Preface

The Growth and Development of GIS in Business

Geographical information systems (GISs) access spatial and attribute information, analyze it, and produce outputs with mapping and visual displays. An early definition stated: GIS is "an information system that is designed to work with data referenced by spatial or geographic coordinates. In other words, a GIS is both a database system with specific capabilities for spatially-referenced data, as well as a set of operations for working with the data" (Star & Estes, 1990).

GIS in business has grown as a significant part of this subject. It has been stimulated by the rapid expansion of GIS use in the private sector during the 1990s and early 21st century. Companies are utilizing this technology for a variety of applications, including marketing, retail, real estate, health care, energy, natural resources, site location, logistics, transportation, and supply chain management. GIS can be combined with global positioning systems, remote sensing, and portable wireless devices to provide location-based services in real-time. GIS is more and more being delivered over the Internet. Increasingly, it constitutes a strategic resource for firms.

This book fills a gap in the scholarly literature on GIS. Although books and journals are devoted to GIS in general (Longley et al., 2000; Clarke, 2003) and to its practical applications in business (Grimshaw, 2000; Boyles, 2002), there has not been a book solely focused on research for GIS in business. As Chapter II points out, there is a deficit of peer-reviewed research on GIS in business, which means this book can be helpful in bringing forward a compendium of current research. Also, by its two literature review chapters and references throughout, this volume can serve to direct interested persons to diverse and sometimes scattered sources of existing scholarship.

The early developments leading to GIS stem from the mid-20th century (Clarke, 2003). Swedish weather mapping was computer-based in the mid-1950s (Longley et al., 2000). In the late 1950s in the UK, Terry Coppock performed geographical analysis of a half million agricultural census records (Longley et al., 2000). At this time, GIS was conceptualized by Waldo Tobler (Tobler, 1959), who foresaw the role of map input, map analysis, and map output (Clarke, 2003). Batch computer programs for GIS were produced in the 1960s by several groups (Clarke, 2003). The early uses of GIS were in government, at the federal, state, and local levels. Canadian governments were especially significant early adopters of GIS. This is not surprising, since Canada is an advanced nation having extensive land area and natural resources, which could benefit by improved public management. In the mid-1960s, Ralph Tomlinson and others utilized computers to perform intensive mapping of the Canada Land Inventory. He led in producing the Canada Geographic Information System (CGIS), which many regard as the first GIS (Longley et al., 2000). In the same period, the Harvard University's Laboratory for Computer Graphics and Spatial Analysis designed and developed software leading to an improved GIS program, Odyssey (Clarke, 2003). Commercial programs became available in the late 1960s by companies such as ESRI Inc. and others. Like other information technologies, early GIS uses were constrained by computers' low disk storage capacity, slow processor speeds, and bulky sizes. GIS was more constrained than the average range of IS applications, because of the additional need to store spatially referenced boundary files. In the late 1960s and early 1970s, remote sensing, i.e., photographs of the earth's surface, was developed and later linked with GIS (Longley et al., 2000).

One of the underlying enablers of GIS over the past 35 years has been the rapid increase in both computer storage capacities and processing speed. As seen in *Table 1*, the ratio of transistors per silicon chip increased at a rate that doubled approximately every one and a half years, a phenomenon known as Moore's Law (for Gordon Moore, who formulated it in 1965). The rate has increased at that amount during the past 40 years. The GISs that ran on bulky mini-computers in the mid-1980s with processing speeds of around 16 megahertz today run on small laptops with speeds of 4 gigahertz (4 billion Hz) or more. Although some have questioned whether Moore's Law and other growth rates will continue in the long range, all prognosticators are indicating storage densities will grow in the mid-term.

For GIS, the faster speeds have allowed much more refined databases, analysis, modeling, visualization, mapping features, and user interfaces. GIS applications and its user base grew rapidly in the 1990s and early 21st century. It has become connected with global positioning systems, the Internet, and mobile technologies. With multiplying applications, it continues to find new uses every year. Datatech projected that the sum of revenues for GIS core-business will be \$1.75 billion in 2003, an 8 percent increase from 2002 (*Directions Magazine*, 2003). The GIS software vendor sales totaled \$1.1 billion, two thirds of the total, while services accounted for 24 percent (*Directions Magazine*, 2003).

Concomitant with the increase in chip capacity has been a dramatic fall in price per transistor (Intel, 2003). From one dollar per transistor in 1968, the price has fallen to a cost of \$0.0000005 per transistor in 2002 (Intel, 2003).

At the level of large-sized systems and applications, expanded computing power, combined with the Internet and modern telecommunications infrastructure, allows GIS to be deployed across an organizations as a worldwide enterprise system. In enterprise applications, the GIS processing is centered in specialized groups of servers that are interconnected through middleware to the client-based end users. The development of enterprise GIS resembles the trend towards enterprise resource planning systems (ERP).

Sometimes they are merged; in fact, many ERP systems allow for interconnections to GIS software.

