GIS and Business Intelligence: The Geographic Advantage

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ESRI 380 New York St., Redlands, CA 92373-8100 USA • TEL 909-793-2853 • FAX 909-793-5953 • E-MAIL info@esri.com • WEB www.esri.com

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Historically, business intelligence (BI) and geographic information system (GIS) technology have followed separate development and implementation paths. Customer requests for a more complete operational picture and the ability to be more proactive have led to the combination of these two technologies. Regulatory requirements have also raised the visibility of both technologies within many organizations. In response to BI and GIS users, leading BI providers have been integrating the two technologies and providing innovative solutions to a growing number of end users. The users are responding with new applications that leverage the synergy of the combined technologies.

This white paper describes the purpose and benefits of both GIS and BI, the technological advancements that have fostered their integration, and the synergistic benefits of integrated applications that can benefit the entire organization without disrupting existing IT environments.

GIS Overview

GIS is a mature technology that began in university computer science departments in the late 1960s. The seminal idea was associating data with geographically referenced map graphics to allow an understanding of the influence of geography on behaviors and outcomes.

Today's GIS recognizes the location component of data and associates data with geographic features maintained in a GIS. Features in a GIS are graphic representations of actual features, such as roads, rivers, and forests, and conceptual features such as political boundaries or service areas. Associating data with features lets users organize data based on the geographic location of each record in the data. This geographic organization, presented as a map, reveals spatial relationships and influences that cannot be identified in traditional tabular views of data.

Geographically organizing data allows the utilization of new data that may not have anything in common with existing data other than location. For instance, GIS analysts for insurance companies can map the addresses of insured structures and overlay floodplain boundaries to identify all structures within the floodplain. With this information, they can calculate the total financial impact on reserves from a potential catastrophic flood. Other organizations, private and public, can perform this same analysis to determine potential impact on facilities, supply chain, and employees.

Business Intelligence Overview

The term *business intelligence* was coined in the mid-1990s to describe the emerging practice of transforming raw data from an organization's disparate operational data into a common data warehouse that could be used for discovering and reporting information. Users interact with an easy-to-use interface that exposes the results of the extraction, transformation, and loading (ETL) process used to populate the data warehouse. The same interface is also the gateway into a structured reporting environment that distributes operational reports and business decision results throughout the organization.

Recently, service-oriented architecture (SOA) has begun supplanting or augmenting data warehousing in BI implementations. One of the business advantages of this platform is that reporting and decision making are based on a common operational picture, or "single version of the truth."

Reporting, a mainstay of BI, has become more graphics intensive. Business graphics, typically charts, are now a common component of reports. As access to BI data became more timely, graphic dashboards were developed to monitor key business processes. Dashboards, named for their similarity to automobile dashboards, convey operational information at a glance.

The Intersection of GIS and BI

GIS and BI were being implemented as the IT landscape was evolving to embrace common ways of compiling, storing, using, and distributing data. Proprietary systems, used by both private and public organizations, had become a hindrance in a business environment that demanded agility to operate effectively.

To address this issue, standards and common ways of interacting with data were proposed by various organizations and IT providers. When these standards were adopted by IT providers, it became easier for applications to interact because they shared common technology foundations. During this time, Internet technology matured and had become a viable communication protocol for exchanging information between the operational units of an organization.

During the adoption of standards, BI and GIS application providers were concentrating on working with the data that was most important to current core users. The BI providers were creating connectors for the most common file formats used by business applications, and ESRI, a GIS provider, was creating connections and transformations for the geographic feature formats then in use worldwide.

The adoption of standards and the rise of the Internet as a data and information exchange medium led, in part, to the vision of enterprise implementations of applications. While ESRI and BI application providers have technology platforms and applications that can meet the needs of enterprise implementations, BI and GIS applications are commonly implemented in unrelated operational units within an organization.

Knowing how BI and GIS were actually deployed in organizations presented opportunities for the proliferation of these technologies. If BI and GIS applications could work together, the benefits of these respective technologies could be realized by operational units not currently using both technologies. This would result in integrated applications expanding throughout the enterprise.

