Sharing Geospatial Data and GIS Applications in Petroleum E&P

The Petroleum Exploration and Production (E&P) industry has significant investments in business and work process applications and data stores. Today's integrated technologies are providing solutions that push data and applications out of isolated caches and into an accessible corporate arena where they can be put to work for a variety of project types and work flows. This paper discusses current problems inherent in Web integrations and suggests solutions including blended structures, GIS-enabled portals, and GIS-Web service options.

Obstacles to Application and Data Sharing

For more than a generation E&P users have performed computationally intensive tasks, and, therefore, accumulated immense amounts of data. These have focused on Geoscience applications, which include Data Management, Engineering, Geology and Geophysics. Many E&P companies realize the value of pushing data out of independent caches. But integrating these datasets across the corporate intranet is a challenge because accommodating the massive amounts of data for these exchanges requires that clients take on fairly major application development.

The most popular architectural components of a corporate data sharing system are a desktop computer with a GIS and third party Geoscience applications, servers that are data warehouses typically linked to desktops, and browsers that support Web services. Desktop, server and web access are synonymous to front-office, back-office and services. Petroleum work flows are, however, often interrupted at the interface between the desktop and the server, or the front- and the back-office. For example, a person begins working in ArcInfo or ArcIMS, integrates or browses data, and then moves away to other applications to access third party Geoscience interpretations that are often not GIS. These applications are often located on separate platforms, such as Linux, or on systems that are not readily integrated because they rely on data import and export functionality rather than direct connections. The efficiency that users gain in individual applications is lost when they switch from one desktop to another. Ideally, the GIS desktop experience should integrate seamlessly with other applications and systems so the user can perform tasks in an uninterrupted work space.

Consider the geoscientist working in ArcMap that selects data, exports it to a gridding and contouring package, and moves onto or stays in the third party Geoscience application. After the contouring is completed, out of habit, the user continues using that third party Geoscience application. That technology often will not support access to valuable data such as satellite imagery or public domain cultural data; for example, it does not allow the user to create GIS overlays upon Geoscience data interpretations. Furthermore, additional data housed on the desktop may not be easily linked to server applications other than by an import/export tool. This can be problematic for many types of tasks, such as performing investigative work over large geographical areas.

These disjointed work process methods are attributed to legacy applications and the traditional practices of industry users. This is usually the result of lack of geospatial integration in an industry that started to process very large amounts of data more than a quarter century ago. Data processing bandwidth in legacy systems limited users to data sets commonly at the project level, and most often in local or un-projected coordinates. Database and network protocols for clients and servers also limit data availability. For example, ASCII file import/export or so-called *half-links* among databases are limited. Culturally, the historic separation of data processing and cartography between information technology (IT) and drafting departments has made it difficult for E&P system users to bridge the vastly differing requirements of data calculation and display. In addition, geographic location was not used as a key to data processing and management, so that managing vast spatial datasets became very difficult; therefore, work flows were sectioned into discrete processes rather than synthesized into a holistic integration.

Problems occur with separate systems that are difficult to locate and use, redundant data and work tasks, and difficulties in creating data set relationships. For example raster data from seismic surveys are typically stored in discrete files rather than in a relational database because the technology to process vast imagery in relational databases is relatively recent. Innovative technologies need further development before they are trustworthy, and workflows of remote sensing and seismic processing thus remain separate.

Strategies for Achieving Interoperability

Tools

Interoperability is the ability to exchange and use information across a large, heterogeneous network made up of several local information system nodes. Faster hardware and modern software and Internet technologies provide options that improve speed and accuracy of data access; storage capacity and richness of data; and completeness and complexity of analyses. To make these systems come together in an easy to use format, it is essential to geo-reference and model data in data bases, and to distribute tasks on servers, desktops or browsers logically. When users can access data and applications with speed and accuracy, the petroleum company's E&P processes will dramatically improve.

ArcSDE is a server software product used to access massively large multiuser geographic databases stored in relational database management systems (RDBMSs). It provides a suite of services that enhance data management performance, extend the range of data types that can be stored in a RDBMS, enable schema portability between RDBMSs, and offer configuration flexibility.

ArcGIS Server is a comprehensive platform for delivering enterprise GIS applications that are centrally managed and support multiple users. ArcGIS Server provides the framework to build and deploy centralized GIS applications and services to meet a variety of needs using a variety of clients.

ArcGIS 9.0 Desktop provides a new Geoprocessing framework for doing geographic analysis and data management. This includes a number of tools to do geographic feature overlay, feature selection and analysis, topology processing, and data conversion resulting in an output dataset. The geoprocessing framework allows you to use each geoprocessing function in a variety of ways. The tools can be directly used from a dialog, they can be executed via command line, they can be combined with other processes in visual models using Model Builder, or used in advanced scripts.

