The use of Geographic Information Systems (GIS) in Business

Lotfy Azaz

Abstract— In spite of the importance of GIS technology, too little research has been done to understand the role of this technology in business. Long time ago, business school researchers had recognized the promise and importance of GIS and mapping. Nevertheless, few business scholars have chosen to follow this stream with the result that researchers from other academic disciplines such as geography and computer science have performed the bulk of the research on GIS applications and functionality. Researchers in disciplines such as information systems, marketing, real estate, and management can add a great deal to the existing GIS research literature by applying theories, frameworks, applications, and perspectives from their respective fields of study. Because of that, the purpose of this paper is to highlight the importance of GIS in business. To achieve this, an overview of GIS technology will be provided. GIS as decision support system was presented. Following this, a framework for GIS applications in business is proposed and examples of representative applications are cited and discussed.

Keywords— Business, Decision support system Geography, GIS, Facilities management, Digital Mapping.

I. INTRODUCTION

Geography seeks to understand the Earth and all of its human and natural complexities. To that extent, Geography is the science of our world.

A geographic information system (GIS) integrates hardware, software, and data for capturing, managing, analyzing, and displaying all forms of geographically referenced information. GIS allows us to view, understand, question, interpret, and visualize data in many ways that reveal relationships, patterns, and trends in the form of maps, globes, reports, and charts. GIS technology can be integrated into any enterprise information system framework (GIS.com. 2011).

II. WHAT GIS CAN DO FOR BUSINESS?

Although GIS have been used for several years in the natural resources, forestry, and environmental industries, only recently have they begun to be used for a broader array of business and management functions such as logistics, site and facilities management, marketing, decision making, and planning. GIS can help a retail business locate the best site for its next store. It helps marketers find new prospects. Placing your data on a map highlights where you have many customers if you own a store. It allows you to view, understand, question, interpret, and visualize your data in ways simply not possible in the rows and columns of a spreadsheet. And with data on a map, you can ask more questions. You can ask where, why, and how, all with the location information on hand. You can make better decisions with the knowledge that geography and spatial analysis are included (ISU GIS, 2011).

The fact that businesses have begun to use GIS is not surprising, particularly given the fact that much of the data that organizations typically use include significant spatial components (estimates range between 50% and 85%). Because of these and other reasons, an increasing number of businesses have begun to make substantial use of GIS for a variety of routine decision support and analysis applications (e.g., market and demographic analyses) (Mennecke, 2000).

According to TechNavio (2009), the market for GIS applications was forecast to reach $3,362.6 million in 2010 from $2,981.4 million in 2007.

Demand from emerging markets like Russia, China and India for location data and analysis is further expected to contribute to the investments made in GIS Systems. Further, a trend towards 'geographically enabled' Business Intelligence (BI) applications is expected to drive the sales of location intelligence applications integrated with BI applications (Technavio, 2009).

III. GIS AS DECISION SUPPORT SYSTEM

Fundamentally, a GIS is a tool for linking attribute databases with digital maps. GIS also provides users with advanced modeling functions, tools for design and planning, and advanced imaging capabilities. While many of these capabilities also exist in other types of systems, such as visualization and virtual reality systems, GIS are unique because of their emphasis on providing users with a representation of objects in a cartographically accurate spatial system and on supporting analysis and decision-making. (Mennecke, 2000).
Mennecke (2000) proposed the model shown in figure 1 to account for the unique features present in GIS. In this model, the distinct characteristics of GIS, as compared to an aspatial DSS, are highlighted by specifically noting the spatial data, spatial data models, and spatial query and reporting features that are part of GIS. This model also shows that although aspatial DSS and GIS possess many similarities, there are important distinctions that must be made between these two types of systems.

**IV. GIS APPLICATIONS IN BUSINESS**

Business requirements for information systems are as diverse as the many types of businesses that exist. Nevertheless, most organizations use information systems for one or more of five applications: transaction processing, operations, inventory control, planning and decision-making, and internal management and control. GIS can be used for these functions because this technology possesses capabilities that are common to traditional aspatial information systems. In addition, GIS also possess characteristics that provide them with capabilities that are not present in other information systems (Landis, 1993).

