The Open Geospatial Consortium Web Map, Web Feature and Web Coverage Service Standards – an Overview

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Abstract— **This workshop will provide a high-level overview of the Open Geospatial Consortium's Web-Map, Web-Feature, and Web-Coverage Service standards. Issues addressed will include the contrasting roles that the standards play in a geospatial web service framework, the characteristics that they share, and the differences between them. These characteristics will be illustrated through reference to a set of services hosted at EDAC running Minnesota MapServer.**

Index Terms— **Information Technology, Standards, Interoperability**

I. INTRODUCTION

The purpose of this workshop is to provide a technical overview of the Open Geospatial Consortium's (OGC) Web Map [1], Web Feature [2], and Web Coverage [3] Services (WMS, WFS and WCS respectively, collectively referred to as WxS throughout this document) in order to give workshop attendees sufficient background information regarding the standards to be able to:

- Identify the applicable web services model for a particular application
- Understand the functional characteristics of each standard
- Provide resource information for support in implementation and more detailed service information

II. OGC WEB SERVICE MODELS

At the highest level, the three OGC web service specifications under discussion represent two methods of representing two types of geospatial data to requesting systems or human users. The two available representation methods are as map data (without provision of the underlying geospatial data) or as geospatial data suitable for ingestion, processing, and updating (in the case of WFS) in geospatially enabled analysis and visualization environments like Geographic Information Systems (GIS). The two types of geospatial data addressed by these standards are *feature* and *coverage* data, also commonly referred to as vector and raster or gridded data. All three standards: WMS, WFS, and WCS; provide a mechanism for accessing geospatial data from distributed service providers, therefore facilitating the development of distributed geospatial data applications and interfaces. Furthermore, the WFS standard defines an optional mechanism for remote data updating.
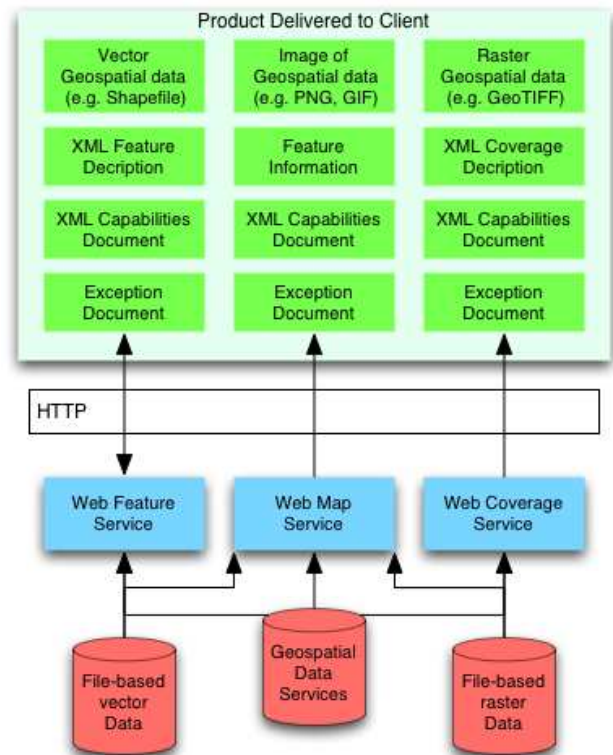

Fig. 1. Relationship between delivered data types and OGC Web Service standards

Figure 1 illustrates the relationship between source data (at the bottom of the diagram), the three service types (in the middle of the diagram), and the provided data products (at the top of the diagram). Specifically, Web Feature Services may be based upon file-based vector data like ESRI Shapefiles or Coverages, GML files [4], or U.S. Census TIGER data; and, depending upon the capabilities of the server providing these services, a WFS may also access and serve data acquired from other geospatial data services such as other WFS servers or OPeNDAP[1] servers. Similarly, Web Coverage Service providers may host file-based raster data in formats such as Arc/Info Binary Grids, ERDAS Imagine .img files, GeoTIFFs, and GRASS rasters; and, again depending upon the

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[1] http://www.opendap.org

server capabilities, may be able to access other data services as a data source. Web Map Services may access file-based raster and vector data while also accessing remote geospatial data services as source. In the cases where the WxS providers are accessing other data services the WxS provider acts as a client to those other services while acting as a server to client request for WxS. Data obtained from other web service providers by the WxS server are known as *cascaded* layers.