A number of other technology trends have led to the expanding use of GIS. They include more sophisticated and robust GIS software, evolving database design, improved visualization display — both hardware and software — and, since 1992, the growth of the commercial Internet (Longley et al., 2000). Like other information systems applications, GIS has benefited notably from the Internet. As a consequence, GIS applications are available as web services, and, in some cases, a single map server responds to millions of requests per week. This area of GIS is rapidly expanding. GIS is utilized in location-based applications refers to applications where small portable devices are connected by the Internet to send and receive data to and from centralized computing resources. Hand-held GIS devices such as ArcPad (ESRI, 2003), coupled with other mobile devices, support these applications.

Another group of related technologies has been more specifically advantageous to GIS in business. Some of the more important ones are given in the attached table.

These associated technologies are discussed in many of the chapters. They have added to the momentum of GIS use in business.

From the standpoint of academia, GIS originated in the 1960s and 1970s in landscape architecture, geography, cartography, and remote sensing (Longley et al., 2000). During the last 20 years, it has branched into other academic disciplines, notably computer science (Longley et al., 2000), statistics, and more particularly geostatistics (Getis, 2000), land administration (Dale & McLaren, 2000), urban planning, public policy (Greene, 2000), social sciences, medicine (Khan, 2003), and the humanities (Gregory, Kemp, & Mostern, 2002).

In the 1990s, it began to spill over into the business disciplines including management (Huxhold & Levinsohn, 1995), information systems (Grimshaw, 2000), organizational

Table 1. Moore's Law — Transistor Capacity of Intel Processor Chips, 1971-2000

Year of Introduction	Chip	No. of Transistors per chip	MIPS*
1971	4004	2,250	0.06
1972	8008	2,500	
1974	8080	5,000	0.64
1978	8086	29,000	0.75
1982	286	120,000	2.66
1985	386	275,000	5.00
1989	486	1,180,000	20.00
1993	Pentium	3,100,000	66.00
1997	Pentium II	7,500,000	1,000.00
1999	Pentium III	24,000,000	
2000	Pentrium IV	55,000,000	14,000.00

** millions of instructions per second*
Source: Intel (2003)

studies (Reeve & Petch, 1999), real estate (Thrall, 2002), retail management (Longley et al., 2003), and telecommunications (Godin, 2001).

In the early 21st century, some business schools have recognized the importance of GIS by including it as a required course or degree emphasis: for instance, the elective GIS course at University of California Berkeley's Haas School of Business, and University of Redlands' MBA emphasis in GIS (UCGIS, 2003). Several business schools have established centers for GIS research, such as Wharton Geographic Information Systems Laboratory. University College London established the interdisciplinary Centre for Advanced Spatial Analysis (CASA), which is an initiative to combine spatial technologies in several disciplines that deal with geography, location, business, and the built environment. The interest of business schools in GIS is just getting started, but is likely to be stimulated by the rapid growth in industry of GIS and location-based services.

Another set of developments contributing to the study of GIS in business consists of its concepts, methodologies, and theories. Geographic information systems utilize methods and techniques drawn from many disciplines, including geography, cartography, spatial information science, information systems, statistics, economics, and business. It is typical of new fields to draw on referent disciplines, eventually combining concepts to form a core for the field. Some of the concepts and theories for GIS in business and their referent disciplines are shown in *Table 3*. Some of them are referred to and elaborated on in chapters of this book. They include decision support systems (from information systems), remote sensing (from geography and spatial information science), geostatistics (from spatial information science and statistics), marketing theories (from marketing), and cost-benefit analysis (from economics and business), and spatial analysis (from geography). The latter two are discussed here as examples of the conceptual origins for business GIS.

Table 2. Examples of Technologies Closely Associated with GIS for Business

Technology	*Importance for GIS in Business*
Global positioning systems	GPS combined with GIS allows real-time locational information to be applied for business purposes.
RFID	Allows portable products of any type to be spatially registered and to carry data that can be accessed and updated remotely. Useful in business because its supply chains and inventories consist of goods that are moved around and can benefit by being tracked (Richardson, 2003).
Spatial features built into leading relational databases, such as Oracle	Makes large-scale GIS applications easier and more efficient to realize. GIS software packages have specific add-ons to link to the database spatial features. Applies to business because enterprise applications are mostly adopted by businesses
Mobile wireless communications	Allows field deployment of GIS technologies in mobile commerce. Useful in supporting the real-time field operations of businesses (Mennecke & Strader, 2003). Combines GIS, GPS, and wireless technologies.
Hand-held GIS, such as ArcPad	A new type of product that is equivalent to PDAs, cell phones, and other mobile devices. It contains GPS and scaled-down versions of standard GIS software. Gives businesses field flexibility in inputting, modifying, and utilizing data. Important in business sectors, such as retail, that have substantial field force (ESRI, 2003).
Map server software	Specialized software to support servers that deliver GIS over the internet. The software converts maps from conventional GIS storage form into versions that are coded and optimized for web delivery

Cost-benefit (C-B) analysis was developed by economists originally, and applied to justify a wide variety of public sector and private sector projects. It takes concepts from economics including the time value of money, the influence of markets on C-B analysis, and determination of break-even point. Business disciplines adopted it and farther refined it for business problems. The information systems discipline in particular expanded the theory to analyze the costs and benefits of information systems (King & Schrems, 1978). The information systems field added the related concepts of the productivity paradox, which analyzes investment in IS and the returns on investment (Brynjolfsson, 1993; Lucas, 1999; Strassmann, 1999; Devaraj & Kohli, 2002). These theories and concepts apply to GIS in business because they form the principal methods and theories for decision-makers to decide whether to adopt and deploy GISs.