Innovators in the public sector who wanted to extract more actionable information from existing data came to the same conclusion. Exposure to "new" technologies in the context of homeland security raised interesting possibilities for improving processes not directly related to homeland security. The fact that public agencies were looking at BI with the idea of integrating it with GIS was not lost on the BI providers whose success in the private sector had not been matched in the public sector.

ESRI and various BI providers realized that the earlier adoption of standard technology architectures would make integrating GIS and BI much easier. Furthermore, each discipline brought solutions to problems that were perceived as major obstacles to enterprise implementations of the respective applications.

For a GIS provider, using tabular data from hundreds of database and file systems could be difficult and expensive. This was a problem addressed by BI providers by using the ETL process or connectors that allow BI applications to use native file formats. Conversely, BI providers were hard-pressed to deal with the variety of geographic data formats, CAD data, and imagery. The myriad of projections and datums used in GIS maps were also challenging. The GIS sector had addressed these issues by adopting standards for the interoperability of GIS data. Two of the major obstacles to integration had already been addressed but had not been effectively communicated between the two application environments.

Integration Strategies

A typical BI implementation consists of applications selected from a suite of applications comprising the entire BI technology stack. This ability to "pick and choose" applications results in solutions tailored to the specific needs of end users. However, there are applications that tend to be common to nearly all implementations by a given provider. These common applications are the most cost-effective points of integration for GIS. The ArcGIS® family of products is well suited to this implementation environment, and BI providers have been quick to see the value in the integration options offered by ArcGIS.

- **Desktop Integration**—Early adopters of GIS-enabled BI most often used an ArcGIS Desktop application such as ArcView®. Connector, or "bridge," applications permitted the GIS application to access and geographically analyze data directly from the BI data repository. Results of geographic analysis could be passed back to the BI data repository for eventual reporting or further nongeographic analysis.

  While this model supports sophisticated analytics, it has one glaring BI shortcoming—no actual maps are created in the BI reporting environment. Maps presenting analytic results must be composed and published entirely within the GIS environment. As Jack Dangermond, president of ESRI, stated, "While business intelligence platforms provide access to data across the enterprise, GIS is able to present this aggregated data as context-rich maps. These maps give organizations a powerful new tool to proactively manage their operations."

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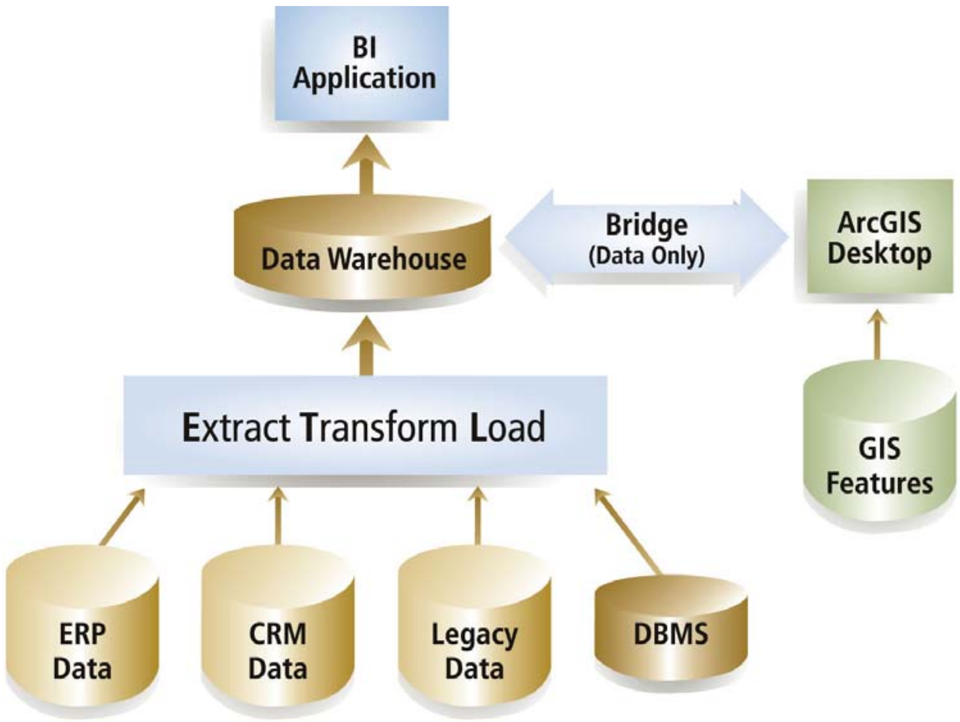
Figure 1



A simple example of using a bridge to integrate GIS and business intelligence applications via a data warehouse. The user interface is either ArcGIS or the BI application; there is no integrated user interface.