These relationships are portrayed in a conceptual model of GIS (Figure 2) that portrays four GIS functions and related applications. The four functions are derived from four unique activities for which GIS can be used to address the needs of business. The GIS functions are spatial visualization, database management, decision modelling, and design and planning. **Spatial imaging** refers to the fundamental GIS capability of representing displays of data and information within a spatially defined coordinate system. The **database management** function represents the capability of GIS to store, manipulate, and provide access to data. The **decision modelling** function represents the capability of GIS to be used to provide support for analysis and decision-making. Finally, the **design and planning** function represents the capability of GIS to be used to create, design, and plan. In addition to these specific functions, the model also represents several specific GIS applications toward which these functions can be applied: spatial data collection and automated mapping, facility management, market analysis, transportation, logistics, strategic planning, decision-making, design and engineering (Mennecke, 2000).

![A Conceptual Model of a Geographic Information System Used For Decision Support (after Mennecke (2000))](image1)

**A. Digital Mapping**

One of the first applications of geographic information technologies was that of capturing spatial data to generate maps automatically (Coppock and Rhind 1991). Computer systems designed to produce digital maps represent powerful tools for business applications because it provides managers with the ability to generate spatial data in-house. In addition, Remote sensing and global positioning systems (GPS) allow more accurate map production (Goodchild 1992).

Utilities companies such as South Carolina Electric and Gas, B.C. Hydro, Alabama Power, Wisconsin Electric Power, and Southern California Edison use GIS technology to produce digital maps. Northern States Power, which provides electric and gas services across five Midwestern states, uses GIS integrated with other corporate systems for produce digital mapping, managing facilities data and customer records, and other activities such as order processing and network analysis. Companies in the petroleum business have some of the largest digital mapping operations in the world. For example, Chevron, Shell Oil, Texaco, and Union Pacific Resources have adopted GIS and digital mapping for supporting their operational and exploratory activities (e.g., managing well locations, lease information, seismic information and other kinds of data). Similarly, Petroleum Information, a firm that provides mapped information for the oil industry, has more than two million well locations that it has captured and stored in its database. Other natural resource industries likewise use GIS for automated mapping. These include the mining industry, represented by companies like Independence Mining, and firms working with groundwater...
and environmental management, such as Ground Water Systems, Inc. (Mennecke, 2000).

**B. Facilities management**

GIS have been used extensively for facilities management (FM) in the public sector and private sector as well. Utility firms, for example, represent one of the largest private-sector GIS end-user groups. In her review of utility applications of GIS technology, Rector (1993) notes that GIS fulfills "an ever-increasing demand for information pertaining to the location, condition, and performance of the utilities' infrastructure" (p. 193). These information requirements are not limited to utilities since many organizations must manage and control facilities such as manufacturing plants, distribution centres, retail outlets, and other components of the organization's portfolio of physical assets. FM provides managers with a powerful tool for supporting real-time monitoring of facilities and is routinely used for emergency management, security, and other applications.

The key functions of GIS used in FM are the spatial visualization and database management functions. In other words, most FM applications use historical or transaction (real-time) data to manage or monitor facilities. They also rely heavily on the imaging capabilities of GIS to represent the spatial arrangement of data elements.

The digital mapping function of GIS are often combined with FM functions to provide organizations with a system for generating, managing, and utilizing maps and other spatial data that can be used to manage an organization's physical plant.

Utilities companies make extensive use of GIS for facilities management. For example, Pennsylvania Power and Light has located more than two million utility poles using geographic information technology. Boston Gas has created an Automated Mains Management System project, which integrates thousands of maps of their distribution system and other information such as leak histories, soil conditions, and construction activity. Wisconsin Electric Power Company is providing a Work Management System, Electronic Map Access, and a Distribution Dispatch Operating System using GIS technology to service its customers. Besides utilities companies, other types of companies also use GIS to manage their facilities. Conrail, a division of CSX, which operates a rail freight network in 14 Northeastern and Midwestern states, and the Province of Quebec, is integrating GIS with its other information technologies and creating an enterprise-wide information system (Mennecke et al. 1998; Vaidya and Lang, 1994). Likewise, billboard companies like Gateway Outdoor Advertising (Somerset, NJ) and Patrick Media Group (Chicago, Illinois) maintain information about billboards, including photographs and regional demographic information, to help manage and promote each billboard (Battista 1994).