Spatial analysis stemmed originally from developments in geography and regional science in the early 1960s (Fischer, 2000). It includes "methods and techniques to analyze the pattern and form of geographical objects, … the inherent properties of geographical space, … spatial choice processes, and the spatial-temporal evolution of complex spatial systems" (Fischer, 2000). A simple example of spatial analysis is the overlay, which juxtaposes two or more map layers on top of each another: the positions of spatial objects can be compared between layers, for instance highways on one layer crossing the boundaries of marketing territories on a second layer.

Chapter III on techniques and methods by Greene & Stager discusses some spatial analysis methods, as well as two more elaborate case studies. Spatial analysis techniques differ from ordinary database functions by involving computations on spatial attributes (such as points, lines, and polygons), rather than just data attributes (such as numbers and characters). Advanced applications of spatial analysis involve elaborate spatial simulation, modeling, and visualization (Longley & Batty, 2003). This side of GIS is less familiar to scholars in the business disciplines. For this reason, some of

Table 3. Referent Disciplines for Concepts and Theories of GIS

Concept or Theory in GIS in Business	*Referent Discipline*
Spatial Analysis	Geography, Regional Science
Location Theory	Geography
Gravity Model	Geography
Remote Sensing	Geography, Earth Sciences
Decision Support Systems	Information Systems
Knowledge-Based Discovery	Information Systems
Data Mining	Information Systems
Location Based Services	Information Systems
Value of IT Investment	Information Systems, Economics
Electronic Business	Information Systems, Economics
Networking Configuration	Telecommunications
Visualization	Computer Science
Geostatistics	Statistics
Customer Relationship Management	Marketing, Information Systems
Adoption/Diffusion Theory	Marketing
Market Segmentation	Marketing
CAMA and AVM Models	Real Estate
Cost-Benefit Analysis	Economics, Business
Organizational Theory	Management, Sociology

its elements are included in the Greene & Stager chapter. Other sections in this volume refer to spatial analysis, including in Chapters VI, VIII, and XII.

Organization of the Book

This book is divided into three parts: Section I: Foundation and Research Literature, Section II: Conceptual Frameworks, and Section III: Applications and the Future. Section I examines the development of the field of GIS in business, summarizes its research literature, and provides a foundation for analytical methods and techniques of GIS in business. Section II examines conceptual frameworks for GIS as seen in the context of information systems and other business discipline. Section III analyzes GIS business applications in the real world, including health care services, marketing, retail, real estate, the power industry, and agriculture. The section and book ends with discussion of future applications of GIS.

Section I: Foundation & Research Literature

The four chapters in Section I examine the body of scholarly research literature on GIS in business, survey techniques and methods of GIS for business, and analyze its costs and benefits. This part critically reviews the body of knowledge available for this field, as well as presenting some of its fundamental business blocks.

Chapter I. GIS in business as a scholarly field developed over the past four decades, drawing from and relating to information systems and other business disciplines, as well as to the real world. In the first chapter, "Concepts and Theories of GIS in Business," Peter Keenan delineates the growth of this field's body of knowledge, referencing and linking together key studies in the literature. The role of GIS has progressed from information reporting to spatially enabled databases and to spatial decision support systems. This paralleled the movement generally of the IS field towards decision support and strategic systems. The literature and key concepts for important areas of business application of GIS are reviewed, notably logistical support, operational support, marketing, service, trends in spatial decision support systems (SDSS), electronic commerce, and mobile commerce. In service, for instance, the movement towards customer relationship management (CRM) systems is further reinforced by GIS. Customers' spatial relationships can be utilized to provide better service. For consumer electronic commerce, GIS supports the delivery logistics. In mobile services, GIS, combined with wireless and GPS, customizes service at the customer location. The chapter later refers to the classical Nolan stage theories of IS growth (Nolan, 1973). It suggests that GIS in the business world today is entering the expansion/contagion stage. GIS will be helpful in the subsequent stage of data integration. However, the data administration stage may pose for GIS problems due to its complexity. The author asserts GIS to have yet unrealized potential in business. This chapter is informative of the growth and maturation of the field's body of knowledge and the diverse literature that supports it.

Chapter II. This chapter, "GIS and Decision Making in Business: A Literature Review," by Esperanza Huerta, Celene Navarrete, and Terry Ryan, focuses on the extent of research during the past 12 years in one area within business GIS, namely GIS and decision support systems. The authors perform a comprehensive and in-depth literature review of leading information systems journals and conference proceedings, predominantly in information systems along with some from the GIS field. Over the dozen years, the 20 publications contained merely nine articles on GIS and decision support! A well-known model of decision support by Todd & Benbasat (2000) is utilized to classify the articles by area, which showed a deficit of studies on "desired effect" and "decision strategy." The paucity of peer-reviewed research in the GIS-DSS area suggests an overall lack of research on GIS in business, underscoring the importance of bringing forward the contributions in this book.

