

Web Services: Mature and Enterprise Ready for Municipal GIS Interoperability

Introduction

While Geographic Information Systems (GIS) have been around for more than 20 years their return on investment has been less than stellar. Potential benefit to decision support, business intelligence, public information, work flow and operations is clear, but their application has been plagued by high cost and low rate of implementation success.

However a sea change in software architecture has led to the emergence of a new wave of products that will reduce costs and vastly improve integration. The new catchwords are integration and interoperability. Through the emergence of industry-embraced standards, business application vendors no longer need to “partner” with specific GIS vendors. Thus customers no longer need to buy and deploy multiple GIS technologies and maintain multiple versions of the same GIS data to suit specific needs of departmental systems.

This unifying new technology is dubbed Web Services. While using web protocols and the world wide web as their network Web Services also deliver significant benefit to municipalities within the enterprise (intranet and integrated with applications) and among community partners (extranet). The name causes some confusion because many municipalities have already adopted Web Mapping, systems that deliver point and click display of properties and services through web browsers. Web services can be used by web mappers and many other viewers and applications.

In this White Paper, we highlight two of the key new GIS web services that every municipal technology manager must know about: Web Map Services (WMS) and Web Feature Services (WFS). As you consider renewal and replacement of your business applications, we prepare you to ask vendors how their solutions will let you reap the benefits of GIS web services.

Trends in Municipal GIS

The emergence of Web Map Services and Web Feature Services is a response to several trends in information technology and GIS. These include evolving municipal information requirements and the changing technology market.

Integration and Interoperability

The biggest trend in GIS has been recognition of the potential benefit of GIS for almost all aspects of municipal business and attempts to integrate it.

Early effort to make maps accessible from planning, licensing, taxation, maintenance and work order applications involved embedding GIS program code into business

GIS WEB SERVICES

applications that caused a full GIS desktop application to start up and highlight the property of interest. For those who needed only a contextual map or visual confirmation, the desktop GIS interface was ridiculously complex and typical business users used probably less than 1 percent of the functionality purchased. Bigger PCs were required to support the GIS software as well. A close relationship between the business application vendor and the GIS vendor was required for this architecture because the code was tightly integrated. This led many municipalities to “own” multiple GIS technologies or limit their business application acquisitions to those that supported their own. Call it a choice between two evils.

The next generation saw desktop GIS broken out into application components such as ESRI MapObjects and Intergraph distributed components (DCOM). This approach was somewhat better, in that the kludginess of opening a second thick application was avoided, and the map could actually be displayed right inside the business application. The back office was still proprietary, the choices remained evil and there wasn't much uptake.

The growing vision of integration brought some new players into the field that shook the foundations. Oracle and IBM both introduced spatial objects and functions in their enterprise databases, which meant that if your application didn't really require a map, but only a spatial query, you didn't need ESRI or Intergraph at all. For example, entering an address in an SAP Work Order form could launch a request to find that address on a virtual earth and return the service area it fell within. You could make a query that combined business data and GIS data in the same standard SQL statement. Also the notion that a single GIS data format could serve data to Mapinfo, Intergraph, Autodesk and ESRI desktop GIS and CAD clients could potentially solve lots of problems for enterprise GIS managers. The cost proved prohibitive for all but the biggest municipalities but the expectations of the back office were changed forever.

The next line of thinking sought to achieve all of these benefits using the internet as the communication medium. People were getting used to finding and using information from all over the world. The new vision was to facilitate the use of maps and map data from anywhere, no matter what technology was used to host it. For business applications, the potential to bring maps into the application without partnerships with specific GIS vendors emerged. These gave rise to the Open GIS Consortium and the emergence of standards.

Open GIS Standards

The Open Geospatial Consortium, Inc. (OGC) is a non-profit, international, voluntary consensus standards organization leading the development of standards for geospatial and location based services. The OGC Vision was "full integration of geospatial data and geoprocessing resources into mainstream computing and the widespread use of interoperable, commercial geoprocessing software throughout the information infrastructure."

GIS WEB SERVICES

The approach was to use web protocols, initially the now familiar HTTP protocol, as the basis for a standard syntax that would allow any GIS program or web browser to request maps from any source, regardless of the GIS system that held and served the data. They have been eminently successful at that, as we shall see, developing or using several other standards including eXtensible Markup Language (XML) and Geography Markup Language (GML).

Mobility and Gadgets

Many departments are now making convincing business cases for deploying a wide range of new mobile tools featuring Global Positioning Systems (GPS), maps, and field data inquiry and collection. These include

- Laptop computers and tablets with web connectivity and or desktop GIS applications,
- Personal Digital Assistants (PDAs), originally standalone but now featuring wide area wireless connectivity (eg. Blackberries, Treos)
- GPS receivers with built-in reference maps or with links to PDAs for data collection
- Dash-mounted mapping systems
- Cell phones

Some require on-board storage of GIS data in proprietary formats, but the issues of currency, flexibility and maintenance encouraged innovators to seek ways to acquire GIS data only as it is needed.

