E-commerce Application for Construction Material Procurement

by

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ABSTRACT

The aim of this research is to make contribution in the domain of applying electronic commerce (E-commerce) applications in construction material procurement. This research reviewed the current construction material procurement process and identified its limitations relating to information retrieving, handling and sharing. A review on current applications of E-commerce and geographical information system (GIS) was undertaken and those functions of E-commerce and GIS that can be applied in construction material procurement are identified. This research also pointed out the inadequacy of existing E-commerce websites in supporting the construction material procurement functions. Based on the findings of the above reviews an E-commerce system that utilize the state of the art E-commerce and GIS technologies was developed for supporting the whole construction material procurement process. This E-commerce system is designed for trading construction materials in Mainland China and is implemented and run by a construction firm in Hong Kong. The system was evaluated based on feedback and quantitative data collected from users of the system. This system is found to be useful in supporting the purchasing personnel to carry out the material procurement jobs. Identified benefits of this E-commerce system include shorter time for searching materials and suppliers information, easier comparison of similar and alternative materials, provision of transportation distance between cities, and reduction of paperwork. This research also discussed the limitations of the developed system and the future works required for providing an E-commerce system with more comprehensive services for buyers.

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INTRODUCTION

1.1 INTRODUCTION

The value of materials that is required to be purchased for any construction contract makes up a large proportion of a project's total contract sum. Typically materials account for 40-45% of the cost of all construction work (Agapiou *et al.*, 1998). Obtaining the right material, in the right quantities, with the right delivery, from the right source, and at the right price are all purchasing functions. To achieve these functions it is necessary to maintain an efficient and effective material purchasing system to streamline the whole purchasing process. Also it is important for the contractors' estimators to keep abreast of market conditions so that they can have the most updated information for selecting materials and suppliers. The emergence of Internet and Web technology has enabled information to be shared and exchanged through a common global network in an efficient and relatively low cost environment. In fact, it has been suggested that electronic commerce (E-commerce) can provide a win-win situation for both suppliers and buyers, as E-commerce can provide an expanded marketplace within which buyers and suppliers can communicate directly with each other (Cheng *et al.*, 2001). It is expected that the efficiency and effectiveness of the construction material purchasing process can be improved by utilizing Internet and Web technology.

1.2 BACKGROUND AND PROBLEM STATEMENT

1.2.1 The Current Construction Material Purchasing Process

Purchasing can be separated into two types of activities, which are procurement, and supplier scheduling and follow up. Procurement includes the functions of establishing specifications, selecting suppliers, determining price and negotiating with suppliers. Supplier scheduling and follow up is concerned with the release of orders to suppliers, working with suppliers to schedule and follow up delivery. The main concerns of material purchasing are the provision of the right materials at the right time, in the right place and to an agreed budget such that progress on site is uninterrupted (Canter, 1993). Currently a purchaser of a contractor starts the purchasing process by searching through physical catalogs to find materials that match the requirement stated in the tender documents. After identifying the suitable materials from physical catalogs the purchaser will have to contact the suppliers to ask for quotations according to the specification he/she prepared. Upon receiving all the quotations from the suppliers the purchaser compares and evaluates the quotations and selects the best suppliers based on the criteria like price and quality of materials, service quality of suppliers, terms of delivery, etc. The purchaser then prepares and issues purchase orders to the selected suppliers. In effect the order becomes a written commitment to accept and pay for goods under an agreed set of

terms and conditions. Orders will be tracked until materials are received and checked on site.

1.2.2 Problems in the Current Material Procurement Process

It is proffered that the traditional material procurement process has the following limitations. First, this process has specific business hours and can only work with suppliers within a defined geographical region. In addition, the traditional process can only collect limited amount of information about the suppliers and their products through the collection of physical catalogs. Physical catalogs are cumbersome to use, and require large storage areas. They also become dated very quickly, and make searching and comparison of prices and quality a nebulous task. These disadvantages make it increasingly difficult for contractors to stay abreast of market conditions and thus select the most suitable materials and suppliers for a given project.

Additionally, the paper-based transaction system that is commonly used within the realm of the traditional process of material procurement is time-consuming (and thus non-value adding). Copies of different documents are produced manually and are used by different parties in the material procurement process. The probability of error increases as information is transcribed from one document to another. Although paper documents can be re-typed into a computer-based environment, data entry of document information requires multiple transcriptions of the information.

Consequently, such process can result in the introduction of additional errors to the system. Furthermore, the paper-based system is also dependent on ensuring that all appropriate departments obtain copies of the documents necessary to do their job. If a small percentage of those documents are lost or misplaced, there can be gaps in the system and orders may go unfulfilled.

1.2.3 E-commerce System

E-commerce is the conducting of business communication and transactions over networks and through computers (Haynes 1995). Before the mature of Internet and World Wide Web technology, Electronic Data Interchange (EDI) technology was heavily used for conducting E-commerce. EDI has been used by businesses for two broad categories of benefits: operational efficiency and strategic advantage. Examples of such benefits can stem from just-in-time (JIT) inventory control, administrative efficiency (information accuracy and data entry reduction) and better buyer/supplier services. Internet and World Wide Web is the new generation of EDI in E-commerce. E-Commerce now has the ability to conduct business via electronic networks such as the Internet and the virtual private network (VPN). Although Internet-based E-Commerce is based on the principles of EDI it goes far beyond EDI in that it aims at supporting the complete supply chain of a purchasing project, including the information stage (electronic marketing, networking), the negotiation stage (electronic markets), the fulfillment (order process, electronic payment) and the satisfaction stage (after sales support). The construction industry's emphasis

these days is on business-to-business E-Commerce applications: taking orders, scheduling shipments, providing buyer service and so on. Construction organizations conducting their business using E-Commerce typically work together in a seamless supply chain as a single unit using various telecommunications and advanced information technologies so as to increase the effectiveness of their business relationships between trading partners. The use of such telecommunications and technologies is set to revolutionize the way that organizations operate in the next millennium. Thus, many construction organizations are now reviewing their information systems so that they can exploit recent technological developments and therefore enable improved organizational competitiveness through E-Commerce.

Many believe that E-Commerce can provide a win-win situation for both suppliers and buyers, as E-Commerce can provide an expanded marketplace within which buyers and suppliers can communicate directly with each other. Online construction trading markets are not limited by the physical limitations of store spaces and can carry a much larger variety of products and different styles and sizes. At the same time, buyers can search through a wide range of products with low transaction costs at any time convenient to them. More importantly, the direct communication between buyers and suppliers will cut off the multiple layers of mid men between suppliers and buyers. These mid men take commissions and fees from both buyers and suppliers. Use of E-Commerce will therefore directly benefit the buyers so they can purchase cheaper products with a variety of choices (Bakos 1991).

1.2.4 Electronic Product Catalog and Geographical Information System

One important application of E-commerce that will play a vital role in the emerging global electronic marketplace is the Internet-based electronic product catalog (IEPC). An IEPC is a Web-based application that provides a company with a new channel to market, sell, and support products and services over an open network environment. From the buyer's point of view, it offers an alternative means of finding out what product or service is currently available in a given market, who the suppliers of that product or service are, and where and how to get such a product or service. As a new medium, IEPC combines many useful features of existing channels, such as the rich content of printed catalogs, the convenience of home shopping, the intimacy of on-site shopping, and the sophisticated searching capability of Compact Disk Read Only Memory (CD-ROM) catalogs. Unlike printed and CD-ROM catalogs, IEPCs are online, permanently up-to-date, ubiquitous, and enable customization and direct communication between sellers and buyers.

Geographical Information System (GIS) is the unique information system, which maintains, manages, integrates and analyses location-related (or spatial) information of different types and scales. Successful implementations of GIS are found in many areas, such as civil engineering, transportation, facilities management, urban planning and business analysis. E-commerce system offers a possible solution for

direct trading between buyers and suppliers with no restriction on space and time. However, online transaction should not only focus on the flow of business-related information but also effective distribution of goods (Yang, et. al, 2000). Transportation of goods among different parties must be involved in any kinds of business activities, even in the era of on-line business. Consequently, cost of transportation is also a critical consideration in E-commerce. Moreover, both regional and local demographic characteristics are important considerations in the successful implementation of the E-commerce system. In this sense, location related, or spatial information plays an essential role in any kinds of business activities, including E-commerce system. GIS is potentially applicable in E-commerce system to manage spatial information, to provide an ideal solution to managing costs of transportation, and to provide market analysis on the overall E-commerce activities.

1.3 RESEARCH OBJECTIVES

The aim of this research is to make contribution in the domain of applying E-commerce applications in construction material procurement. In recent years researchers are aware of the potential benefits of E-commerce applications and advocated its importance in supporting the construction material procurement functions. Applying E-commerce applications in the construction area is a new research topic. There are many interesting issues of E-commerce worth of pursuit. This research takes the initiative to study the limitations of the current material procurement method and to identify those functions of E-commerce that can be

applied to remove these limitations. It aims to develop and implement an E-commerce system that is feasible and applicable to apply in the construction material procurement process. In particular this research will integrate GIS in the developed E-commerce system. The objectives of this research are:

- To review the traditional construction material procurement process and identify its limitations relating to information retrieving, handling and sharing.
- To review current applications of E-commerce and GIS, and identify those E-commerce and GIS functions that can be applied in construction material procurement.
- To develop a system for construction material procurement that utilizes E-commerce and GIS technology.
- To implement the developed system and evaluate the benefits and limitations of this system.

1.4 RESEARCH METHODOLOGY

Research activities were performed to achieve the objectives stated above. A review of existing literature relating to construction material procurement, E-commerce and GIS was undertaken to formulate a list of limitations of the current material procurement method, and a list of E-commerce and GIS functions that maybe useful for removing those limitations. A review of the existing E-commerce website of

construction material was also carried out to identify the inadequacy of those website in supporting the material procurement functions. The current available technologies of E-commerce including operation system, database engine, Internet platform and programming language were evaluated and selected for the development of a E-commerce system. A discussion with some marketing and purchasing personals of a construction firm in Hong Kong was carried out to identify the current business environment for trading construction materials in Hong Kong and Mainland China. An E-commerce system for trading construction materials in Mainland China was proposed and developed. This system was then implemented and run by a Hong Kong construction firm. Feedback from users of the system was collected and evaluation of the system was carried out to identify its benefits and limitations.

1.5 ORGANIZATION OF THESIS

This thesis consists of seven chapters. Literatures relating to material procurement, E-commerce applications, Internet-based electronic catalog, and geographical information system are reviewed in Chapter 2. Chapter 3 introduces the business model, system architecture and functional design of the developed E-commerce system named COME. The electronic product catalog of COME is introduced and discussed in Chapter 4 and, in Chapter 5 the geographical information system of COME is presented and evaluated. Chapter 6 discusses the implementation of COME in Mainland China and gives an evaluation on this system based on feedback

collected from users of the system. Finally conclusion and recommendations for future work are included in Chapter 7.

1.6 SUMMARY

This chapter introduced the background and motivation for carrying out this research and presented the aim and objectives of this study. In addition it includes the methodology of this research and introduced the structure of this thesis.

Chapter 2

CHAPTER 2

LITERATURE REVIEW

2.1 LITERATURE RELATING TO CONSTRUCTION MATERIAL PROCUREMENT

2.1.1 Purchasing and Procurement Objectives

Purchasing is responsible for establishing the flow of materials into the firm, following-up with supplier, and expediting delivery. Procurement is part of the purchasing functions, which is concerned with establishing material specifications, selecting suppliers and products, determining price and negotiating with suppliers. The main concerns of material procurement are the provision of the right materials at the right time, in the right place and to an agreed budget such that progress on site is uninterrupted (Canter, 1993). Procurement shares the same objectives as purchasing which are:

- Obtaining goods and services of the required quantity and quality.
- Obtaining goods and services at the lowest cost.
- Ensuring the best possible service and prompt delivery by the supplier.
- Developing and maintaining good supplier relations and developing potential suppliers.

2.1.2 Purchasing and Procurement Cycle

Generally the purchasing cycle in most of the businesses consists of the following steps:

1. Receiving and analyzing purchase requisitions.
2. Selecting suppliers. This step involves finding potential suppliers, issuing requests for quotations, receiving and analyzing quotations, and selecting the right supplier.
3. Determining the right price.
4. Issuing purchase orders.
5. Following-up to assure prompt delivery.
6. Receiving and accepting goods.
7. Approving supplier's invoice for payment.

Material procurement includes step 1 to step 4. Firstly the purchasing department receives purchase requisitions from the department that require materials. According to the material specifications the purchaser look for suppliers that provide those materials. For those materials that have been purchased before, there is usually a list of approved suppliers for the purchaser to select. In case there is no relevant supplier information the purchaser will look for information from catalog, trade journal, or directory. Although catalogs may contain prices of materials, it is usually desirable to issue a request for quotation especially when performing bulk purchase. The request for quotation is a written inquiry that is sent to enough suppliers to be sure

competitive and reliable quotations are received. After the suppliers have completed and returned the quotations to the purchaser, the quotations are analyzed for price, materials' compliance to specifications, terms and conditions of sale, delivery, and payment terms. The purchaser will then determine the prices of the selected suppliers. Price negotiation with the suppliers is necessary when quoted price is not satisfactory. After arriving a suitable price the purchaser will issue a purchase order to the selected supplier. Copies of purchase order are usually sent to other department like accounting, receiving and the department that issue the purchase requisition.

2.1.3 Material Purchasing Process in Construction Firm

The purchasing process in construction firm is different from other business firms. In a construction firm the purchasing process splits into two stages: the tender stage and the post-contract stage. Figure 2.1 depicts the activities and their sequence in a typical material procurement process. In the tender stage, a contractor starts estimating after receiving tender documents from client and send out enquires to suppliers. When quotes are received from suppliers, contractor will select the best quotes and complete the tender documents. If contract is awarded in the later stage, the purchasing process will be repeated from step 2, which is selection of suppliers. This is because market condition may change from time to time. Sometimes quotes received from suppliers are no longer valid at the post-contract stage. Even quotes are still valid at the post-contract stage the purchaser should send request for

quotation to the suppliers again to get the most updated market price. Once a suitable supplier has been selected, the next step in the purchasing process is to raise and issue a purchase order to the supplier, which will constitute a legal contract when the supplier accepts or acknowledges receipt of the order. In effect the order becomes a written commitment to accept and pay for goods under an agreed set of terms and conditions. Orders will then be tracked until materials are received and checked on site.

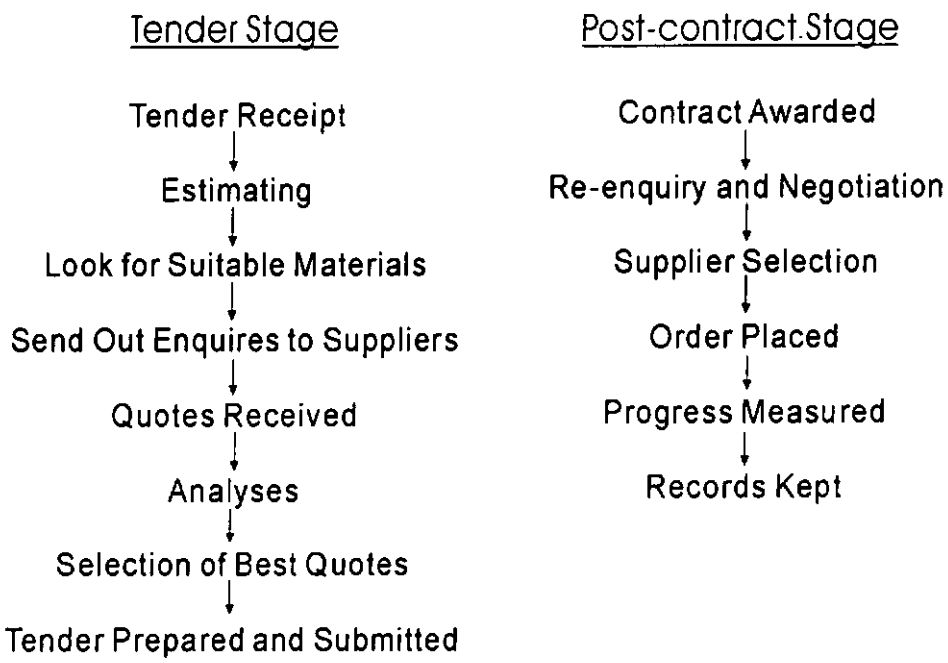


Figure 2.1: Typical material purchasing sequence.

2.1.4 Information Flow in the Material Purchasing Process

From the requisition of quotations at the tender stage to the actual receipt of materials and signing invoices, different paper-based documents are produced, copied, passed and referenced by different groups of participants in the traditional

material purchasing process. During the tender stage the estimating teams of contractors obtain construction materials information from physical catalogs of suppliers. Based on these catalogs they compare and select suppliers and send enquiries to and receive quotations from the selected suppliers.

Figure 2.2 shows a typical paper-based document system of a purchasing function during the post-contract stage of a project. In a typical paper-based document system, the site office prepares two copies for the requisition of materials. One copy is sent to the buying department and one copy is filed. The buying department then prepares four copies of the purchase order. One copy is sent to the selected supplier and the site office, the accounts department and the buying department keep the remaining copies for their records. The site office will receive invoice issued by the supplier when materials arrive on site. The invoice will be compared with the purchase order by the buying department and after confirmation, be passed to the accounts department to issue payment (Calvert, 1995).

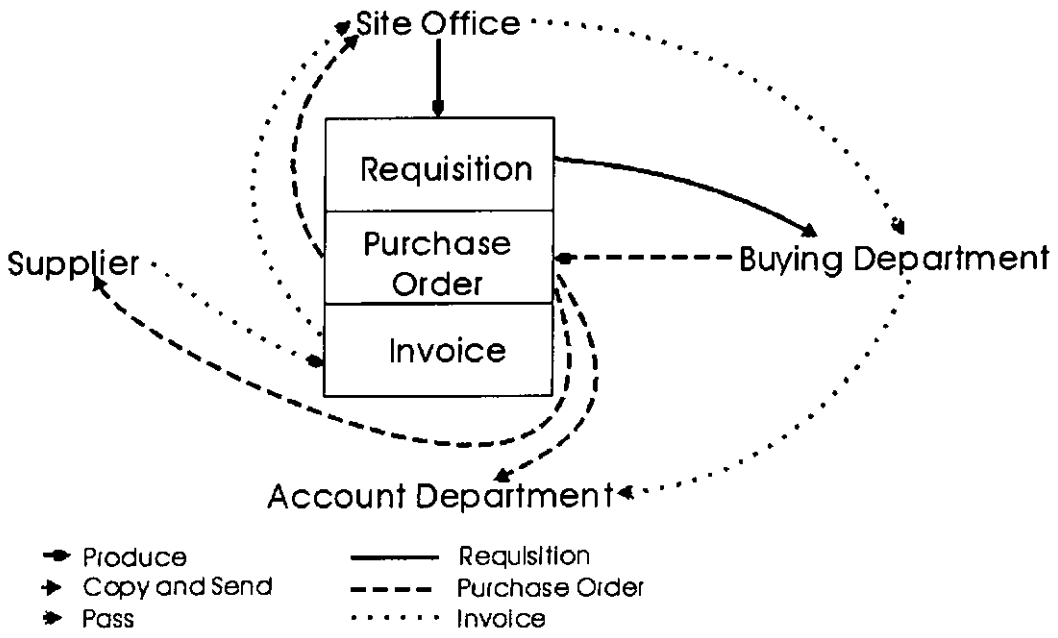


Figure 2.2: Paperwork required in the purchasing system

2.1.5 Limitations of Traditional Material Procurement Process

It is proffered that the traditional material procurement process has the following limitations. First, this process has specific business hours and can only work with suppliers within a defined geographical region. In addition, the traditional process can only collect limited amount of information about the suppliers and their products through the collection of physical catalogs. Physical catalogs are cumbersome to use, and require large storage areas. They also become dated very quickly, and make searching and comparison of prices and quality a nebulous task. These disadvantages make it increasingly difficult for contractors to stay abreast of market conditions and thus select the most suitable materials and suppliers for a given project.

Additionally, the paper-based transaction system that is commonly used within the realm of the traditional process of material procurement is time-consuming (and thus non-value adding). As mentioned above, copies of different documents are produced manually and are used by different parties in the material procurement process. The probability of error increases as information is transcribed from one document to another. Although paper documents can be re-typed into a computer-based environment, data entry of document information requires multiple transcriptions of the information. Consequently, such process can result in the introduction of additional errors to the system. Furthermore, the paper-based system is also dependent on ensuring that all appropriate departments obtain copies of the documents necessary to do their job. If a small percentage of those documents are lost or misplaced, there can be gaps in the system and orders may go unfulfilled.

