

Interoperable Solutions in Web-based Mapping

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ABSTRACT

Interoperable Web-based mapping increases the capability to visualize geospatial data by enabling users to dynamically integrate multiple online data sources, unconstrained by format, data model, coordinate system, or vendor. This paper discusses the current status, benefits and practical uses of interoperable Web mapping technology. Particular emphasis is placed on the role of Web mapping protocols and standards adopted by the OpenGIS Consortium.

The combination of Web-based tools and services from multiple vendors, each with their own strengths and advantages, can result in even more powerful Web-based mapping and GIS solutions and support the development of “best-of-breed” end-user applications. These interoperable Web-based mapping applications are also able to utilize the various investments that organizations may already have made in Web-based technologies, as well as allowing integration with other organizations Web-mapping applications.

Interoperable Web-based mapping solutions can provide fast, efficient and seamless access to many types of data including raster imagery, vector GIS data, CAD files and 3D models, and can be integrated with metadata and databases. Case studies from the diverse realms of natural resource management and AM/FM will be used to demonstrate Web-based access and integration of multiple data types from various Web Map Servers and Image Web Servers.

Keywords

Interoperability, Web Mapping, Internet GIS, OpenGIS, Web Map Service

1. Introduction

Today, thousands of maps and images suitable for Web mapping are available on the Internet and there are expectations for ready access to, and integration of these data through a common Web browser. To meet these expectations, emerging industry standards for spatial data interchange and access across the World Wide Web (WWW) are being adopted by leading-edge software developers, often supported or complemented by government initiatives. The OpenGIS Consortium (OGC), an industry consortium of private companies, government agencies and universities, develops interface specifications for GIS interoperability through testbed activities and regular standard development procedures. This paper focuses on the success of simple interoperable Web mapping concepts and tools. We show that online integration of spatial information originating from various organizations and servers across the WWW, is possible through the implementation of interface specifications developed by the OGC. This is illustrated in Figure 1.

Web mapping implemented with proprietary software can work well if the same proprietary software is used both within your organization and externally in other organizations. However, this is already proving impractical as organizations are choosing different Web mapping software and technology based on functionality, price, ease of implementation, and other factors that best suite their requirements. Interoperable Web mapping increases the capability to visualize the data by enabling users to dynamically integrate multiple online data sources, unconstrained by format, data model, coordinate system, vendor technology, or rendering methods. Prior to the OGC specifications, it was only possible to connect a Web client to a specific vendor's Web server. The true realization of interoperable Web mapping requires the development of spatial interface specifications openly available for global use by software and technology providers. Recently, a prime

focus of the OGC has been in Web mapping interoperability. More than 50 draft specifications that are gradually being incorporated into commercial products currently exist. In the next few years this will have a revolutionary impact on Web mapping.

With OGC-compliant Web Clients and Servers, it is possible to connect to multiple map servers from various vendors and display a single, integrated map product. Organizations that deploy Web mapping technology, and who choose not to limit their users to a single vendor Client/Server software solution, will depend on interfaces that conform to OGC specifications. This will give them the advantage of being able to select the best products and solutions for their needs.