There has been recent renewed interest in bridging applications as rapid development and proof-of-concept tools. Also, as server-based integrations make mapping more visible throughout organizations, demand has risen for more cartographically pleasing maps for formal presentations.

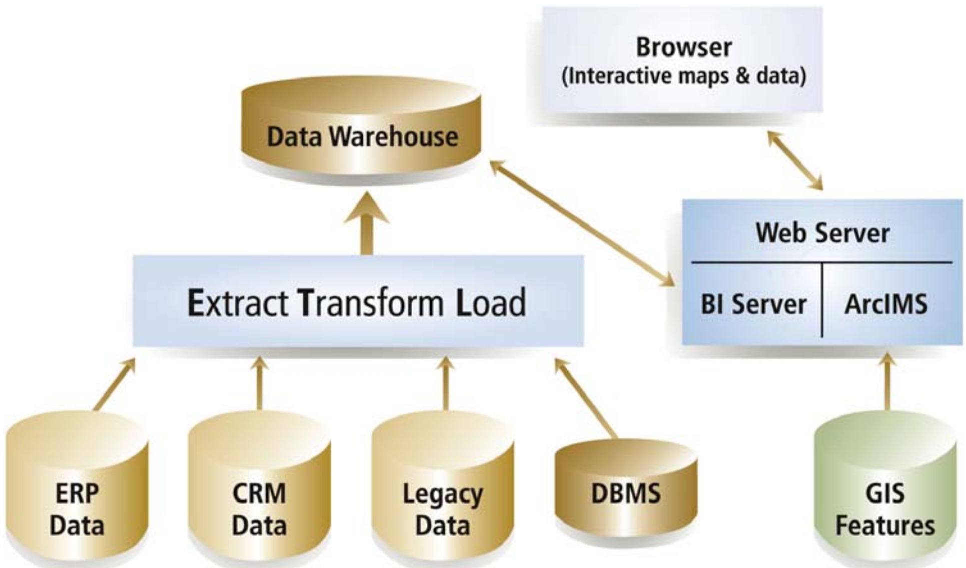
- **Server Integration**—Server-based BI and GIS integration efforts were driven by end users wanting to utilize the BI reporting environment to distribute GIS-generated maps.

  ESRI's ArcIMS® fulfills this requirement with a Web-based application that is easily integrated with today's BI Web-based reporting environments. Publishing a thematic map as a business graphic in a report, a low level of GIS functionality, met the early requirements of the BI community.

  However, BI developers exposed to the capabilities of ArcIMS expanded the scope of their efforts to allow bidirectional interaction with BI data via the map interface of ArcIMS. A user can now select areas on the map and have those selections be reflected in the table portion of the report.

  Conversely, records in the table portion can be selected and appear as selections on the map. The latest ArcIMS integrations permit map layers to be turned on and off; map feature identification by clicking; and the addition of transparent, or acetate, layers that superimpose pertinent business data over the appropriate map feature.

Figure 2



In this example, the BI application and ArcIMS are integrated via one or more Web servers. The user experiences an integrated map and data application within a Web browser.

While ArcIMS was being implemented to meet the map reporting needs of the BI community, the BI landscape was shifting. Reporting and dashboard applications had been successful in providing consistent visibility into operations and timely performance monitoring but were not forward looking. The ability to more successfully plot the future course of business has increased demand for predictive analytics in BI implementations. GIS has long been used for predictive analytics. Urban planners have been using GIS for decades to predict population growth and migration patterns to effectively plan infrastructure projects. Reinsurers have long used GIS to analyze environmental risks, such as flood and wildfire zones, to determine if there are sufficient reserves to meet potential needs.

However, these analyses have historically been done by trained GIS technicians using powerful desktop GIS applications. This domain expertise-intensive approach to analytics is the antithesis of what end users expect of BI applications.

