Open Geospatial Consortium Inc.

Date: 2004-07-02

Reference number of this OpenGIS® document: **OGC 04-039**

Version: 0.2

Category: OpenGIS® Discussion Paper

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Geospatial Portal Reference Architecture

A Community Guide to Implementing Standards-Based Geospatial Portals

This Guide has been developed by the members of the Open Geospatial Consortium, Inc. to assist the global geospatial technology community in implementing standards-based geospatial portal solutions that are compatible with Spatial Data Infrastructures in every nation. We offer this document as a resource for rapid development and informed acquisition of portals and portal-exploiting applications that can plug and play with geospatial data and services in your organization and other organizations in your community and around the world.

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Preface

This guide provides a resource to decision makers and technologists who are working to implement geoprocessing solutions within their organizations. Whether you are a procurement official working to procure geoprocessing technologies or a technology provider extending existing systems or developing new technology solutions, this guide will be an important resource.

The Geospatial Portal Reference Architecture documents a “core” set of interoperability agreements that provide instructions for bridging the gaps between different organizations and communities that have heretofore shared geospatial information only with great difficulty. The portal addresses technical interoperability between diverse systems and it also helps address "information interoperability" between groups whose content has been created with different data models and metadata schemas.

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Revision History

Date	Release	Author	Paragraph modified	Description
6/29/04	0.1	Louis Rose	All	Re-written to be more generically presented
7/2/04	0.2	Louis Rose	All	Incorporated initial review comments from the GovSIG

Future Work

OGC welcomes improvements in this document that reflect the experience of those implementing this service architectural framework in their own service types and instances.

Executive Summary

The Geospatial Portal Reference Architecture documents a "core" set of interoperability agreements that provide instructions for bridging the gaps between different organizations and communities that have heretofore shared geospatial information only with great difficulty. The Geospatial Portal Reference Architecture provides the basis for an open, vendor-neutral portal that is intended to be a first point of discovery for geospatial content in the context of designing and implementing the Spatial Data Infrastructures being developed by over 50 nations throughout the world. In addition, the Geospatial Portal Reference Architecture has been developed in a manner that allows it to be aligned with other reference models and high level enterprise architectures.

The Geospatial Portal Reference Architecture is founded on the tenants of a Service Oriented Architecture (SOA). An SOA is an architecture that represents software functionality as discoverable services on a network yielding the following benefits:

- Easier extension of legacy logic to work with new business functionality
- Greater flexibility to change without the need to constantly re-architect for growth
- Cost savings by providing straight-forward integration.

The Geospatial Portal Reference Architecture specifies four service classes that are needed to procure a comprehensive geospatial portal implementation and it identifies the OpenGIS Interoperability Standards that are applicable to the services. The four service classes are:

- **Portal Services** –Provide the single point access to the geospatial information on the portal. In addition, these services provide the management and administration of the portal.
- **Catalog Services** –Used to locate geospatial services and information wherever it is located and provide information on the services and information if finds to the user.
- **Portrayal Services** –Used to process the geospatial information and prepare it for presentation to the user.
- **Data Services** – Used to provide geospatial content and data processing.

The Geospatial Portal Reference Architecture is a major step forward for E-Government, National Spatial Data Infrastructures, enterprises and Information Communities. It enables geoprocessing interoperability that make it possible to exchange heterogeneous geographic information content and share a wide variety of geospatial services over the World Wide Web.

1 Introduction

A portal is a website that acts as gateway providing a single access point to multiple resources. It is a web environment that allows an organization or a community of information users and providers to aggregate and share content. It is an organized collection of links to other sites. A portal may be secure and it may be personalized. A geospatial portal is a human interface to a collection of online geospatial information resources, including data sets and services.

Around the world, over 50 nations are developing Spatial Data Infrastructures (SDI). These national activities are supported by regional collaborative efforts in Asia and the Pacific, Europe, the Americas and Africa and in an emerging Global Spatial Data Infrastructure (GSDI) effort. While there are many differences in economic, social and legal frameworks around the world, the GSDI is being fueled by widespread agreement on common approaches in many fundamental Spatial Data Infrastructure development and implementation practices.

Through the coordination efforts of the Global Spatial Data Infrastructure Steering Committee (now the GSDI Association), the GSDI is taking on a clear form and substance. It consists of standardized Geospatial Metadata, a Network of Spatial Data Clearinghouses operating on common standards-based protocols, and an emerging agreement on a set of core data sets that will be globally available to serve as base content for SDI linkage, for common use in spatial data applications, and for further attribution and densification for larger scale use. The GSDI includes OpenGIS Standards as a key enabler of interoperability between geoprocessing systems.