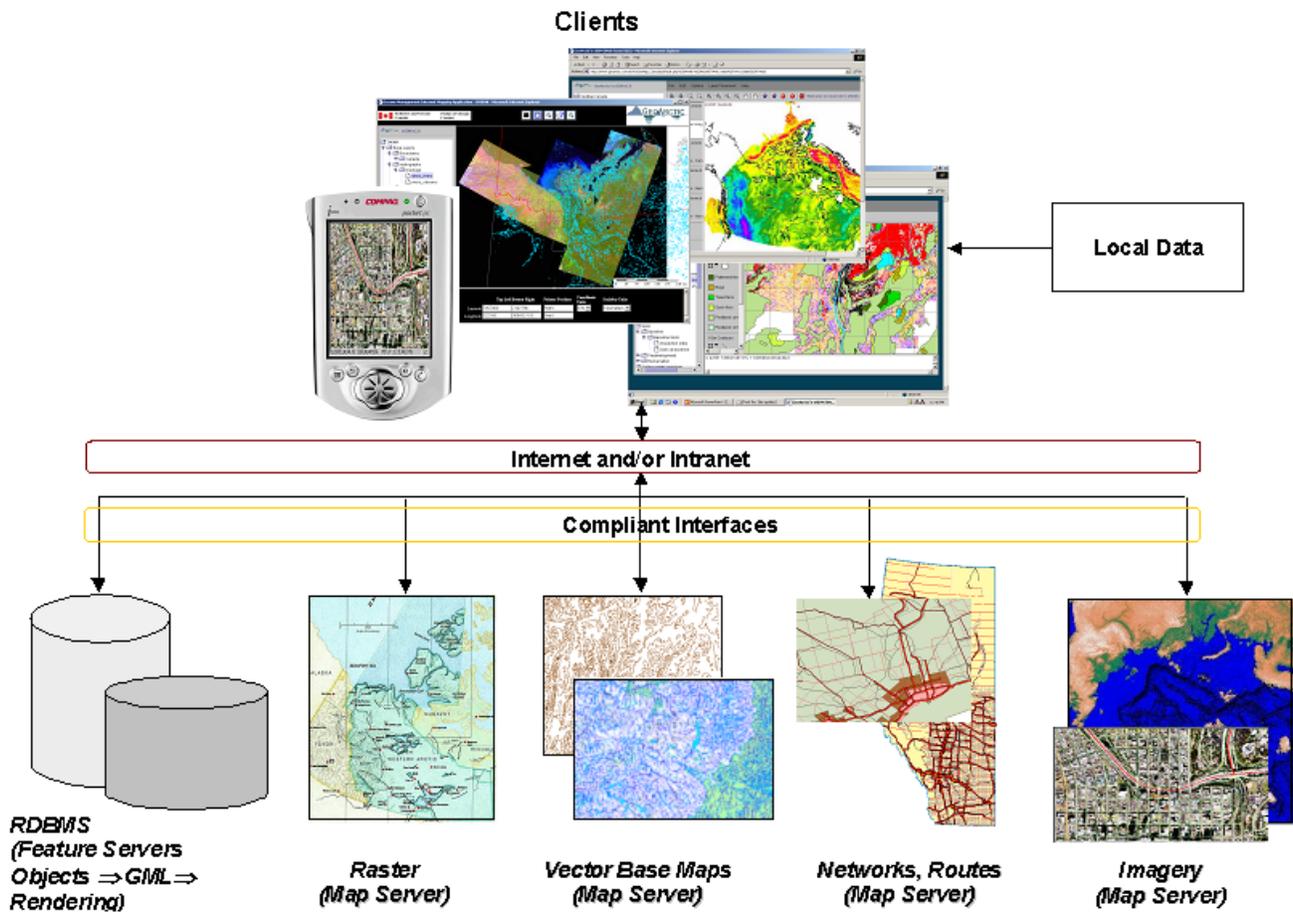


Figure 1: Summary Diagram Showing the OGC Web Map Service Architecture.

2. Interoperability and OGC Specifications

Consensus among software vendors and other participants in the *OGC Web Mapping Testbed* has created ways to develop software that enables users to overlay and manipulate geospatial data from different online sources and through different vendor software. This has resulted in the *OGC Web Map Service Implementation Specification* (hereinafter referred to as the OGC WMS) that describes a set of common interfaces for communicating a few basic commands and parameters that enables automatic overlay of geospatial data. Additionally, other OGC specifications will enable the sharing of geoprocessing services, such as coordinate transformation, over the WWW. Software developers and integrators who develop Web mapping software or who wish to integrate Web Mapping capabilities into broader Web-based information systems can easily add these open Web mapping interfaces to their products.

The OGC WMS specifications are evolving. WMS 1.0.0 was released in April 2000, WMS 1.1.0 was released in June 2001, and WMS 1.1.1 in December 2001 each with significant changes from its predecessor. The specifications define the request and response protocols for open Web-based Client / Map Server interactions to provide uniform access by HTML Clients to map layers from various Map Servers on the Internet. The specification provides a standardized way in which Clients request maps via the Web and the way that Map Servers describe their data holdings. The specifications are designed to work with catalog services defined in the *OpenGIS Catalog Services* specification. Software conforming to the WMS specification enables automatic overlay, in ordinary Web browsers, of maps obtained from multiple Map Servers.