BI providers adopted ArcGIS Server integration to provide sophisticated GIS analysis in a user-friendly format. ESRI and BI providers work closely with the user to define a set of persistent analytic requirements that can be initiated with very little input from the user. In essence, the end user runs a preconfigured model that does the heavy business and geographic analysis on the server and returns the results to the user in the form of a Web report. Because ArcGIS Server takes a centralized approach to GIS management and application support, it requires that an organization either has GIS expertise available in-house or can access outside GIS application support.

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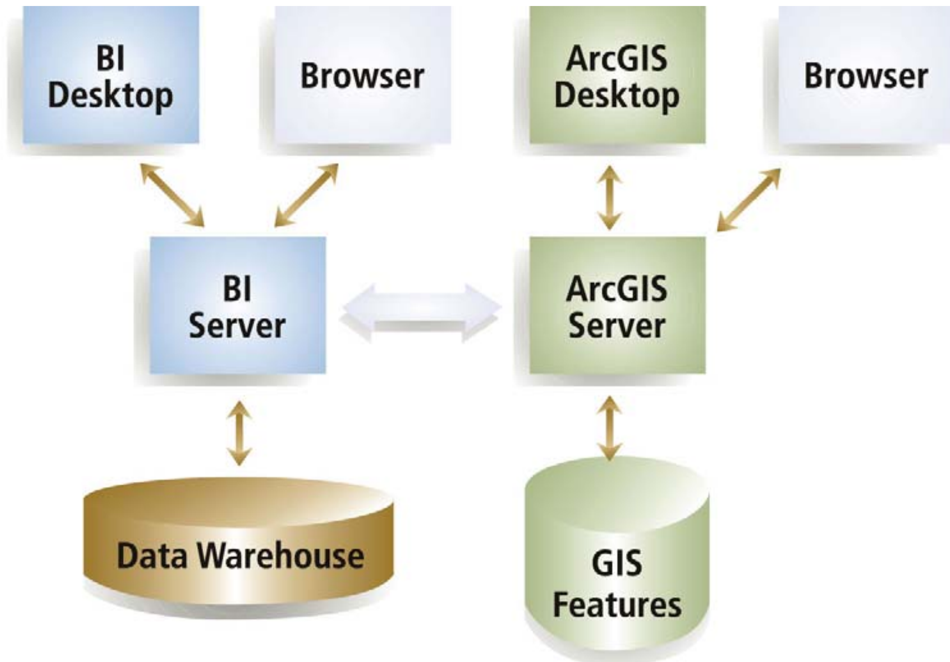
Figure 3