Web Services

The key product of the OGC is a non-proprietary framework for requesting and receiving spatial information over the Internet. Data providers can publish their geographic data for use in any internet mapping or desktop GIS system in a single straightforward and standard format. Users and application builders can read data from several different sources, extracting only what they need as they need it, and treat each source as any other layer in the traditional GIS sense.

While utopian visions of world collaboration and greater cumulative utility drive some of the agenda, the standards have made a huge impact on interoperability within municipalities and among their more immediate community partnerships. The notion of standards and services is embraced by Canada's federal government, an early adopter and cultivator of framework technologies including metadata standards, prototype gazetteer services and the web services enabled uDIG desktop GIS viewer.

Standards and web services are also embraced by the Ontario government, which has been encouraging data collaboration, and use of web services and Open Source tools by municipalities through the Ontario Geospatial Data Exchange (OGDE), Land Information Ontario (LIO) portal and in the terms of reference for GeoSmart strategic planning.

GIS WEB SERVICES

We focus in this white paper on the two most important and mature web services standards, Web Map Services and Web Feature Services, both delivering immediate benefit for municipal government.

Web Map Services

As the name implies the key deliverable of Web Map Services is a map. Actually “map layer” may be more appropriate, because you can treat the output of a web map service as a layer in your own GIS applications. You can request maps from several web map services and stack them as needed.

The map is delivered in the form of a “raster” image, a picture comprised of dots like a digital photo. They’re not quite as “dumb” as a snapshot of your pet though, because they have real geographic coordinates assigned to their corners, and thus support computation of coordinates of any point within. In this way they replace the large amounts of data describing each element that are drawn in a traditional GIS data file.

A map that you request can be comprised of several layers from the WMS server and assembled using the provider’s display rules. For example, a base map for Roads might be comprised of separate layers for Highways, Arterials and Local Roads, with the local roads only showing when zoomed in close. The end user sees only a map published as Roads, with metadata describing it available . This greatly simplifies access for casual users who need to know nothing about GIS except that they need to show roads. The publisher sets line thickness and colour and visibility rules defining the level at which certain features are shown and others not. Thus, they might show a simplified set of lake polygons when zoomed out and more complex ones when zoomed in. This greatly reduces the amount of work their server does grinding out useless detail and lets the provider build one sensible set of rules for use by all.

A key benefit of this approach is for displaying maps on devices for which there is no GIS software. A cell phone, for example, has neither software nor processing capability to apply the plethora of rules concerning projection, symbology, scale visibility, labeling, etc. that we think of as GIS. However, using the WMS standards, they are able to request complete maps with simple requests and receive the result using very little bandwidth.

So what does the request look like? All WMS requests are in the form of an HTTP URL such as:

<http://mapthat.net/cgi-bin/wmsdemo?SERVICE=wms&VERSION=1.1.1&REQUEST=GetMap&LAYERS=States,Cities>

Additional clauses can be added to control key display features as illustrated:

Size of the map image returned (in pixels)	&WIDTH=200&HEIGHT=150
Desired Projection (standard codes)	&SRS=EPSG:4326
Background Transparency	&TRANSPARENT=TRUE
Area of interest (lower left, upper right)	&BBOX=-97.1,35.1,-87.5,41.5

GIS WEB SERVICES

The Area of Interest clause is a key component to programmatic use of the service. For example, a property tax system that is to display a customer's property for visual confirmation could use an address or roll number to find the coordinates of the property then compute a bounding box for the map request. In the Services Oriented Architecture (SOA), this too would be accomplished by requesting another service, a geocoder service, then passing the result on to the WMS for display.

This approach makes programming much simpler and consistent through a municipality's application framework. The same geocoder and web map services can be used by tax, parks, maintenance, CRM applications and others. The complexities of the data model, access control and much of the presentation details are hidden, leaving the programmer concerned only with making the map appear within the application where appropriate. They need not learn a specific vendor's Application Programming Interface (API); their programming will work regardless of the customer's GIS environment.

What about point and click Info about a property or facility? WMS fully supports return of attribute information for the features that are displayed. It does this by using the x-y screen coordinates of the mouse click and identifying features near that click point. The rules concerning which attribute data is displayed are specified at the server. Again the protocol is standardized and the benefits of the service oriented define-once-use-everywhere architecture make integration and interoperability more feasible than ever.

Web Feature Services

While WMS satisfies most location based service inquiry needs, there is one more functionality that municipal business applications might need -- the ability to extract or change the GIS or attribute information. For this need the OGC created Web Feature Services (WFS).

Web Feature Services differ from WMS in that the spatial information is in the form of a collection of vectors rather than a single raster image. Thus each point appearing on the map is defined as a pair of x-y coordinates; each street segment as a series of x-y coordinates; and each parcel, also a series, but one that ends back at its starting point. To achieve a universal way of expressing and transporting these collections, the OGC created the Geographic Markup Language (GML), a specialized subset of XML.

