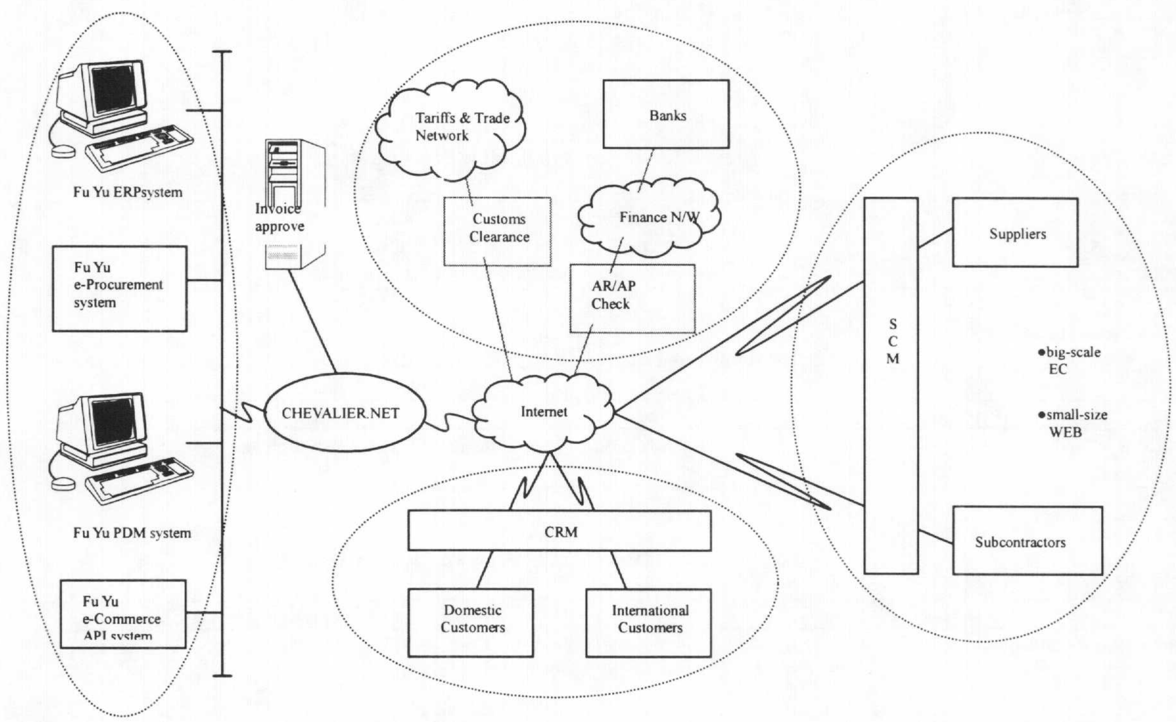


TABLE 7
Information Between Fu Yu and Its Customers

System	Information Flows
WWW Customer Order Processing Platform	• Inquiry and order placing system to provide on-line inquiry and order placing processes • Order status follow-up
Customer Relationship Management	• Customer data management to keep records of all customers' transaction data • World-wide warehousing and on-delivery inventory system to keep track of each sales branch world-wide • Customer-specific web pages to provide differential service for customers
After-sales Service	• Maintenance parts handling system to provide after-sales service and all related records • Customer complaint processing
Customization Service	• Product selecting consulting system to provide information for customers to choose product • Inquiry of machines with special purpose feature
Production Schedules Follow-up	• Shares information about production scheduling and shop floor status

DISCUSSION AND CONCLUSION

Table 11 shows the cross reference of organizational attributes and knowledge flows for each case. From these three case studies proposed above, we have observed some interesting phenomenon that are worth discussing.

1. For the design-centric industries, i.e., industries whose supply chain activities focus on product design knowledge and information, knowledge flows between the supply chains tend to be informally structured. Yung Mao is a typical example. There are tremendous flows between customers and Yung Mao and between

Yung Mao and its suppliers about design, specification and techniques of molds and dies. These flows are usually informally structured and transferred through e-mail, BBS, and even videoconference. On the other hand, for the production-centric industries such as textile industry, whose supply chain activities focus on production information, knowledge flows tend to be formally structured.

TABLE 8
Information Between FuYu and Its Suppliers

System	Information Flows
Supply Chain Management System	• Electronic procurement process to quickly and efficiently transmit all procurement data to suppliers • To provide capability information data of suppliers • Procurement orders follow-up process to assure delivery schedule • Material in-coming informing process to arrange inspection in advance • Subcontracting inventory data transferring process to transfer finished material data to next subcontractor • Incoming quality analysis for each supplier

TABLE 9
Knowledge Between FuYu and Its Customers

System	Knowledge Flows
WWW Customer Order Processing Platform	• Customer preference analysis
Customer Relationship Management	
After-sales Service	• Troubleshooting database to provide on-line Q&A
Customization Service	• Process capability simulation and analysis of specific machines
Production Schedules Follow-up	• Customized production model to arrange assembling processes according to customer's requirement

TABLE 10
Knowledge Between FuYu and Its Customers

System	Knowledge Flows
Supply Chain Management System	• Machinery common parts database through "resource sharing community" to provide virtual inventory and resource sharing