2.2 Literature Relating to E-commerce

2.2.1 Introduction to E-commerce

Electronic commerce (E-commerce) is the conducting of business communication and transactions over networks and through computers (Haynes 1995). Narrowly, electronic commerce is used to refer to the buying and selling of products and services, and the transfer of funds, through public or private digital networks. E-commerce includes all types of inter-company and intra-company business interactions, transactions, functions processes (such as marketing, advertising, sales,

support, recruiting, research & development, administration, and corporate communication) that enable commerce by utilizing technologies such as e-mail, electronic data interchange (EDI), electronic funds transfer (EFT), the World Wide Web, video conferencing, electronic forums and bulletin boards, and distributed databases.

There are two types of technology necessary for supporting E-commerce: network infrastructure and applications. At the core of an E-commerce environment lies the digital network, which interconnects all parties together so that they can communicate and transact business with one another. Until recently, EDI has been the predominant form of E-commerce. EDI transactions are transported in two primary ways: direct dial-ups and value added networks (VANs). Direct dial-ups offer point-to-point connection, and allow a company to periodically pick up EDI data from or deposit EDI data into its trading partners' computers. By using a VAN, a company can multicast the same EDI transaction to multiple business partners. The VAN is responsible for holding the data in the receiving company's mailbox until the data is picked up. Studies have shown that using EDI for linking with business partners in the supply chain can help reduce processing, cycle-time, improve accuracy, and create strategic value (Mukhopadhyay, 1998). However EDI fails to be widely adopted due to its high setting up and running cost, and its technological limitations. The cost of subscribing to a third party VAN and related services is still high. The high cost is only justifiable for those large firms that often have large volume and batch oriented transactions with their trading partners. Also when

implementing EDI firms have to follow the message standard and integrate EDI into their existing legacy applications. It is expensive and lengthy to do these setting up works. It has been postulated that the text-based and preordained formats of existing EDI standards are too rigid and outdated, given the current dynamics of business environment and marketplace which demands non-text capability, flexibility and customizable business logic (Marchal et al 1998). The cost of implementing EDI for the construction firms is especially high due to the fragmented and one-off nature of construction project. Contractors usually have to deal with a large number of suppliers, which are invariably different for each project. The costs associated with EDI can be further exacerbated when sources of construction materials are geographically remote.

The limitations and barriers in EDI are overcome by the introduction of Internet and Web technology. The Internet is the world's largest and fastest growing collection of public networks. In year 2000, there are 336 million Internet users. Catalyzed by the Internet, the worldwide electronic business increased to US$31.2 billion from US$11.2 billion in 1998 (Robert and Toby 2001). Internet is now the only viable network infrastructure that can serve as the backbone of a global electronic marketplace, connecting together businesses both large and small, and foreign and domestic. Network infrastructure is now not the barrier of E-commerce. The remaining area of concern is whether application software can fulfill the requirement of E-commerce.

The computing industry divides E-commerce application software into two components: front-end and back-end. Front-end application produces interactive interface for the users. The enabling technology is a Web browser that can compile standard Hypertext Markup Language (HTML) and those cross-platform languages like JavaScript. Common elements of front-end interface include text, graphic, button, form, hyperlink, table, etc. Back-end application often involves interfacing with existing databases and applications in the server.

2.2.2 Benefits of E-commerce

Web technology can be used to overcome the system incompatibility problem of EDI by encapsulating enterprise systems as object components, made accessible by standardized interfaces, and standardized protocol for transmitting documents between these components through the Internet (Gek, 2000). The Internet provides a transparent means of communication between the buyers and suppliers. Users only need to know the address of the other party. Even though the Internet is a complicated network of switches, communication lines, software, and equipment, it is of no concern to users. The key to this simplicity is the separation of the various user organizations into islands with their own Internet networks connected to the islands by a common protocol (Andreoli *et al,* 1997). The standardization of network communication technology has significantly reduced the cost for installing a Web site and the unit cost for information transmission also becomes virtually negligible. From the technological point of view, Web technology should be able to

provide a cheap and efficient means for the contractors and suppliers to trade construction materials online. Generally a company applying Internet and Web-based E-commerce has the following benefits (Greenstein and Feinman 2000):

- Internet and Web-based E-commerce is more affordable than traditional EDI;
- Internet and Web-based E-commerce allows more business partners to be reached than with traditional EDI;
- Internet and Web-based E-commerce can reach a more geographically dispersed customer base;
- Procurement processing costs can be lowered;
- Cost of purchases can be lowered;
- Reductions in inventories;
- Shorter cycle times;
- Better customer services; and
- Lower sales and marketing costs.

Procurement cost can be lowered by traditional EDI systems by consolidating purchases, developing relationships with key suppliers, negotiating volume discounts, and greater integration of the manufacturing process. Internet E-commerce offers additional benefits and potential for cost reductions over traditional EDI. Procurement costs can be lowered for all companies, regardless of size, due to the increased ability to transact electronically with one another. In the suppliers' side, a reduction in inventory is desirable because of the associated reductions in storage, handling, insurance, and administrative costs. E-commerce can help firms to

more optimally order the inventories by electronically linking suppliers and purchasers together and allowing them to share updated production forecasts and projected inventory levels in order to allow both parties to collaboratively fine-tune their production and delivery schedules. Customer services can be enhanced using Internet-based E-commerce by helping the customer to access information before, during and after the sale. Before the sale is made, customers can electronically retrieve product specifications, quantity, and pricing information. During the products fulfillment cycle, customers can electronically check on the status of the order. After sales services that can be provided to customers include electronic notification of returned items and the ability to download and print the necessary documentation and shipping labels to return an item for servicing. Generally benefits that consumers may expect to receive are:

- Increased choice of vendors and products;
- Convenience from shopping at home or office;
- Greater amounts of information that can be accessed on demand;
- More competitive prices and increased price comparison capabilities; and
- Greater customization in the delivery of services.

2.2.3 Business Models of E-commerce

There are currently three types of classification on business models of E-commerce: 1) by types of order and delivery, 2) by types of trading parties, and 3) by types of

business activities. These three types of classification will be discussed in the following sections.

2.2.3.1 Classification by Types of Order and Delivery

There are four types of business models by this classification: 1) off-line order off-line delivery, 2) on-line order off-line delivery, 3) on-line order on-line delivery, and 4) off-line order on-line delivery (Liang and Huang 2000). For the off-line order, off-line delivery type, information of products is available from the Internet, but both ordering and delivery are executed off-line. The on-line order, off-line delivery type of E-commerce system provides on-line information of products and also allows users to make orders on-line. Once ordered, the product will be delivered off-line. In an on-line order, on-line delivery E-commerce system, information of products is provided on-line, and users can order the products in the system. Once ordered, the products or services will be delivered to the customer on-line. The off-line order, on-line delivery type of E-commerce requires customers to make orders in the traditional way, but the products or services is delivered through the Internet.

2.2.3.2 Classification by Types of Trading Parties

According to the European Commission (1999), E-commerce can be divided into four distinct categories: 1) business to business (B2B), 2) business to consumer (B2C), 3) business to administration (B2A), and 4) consumer to administration (C2A). Business to business E-commerce is the carrying out of business transaction between two businesses parties using electronic means. An example is a contractor

ordering materials from a supplier's website and paying online. Business to consumer E-commerce is the trading of consumer products online. Consumers can buy products from the manufacturers directly from the website. This can cut off middleman and thus allowing business firms to get higher profits while charging lower price. An example is a customer buying computer directly from Dell's website (http://www.dell.com). The business to administrator type covers transactions between companies and government organizations. For example in Hong Kong, the government takes the initiative to promote B2A E-commerce. An example is the Electronic Tendering System implemented by the Government Suppliers Department of Hong Kong SAR (http://www.ets.com.hk). This tendering system allows registered suppliers to search tender notice and to submit tender offer. The last type, consumer to administrator, covers transactions between citizens and government. The Hong Kong government has already implemented a comprehensive electronic payment system for the citizens to pay different fees online using credit card account (http://www.esd.gov.hk). The available services include payment for vehicle license, education loan, business registration, examination fee, etc.

2.2.3.3 Classification by Types of Business

A classification of business models of E-commerce by types of business is presented by Laudon and Laudon (2000). This classification introduces nine category of business models, namely Virtual Storefront, Market Place Concentrator, Information Brokers, Transaction Brokers, electronic clearinghouses, reverse Auction, Digital

Product Delivery, Content Provider, and On-line Service Provider. The description and examples of these categories are presented in Table 2.1.

Table 2.1: Internet Business Models (from Laudon & Laudon, 2000)

Category	Description	Examples
Virtual Storefront	Sells physical goods or services on-line instead of through a physical storefront or retail outlet. Delivery of nondigital goods and services takes place through traditional means.	Amazon.com Virtual Vineyards Security First Network Bank
Market Place Concentrator	Concentrates information about products and services from multiple providers at one central point. Purchasers can search, comparison-shop, and sometimes complete the sales transaction.	Internet Mall DealerNet Industrial Marketplace InsureMarket
Information Brokers	Provide product, pricing and availability information. Some facilitate transactions, but their main value is the information they provide.	PartNet Travelocity Auto-by-Tel
Transaction Brokers	Buyers can view rates and terms, but the primary business activity is to complete the transaction.	E*Trade Ameritrade
Electronic Clearinghouses	Provide auction-like settings for products here price and availability are constantly changing, sometimes in response to customer actions.	Bid.com OnSale
Reverse Auction	Consumers submit a bid to multiple sellers to buy goods or services at a buyer-specified price.	Priceline.com
Digital Product Delivery	Sells and delivers software, multimedia, and other digital products over the Internet.	Build-c-Card PhotoDisc SonicNet
Content Provider	Creates revenue by providing content. The customer may pay to access the content, or revenue may be generated by selling advertising space or by having advertisers pay for placement in an organised listing in a searchable database.	Wall Street Journal Interactive Quote.com Tripod
On-line Service Provider	Provides service and support for hardware and software users	Cyber Media Tune Up.com

2.2.4 Security Issues in E-commerce Development

One of the Internet's greatest benefits, increased connectivity, is also at the root of a business' greatest fear. The Internet was not created with the intention of using it as a communications network to conduct sensitive transactions securely and reliably. A public network by its nature is susceptible to information being viewed, copied, or

altered while in route to its final destination. Consumers have long heard horror stories about hackers intercepting credit card data on the Internet. This fear consumers have about secure payment processing has been a major stumbling block for Internet commerce thus far. With the use of encryption technology and digital signatures, consumers can be assured that the risk of credit card details being intercepted are less than the risk many cardholders run today when they hand over their card to a waiter in a restaurant.

Security threats upon information will exist in any networking environment, whether a document is sent over the public Internet or by using a proprietary VAN. However, a large advantage that a VAN has over a public network is an assurance that the data sent over the VAN will not be compromised in any way. Several measures must be taken to increase the security posture of an open network to meet the level of standards that subscribers to a VAN would expect.

2.2.4.1 Security of Data during Transmission

Trading partners subscribing to a VAN and transmitting data over private lines can be relatively comfortable that an EDI document will be routed to its recipient without any modifications. However, this level of assurance is not provided when connecting to the Internet via Internet service provider (ISP). This can be illustrated by performing an Internet network trace. By utilizing program commonly called Traceroute, any Internet user can follow the route traveled by an Internet Protocol (IP) packet from its source to its final destination. This exercise yields some

interesting observations. First, the Internet does an efficient job of routing packets to their final destination. Second, between the source and the destination many different intermediate network nodes handle the packet. At any one of these nodes, any individual with a network protocol analyzer, or sniffer, could easily capture, view, or reassemble the packets that make up a data packet. Additionally, a technical glitch occurring at any one of the hops in the route could cause the packet to be dropped or discarded. If the information contained in the packets contains sensitive information, measures must be taken to prevent such threats from occurring when an EDI document is sent over an open network such as the Internet.

2.2.4.2 Audit Trails and Acknowledgements

VAN subscribers have the capability to track an EDI document through the VAN. An example of this involves notifications sent to the trading partner upon the download of the EDI document by the recipient from its VAN mailbox. A second example is a functional acknowledgement sent by a VAN to the sender which indicates the receipt of a transaction by its recipient. Document tracking and functional acknowledgements offered by the TCP/IP protocol suite or supplied by an ISP do not meet the level of service provided by a VAN. This tracking information is very important in designing any on-line application, as well as in meeting the approval of financial auditors and legal counsel.

2.2.4.3 Authentication

The process of determining that a trading partner is indeed who he or she claims to be is called authentication. It eliminates the possibility of spoofing the identity of a trading partner while a document is in transit on a public network, such as the Internet. In the case of a VAN, a trading partner can only send or receive documents after they have been authenticated by the VAN. This process usually consists of the user logging into the network with the appropriate username and password.

2.2.5 Risks of Insecure E-commerce System

Risk can be defined as the possibility of loss or injury or someone or something that creates or suggests a hazard. Losses or injuries on the electronic frontier may occur in many different ways. Data may be stolen, corrupted, misused, altered, or falsely generated. Attacks on hardware may occur that render systems unable to operate properly. Hardware or software may be used without authorization, which may translate into lost revenue or slower response time for authorized users. Programs may be altered to cause systems to perform incorrectly or even to crash. In terms of electronic commerce, risk is viewed as the possibility of loss of confidential data or the destruction, generation, or use of data or programs that physically, mentally, or financially harms another party, as well as the possibility of harm to hardware. This section introduces the issues faced by firms that have connections to the Internet and that use the Internet for electronic commerce.

2.2.5.1 False or Malicious Web Sites

Malicious web sites are typically set up for the purpose of stealing visitors' Ids and passwords, stealing credit card information, spying on a visitor's hard drive, and uploading files from the visitor's hard drive.

2.2.5.2 Theft of Customer Data from Selling Agents and Internet Service Providers

Customers purchasing goods and services on the Internet typically pay with credit cards. This credit card information is stored by the selling agents and ISPs. Unfortunately for the customers, hackers are occasionally successful at breaking into the selling agent's and the ISP's systems and obtaining the customers' credit card data. This risk is comparable if someone use his/her credit card for any other purpose since corporate database containing non-Internet customer credit card information may also be penetrated and stolen.

2.2.5.3 Customer Impersonation

One risk to the selling agent is that the customer is not the entity they claim to be, also called impersonation. If one can misrepresent himself/herself as a legitimate customer, he/she can order goods and services for a variety of reasons. One reason may be to obtain a free service or product, such as to purchase and download software paid for with a false credit card number. Another reason may be to have goods shipped with no intention to receive or to pay.

2.2.5.4 Denial of Service Attacks

Selling agents, among other web site servers, may be the target of malicious attacks called denial of service attacks. A denial of service attack is used by an individual to destroy, shutdown, or degrade a computer or network resource. The goal of such attacks is to flood the communication ports and memory buffers of the targeted site to prevent the receipt of legitimate messages and service of legitimate requests for connections. The primary loss is down time and the system can usually be easily recovered by rebooting it. For many business on the Internet, however, lost time can mean lost sales and, therefore, lost revenue.

2.2.5.5 Data Theft

Data files such as customer lists and engineering drawings that are stored digitally and connected to public telecommunications lines can potentially be accessed by an unauthorized user without the perpetrator ever having to leave the comfort of home. Furthermore, the perpetrator may be miles or oceans away from which the data is stolen. Additionally, if perpetrators suspect exposure, they can quickly disconnect and likely not be traced. The risks of theft of data can be reduced by preventive techniques such as firewalls and encryption.

2.3LITERATURE RELATING TO ELECTRONIC PRODUCT CATALOG

2.3.1 Introduction to Electronic Catalog

The term "electronic catalog" is defined broadly here to include any World Wide Web (WWW) page that contains information about the products and services a commercial entity offers. A typical electronic catalog contains detailed pricing information which potential customers can use to help make purchasing decisions. Moreover, it may also support online shopping, ordering, and payment capabilities. There are catalogs, especially of non-commodity items, that do not provide detailed pricing but rather only pointers of where to obtain such information, how to order a product, and how to pay for the order. A web site may contain one or more catalogs. An electronic mall, for example, is a collection of catalogs from different companies. Like in a physical mall, these companies rent virtual store space on the server of a common service provider. The terms electronic storefronts and web catalogs are used interchangeably with electronic catalogs.

An electronic catalog is not an electronic replica of a printed catalog. Rather, it is an entirely new medium that can be more appropriately viewed as the virtual gateway or front-door to a company, and a front-end to the global electronic marketplace. Electronic catalogs possess four important characteristics: interactivity, dynamic updating, hypertextuality, and global presence:

- **Interactivity**: Printed catalogs represent a one-way flow of information from the company to its potential customers. Electronic catalogs, in contrast, provide a two-way communication channel between the company and its customers. For example, if a customer has a question or comment about a product while viewing its catalog, he or she can simply click on the e-mail button and enter his or her comments. The feedback is instantaneous, contextual, and almost effortless. This ability to carry out "dialogues" with potential customers enables the company to develop closer relationships with its customers and be more responsive to their needs.
- **Dynamic updating**: Electronic catalogs are stored in a centralized server and accessed by client browsers distributed throughout the world. The catalog content can be easily and constantly updated on the server, and the update is instantaneously visible to all clients. This dynamic nature of electronic catalogs enables companies to rapidly respond to changing market conditions through repackaging, re-pricing, re-channeling, and so on.
- **Hypertextuality**: The Internet represents a rich repository of information resources, ranging from anonymous FTP files and gopher documents to newsgroups. The World Wide Web, on which electronic catalogs are built, provides an elegant way of linking related resources together. For example, a wine catalog might contain not only such essential information as taste and price but also pointers to information such as the winery that makes a particular wine, recipes that go with the wine, and third-party wine reviews.

These hyperlinked resources form value-added content which the user may choose to navigate when needed.

- **Global presence**: The Internet is a global network of networks. Hence, any electronic catalog is a "shopping stop" in a global marketplace that transcends the traditional limitations of time and space. Since the cost for establishing such a global presence is minimal compared to that required to print a traditional paper catalog, electronic catalogs offer small and medium-sized companies a special advantage in competing globally.

Because of the above characteristics, electronic catalogs can be viewed as an interactive channel that links together a company with its suppliers, business partners and consumers. They may be used to create brand awareness, market a product or service, test-run a product, generate sales or sales leads, and provide after-sale support.

2.3.2 Role of Electronic Catalog in E-commerce System

One important application of electronic commerce which will play a vital role in the emerging global electronic marketplace is the electronic catalog. An electronic catalog is a World Wide Web based application that provides the company with a new channel to market, sell, and support products and services over an open network environment such as the Internet. From the customer's point of view, it offers an alternative means of finding out what product or service is currently available in a given market, who the suppliers of that product or service are, and where and how to

get such a product or service. As a new medium, electronic catalogs combine many useful features of existing channels, such as the rich content of printed catalogs, the convenience of home shopping, the intimacy of on-site shopping, and the sophisticated searching capability of CD-ROM catalogs. However, the most important characteristic of electronic catalogs is that they can be seamlessly integrated with other functions of the company and of its business partners. For example, the content of an electronic catalog can be dynamically generated from the company's product database in response to the user's query. Since the company's inventory database can be linked to its supplier's ordering system, the supplier can be automatically alerted to ship any particular product when its inventory level reaches a certain threshold value. When a customer makes a payment through an electronic catalog, the transaction can first be sent electronically to the merchant's bank, which, perhaps through a third-party, transfers funds from the customer's account to the merchant's account. In an electronic environment, the above process is carried out transparently. The electronic catalog serves as a front-end application that provides a uniform interface to the global electronic marketplace. Moreover, it can also serve as a "virtual gateway" to the individual company through which customers gain access to the company's product information, people, and support services, as well as provide feedback about the company's products and services.

2.4 Literature Relating to Geographical Information System

2.4.1 Introduction to Geographical Information System

Geographical Information Systems (GIS) usually refers to an information systems which facilitates input, query, analyse, output and visualization of geo-referred spatial information. GIS differs from other information systems with its abilities to handle spatial information from scales and any sources (for examples, locations of suppliers and construction sites, railway network and administrative regions obtaining from local maps, and regional distribution of land uses obtaining from satellite images). GIS can be understood through its roles in data management and integration, data analysis and data visualization.

2.4.2 Spatial Data Management and Integration

Figure 1 demonstrates a well-known layer-based architecture, which is commonly employed in traditional GIS. Each layer in the GIS denotes a single theme (or fact) in a particular area. Although these layers seem to be separated, they are connected via their common representation framework – a coordinate system. Although GIS closely links to database management systems (DBMS) as general information systems, GIS differs from other information systems with its own data indexing system. Queries in general information system bases on values of stored data, for example, retrieve all suppliers with their annual revenues greater than $1 million. In

order to optimise performance of the query, data is usually managed according to their numerical / alphabetical order. GIS, on the other hand, queries base on the locations of the features, for example, retrieve all suppliers locate within 10km from of a city. Data in GIS is managed according to their locations in space, that is, adjacent features in space are stored in near locations in physical storage devices. This approach of data management is unique in GIS and facilitates many types of spatial queries and analyses that are practically impossible in other information systems. Moreover, with this architecture, information about one particular location or area can be easily managed and integrated, even though they are obtained from different disciplinary, different data types and different scales.