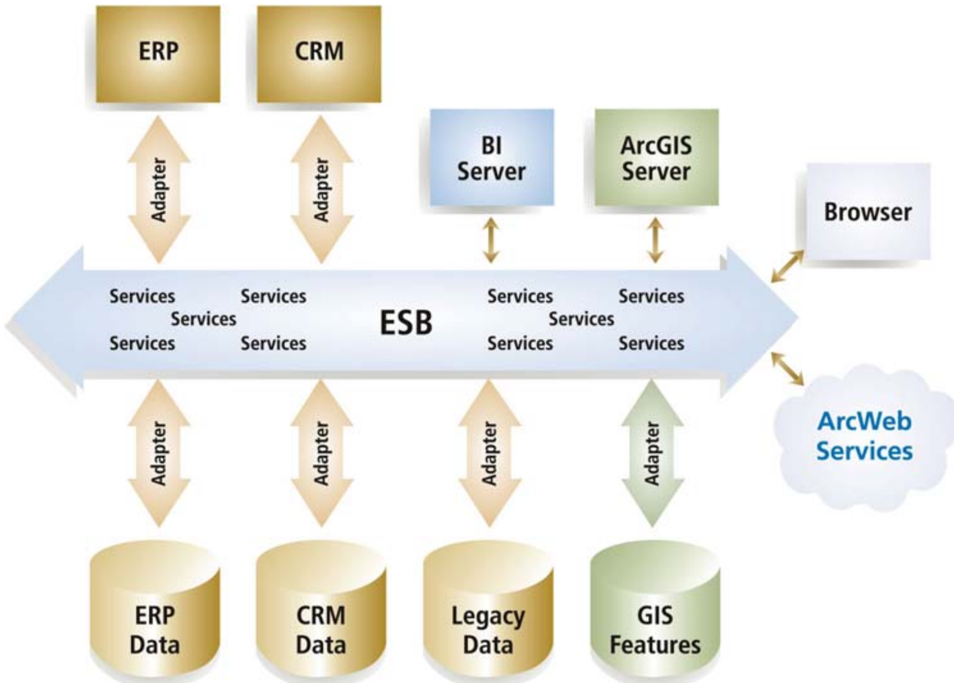


In this example, the BI application and ArcGIS Server are integrated to expose GIS functionality, or the results of geographic analysis, in the BI user interface. Conversely, BI functionality, or the results of statistical business analytics, can be exposed in the GIS user interface.

The recent adoption of SOA by organizations has expedited the utilization of server-based BI and GIS. Early BI providers excelled in developing connections to disparate operational data assets. However, these connections can be more than just connectors or data translators for populating a data warehouse; they can sense activity in the parent data store and initiate higher-level services.

SOA can take advantage of these sophisticated connections, or adapters, to periodically update a higher level of data aggregation, such as an online analytical processing (OLAP) cube, and/or run a persistent model in real time. An example of this could be the adapter detecting a new customer record in the customer relationship management (CRM) system and initiating a geocoding service that would in turn populate the features data with a new customer location or point. This ability is now available to all participants in the SOA environment, not just the BI server.

Figure 4



A simplified view of service-oriented architecture utilizing the enterprise service bus (ESB) to pass services between various applications. Applications in ArcGIS Server can use aggregated data managed by the BI server and utilize its reporting platform. The ArcGIS Server could also use enterprise resource planning (ERP) or CRM data via a service independent of the BI server.

While both BI servers and the ArcGIS Server are well suited to participate in an SOA environment, it is not required for their implementation. Most organizations will meet the need for BI and GIS analytics by linking the BI and GIS servers with an adapter, independent of an enterprise SOA.

- **ArcWeb℠ Services**—A number of issues concerning GIS data have been obstacles to wider adoption of GIS in the business community. While the value of GIS can be grasped by nearly all businesspeople, data issues can have a very negative impact on IT personnel tasked with researching an implementation.

  Traditionally, GIS data providers or GIS application providers have addressed many of these issues by providing packages of data tailored to the user. However, when data is provided, the user needs some understanding of GIS to get the data into the system without disrupting operations.

  The cost of purchased data can also be prohibitive when large geographic areas are being analyzed at a detailed level. High-resolution imagery for large areas also requires a tremendous amount of storage capacity.

  ArcWeb Services addresses these issues by making GIS-ready data available as a service on a subscription basis. ESRI hosts the data, maintains currency, and cartographically enhances it for seamless incorporation into ArcGIS software-enabled BI applications. Among the many types of data available from ArcWeb Services are those most commonly used in BI applications: demographics, streets, aerial imagery, and Federal Emergency Management Administration floodplain boundaries.

While this integration overview suggests that an organization needs to identify a single way of integrating GIS into BI implementations, this is not necessarily the case. Some organizations will choose a bridge application to build models and geographic datasets with the intent of migrating them into an ArcGIS Server or ArcIMS environment. Other organizations may choose to have an ArcIMS integration to serve map-enabled reports to a large audience and an ArcGIS Server implementation to serve applications to a smaller audience of analysts.

Business Cases for Integration

Business Case 1

Organizations that have implemented large BI systems are looking for ways to extract more value from their significant investments. Incorporating GIS to analyze and display existing but underutilized location data is a relatively inexpensive approach to improved return on investment (ROI).

Business Case 2

The power of BI to provide specific reports to select audiences at specified times is a powerful communication and decision-making capability not available to today's GIS applications. By implementing BI reporting systems, the proven analytic capabilities of GIS can be made available to a wider audience in an organization.

Business Case 3

Many organizations have implemented both BI and GIS but in different operational departments. ESRI and ESRI's BI business partners have compared customers and found 50 to 80 percent of BI customers also have ESRI® GIS somewhere in the organization. These "shared customer" sites can realize the benefits of integration by obtaining an integration application and not an entire GIS or BI package.

