No longer the exclusive domain of geophysicists, spatial applications offer everyday solutions for business, industry, and government

GEOSPATIAL TECHNOLOGY COMES DOWN TO EARTH

In these days of escalating gasoline prices, the continuing availability of the earth's natural energy resources is once again a hot topic. At the United States Geological Survey (USGS) Energy Resources Program, scientists study and compile data on the location, abundance, and quality of undeveloped energy resources, and the impact on the environment from the extraction and use of these resources.

Until recently, access to this information was cumbersome at best, says Marc Levine, a supervisory computer scientist in the USGS Energy Resources Division. "Users had to have a pretty thorough understanding of geographical information system (GIS) technology in order to tap into and manipulate the system," he says. Users without this expertise had to contact people within USGS to satisfy their information requests—a lengthy process that was becoming less and less viable, Levine adds.

Geographical information systems take geographic data stored in a database and display it visually on a map or some other kind of graphical interface. Information is typically displayed in thematic layers, revealing patterns and trends that might otherwise be difficult for technicians and other users to perceive. (For a look at how geospatial technology works, see "Points, Lines, and Polygons," page 16.)

by Erin Tribble

PHOTOGRAPHS BY NOLA LOPEZ

ESRI leading the way

To give users immediate and direct access to USGS's wealth of geographic information, Levine and a team of programmers developed an interactive Web site called GEO Data Explorer, or GEODE (http://dss1.er.usgs.gov), launched in March 1999. The site allows users without GIS expertise or the help of USGS staff to do sophisticated spatial queries and analyses. The GEODE site runs on Informix Dynamic Server.2000 with the ESRI Spatial Database Engine (SDE) DataBlade® module. ESRI (Environmental Systems Research Institute; www.esri.com), based in Redlands, California, is a leading developer of spatial applications.

GEODE users access the system through a Java-enabled Web interface, which lets users request and display multilayered maps. "GEODE puts information directly in the hands of end users," says Levine. "Through their browser they can select data sets specific to their information needs. They don't need to use specialized tools."

Len McWilliams, now a senior systems engineer at Informix Software, was a consultant with Computer Associates on the GEODE project for four years prior to joining Informix. While Levine defined the scope and purpose of the project, McWilliams managed the technical side. "One of our main concerns was finding the most effective database implementation for spatial data," he says. "After testing many vendors' products, we decided on Informix Dynamic Server.2000 with ESRI's SDE."

A middleware component, called MrSID, from Seattle-based LizardTech (www.lizardtech.com/index.pl), allows the GEODE server to store and retrieve

large images such as satellite and aerial photography. These images are often used as background layers for other sets (or layers) of data on endangered species, rivers, roads, schools, environmental pollutants, or earthquake zones. Another middleware component from Professional Geo Systems (www.pgs.nl/), based in Amsterdam, the Netherlands, sends spatial queries to the Informix/ESRI SDE database, then returns the requested data to a customized Professional Geo Systems Java applet running on the user's Web browser. This applet then renders the data on a map.

McWilliams says there are key advantages to using Informix/SDE for geospatial data storage and analysis. "High-performance access and analysis are made possible by a sophisticated R-tree index that is part of the core Informix database engine," he says of the built-in, native access method designed to handle spatial data types and functions. "True spatial data types and spatial operations, enabled by SDE, are built into the Informix database engine—they're not middleware." McWilliams says this proved to be the best-performing, most functional, most flexible, and easiest-to-use spatial database implementation.

instant topography

At NORUT Information Technology Ltd. (NORUT IT; www.itek.norut.no/itek/), a research institute based in Tromsø, Norway, scientists and engineers are hard at work on a new project. When it's completed, Internet users of all types—from area planners and research scientists to business owners and tourists—will be able to generate customized maps on the fly by means of a Web browser. Called Geographical Information Networks (GIN; www.itek.norut .no/gin/), the project is designed to connect, via the Internet, several large spatial databases scattered throughout Norway. These systems contain geographic data from a number of sources, including government agencies, private industry, and satellites.

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Geospatial issues are more integral to our lives than most people would imagine, says Kevin Daugherty, manager of strategic accounts at ESRI. Whether it's maintaining a safe distance between planes in the sky, delivering water from the Colorado River to a farmer in the Central Valley, or determining the best location for a landfill or nuclear reactor, geography comes into play in all of these situations. And in each case, a solution may lie in geospatial technology.

"Whether you're a research scientist needing to track changes in the global climate or a businessperson needing to figure out the best place to open a new franchise," says Daugherty, "many of the issues we face today are related to geography."