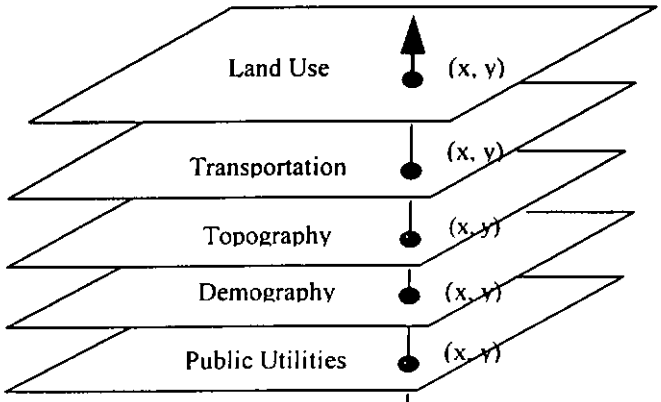


Figure 2.3: Architecture of GIS

2.4.3 Spatial Data Query and Analysis

With the architecture mentioned above, GIS is a unique tool from which users are able to ask questions concerning with locations and relationships among locations. Depending on natures of applications, questions to be answered by GIS ranges from simple data query including one data set or data query including multiple data sets

based on their spatial relationships, to complex spatial analysis. GIS is usually supplied with built-in functions to perform queries relating to locations, to examine spatial relationships or patterns among multiple spatial data sets, and to combine with external databases and software. Once these functions are put into right places and right applications, GIS not only save time and money in many labor-intensive tasks (e.g. co-relates thousands of paper maps on a light box), but also is a significance tool in supporting decision-making over the space.

2.4.4 Network Analysis

Network can be effectively represented in the location-based architecture of GIS. Network is usually defined as a set of connected linear segments. Lines that compose the network are arcs and the intersections that connect arcs are nodes. Network is essential to represent many natural and cultural phenomena in the real world, e.g. stream network, street network, bus routes system and highway system. A commonly asked question about the network is: What is the optimal way to transport resources from one location to another location in the network? GIS can be used to assist the decision making process over the network. Among the different kinds of network analyses, finding the shortest path is the almost fundamental and significant one. This is because solutions of the shortest path analyses are usually applied to higher-level or complex analysis.

Dijkstra's algorithm is the most well-known approach to calculate the shortest path between two point in the network (Dijkstra, 1959). The algorithm computes firstly, shortest paths from the given starting node to all other nodes in the network. For the network shown in figure 2a, node *a* is the starting node. With distances of the arcs, it is known that nodes *b* and *d* are nearest to *a* and shortest paths from *a* to *b* and *d* are arc *ab* and *ad* respectively. Figure 2b shows the tree of paths in figure 2a. The tree starts from *a*. Since the nodes *b* and *d* are the immediate neighbours of *a*, arcs *ad* and *ab* are added as first level leafs of the tree. The search is now performed for nodes *b* and *d*. At node *d*, nodes *a*, *b*, and *e* are the immediate neighbours of node *d*, and at node *b*, nodes *d*, *e* and *c* are the immediate neighbours of node *b*. Arcs *ab* will not be added to the tree, since the arc has been recorded already. Consequently, arcs *de* and *db* are added as leafs of *ad*. For leafs of arcs *ab*, *bd* will not be added since this has already been a leaf of arc *ad*. If arc *be* is added, there are two possible paths from *e* to *a*, those are *e-b-a* and *e-d-a*. This is known that the path is shorter when this passes though node *d*, so *be* will not be added as a leaf of *ab*. Eventually, only *bc* is added. Now, nodes *e* and *c* are undergone similar search methods, arcs *ec* and *ef* are added. Arcs *ce* is duplicated. Arc *cf* gives another path *f-c-b-a*, which is longer than the path *f-e-d-a* and therefore, *cf* is not added. Eventually, the tree shown in figure 2b is completed.

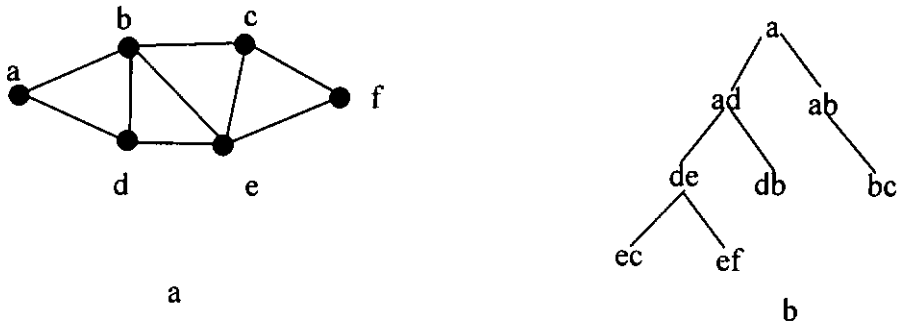


Figure 2.4: a. A simple network, b. tree structure of shortest path

From figure 2b, shortest paths form node a to all other nodes in the network can be traced. For the shortest path from node *a* to node *f* as an example, at the bottom of the tree, this is known that immediate neighbor of *f* is *e*, and neighbor of *e* is *d*, and the neighbor of *d* is *a*, therefore, the shortest path from node *a* to node *f* is *a-d-e-f*.

Here are some examples of the questions concerning network analysis:

- Where are the suppliers of Cement *within* Guangdong province of China?
- Where are the suppliers of Door *near* to my construction site?
- What is the shortest route and best transportation method from supplier A to buyer B and what is the cost of transportation?

2.4.5 Spatial Data Visualization

Another important application of GIS is to present data in form of maps automatically. It is known that about 80% of all data are related to locations, hence most data can be analyzed and viewed spatially (www.gis.com). Actually in many

cases, map-based presentation of these data is much informative than other formats of presentation, such as table or charts. For example, map-based presentation is more appropriate for census information (figure 2.5). GIS usually provides various cartographic functions, such as automatic symbolization based on values of data, automatic text placement, contouring or surface fitting. Some advance GISs even provide three-dimensional mapping ability for multiple-dimensional data.

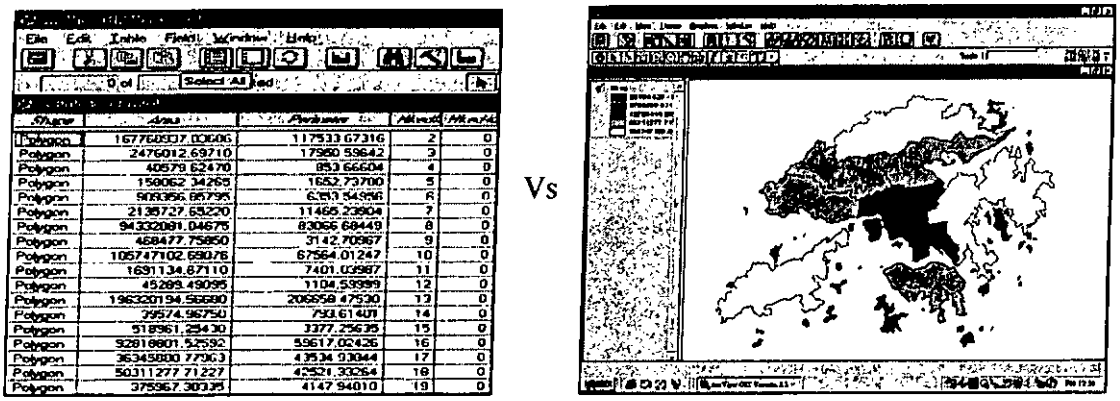


Figure 2.5: Visualising data using GIS

Apart from mapping a single status of feature at space, GIS can map changes in space as well (www.gis.com). Representation of changes in space is valuable in predicting future conditions and in deciding further actions. GIS maps change by showing where and how feature moves/changes over a period of time. Another approach is to map the statuses before and after an action in order to examine impact of the action.

2.4.6 Roles of Geographical Information (GI) and Geographical Information Service (GIService) in E-commerce

Conceptually, the electronic trading process itself is not bounded by the geographical locations of both buyers and suppliers. The system should open for any buyers and supplier in the construction industry all over the world. However, in the industry, buyers consider cost of transportation as one of the deterministic factors in choosing their suppliers. A large percentage of the overall expenditure of the purchase is spent on the cost of transportation. In this sense, geographical location is the only data that provides information about transportation cost. Most importantly, in the platform of electronic market, buyers have relatively less knowledge about suppliers then in the conventional trading process. Apart from the descriptive information of suppliers provided by the system, geographical locations of the suppliers give the buyers some implicit information about the suppliers and qualities of their material. From the suppliers' point of view, the Internet offers opportunity to invest anywhere in the world. However, before an investment is made, economic characteristics of a particular region, for example the rate of establishing new apartments, must have to be carefully considered. Geographical information is a valuable and, many times the only source to compare and to analyze business environments of different regions. Three kinds of geographic information services offered by Web-based GIS in e-commerce applications will be introduced in the following sections.

2.4.6.1 Publishing Geographical Data on the Web

The most foundational use of Web-based GIS in supporting the electronic market system is to provide geographical data associated with suppliers and materials. The underlying idea of the electronic market is to provide a platform from where buyers can find service from a large number of service providers. Since the buyers are not necessary to contact the supplier personal in the on-line ordering system, provision of detail, accurate and up-to-dated information of suppliers and material is the most important consideration. Geographic representation is usually the more expressive way to present a large volume of information, than charts or table. Web-based GIS deliveries geographical data of suppliers to all users of the system, for example, Web-based GIS can provide a directory of supplier and visualizes their locations in form of maps.

2.4.6.2 Spatial Query and Analysis

With the comprehensive geographical database of goods and suppliers, general users without specific training can perform spatial query and analysis in the Web-based GIS. The users can search, for example, the suppliers that provide the most competitive price of material around 5 miles away. Moreover, Web-based GIS allows marketing specialist to see various trading patterns. The specialist can analyze the area in which suppliers of a particular material are highly condensed. On the other hand, suppliers are able to analyze the purchasing behavior of buyers all over the world and to compare the behavior against demographic information in

different regions. All results of the analysis can be presented in form of map and included in other documents for further references.

2.4.6.3 Transportation and Logistic

As have been mentioned above, no matter which types of business practice are adopted, the E-commerce system ultimately lead to direct or indirect transportation of goods from suppliers to buyers. Although the principle of online business is to provide a platform from which business activities can be performed without limitations on space and time, costs of physical transferring of goods must be considered. Web-based GIS not only maintains a comprehensive geographical database for transportation networks, but also provides tools to analyse the most cost-efficient transportation route to deliveries goods from the suppliers to construction site of the buyer.

2.5 Summary

This Chapter reviewed literatures relating to construction material procurement, E-commerce application, Internet-based electronic product catalog, and geographical information system.

Chapter 3

CHAPTER 3

BUSINESS MODEL, SYSTEM ARCHITECTURE AND FUNCTIONAL DESIGN OF COME

3.1 INTRODUCTION

Electronic Commerce (E-Commerce) has the ability to conduct business via electronic networks such as the Internet and the World Wide Web. Although Electronic Commerce is based on the principles of Electronic Data Interchange (EDI) it goes far beyond EDI in that it aims at supporting the complete supply chain of a construction project, including the information stage (electronic marketing, networking), the negotiation stage (electronic markets), the fulfillment stage (order process, electronic payment) and the satisfaction stage (after sales support).

Emphasis these days is on business-to-business (B2B) E-Commerce applications: taking orders, scheduling shipments, providing customer service and so on. However, present E-Commerce implementations automate only a small portion of the electronic transaction process. Moreover, E-Commerce is hampered by closed (self-contained) markets that cannot use each other's services, incompatible frameworks that cannot interoperate or build upon each other, and a bewildering collection of security and payment protocols. In general, E-Commerce applications do not yet provide the robust transaction, messaging and data access services typical of contemporary client/server applications. While there is considerable interest in

developing robust Internet applications, protection of significant investments in client/server technology and interoperation with mainframe transaction servers and legacy systems is a serious requirement.

Construction organizations conducting their business using E-Commerce typically work together in a seamless supply chain as a single unit using various telecommunications and advanced information technologies so as to increase the effectiveness of their business relationships between trading partners. The use of such telecommunications and technologies is set to revolutionize the way that organizations operate in the next millennium. Thus, many construction organizations are now reviewing their information systems so that they can exploit recent technological developments and therefore enable improved organizational competitiveness through E-Commerce.

Many believe that E-Commerce can provide a win-win situation for both suppliers and buyers, as E-Commerce can provide an expanded marketplace within which buyers and suppliers can communicate directly with each other. Online construction trading markets are not limited by the physical limitations of store spaces and can carry a much larger variety of products and different styles and sizes. At the same time, buyers can search through a wide range of products with low transaction costs at any time convenient to them. More importantly, the direct communication between buyers and suppliers will cut off the multiple layers of middlemen between suppliers and buyers. These middlemen take commissions and fees from both buyers

and suppliers. Use of E-Commerce will therefore directly benefit the buyers so they can purchase cheaper products with a variety of choices (Bakos 1991).

3.2 BUSINESS MODEL OF THE PROPOSED SYSTEM

The proposed system is designed for facilitating the construction material procurement function. Before designing the system, some professionals in a Hong Kong construction company were consulted to identify current construction material trading situations.

3.2.1 The Current Construction Material Trading Situations

In most construction material trading circumstances, there are three major players: *buyers*, *suppliers* and *agents*. Buyers are customers who purchase certain materials and products. Suppliers are products and/or services providers. Agents are intermediaries who help the buyers and suppliers to complete a transaction. The buyer and supplier must exist in any trading, while the agent exists only in certain trading situations. A good E-commerce system should support various trading situations. In the following section, some major trading situations are discussed.

By discussing with professionals involved in construction material procurement, four trading situations frequently encountered in construction material trading are identified. The four trading situations are *bargaining, bidding, auction* and *contract*.

3.2.1.1 Bargaining

Bargaining is a trade situation in which the buyer negotiates with the supplier until an acceptable deal is reached. Usually, the buyer finds a supplier, examines product price and other terms, and negotiates in order to obtain a better deal. If the deal fails, the buyer finds another supplier to bargain again until the buyer is satisfied with the deal.

3.2.1.2 Bidding

Bidding is a trading situation that involves a buyer and many potential suppliers. The buyer compares the received bids from suppliers and chooses the best one. A typical bidding process includes the following steps: the buyer firstly calls for bidding after determining the specification amount and base price; bidders then submit their bids; the buyer chooses the best bid; at last the buyer pays for and the winner delivers the products and/or services.

3.2.1.3 Auction

Auction is a trilateral trading situation that involves a supplier, many potential buyers and an agent who handles the auction. The buyers bid sequentially to compete for the object to be sold. A typical auction process includes the:

- supplier determines the bottom price of the object to be sold;
- agent announces the object and calls for an auction;
- potential buyers assess the value and bid for the object sequentially;

- agent chooses the buyer who offered the highest price which is also higher than the bottom price; and
- winner pays and the supplier delivers the object. Commission fees are paid to the agent.

3.2.1.4 Contract

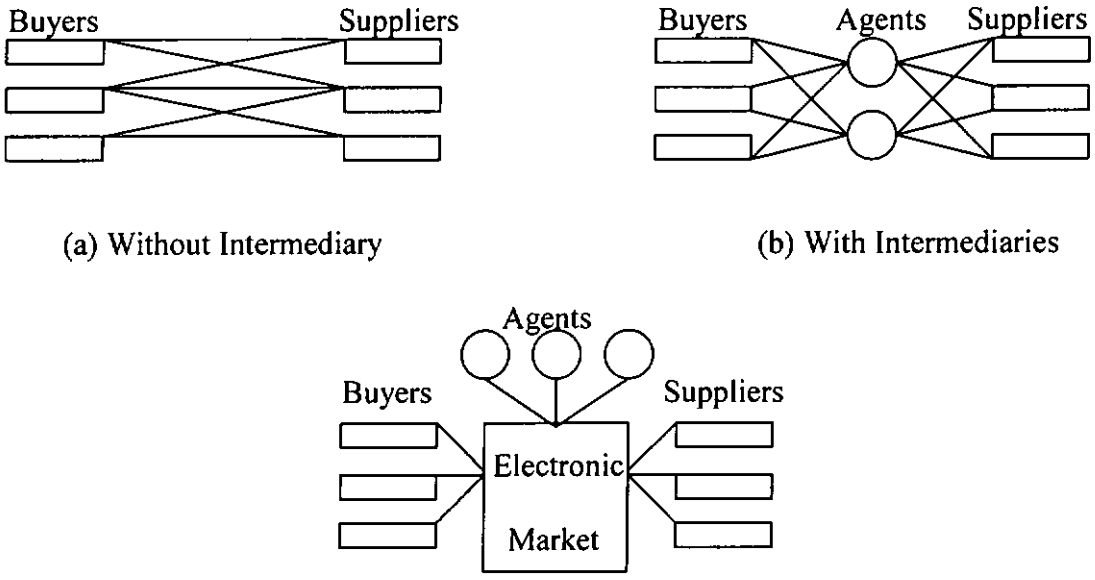
Contract is a trading situation in which both buyers and suppliers are constrained by a set of mutually agreed rules. If there is no contract, then both sides need to negotiate for an agreement. If a contract already exists, then ensuring accurate implementation of individual orders under the regulation of the contract becomes the primary concern. A typical trading process under contract often includes the:

- buyer informs the supplier to deliver certain products or services,
- supplier confirms the request, and
- buyer pays and the supplier delivers the products and services according to the contract terms.

3.2.2 Electronic Links between Trading Parties in E-commerce Environment

An E-commerce system for assisting product procurement creates electronic links between suppliers, buyers and agents (Sirinivasan, 1994; Wang and Seidmann, 1995; Choudhury and Konsynski, 1998). These links can be organized in different ways. As shown in figure 3.1, buyers and suppliers can either form direct

connections without any intermediary (a), with intermediaries (b), or acquire the products through electronic markets (c) (Strader and Shaw, 1997). These three types of connections allow product information of suppliers and the request for product by buyers to be accessed through a network, which provides a platform for buying and selling of products electronically.



(a) Without Intermediary

(b) With Intermediaries

(c) Electronic Market

Figure 3.1: Three types of buyer-supplier communication structure

From Figure 3.1, it can be seen that type (a) provides direct linkage between suppliers and buyers, which supports bargaining and bidding trading situations, but it is difficult to support other trading situations. Type (b) allows buyers to search and compare more products from the intermediary's platform and facilitates trading situations such as auctions and contracts based trading, but the intermediary becomes an unavoidable part of the supply chain which makes it inconvenient to

have direct communications between buyers and suppliers. Therefore, type (b) cannot support bargaining and bidding trading situations. The electronic market in type (c) provides a platform for the suppliers to put their product information online. Buyers can easily search and compare products of a pool of suppliers, and to contact suppliers directly. If necessary, buyers can also invite the agents to undertake certain tasks required in order to complete a transaction. Thus, type (c) has the most flexibility and functionality to support all the four trading situations encountered in construction material trading. The E-commerce business model presented in the following section is therefore based on the type (c).

3.2.3 The Business Model

The name of the proposed E-commerce system is COME, which is the short form of 'COnstruction Material Exchange'. In designing the COME system, it is assumed that most suppliers would be from China, whereas buyers can be from anywhere in the world. The reasons for making such assumptions include that firstly over 90% of the construction materials used in Hong Kong are from China and contractors in Hong Kong have expressed the need of an E-commerce system to expedite the trading process. Secondly, most material producers and suppliers in China have no proper channel to contact buyers from outside of China. The E-commerce system developed is therefore intended to provide a platform for suppliers in China to advertise their products so that trading activities with buyers from anywhere in the world can be conducted online.

Chapter 3 BUSINESS MODEL, SYSTEM ARCHITECTURE AND FUNCTIONAL DESIGN OF COME

In the current legal and business environment, exporting goods and products out of China involves preparing considerable amounts of paperwork required by various governmental bodies, buyers who do not have sufficient knowledge of the statuary regulations and business culture in China will have difficulties to fulfill the paperwork. To solve this problem, the E-commerce system has not only the buyers and suppliers as two major user groups, but also the agents in China who can be the brokers in negotiations and auctions, and also carry out all other duties required by the buyers and the suppliers. These duties include the search of suppliers' information, the preparation of all paperwork required in executing the trading transaction and shipping the products and materials to the buyers. This is because the agents are familiar with the business environment and regulations in China. Without them, it is very difficult if not impossible to sort out all the paperwork involved in exporting commodities from China. On the other hand, without agents, buyers from outside of China will find that it is very troublesome and expensive to conduct negotiations with suppliers in China. The agents can therefore be very helpful to these buyers.

