Internet-Based Geographical Information Systems System for E-Commerce Application in Construction Material Procurement

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Abstract: This study combines two luminous areas, geographical information systems (GIS) and E-commerce system, and applies the combined technology in the business of construction material trading. In the era of electronic business, trades can be accomplished without limitations on time and space. The statement is true in principle only, but in reality, any kind of business activity must involve transportation of goods from one place to another, and therefore, constrain in space is always in existence. GIS is capable to integrate, to manage, and to analyze information regarding to space (spatial information). This study investigates the roles of internet-based GIS in E-commerce systems. It is identified that there is a great potential to use GIS in E-commerce system to provide better services in location-based queries, business area analysis, and transportation analysis. Accordingly, an E-commerce system for the business of construction material is developed. The implemented system is called construction materials exchange, this is currently operating for the over 2,000 buyers, 29,000 suppliers, and 1,000 agents, and the system mainly servers for the great China region. This paper presents the system from its conceptual business model, logical system design, to the system implementation.

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This paper reports the development of an internet-based geographical information system (GIS)—for E-commerce application, the paper covers the background knowledge of GIS, conceptual design of the E-commerce system, and the current status of implemented system.

Geographical information system (GIS) is a unique information system, which maintains, manages, integrates, and analyzes, 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. On the other hand, an E-commerce system offers a possible solution for directly 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 on the effective distribution of goods (Yang et al. 2000). Transportation of goods among different parties must involve all kinds of business activities, even in the era of on-line business. Consequently, cost of transportation is also a critical consideration in E-commerce.

The following section outlines the principles of geographical information system and E-commerce. Section II discusses the roles of GIS in E-commerce applications. The section III presents a conceptual design of an internet-GIS-based E-commerce application. Section V covers the business environment and functional design of the system. The section V describes the current status of an implemented E-commerce system: construction materials exchange (COME). Concluding remarks for the GIS technologies and the implemented system are given in the last section.

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Geographical Information System and E-Commerce Applications

Geographical Information System

Geographical information systems (GIS) usually refer to an information system which facilitates input, query, analyze, output, and visualization of georeferred 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 though its roles in data management and integration, data analysis and data visualization.

Spatial Data Management and Integration

Fig. 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 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 optimize 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 located within 10 km from 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.

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 the natures of applications, questions to be answered by GIS ranges from simple data query includes one data set, data query includes 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., correlates thousands of paper maps on a light box), but also is a significance tool in supporting decision-making over the space.

Network Analysis

Network can be effectively represented in the location-based architecture of GIS. A 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 systems, and highway systems. A commonly asked question about the network is that 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 points in the network (Dijkstra 1959). The algorithm computes first, shortest paths from the given starting node to all other nodes in the network. For the network shown in Fig. 2(a), Node a is the starting node. With distances of the arcs, this is known that Nodes b and d are nearest to a and shortest paths from a to b and d are Arcs ab and ad, respectively. Meanwhile a tree shown in Fig. 2(b) is created, the tree is starting from a. Since Nodes b and d are the immediate neighbors of a, Arcs ad and ab are added as first level leaves of the tree. The search is now performed for Nodes b and d. At Node d, Nodes a, b, and e are the immediate neighbors of Node d, and at Node b, Nodes d, e, and c are the immediate neighbors 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 leaves of ad. For leaves 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 through Node d, so be will not be added as a leaf of ab. Eventually, only bc is added. Now, Nodes e and c have undergone similar search methods, Arcs ec and ef are added. Arc ec 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 Fig. 2(b) is completed.

From Fig. 2(b), shortest paths form Node a to all other nodes in the network can be traced. From for Node a to Node f, for
example, at the bottom of the tree, this is known that the immediate neighbor of f is e, and the 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:

\begin{itemize}
  \item Where are the suppliers of Cement \textit{within} Guangdong region?
  \item Where are the suppliers of Door \textit{near} to my construction site?
  \item What is the best and the shortest route and transportation method from Supplier A to Buyer B and what is the cost of transportation?
\end{itemize}

**Spatial Data Visualization**

Another important use 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 more informative than other formats of presentation, such as table or charts. For example, map-based presentation is more appropriate for census information (Fig. 3). 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.