Chapter III. "Techniques and Methods of GIS for Business" focuses on spatial methods that are commonplace for GISs and can be applied in the business world. The chapter starts with rudimentary elements, such as spatial databases, spatial queries, mapping classifications, table operations, buffers and overlays. It provides simple instances of how those operations can be applied to business. The chapter ends with two case studies of more sophisticated spatial analyses, one on industrial specialization and location quotient analysis in an urban labor market, and the second on trade area analysis, based on the gravity model, which examines the specific instance of opera houses in the Midwest. The chapter is somewhat introductory, and will benefit the reader having limited knowledge of spatial analysis.

Chapter IV. In anticipating applying GIS in an organization, a crucial aspect is to assess the costs and benefits. The chapter on "Costs and Benefits of GIS in Business" examines the key factors and methods for assessing costs and benefits. Cost-benefit (C-B) analysis for GIS differs from C-B analysis in non-spatial IS in two ways. First, GIS software tends to be linked with other technologies and software, such as GPS, wireless technologies, RFID, statistical software, and modeling packages. This need to link up may result in added costs as well as benefits. Second, GIS data and data management must deal with both attribute and spatial data, which influence C-B differently. Third, the visualization aspect of GIS is hard to quantify and therefore adds to intangible costs and benefits. The costs and benefits are related to the organizational hierarchy of an organization. There is a long-term trend for GIS business applications to move up this hierarchy, i.e., from the operational to managerial to strategic levels. At the higher levels, benefits become more difficult to assess. A related topic considered with respect to GIS is the productivity paradox. The productivity paradox refers to studies that have had ambiguous results on whether IT investments lead to added value. The productivity paradox and value of IT investment literature is discussed as it relates to assessing the payoff of GIS.

Section II: Conceptual Frameworks

This part of the book includes studies that expand on and contribute to conceptual frameworks drawn mostly from the information systems field.

Chapter V. Scholars and industry specialists tend to be familiar with desktop or laptop GIS, but less so with enterprise deployments of GIS. Those have a variety of architectures, comprising spatial processors, databases, networking, and interconnecting components such as middleware. In "Spatial Data Repositories: Design, Implementation, and Management Issues," Julian Ray presents a new taxonomy for the architectures of large-scale GIS, and analyzes the design, implementation, and management issues related to this taxonomy. Special attention is given to how spatial data repositories (SDR) function in these enterprise arrangements. The design issues include how databases perform, physical storage, provision of real-time data, how to update data, and the integration of multi-vendor products. Implementation considers the formats of spatial data, steps to load spatial data, and the compatibility of spatial data within SDRs. Enterprise GIS systems raise management issues that are discussed, notably the costs, staffing, licensing, and security of SDRs. The future movement is towards real-time systems and subscription-based web services. The chapter will be useful to companies planning enterprise-wide geographic information systems, and to scholars studying them.

Chapter VI. Knowledge discovery, or the process of extracting data from large datasets, has undergone thorough study for non-spatial relational databases. On the other hand, knowledge discovery spatial databases have been little investigated. "Mining Geo-Referenced Databases: A Way to Improve Decision-Making," by Maribel Yasmina Santos and Luis Alfredo Amaral, presents a model and application of spatial knowledge discovery. It is based on a new model of qualitative relations between spatial attributes, which retains standard data-mining features as well. The model includes qualitative spatial relations of three types — direction, distance, and topology. The model is expressed in tables that apply these relations singly or in sequence. The authors have designed and built a working prototype system, PADRÃO, for knowledge discovery in spatial databases (KDSD). PADRÃO is built on top of the components of Microsoft Access, the Clementine data-mining package, and the GIS software Geomedia Professional. PADRÃO prototypes an application to regional banking credit decisions in Portugal. The KDSD approach draws on and leverages from existing literature about knowledge discovery to provide a conceptual base, logic, algorithms, and software to give convincing results for its spatial rendition. Besides academics, industry designers and other practitioners will benefit from the chapter.

Chapter VII. The movement of GIS upward in organizational level has occurred over the past 30 years and has paralleled similar steps in development in conventional ISs from transaction processing to MIS to decision support systems. "GIS as Spatial Decision Support Systems," by Suprasith Jarupathirun and Fatemeh Zahedi, centers on the decision-support role of GIS; it analyzes what is unique about spatial decision support systems (SDSS) vs. DSS. Besides SDSS's wide range of applications, SDSS has spatial analytical tools that go beyond ordinary DSSs and include standard zoom, buffer, overlay, and other spatial functions, many reviewed in Chapter III. It also has advanced, specialized functions for special purposes that are both spatial and analytical including, for example, 3-D visualization, statistical modeling, and network analysis. The authors dig deeper on visualization by identifying through the literature the unique visualization features of SDSS that include the dynamic nature of map visualization, visual thinking, and the behavioral impact on decision makers. Given all this, how can the efficacy of an SDSS be evaluated and tested? The authors present a conceptual model of SDSS that can constitute a basis for testing and evaluation. The model includes technology, problem tasks, and behavioral abilities, and the resultant tasktechnology fit, as well as incentives, goals, performance, and utilization. Future enhancements of SDSS may include use of 3-D, animation, and intelligent agents. A chapter rich in its literature references, it advances understanding of the properties of SDSS and enlarges its conceptual theory. SDSS is at the core of why GIS is essential to real-world decision makers, so practitioners should be interested as well.