The business model of COME is illustrated in figure 3.2. This figure summarizes the roles and functions of the three major parties in the COME system: buyers, suppliers, and agents. The COME system is designed to be an electronic market for facilitating the four kinds of trading situation introduced in the previous sections. The system will be owned by an application services provider (ASP) who

implements and runs it. Basically suppliers post their material information in the COME system and sell their material by directly dealing with buyers or through the agents in COME. Buyers can buy materials from suppliers by bidding, posting tender, negotiating with suppliers or through agents. The different functional modules of the COME system will be presented in detail in the later sections.

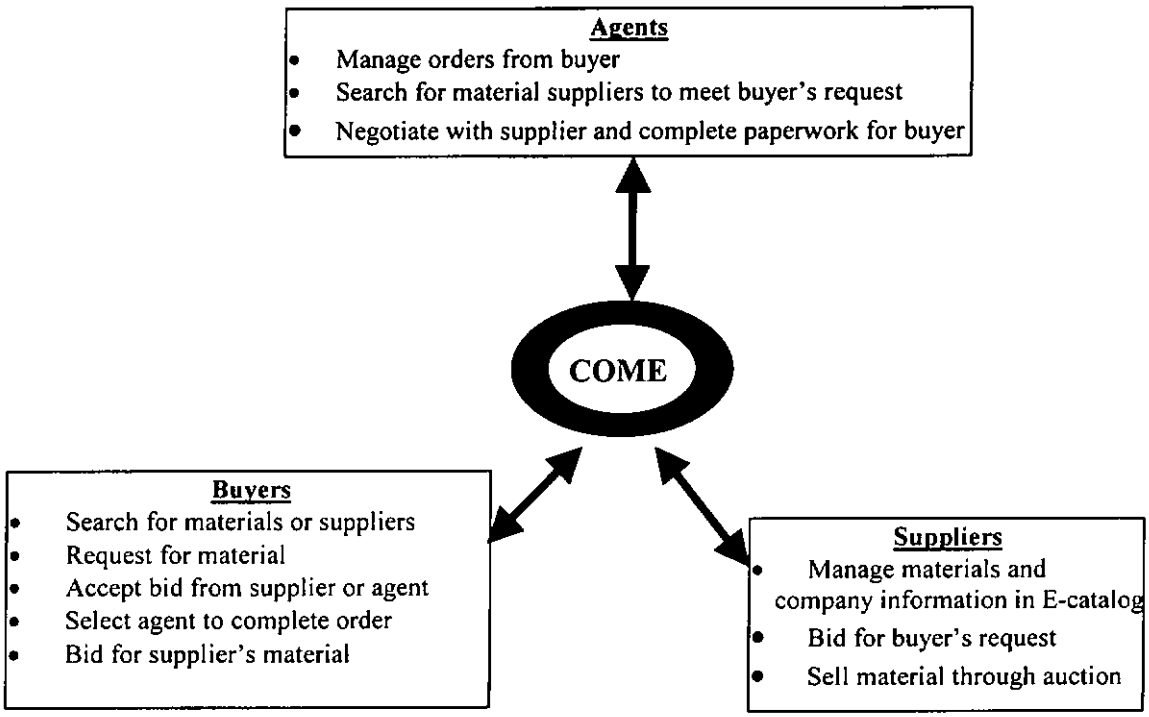


Figure 3.2: Business Model of COME

3.3 SYSTEM ARCHITECTURE

The COME system is developed on the Microsoft Windows 2000 Advanced Server platform running Internet Information Services version 5 that incorporate Active Server Pages (ASP) engine. It can be accessed at the URL:

http://bsnt42.bre.polyu.edu.hk. This system is hosted in a server located in the Department of Building and Real Estate of the Hong Kong Polytechnic University. The software and hardware configurations of the COME system are shown in table 3.1.

Table 3.1: Software and hardware configurations of COME

Software	
Operating System	Microsoft Windows 2000 Advanced Server
Internet Server	Microsoft Internet Information Services 5.0
Database Server	Microsoft SQL Server 7
Programming Language	VBScript, Active Server Pages, SQL Statement
GIS Server	Maptitude 4.2, TransCAD 3.0
File Transfer Tool	AspUpload 3.0
Hardware	
Processors	2 Intel Pentium III 800MHz processors
Physical Memory	512MB RAM with error correction function
Hard disk	3 9GB SCSI hard disks in RAID 5, 1 spare 9GB SCSI hard disk

VBScript is selected as the server-side programming language and Microsoft SQL Server 7.0 is its database engine. VBScript is a derivation of Visual Basic's language but doesn't have as many features as Visual Basic itself. The language is easy to learn and is well suited for working in the Active Server Pages environment. SQL Server is a scalable and powerful database engine that can be queried by Hypertext Transfer Protocol to perform full-text search on text and documents stored in database and to run queries over the Web with natural language. The AspUpload software is used for uploading file from the client's computer to COME's server through the interface in Web browser. As mentioned in the earlier chapter, this research will study the feasibility of incorporating geographical information system (GIS) in E-commerce platform to support material searching and evaluation. Two

GIS software is selected for implementation: Maptitude 4.2 and TransCAD 3.0. Maptitude has the richest feature set and highest performance of any PC-based mapping system. It can create interactive map, find geographic patterns, answer geographic questions, and incorporate interface in Hypertext Markup Language (HTML) page with the use of its geographic information system developer's kit (GISDK). TransCAD is the first and only GIS designed specifically for use by transportation professionals to store, display, manage, and analyze transportation data. This software is used in this research to manage and analyze the transportation network of China.

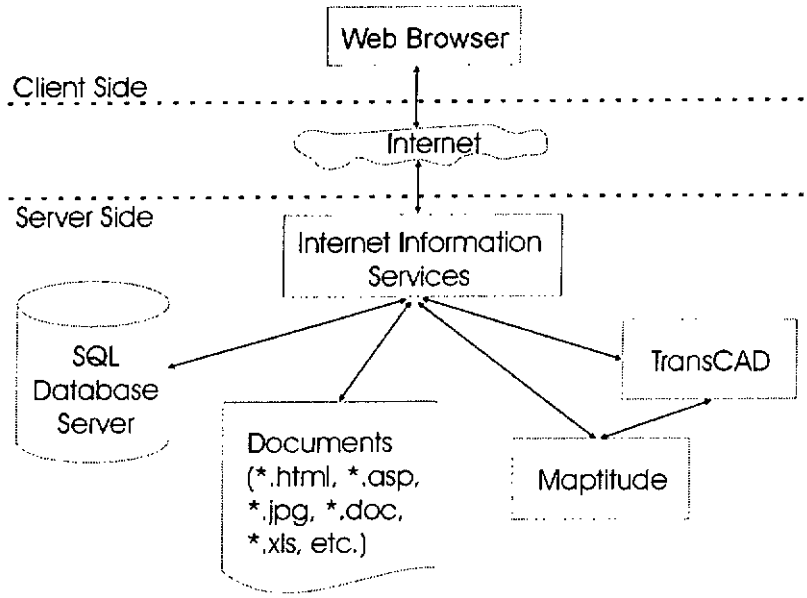


Figure 3.3: System architecture of COME.

The system architecture of COME is shown in figure 3.3. The COME system adopts the client-server architecture, or sometimes called two-tier architecture. It is a network architecture in which each computer on the network is either a client or a

server. Servers are powerful computers dedicated to managing disk drives (file servers), printers (print servers), network traffic (network servers), etc. Clients are PCs or workstation on which users run applications. Clients rely on servers for resources, such as files, devices, and even processing power. Clients may be 'thin' or 'fat', depending on how much of the software is running on the client. Factors affecting the right client weight include the speed and reliability of the network, the degree of required security, cost (thin client machines are cheaper). Thin client requires less remote support to maintain software, because more of the software resides on the server. The COME system uses the thin client approach. Users of COME need only a PC or even a pocket PC with Web browser. All applications are run in the server side. In this research project, all the servers in the COME system, including database server, GIS server, application server and file server, are installed in a single computer. In real world situation, these servers are installed in separate computers to increase system performance. Interfaces of the COME system in HTML format are sent to the client's browser throng Internet Information Services in the server. Most of the HTML pages are generated dynamically by compiling the ASP commands, VBScript, and SQL statement embedded in the ASP files. These HTML pages incorporate data in the SQL server and GIS server, and also files like image, Word documents, Excel documents, etc.

3.4 FUNCTIONAL MODULES OF COME

The seven functional modules, namely E-catalog module, GIS module, Bidding module, Auction module, Requisition module, Quotation module and Order module, and their functions provided for buyer, supplier and agent are shown in figure 3.4. These functional modules are designed to facilitate the four trading situations and streamline the whole material procurement process. The users of COME can use the electronic forms in these modules to minimize paper documents generated in the procurement process, and to maximize the efficiency and effectiveness of data sharing. These modules will be presented in the following sections. In this research, much effort is paid to the E-catalog module and GIS module and therefore these two modules will be discussed further in later chapters.

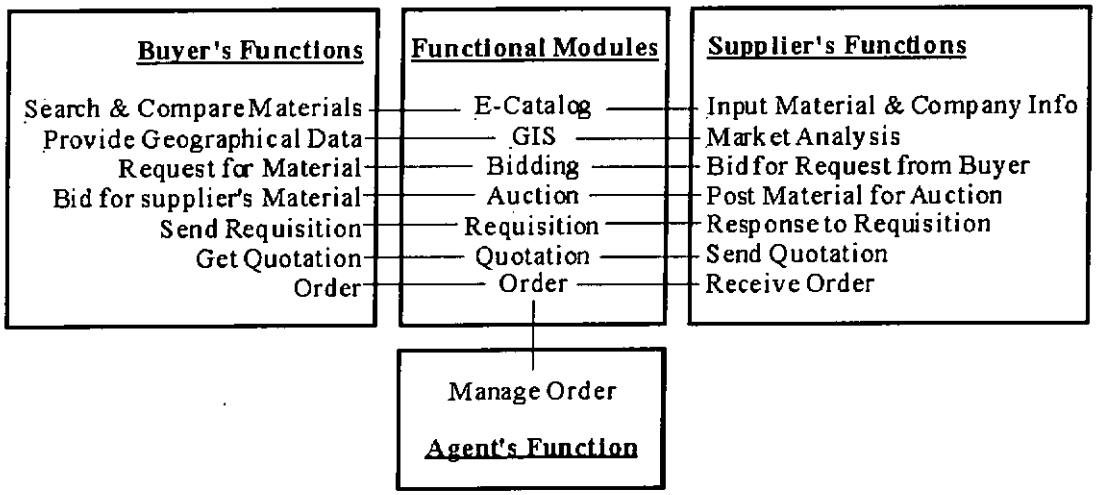


Figure 3.4: The functional modules of COME.

3.4.1 E-catalog Module

The E-catalog (electronic catalog) module provides interfaces for suppliers to input their product information into a classified material catalog. The product information includes price, unit, photo, brand name, quality standard and other relevant detail so as to allow the buyers to make judgments on the suitability of the products. Information on suppliers such as the company name, address, telephone, email and service details can also be input to the COME system for the buyer's reference. The searching function of the E-catalog allows buyers to specify searching criteria such as a price range, categories and keywords so that the desired materials and products can be found quickly. Also, retrieved results will be presented in a way that enables comparisons to be made. The E-catalog module is linked to the Order module where buyers can order the materials found in the E-catalog. A comprehensive study was carried out to identify the material searching mechanism in E-commerce system and the criteria of a good E-catalog. The E-catalog in COME is designed for the buyers' ease of searching, comparing and selecting construction materials. Details about the E-catalog modules are presented in Chapter 4.

3.4.2 GIS Module

Trading of construction materials unavoidably involves transportation. Transportation cost is an important factor for deciding where to buy materials, especially when the material is cheap and bulky. Another factor need to be

considered when purchasing material is delivery time. Material has to be delivered to construction site on time so that work progress will not be delayed. In order to provide the material purchaser with information about transportation cost and delivery time of materials, a GIS module is developed and is linked with other modules in the COME system. This GIS module automatically calculates transportation cost and delivery time between cities in China based on the existing transportation network. The GIS server in the COME system generate interactive GIS map for the buyers to select cities or define region for searching materials. Details about this GIS module are presented in Chapter 5.

3.4.3 Bidding Module

The bidding module allows buyers to specify materials they want to buy when they cannot find suitable materials from the E-catalog or when they want to use tendering method to get a competitive price from suppliers. Buyers firstly fill in the electronic form in the COME system to provide specifications of materials, date of delivery and other terms of service. Suppliers can then view the bidding information online and to bid for the material request. Messages are sent instantly to the buyers through email to inform them of the responses from suppliers. A buyer can check the bidding status and accept a bid online and this will constitute an order from the buyer to a supplier. The buyer and supplier can then use the order module to follow up the order.

3.4.4 Auction Module

The Auction module is built for the suppliers to sell their materials through auction. Suppliers can post their material information in the Auction module by filling in electronic forms in the COME system. Buyers can view the auction materials and bid for it online. At the end of the auction, the buyer who places the highest bid will win the order of materials. In case the supplier sets a reserved price in an auction, the winning bidding price must have to be higher than the reserved price. After the auction, the supplier and buyer can use the order module to follow up the order.

3.4.5 Requisition Module

The requisition module allows buyers to send requisitions to suppliers after suitable materials have been identified from the E-catalog. Although the unit price of each material is stated in the system, suppliers may give discounts to buyers according to the amount of purchases, payment methods and their relationships with buyers. Supplier can view the requisition online and then use the quotation module to reply to the buyer.

3.4.6 Quotation Module

The quotation module provides interface for the suppliers to send quotations to buyers after receiving requisitions. Buyers will receive notice of the quotations and

be able to view the quotation details online. In case buyers are satisfied with the quotation, they can then use the order module to make an order.

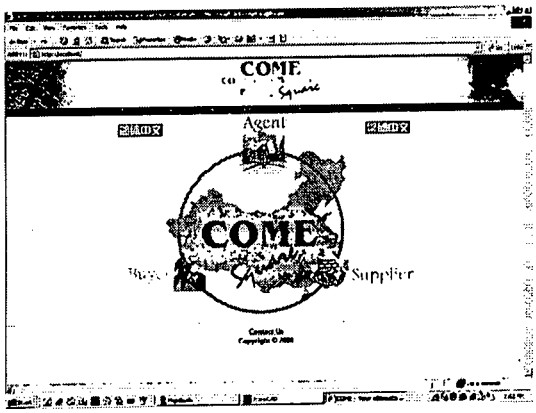
3.4.7 Order Module

The order module allows buyers to make orders. The buyer can use the order module in four situations: 1) the buyer finds suitable materials from the E-catalog and wants to make a direct order, 2) the buyer receives a quotation from the supplier, 3) the buyer accepts a bid from the supplier, and 4) the buyer wins an auction. The COME system provide interfaces for both buyer and supplier to check order information, including material specification, quantity required, price, delivery date, delivery place, and terms of service. The Order module also allows buyer to specify an agent registered in the COME system to follow up order. In this case the selected agent will assist the buyer to order the materials and be able to use the COME system to check the order information.

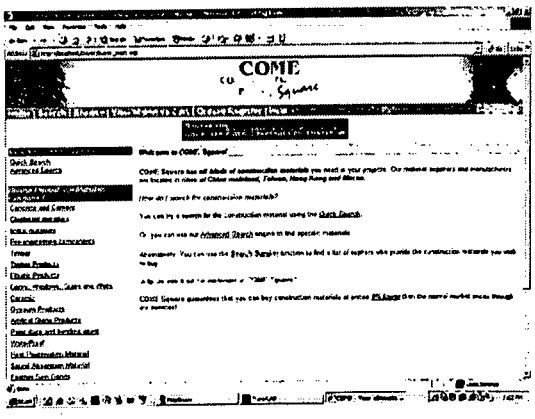
3.5 INTERFACES OF COME

Interfaces of COME are in HTML format. Most of the interfaces are generated dynamically according to the user's query. Basically the interfaces compose of text, image, table, form, and link. All the interfaces are assessed through the Web browser. Figure 3.5 shows the welcome page of COME and the main pages for

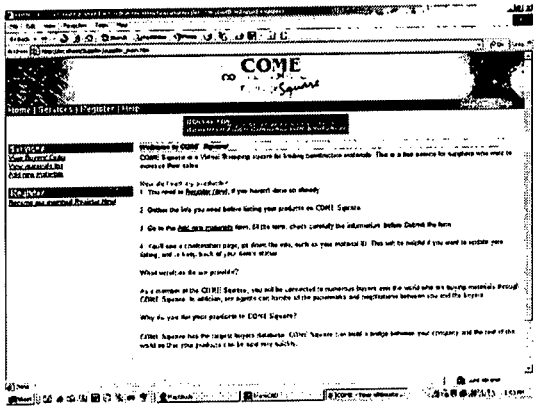
buyer, supplier and agent. Figure 3.6 shows interfaces of the different modules presented in the above section.



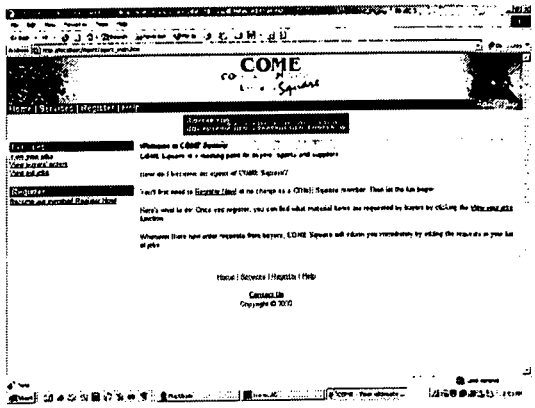
Welcome page



Buyer's main page

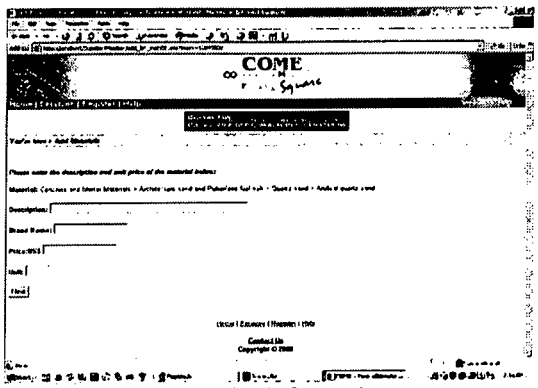


Supplier's main page

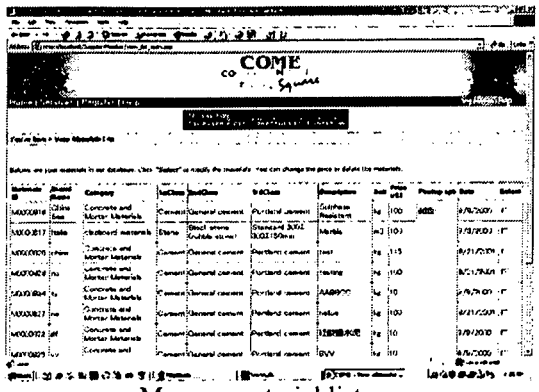


Agent's main page

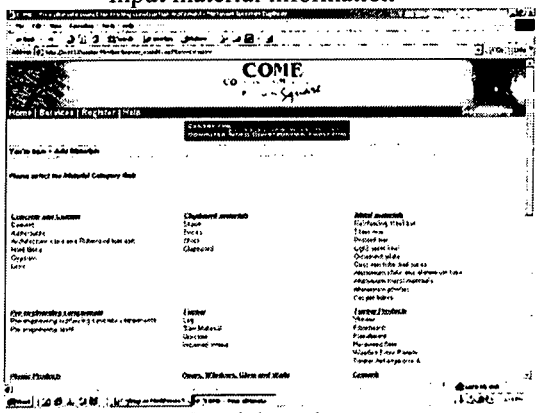
Figure 3.5: Welcome page and main pages of COME.