2. The volume of transaction flowing on the supply chain seems to affect the IT tools used and even the knowledge flow types. Taking Chia Her, for example, it receives orders from its large number of customers and passes its purchasing orders, dyeing instructions, shipping notifications, and packing list to its suppliers and subcontractors. The amount of information is very large. All these information flows are codified in formally structured form and transmitted using EDI/XML-based web pages.
3. The structure of the supply chain network (1 to 1 to 1, many to 1 to 1, 1 to 1 to many, or many to 1 to many) and the IT capabilities of organizations in the supply chain will affect the KM tools adopted, Chia Her has many customers and few critical suppliers in its supply chain, and it selects key suppliers to set up e-commerce and knowledge management system first. Similarly, FuYu classified its suppliers into two kinds – large-scale and small size – each adopts a different e-commerce strategy.
4. We expect the size of the case companies to have impact on the knowledge flow types and KM tools adopted, but there is no significant sign validating this assumption.

In our search, we have examined the knowledge flows in collaborative supply chain, categorized knowledge into seven kinds according to the function it plays in collaborative supply chain, and proposed a four-layer knowledge management architecture facilitating knowledge management activities. This architecture offers organizations which want to precede their knowledge management system in supply chain a reference model to start with. Also, it is a good framework for researchers to conduct case study to explore the knowledge management activities in supply chain. Further research can be focused on the analysis of the knowledge flows in different types of organizations. Three cases are presented to outline how different industries build their e-business models and how knowledge flows in these models. The results show that different network type of supply chain, the amount of transaction, and the main collaborative function in supply chain will lead to different knowledge flows and different tools adopted.

For organizations that want to facilitate their knowledge flows in supply chains, these observations may be helpful. First organizations should classify themselves by their focal function in supply chain – design centric or production centric. Usually design-centric organizations will require more collaborative processes in the supply chain; therefore, tools supporting collaborative are important for these organizations. Secondly, for organizations conducting huge amounts of transactions via e-business, knowledge crating tools such as data mining and intelligent agents would be useful after transmitting information using data exchange tools.

TABLE 11
The Impact for Organizational Attributes on Knowledge Flows

	Organizational Attributes				Knowledge Flows		
	Design/ Production Centric	**Transaction Amount**	**Company Size**	**Supply Chain Type**	**Knowledge Source**	**Knowledge Structure**	**KM Tools**
Chia Her	Production centric	Large	Big	1-1-many	• Sales • Production • Delivery • Finance	Formally structured	• EDI/XML based web page
Yung Mao	Design centric	Small	Small	Many-1-many	• Design & development	Informally structured	• BBS • E-mail • Video-conference
FuYu	Design centric	Medium	Medium	Many-1-1	• Design & development • Service & support	Formally and informally structured	• Data mining • Web pages • BBS • E-mail

REFERENCES

1. Abell, A. "Skills for Knowledge Environments," **Information Management Journal**, July 2000, pp. 33-41.
2. Anderson, D.L., F.F. Britt, and D.J. Favre. "The Seven Principles of Supply Chain Management," **Supply Chain Management Review**, Spring 1997, pp. 31-41.
3. Baker, M., M. Barker, J. Thorne, and M. Dutnell. "Leverage Human Capital," **Journal of Knowledge Management**, 1:1, 1997, pp. 63-74.
4. Balasubramanian, P., K. Nochur, J.C. Henderson, and M.M. Kwan. "Managing Process Knowledge for Decision Support," **Decision Support systems**, 27, 1999, pp. 145-162.
5. Beckett, R.C. "A Characterization of Corporate Memory as a Knowledge System," **Journal of Knowledge Management**, 4:3, 2000, pp. 311-319.
6. Benjamin, R.I., W.T. Male, and J. Yates. "Electronic Markets and Electronic Hierarchies," CISR Working Paper No. 137, Center for Information Systems Research, Sloan School of Management, Massachusetts Institute of Technology, Boston, MA, 1986.
7. Bhatt, G.D. "Knowledge Management in Organizations: Examining the Interaction Between Technologies, Techniques, and People," **Journal of Knowledge Management**, 5:1, 2001, pp. 68-75.
8. Binney, D. "The Knowledge Management Spectrum – Understanding the KM Landscape," **Journal of Knowledge Management**, 5:1, 2001, pp. 33-42.
9. Bollinger, A.S. and R. Smith. "Managing Organizational Knowledge as a Strategic Asset," **Journal of Knowledge Management**, 5:1, 2001, pp. 8-18.
10. Bollo, D. and M. Stumm. "Possible Changes in Logistic Chain Relationships Due to Internet Developments," **Intl. Trans. Operational Res.**, 5:6, 1998, pp. 427-445.
11. Cross, R. and L. Baird. "Technology is Not Enough: Improving Performance by Building Organizational Memory," **Sloan Management Review**, Spring 2000, pp. 69-78.
12. Dawson, R. "Knowledge Capabilities as the Focus of Organizational Development and Strategy," **Journal of Knowledge Management**, 4:4, 2000, pp. 320-327.
13. Duffy, J. "Knowledge Management: What Every Information Professional Should Know," **Information Management Journal**, July 2000, pp. 10-16.
14. Holsapple, C.W. and M. Singh. "From E-commerce to E-Knowledge," **Proceedings of the Americas Conference on Information Systems**, 2000, pp. 901-904.
15. Kanji, G.K. "An Innovative Approach to Make ISO 9000 Standards More Effective," **Total Quality Management**, 9, 1998, pp. 67-68.
16. Khan, M.K. and N. Hafiz. "Development of an Expert System for Implementation of ISO 9000 Quality System," **Total Quality Management**, 10:1, 1999, pp. 47-59.
17. Kocharekar, R. "K-commerce: Knowledge-based Commerce Architecture with Convergence of E-commerce and Knowledge Management," **Information System Management**, spring 2001, pp. 30-35.
18. Krogh, G.V. "Care in Knowledge Creation," **California Management Review**, 40:3, 1998, pp. 133-153.
19. Lang, J.C. "Managerial Concerns in Knowledge Management," **Journal of Knowledge Management**, 5:1, 2001, pp. 43-57.
20. Marakas, G.M. **Decision Support Systems in the Twenty-first Century.** Englewood Cliffs, NJ: Prentice-Hall, 1999.
21. Mårtensson, M. "A Critical Review of Knowledge Management as Management Tool," **Journal of Knowledge Management**, 4:3, 2000, pp. 204-216.
22. McDermott, R. "Why Information Technology Inspired but Cannot Deliver Knowledge Management," **California Management Review**, 41:4, 1999, pp. 103-117.
23. McDermott, R. and C. O'Dell. "Overcoming Cultural Barriers to Sharing Knowledge," **Journal of Knowledge Management**, 5:1, 2001, pp. 76-85.
24. McIvor, M., P. Humphreys, and G. Huang. "Electronic Commerce: Re-engineering the Buyer-Supplier Interface," **Business Process Management Journal**, 6:2, 2000, pp. 122-138.