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 the impact of the action.

**E-Commerce Applications**

E-commerce refers to business activities involving consumers, manufacturers, service providers, and intermediaries using computer network. Electronic data interchange (EDI) has been used to forge automated linkages between the buyers and suppliers to transmit orders, receipts, and payments electronically. Studies have shown that using EDI for linking with so-called “channel partners” can help reduce processing, cycle-time, improve accuracy, and create strategic value (Mukhopadhyay 1998). However, EDI requires the support of private lines or value-adding networks and relies on software that can incorporate varying formats, which limits its coverage. Moreover, EDI requires significant investment to facilitate trading among business partners, especially when contractors 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.

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. Web technology thus enables contractors and suppliers to trade construction materials online easily with low transaction cost and to eliminate errors existing in the paper-based document system.

E-commerce as a proliferated business practice has at least four types on the Internet: off-line order off-line delivery; on-line order off-line delivery; on-line order on-line delivery and off-line order on-line delivery (Liang and Huang 2000). For the off-line order, off-line delivery type, information 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 for 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 for the 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.

Among these four types of business practice, off-line order, off-line delivery and the on-line order off-line delivery types are applicable in developing E-commerce systems for construction material exchanges. However, as the off-line order off-line delivery type only makes available information related to material and suppliers on the internet, both ordering and delivery are executed off-line. This type of E-commerce cannot overcome all the prob-
Roles of Geographical Information (GI) and Geographical Information Service (GIService) in the 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 per chance 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 than 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 of 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 be carefully considered. Geographical information is a valuable and, many times the only source to compare and to analyze business environments of different regions. Web-based GIS offers the following geographic services in E-commerce applications.

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 associating with suppliers and material. 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 in person in the on-line ordering system, provision of detail, accurate, and up-to-date 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 tables. Web-based GIS delivers geographical data of suppliers to all users of the system, for example, web-based GIS can provide a directory of suppliers and visualizes their locations in form of maps.

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 who provide the most competitive price of material within five miles. Moreover, web-based GIS allows a 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 the results of analysis can be presented in the form of maps and included in other documents for further references.

Transportation and Logistic

As 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 analyze the most cost-efficient transportation route to deliver goods from the suppliers to construction site of the buyer.

Development of Web-Based Geographical Information System for an E-Commerce System

Trading Situations

In most construction material trading circumstances, there are three major players: buyers, suppliers, and agents (brokers). 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 trade situations.

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 Fig. 4, 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.

From Fig. 3, 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 platform for the suppliers to put their products 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 four trading situations encountered in construction material trading. The E-commerce business model presented in this paper is therefore based on the type (c).

System Design

To facilitate the four trading situations, the E-commerce system presented has the following modules: GIS, E-catalogs, bidding, requisition quotation, and order, as shown in Fig. 5. Each of the module functions within the E-commerce system will now be discussed.

Geographical Information System Module

The GIS module is considered as the integrator of all information in the electronic market. As long as a piece of information is related a 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 electronic market, city is chosen as the common item of all sets of information (Fig. 6). Buyers, suppliers, material, and other information are linked to the layer of city through a unique identification for each city. In the other words, the GIS module can provide a single interface from which users can search all different types of data and services belonging to a city. The module provides mapping services for locations of buyers and supports, and other geographic information relating to the trading process, e.g., transportation, land use, and demography. The module provides as well all types of spatial queries and analysis for entities used in other modules in the system. For example, with the GIS module, buyers can browse how a particular type of product in the E-catalog distributes over several cities of a region. On the other hand, suppliers can use the GIS module to produce a map that shows bids, requisitions, quotations, and orders made by buyers in different cities.