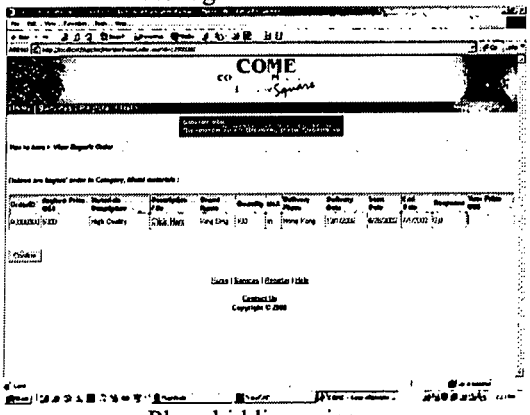
Input material information



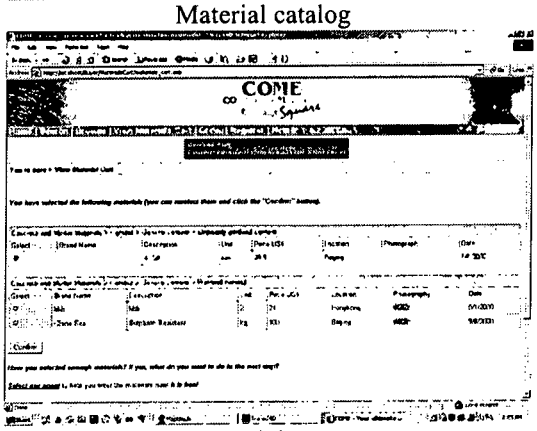
Manage material list



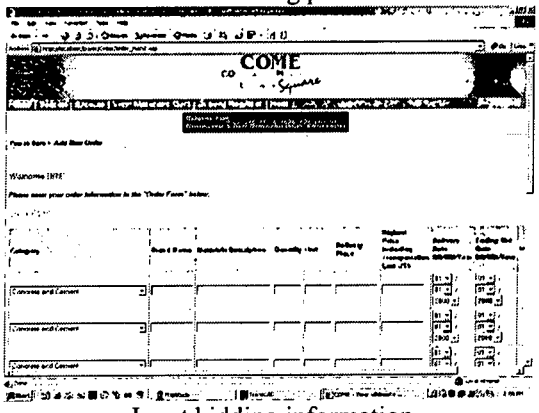
Material catalog



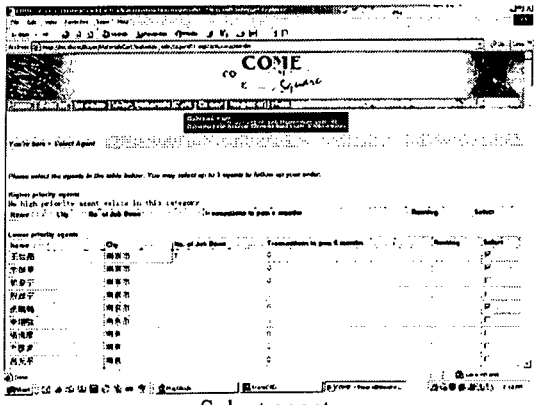
Place bidding price



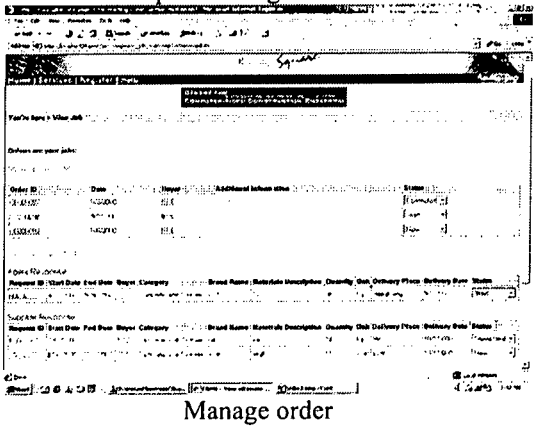
Material cart



Input bidding information



Select agent



Manage order

Figure 3.6: Interfaces of COME.

3.6 SUMMARY

This chapter presented the four types of existing material trading situations, which are negotiation, contract, bidding and auction. The COME system is designed to facilitate these four kinds of trading situation and to streamline the whole material procurement process. The business model, system architecture and functional modules of COME are presented and discussed in this chapter.

Chapter 4

CHAPTER 4

THE ELECTRONIC PRODUCT CATALOG IN COME

4.1 INTRODUCTION

Internet-based electronic product catalog (IEPC) is a very important element in the electronic markets. Frequently, an IEPC offers multimedia presentation of products, provides classification and retrieval support, and acts as interface to other e-commerce services such as quotation, bidding and ordering. Unlike paper based or Compact Disk (CD) based catalogs, IEPCs are online, permanently up-to-date, ubiquitous, and enable customization and direct communication between sellers and buyers. IEPCs are the interactive front end to global marketplace.

Suppliers in the construction industry are also aware of the potential of e-commerce and have started to put their product catalogs online. However, before the suppliers can really benefit from e-commerce, they must first provide a comprehensive and user friendly IEPC to the buyers so that buyers are willing to use their e-commerce system to find products.

The first part of this chapter discusses the functions and requirements of an IEPC. The second part reviews existing IEPCs for construction material marketplace from

the perspective of information organization, management and retrieval within IEPCs. The last part presents the implemented IEPC in the COME system.

4.2 ARCHITECTURE OF IEPC

IEPCs are transcended from paper-based product catalogs. Paper-based product catalogs contain colorful and structured presentations of products. Over time, product catalogs have changed their styles along with the carrier of information for which they were created. The first type of electronic product catalogs (EPCs) were CD based catalogs. Most of them are still offline catalogs, but compared to their paper-based predecessors, CD based catalogs offer sophisticated search functionalities as well as multimedia product presentation.

IEPCs are an evolved generation of EPCs, which are based on a powerful ubiquitous carrier of information. Based on the features of the Internet, they are online and can seamlessly integrate with other business functions of the company and its business partners. Thus, in comparison with CD based catalogs, they are up-to-date, they allow for dynamic adoption of content presentation according to the needs of buyers and they provide a direct communication channel between the buyers and the sellers.

4.3 DEFINITION OF IEPC

Timm and Rosewitz (1998) define IEPC as a system that allows customers to browse through multimedia product representations and to get relevant information concerning the product. Another definition is given by Keller and Genesereth (1997) who see IEPC as the reference for product selection that can assist with source selection and description of terms and conditions. A more comprehensive definition is given by Stanoevska-Slabeva and Schmid (2000): "IEPCs are interactive and multimedia interfaces between buyers and sellers on the Internet, which support product representation, search and classification and have interfaces to other market services as negotiation, ordering, and payment." The author see IEPC as an interactive front-end interface that provides classified and structured product information, and supports product searching, comparison and evaluation, and may have linkage with other e-commerce services such as bidding, ordering and payment.

4.4 ELEMENTS AND FUNCTIONS OF IEPC

Any IEPC contains two constitutional elements: 1) Keywords or abstract references to the available information and 2) detailed information about products in various forms. In an IEPC of construction materials, keywords are usually the product categories. Detailed information includes structured product information, unstructured product information and buyer-generated information. Structured

information is stored in relational databases and can easily be offered online with available state-of-the-art databases and online merchant technology (Lincke 1998). The form of the unstructured information varies from documents to complex multimedia data structures (Elsworth and Ellsworth 1995). Buyer-generated information appears in different forms: ratings of products, contributions to discussions, contribution to virtual communities, customer testimonials or comments (Hagel and Armstrong 1997).

IEPC serve as a tool to facilitate efficient search for product offering over the Internet (Kalakota and Whinston 1996, Whinston *et al* 1997). The core functionality of IEPCs is to provide an easy access to product information and selection. As shown in figure 4.1, there are generally three steps in the online product selection process: product browsing or searching, product evaluation and comparison, and product selection. Each of these steps will be explained in the following sections.

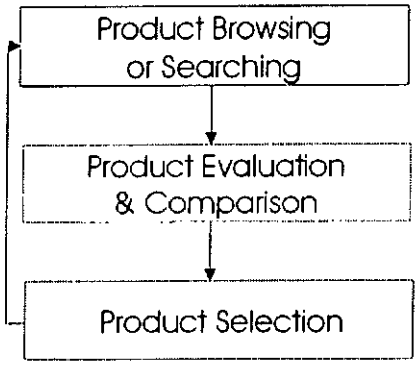


Figure 4.1: Product selection process in IEPC.

4.4.1 Product Browsing

Buyers access the catalog of a supplier in order to browse through the offered products or to find a specific product they need. During product browsing, the most important function of an IEPC is the establishment of a common understanding between the buyer and the supplier through the offered information. This can be best achieved when all information related to a product is offered at once. Keywords are used as placeholders and representatives for retrievable information. The common understanding usually has to be established on a first compressed abstraction of the other content. For instance, a buyer may need to go through certain levels of keywords of product category before he/she can view the detailed description of a product (figure 4.2). It would be very helpful to get more information about the meaning of the keywords or about the next level of keywords before selecting.

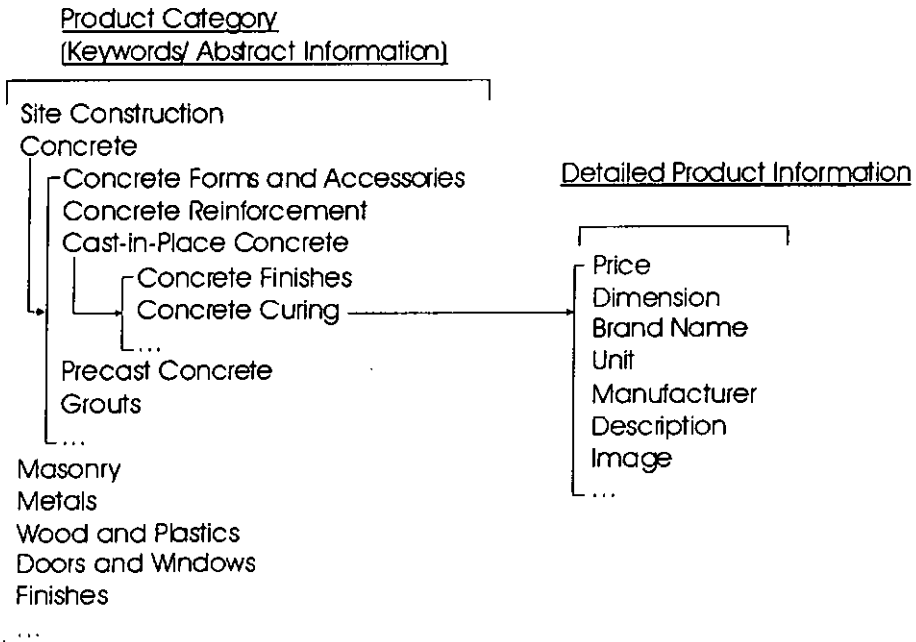


Figure 4.2: Linkage between keywords and detailed description of a product.

4.4.2 Product Searching

An electronic product catalog can be viewed as a search service operating in a search market to facilitate the process of selection (Whinston *et al* 1997). Depending on the types and amount of product information provided in IEPCs, the search service can operate sequentially or simultaneously. In the case of searching product on a website of a single supplier, buyers will need to search through different suppliers' sites one by one to compare products. However, in the case of searching product in an electronic market, where products of many different suppliers can be found, buyers can search through different suppliers' products simultaneously. In any case, search technologies in IEPCs allow buyers to engage in a sophisticated and efficient search.

The process of searching is composed of two major sections: collection of query criteria and the actual search operation. In a simple search function, a buyer will only need to enter keywords to query for results. In a more sophisticated search function, apart from query by keywords, a buyer can set query constraints like price range, physical dimension, weight of product, brand name, category, etc. In some more advanced search functions, the query constraints may be entered in more than one step. The constraints entered in the earlier steps will refine the available query criteria in later steps. More sophisticated search functions can yield more accurate and fewer numbers of search results, which can prevent information overload and shorten the buyers' product selection time.

The actual search process passes the query set by the buyers to the search engine. The search process can be as simple as querying a single database, but can also be as complex as querying multiple databases of different electronic market through agent system or mediating ontology (figure 4.3).

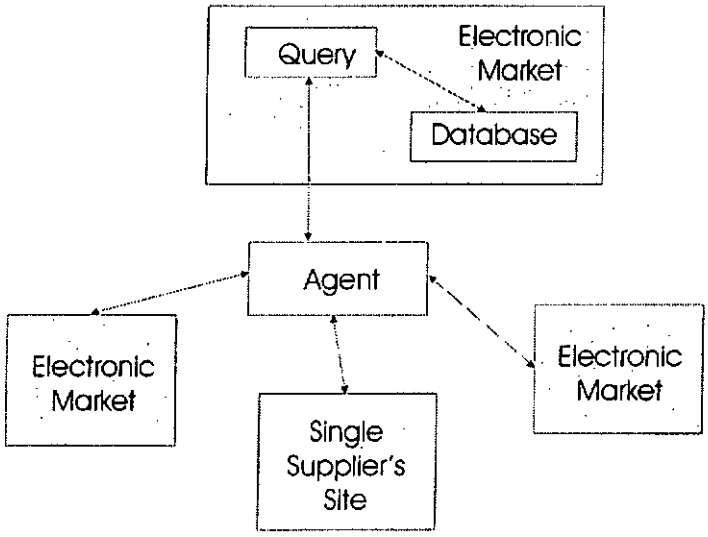


Figure 4.3: Searching mechanism in IEPCs.

Querying databases in heterogeneous systems requires the understanding of all systems' database schemas and the ontology used for communication. In any case, all search results matching the query constraints will be passed back to the IEPCs for arranging display to the buyer.

4.4.3 Product Evaluation and Comparison

In the product evaluation and comparison stage, IEPCs must enable individual storage of interim results and be able to provide sophisticated functionality for their interactive management and processing to the buyer. It is better to display search results in a single page so that buyers do not need to click back and forth to compare different products. To facilitate evaluation of products, rich content of product information is necessary. Besides text-based product description, multimedia like images, videos and CAD models can be very helpful for buyers to evaluate products. In addition, customer generated information like comments and ranking of products, and external information like news and industrial standard can also assist the buyers in product evaluation.

4.4.4 Product Selection

Product selection has two processes: product pre-selection and product reselection. After evaluating and comparing products in the search or browse results, a buyer will need to put his/her pre-selected products in a temporary storage area so that he/she can go on to search for similar or alternative products. The accumulated pre-selected products in temporary storage area should be arranged for easy comparison. Also, functions for changing the elements of the set of pre-selected products should be provided. In addition, transparent interfaces to other e-commerce services like ordering and negotiation must be provided.

4.5 BENEFITS OF IEPC

An IEPC allows companies to bypass the need for costly printed catalogs, it is easier to update, and can also be linked directly to the purchase process (Kosiur and David 1997). It provides valuable assistance to a customer during the product identification and evaluation stages because it embodies two major aspects: content description and search interfacing (Whinston *et al* 1997). It also possesses four important characteristics: interactivity, dynamic updating, hypertextuality, and global presence (Segev *et al* 1995). All these benefits contribute to lower running cost and attraction of more customers.

4.6 REVIEWS ON EXISTING IEPCS FOR CONSTRUCTION MATERIALS

An IEPC should allow buyers to quickly and easily find the products they need. To accomplish this functionality, an IEPC should have comprehensive product information provision and navigation functions. The information pools that should be accessible through an IEPC include keywords about types of products, structured and unstructured product information, external information source, buyer-generated information, and interim search results. The navigation functions that should be provided include structured and fast access to product information, smooth integration of structured and unstructured product information and external information, and management and processing of interim results.

Although IEPCs can be more sophisticated than paper based and CD based catalogs, searching of products on the Internet is still a cumbersome process. A research project shows that most existing IEPCs provide limited functionality such as embedded graphics and simple browsing (Segev *et al* 1995). They were not yet as successful in selling products directly over the Internet. Experts on the use of the Internet have reported that buyers have difficulty finding the products they are looking for, and many abandon the online search before buying (http://www.nua.ie/surveys/?f=VS&art_id=905355366&rel=ture). This shows that great potential for online sales is lost and that IEPCs do not fulfill their tasks successfully.

A review on some existing IEPCs of construction materials discovered a number of common problems related to product information provision and navigation, which may hinder buyers in finding products. These problems are discussed in the following sections.

4.6.1 Lack of Structured Product Information

Some IEPCs of construction materials provide a structured product category but do not provide structured product information. These IEPCs direct buyers to product information Web pages prepared by suppliers or to a supplier's website where the buyers can find products in the categories they specified. In both cases the product

attributes are not standardized, i.e., different suppliers present different product attributes for products of the same categories. This approach is good for the suppliers as the suppliers can highlight the strength of their products and hide the products' shortfall to attract buyers. However, it introduces many problems for the buyers. Firstly, it is difficult for the buyers to compare products based on the information provided on the web pages if some standard product attributes, such as price, dimension, international standard and brand name, are not provided for all products. Secondly, the buyers have to click back and forth to see and compare suppliers' products on different Web pages. This is time-consuming and difficult for buyers. Thirdly, this approach does not facilitate product searching function as product attributes are scattered on different web pages, instead of being stored in a structured database.

4.6.2 Poor Search Function

Search function is necessary for fast and accurate identification of construction materials the buyers required. Some IEPCs of construction materials have only very simple search functions and some even do not provide any search function. For an IEPC with a structured product category but without search function, buyers have to look through all materials in a specified product category to find products they need. This is very time consuming, especially when the IEPC contains only a few product categories and the amount of materials in each category is large. For an IEPC with only simple search functions like keyword search, it usually has the problems of

information overload and provision of irrelevant information. Keyword search cannot allow buyers to precisely specify different product attributes. Usually the mechanism of keyword search is to match the word(s) entered by the buyers and the word(s) in one or more product attributes stored in database(s) regardless of product category.

4.6.3 Lack of Interoperability

Unlike traditional paper-based or CD-based catalogs, IEPCs can be linked together to provide a greater pool of product information. By developing interoperable IEPCs that integrate the content of several suppliers' IEPCs, it is possible to achieve market transparency as buyers can make more informed purchasing decisions and suppliers can extend their market reach (Ware *et al* 1997). Interoperable IEPCs benefit buyers by allowing them to search product information in more than one IEPCs at one time only. Buyers need shorter time for searching and evaluating products in interoperable IEPCs than non-interoperable IEPCs. However, most of the IEPCs of construction materials are non-interoperable. The variety and heterogeneity of the non-interoperable IEPCs create problems for buyers. Finding products in non-interoperable IEPCs requires buyers to acquire and maintain a list of suppliers' web addresses, to interpret and understand the semantics and navigation methods in different IEPCs, and to integrate product information in different IEPCs for evaluation manually.

The major reason that hinders the wide adoption of interoperable IEPCs is the difficulty in creating a widely accepted standard for inter-catalog communication. Many of the researchers attempt to solve this problem by using the idea of mediation among information sources in an attempt to achieve interoperability and integration. Two major approaches are 1) concepts for integration of heterogeneous database systems through schema integration (Elmagarmid *et al* 1999) and 2) approaches for mediating ontologies (Lincke and Schmid 1998, Keller 1997). The first approach requires deep knowledge of available database schemas. However database schemas are usually not defined in a user-friendly manner and so this approaches requires semantic reconstruction in a customer-friendly form along with schema integration. Ontologies are controlled vocabularies with rich semantics, which provide an explicit specification of a conceptualization. It will be easy to have communication between IEPCs if all IEPCs use common ontology. However it is difficult to achieve in reality as many marketplaces all over the world have been established already and diversity is considered as an important differentiation possibility to attract customers (Keller and Genesereth 1996). Two identified comprehensive approaches for mediating ontologies are Stanford approach (Keller and Genesereth 1997) and Q-Technology-based approach (Handschuh *et al* 1997).

4.6.4 No Connection to other E-commerce Services

Many of the construction materials suppliers' websites do not link IEPCs to other e-commerce services. These websites only present products information to buyers but

do not take advantage of the Internet and Web technology's interactive property. A buyer needs to go through all the traditional offline purchasing processes after finding the suitable construction materials from these websites. By utilizing the Internet, Web and advanced database technology, IEPC can be linked to other e-commerce services such as quotation, ordering, bidding and payment to cut off many manual procedures in the traditional offline purchasing process. Figure 4.4 shows a typical relational database in an e-commerce system and the e-commerce services that utilize it. In this e-commerce system product information used by an IEPC are linked with other information like supplier, buyer, order and payment in a relational database. Buyers can request for quotation or even order online after finding the suitable products from IEPC.

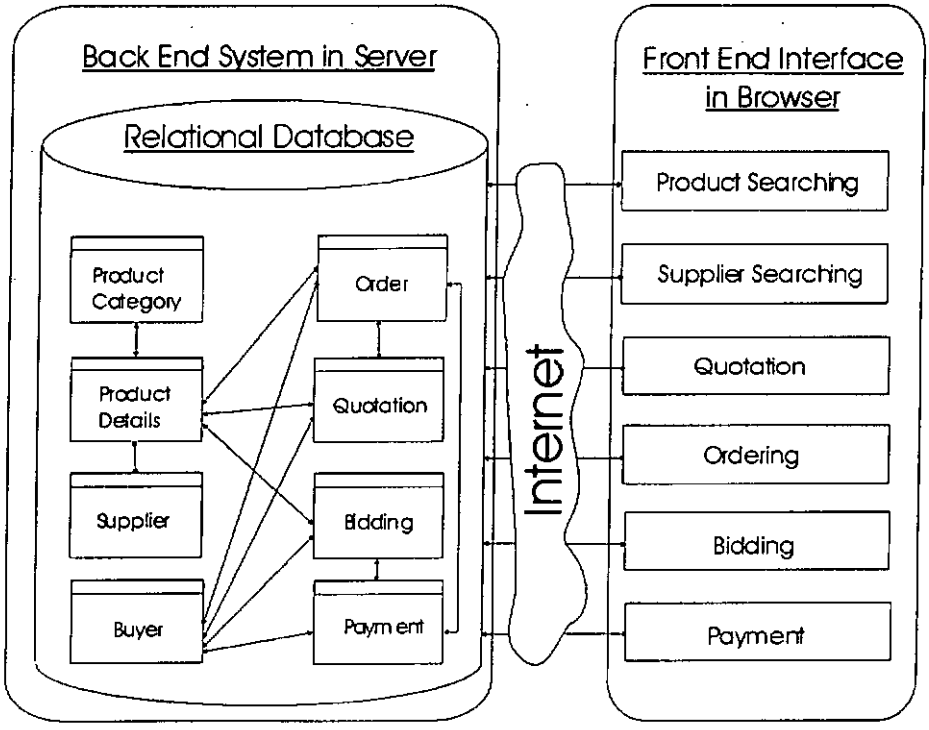


Figure 4.4: Typical relational database and services in an e-commerce system.