Chapter VIII. Although 80 percent of business data is potentially spatially-referenced, opportunities to utilize its spatial aspects are often missed in industry. However, managers possessing spatial mindsets can tap into considerably more of the spatial potential and bring new types of spatial data, such as remotely-sensed data, to bear on improved decision-making. Spatiotemporal data, i.e., spatial data that is not from a single time slice but extending over time, can enhance business decisions. In "The Value of Using GIS and Geospatial Data to Support Organizational Decision Making," W. Lee Meeks and Subhasish Dasgupta emphasize the data side of spatial decision-making models. Where do the data come from? What is the data's accuracy and utility for the problems at hand? Have all available sources of data been looked into? Can automated tools such as search engines ease the challenge of identifying the right spatial data? Once the spatially-referenced data are available, do managers have the mindset to take advantage of it? The chapter starts with the conventional SDSS model, but enlarges it to include data sources and the ability to comprehend/use the data. It expands the range of sources of spatial data from maps, scanning, and GPS to include remotely-sensed data. The potential of remotely-sensed data is growing, since satellites' spectral resolution, spatial resolution, and accuracy have increased. Managers in industry need to be open to including remotely-sensed data for decision-making. The chapter forms a complement to Chapter VII, since it elaborates greatly on the data side of the SDSS model, whereas Chapter VII emphasizes decision-making and visualization.

Chapter IX. There is potential for spatially-enabled business, or geo-business as this chapter's authors refer to it, to advance from physical to digital to virtual applications. However, reaching the state of virtual application depends on appropriate business conditions in which the spatially-enabled virtual business is justified to be beneficial. In the chapter "Strategic Positioning of Location Applications for Geo-Business," Gary Hackbarth and Brian Mennecke present conceptual models that help to understand whether the spatially-enabled virtual business is appropriate or not. The first model, the net-enablement business innovation cycle (NEBIC), modified from Wheeler (2002), consists of the steps of identifying appropriate net technologies, matching them with economic opportunities, executing business innovations internally, and taking the innovation to the external market. The process consumes time and resources, and depends on organizational learning feedback. The second model, modified from Choi et al. (1997), classifies geo-business applications into 27 cells in three dimensions, consisting of virtual products, processes and agents. Each dimension has three categories: physical, digital, and virtual. The authors discuss examples of spatially-enabled applications that fall into certain cells of this model. The model is helpful in seeing both the potential and limitations for net-enabled applications. A final model classifies spatially-enabled applications by operational, managerial, and individual levels. Examples are given that demonstrate spatial applications at each level. The chapter helps to establish frameworks for virtual geo-business applications, which include evolving stages over time of e-enablement; a classification of physical-digital-virtual processes, products, and agents; and the differences in spatial applications at the operational, managerial, and individual levels of decision-making. These models are useful in not perceiving geo-business applications as all or nothing in virtual enablement, but rather as located somewhere across a complex multidimensional range.

Section III: Applications & the Future

This part of the book examines GIS applications in a number of sectors. It is not intended to be comprehensive, but to give in-depth analyses of several varied areas. It finishes with a teaching case of GIS in agriculture and a study that considers the future of GIS in the business world.

Chapter X. Chapter X begins Section III of the book on Applications and the Future by addressing GIS in health care services. The authors Brian Hilton, Thomas Horan, & Bengisu Tulu emphasize the variety of health care uses, presenting the results of three case studies at the operational, managerial, and strategic levels. "Geographic Information Systems in Health Care Services" refers to Anthony's classical theory of organizational levels and illustrates its relevance with three cases, the first at the operational level of a health care company operating a spatially-enabled system for making physician appointments for claimants with disabilities. In a managerial level case, government providers of emergency medical services need to provide spatial technologies to connect with mobile devices accessing the emergency 911 system. At the strategic level, spatial technologies are utilized to support the display of epidemiological data on SARS as part of the large-scale National Electronic Disease Surveillance System (NEDSS). The authors analyze the solutions and outcomes of these case studies, as well as future issues that need to be addressed by the management of the case organizations — for instance, the health care company needs to better integrate its spatial and non-spatial databases. This chapter is helpful in its analysis and comparison of the successes of three varied cases of GIS in healthcare services.

Chapter XI. Marketing that includes spatial analysis has enhanced utility. For instance, a marketing study of a person's residential location can indicate his/her likely consumption pattern. Nanda Viswanathan, in "GIS in Marketing," considers key constructs of the marketing field and how GIS and spatial science have the potential to enlarge the dimensions of marketing and increase its efficiency. The chapter begins by considering marketing in terms of space, time, and demographics. These three components are nearly always present for real-world marketing problems.