GIS portals organize content and services such as directories, search tools, community information, support resources, data, and applications. They provide capabilities to query metadata records for relevant data and services and link directly to the online sites that host content services. The content can be visualized as maps and used in geographic queries and analyses. Dashboards can, moreover, view several portals on a single web or desktop interface, for example ArcIMS and corporate finances or performance.

The goal for the ArcGIS Data Models is to provide a practical template for implementing GIS projects. While most users will find the models a great starting point for work on their specific data model, they will also find related models useful in the development of their system. Beyond the benefits to a specific organization, this common starting point results in the creation of data model design templates that simplify the integration of similar data sets at the local, state/provincial, national, and global levels.

Operations

Petroleum E&P work flows are cyclical. They integrate harvesting, analysis and interpretation in iterative rapid-response cycles. Here is an example: Seismic, satellite and land data are interpreted to suggest a drilling location near an environmentally sensitive area. Drilling is performed horizontally to attain distant targets outside environmentally sensitive areas, and inside the areas of drilling permits. Drilling data is collected on an offshore platform and sent to the office onshore. That data helps tweak the original seismic interpretation that respects the geographic bounds of permissible drilling. These results in a new recommendation to drill further and reach a target that may have otherwise been missed. And the drilling program stayed with permitted environmental areas. Geoscience interpretations thus demand the integration of disparate datasets. If work flows are broken at the interface between desktop or browser and server, then work processes are disjointed, redundant, delayed, and can produce inaccurate and incomplete results. The proposed solution is to integrate these work flows by allowing data and interpretations to be *pushed* and *pulled* automatically through GIS portals.

A petroleum company's solution for sharing data may be a specific objective. One object is to keep users on their desktop applications that are appropriate to their task by providing a thicker more powerful desktop client for power users and technical personnel, and a thinner easier to use desktop client for managing or contracting personnel. A second objective would be to help users spawn processes that launch parameters to legacy server applications and retrieve the result to the desktop for further GIS interpretation. Upgrading existing work flows by moving them into a fully geographic referencing system, allows the integration in a geospatial reality of true GIS. This module includes dashboards to portals that allow the full cycle of pushing and pulling data for both harvesting and interpretation. Server-side applications enable the company to centralize integrated Geoscience processes. It must contain geospatial protocols in SOAP/XML that allow users to collect appropriate data for analysis; launch processes on the legacy application; return analytical results quickly and accurately; and continue GIS analysis and redo as necessary.

Examples
Users and vendors have crafted browser interfaces and GIS-enabled Internet portals for accessing multiple databases. The term spatial portals describes a wide range of services and tools for accessing geographically referenced data. Spatial portals are Web sites that allow organizations to pool information together and make it accessible. These solutions offer simple browse and query functionality and more powerful browser interfaces that are portals based on Java. These desktop interfaces create the structure for efficient recurrent work flows.

Royal Dutch Shell has developed a robust spatial portal. Shell's E&P GIS team is moving toward integrating data at the application (client) level rather than at the database level, linking basic attributes in the GIS layers to data sets elsewhere and using the application to resolve data translation issues. They have built targeted portals to meet specific corporate or project needs. Shell's Discovery Portal, for example, coordinates information on North Seal Oil and gas operations for Shell offices through Europe. This portal integrates subsurface (textual) databases with geospatial information. It draws some datasets from the master database and others from regional- and project-based databases and electronic document management systems. The Discovery Portal provides a heavily tailored environment for scientists to retrieve and work with technical information from a variety of sources.

The ideal GIS work environment includes clients that can access data as soon as it is validated and added to the master database. Web service architecture depends on robust servers. Because the Web has brought a sharper focus to the power and efficiencies of standardization, expect GIS to become more server-centric. The user can come to the Internet and identify remote services that provide both necessary data and modeling functionality. These can be integrated within the user's own system The user system can trigger data hosted on one or more remote servers to be passed to data models on another remote server, with the result being returned in a form that can be directly integrated with the original user's existing applications. There is no need to store or develop the data or services to be accessed at each and every location; they can be consumed as and when required, and are invisible to the end-user client.

Internet data delivery via Web services is a solution already being favored by the industry. For example, IHS Energy provides a Web map service. It can be used to either allow distributed intranet-based access to existing IHS Energy spatial datasets or to allow direct Internet access from anywhere in the world to data hosted by IHS Energy. The latter entirely removes the need to maintain data at the client site, greatly reduces dissemination, maintenance and update overheads, and enables clients to access data as soon as it is updated in IHS Energy Central database.