The philosophy and work of the various nation SDI efforts as well as the GSDI Association are clearly in line with the Declaration of Principals from the World Summit on the Information Society was hosted in Geneva by the Government of Switzerland from 10 to 12 December 2003. The Declaration of Principles WSIS-03/GENEVA/DOC/0004 concluded in paragraph 44:

> ***Standardization is one of the essential building blocks of the Information Society.*** *There should be particular emphasis on the development and adoption of international standards. The development and use of open, interoperable, non-discriminatory and demand-driven standards that take into account needs of users and consumers is a basic element for the development and greater diffusion of ICTs and more affordable access to them, particularly in developing countries. International standards aim to create an environment where consumers can access services worldwide regardless of underlying technology.*

This document defines the Geospatial Portal Reference Architecture that provides the basis for an open, vendor-neutral portal that is intended to be a first point of discovery for

geospatial content in the context of designing and implementing an SDI. The reference architecture described in this document is a general architectural framework for standards-based geospatial portals that provide open Web access to geospatial content and online geoprocessing services from diverse public and private sector sources. Such portals can be built from interoperating products supplied by vendors whose products use interfaces, protocols, schemas, and encodings that implement OGC's OpenGIS Standards.[1] The essential requirement is that it must be "as open as the Web," open to as many other Web-based geospatial resources as possible, through interfaces, encodings and schemas that conform to OpenGIS Specifications.

1.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply:

binding: specific syntax and parameter values used by a client to invoke a specific server operation

catalog: <<< First mention of a Catalog. Need a definition that includes the fact that a Catalog is also a registry>>>

client: software component that can invoke an operation from a server or conceptual role as originator of an operation request.

content: data or information stored in a server

feature: an abstraction of a real world phenomenon (from ISO 19107)

interface: named set of operations that characterize the behavior of an entity [OGC AS 12]

map: pictorial representation or portrayal of geographic content

operation: specification of a transformation or query that an object may be called to execute [OGC AS 12]

request: invocation of a server operation by a client

response: result of an operation returned from a server to a client

server: actual implementation of a service or conceptual role as recipient of an operation request.

service capabilities: service-level metadata describing the types, operations, content, and bindings available at a service instance. Organization, classification, and presentation of those entities may also be conveyed by the capabilities information.

service: A collection of operations, accessible through an interface, that allows a user to invoke a behavior of value to the user (definition from ISO 19119).

spatial reference system (SRS or CRS): a projected or geographic coordinate reference system

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[1] OpenGIS Specifications are consensus-derived global standards for distributed geoprocessing.

2 Geospatial Portal Overview

2.1 Geospatial Portal Description

The overall goal for Geospatial Portal Reference Architecture is to make it easier, faster, and less expensive for any organization wishing to implement a standards based geospatially enabled portal application. A primary objective of the reference architecture is to define the requirements of an architectural framework that can be used as a guide to the implementation of an operational portal that provides access to geospatial content, maps, and metadata. This reference architecture specifies the scope, objectives and behavior of a portal and identifies its functional components. In addition to identifying the general requirement of an effective geospatial portal, this document highlights how OpenGIS Standards explicitly support the capabilities of the reference architecture.

The Geospatial Portal Reference Architecture is shown in Figure 1. The reference architecture contains five different classes of services that support the requirements of a geospatial portal.

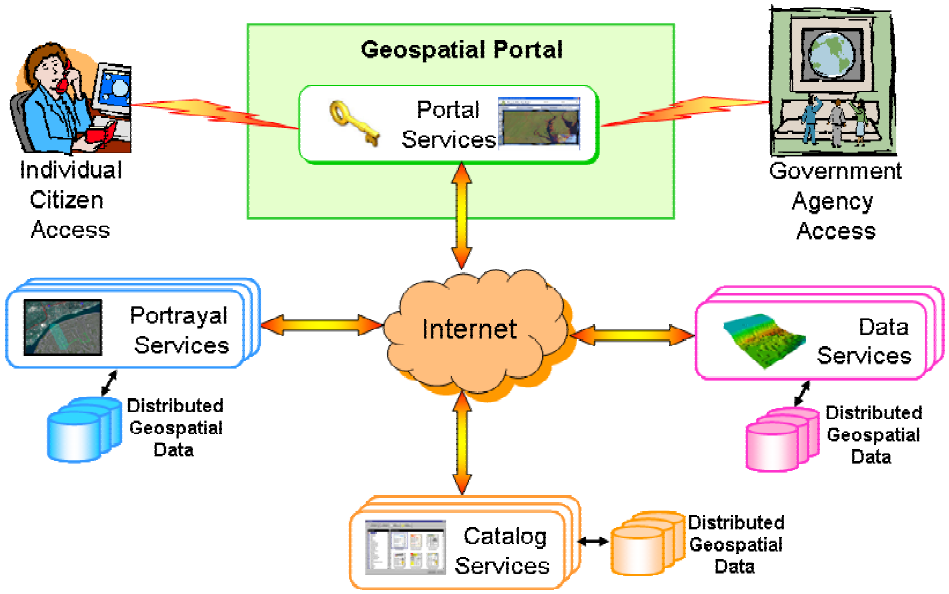

Figure 1. The Geospatial Portal Reference Architecture

A brief description of these service classes is presented here with more detailed descriptions provided in section 3 of this documents:

- **Portal Services** –Provide the single point access to the geospatial information on the portal. In addition, these services provide the management and administration of the portal.