The middle objects in Figure 1 (the blue rectangles) represent the WxS server types to which requests may be submitted. Requests are submitted using the HTTP protocol's [5] GET or POST request types with the response types associated with those requests defined by the service type (WMS, WFS, WCS) and the request made.

Common to all three service types is the *GetCapabilities* request which returns an XML document providing high-level information about the service (metadata) and its component layers. Additional metadata about specific features (WFS) or coverages (WCS) may be requested through the WFS *GetFeatureType* and WCS *DescribeCoverage* requests, respectively.

The metadata requests listed above are generally a precursor to requests for actual data, either in the form of a file containing geospatial data (WFS and WCS), a mapped representation of those data (WMS), or attribute information about a given feature or features (WMS). The responses to these requests are the primary distinguishing characteristics between the WxS services. WMS is oriented towards the provision of mapped data (an image representing the data, not the actual data themselves) in response to the *GetMap* request. The attributes of specific features may be requested through the WMS *GetFeatureInfo* request.

In contrast, the WFS and WCS standards provide request methods that return geospatial data suitable for use in GIS or other geospatial analysis environments. WFS specifies two request types that return geospatial feature data, the *GetFeature* and *GetGmlObject* requests. Both of these requests may return a subset of features, in GML or another specified and supported geospatial data format, that meet query and other criteria specified in the request. WCS provides data access functionality through the *GetCoverage* request. A WCS will provide raster geospatial data (a coverage) in at least one of five specified formats (GeoTIFF, HDF-EOS, DTED, NITF, or GML), and may provide the data in other formats, if configured to do so [3, pg. 29-30].

Specific to the WFS standard is an additional remote data update capability that is enabled by the *LockFeature* and *Transaction* operations, the first of which provides feature locking while an update is in process, and the second of which submits the update to the server for action. These advanced features are optional in WFS implementations that meet the requirements of the standard.

Common to all three WxS standards is a mechanism for reporting error conditions (exceptions) to the client in a standard, defined format. Typically, exception documents are returned in XML, but other formats may be requested by the client, if supported by the server.

The next section expands upon the above discussion by providing more detailed information about each of the above

listed requests, specifically in terms of supported request formats and required and optional parameters associated with each request.

III. FUNCTIONAL CHARACTERISTICS

In examining the functional characteristics of the WxS standards the primary focus is on the types of requests, the required and optional parameters for those requests, and the resultant responses and their potential formats. Detailed descriptions of all of the parameters for each standard may be found in the OGC specification documents [1]–[3] from which this information was derived. Each standard-specific section below begins with a description of the request and response formats which is then followed by a table summarizing the parameters associated with each request type.

A. Web Map Services (WMS ver. 1.3, Draft International Standard ISO/DSO 19128)

Compliant WMS servers must support requests submitted as HTTP GET requests, while they may optionally also support HTTP POST requests. When a request is made as an HTTP GET request, the parameters are provided as a set of name-value pairs appended to the URL in a manner consistent with the HTTP standard. If the request is made as an HTTP POST request, the provided paremeters must be encoded into an XML document included in the body of the POST message.

The output formats specified by the WMS standard vary depending upon the submitted request. In the case of a *GetCapabilities* request, the output format for the returned capability document is XML. In the case of a *GetMap* request, the output format is required to be "either 'picture' formats or 'graphic element' formats" [1, pg. 7]. Picture formats are exemplified by files of type Graphics Interchange Format (GIF), Portable Network Graphics (PNG), Joint Photographics Expert Group (JPEG), or Tagged Image File Format (TIFF). Graphic element formats provide a scale-independent representation of graphic objects and are exemplified by the Scalable Vector Graphics (SVG) and Web Computer Graphics Metafile (WebCGB) formats [1, pg. 8]. Response documents generated for *GetFeatureInfo* requests are most commonly XML files.

Table I outlines the parameters that make up the above listed request types.