Business Case 4

Multiple GIS and BI implementations from various vendors can produce different answers to the same question. There is no consistent repository of data, applications, or domain expertise across the organization on which to base decisions. This information anarchy reduces the confidence decision makers have in processes they rely on to run their organizations. A lack of confidence in business processes can lead to decisions that are overly influenced by risk aversion and not adequately responsive to dynamic markets. Furthermore, regulatory compliance regulations have made consistent and replicable business process and activity reporting a necessity for publicly traded organizations.

The selection of a particular integration strategy often leads to an examination of the entire organization's current GIS and BI implementations. This invariably leads to a consolidation of applications from different providers and a reduction in overall annual software maintenance fees. These fee reductions effectively lower the costs of the BI/GIS integration.

Business Case 5

Combining BI and GIS capabilities results in greater value from both applications. The rudimentary (by business standards) charting capability of GIS is vastly improved by the business charting abilities of BI applications. Conversely, GIS brings unique charting capabilities to BI in the form of spatial relationship and distribution charts. The portrayal of BI data as maps addresses a recognized shortcoming in BI graphics—the lack of context needed for informed decisions. For example, node-to-node supply chain performance data presented as bar charts or dashboards does not supply the location information needed for planning improvements. The same performance report presented as a map immediately shows spatial relationships between nodes that could explain variations in performance.

Many organizations, both public and private, have come to understand the business cases for integrating BI and GIS and are actively exploring integration strategies. In recognition of this shift in the BI marketplace, the latest product releases from leading BI providers, such as Business Objects™, Information Builders®, and SAS®, were built to take advantage of ESRI ArcGIS applications. ESRI business partners, such as Integeo, Galigeo, and APOS Systems, have built products that bring ArcGIS mapping and other business visualization tools to BI applications from other providers. The open architecture of ArcGIS has also allowed leading system integrators, such as BearingPoint® and Accenture, to easily integrate ArcGIS with BI applications from a number of BI providers.

Integrated Application Examples

Insurance

Rate areas for properties are typically defined by artificial boundaries such as ZIP Codes. ZIP Code boundaries were created to meet the business needs of the U.S. Postal Service and do not reflect the economic reality of the locations within a particular ZIP Code. Real estate agents understand the profound effect precise location has on property value. However, this view of property value is lost on most of the insurance industry.

GIS is used by some forward-looking insurance companies to create continuous rating surfaces based on economic reality across the entire area of interest, no artificial boundaries. This rating methodology results in realistically comparable values for similar properties on opposing sides of a ZIP Code boundary. When this geographic rate analysis is performed in the BI environment, with access to other operational data, results can be quickly distributed to those making decisions on issuing a policy, making the process more efficient.

Retail and Services

Siting of goods and services outlets has traditionally been performed at a departmental level, and the process was not visible throughout the organization. In many cases, the methodology used was known to a few individuals in the real estate department and was not necessarily replicable.

When an established GIS/BI siting model is used in the greater BI environment, it not only becomes replicable but can be used as a collaboration tool, inviting input from those in an organization that may have firsthand knowledge of a potential location. Furthermore, with International Convergence of Capital Measurement and Capital Standards—A Revised Framework (Basel II) compliance expected to become a reality, the need to accurately account for current real estate asset value can be more easily accomplished in a GIS. Value affecting data such as demographics and geographically influenced risk can easily be updated in GIS models.

Manufacturing Warranty Analysis

Automakers and some home improvement materials suppliers have added GIS capabilities to existing BI-based warranty analysis applications. An automaker discovered previously unrecognized geographical patterns in its BI-based warranty claims system that identified factors other than manufacturing as the cause of some component failures.

When a building material manufacturer GIS enabled its BI-based warranty system, it became apparent that the claims related to premature product degradation were clustered. The location of these customers shared some unusual climate characteristics that were not considered in the formulation and design of the product. Using historic climate data from the government and its own sales history, it was then able to predict future areas of product failure and proactively address the problem. Map-based reports showing the progress of the remediation campaign were regularly distributed throughout the organization.