E-Catalog Module

The E-catalog module provides an interface for suppliers to advertise their product information into a classified material catalog. The product information includes the price, units, photos, brand names, quality standard, and other relevant details so as to allow the buyers to make judgments on the suitability of the products. Information of suppliers such as the company name, address, telephone, E-mail, and service details should also be provided. 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.

Bidding Module

The bidding module allows buyers to specify materials they want to buy when they cannot find suitable materials from the E-catalog. Suppliers can view buyers’ requests for materials online and to bid for the request. Messages are sent to the buyers instantly to inform them of the responses from suppliers. A buyer can accept a bid on-line 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.

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

![Fig. 6. GIS as data integrator](image-url)
amount of purchases, payment methods, and their relationships with buyers. Supplier can view the requisition on-line and then use the quotation module to reply to the buyer.

**Quotation Module**
The quotation module allows suppliers to send quotations to buyers after receiving requisitions. Buyers will receive notice of the quotations and be able to view the quotation details on-line. They can then use the order module to raise orders.

**Order Module**
The order module allows buyers to send orders to suppliers. The buyer can use the order module in three cases: (1) once suitable materials are identified from the E-catalog the buyer wants to make a direct order; (2) the buyer receives a quotation from the supplier; and (3) the buyer accepts a bid from the supplier. Both the buyer and the supplier can use the order module to proceed with the transaction.

The above modules are the main modules of an E-commerce system developed to facilitate construction materials trading. The E-commerce system has been implemented using an application service provider (ASP) as the web programming language and ORACLE as the database for storing data and information on a server. The implementation of the E-commerce system is described in the following section.

**Implementation of the E-Commerce System**
The web address of the E-commerce system is (http://bsnt42.bre.polyu.edu.hk). The E-commerce system is called COME, which is an acronym for “construction materials exchange.” The COME system adopts an on-line order off-line delivery model of operation. It is a trading model that is based on the type (c) of the buyer-supplier communication structure, as illustrated in Fig. 3. The COME system has five main modules, as indicated in Fig. 4, which enable buyers and suppliers to execute the four trading situations previously described. To cope with unexpected trading situations, the system also provides additional services such as building up user profiles, tracking the trading process, and learning the trading experiences.

**Business Model of COME**
In designing and implementing 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 first over 90% of the construction materials used in Hong Kong are from China and contractors in Hong Kong have expressed the need for an E-commerce system to expedite the trading process. Second, most material producers and suppliers in China have no proper channel to contact buyers from outside of China. The E-commerce system to be 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 on-line.

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 statutory regulations and business culture in China will have difficulties fulfilling 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 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 Fig. 7. This figure summarizes the roles and functions of the three major parties in the COME system: buyers, suppliers, and agents.

**Implemented Functions**
GIS is implemented to assist in the search of material information in specific geographic regions of China. 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 the sense, COME is a GIS application service provider (ASP) to its users as well. The client-side responses for only displaying maps sent from the server and requesting geographic services through our provided map-based interface, for example, selection of a city on the map. The approach ensures a thin-client
architecture in which additional software or plug-in are not requested in the Internet browser on the client side.

By using the GIS system, the buyers can define the searching areas by selecting the cities on the map [Figs. 8(a) and (b)] or by specifying circular area with a given central point and its radius [Fig. 8(c)]. The system will then find all suitable material information within the area together with the associated costs for transporting the material and/or products from the suppliers to the buyers [Fig. 8(d)].

The E-catalog in the COME system contains over 2,000 categories of construction materials classified into 17 trees with a maximum of four levels of information. With this structure, the search for product information commences at a general level. If more specific information is required, then the searching process will lead to the next level of information. All suppliers and buyers are geographically associated to the GIS database via their located cities.