NORUT's GIN is a prime example of the changing landscape of geospatial technology. No longer the exclusive domain of geophysicists, cartographers, and other scientists, geospatial technology has become available to a broad range of users, enhancing the technology's existing applications and enabling new ones to be developed.

This expanded base of users is due in no small part to the emergence of object-relational database management systems, which can be extended to support geospatial data types. Informix has been at the forefront of this trend, says Chebel Mina, director of strategic alliances at MapInfo, a leading provider of location-based solutions for customer relationship management and a key Informix partner, based in Troy, New York.

"Informix was a pioneer in the geospatial arena with its DataBlade module technology, which allows spatial extensions to be built into the database," Mina explains. "This was a major change because it brought geographic data out of proprietary graphical information systems into a core database that could be deployed across organizations and shared by many people." (For more information on geospatial DataBlade modules, see Teamwork, page 34.)

Businesses are arguably the biggest beneficiaries of the expanded use of geospatial technology. They can now incorporate the advanced visualization and analysis techniques of spatial applications into their business processes.

"By adding a spatial dimension to their business systems, companies find that they make better decisions," says David Sonnen, president of Integrated Spatial Solutions and an analyst with IDC. "For example, if I'm a cellular services provider who wants to build a new cell tower to expand my coverage area, I need to figure out where my potential customers are. Geospatial technology can help me answer that question and make a better, smarter business decision."

GIS tech for everyone

While the trend toward database-driven spatial technology is having the biggest impact on the business segment—Sonnen predicts a compound annual growth rate of 30 percent over the next five years—other types of users are also reaping the rewards.

Before focusing its efforts on GIN, NORUT Information Technology had worked on a project called

POINTS, LINES, AND POLYGONS
THE LANGUAGE OF GEOSPATIAL TECHNOLOGY

To take advantage of geospatial technology, spatial extensions such as DataBlade modules must be added to your database. In essence, these components enable your database to understand geospatial data types and functions.

Geospatial data types, as defined by the OpenGIS Consortium Simple Feature Specification, include points, lines, and polygons (or areas). A point might be a fire hydrant, a telephone pole, or a cell tower. A line could be a highway, a power line, or an underground pipeline. And a polygon might be a lake, a city, or a state boundary.

Spatial functions let you perform operations, or queries, against these types. For instance, you could ask the database whether a particular point—a fire hydrant, for example—was inside, outside, or on the edge of a particular area. "Inside," "outside," "touching," and "distance" are just some of the many user-defined functions that can be run against the database.

The other important piece of a geographical information system is the client application, which handles visualization functions, such as map or graph renderings, and query and analysis functions. For example, when a user performs a query, the client application writes it up in SQL, then passes it to the database, where the query is executed. The database sends the results of the query back to the client, which understands how to present, or render, the data. The client might draw freeways as red lines and minor roads as gray lines, and represent fire hydrants and other point types as icons. Clients can also perform analytic functions such as calculating the distance between two points.

In Web-based implementations of GIS, much of the client functionality is handled by middleware, which resides on an application server.

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KARL JOHAN GRØTTUM, research scientist, NORUT Information Technology, Ltd.

Marine Geographical Information Technology (MARGIT; www.itek.norut.no/itek/ikt/projects/Margit/), which was designed to provide affordable GIS functionality to area planners in the coastal regions of northern Norway. These users, who depend on customized, high-quality maps to do their jobs, often don't have the resources or expertise to purchase and maintain a GIS that would allow them to produce the maps themselves.

"To enable these users to take advantage of GIS technology, we built a centralized spatial database on Informix's Illustra platform and developed interactive Java applets for Web-based access to the system," explains Karl Johan Grøttum, a research scientist at NORUT.

Through a Java-enabled browser, a user was able to select a map of a particular area, then choose which features, or themes, they want to appear on the map: bodies of water, roads, recreational areas, fisheries, topographical features, and so on. Once the user was satisfied with the selection, the Illustra database retrieved all the topographical data, generated an Adobe Illustrator file (or distilled to PDF, if necessary, for viewing and printing), and then sent it to the Web browser via file transfer protocol.

Grøttum says the MARGIT system substantially reduced the cost of map production and gave users a cost-effective means of using geospatial technology. But after completing the project in 1998, NORUT decided not to develop the system any further. "We wanted to take the interactive Java-based mapping technology we developed for MARGIT and put it into GIN," he says.

GIN will open the doors to a much broader range of users and applications, appealing not only to the traditional GIS segment, but also to commercial markets. "The purpose of GIN," says Grøttum, "is to provide access to multiscale and seamless geospatial data about all of Norway. Users of all kinds will be able to pull a variety of spatial data from different resources and build maps for screen display, printing, or analysis."