B. Web Feature Services (WFS ver. 1.1.0)

Three classes of WFS are defined in the specification:
- **Basic**: a read-only WFS that supports the *GetCapabilities*, *DescribeFeatureType*, and *GetFeature* requests.
- **XLink WFS**: adds the *GetGmlObject* operation, including local and/or remote XLinks capabilities to the Basic WFS.
- **Transaction WFS**: adds the *Transaction* operation and optionally the *GetGmlObject* and/or the *LockFeature* operations. This WFS enables remote updating of features from the client.

The WFS specification requires support for one or both of the HTTP GET and POST request methods. This is in

Parameter	Request		
	GetCapabilities	GetMap	GetFeatureInfo
VERSION	O	M	M
SERVICE	M		
REQUEST	M	M	M
FORMAT	O	M	GetMap
UPDATESEQUENCE	O		
LAYERS		M	GetMap
STYLES		M	GetMap
CRS		M	GetMap
BBOX		M	GetMap
WIDTH		M	GetMap
HEIGHT		M	GetMap
TRANSPARENT		O	GetMap
BGCOLOR		O	GetMap
EXCEPTIONS		O	O
TIME		O	GetMap
ELEVATION		O	GetMap
other dimensions		O	GetMap
QUERY_LAYERS			M
INFO_FORMAT			M
FEATURE_COUNT			O
I			M
J			M
M=Mandatory, O=Optional			

TABLE I

WEB MAP SERVICE (VER. 1.3) PARAMETERS

contrast to the WMS specification of required support for GET requests and optional support for POST requests. Requests submitted using the GET method are encoded using keyword-value pairs while the POST method required that request parameters be encoded using a specified XML schema. The WFS specification also addresses the capability of submitting a Simple Object Access Protocol (SOAP) request to a WFS server (if this capability has been enabled) with the WFS request XML being inserted into the soap:Body element.

Extensible Markup Language (XML) is the primary encoding for data returned in response to WFS requests, with Geography Markup Language (GML, an encoding of geospatial data in XML) used as the standard method of providing geographic data. Exception reporting consists of returning an XML document compliant with the OGC Web Services Common Specification exception response schema [6].

Table II summarizes the parameters associated with the request types listed above for the WFS specification.

C. Web Coverage Services (WCS ver. 1.0.0)

The Web Coverage Services (WCS) specification provides a method for the provision of data that are continuous across space and are generally represented as regularly spaced grids of values, also known as rasters. This type of data contrasts with that provided by WFS in that WFS provides access to geospatial entities (features) that have distinct geometries (points, lines, polygons) and attributes associated with those entities.

The WCS specification defines three request types, *GetCapabilities*, *DescribeCoverage*, and *GetCoverage*. Like WFS, WCS allows for implementing services to accept HTTP GET and/or POST requests, with GET requests consisting of keyword-value pairs encoded into the URL of the request, and POST requests also encoding keyword-value pairs into the message body. Extensible Markup Language (XML) is also supported as an alternative method for GET (uncommon), and

POST method requests. Similar to the WFS specification, an XML WCS request may be embedded into a SOAP request by inserting the XML WCS request into the soap:Body element.

The data returned to in response to a given request depends upon the request and its associated parameters. The standard response encoding for the *GetCapabilities* and *DescribeCoverage* requests is XML, with the format of the returned XML document defined by the XML schemas defined in the WCS specification. A WCS will provide raster geospatial data (a coverage) in at least one of five specified formats (GeoTIFF, HDF-EOS, DTED, NITF, or GML), and may provide the data in other formats, if configured to do so [3, pg. 29-30].

Table III provides a summary of the parameters associated with the *GetCapabilities*, *DescribeCoverage*, and *GetCoverage* requests.

IV. ADDITIONAL RESOURCES

The key references for these specifications are available from the Open Geospatial Consortium's Specifications[2] web page, where Portable Document Format (PDF) versions of the current specification documents are available for download. Server and client implementation information for these standards may be obtained from the OGC Registered Products[3] web page.