Functions provided for buyers also include sending requests for materials and accepting bids from suppliers, selecting agents to complete orders, and purchasing contact information of suppliers. Readers should note that the buyers do not know who the supplier is when they find materials from the E-catalog. Buyers have to choose to purchase the contact information of suppliers so that they can contact the suppliers directly, or to select an agent to complete the order for them.

The suppliers can use the COME system for the following purposes: adding and maintaining materials and company information in the E-catalog, reviewing the current market situation in terms of material prices and buyers’ requests, and bidding for buyers’ requests. Functions provided for the agents include managing buyers’ order, and bidding for buyers’ request. Some screen captures of the COME system interfaces are shown in Fig. 9.

**Current Status of Construction Materials Exchange**

The GIS has been created successfully in the COME system. User can use the GIS function through the internet easily. The travel time of the data, which is needed to send to the client, on the internet is reasonable. The reason is that most of the data needed to be transformed is just in text and image format. The average size of an image file is just 60 K bytes. Moreover, since all the process is running on the server side, the performance is dependent upon the programming load and processing power on the server but not the client computer. Less than 1 s of processing time is taken for every request sent by a user on our server.

Linking bidding, requisitions, quotation, and order to the GIS database is the next step of the development. Buyers and suppliers are geographically referenced to the GIS database, the current system supports spatial query and analysis for suppliers. When all related information to the trading processes are linked to the GIS database, suppliers can use the database to manage those different types of information in a unique system. This is important for the supplier to manage site offices and arrange transportation to delivery material effectively. Moreover, the suppliers can use the GIS module to analyze business areas and customer patterns at different regions of China. The GIS module can offer valuable...
add-on services in COME to attract both supplier and buyers. Currently the professional version of the E-commerce system contains over 2,000 registered buyers, 29,000 registered suppliers, and 1,000 agents registered in the COME system. Experiments are being conducted to compare the time and costs required to procure construction materials in the traditional way and through the E-commerce system. Users’ opinions about the effectiveness of the COME system will also be collected and analyzed.

Conclusions

Development of an internet-based GIS for an E-commerce application is presented in this paper. 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 paper mentioned how an internet-based GIS enhances functionality of an E-commerce system for construction material. This paper also presented a design and implementation of integrating geographical information and business related information (e.g., products’ catalog, quotations, and orders).

It is necessary to note that costs for transporting construction materials is not only dependent on the distance. Although the longer the distance, the higher the costs, the transporting costs may involve many other variables, such as the locations of local distributors, reduced shipping costs because of combining shipment to various buyers in the same area. In general, transporting cost is a complex subject which deserves further investigation in the future. On the other hand, although the use of an intelligent agent in the E-commerce has been mentioned in the paper, the current system does not facilitate the use of intelligent agents. Again, further study is needed to identify the role of intelligent agents in the COME system, and to design and implement such agents if they are deemed useful.

In summary, this study identified that the essential role of internet-based GIS plays in electronic business of construction material. The GIS provides a total solution for integrating and managing different types of textual information in the underlying database; for suppliers to study the business environments of dif-
different areas; and for buyers to compare different suppliers and to
determine costs of transportation from different areas.

This paper also identified the limitations of the traditional con-
struction material procurement method and identifies those areas
of E-commerce applications that may help to solve the problems.
Models of trading situations, as well as the typical types of com-
munication structures used in E-commerce development are dis-
cussed. A design and implementation of an E-commerce applica-
tion for construction material procurement is presented. The
E-commerce system has been upgraded to a professional version,
which is now used by suppliers in China and buyers in Hong
Kong.

There is a long history for human to use maps to make differ-
ent types of decisions, from daily route planning to national mili-
tary strategy. Maps or the geographical information on the maps
actually have become indivisible part of our daily life. This paper
aims to use an example and initiative of using GIS in E-commerce application of construction and architecture. This is
anticipated that GIS and systems with similar functionality will be
more widely adopted or even a must in future E-commerce appli-
cations.

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