- **Catalog Services** –Used to locate geospatial services and information wherever it is located and provide information on the services and information if finds to the user.

- **Portrayal Services** –Used to process the geospatial information and prepare it for presentation to the user.

- **Data Services** – Used to provide geospatial content and data processing.

It is important to understand that the Portal Services and any required Infrastructure Services are the only ones that need be resident on the platform on which the portal is operating. All of the other services can be distributed across the Internet and can be dynamically registered and executed. Also notice that the Portal does not store the geospatial data processed by the distributed services. This loosely coupled service orientation is known as a service oriented architecture, which is described in more detail subsequence section.

2.2 Service Oriented Architecture (SOA)[2]

Service orientation is a way of viewing software assets on the network—fundamentally, the perspective of IT functionality being available as discoverable Services on the network. Essentially, Service orientation provides business users with understandable, high-level business Services they can call upon and incorporate into business processes as needed. The Service orientation vision is therefore one of agility and flexibility for users of technology, coupled with an abstraction layer that hides the complexity of today's heterogeneous IT environments from those users.

Service-Oriented Architecture (SOA) is an architecture that represents software functionality as discoverable Services on the network. SOAs have been around for many years, but the difference with the SOAs we talk about today is that they are based on standards, in particular, *Web Services*. Web Services provide standards-based interfaces to software functionality. Producers of these Services may publish information about them in a Service registry, where Service consumers can then look up the Services they need and retrieve the information about those Services they need to bind to them.

Applications designed using SOA can provide the same functionality as that found in a monolithic architecture coupled with the following additional benefits:

- Easier extension of legacy logic to work with new business functionality
- Greater flexibility to change without the need to constantly re-architect for growth
- Cost savings by providing straight-forward integration

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[2] The 2004 ZapThink paper *The SOA Implementation Framework*: *The future of service-oriented architecture Software* is an excellent reference on SOA.

Within the SOA context, therefore, the Portal is the ideal mechanism for realizing the Web Services vision of "enter once, use often" by providing a bridge between "separate islands of data and processing services." The portal does not store any content. Therefore, the geospatial content and services remain with the responsible authority- those agencies or private sector organizations responsible for the collecting and maintaining geospatial content continue to retain control of those activities. The authoritative source for geospatial content and services becomes the Portal as the conduit to disparate and distributed content and services. The OGC reference architecture is a service-oriented architecture based on the now recognized Web Services paradigm of the publish/find/bind pattern and supports the dynamic binding between service/content providers and requestors since sites and applications are frequently changing in a distributed environment. Content and service providers publish their availability to the portal's catalog making their information "known" to the portal.

2.2.1 Publish-Find-Bind

The core method of communications within the portal is based on service-oriented architecture that follows a service trading paradigm. Service trading is a fundamental concept that addresses the discovery of available service instances. Publishing a capability or offering a service is called "export" (publish). Finding a service request against published offers or discovering services is called "import" (Find). Binding a client to a discovered service is called "service interaction" (Bind). This can also be depicted in an equivalent manner as the "Publish – Find – Bind" (PFB) pattern of service interaction. These fundamental roles and interactions are depicted in Figure 2.

This service trading function is elaborated in a separate document (ISO/IEC 13235-1) and refined somewhat in the Object Management Group (OMG) Trading specification, which is technically aligned with the computational view of the ODP trading function. Most importantly, a broker supports dynamic (i.e. run-time) binding between service providers and requesters, since sites and applications are frequently changing in large distributed systems. A broker registers service offers from provider objects and returns service offers upon request to requestor objects according to some criteria.

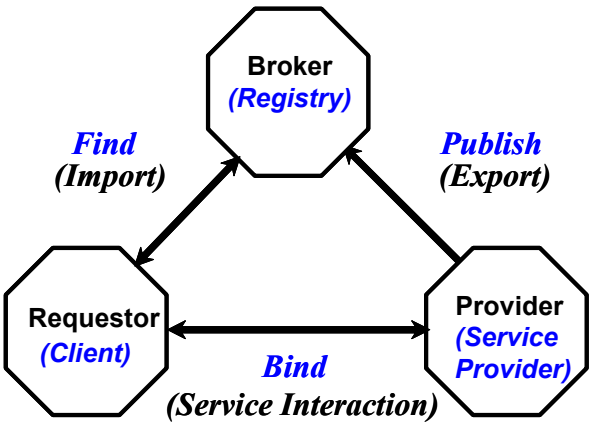

Figure 2. Service Trading Communication Structure

In the portal reference architecture, there are three fundamental roles that are defined to actuate the service trading. They are:

Broker - a role that registers service offers from service providers and returns service offers upon request to requestor according to some criteria.

Provider - a role that registers service offers with a broker and provides services to clients.

Requestor - a role that obtains service offers, satisfying some criteria, from the broker and binds to discovered services provided by the provider.