GIS supports marketing models of both space and time that include demographics as attributes. The chapter examines spatially-enabled strategies for products, pricing, promotions, and distribution. For instance, the product life cycle traditionally is applied to the whole economy. For instance, a car product is marketed differently at initial roll-out, versus its peak sales time, versus as a mature product. GIS allows product-life-cycles models to be disaggregated into small geographic areas, with the tapestry of differences revealed through mapping and spatial analysis. For distribution, the supply chain can be modeled spatially. A further enhancement is to add real-time, location-based information to achieve a dynamic view of the supply chain. What are the locations and destinations of certain products at this moment and how can their movement and deliveries be spatially-optimized?

Another chapter topic is GIS to support marketing analysis and strategy. Spatial models can support market segmentation, customer relationship management, competitive analysis, and simulating dynamic markets. For example, competitive analysis of products can be done for small areas, for instance census tracts. The interaction effects of competition in one small zone influencing other small zones can be included in spatial competition models. Mapping and visualization can inform marketers of fine differences in competition by location. A final chapter segment cautions that the combined spatial marketing techniques of GIS, GPS, mobile devices, and the Internet may pose serious privacy and ethical issues. The author recommends that the American Marketing Association's ethical codes for Internet marketing be extended to GIS and location-based services. As costs decrease and data-availability expands, marketers can realize the diverse uses suggested in this chapter.

Chapter XII. Retailing is inherently spatial. Stores, customers, and advertising have intertwined physical locations that underpin business outcomes. In "The Geographical Edge: Spatial Analysis of Retail Loyalty Program Adoption," spatial analysis is utilized to spatially-enhance a traditional production diffusion model, which is illustrated for a single store of a major retailer. Authors Arthur Allaway, Lisa Murphy, and David Berkowitz discuss in detail a prototype of a cutting-edge marketing technique. Data recorded in the store's POS system from the loyalty card data that customers entered is supplemented with census and other community data. The customer addresses are geocoded, in order to obtain X-Y coordinate locations. Other data on the loyalty adoption cards include the products purchased, time and date of purchase, previous adoptions, and spending behavior. This is supplemented by adding in U.S. Census sociodemographic data at the block group level.

The ensuing database contains records on 18,000 loyalty-program adopters in the store's territory. Spatial diffusion results show the particular influence of early innovators on their neighborhoods and the entire course of adoption and diffusion. Three distinct spatial diffusion stages are evident. Furthermore, the location of the store and the billboards advertising the loyalty program are influential. The authors demonstrate that the billboards can be manipulated experimentally to test assumptions. The chapter reinforces a common point in the book that there is potentially much more spatially-enabled data than people recognize, and that new, innovative uses are waiting to be discovered.

Chapter XIII. Real estate valuation can be done for large samples of properties encompassing whole municipalities and regions. With the increasing affordability of GIS software, spatial analysis can be added to traditional non-spatial estimation methods, increasing their predictive accuracy. Susan Wachter, Michelle Thompson, and Kevin Gillen, in "Geospatial Analysis for Real Estate Valuation Models," give theoretical background on models that include spatial variables, and then illustrate the Automated Valuation Model (AVM) with a case study of a community in southern California. The traditional Computer Assisted Mass Appraisal (CAMA) model estimates real estate values based on prior prices, while the classic, non-spatial hedonic model estimates values from housing characteristics of the immediate area. The authors combine the hedonic and spatial models in the form of a linear regression. The spatial part of this model consists of real-estate prices at particular radial distances from the property being estimated. Their results for Yucca Valley, California, demonstrate substantial improvement in regression significance and predictive power for the mixed hedonic-spatial model, compared to hedonic alone or spatial alone. The real estate industry and local and regional governments are beginning to adopt such mixed models. This chapter substantiates the benefit of including spatial components in real estate valuation models. It also suggests that there is future potential to build valuation models with more spatial dimensions, enhancing their significance and accuracy.

Chapter XIV. Large-sized power systems are essential elements for advanced societies. Their software support systems need to be reliable, well-maintained and able to respond to emergency situations. Although these large systems are mostly taken for granted by consumers, system failures such as the widespread U.S.-Canadian electrical grid failure in the summer of 2003, raise questions and concerns. "Monitoring and Analysis of Power Line Failures: An Example of the Role of GIS," by Oliver Fritz and Petter Skerfving, explains the role of GIS in these multilayered and geographically-distributed software systems. The chapter starts by explaining software support systems for power lines. The systems function at the operational level to support line monitoring and maintenance, while the management level, they support optimization of the system, as well as capacity and economic planning of the network, such as pricing and estimates of customer base.

GIS is a modular component that offers advantages to these software systems. At a low level, it can provide basic mapping of fault locations, to assist in emergency repair. Other benefits appear post-incident since fault maps can be overlaid with weather and topographic maps, assisting experts to analyze of the causes of outages. At a higher level, GIS displays and analysis can assist in investment planning of new lines and other assets. An aspect of GIS of profound significance is its integrative role in encouraging cross-department applications and managing the power line systems. The authors present a case study that combines Power System Monitoring (PSM) software for fault detection with GIS for map display. The chapter emphasizes the role of GIS in the power industry, as one modular component within large-scale monitoring, maintenance, and analysis of software systems.