Sales Force Efficiency

The balancing of sales territories has traditionally been map based but only at a very rudimentary level. In the worst case, a sales area might be divided into territories by equal geographic size or by assigning the same number of cities or counties to each salesperson. Now forward-looking companies are applying GIS analysis to BI-managed CRM software, facilities, and personnel information to balance sales territories. By considering the locations of the salesperson and targeted customers in the context of drive time, territories can be much more realistically tailored and more efficiently served.

Supply Chain Management

Presenting supply chain performance data in the form of a spreadsheet neglects the real-world influence of geography on transportation. One retailer knew the nodes of the supply chain (rows on a spreadsheet) well, but when the routes between the manufacturers and distribution warehouses were actually mapped, it was discovered that every shipment ended up crossing the same bridge. The entire company's operation would be negatively impacted if this particular bridge was closed.

The graphing and network display capabilities of GIS are particularly well suited to supply chain management. Manufacturing and distribution centers can be represented on a map as charts showing product supply or manufacturing capability. The route can indicate volume (by using line thickness) and whether products at different places on the route will be delivered on time (by using different colored route segments). When supply chain performance is mapped in this way, problems are immediately apparent and alternatives, such as rerouting production from another facility, are much easier to explore.

Product/Service Delivery

The use of GIS for optimizing routes for the efficient delivery of goods and services is not new. However, getting product and destination data into these applications can be difficult given the variety of input data needed to effectively deploy the solution. The ability of BI to provide seamless access to inventory and CRM data is making the implementation of such applications much simpler and less expensive. Organizations are now using the route optimization capabilities of GIS in conjunction with facilities data to streamline the loading of delivery trucks and more efficiently manage interfacility shipments of inventory.

Fraud Detection

Issuers of credit are validating identification of customers calling for assistance by displaying a map identifying the customer's address and nearby landmarks. Call center personnel can then ask questions that can only be answered by someone familiar with the customer's neighborhood. Some of these questions might be, What is the nearest cross street to your house? What is the name of the nearest lake or river? What is the nearest highway? Which direction do you drive to get to the airport? or Where is the nearest school? The detail of questions is only limited by the richness of the GIS data.

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Phone: 909-793-2853
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For more than 35 years, ESRI has been helping people make better decisions through management and analysis of geographic information. A full-service GIS company, ESRI offers a framework for implementing GIS technology and business logic in any organization from personal GIS on the desktop to enterprise-wide GIS servers (including the Web) and mobile devices. ESRI GIS solutions are flexible and can be customized to meet the needs of our users.

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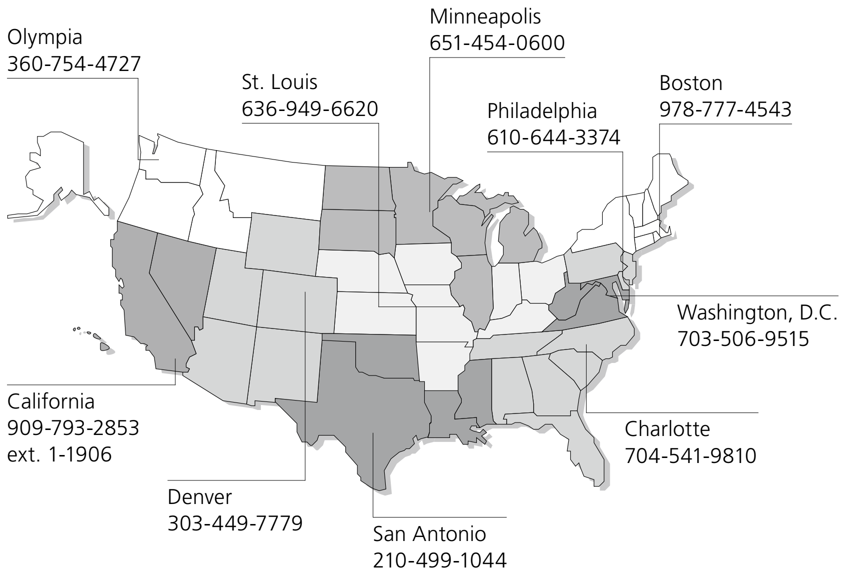

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