To export (i.e. publish a service offer), an object gives the broker a description of a service, including a description of the interface at which that service instance is available. To import (i.e. find suitable service offers), an object asks the broker for a service having certain characteristics. The broker checks against the descriptions of services and responds to the requestor with the information required to bind with a service instance. Preferences may be applied to the set of offers matched according to service type, some constraint expression, and various policies. Application of the preferences can determine the order used to return matched offers to the requestor.

2.2.2 Self-Describing Services

In order for a service oriented architecture to operate in an effective and efficient manner, the services must be self describing. That is, each service must provide a machine readable description of its location and capabilities. This self describing information is what is registered to the portal catalogs and enables the services to be dynamically invoked with no modification needed to the portal software. The description of the self describing services

is usually based on the eXtensible Markup Language (XML). An example of a standard that uses XML for describing a service is WSDL (Web Services Description Language). Expressed in XML, a WSDL definition describes how to access a web service and what operations it will perform.

2.3 Alignment with other Reference Architectures

The Geospatial Portal Reference Architecture has been developed in a generic enough manner that allows it to be aligned with other reference models and high level enterprise architectures. Several examples are discussed in the subsequent sections.

2.3.1 OpenGIS Reference Model

The Geospatial Portal Reference Architecture follows the tenants set forth in the OpenGIS Reference Model (ORM)[3]. The ORM documents a framework of interoperability for geospatial processing ranging from tightly coupled, real time systems on a single CPU to the "Spatial Web" -- the open environment that enables barrier-free communication of geographic information among users of the World Wide Web. The ORM provides the overall conceptual framework for building geospatial processing into distributed systems in an incremental and interoperable manner. The ORM is a living document and is updated periodically as OGC membership continues to advance geoprocessing interoperability.

2.3.2 Federal Enterprise Architecture (FEA)[4]

To facilitate efforts to transform the Federal Government into one that is citizen-centered, results-oriented, and market-based, the Office of Management and Budget (OMB) is developing the FEA, a business-based framework for Government-wide improvement. The FEA is being constructed through a collection of interrelated reference models designed to facilitate cross-agency analysis and the identification of gaps, duplicative investments, and opportunities for collaboration within and across Federal Agencies, addressing key areas such as:

- Budget Allocation;
- Horizontal and Vertical Information Sharing;
- Performance Measurement;
- Budget / Performance Integration;
- Cross-Agency Collaboration;
- E-Government;
- Component-Based Architectures.

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[3] http://portal.opengeospatial.org/files/?artifact_id=3836

[4] http://www.feapmo.gov/

2.3.3 Infrastructure for Spatial Information in Europe

INSPIRE (Infrastructure for Spatial Information in Europe) is a European initiative aimed at making geospatial content more readily available and useful for sustainable development and increased protection of the environment. It is to be implemented throughout the European Union (EU) over the next few years with different types of geographical information gradually harmonized and integrated, leading to a European Spatial Data Infrastructure (ESDI). The ESDI will deliver to users integrated spatial information services, which cannot practically be integrated except through the standards referenced in the Geospatial Portal Reference Architecture.

2.3.4 European Public Sector Information Network (ePSINet)

ePSINet aims to help the adoption of beneficial regulatory, standards, and information management frameworks for Public Sector Information by providing structured access for stakeholders in this area to:

- Policy and legislation information linked to legal cases;
- Innovation and good practice in the management of PSI over the whole information lifecycle, covering back office, workflow, content and records management, preservation, search technologies, multilingual applications and delivery channels such as web portals, Digital TV, mobile devices and kiosks;
- Developments in the related standards, especially those needed to ensure wide, cross-domain interoperability including those related to data formats, metadata, identifiers, terminologies, preservation, rights management, multilingual applications and the emerging standards for the semantic web.

2.3.5 European Information Architecture for Public Administration

The InfoCitizen European Information Architecture for Public Administration is the conceptual basis for the InfoCitizen system and its components. It contains the necessary models and descriptions that have been developed in order to fulfill the requirements analyzed in WP1 and that meet the goal of developing an interoperable system integrating business processes in European Public Administrations.

The InfoCitizen European Architecture is divided into three parts:

- The conceptual part, defining the business processes, information objects and the basic interoperability mechanisms (InfoCitizen Conceptual Architecture).
- The technical description, defining the structure of the InfoCitizen Platform, its various components that compose the platform as well as the interrelationships amongst them (InfoCitizen Technical Architecture).
- The system description, detailing the software-technical consequences and limitations exposed by the overall architecture. Also, there will be a focus on the low level details that include the Standards Profile and the Security Profile (InfoCitizen System Architecture).