Chapter XV. In "GIS in Agriculture," Anne Mims Adrian, Chris Dillard, and Paul Mask delineate modern precision agriculture and explain the role of GIS. Precision agriculture utilizes measurements of soil type, crop yield, and remote sensing data to pinpoint micro-areas for special treatments. Farm equipment can be automated to deliver exact amounts of fertilizers and chemicals to particular micro-areas. Since the movement of farm vehicles can be detected precisely, GIS and GPS together sense exactly where the micro-areas are and inform automated systems when to effect precision treatment. The systems yield large amounts of information. Unfortunately, farmers and agricultural managers may not be able to process more than a small fraction of it. The authors suggest that farmers need to become better trained in these technologies, and to gain greater confidence and motivation to utilize them. Until now, adoption rates for GIS have been slow. One reason is that farmers struggle with economically justifying the new technologies. There is potential that a higher percentage of farms will adopt GIS and GPS technologies. GIS in agriculture has so far been primarily at the levels of supporting operations on the ground, but the time is ripe for expanding the use of spatial decision support systems by farmers.

Chapter XVI. "Isobord's Geographic Information System Solution," by Derrick Neufeld and Scott Griffith, is an educational case study of a GIS adoption decision confronting a small Canadian firm, Isobord. The firm was later acquired by Dow Bioproducts. The case pertains to many issues raised in this book. Isobord is a small particleboard firm operating on the Canadian prairies in Manitoba that has discovered an environmentally sound approach to acquiring its materials, namely to substitute straw instead of wood. However, since it doesn't make economic sense for farmers to deliver the straw, Isobord had to develop its own pick-up service over a large area with a radius of 50 miles. However, pick-up is very difficult in the flat prairie landscape, which lacks markers and has rough roads.

The answer was to utilize a combination of GIS and GPS to pinpoint pick-up locations. The case details how Isobord begin with its own local software solutions and then graduated to the use of commercial packages. At the end of the case, the firm is at the point of deciding on one of three alternative software solutions, each offering a different platform, software, and servicing. The case raises the issues of GIS costs and benefits, planning, human resources, outsourcing, and project scope. The firm differs from most other cases in this book in its small size and budget, and its limited training and experience with GIS. The chapter can be useful to teachers, researchers, and practitioners.

Chapter XVII. How are spatial technologies and GIS moving towards the future? What changes in hardware, software, platforms, delivery, and applications are anticipated? The book's final chapter, "GIS and the Future in Business IT," by Joseph Francica, identifies areas of rapid enhancements and changes, and extrapolates trends into the future. The chapter is practitioner-grounded, since the author is familiar with the cutting-edge in industry.

Several factors underlying anticipated changes are the declining prices of GIS products, database products that are spatially enhanced, location-based services, and web delivery of spatial data and services. Price reductions have contributed to making GIS products ever more widely available, while the inclusion of spatial components in standard databases expands spatial analysis capabilities to a much broader customer group of general-purpose database users. The chapter examines the future trends of web services, wireless location-based services, open-source GIS, further database spatial enhancements, scalable vector graphics, and spatially-empowered XML. Open source refers to software products for which the source code is freely and readily available. It is a software industry-wide trend that offers pluses and minuses that apply as much to GIS as to other technologies. For GIS, open-source offers affordability and ability to change code, but brings along problems of software quality and robustness, standards, and maintenance.

Some examples of future applications are examined, including truck fleet management and field service, and customer relationship management (CRM) to identify and understand the relative locations of customers, suppliers, and the sales/marketing force. CRM can be implemented alongside an enterprise resource planning systems (ERP).

Another future scenario is GIS accessing satellite-based remote imagery combined with the widespread and rich government databases available in the U.S. and some other nations. The e-environment will profoundly affect GIS use, since non-technical users will be able to easily access sophisticated spatial web services that will provide everything a traditional desktop GIS offers, and much more.

Conclusions

In conclusion, the chapters in this volume add to the foundation of research on geographic information systems in business. The authors provide substantial review of the literature, offer revised and updated conceptual frameworks to unify and weave together geographic information science with conceptual theories in academic business disciplines, and give examples of empirical investigations and case studies that test or challenge the concepts. The book should complement other publications that have focused on applied aspects of GIS in business.

It is hoped that the readers will regard this volume as a starting base, from which to expand the theories and empirical testing. As GIS and its related technologies continue to become more prevalent and strategic for enterprises, a growing academic base of knowledge can provide useful ideas to the wider group of real-world practitioners, and vice versa. It is hoped this volume will stimulate further opportunities for researchers on GIS in Business to develop what is today a limited research area into a full-fledged scholarly field, linked to business practice.

References

Boyles, D. (2002). *GIS means business* (Vol. 2). Redlands, CA: ESRI Press.

Brynjolfsson, E. (1993). The productivity paradox of information technology. *Communications of the ACM, 36*(12), 67.

Castle III, G.H. (1998). *GIS in real estate: Integrating, analyzing, and presenting locational information.* Chicago, IL: Appraisal Institute.