**C. Market and demographic Analysis**

The primary function of market analysis is to understand the marketplace; in other words, "market analysis means using customer information to estimate the size and character of a market" (Francese and Piirto 1990, p. 105). GIS is a powerful market analysis tool because it provides a platform for representing the spatial relationship between the components of the market; that is, the customers, suppliers, and competitors. This has become all the more important as greater competition has forced many firms to find new ways to manage their relationships with customers.

Strategies such as target marketing, micro marketing, and relationship marketing all require that firms capture and maintain detailed information about their customers (Webster 1994). The ultimate goal of all of these efforts is usually to bring a product or service to someone, somewhere; thus, an understanding of the geo-demographic characteristics of the firm's customers is critical to a successful marketing strategy.

In most cases, market analysis applications use historical or transaction (real-time) data in combination with decision modeling and support tools to analyze the organization's marketing environment. Furthermore, GIS is a powerful tool in market analyses because it also provides a way to bring together data from multiple sources and link them based on spatial attributes. This often involves a process of layering different types of data on the same map projection so that the decision maker can identify and visualize how data intersect and interact. Thus, GIS is a useful and unique query tool for accessing and displaying components of a database based on the data's spatial characteristics (Mennecke, 2000).

A number of organizations have successfully applied GIS to their marketing intelligence and analysis needs. For example, fast food restaurants and other food service firms have been one of the most prominent business users of geographic technologies. Firms such as Arby's, Burger King, The Olive Garden, Popeyes, Red Lobster, and others use GIS for market analysis, franchisee selection and placement, site location analysis, and demographic profiling (Battista 1995). MacDonald's has used geographic technologies for a number of years and is recognized as an industry leader in the use of geographic information technologies because of its progressive use of GIS for a wide variety of marketing and operational applications. Many firms apply GIS in market-based site selection and market analyses. Val-Pak Direct Marketing Services, Inc., the largest US local cooperative direct mail advertising company, uses GIS to micro market, analyze trade areas, and manage territories (Wendelken 1994). Texaco uses GIS to explore markets for sitting new Texaco stations and for enhancing existing facilities. Included in these activities are demographic analyses of neighborhoods and competitor locations to identify likely locations for new stations and the appropriate advertising and product mix for existing stores (Lang 1996b).

Levi Strauss and Co., a leader in the casual apparel market, uses GIS for a broad spectrum of marketing applications. For example, they use geographic technologies to customize their
regional advertising and promotions; to select billboards based on location, traffic patterns, and visibility; to select and customize the content of billboards and other local advertisements based on regional demographics; and to customize advertising associated with special-events promotions. GIS is also used to support national promotional efforts, such as new product launches, target marketing, custom mailings, advertising, and media selection (see Mennecke et al. 1998). Many car manufacturers such as the American Honda Motor Company and the American Isuzu Motor Company are also using GIS in a broad spectrum of activities. For example, these firms use GIS for both internal market analysis and assisting their dealers in analyzing their local markets (Hoerning 1996; Mennecke et al. 1998).

D. Transportation and Logistics

GIS and related geographic information technologies are increasingly becoming critical tools for addressing logistics and transportation problems. In this context, GIS is used both as a platform for supporting decision modeling activities and as a tool for displaying the results of these analyses (see Grabowski and Sanborn 1992). A number of specific tools fit into this category of GIS. These tools include vehicle routing and navigation systems, intelligent vehicle highway systems (IVHS), dispatch systems, production control systems, and inventory systems (White 1991). Each of these technologies represent useful applications that managers can use to develop tactics to reduce waste, lower personnel and fuel costs, and provide better customer service (see Lapalme et al. 1992; Kunze 1993).

Transportation systems use tools and algorithms such as transportation network models and material flow models that come from disciplines such as operations research and production management. Thus, transportation and logistical systems rely primarily on the decision modeling function of GIS (Choy et al. 1994).

Logistical problems are common to many industry segments; thus, many applications for GIS in addressing or supporting logistical problem solving can be cited. Such applications range from Pennsylvania Power and Light's use of GIS to produce location maps so that managers can show meter readers their daily routes in advance, to General Motors' use of GIS-related technology to provide vehicle navigation systems. Similarly, the American Automobile Association uses GIS to support routing analysis and travel information reporting for its members. Car rental firms are increasingly including navigation systems in their rental vehicles. Both Avis and Hertz have been test marketing GPS in-vehicle guidance systems in a number of test markets (Avis calls their system Guidestar® and Hertz calls theirs Neverlost®).