Grøttum says one potential application of GIN is mobile location-based services, which allow users to request and download location-specific information through a cellular phone or handheld computer. The information might be a map of a specific area that shows where certain types of shops, restaurants, or services are located. It could also be a local weather forecast or traffic report.

On the traditional GIS side, GIN could be used to facilitate land management projects. "A field worker with a handheld computer and a GPS [Global Positioning System] could input, via the Internet, new point themes into the database," explains Grøttum. This new data would be automatically registered in the system, making it easy to create and maintain up-to-date maps.

For the next year or so, MARGIT will continue to run on Illustra, after which it will be phased out. GIN will operate on Informix Dynamic Server.2000 with SpatialWare 4.0. NORUT has a long history with Informix as well as extensive knowledge of object-relational technology and its suitability to spatial applications.

Grøttum believes one of the key advantages of Informix's architecture is the R-tree index. "Our database is a seamless database of all of Norway," he explains. "It has lots of data, and when you're in one part of Norway, you're not interested in all the other parts. The R-tree lets the database find and retrieve only those objects you're interested in."

Because the R-tree is native to the Informix database, all the geospatial DataBlades automatically take advantage of it, says Ed Katibah, director of DataBlade Partner Engineering at Informix. "They use it just like an integer type uses the B-tree index," he says. (See Katibah's Inside Edge column on the past, present, and future of geospatial technology, page 40.)

covering your bases

While NORUT IT is using geospatial technology to develop a back-end infrastructure that can enable numerous applications, Arch Communications—a leading provider of wireless messaging and communications services—is using the technology for a very specific purpose: customer relationship management.

"When people call to inquire about our paging services, one of the first things they want to know is, 'Where do you have coverage?' " says Scott Francis, Web development manager at the Westborough, Massachusetts–based company. "A couple of years ago, we had to manually build these gargantuan map books to answer that question. Now our coverage maps just come up on the computer screen."

To generate these maps, Arch Communications used Informix Internet Foundation.2000 and MapInfo SpatialWare DataBlade. Users query the database via a Web-based interface. MapXtreme, which resides on a separate application server, sends the queries to the database, then draws the maps based on the data it receives. The maps are coded as GIF files, then sent to users' browsers.

"When people call and say they've lost coverage, we ask them for some information—usually from the back of their pagers, which indicates what frequency they're operating on," says Francis. Based on that information, which is used to generate a map, the customer support user can determine whether someone has gone out of the coverage area or whether there might be some kind of problem with the Arch network.

Francis says the primary users of the system are Arch Communications' sales and customer support teams and people visiting the company's Web site. "People coming to the site can go to our online store, punch in their zip code, and receive a map indicating whether there's coverage in their area," says Francis. Customer support people use the system to help their existing customers troubleshoot problems with pagers.

Retail partners can also access the database via an extranet to determine where they're authorized to sell coverage.

Francis says Arch chose Informix because of its products' spatial capabilities: "Location-specific information is a key component of our business, so the ability to store, track, and search that information in a database is very valuable to us." Being able to treat spatial data like any other type of data is also a key benefit of Informix, says Francis. "You can write applications against [the data], develop graphical interfaces for it to make it easy to understand, and so on. [The spatial data] just becomes another piece of information you can use and manipulate in your business."

the sky's the limit

The NORUT IT and Arch Communications geospatial implementations represent only a fraction of what the technology can deliver. Now that it's available to a much wider audience, the applications of the technology appear to be limited only by the imagination.

One area analyst Sonnen is keeping his eye on is the business-to-business market. "This will turn out to be a high-growth market," he says. "Companies can incorporate the technology into their supply-chain management to track the location of a particular customer order, or they can use it to deliver targeted ads."

Sonnen says America Online is one company currently using geospatial technology in this capacity. "AOL knows where all its customers are—or at least where their billing address is," he says. "This allows them to deliver targeted [banner] ads to customers who meet a specific geo-demographic profile. In spite of the 'locationless-ness' of Internet technology, people do live on the earth and have common buying patterns."

> "People coming to our site can go to our online store, punch in a zip code, and receive a map indicating whether there's coverage in their area."
>
> SCOTT FRANCIS, Web development manager, Arch Communications

Geospatial is coming into play for Enhanced 911 services, due to an FCC mandate that requires all cellular phones to be GPS (Global Positioning System)–enabled by October 2001. This technology will allow emergency services to pinpoint a caller's location within 400 feet. Currently, Public Safety Answering Points—the call centers that take emergency calls—are upgrading their systems to translate latitude and longitude information (point data types) into digital maps.