ACKNOWLEDGMENTS

RESOURCES

Open Geospatial Consortium: http://www.opengis.org

[2]http://www.opengeospatial.org/specs/?page=specs
[3]http://www.opengeospatial.org/resources/?page=products

Parameter	GetCapabilities	DescribeFeatureType	GetFeature & GetFeatureWithLock	GetGmlObject	LockFeature	Transaction
			Request			
VERSION	O	M	M	M	M	M
SERVICE	M	M	M	M	M	M
REQUEST	M	M	M	M	M	M
NAMESPACE	O	O	O	O	O	O
TYPENAME		O	O/M		O/M	O/M
OUTPUTFORMAT		O	O			
RESULTTYPE			O			
PROPERTYNAME			O			
FEATUREVERSION			O			
MAXFEATURES			O			
EXPIRY			O		O	
SRSNAME			O			
FEATUREID			O		O	O
FILTER			O		O	O
BBOX			O		O	O
SORTBY			O			
TRAVERSEXLINKDEPTH			O[a]	M		
TRAVERSEXLINKEXPIRY			O[a]	M		
PROPTRAVXLINKDEPTH			O[a]			
PROPTRAVXLINKEXPIRY			O[a]			
GMLOBJECTID				M		
LOCKACTION					O	
OPERATION						M
RELEASEACTION						O
Vendor specific	O	O	O	O	O	O

M=Mandatory, O=Optional
[a] GetFeature only

TABLE II

WEB FEATURE SERVICE (VER. 1.1.0) PARAMETERS

Parameter	GetCapabilities	DescribeCoverage	GetCoverage
	Request		
REQUEST	M	M	M
VERSION	O	M	M
SERVICE	M	M	M
SECTION	O		
UPDATESEQUENCE	O		
COVERAGE		O	M
CRS			M
RESPONSE_CRS			O
BBOX			M[a]
TIME			M[a]
PARAMETER			O
WIDTH			M[b]
HEIGHT			M[b]
DEPTH			M[b]
RESX			M[b]
RESY			M[b]
RESZ			M[b]
FORMAT			M
EXCEPTIONS			O

M=Mandatory, O=Optional
[a] Either BBOX or TIME is mandatory
[b] Either WIDTH/HEIGHT/DEPTH or RESX/RESY/RESZ are mandatory

TABLE III

WEB COVERAGE SERVICE (VER. 1.0.0) PARAMETERS

REFERENCES

[1] J. de La Beaujardiere, Ed., *Web Map Service*. Open Geospatial Consortium, 2004, no. OGC 04-024, version 1.3.

[2] P. A. Vretanos, Ed., *Web Feature Service Implementation Specification*. Open Geospatial Consortium, 2002, no. OGC 02-058, version 1.0.0.

[3] J. D. Evans, Ed., *Web Coverage Service (WCS), Version 1.0.0.* Open Geospatial Consortium, 2003, no. OGC 03-065r6.

[4] S. Cox, P. Daisey, R. Lake, C. Portele, and A. Whiteside, Eds., *OpenGIS Geography Markup Language (GML) Implementation Specification*. Open Geospatial Consortium, 2003, no. OGC 02-023r4, version 3.00.

[5] J. Gettys, J. Mogul, H. Frystyk, L. Masinter, P. Leach, and T. Berners-Lee, Eds., *RFC 2616 – Hypertext Transfer Protocol – HTTP/1.1.* Internet Engineering Task Force (IETF), 1999, version 1.1.

[6] A. Whiteside, Ed., *OGC Web Services Common Specification*. Open Geospatial Consortium, 2005, no. OGC 05-008, version 1.0.

Karl Benedict Dr. Benedict's technical background includes 18 years hands-on computer solution implementation experience including: relational database design and administration; information needs assessment; network design, implementation, and administration; system specification, configuration, and administration; end-user support provision; multiple system and application integration; and Internet application development employing a combination of commercial and open-source server applications based upon Perl, PHP, Python, ColdFusion, Zope and Plone. Dr. Benedict has worked with applications running under AIX, Linux, Microsoft Windows, and the Macintosh OS, and currently is a Senior Research Scientist at and manages the IT program for the Earth Data Analysis Center at the University of New Mexico.