Developing Web Mapping Applications that Leverage GIS

Introduction

Most organizations have already integrated Geospatial Information Systems (GIS) into at least some critical line of business workflows. GIS departments along with software from ESRI, Pitney Bowes/MapInfo, GE Smallworld, or AutoDesk provide customized spatial services across the enterprise. GIS systems are useful because of their powerful feature sets for geospatial data creation, queries, analysis, and data visualization. Many organizations have invested heavily in GIS infrastructure, hiring professional analysts and developers to create and maintain spatial data resources and services that are key to critical business decision systems. However, these traditional GIS tools have often evolved from client/server architectures and are not always well suited to newer web distribution models.

GIS departments are seeing rapidly growing demand for mapping and location solutions across the entire organization. This demand includes internal business decision systems, chain of supply relationships, and externally facing consumer applications. Map and location application users are no longer predominantly professional GIS analysts. Increasingly, users require access to location information and geospatial data visualization as easy to use web map applications.

By enhancing existing GIS systems with newer web mapping technologies, like Bing Maps, organizations can gain additional business value from GIS investments. Leveraging modern web based distribution models allows complex GIS analysis to be shared across the entire organizational spectrum of users. Location data visualization is then available at every stage of internal work flow processes, while easy to use consumer access can drive value out to the market attracting additional customers.

Web mapping is not new. Microsoft and other companies have been offering web mapping technologies for many years. This includes applications for almost every vertical market including real estate, travel, retail, government, and transportation. Web mapping applications can be developed quickly using common web technologies (such as JavaScript, Flash/Flex, or Silverlight).

Common web mapping platforms provide data visualization features that include…

- Mapping/Imagery – Road information, surface features, aerial imagery, in 2D and 3D views
- Find/Geocoding – Find specific addresses (geocoding) or Points of Interest like landmarks or business
- Routing/Directions/Traffic – Route query and display, driving directions, distance/time and traffic conditions.

Most web mapping services use industry standard web mapping techniques including Mercator projection, latitude and longitude (WGS-84) coordinate systems, and pre-rendered raster tile layers, commonly known as a tile pyramids. Pre-rendered tile pyramids, available from high capacity server clusters, provide enhanced user experience with near real time zoom and pan in client browsers.

Web Mapping Advantages

- Rich mapping and imagery – road and surface features, orthorectified imagery, oblique (Bird's Eye) imagery, 3D
- Services designed for the web – high performance raster tile pyramids (quad trees) for smooth user navigation in client browsers
- Scalability – web mapping platforms can easily scale from a few users to millions.
- Cloud computing – base map features flow from cloud servers outside an organization's infrastructure directly to a user's browser reducing required server capacity, bandwidth, and IT support.
- Data maintenance – creation and maintenance of base map features is handled by the web service, so additional personnel are not required by the organizations using these services.
- Users – Web mapping application require very little training, and can be tailored for non-GIS users who need to visualize data quickly to make better decisions.

GIS Advantages

- Spatial data creation/manipulation (e.g. creation of street features)
- Thematic mapping (e.g. choropleth maps, heat maps, etc)
- Geospatial analysis (e.g. plume modeling, drive time analysis, buffer queries, etc)
- Geo-processing (e.g. re-projection, spatial feature manipulation etc)

By merging web mapping services with existing GIS infrastructure, organizations can create best of breed web map applications, extend GIS investments, and deliver more value both internally and externally.

Solution Overview and Architecture

Web mapping applications that leverage existing GIS capabilities are typically implemented using software (i.e. local premise systems) + services (i.e. SaaS or Cloud computing) architecture. GIS data and services remain in an organization's current systems. GIS analysts and users continue to create and manage this data in the same way they always have. However, additional web mapping services integrate with these existing GIS data layers and services to create high performance web mapping interfaces for web browsers. Since GIS systems produce data in both raster and vector formats, tools and techniques are required to integrate these data formats from existing GIS systems and merge them with web mapping capabilities.

Vector Data – consists of combinations of spatial primitives: points, lines, and polygons. These mathematically defined features are easily transformed using matrix algebra. As objects it is possible to attach event handlers directly to primitive features, producing highly interactive user interfaces. Additionally, attributes can be directly associated to individual spatial features. Common vector data formats for web mapping applications include JSON/GeoJSON and XML such as KML, GML, or GeoRSS. GIS vector datasets need to be transmitted as one of these formats for use in typical web mapping applications. Special consideration should be given to the quantity of vector primitives transmitted to a web application's interface, as too much vector data can affect an application's performance in the client browser.

Raster Data - Raster data can include native raster images, like aerial imagery e.g. GeoTIFF, or raster images rendered from large vector datasets at the server, e.g. land parcels. Raster data is supported in web mapping technologies as jpeg, png or PDF images. Raster data resources do not provide the level of geometry abstraction found in vectors and therefore lack some of the rich event handling capability found in vector data.

Raster + Vector data - Many web mapping applications take advantage of hybrid raster/vector approaches. Custom imagery or large vector data sets are displayed as images, either directly or in cached tile pyramids. Smaller vector sets can be displayed as additional vector overlays. User selection events can directly access any vector layers, but must make server requests for additional information associated with features in raster

layers. In hybrid approaches only vector data of interest is loaded providing the balance between performance and data richness.

Many GIS tools have the ability to export, or expose layers as a service that can be called once or many times during a user session to retrieve data. Newer versions of GIS tools e.g. ESRI 9.3.x can do this natively, while some older GIS systems require an additional application to process and format data correctly. ArcGIS Server 9.3.x provides a number of ways to access existing GIS data and integrate with Web Maps...

1) ArcGIS JavaScript Extension for Microsoft Bing Maps – This JavaScript library can be added to any web mapping application. It allows developers to call ArcGIS server layers and services directly and show results in web maps. This includes functions to access tile layers, query layer attributes and execute geo-processing tasks (e.g. drive time analysis or plume modeling)
2) ArcGIS REST APIs – These APIs provide more direct access to ArcGIS server layers and services. For web mapping they can provide results directly in tile formats which can easily be overlaid on your web map.

This integration with GIS systems and data is often known as spatial extract, transform and load (ETL), where spatial data sets can be created in vector and raster formats required by web mapping applications

Tile Servers are often considered part of a web mapping solution when integrating with GIS. Tile servers process datasets into small raster tiles, stored in tile pyramids for use in web mapping interfaces. Tile pyramids enhance browser navigation performance but require pre-rendering at the server. Relatively static data can be pre-rendered as part of the data creation process. Tiles are stored as a pyramid directory structure of image files which can easily be hosted in a web server or in a Cloud repository. However, more dynamic data sources that get updated frequently or in near real time (e.g. weather), require tile and cache capability as part of the originating web service. The first time a user requests a tile the rendering process occurs, while subsequent requests come directly from a tile cache.

Web mapping platforms like Bing Maps provide high resolution worldwide base features without the significant cost of producing and serving this data internally. Some GIS vendors do offer web mapping capabilities, but world wide data resources must still be obtained and maintained by the user. Scalability of the resulting solution is then dependent on limited user administration resources. It is generally best to leverage web mapping platforms using the supplied APIs to build applications that merge with value added GIS datasets and analysis services.

Conclusion

Many organizations have powerful GIS platforms for creating, managing, and analyzing spatial data. Maps complements these features by providing rich web mapping capabilities including UI controls, common map layers, aerial imagery, geo-coding, and routing capabilities. GIS provide rich web mapping solutions for a wide spectrum of organizational scenarios.