4.7 THE IEPC IN COME

The IEPC in COME system is designed for the buyers' ease of searching, comparing and selecting construction materials. The following sections describe the details of the COME's IEPC.

4.7.1 Product Information Provided in COME's IEPC

As discussed in the previous sections it is better to provide more than one supplier's product information on a website so that buyers can use less time to search and compare products. It is ideal to have a website that can search products information in all suppliers' websites, but we all know that it is very difficult, if not impossible, to do this practically. In light of this, the COME system is designed to be a construction material marketplace so that all suppliers can input their product information into the system. Thus, buyers can search many suppliers' products in COME's IEPC at the same time. As shown in figure 4.5, information related to products in the COME system includes product category, product details, supplier details, buyer's ranking on suppliers, product image, document of additional supplier information and Geographical Information System (GIS) data. The first four types of information are stored in a relational database for ease of searching products.

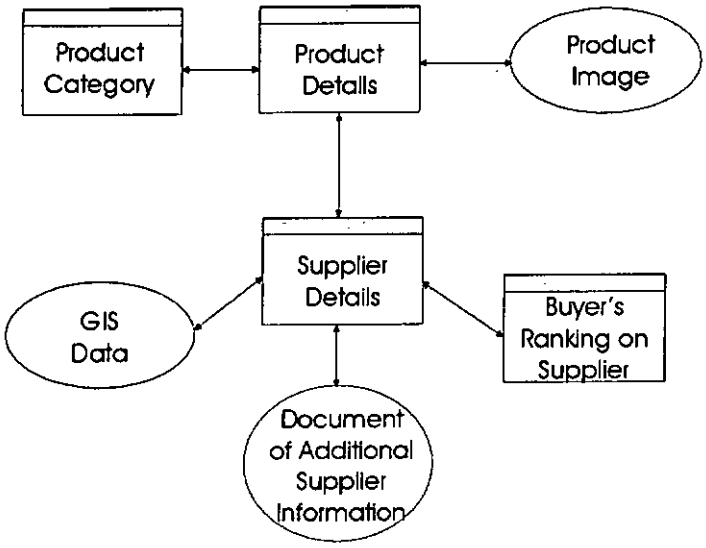


Figure 4.5: Information related to product in COME system.

4.7.1.1 Product Category

The COME's IEPC contains over two thousand categories of construction materials classified into seventeen trees with a maximum of four levels of information. The first level is main category while the other levels are subdivision of the main category. The object of classifying material category is to assist the many functions of buyer by providing a logical and meaningful system of identification for materials information. The definition of the classification categories must be precise and unambiguous. Also the classification must be comprehensive, i.e. the categories are capable of including all that which comes within the scope of the classification (MacConnell 1971). In view of this the COME system uses the standard category structure commonly used by the construction professionals in Mainland China. This category structure is comprehensive and is familiarized by people in the construction industry of Mainland China. Therefore users in Mainland China can easily identify materials information using this category structure.

4.7.1.2 Other Information Related to Product

To support the buyers in selecting suitable products, the COME system hold many structured and unstructured information of products. Structured product information includes price, brand name, unit, supplier details of product, buyer's ranking on supplier and GIS data of supplier. Unstructured information includes product images (real pictures or CAD drawing image), suppliers defined description of products and document files of additional suppliers information. Buyer's ranking on a supplier is generated by the buyer after completing a transaction on the COME system. The GIS data come from a subsystem of COME, which can calculate the shortest distance between two cities of China based on China's traffic network. This data can support the buyers in selecting product when transportation cost and time are the criteria they are concerned about.

4.7.2 The Mechanism of Browsing and Searching Product in COME's IEPC

Buyers can use the browsing or searching functions in COME's IEPC to find products. The searching function includes a quick search and an advanced search that utilizes the GIS subsystem.

4.7.2.1 Browsing Function

The browsing function in COME's IEPC provides an easy to use interface for the buyers to interact with the product categories. The browsing function can display all

products of a particular category specified by buyers. It displays two levels of categories each time so that buyers can have a better understanding on the meaning of the categories. Figure 4.6 shows the interface of the browsing function.

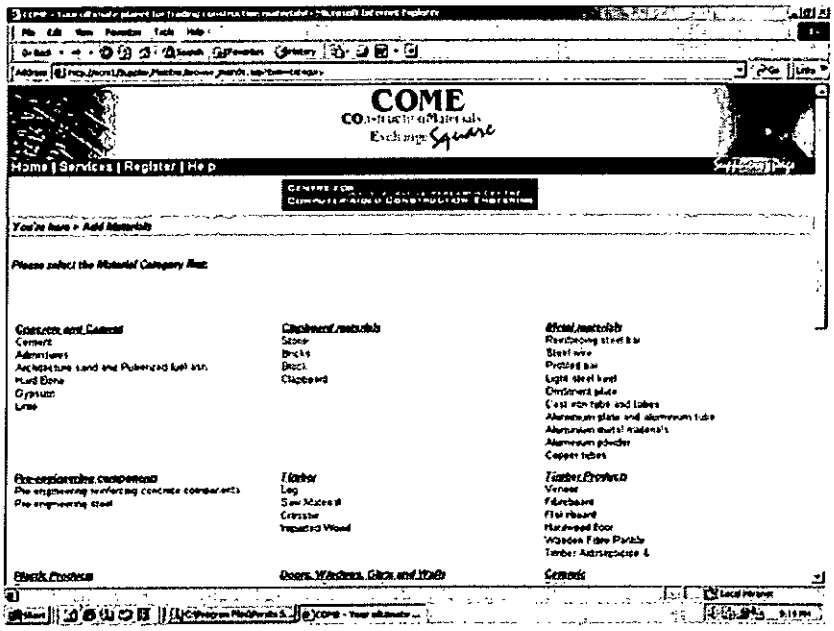


Figure 4.6: Interface of browsing function in COME.

4.7.2.2 Quick Search

Quick search in COME's IEPC allows buyers to specify simple search criteria in one step. The criteria are the main category of product, the highest unit price, location of the supplier, brand name and keywords in the product description. Figure 4.7 shows the quick search interface.

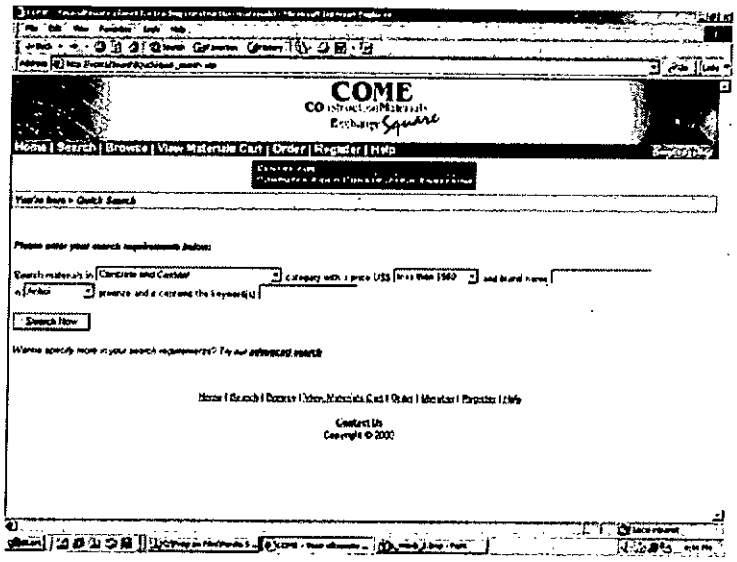


Figure 4.7: Quick search interface in COME

4.7.2.3 Advanced Search

Apart from the function provided by the quick search, the advanced search includes additional functions for buyers to fine-tune the product categories and location of suppliers, and to utilize the GIS subsystem to specify location of suppliers in a specified region. Buyers can use the advanced search function to select one or more subcategories of products. This function allows buyers to find similar or alternative products in a single search. In the quick search, buyers can only specify location of suppliers at the province level. In the advanced search, buyers can specify one or more provinces and cities. This function is useful for the buyers to compare prices of similar products in different regions. The advanced search provides an interface for the buyers to select provinces and cities from the table or GIS map. In particular, buyers can specify a circular area on the GIS map by selecting a city on the map as the center of circle and entering the radius in kilometer. Figure 4.8 shows some of the GIS interfaces. Using this GIS function will generate search results with

information of transportation distance, time and cost between the selected city and the cities within the selected circular region. The fine-tuning functions provided in the advanced search can prevent provision of irrelevant information and overloading of search results.

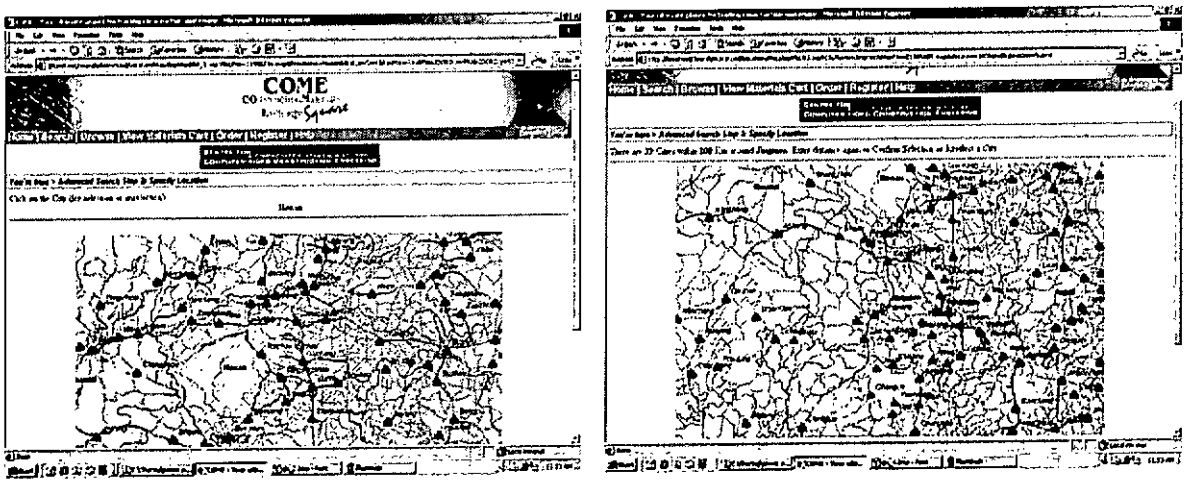


Figure 4.8: Some GIS interfaces in COME's IEPC

4.7.3 Functions of COME's IEPC in Supporting Comparison and Selection of Product

It is important for an IEPC to have the function that allow buyers to compare the products they find from browsing or searching, or else the buyers will have to remember or to jot down the product information themselves. The IEPC in COME displays search results in table format where product information is listed row by row. Buyers can easily compare different structured product information as the same structured product information is listed in the same column. Product selection

function is provided in the search result interface where the buyers can select the products they want and then put them into the product cart in the COME system. The product cart holds products selected by buyers from every search result. In addition, the product cart interface allows buyers to remove the products from cart.

4.7.4 Linkage of COME's IEPC with Other E-commerce Services

The IEPC in COME is linked to other e-commerce services within the system. Information related to products, suppliers, buyers, agents, ordering and bidding are all stored in a relational database in the Microsoft SQL Server. By utilizing the relational database technology product information can be shared by different e-commerce services. For instance the product ordering function does not need to require a buyer to enter the product information again after selecting product from an IEPC. Also the integration of IEPCs with other e-commerce services can streamline the purchasing process from product searching to final confirmation of ordering and even the final confirmation for receiving of product by the buyer. This kind of integrated system allows different parties involved in the purchasing process to utilize the same information and functions at anytime and anywhere without copying and transcribing information manually.

In the COME system, after finding the suitable products from the IEPC, buyers can choose to trade with suppliers directly or to select agents registered in the COME system to make the deal for them. Ordering can be done online instantly and order

tracking services are provided by the system to let the involved parties to check the progress of orders from the Web browser.

4.8 SUMMARY

IEPC is the front-end interface to the rapidly growing e-commerce marketplace. It is a gateway to a company through which buyers from many places of the world can obtain product information, order goods, make payment and even provide feedback on services of the company. This chapter reviewed the functions of IEPC and discussed its potential benefits in presenting construction materials to the buyers. Some problems of existing IEPC of construction materials are identified which are 1) lack of structured product information, 2) poor search function, 3) lack of interoperability and 4) no connection to other e-commerce services. These problems have to be resolved in order to provide a electronic marketplace where buyers can find products they need in a efficient and effective manner, and process the entire purchasing function online seamlessly.

This chapter also introduced the IEPC in COME system, which is designed for the buyer's ease of searching, comparing and selecting construction materials. This IEPC uses the material classification system used by many of the construction professionals in Mainland China due to the fact that material classification should support easy identification of material information. The IPEC is linked with other E-commerce services in the COME system to provide a seamless and streamlined

purchasing process starting from product searching to order tracking. Although the IPEC in COME can store material information from many different suppliers, it is unable to communicate with other IEPCs to provide more product information for the buyers. It is until a standardized database schema and ontology for IEPCs communication is set that IEPC can really provide transparent market information of materials to the buyers. However it should be noted that buyers' confidence on reliability of material information would decrease if the material information provided is not from an accountable IEPC. Therefore when constructing interoperable IEPCs we should make sure that the reliability of material information in different IEPCs are of the same level. Usually reliability of material information in an electronic market depends on the control and checking of the suppliers that use the system.

Chapter 5

CHAPTER 5

THE GEOGRAPHICAL INFORMATION SYSTEM OF COME

5.1 INTRODUCTION

Geographical Information System (GIS) is the unique information system, which maintains, manages, integrates and analyses, location-related (or spatial) information of different types and scales. Successful implementations of GIS are found in many areas, such as civil engineering, transportation, facilities management, urban planning and business analysis. E-commerce system offers a possible solution for direct trading between buyers and suppliers with no restriction on space and time. However, online transaction should not only focus on the flow of business-related information but also effective distribution of goods (Yang *et. al*, 2000). Transportation of goods among different parties must be involved in any kinds of business activities, even in the era of online business. Consequently, cost of transportation is also a critical consideration in E-commerce. Moreover, both regional and local demographic characteristics are important considerations in the successful implementation of the E-commerce system. In this sense, location related, or spatial information plays an essential role in any kinds of business activities, including E-commerce system. GIS is potentially applicable in e-commerce system

to manage spatial information, provides an ideal solution to manage costs of transportation and market analysis in the overall E-commerce activities.

This chapter presents the development of the GIS module in the COME E-commerce system. The system architecture, functions, and evaluation will be presented in the following sections.

5.2 SYSTEM DESGIN

The GIS module is implemented to assist searching of material information in specific geographic regions of China and to support selection of materials by providing transportation time and cost information. The implementation adopted the principle of server-side Internet GIS (Hardie 1998) in which all complicated GIS operations are handled on the server-side. In this sense, COME is a GIS Application Service Provider to its users as well. The client-side is only responsible for displaying maps sent from the server, and requesting geographic services though the received map-based interface, for example, selection of a city on the map. This approach ensures a thin-client architecture in which additional software or plug-in are not required in the Internet browser on the client side.

The GIS module can be considered as the integrator of all information in the COME system. As long as a piece of information is related to location, it can be linked up to all other information in the system though the geographic database. However, a key

is required to link up all sets of information. In the COME system, City is chosen as the common item of all sets of information (figure 5.1). Information related to buyers, suppliers, agents, and materials are linked to the layer of City though a unique identification for each city (a City ID). In other words, the GIS module provides a single interface from which users can search all different types of data and services belong to a city. As presented in the previous chapter, Maptitude 4.2 and TransCAD 3.0 are GIS servers of this GIS module. Functions of these two software are called in the VBScripts of the Active Server Pages interfaces. The China map used in the COME system is obtained from the Maptitude 4.2 software package and is updated in 1999. This map contains information about province and city locations, road network, railway network, demography data, etc.

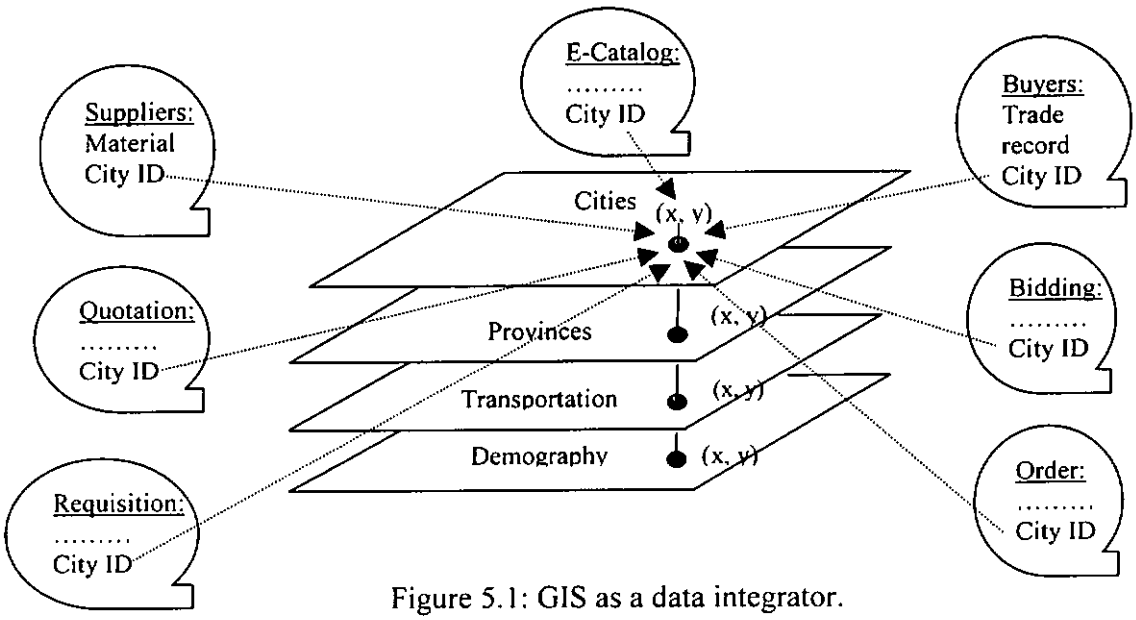


Figure 5.1: GIS as a data integrator.

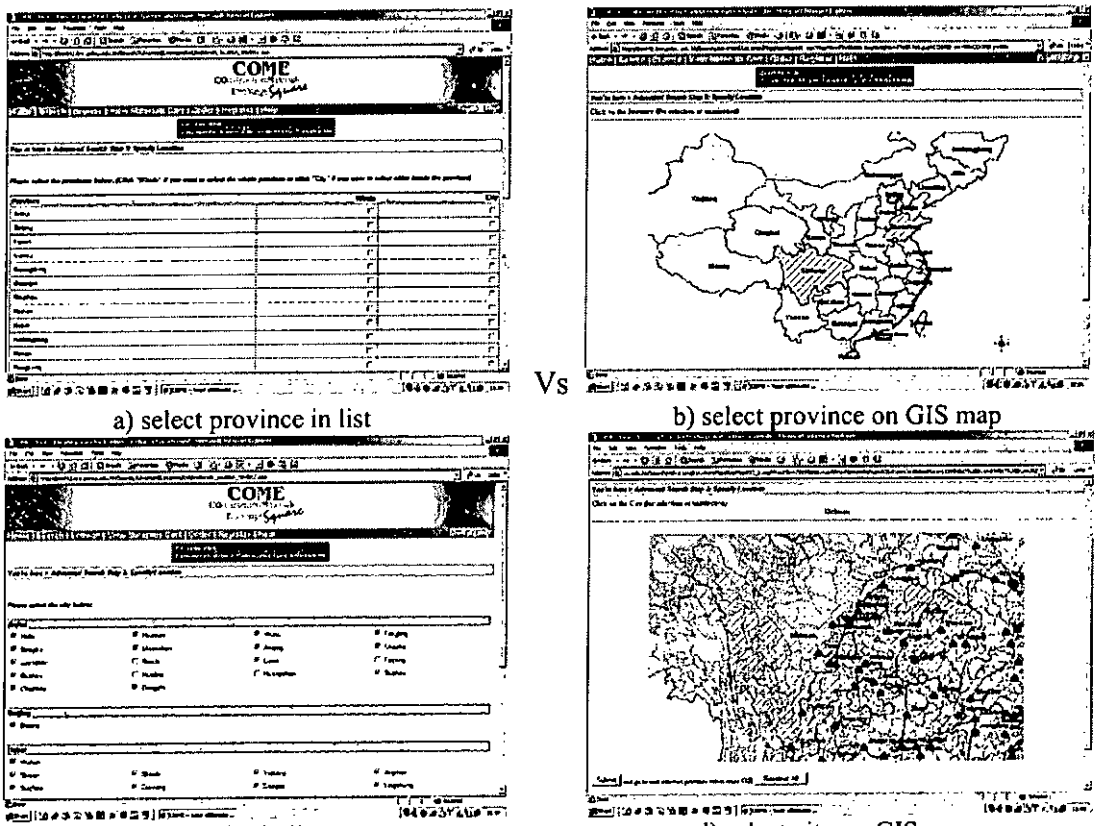
5.3 IMPLEMENTED GIS FUNCTIONS

The implemented functions can be classified into two types: 1) functions for supporting searching of materials, and 2) functions for supporting selection of materials. These two types of functions are presented in the following sections.