3 Geospatial Portal Service Requirements

The Geospatial Portal Reference Architecture describes a framework within which an organized collection of open standard specifications can be implemented to create spatial content and vendor neutral "plug and play" portal infrastructures. The Geospatial Portal Reference Architecture is also a guide for the development of affordable Web sites that make geospatial content and geoprocessing services easily discoverable and usable and easily integrated into larger enterprise workflows and information systems. It is explicitly open, vendor-neutral, and not dependent on any particular geographic information system (GIS), programming language, database, middleware or operating system. Components of portals based on the Geospatial Portal Reference Architecture – servers, clients, servlets, applets, middleware, databases, applications, etc. – and the external resources that link to them can be commercial-off-the-shelf (COTS), government-off-the-shelf (GOTS), custom, shareware, open source, and/or legacy. These components communicate through the standard interfaces, protocols and schemas defined in the Geospatial Portal Reference Architecture.

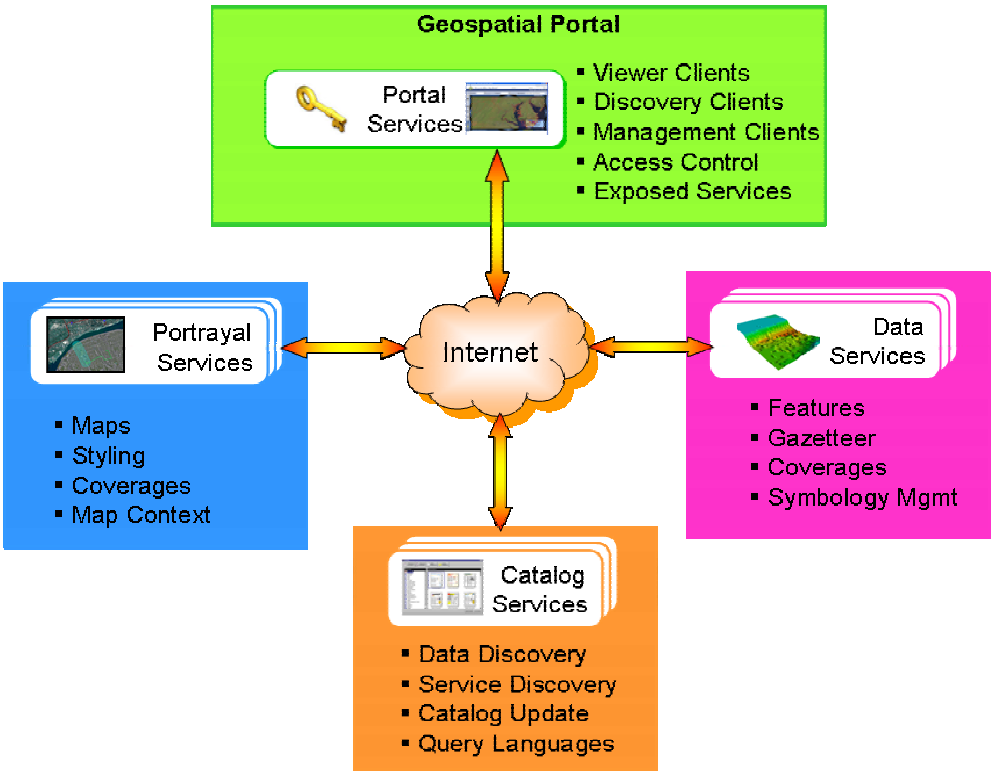

Figure 3. Geospatial Portal Reference Architecture Services Distribution.

In Figure 3, the Geospatial Portal Reference Architecture is presented again this time identifying the particular services that fall within each class of service. In the subsequent section, each of the services is discussed along with identifying which OGC Implementation Specification is applicable for that service.

3.1 Portal services

The Portal Services are accessible from the Portal Platform (e.g. desktop, laptop, etc.) or servers that have network connectivity. Users may leverage Portal Services to access the distributed Portrayal, Catalog and Data services, depending upon the requirements and designed implementation of the application. The access to these services is provided by client software that is resident on the portal platform. More specifically, when accessed as a World Wide Web application a Client runs on an HTTP server and generates HTML pages to be displayed in the User's web browser (the thin client).

3.1.1 Viewer Client

The Viewer Client provides a visualization user interface to display and navigate content retrieved from the Portrayal and Data services.

3.1.2 Discovery Client

The Discovery Client provides means for users to locate needed content and services according to user-defined criteria. More specifically, the Discovery Client enables the portal catalog containing the information about the content and services tat have been registered to the portal to be searched and the request displayed to the user. The Discovery Client will also allow the user to select a desired content or service and have the service invoked for presentation in the viewer client.

3.1.3 Publisher Client

The Publisher Client provides means for portal maintainers and authorized users to publish services or content discovered using the portal catalog. The Publisher Client allows authorized users to register primary information sources, pre-defined symbolization rules, and possibly other information. This published information is then made available to the Discovery Client where the published information can be found and services invoked.

3.1.4 Gazetteer Client

The Gazetteer Client provides users the ability to navigate through spatially organized features with well-known feature names. Gazetteer Clients allow users to formulate queries to retrieve named features. The Gazetteer Client should utilize the USGS Geographic Names Information System as a primary database of feature names.

3.1.5 Data Extraction Client

Data Extraction Clients provide users the ability to extract specific content from the Data Services class of services.