3. Interoperable Servers and Clients

Implementation of OGC WMS specifications would allow users to open a Web browser with a Web mapping Client application, search the Web for mapping sources, and connect a map browser to various Map Servers. Web mapping services can be discovered through online directories that serve both spatial data and services information. Already there are commercial and non-commercial products and Web sites that demonstrate the effectiveness of the OGC WMS specifications. Implementation has been taking place even as the specifications are being developed. A number of companies report OGC-compliant Web mapping servers, including Autodesk, ESRI, Intergraph, CARIS, Cubewerx, and GeoArctic. GeoArctic has successfully implemented several specifications that have been agreed on by the OGC including a Web Map Service authoring toolkit for their core spatial data management product (SDM-geo), and an OGC-compliant Client that can connect to and display geospatial data from multiple Web Map Servers. Generally vendors have the ability to implement OGC interfaces quickly and effectively with few or no changes to the existing architecture of their core products.

Today, the OGC WMS defines three main interfaces that support Web Mapping:

- **GetCapabilities** – returns specifics on a map server, and available data and its formats
- **GetMap** – returns an image of a map according to the request.
- **GetFeatureInfo** – returns information about feature(s) as a query location.

A compliant Web Map Server can accept requests from a compliant Client and respond with map layers. Web Map Servers accept requests from Clients as standard HTTP URL strings and return results encoded as GIF, JPEG, PNG, GML, etc. The two mandatory operations defined in WMS 1.1.1 are *GetCapabilities* and *GetMap*. When a Client application needs to see what the Map Server is capable of serving, a *GetCapabilities* request is sent to the Map Server. *GetCapabilities* is used to obtain service-level metadata, which is a description of the Web Map Services information content and acceptable request parameters. The Server responds to the Client request by sending the *Capabilities* XML file, a document that advertizes what data types the Map Server can provide as well as the available data layers. GeoArctic's *Web Map Service Authoring Toolkit* reads project structure information from projects created with their SDM-geo software, converts it to a layer structure, and encodes it as a *Capabilities* XML. The output from *GetCapabilities* is a combination of static data about the Map Server capabilities and dynamic data queried from the SDM-geo database.

The *GetMap* operation is used to obtain a map. The content of the URL depends on which of the tasks is requested. *GetMap* has nine mandatory parameters that must be passed:

VERSION=version The WMS version.

REQUEST=GetMap Request name

LAYERS=layer_list Comma-separated list of one or more map layers.

STYLES=style_list Comma-separated list of one rendering style per requested layer.

SRS=namespace; identifier Spatial Reference System

BBOX=Bounding box corners (LL, UR) in SRS units.

WIDTH=output_width Width in pixels of map picture.

HEIGHT=output_height Height in pixels of map picture.

FORMAT= output_format Output format of map.

A compliant Map Server generates a map layer in response to a parameterised request issued by a Client. This is transferred in the normal way and displayed in the Web browser. In response to a *GetMap* request the Server sends a map back to the Client conforming to the exact geographic area, size, projection, style, and encoding specified by the Client. When two or more maps are produced with the same Bounding Box, Spatial Reference System, and output size, the results can be accurately layered to produce a composite map.

The OGC WMS provides a mechanism to generate maps dynamically and to overlay them in Web browsers. The maps are displayed in a Viewer Client, which is a software component that issues requests to Map Servers and renders or displays the map layers from those Map Servers. In its simplest form a View Client is an HTML page running inside a Web browser. However, a more sophisticated View Client can be implemented in any number of ways — JavaScript, VBScript, Java, Java Servlets, Java Applet, Active X Control, Browser Plugin, etc. Clients can run on various devices including mobile devices and desktop computers. Geospatial information is stored on the Server side and displayed on the Client side, which means that the geospatial information has to be transferred in some way from Server to Client. Data can be transferred as vectors or as bitmaps, both of which enable layers to be combined from different sources. Custom client applications can be built that can integrate CAD, vector, raster, and other data to provide a “best-of-breed” solution.