5.3.1 Functions for Supporting Searching of Materials

One of the Advanced Search functions in COME is to let buyers select locations of material suppliers. Buyers can select multiple provinces and cities through the provided interfaces. Figure 5.2 shows the interfaces for selecting provinces and cities in a list and on a GIS map. To select provinces and/or cities in a list, buyers first select the provinces (figure 5.2a) and then select the cities in selected provinces (figure 5.2c). The province and city selection process is similar in the GIS module. Buyers firstly select provinces on the GIS map interface by clicking on the province area in the map. Selected provinces are highlighted with parallel lines (figure 5.2b). After finishing province selection, buyers can then select cities province by province (figure 5.2d). Cities within the selected province are red and cities outside the selected province are black. Selected cities are highlighted in yellow. All the GIS map interfaces are generated by the Maptitude server. At the end of the city selection process, the GIS module passes the CityIDs of the selected cities to the E-catalog module to carry on the material searching process. The GIS module supports the material searching process by providing location information of those provinces and

cities in China. The GIS map interfaces are very useful to those buyers who are not clear about the locations of the many provinces and cities in China.



a) select province in list b) select province on GIS map

c) select city in list d) select city on GIS map

Figure 5.2: Select location in list Vs on GIS map.

5.3.2 Functions for Supporting Selection of Materials

The GIS module supports buyers to select materials by providing transportation distance, time and cost for delivery of materials. Buyers using the GIS module can firstly define the city for receiving materials, and then select provinces or cities for searching materials. Instead of selecting provinces and cities one by one, like the normal searching method described above, buyers can define a region by specifying

a maximum distance away from the selected city for receiving materials. Figure 5.3a and figure 5.3c show the interfaces for selecting city for receiving materials from lists and specifying the maximum distance. Figure 5.3b and figure 5.4d show the GIS interfaces for these functions. The GIS interfaces show the selected cities clearly on a GIS map. The selected city for receiving materials is yellow and the cities within the specified distance are green (figure 5.3d).

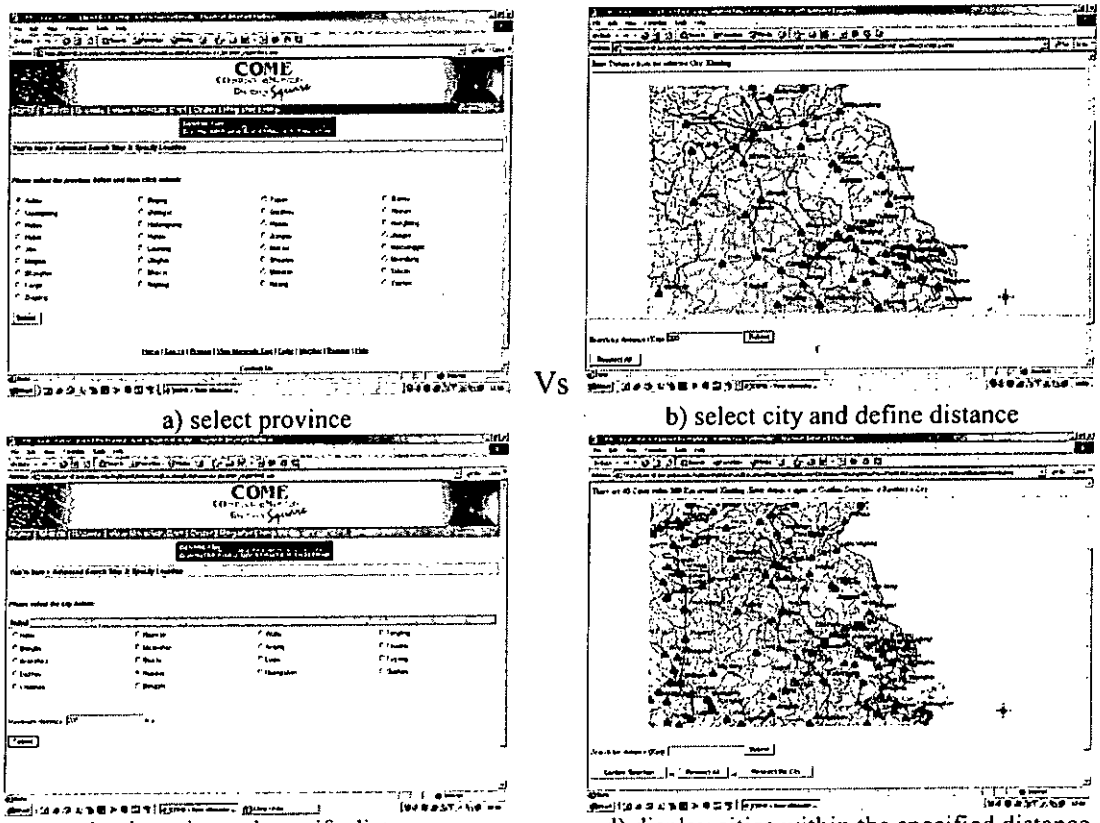


Figure 5.3: Define region in list Vs on GIS map.

After defining the region for searching materials, the Maptitude server passes CityIDs of the selected cities to the Advanced Search module where cities with the specified materials are filtered. The Advanced search module then passes the filtered

CityIDs to the TransCAD server for calculating the shortest distance between the city for receiving materials and those cities with the specified materials based on the road network information in the China map. Besides road network information, the China map used in the COME system also contains railway network information. The system is able to find shortest distance based on the combined road and railway network. Transportation time and cost are then calculated based on the shortest distance. The calculation can be represented by the following equations:

$$\textit{Shortest distance} = D_1 + D_2 \qquad (1)$$

$$\textit{Transportation time} = S_1 D_1 + S_2 D_2 + T \qquad (2)$$

$$\textit{Transportation cost} = C_1 D_1 + C_2 D_2 + C_3 \qquad (3)$$

D_1: shortest travelling distance on road in Km
D_2: shortest travelling distance on railway in Km
S_1: speed of travelling on road
S_2: speed of travelling on railway
T: time for transition between road and railway
C_1: cost of transportation on road per Km
C_2: cost of transportation on railway per Km
C_3: cost of transition

D_1 and D_2 are obtained from the TransCAD server. The GIS module can be used to find the appropriate path of transportation based on two constraints: 1) shortest transportation time, and 2) lowest transportation cost. To find path of transportation with shortest transportation time, the GIS module needs to convert distance into time by multiplying distance by speed and adding time of transition between road and railway. To find path of transportation with lowest cost, the GIS module needs to convert distance into cost by multiplying distance by unit cost of transportation and adding cost of transition. However unit cost of transportation is difficult to set as size, weight, quantity and packing of materials can affect the unit cost. This unit cost

information has to be provided by suppliers for the GIS module to calculate an accurate cost of transportation. After calculating the distance, time and cost of delivery, the GIS module will pass these information to the E-catalog module for displaying search result.

5.4 EVALUATION AND DISCUSSION OF THE GIS MODULE

The GIS module has been created successfully in the COME system. User can use the GIS function through Internet easily. The reaction time and data traveling time of the GIS module is reasonable. This is because most of the data needed to be transferred is in text and small size image format. The average size of a GIS map image file is just 60K bytes. Moreover, as all the programming processes are run on the server side, the system performance depends on the programming load and processing power of the server but not the client computer. Less than 1 second of processing time is needed for every GIS task on the COME server.

In summary, the GIS module provides mapping services and transportation information for the buyers. The functions of this GIS module can be greatly extended by linking more information to the GIS database. For example, with material information linking to the GIS module, buyers can browse how a particular type of product in the E-catalog distributes over several cities of a region. When all information related to trading process are linked to the GIS module, suppliers can use the GIS module to produce a map that shows bids, requisitions, quotations and

orders made by buyers in different cities. Moreover, suppliers can use the GIS module to analyze business areas and customer patterns at different region of China. The GIS module can offer valuable add-on services in COME to attract both suppliers and buyers.

There is a long history for human to use maps to make different types of decisions, from daily route planning to national military strategy. Maps or the geographical information on the maps actually, have become indivisible part of our daily life. The implementation of the GIS module aims as an example and initiative of using GIS in E-commerce application of construction material trading. This is anticipated that GIS and systems with similar functionality will be more widely adopted or even a must in future E-commerce applications.

5.5 SUMMARY

Development of the GIS module in the COME system is presented in this chapter. In the era of electronic business, motivation for a buyer to procure over the Internet largely depends on the completeness, accuracy and availability of information about the product and the supplier. Apart from textual information, location-related information (or geographical information), that is an important consideration in any kind of traditional trading activities, must be put into E-commerce application as well. GIS is a unique tool to manage and to analyze huge amount of geographical information. This chapter mentioned how the GIS module enhances functionality of the COME system for construction material trading. GIS can provide a total solution

for integrating and managing different types of textual information in the underlying database; for suppliers to study business environment of different areas; and for buyers to compare different materials and to determine costs of transportation from different areas.

Chapter 6

CHAPTER 6

THE IMPLEMENTATION AND EVALUATION OF COME

6.1 CURRENT STATUS OF COME

The COME system is adopted by a construction company in Hong Kong, Yau Lee Holdings Limited, and is now running in Mainland China. A professional version of COME was developed by the construction company, which has a commercialized interface and is available at http://www.vhcome.com. Except the GIS module, all other functional modules of the COME system are in use in the professional version. The reason for not using the GIS module is that the location information and transportation network information in the China GIS map is not up to date. At the moment the construction company cannot find an efficient and cost effective way to update the GIS map. Therefore the GIS module is temporarily not used. Currently the professional version has over two thousand registered buyers, twenty-nine thousands registered suppliers and one thousand registered agents. Experiments were conducted to compare the purchasing time and obtained price of procuring construction materials in the traditional way and through the COME system. Users' opinions about their concern and effectiveness of the COME system were also collected and analyzed.

6.2 METHOD OF EVALUATION

6.2.1 Method for Finding Time of Procurement and Price of Material

An experiment was conducted by using COME to facilitate the construction material trading between Shanghai and Hong Kong. Two purchasing staff of the construction company that adopted the COME system was invited to participate in the experiment. One of the staff was asked to be a "buyers" to use the COME system to purchase 100 tones of general-purpose cement from Shanghai. At the same time, four agents in Shanghai were appointed to help the negotiations with the manufacturers and to prepare paperwork involved in the business transactions.

Concurrently, the other staff was asked to purchase the same type and amount of cement from Shanghai using the traditional procurement method. This method required the staff to contact four local agents in Hong Kong. The local agents then contacted a local supplier who imported large quantities of construction materials from China mainland, including Shanghai. The local supplier then contacted the agents in Shanghai who contacted the manufacturers for making orders and conducting negotiations. The communications between parties involved were largely based on telephone and fax messages.

The communication chains for purchasing the cement with and without the use of COME system are shown in Figure 6.1. Through the use of the COME system the buyer can actually contact the manufacturer directly. In this experiment the buyer

was asked to contact the agents in the COME system to due with the manufacturer because in the real life situation a purchaser of a construction company usually cannot get all the materials he needed from one or two manufacturers. After the completion of the purchasing process, the average procurement times spent by the staff, as well as the average prices obtained by the staff through the COME system and the traditional procurement method were recorded.

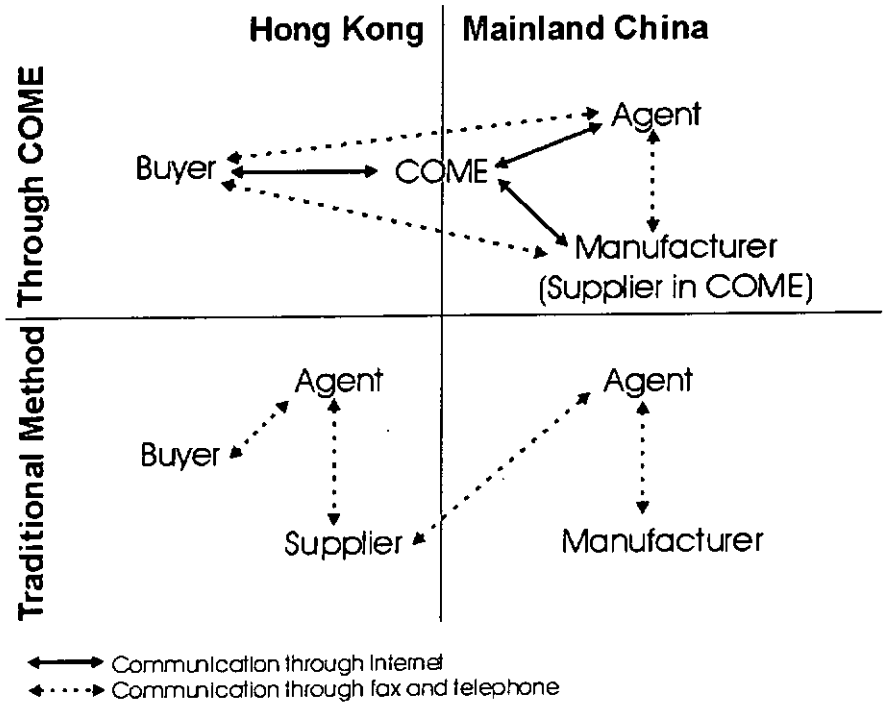


Figure 6.1: Communication chains of two different purchasing processes.

6.2.2 Method for Collecting Users' Concern and Opinion on the COME System

A questionnaire was designed to collect users concern and opinion on the professional version of the COME system. The questionnaire was distributed to 50 buyers who use the COME systems and 26 completed questionnaires were collected. The types of information collected through the questionnaire include content quality,

system performance, security related technologies and services, security issues, and risks of using the system. Table 6.1 lists the detailed categories of the above issues. The questionnaire respondents were asked to give mark to the importance of and their satisfaction with the content quality and system performance issues. A 5-points scale was used to measure the degree of importance and satisfaction, with 5 meaning very important or very satisfied, and 1 meaning the opposite. The respondents were also asked to show their knowledge on different security technology and services, and level of confidence on security issues. Finally they were asked to compare the degree of risk in doing business in the traditional way with the degree of risk in doing business using E-commerce system.

Table 6.1: Different issues relating to the use of the COME system.

Content Quality	**System Performance**	**Security Technology and Services**	**Security Issues**	**Risk of Doing Business**
Variety of information	Speed of Operation	Passwords	Confidentiality	Selling of customer information
Detail of information	System Reliability	Cryptography	Message integrity	Stolen of customer information
Update of information	Ease of use	Hashing	Authentication	Transaction with fake company
Presentation format of information	Ease of access	Digital signature	Non-repudiation	Loss of transaction record
Reliability of information		Biometrics	Access controls	Wrong billing
Provision of business policy information		Time stamps		Receiving wrong item
Provision of privacy policy information		Firewalls		
		Web site seal		

6.3 RESULTS AND EVALUATION

6.3.1 Results of Procurement Time and Material Price Comparison

The average times of procurement and average prices obtained for 100 tones of general-purpose cement are shown in table 6.2. Time of procurement in this experiment is the period of time from the sending out of specification to the receiving of quotation, and is measured in the unit of business day. The average procurement times and average material prices obtained by traditional method and using the COME system are 3 business days and RMB$83,100, and 1 business day and RMB$78,600 respectively. The experiment shows that using the COME system requires shorter time of purchase and at the same time can obtain a lower material price when comparing with the traditional method.

Table 6.2: Average procurement times and average material prices obtained in the experiment.

	Using COME	Traditional method
Average purchasing time	1 day	3 days
Average material price	RMB$78,600	RMB$83,100

The reason for obtaining a lower material price by using the COME system is the cut off in middleman involved in the procurement process. The more middlemen involved, the more commission will be charged. In this experiment the cut off of two layers of middleman save around 5% of material cost.

The shorter time required for procuring material through the COME system is contributed by the following factors:

- Fewer layers of communication
- Sharing of information
- Faster information retrieving
- More comprehensive information

Fewer layers of communication: As shown in figure 6.1, the traditional procurement method contains five layers of communication which include the five parties: buyer in Hong Kong, agent in Hong Kong, supplier in Hong Kong, agent in mainland China, and manufacturer in mainland China. However there are only three layers of communication in the case of using the COME system, which include three parties: buyer in Hong Kong, agent in mainland China, and manufacturer in mainland China. The cut off in layers of communication reduces the work required for transmitting information between the communication parties and more importantly reduces the time for waiting the other side to reply.

Sharing of information: In the traditional procurement process, each party maintains their own set of information. To order materials in this situation, the buyer in Hong Kong has to first produce a specification for their own and then make a copy by fax to the local agent. Another method is to tell the local agent the specification of materials through telephone. The local agent then passes the specification to the local supplier by fax or by telephone. Finally after passing the

information through all the parties, the manufacturer in mainland China will have his own copy of specification. By using the COME system, the material specification no longer need to be reproduced for sharing among the parties involved. Once the buyer entered the material specification in the COME system, all the parties involved can access that information through the COME system. Therefore the time for producing information is saved.

Faster information retrieving: In the traditional procurement system, material specifications are written in paper and they have to be filed systematically so that they can be easily retrieved. The COME system eliminates the filing process for all the parties involved in the procurement process, as all material specifications are stored electronically and can be retrieved and presented in systematic order easily. Moreover the information retrieving time in the COME system is only a few seconds while that of the traditional procurement system may require a few minutes to even hours depending on the efficiency of the filing system and the availability of the information at the time of retrieving.

More comprehensive information: In the material procurement process, agents and suppliers need to collect pricing information of the products required by the buyers. The traditional way is the look at historic trading records and books of material price list given by their trading partners. In case the required product information cannot be found from those sources, the agents or suppliers will have to ask for that information from their trading partners or even to find new trading partners whom

provide those products. This process can be time consuming and require a lot of human effort. The COME system reduces the time required for this process by providing much more comprehensive product information. Users of the COME system can view not only their trading records and product information from their trading partners, but also product information from other suppliers of construction materials. In addition the time required for retrieving, viewing and comparing product information in the COME system is shorter than that of the traditional method. This is because the COME system can present all the required product information systematically in a single page by a simple query but the traditional method requires the agents or suppliers to look at different books and files to get the necessary information.

6.3.2 Results of Users' Concern and Opinions on the COME System

6.3.2.1 Content Quality and System Performance

The results of users' concern on and satisfaction with content quality, system performance and customer services are shown in table 6.3, table 6.4 and table 6.5 respectively. Users' concern is measured by degree of perceived importance. Satisfaction in this study means the attribute under evaluation is at least as good as it was supposed to be.

Among the content quality attributes, two standout attributes are *update of information* and *reliability of information*, which have mean score of 5.00 and

standard deviation of 0 meaning that all the respondents think that these two attributes are very important. The other attributes that received high score are *variety of information*, *detail of information* and *provision of privacy policy information*, which have mean score of 3.88, 4.21 and 4.25 respectively. An interesting result is that *provision of business policy information*, with mean score of 3.21, is not considered to be a very important attribute. A possible reason is that the buyers expect the trade to be carried out in their usual practice which they already know very well. *Presentation format of information* is the least important among the content quality attributes, which has mean score of 2.5 only. The result of satisfaction level for all content quality attributes are quite positive, with mean scores ranging from 3.96 to 4.33. It shows that the COME system performs quite well in the content quality issue.

Table 6.3: Importance of and satisfaction with content quality.