3.1.6 Data Manipulation Client

Data Manipulation Clients provide users the ability to access, modify, add, and delete geospatial content stored at remote Data Services providers.

3.1.7 Symbol/Style Management Client

Symbol/Style Management clients allow users to browse the styles available from a given server and obtain and apply a predefined style definition for a particular feature type(s).

3.1.8 Authentication and Access Control

The Portal may enable Authentication and Access Control that restricts access to an organization's content and service offerings based on criteria that are controlled locally and documented in the Portal site as a set of rules. At a minimum, the portal should not prohibit Providers from defining access restrictions. In other words, the portal must not cause all Users to appear as a single anonymous user when invoking services through the portal.

Providers may enforce access restrictions at the network TCP/IP level, at the HTTP server level, at the web service component level, or at any other point of the service request's passage through the Provider's network. Providers should not be required to register their access restrictions at the portal; however, service metadata and dataset metadata should include information about restrictions to minimize failed access requests. Portal participants may select and document appropriate metadata fields for this purpose.

3.1.9 Exposed Services

In addition to the client Portal client access discussed above, the Portal can also be a service provider unto itself by furnishing Exposed Services to users, customers and client software that is external to the portal. Basically, the Portal can be constructed to take advantage of the access that the portal has to the content and services that have been registered to the Portal and expose services of its own, These services can be a reflection of the registered services, where the Portal acts as a single proxy to the many registered services, or the Portal can offer up services that have been specifically constructed to meet some special needs of the organization hosting the Portal.

3.2 Application Integration Framework

One of the key overall goals of the Geospatial Portal Reference Architecture is that an instance of the reference architecture will create an Application Integration Framework (AIF). This AIF will provide an operational environment that will have the ability to dynamically integrate an ever expanding set of geospatial content and services into the Portal. This capability is accomplished with the cataloging of geospatial content and services that can be discovered by the users and dynamically evoked using tools that are compliant with the OpenGIS Standards that enable geospatial information interoperability.

The AIF includes an integrated infrastructure to maintain and pass parameters between OGC compliant components, as well as a client-side web-based presentation framework for the Portal. The AIF communicates with other portal components through well-defined software interfaces, such that different instances of such modular components could be substituted. The AIF is able to construct valid requests to service provider such as WMS, WFS and WCS instances to be executed either by the portal or by the user.

3.3 Portrayal Services

Portrayal Services provide specialized capabilities supporting visualization of geospatial information. Portrayal Services are components that, given one or more inputs, produce rendered outputs (e.g., cartographically portrayed maps, perspective views of terrain,

annotated images, views of dynamically changing features in space and time, etc.) Portrayal Services can be tightly or loosely coupled with other services such as Data and Processing Services and transform, combine, or create portrayed outputs. Portrayal Services may use styling rules specified during configuration or dynamically at runtime by Application Services.

Portrayal Services provide specialized capabilities supporting visualization of geospatial information. Portrayal Services are components that, given one or more inputs, produce rendered outputs (e.g., cartographically portrayed maps) or leverage the parameters of rendered outputs to coordinate multi-source display (e.g. create scale and view-dependent displays). Portrayal Services are loosely coupled with other services such as Map and Data Services and transform, combine, or create portrayed outputs. Five possible components as identified with the OGC Reference Architecture are described below.

3.3.1 Map Portrayal

The OpenGIS Web Map Server Specification[5] (WMS) is a set of protocols that provide access by Web clients to maps rendered by map servers on the Internet. The WMS interface allows the client to query the "capabilities" of a given map server. Based on the capabilities, the WMS interface allows a server to return a Portable Network Graphics (PNG), Graphics Interchange Format (GIF), Joint Photographic Expert Group format (JPEG), or Tagged Image File Format (TIFF) image for a given area of interest and a specified coordinate reference system. These returned images (pictures) can be viewed in transparency mode, thus allowing for example, the display of roads on top of a satellite image. The WMS interface support user queries of displayed spatial content that indicates the Spatial Reference System (SRS) and Bounding Box of the portion of the Earth to be mapped, and the output width, height and format of the picture. The WMS can have an addition capability to define styles that control the presentational rules that are to be used when displaying geographic features. This ability to control the display styles in defined in the Styled Layer Descriptors Specification[6] (SLD).

3.3.2 Cascading Map Reference

The Cascading Map Server is a special case of the WMS in that it does not hold any content of its own; rather, it serves as a gateway for other data providers, both OGC-compliant and not. Cascading Map Servers incorporate clients for a number of services. These clients, however, do not have to be just for OpenGIS interfaces. Legacy data providers can be accessed, their content retrieved, adjusted, and re-presented through the OpenGIS® Web Mapping Service interface. As such, the Cascading Map Server can serve a key role in presenting legacy data that may otherwise be inaccessible.