The various available Map Servers can provide data from in a variety of proprietary and non-proprietary formats. However, one of the standard transfer protocols supported and developed by the OGC is GML or Geography Markup Language. GML is an XML based encoding standard for geographic information that has been designed to separate data content from data presentation. In other words, GML provides mechanisms for the encoding of geographic feature data without regard to how the data may be presented for display. GML can be styled into a variety of presentation formats including vector and raster graphics, text, sound and voice and can be used for many different purposes on many different devices. Generation of graphical output such as maps is one of the most common presentations of GML and to make maps from GML the GML elements may be styled into forms that can be interpreted for graphical display in a web browser, using graphical display formats such as the WWW Consortium (W3C) Scalable Vector Graphics (SVG).

4. Applications of Interoperable Web-Based Mapping

Servers conforming to OpenGIS WMS 1.1.1 will provide Web sites and mobile devices with many new applications of Web mapping technology. The applications and uses of interoperable Web Mapping are limitless and GeoArctic has worked on several successful and diverse implementations.

GeoArctic, the Geological Survey of Canada and the Canada-Nunavut Geoscience Office collaborated on a GeoConnections initiative to Web-enable eastern Canadian Arctic geoscientific data. The purpose of the project was two-fold: consolidation of geoscientific datasets for the region; and implementation of interoperable Web mapping technologies to manage and deliver geospatial data to multiple users. The project objective was to provide distributed Web-enabled geoscientific data for the Eastern Canadian Arctic, which are discoverable via the GeoConnections Discovery Portal (formerly CEONet), and that could be accessed, integrated, and manipulated in a GIS applet. The GeoConnections Discovery Portal is the prime discovery and access component of the Canadian Geospatial Data Infrastructure (CGDI), which is an inter-governmental, private sector and academia effort to provide easy, consistent and harmonized access to geographic information and services. The project resulted in one of the first operational implementations of the WMS 1.1.0 specification, and demonstrated how geospatial data from distributed Map Servers could be accessed and integrated via the GeoConnections Discovery Portal. Providing users with the capability to access and integrate the geoscientific data, independent of their physical location will help to communicate natural resource potential, support exploration planning, and aid scientific research in the region.

Oceans Management Internet Mapping Application (OMIMA) is a pilot Internet-based mapping project undertaken by the Oceans Program Division of the Department of Fisheries and Oceans for Central and Arctic region (OPD-C&A) in partnership with GeoArctic International Services Ltd. Oceans Program Division is responsible for the implementation of the Oceans Act, which came into force in 1997. DFO-C&A partnered with GeoArctic International Services to participate in an OMIMA pilot project and provide a testbed for the development of new Web-GIS tools for GeoArctic’s *SDM-geo* software. GeoArctic is developing a Web Mapping Service (WMS) Authoring Toolkit to publish geospatial data to the Internet in a project supported by a Natural Resources Canada funded GeoInnovations initiative. The toolkit will conform

to OGC specifications, in particular to the OGC Web Map Service Interface (Michalak and Wojnarowska, 2002). This will integrate with other OGC compliant initiatives such as the Marine Geospatial Data Infrastructure (MGDI) DFO geportal.

An application developed by GeoArctic for the utilities industry provides users with a sophisticated custom Client that allows for the integration of CAD, high-resolution compressed imagery, and vector data, as well as supports query of a proprietary utilities database. Imagery is served from Earth Resource Mapping's Image Web Server, vector basemap and transmission line and station data is served from an open source map server, and CAD engineering and plan and profile drawings are linked to the map using Autodesk's WHIP viewer. Other geospatial information such as environmental data, soils, and other layers may be accessed and retrieved from OGC-compliant Servers hosted by government agencies and data brokers as they become available.

5. Conclusion

Dramatic changes in Web mapping are likely to arise from the many Web mapping interoperability projects conducted by the OGC. Interoperable Web-Based Mapping solutions will provide fast, efficient and seamless access to many diverse data. In the future interoperable Web mapping will reduce duplication of datasets and services, providing users with a single window access to geospatial data and services.

Interoperable Web-based mapping increases the capability to visualize geospatial data by enabling users to dynamically integrate multiple online data sources, unconstrained by format, data model, coordinate system, or vendor. The implementation of OGC specifications means that organizations need not limit their users to a single vendor Client/Server software solution, which will enable them to select the best Web mapping products or develop "best-of-breed" custom Client applications to suit their needs.

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