25. Mentzas, G., D. Apostolou, R. Young, and A. Abecker. "Knowledge Networking: A Holistic Solution for Leveraging Corporate Knowledge," **Journal of Knowledge Management,** 5:1, 2001, pp. 94-106.
26. Meso, P. and R. Smith. "A Resource-based View of Organizational Knowledge Management Systems," **Journal of Knowledge Management,** 4:3, 2000, pp. 224-234.
27. Millar, J., A. Demaid, and P. Quintas. "Trans-organizational Innovation: A Framework for Research," **Technology Analysis & Strategic Management,** 9:4, 1997, pp. 399-418.
28. Millen, R., A. Sohal, and S. Moss. "Quality Management in the Logistics Function: An Empirical Study," **International Journal of Quality & Reliability Management,** 16:2, 1992, pp. 166-180.
29. Nonaka, I. "The Knowledge-creating Company," **Harvard Business Review,** 69, November-December 1991, pp. 96-104.
30. Nonaka, I. and H. Takeuchi. **The Knowledge Creating Company – How Japanese Companies Create the Dynamics of Innovation.** Oxford: Oxford University Press, 1995.
31. Pakstas, A. "Towards Electronic Commerce via Science Park Multi-extranets," **Computer Communications,** 22, 1999, pp. 1351-1363.
32. Pawar, K.S. and H. Driva. "Electronic Trading in the Supply Chain: A Holistic Implementation Framework," **Logistic Information Management** 13:1, 2000, pp. 21-32.
33. Pitt, M. and K. Clark. "Competing on Competence: A Knowledge Perspective on the Management of Strategic Innovation," **Technology & Management,** 11:3, 1999, pp. 301-316.
34. Rao, S.S. "Enterprise Resource Planning: Business Needs and Technologies," **Industrial Management & Data Systems,** 100:2, 2000, pp. 81-88.
35. Roberts, B. and M. Mackay. "IT Supporting Supplier Relationships: The Role of Electronic Commerce," **European Journal of Purchasing & Supply Management,** 4, 1998, pp. 175-184.
36. Shaw, M., R. Blanning, T. Strader, and A. Whinston. **Handbook on Electronic Commerce.** Berlin: Springer-Verlag, 1998.
37. Shin, M., T. Holden, and R.A. Schmidt. "From Knowledge Theory to Management Practice: Towards an Integrated Approach," **Information Processing & Management,** 37, 2001, pp. 335-355.
38. Stank, T.P. and T.J. Goldsby. "A Framework for Transportation Decision Making in an Integrated Supply Chain," **Supply Chain Management: An International Journal,** 5:2, 2000, pp. 71-77.
39. Stock, J.R. and D.M. Lambert. **Strategic Logistics Management,** 2nd ed. Homewood, IL: Richard D. Irwin and Co., 1987.
40. Tiwana, A. **The Knowledge Management Tool Kit: Practical Techniques for Building a Knowledge Management System.** NJ: Prentice Hall, 2000.
41. Warkentin, M., V. Sugumaran, and R. Bapna. "E-knowledge Networks for Inter-organizational Collaborative E-business," **Logistic Information Management,** 14:1/2, 2001, pp. 149-162.