This service communicates with Provider WMS instances (both basic and SLD-enabled) to formulate and possibly execute valid operations to request service metadata, to request maps, or to perform other operations available from the Provider. The Cascading WMS component can transform map formats and map projections. It allows users to discover and

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[5] https://portal.opengeospatial.org/files/?artifact_id=5316

[6] https://portal.opengeospatial.org/files/?artifact_id=1188

select appropriate styles (either named or SLD-based) for each map layer and composes the SLDs so that map portrayal can be requested.

3.3.3 Symbol/Style Management Service

The Symbol/Style Management Service is a multi-component system that enables map and content retrieval, and includes the capability for creating, storing, and/or retrieving styles and symbols from multiple communities or user groups and combining all these elements of information into an appropriately symbolized map. This service may consist of multiple components including a Style Registry, Style Repository, Symbol Registry, and Symbol Repository presented through a common, standard interface. A formal description of the Symbol/Style Management Service is currently in the change proposal process with the OGC Specification Program as a modification to the Styled Layer Descriptors Specification.

3.3.4 Map Context Encoding

The OpenGIS Web Map Context Specification[7] allows users to save complex multi-source presentations so they can be retrieved in total in the future so they do not have to be rebuilt from scratch. It is useful to be able to record the state of a WMS client application at a view of interest to a user, and then to restore that state at a later time.

3.3.5 Coverage Portrayal

The Coverage Portrayal Service (CPS) (a discussion paper, not yet an adopted OpenGIS Specification) enables users to produce visual pictures from coverage data (such as digital elevation data or Earth image data). The CPS works much like a WMS instance, but includes additional parameters to control the retrieval and/or rendering of coverage data.

3.4 Catalogue Services

Catalog Services provide a common mechanism to classify, register, describe, search, maintain and access information about *resources* available on a network. Resources are network addressable instances of typed data or services. Types of registries are differentiated by their role such as registries for cataloging data types (e.g., types of geographic features, coverages, sensors, and symbols), online data instances (e.g., datasets, repositories, and symbol libraries), service types and online service instances. Catalog services allow:

1) Providers of resources to publish descriptive information about resource types and instances;

2) Requestors of resources to discover information about resource types and instances; and

3) Requestors of resources to access (bind to) resource providers.

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[7] https://portal.opengeospatial.org/files/?artifact_id=3841

Catalogue services support the ability to publish and search collections of descriptive information (metadata) for data, services, and related information objects. Metadata in catalogues represent resource characteristics that can be queried and presented for evaluation and further processing by both humans and software. Catalogue services are required to support the discovery and binding to registered information resources within an information community.

The OpenGIS® catalog document specifies the interfaces, bindings, and a framework for defining application profiles required to publish and access digital catalogues of metadata for geospatial content, services, and related resource information. Metadata act as generalized properties that can be queried and returned through catalogue services for resource evaluation and, in many cases, invocation or retrieval of the referenced resource. Catalogue services support the use of one of several identified query languages to find and return results using well-known content models (metadata schemas) and encodings. This OpenGIS® document is applicable to the implementation of interfaces on catalogues of a variety of information resources.

3.5 Data Services

Data Services provide access to collections of content in repositories and databases. Resources accessible by Data Services can generally be referenced by a name (identity, address, etc). Given a name, Data Services can then find the resource. Data Services usually maintain indexes to help speed up the process of finding items by name or by other attributes of the item. The OpenGIS Framework defines common encodings and interfaces in which multiple, distributed Data Services are accessed and their contents "exposed" in a consistent manner to other major components. The sections below describe the current set of Data Services of the OpenGIS Framework.

3.5.1 Feature Services

The OpenGIS Web Feature Service Specification[8] (WFS) supports the query and discovery of geographic features and attributes. In a typical Web-base scenario, WFS delivers Geography Markup Language[9] (GML) representations of simple geospatial features in response to queries from HTTP clients. Clients (service requestors) access geographic feature data through a WFS by submitting a request for just those features that are needed for an application. The client generates a request posts it to a WFS instance (a WFS server on the Web). The WFS instance executes the request, returning the results to the client as GML. A GML-enabled client can manipulate or operate on the returned features.

3.5.2 Symbology Management

This service is a multi-component system that enables map and content retrieval, and includes the capability for creating, storing, and/or retrieving styles and symbols from multiple communities or user groups and combining all these elements of information into

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[8] https://portal.opengeospatial.org/files/?artifact_id=7176

[9] https://portal.opengeospatial.org/files/?artifact_id=7174

an appropriately symbolized map. This service may consist of multiple components including a Style Registry, Style Repository, Symbol Registry, and Symbol Repository presented through a common, standard interface.

3.5.3 Gazetteer

A Gazetteer is a directory of features containing some information regarding position. A Gazetteer Service is a network-accessible service that retrieves one or more features (after the ISO feature model), given a query (filter) request. This filter request must support selection by well-known feature attribute values, and especially by published or context-unique identifiers.. The queryable feature attributes are any properties that describe the features, including but not limited to feature type, feature name, authority, or identification code. Each instance of a Gazetteer Service has an associated vocabulary of identifiers. Thus, a Gazetteer Service may apply to a given region, such as a country, or some other specialized grouping of features. The returned features will include one or more geometries expressed in an OGC Spatial Reference System. This Gazetteer interface extends the WFS specification by defining additional behavior and formalizing the response schema elements. The Gazetteer is service is described in the OGC discussion paper "Gazetteer Service Profile of a WFS[10]".