	Importance		**Satisfaction**	
	Mean score	Standard deviation	Mean score	Standard deviation
Variety of information	3.88	0.61	3.96	0.69
Detail of information	4.21	0.59	3.96	0.62
Update of information	5.00	0	4.17	0.38
Presentation format of information	2.50	0.78	3.71	0.62
Reliability of information	5.00	0	4.21	0.41
Provision of business policy information	3.21	0.66	4.33	0.48
Provision of privacy policy information	4.25	0.44	4.21	0.66

The overall mean score of the importance of system performance is very high, which is 4.55. The mean score of *system reliability* is highest among the 4 attributes, which is 5.00. The mean scores of *speed of operation*, *ease of use* and *ease of access* are 4.25, 4.13 and 4.83 respectively. The overall mean score of satisfaction on system

performance is 3.59, which is lower than the overall score of importance by 1 point, showing that the COME system has to be improved to provide a better system performance. The level of satisfaction on attributes like *speed of operation* and *ease of access* can be advanced by upgrading to a higher performance computer system and choosing a better network services provider. The other two attributes, *system reliability* and *ease of use* can be improved by modifying system and interface design.

Table 6.4: Importance of and satisfaction with system performance.

	Importance		**Satisfaction**	
	Mean score	Standard deviation	Mean score	Standard deviation
Speed of Operation	4.25	0.44	3.00	0.59
System Reliability	5.00	0	3.83	0.64
Ease of use	4.13	0.61	3.79	0.66
Ease of access	4.83	0.36	3.75	0.79

6.3.2.2 Knowledge on Security Technologies and Services

In E-commerce environment, the primary security issues are confidentiality, message integrity, authentication, non-repudiation, and access control. These issues are resolved by the following technologies and services: cryptography, hashing, digital signature, passwords, biometrics, time stamps, firewalls, and Web site seal. The percentage of respondents that know the above security related technologies and services are shown in table 6.6. Below are brief introduction of the sixth technologies and services:

Cryptography: Cryptography is a method of mathematical encoding used to transform message into an unreadable format in an effort to maintain confidentiality of data. The encryption process transforms a cleartext message into a non-decipherable form known as ciphertext. Encryption and decryption keys are necessary to transform cleartext into ciphertext and vice-versa. The strength of the encryption process is largely dependent on the key size. The larger the key size, the stronger is the encryption process. Currently a code with 40-Bit key can be broken in 3.5 hour and a code with 128-Bit key will take more than 2,000 years to break.

Hashing: When a message is sent electronically, both the sender and the receiver want to ensure that the message received is exactly the same as the message transmitted by the sender. A message that has not been altered in any way, either intentionally or unintentionally, is said to have maintained its integrity. For electronic commerce, verifying that the order details sent by the buyer have not been altered is one major security concern. An effective means of ensuring message integrity is through the use of hashing, where a hash of the message is computed using an algorithm and the message contents. The hash value is sent along with the message. Upon receipt, a hash is calculated by the recipient using the same hashing algorithm. The two hash values are compared, and a match can indicate that the message received is the same as that sent.

Digital signature: Digital signature is designed to bind the message originator with the exact contents of the message. The message sender uses his/her private

encryption key to compute the digital signature. In order to compute the digital signature, a one-way hashing algorithm may be used to first calculate a message digest. The sender's private key is used at this point to encrypt the message digest. The encrypted message digest is what is commonly referred to as a digital signature. It is generated from the message content and the sender's private key; thus it is a unique creation of the contents of the message and the sender's private key. The message, therefore, can be attributed to no one else, and the message content is virtually indisputable. The message and the digital signature are transmitted to the receiver. The hashing algorithm is used by the recipient to recalculate the message digest. The recipient uses the sender's public key to decrypt the message digest. If the recalculated message digest is identical to the decrypted message digest, then the message can be attributed to the sender and its contents considered to be in its original form.

Passwords: Similar to digital signature, passwords are used to verify the origin of users of an E-commerce platform. Password is sent to the receiver together with a username for authentication.

Biometrics: Biometrics is another form of authentication. It requires that some physically unique characteristics if the user be used for identification. The use of thumbprint is an example of biometric device. Voice recognition, face recognition, signature recognition, and retina scans are other biometric devices in use, with retina scans currently considered to be most secure.

Time stamps: For important paper documents, mail services that require a signature for the receipt of a letter or package provide proof of date sent and receipt. Electronic documents can also be sent through electronic mail services that provide timestamping features. A digital time stamp is used to determine the exact time in which a message was created, while a messaging service can attest to the exact time the message was sent and received.

Firewalls: The term 'firewall' is borrowed from the construction industry. Firewalls are built out of fire-resistant material to protect apartments or office buildings. If a fire breaks out in one section of the building, these walls retard the spread of the fire to other locations. In regard to networking, firewalls provide similar controls. They can allow employees on a corporate network to access resources on other networks, such as the Internet, while preventing unauthorized users on these other networks access to systems on the corporate networks. Firewall can be defined as a system or group of systems that enforces an access control policy between two networks.

Web site seal: A Web site seal is issued by a third party organization to E-commerce companies for placing in their Web site. To obtain a Web site seal the E-commerce companies have to show the third party organization that their web sites comply with the standard of the third party organization in these four issues: security of data, privacy of data, transaction processing integrity, and business policies.

As shown in table 6.5, the most well known security technology is password, 100% of the respondents know this technology. The other three more commonly known technologies are cryptography, biometrics and firewalls, which is known by 80.1%, 69.2% and 69.2% of the respondents respectively. Digital signature is known by half of the respondents, 50%. Only few or even no respondents known hashing, time stamps, and Web site seal service (0%, 3.9% and 11.5% respectively). The average percentage of respondents that know these technologies and service is 49.0%, showing that their overall knowledge is low.

Table 6.5: Percentage of respondents that know security related technologies and services.

	Percentage
Passwords	100
Cryptography	80.1
Hashing	0
Digital signature	50.0
Biometrics	69.2
Time stamps	3.9
Firewalls	69.2
Web site seal	11.5

6.3.2.3 Level of Confidence on Security Issues

As mentioned in the previous section, the primary security issues in E-commerce are confidentiality, message integrity, authentication, non-repudiation, and access controls. Below are objectives of these issues:

- Confidentiality: ensure privacy of message;
- Message integrity: detect message tampering;
- Authentication: verify origin;

- Non-repudiation: provide proof of origin, receipt, and contents (sender cannot falsely deny sending or receiving the message);
- Access control: limit entry to authorized users.

The respondents' level of confidence on the above security issues are shown in table 6.6, with 5 meaning the highest level of confidence and 1 meaning the lowest level of confidence. The respondents have high level of confidence on confidentiality, message integrity, and authentication, with mean score of 4.31, 4.08 and 4.04 respectively. However they don't have much confidence on non-repudiation and access controls, with mean score of 3.21 and 2.67 respectively.

Table 6.6: Level of confidence on security issues.

	Mean score	Standard deviation
Confidentiality	4.31	0.34
Message integrity	4.08	0.50
Authentication	4.04	0.45
Non-repudiation	3.21	0.66
Access controls	2.67	0.76

6.3.2.4 Comparison of Risk on Traditional Trading and E-commerce Trading

The comparison of risk on traditional trading and E-commerce trading are shown in table 6.7, with 5 meaning much higher risk in E-commerce trading and 1 meaning much higher risk in traditional trading. The risks of *selling customer information*, *wrong billing*, and *receiving wrong item* are considered by the respondents as having similar level in both types of trading. However, *stolen of customer information*, *transaction with fake company*, and *loss of transaction record* are regarded as much more risky in E-commerce trading than in traditional trading, with mean score of

4.46, 4.48 and 4.88 respectively. The open nature of the Internet, intranets and extranets and the sharing of data make security a serious challenge in E-commerce, and thus induce many risks of trading. Although many of the security issues can be resolved by the different technologies discussed in the previous sections, security holes often exist due to improper implementation and monitoring of security measures. Intrusion by hackers, stealing of information by employees or outsiders, attack by virus, and loss of information due to hardware failure are common security problems.

Table 6.7: Comparison of risk on traditional trading and E-commerce trading.

	Mean score	Standard deviation
Selling of customer information	3.17	0.38
Stolen of customer information	4.46	0.51
Transaction with fake company	4.48	0.50
Loss of transaction record	4.88	0.34
Wrong billing	3.04	0.46
Receiving wrong item	3.21	0.59

6.4 SUMMARY

This chapter presents two evaluations on the COME system. The first evaluation is to assess the COME system's capability to shorten the material procurement time and to obtain a more competitive material price. The results show that the COME system can shorten the procurement time by 66% (2 days in this experiment) and obtain a material price 5% lower. The second evaluation assesses users' concern on and satisfaction with the COME system. Overall, the respondents are highly satisfied with the content quality of the COME system. However the system performance of

the COME system is just above satisfactory level. Some of the attributes that are regarded by all the respondents as highly important are update of information, reliability of information, and system reliability. The overall knowledge of the respondents on security technologies and services are low. However, they are quite confident of the security issues. Finally they think E-commerce trading is more risky than traditional trading.

Chapter 7

CHAPTER 7

CONCLUSIONS AND FUTURE WORK

7.1 INTRODUCTION

The COME E-commerce system for construction material procurement was successfully developed and implemented in this research. The COME system is the first business-to-business construction material trading platform debuted in Hong Kong, and is one of the few construction material trading platforms that remain running after the dot.com recession. This final chapter summarizes the research contributions, presents the research limitations, and suggests future works for improvement.

7.2 RESEARCH CONTRIBUTIONS

This research makes contributions by achieving the objectives that are:

- To review the traditional construction material procurement process and identify its limitations relating to information retrieving, handling and sharing.
- To review current applications of E-commerce and GIS, and identify those E-commerce and GIS functions that can be applied in construction material procurement.

- To develop a system for construction material procurement that utilizes E-commerce and GIS technology.
- To implement the developed system and evaluate the benefits and limitations of this system.

The following sections present the research contributions.

7.2.1 Limitations of Traditional Construction Material Procurement Method

This research identified the following limitations of traditional construction material procurement method:

1. Procurement can be done in specific business hours only and can only work with suppliers within a defined geographical region.
2. Limited amount of information about suppliers and materials are available in the CD-ROM or physical catalogs.
3. Searching and comparison of materials in CD-ROM and physical catalogs are cumbersome and time consuming.
4. Information on CD-ROM or physical catalogs is usually not up to date and thus making it difficult for contractors to stay abreast of market conditions and to select the most suitable materials and suppliers for a given project.
5. Procurement process involves production, copying and transmission of many paper documents, which is time consuming and is easy to introduce error.

7.2.2 Potential Benefits of E-commerce and GIS in Construction Material Procurement

The identified potential benefits of E-commerce for contractors to procure construction material are as follows:

1. *More comprehensive and updated material and supplier information:* E-commerce platform can provide an expanded marketplace for suppliers to sell their construction materials. Contractors can easily get the updated information from suppliers of different geographical locations.
2. *More efficient searching of material and supplier information:* Contractors can easily search information of many suppliers simultaneously through the searching interfaces of E-commerce system.
3. *Procurement simplicity:* Paper works are reduced as procurement information is entered and stored in the database of E-commerce system. The procurement information can then be easily retrieved and shared by users of the E-commerce system.
4. *Reduced process cost:* Procurement processing cost can be reduced because the purchasing staff need less time to complete his/her task due to: 1) less effort for searching material and supplier information, 2) fewer paper works.
5. *Reduced material price:* Increased competition among suppliers in E-commerce marketplace can reduce material price. The cut off of middlemen due to direct trading between contractors and suppliers in E-commerce platform can also reduce material price.

6. *Reduced process time:* Procurement processing time can be reduced because: 1) material and supplier information are easier to retrieve, 2) less paper works is required, and 3) there are fewer layers of communication due to cut off of middlemen.

The identified potential benefits of GIS for contractors to procure construction material are as follows:

1. *Provision of GIS map for selecting supplier:* GIS can generate maps to show location information of suppliers. The GIS maps can help contractors to identify location of suppliers.
2. *Provision of transportation information:* GIS can calculate shortest distance between cities and can show the transportation route on GIS map. The transportation distance information can also be converted to transportation time and transportation cost information. These transportation information will be valuable to the contractors if transportation time and cost are their constraint in selecting suppliers.
3. *Market analysis:* Besides location related information, GIS can be used to manage marketing information of different locations, like price variation, transaction records, material distribution, etc.

7.2.3 Developed and Implemented an E-commerce System for Construction Material Procurement

This research successfully developed and implemented the COME E-commerce system for construction material procurement. Before developing the COME system, the current construction material trading situations in China and the material procurement process were studied. The four kinds of trading situations are bargaining, bidding, auction and contract, and the common material procurement process involves sending out requisition, receiving quotation, and sending out order. The COME system is designed to facilitate the four kinds of trading situation in China and to streamline the whole material procurement process. The functional modules of COME include E-catalog module, GIS module, Bidding module, Auction module, Requisition module, Quotation module, and Order module. The E-catalog module is designed for contractors' ease of searching, comparing and selecting construction materials, which does not have common problems of other E-catalog like lack of structured product information, poor search function, and no connection to other E-commerce services. The COME system is the first construction material procurement platform that incorporates GIS. The GIS module supports contractors to select material by providing location information of suppliers on GIS maps. In addition, the GIS module supports contractors to select material by providing material transportation distance, time and cost information.

The COME system is adopted and implemented by a Hong Kong construction company and it is now being used by many suppliers, agents and buyers in Mainland China. The successful implementation shows the practical value of this research. Although the GIS module is not implemented in the commercialized COME system, the successful development shows that incorporating GIS in E-commerce system to support material selection is possible.

7.2.5 Evaluation of the COME System

Experiments were conducted to compare the purchasing time and obtained price of procuring construction materials in the traditional way and through the COME system. Users' opinions about their concern and effectiveness of the COME system were also collected and analyzed based on a questionnaire survey. It is found that material price obtained by using COME system is lower than the price obtained by using the traditional material procurement method. Also the process time of procuring material can be shortened by using the COME system. The questionnaire survey shows that users of COME are highly satisfied with the content quality of COME. Some of the quality attributes of E-commerce system that are regarded by all the respondents as highly important are update of information, reliability of information, and system reliability.

7.3 LIMITATIONS

On one side the COME E-commerce system developed in this research study has many advantages for procuring construction materials, on the other side it produces some problems that the traditional procurement method does not have. The problem issues include security, information accuracy, contract formation, and jurisdiction.

7.3.1 Security Issues

E-commerce system relies on open network, including Internet, for connecting client and server. Open network is susceptible to malicious attacks from third parties. Although technology like firewall can prevent most of the malicious attack, no E-commerce system is 100% safe. Many of today's E-commerce systems have experienced malicious attack. The result is having system down time. Users of the E-commerce system will not be able to carry out their purchasing activities and in the worst case information in the system was lost.

Like many other E-commerce system, users of COME use a combination of username and password to login to the system to carry out the trading activities. In case someone who is not a legitimate user gets the username and password, he/she can become the legitimate user and can carry out fraud trading activities.

7.3.2 Information Accuracy

In the COME system, information about products and suppliers are input by suppliers. As there can be many suppliers registered in the COME system, it is very difficult to validate all the products and suppliers' information before it is presented to the buyers. Accuracy of this information depends solely on the suppliers. Buyers may suffer if they make order based on deceptive information provided by suppliers. Using traditional procurement method has lower chance to be cheated as buyers usually trade with familiar suppliers and they can check physical sample before ordering.

7.3.3 Contract Formation

Like many other countries, Hong Kong has Electronic Transaction Ordinance (ETO) that defines a valid electronic contract. A valid electronic contract composes of a recognized electronic record and a digital signature. Digital signature is generated by digital certificate that is issued by authorized Certification Authority to a valid user (can be a person or an organization). At the moment, COME does not have digital signature signing function. A reason is that digital certificate is not inter-country recognized. As a result, when there is dispute about an order in COME, the digital records of material purchasing activities in COME cannot be used as a valid contract. To secure the trading parties, it is necessary to prepare the contract by other means.

7.3.4 Jurisdiction

Electronic market like COME has suppliers and buyers from different countries. Multiple jurisdictions raise various issues like contract formation, information control, intellectual property rights, and taxation. As these issues can be very different in different countries, users of E-commerce system must note the country of their trading partners. The trading parties should state the governing law and forum in the contract to secure themselves.

7.4 FUTURE WORKS

Although the COME system developed in this research allows contractors to search information provided by many suppliers that use the system, it does not provide material and supplier information in other websites. To improve market transparency, it is necessary to know material and supplier information in other website as well. This can be achieved by building interoperable E-catalog and using web mining technique. Multiple websites can share the same database schemas of construction material and supplier information and allow each other to read those information. Web mining technique can be used to search material and supplier information in web page of other E-commerce website and then distill and reconstruct the information for storing in database.

GIS is not fully utilized in the COME system. Besides displaying location of suppliers and calculating transportation distance, time and cost, GIS can be used to support contractors and suppliers to do market analysis. For example, with material information linking to the GIS module, buyers can browse how a particular type of product in the E-catalog distributes over several cities of a region. When all information related to trading process are linked to the GIS module, suppliers can use the GIS module to produce a map that shows bids, requisitions, quotations and orders made by buyers in different cities. Moreover, suppliers can use the GIS module to analyze business areas and customer patterns at different region of China.

The COME system can be further developed by incorporating features such as intelligent agents and data mining techniques. Intelligent agents are software entities that possess internal knowledge to perform certain tasks intelligently. The use of intelligent agents in an E-commerce system can support the users at three different levels (Liang and Huang, 2000): *market level*, *transaction level* and *activity level*. At the market level, intelligent agents can assist the users to select a proper trade type for their business deal. Intelligent agents at the transaction level ensure that the selected trading type is executed properly. At the activity level, intelligent agents can perform a specific task in the users' decision making process. Data mining technique is used to distill knowledge from raw data. The application of data mining techniques will enable us to generalize useful knowledge and information such as the profiles of users, the most frequently used searching patterns, and the general patterns in delivery, payment and other issues. These types of information will be

extremely useful not only to the users, but also to the system administrator responsible for maintaining the operation of the E-commerce system.

Customer's purchasing psychology is another research area that worth of pursuit. A study finds that perceived control and shopping enjoyment can increase the intention of new Web customers to return. It also finds that a Web store that utilizes value-added search mechanisms and presents a positively challenging experience can increase customers' shopping enjoyment (Koufaris *et al* 2002). Turban *et al* (2000) suggest that there are various features related to a Web shop, such as speed of operation and the ease of use, that determine the navigational experience of the customer. Navigational experience is, in turn, one of the key determinants of overall shopping experience, or customer satisfaction. Increased customer satisfaction leads to an increase in the likelihood of a repeat purchase. However customers' preference on website's features differ from one Web domain to another and there is no single quality checklist will be good for very long (Zhang and Dran 2001). Also preference of people in different countries may be different as they have different cultures. Research works should be carried out to understand the purchasing psychology of targeted users of COME so that the COME system can be designed to better serve the users.

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Appendix

APPENDIX

A Questionnaire on User's Opinion and Knowledge on E-commerce Website of Construction Materials Trading

Interviewee Information:
Name: _____ Company: _____
Position: _____

The aim of this survey is to collect your opinion on E-commerce website of construction materials trading. Please put a tick in the appropriate box.

1. How important do you think the following issues are? (5 represents very important and 1 represents very unimportant)

1.1 Content Quality:

	5	4	3	2	1
Variety of information	☐	☐	☐	☐	☐
Detail of information	☐	☐	☐	☐	☐
Update of information	☐	☐	☐	☐	☐
Presentation format of information	☐	☐	☐	☐	☐
Reliability of information	☐	☐	☐	☐	☐
Provision of business policy information	☐	☐	☐	☐	☐
Provision of privacy policy information	☐	☐	☐	☐	☐

1.2 System Performance:

	5	4	3	2	1
Speed of Operation	☐	☐	☐	☐	☐
System Reliability	☐	☐	☐	☐	☐
Ease of use	☐	☐	☐	☐	☐
Ease of access	☐	☐	☐	☐	☐

2. What is your level of satisfaction on COME about the following issues? (5 represents highly satisfied and 1 represents highly unsatisfied)

2.1 Content Quality:

	5	4	3	2	1
Variety of information	☐	☐	☐	☐	☐
Detail of information	☐	☐	☐	☐	☐
Update of information	☐	☐	☐	☐	☐
Presentation format of information	☐	☐	☐	☐	☐
Reliability of information	☐	☐	☐	☐	☐
Provision of business policy information	☐	☐	☐	☐	☐
Provision of privacy policy information	☐	☐	☐	☐	☐

2.2 System Performance:

	5	4	3	2	1
Speed of Operation	☐	☐	☐	☐	☐
System Reliability	☐	☐	☐	☐	☐
Ease of use	☐	☐	☐	☐	☐
Ease of access	☐	☐	☐	☐	☐