Conrail's growing enterprise GIS uses the technology in many aspects of its business, including transportation, where dynamic segmentation tools can manage rail maintenance history by route and milepost down to each individual rail. The system can also relate customers and potential customers to Conrail facilities, locations, and routes. Similarly, Yellow Freight, which specializes in "less than truckload" shipments, has some 640 terminals across the country; it uses GIS to support the creation of service maps, terminal service area analysis, and facility/capacity displays. Other firms such as LEGO and the Coca Cola Co. use GIS to support transportation logistics, shipment tracking, and planning of product manufacture and delivery (Sherwood 1995).

E. Design and Engineering

Computer drafting and design systems have been widely used for many years for business applications related to engineering, drafting, and design. Computer aided design (CAD) systems, for example, are routinely used by engineering firms to develop and archive architectural drawings. Like CAD systems, GIS technology can be used to design plans, layouts, and maps. GIS do differ, however, from traditional CAD systems. For instance, Maguire (1991) notes that CAD systems have rudimentary links to databases, they deal with relatively small quantities of data, they do not usually allow users to assign symbology automatically based on user defined criteria, and they have limited analytical capabilities. Nevertheless, Maguire also suggests that GIS are related and were, in effect, born of CAD and other information systems (Maguire 1991, p. 13). GIS applications for design and engineering make use of both the imaging and the planning functions of GIS. In the majority of cases, the same GIS used for design and engineering are later adopted for FM functions as well.

These systems are commonly used in landscape engineering, environmental restoration, commercial and residential construction and development, and a host of other design activities. Nearly all the utilities use GIS for design and engineering work, usually by coupling GIS and CAD technologies. Boston Edison, for example, uses GIS for design, planning, operations and maintenance activities; the system stores land-based service territory, facilities and circuit information, which is used to manage the company's transmission and distribution network. South Carolina Electric and Gas uses its GIS for work order sketching, mapping, and planning for applications to perform voltage drop analysis and "what-if" modeling scenarios in responding to electrical supply problems (Mennecke, 2000).

A number of telecommunication companies are now using GIS to support their expansion of optical fiber or coaxial networks, including AT and T Network Systems and Pactel (see Cheu 1994). Peabody Holding Company's Coal Services Corporation uses GIS to assist mining companies in complying with rapidly changing government regulations affecting the coal mining industry. Environmental firms like Camp Dresser and McKee (CDM) use GIS in environmental engineering and remediation projects while Pacific Power and Light has used GIS to help with managing wildlife habitat in connection with hydroelectric projects.
V. CONCLUSIONS

GIS is important for business because most business problems include significant spatial components and GIS enables decision makers to leverage their spatial data resources more effectively. GIS is useful for managing databases, even extremely large applications such as data warehouses, because it provides an enhanced data structure that is based on the natural organization that geography provides. Today, GIS-based data sources vary from satellite imagery used to validate the number of new houses in a retail-market to the individual people-point data of the consumers living in those houses. Data such as these can add significant value to an organization's database by helping to validate and extend their own proprietary resources.

Although geographic information technologies have existed for several decades, much research needs to be completed, particularly research examining issues associated with the development, implementation, and use of this technology in business settings. One reason for this is that GIS have traditionally been developed, operated, and researched by people with ties, in one way or another, to geography and computer science. This has naturally led to a greater research focus on the technical and cartographic principles related to capturing, representing, and displaying spatial data (Onsrud and Pinto 1991).

As GIS have spread into other areas such as biology, forestry, geology, and similar scientific disciplines, research has similarly tended to focus on technical concerns associated with each of these disciplines. Although the literature on GIS from these areas is rich, great potential exists for researchers from business and information systems to contribute to this stream of research.

Although some important work on the management of GIS had been published such as (Campbell and Masser 1996; Huxhold and Levinsohn 1995; Obermeyer and Pinto 1994), much more research is still needed to better understand issues such as how GIS should be managed in a business setting. What types of business problems it should be used for, how it compares to other types of information systems, and its overall effectiveness as a decision-making tool (Aangeenbrug 1991; Crossland et al. 1995; Campbell and Masser 1996).

REFERENCES