3.5.4 Coverage Services

The OpenGIS Web Coverage Service Specification[11] (WCS) supports the networked interchange of geospatial content as "coverages" containing values or properties of geographic locations. Unlike the Web Map Service, which filters and portrays spatial content to return static maps (server-rendered as pictures), the Web Coverage Service provides access to intact (unrendered) geospatial information, as needed for client-side rendering, multi-valued coverages, and input into scientific models and other clients beyond simple viewers.

3.6 Procurement Issues

The Geospatial Portal Reference Architecture represents a big step forward for procurement officials seeking to satisfy their agencies' spatial information requirements at the lowest possible cost, and with the greatest adherence to laws and policies regarding standards and interoperability.

A portal based on interoperable components using standard interfaces and protocols is highly flexible and "agile". As requirements or technology change, as market demand grows, as new functions must be added, a standards based portal can be cost effectively and quickly enhanced. As new standards and specifications are approved in OGC and implemented in products, new services and content sources can be effectively integrated into the Portal infrastructure.

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[10] https://portal.opengeospatial.org/files/?artifact_id=7175

[11] https://portal.opengeospatial.org/files/?artifact_id=3837

Existing content producers can usually extend their systems with open interfaces to become part of geospatial information networks with open portals. Most providers of GIS, Earth imaging, facilities management, automated mapping, decision support, navigation and location based services software are implementing these open interfaces on their servers and clients. Agencies employing the component-based Geospatial Portal Reference Architecture reduce their risk of "vendor lock in," save money through a buy-as-you-go approach, and maximize their compatibility with other resources in their networks.

Rapid build-out of the Global Spatial Data Infrastructure (GSDI) depends on agencies purchasing products with interfaces that implement OpenGIS Specifications. You can't have a network if the nodes don't interoperate. If they interoperate, it doesn't matter which vendor provided the software – You can pick the best and/or least expensive. Different vendors have different strengths and different users have different needs, which is why agency-wide single vendor mandates seldom hold up over time.

OGC programs reduce ***technology risk*** by providing an alternative to "putting all your eggs in one basket". When the market offers a new component that is better than a similar component being used by an old component, the old component can be quickly and inexpensively replaced. Such upgrades are much smaller and more future-compatible when a non-proprietary framework connects the parts. Governments are seeking ***procurement reform***. By participating in OGC programs, agencies enhance the market's ability to meet future procurement needs with standards-based solutions. Two or ten or twenty competing vendors produce far more options than one vendor contracted to incrementally enhance its own proprietary systems. All Spatial Data Infrastructure initiatives worldwide are moving rapidly and inexorably toward interoperability based on open standards, not interoperability based on one vendor's proprietary architecture.

Governments seeking procurement reform establish policies to support information technology standards, including standards for interconnectivity and interoperability. Interconnectivity and interoperability depend on vendor-neutral standards such as TCP/IP, HTML, SQL and XML. To achieve interoperability in GIS, agencies need to purchase software with interoperability interfaces that implement the vendor-neutral OpenGIS® Specifications coming from the Open Geospatial Consortium (OGC). Most of these specifications get put on track to become ISO/TC 211 standards, and they are endorsed by the Federal Geographic Data Committee and by a growing number of spatial data agencies in other countries. OGC is working in a joint coordination effort with ISO TC/211 (Geomatics) as to ensure that market-derived approaches mesh with the global de jure standards program. This is important for agencies because they need assurance that their strategies to modernize and stay efficient will be durable and part of the mainstream of technology development.

4 Summary

The standards-based, vendor-neutral **Geospatial Portal Reference Architecture**

- Describes how to build standards-based portals for easy publishing and use of geodata and services,
- Shows procurement officials how to acquire geoprocessing software that "plugs and plays" in government enterprise information systems,
- Makes it easy to add geospatial capabilities to otherwise non-spatial federal, state and local E-Government portals, and portals belonging to businesses, organizations and communities,
- Shows how existing GIS's and other geoprocessing systems can be made interoperable through implementation of OpenGIS standards.

The Geospatial Portal Reference Architecture is a major step forward for E-Government, National Spatial Data Infrastructures, enterprises and Information Communities. It is made possible by recent advances in industry consensus on geoprocessing interoperability interfaces that make it possible to network heterogeneous geographic information systems and systems for digital cartography, facilities management, Earth imaging, navigation and location based services. Prior to this time, diverse proprietary data formats and processing approaches made it very difficult to share digital geospatial content. Now geospatial content is part of what can be accessed and used on the Web. The Web – and government enterprise information systems – have been spatially enabled. The Geospatial Portal Reference Architecture represents the most recent step, and a very important step, in this extremely valuable progress.