Choi, S.Y., Stahl, D.O., & Whinston, A.B. (1997). The economics of electronic commerce. Indianapolis, IN: Macmillan Technical Publishing.

Clarke, K. (2003). *Getting started with geographic information systems*. Upper Saddle River, NJ: Prentice Hall.

Dale, P.F., & McLaren, R.A. (2000). GIS in land administration. In P.A. Longley, M.F. Goodchild, D.J. Maguire, & D. W. Rhind (Eds.), *Geographical information systems* (Vol. 1, pp. 859-875). New York: John Wiley & Sons.

Devaraj, S., & Kohli, R. (2002). *The IT payoff: Measuring the business value of information technology investments.* New York: Pearson Education.

Directions Magazine. (2003, August 9). Datatech reports GIS revenues forecast to grow 8% of $1.75 billion in 2003: Utilities and Government Increase Spending. Retrieved November 2003: www.directionsmag.com.

ESRI. (2003). *ArcPad: Mapping and GIS for mobile systems*. Redlands, CA: ESRI Inc. Retrieved November 2003: http://www.esri.com/software/arcpad.

Fischer, M.M. (2000). Spatial analysis: Retrospect and prospect. In P.A. Longley, M. F. Goodchild, D. J. Maguire, & D. W. Rhind (Eds.), *Geographical Information Systems* (Vol. 1, pp. 283-292). New York: John Wiley & Sons.

Getis, A. (2000). Spatial statistics. In P.A. Longley, M. F. Goodchild, D. J. Maguire, & D. W. Rhind (Eds.), *Geographical Information Systems* (Vol. 1, pp. 239-251). New York: John Wiley & Sons.

Godin, L. (2001). *GIS in telecommunications*. Redlands, CA: ESRI Press.

Greene, R.W. (2000). *GIS in public policy*. Redlands, CA: ESRI Press.

Gregory, I., Kemp, K.K., & Mostern, R. (2002). Geographical information and historical research: Integrating quantitative and qualitative methodologies. *Humanities and Computing*.

Grimshaw, D. (2000). *Bringing geographical information systems into business* (2nd ed.). New York: John Wiley & Sons.

Harder, C. (1997). *ArcView GIS means business*. Redlands, CA: ESRI Press.

Harder, C. (1999). *Enterprise GIS for energy companies*. Redlands, CA: ESRI Press.

Huxhold, W. E. & Levinsohn, A.G. (1995). *Managing geographic information system projects*. New York: Oxford University Press.

Intel. (2003). Moore's Law. Retrieved December 2003: http://www.intel.com.

King, J.L., & Schrems, E.L. (1978). Cost-benefit analysis in information systems development and operation. *ACM Computing Surveys*, *10*(1), 19-34.

Longley, P.A. & Batty, M. (2003). *Advanced spatial analysis: The CASA book of GIS*. Redlands, CA: ESRI Press.

Longley, P.A., Boulton, C., Greatbatch, I., & Batty, M. (2003). Strategies for integrated retail management using GIS. In P.A. Longley & M. Batty (Eds.), *Advanced spatial analysis: The CASA book of GIS* (pp. 211-231).

Longley, P.A., Goodchild, M.F., Maguire, D.J. & Rhind, D.W. (2000). Introduction. In P.A. Longley, M.F. Goodchild, D.J. Maguire, & D.W. Rhind (Eds.), *Geographical Information Systems* (Vol. 1, pp. 1-20). New York: John Wiley & Sons.

Longley, P.A., Goodchild, M.F., Maguire, D.J., & Rhind, D.W. (eds.). (2000). *Geographical Information Systems* (two vols.). New York: John Wiley & Sons.

Mennecke, B.E., & Strader, T.J. (2003). *Mobile commerce: Technology, theory, and applications*. Hershey, PA: Idea Group Publishing.

Nolan, R.L. (1973). Managing the crises in Data Processing. *Harvard Business Review*, *57*(2), 115-126.

Richardson, H.L. (2003). Tuning in RFID. *World Trade*, *16*(11), 46-47.

Star, J.L., & Estes, J.E. (1990). *Geographic information systems: Socioeconomic applications* (2nd ed). London: Routledge.

Strassmann, P.A. (1999). *Information productivity: Assessing the information management costs of U.S. industrial corporations.* New Canaan, CT: The Information Economics Press.

Tobler, W.R. (1959). Automation and Cartography. *Geographical Review*, *49*, 526-534.

Todd, P., & Benbasat, I. (2000). The impact of information technology on decision making: A cognitive perspective. In R.W. Zmud (Ed.), *Framing the domains of IT management* (pp. 1-14). Cincinnati, OH: Pinnaflex Education Resources.

UCGIS. (2003). University consortium for geographic information science home page. Retrieved November 2003: http://www.ucgis.org. Leesburg, VA: University Consortium for Geographic Information Science. Note: this home page indicates where GIS is taught in the member group of universities.

Wheeler, B.C. (2002). NEBIC: A dynamic capabilities theory for assessing net-enablement. *Information Systems Research*, *13*(2), 125-146.

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