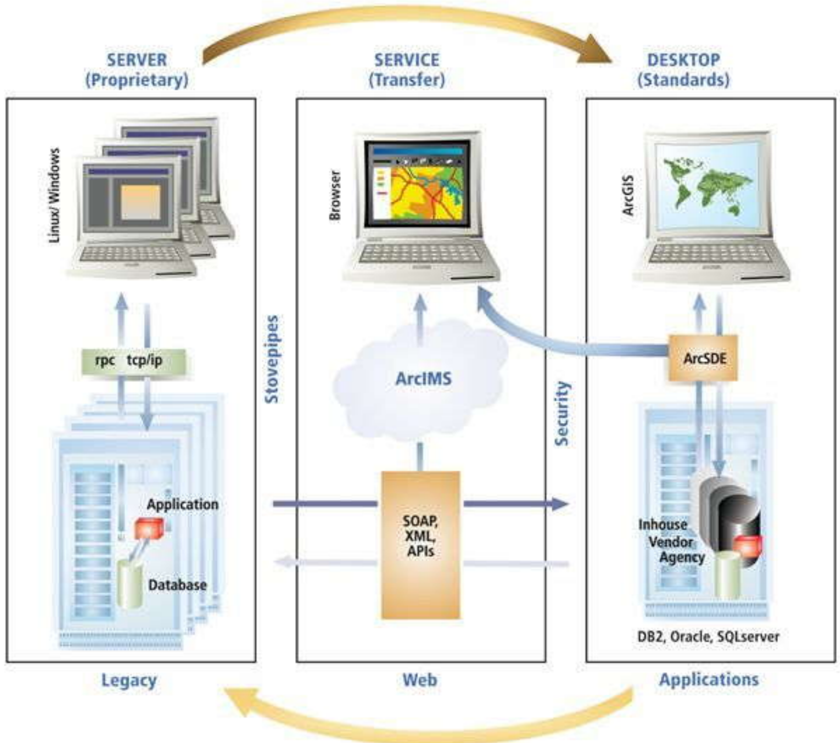
The Benefits GIS for Data Sharing

Developing an integration plan with an objective of improving user work flows is the best way to extend the GIS desktop experience. Many users prefer their desktop ArcInfo and ArcIMS because they can perform complex analyses. Users, however, also want to push data to servers and pull back interpretive results for GIS integration. For example, an analyst may want to push a data layer about targeted formation from well spots to a server, pull back interpretations for grids and contours of a particular formation top, and then use GIS to represent the results geospatially, in order to ensure that is falls within legally or environmentally permitted areas. ArcGIS supports data integration that meets both business and regulatory needs.

Regulatory Compliance
Recent natural and man-made events have added further impetus to migrate toward integrated information technology systems. Security issues around petroleum infrastructure abound, as facilities are spread across boundaries and along shorelines. Along with these concerns come new sets of legalities. In the United States, petroleum operators are required to comply with an increasing number of regulation requirements from the US Securities and Exchange Commission's Sarbanes-Oxley Rules. The European Union will soon be increasing regulations proposed by its Environmental Action Program. Regulatory compliance can be supported by GIS, which generates reports, automates workflow processes, maintains historical data, and schedules compliance projects. More importantly, it supports the architecture for data exchange with these agencies.

Major oil operators have built emergency operating centers and have so-called *immersive* environments in place; these allow users to access multiple views of their data and interpretation in dark rooms across multiple screens to give the impression they are immersed in their data, and enhance collaboration efforts by merging Geoscience data all in one place. The challenge still remains of integrating GIS datasets as described earlier, effectively and economically in workflows that allow quick turnarounds. Creating GIS-enabled Internet infrastructures that support data sharing between oil companies and outside agencies will speed compliance processes and accommodate data sharing for fast prevention and responsive actions in crisis. Accessible integrated data sets serve to respond to regulatory agencies and stake holders' inquiries, concerns, and reporting requirements.

Creating data sharing structures is an essential design goal for an enterprise that pushes information up to managerial levels and out to the public and remote users. The E&P work flow consists for serving maps and other information in a ready-made format that informs the layman without creating a distraction from the task. GIS can achieve this on a desktop, through spatial portals, or via Web services. The results are interoperable solutions that are scalable across a range of bandwidths. These solutions will reincorporate the company's data islands, extend the use and variety of applications to users, improve data quality and currency, and improve work flows.



Current (darker) and proposed (lighter) GIS processing in Petroleum E&P
Currently, Geoscience applications run on separate desktops or servers (left) – GIS can access these (left to right) via web or desktop, as one-way portals. Efficient interpretations merge GIS with Geoscience data and allow rapid reiteration – they will need full-cycle processes (add right to left) in two-way portals.

Suggested Reading

Connecting Our World: GIS Web Services. Dr. Winnie Tang and Jan Selwood. ESRI Press. 2003.

Spatial Portals: Gateways to Geographic Information. Dr. Winnie Tang and Jan Selwood, ESRI Press. 2003.