Once again, any application or device able to use WFS, can use the same GML file to recreate the map. There is more flexibility in how these features are displayed and used. For example, a programmer can create a copy of a land parcel polygon and colour it red to show that it is selected. They can show the endpoints of a line as big dots, that you can drag and drop to a new position. In this way you can change the geographic information.

A WFS enabled application can also let the user create completely new geographic features. A bylaw enforcement officer, for example, could create or add to a layer of mark ups or red lines using a light-weight map tool, showing the position of a non-compliant fence or outbuilding, or health inspector a well or stinking septic tank. On the

GIS WEB SERVICES

attribute side, WFS also allows a user to add or edit descriptive information about a new or existing feature gathered in the field using a handheld device.

The WFS standard currently supports the following operations for the geometry or attributes:

- 1.Create a new feature
- 2.Delete a feature
- 3.Update a feature and
- 4.Query features based on spatial and non-spatial criteria.

The other key benefit of WFS is that you can extract and copy the data for use in various end user devices. Thus the service can be used as a mechanism for distributing data to your extended network. Surveyors, for example, can select a polygon representing the limits of a development parcel and your horizontal and vertical control reference points. They can use this information in whatever CAD system they choose as the base data on which to build a subdivision plan. This provides a solution to one of the major roadblocks to the usefulness of electronic plan submission, speeds the development analysis process, and nullifies a traditional excuse developers use for keeping you on paper.

Benefits of Web Services

In making decisions about how and where to use GIS web services in your organization the following summary of benefits will be useful.

Flexibility

The key benefit of web services and the standards on which they are based is their ability to be used in almost all applications and on all devices. End users of desktop GIS are no longer bound to specific technologies because of the storage format and application interface of the geographic data store. Even the expensive proprietary spatial database engines like Oracle Spatial and SDE cannot match the universality of WMS. Now GIS can be delivered cheaply to all users through the application most suitable to their requirements. This opens new doors to desktop cost savings and opportunities for collaboration with external agencies.

Centralized Information Management

Another key benefit of the web services is the centralized nature of the architecture. The GIS management group can now focus on defining what information is to be displayed, how it should look and who can use it. Creating multiple copies of data sets and keeping track of what version of the truth shows up in reports and information products are time consuming and expensive information management tasks that are reduced to a single task in a single location.

Thinner and Faster

Since most of the reading, processing and writing of massive GIS data is done on a server, web services offer great opportunity to reduce load on LAN bandwidth, open doors for WAN access, and can deliver GIS to the lowliest, diskless desktop. The typical WMS output is 1-25 kB. Even with WFS, which send vectors in a somewhat bulky GML format, huge network efficiencies are achieved by sending only the data needed for the area of current interest.

Portability

The emergence of OGC standards and WMS and WFS services have created opportunities to put maps and mapping functionality everywhere, including GPS devices personal data assistants and phones. Innovation abounds in this area.

Multi Source Applications

Both WMS and WFS allow the application builder and end user to treat an individual service as one layer among many. This means that you can grab aerial photos from one service (eg Terraserver), lakes and rivers from another (eg NHD), and streets and administrative areas from another. This obviously opens new doors to outsourcing (eg orthos) and partnering (eg. Conservation Authority areas), making access to the most up to date and appropriate information possible and correctly managed by its stewards.

Information Product Focus

A long-standing bane of GIS has been the effort required for the preparation, maintenance and dissemination of raw data. Creating useful information from the data has traditionally required the same knowledge and skill as maintaining data, and since the value of the data asset must be maintained to be useful at all, making maps and spatial queries often take a lower priority.

For small organizations, this means that GIS technicians are stressed, forced to make uncomfortable prioritization decisions, or never seem to deliver anything visible. The build-once-use-everywhere architecture relieves these technicians of much of the back office work giving them time to produce information products and easier tools to help departmental users learn to build their own.

Lower Cost

Clearly the human resource cost of maintaining and disseminating data can be lowered with web services architecture. In addition, this new approach opens doors to many new technologies outside of the traditional desktop and web mapping realm. Installing and maintaining full function GIS software on desktops for simple map viewing can hardly be justified for any but the most advanced users anymore.

Every deployment and integration decision should now consider the browser (popup or embedded), browser components (ie J2EE and .NET), mapper components (ArcObjects, Geomedia Objects and Mapinfo MapX), and free WMS/WFS viewers (uDig). There are several other Open Source applications and components as well, but these are the subject of a future paper.

Conclusion

We trust that our description of web services, including WMS, WFS and geocoding services, has sparked questions and ideas on how they can be used in your organization. Our expectation is that the Service Oriented Architecture will grow rapidly over the next few years, having been embraced, cultivated and supported by the big GIS vendors.

OGC and the web services platform have been in the works since 1996. The WMS standard is ubiquitous and mature. WFS has some way to go at this time, but the standard is stable and the catch-up is just in the desktop implementation and integration. Mapinfo, Geomedia, Autodesk and uDig currently work can read and edit WFS features.

As you purchase your next generation applications to support your departmental business and enterprise information management ask yourself and your prospective vendors how you can achieve the benefits of web services.