

# **Design and Implementation of an OGC Web Map Service for Iran's National SDI**

Mahdi Farnaghi, MSC student of GIS, Geodesy and Geomatics Faculty,

KNT University of Technology, Tehran, Iran

E\_Mail: [m\\_farnaqi@yahoo.com](mailto:m_farnaqi@yahoo.com)

Ali Mansourian, Assistant Professor, Geodesy and Geomatics Faculty,

KNT University of Technology, Tehran, Iran

E\_Mail: [mansourian@kntu.ac.ir](mailto:mansourian@kntu.ac.ir)

## **Abstract**

Spatial Data Infrastructure (SDI) is considered as a fundamental initiative in which spatial data and analysis stakeholders and users can achieve their goals in an appropriate manner through cooperation in producing of spatial data and analysis and sharing them among each other.

In order to realize such a sharing in SDI environment, an interoperable Distributed Computing Platform (DCP) on the Internet is required. Web Services is one of the underlying DCP technologies which provides an interoperable distributed mechanism based on open standards and protocols such as HTTP, XML, SOAP, WSDL, and UDDI. In addition to these standards and protocols, Open GIS Consortium (OGC) is developing a set of standard interfaces for Geospatial Web Services including Web Map Service (WMS), Web Feature Service (WFS), and Web Coverage Service (WCS).

Based on a research project in KNT University of technology, in this paper, various steps over design and development a Web Map Service, using Microsoft .Net technology are presented. The paper is begun with a brief look at Web Services and OGC Web Services concepts. OGC WMS implementation specification is reviewed afterward. At last implementation of the system using C# programming language and ASP.Net Web Services technology is mentioned.

## **1- Introduction**

We live in an age of information, and spatial information is one of the most critical elements affecting decision-making. It is difficult to find piece of information, which is not related to position. It has been estimated that over %80 of governmental data

has spatial nature, characteristics, or basin ([9], [5], [6]). It has been also observed that a large majority of all decisions depend on spatial situation or have spatial affect [3]. However, with such a role of spatial data in everyday business and decisions, there are substantial problems with collection, dissemination, access and usage of these data. Spatial Data Infrastructure (SDI) is an initiative intends to resolve these problems by creating an appropriate partnership environment for data collection, dissemination, access and usage. SDI is fundamentally about facilitation and coordination of the production, exchange and sharing of spatial data among stakeholders in the spatial data community.

From political/administrative point of view, different SDI initiatives at local, state/provincial, national and multi-national levels have been defined in the context of SDI hierarchy model [4]. Each SDI initiative is to facilitate data production, exchange and sharing among spatial data community at that level that is a challenging task.

Different initiatives have considered different components for SDIs in order to be used for SDIs implementation. These components are interconnected and aim to create an environment in which people (data producers, value-adders and users) can access to and use spatial data [2]. By studying these components, five core components can be considered in general for SDIs including people, policies, standards, accessing networks and data [4] that all are affected by technology (Figure 1). SDI core components have dynamic nature due to change in technology and also change in user needs. As a result, SDI has a dynamic nature.

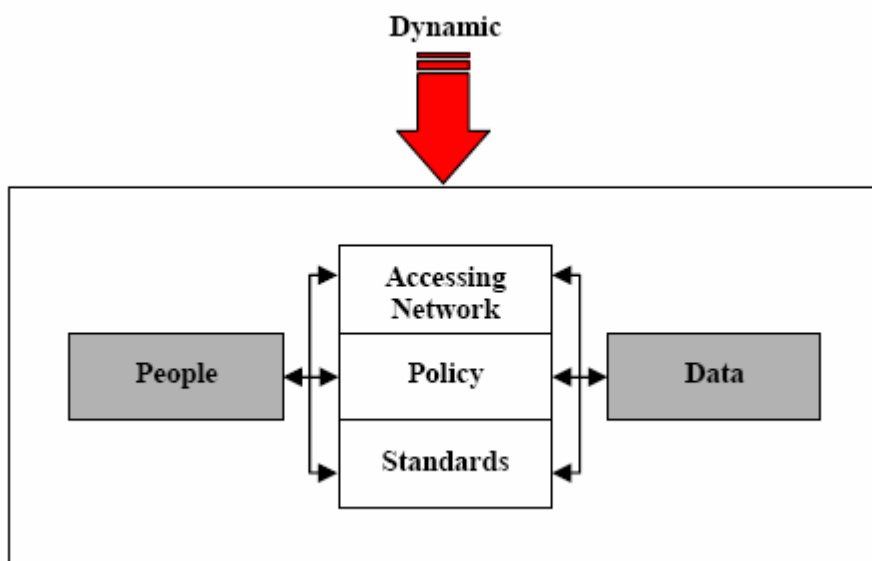


Figure 1: General SDI Model [4]

In SDI core component, accessing Networks are the avenue, by which data and processing services within the SDI is made available for everyone. However interoperability is the most important factor which can guaranty the suitability and applicability of the Access Networks. In order to provide a proper environment in which spatial data stockholders and users can interact with each other through diverse networks, hardware, operating systems and application programs, SDI needs to have an *Interoperable Distributed Architecture* over its Accessing Networks. Such architecture can be made up using Standard component of SDI.

With this in mind, an appropriate architecture for Iran's National SDI was proposed by Farnaghi [1]. This Architecture was designed using ISO's Reference Model for Open Distributed Processing [ISO/IEC 10748] (RM-ODP) of ISO from five different points of views including:

- Enterprise Viewpoint
- Computational Viewpoint
- Information Viewpoint
- Engineering Viewpoint
- Technology Viewpoint

Based on the proposed architecture, one of the most important services which should be developed in SDI environment is mapping services based on WMS implementation specification of OGC [7]. In the next chapters of this paper, various steps over design and development of a WMS Service which is on going in KNT University of Technology are described.

## **2- OGC Activities and WMS Implementation Specifications**

The OpenGIS Consortium (OGC) is a global industry consortium that envisions:

“A world in which everyone benefits from geospatial information and services made available across any network, application, or platform” [8].

The OGC has more than 255 members - geospatial technology software vendors, systems integrators, government agencies and universities – which participate in a consensus process to develop, test, and document publicly available interface specifications and encodings for the geospatial industry. OGC is going to develop open interfaces and protocols which provide the ability to support interoperable solutions that "geo-enable" the Web, wireless and location-based services, and

mainstream IT, and to empower technology developers to make complex spatial information and services accessible and useful to all kinds of applications.

OGC in order to reach its vision commenced a vast range of activities. One of the most important activities of the consortium is to develop Open Interfaces. The Open Interfaces permit application programmers to develop Open Systems. Open systems are usually considered to be systems that interoperate through Open Interfaces. In fact an Open Interface is simply a common boundary, a means to make a connection between two software components. An Interface on the client presents an ordered set of parameters and instructions to an interface on the server [9]. Currently a branch of OGC activities, which concentrate on definition of Open Interfaces for Geospatial Web Services, have resulted in development of three standards including:

- Web Map Service Implementation Specification (WMS) [7]
- Web Coverage Service Implementation Specification (WCS) [10]
- Web Feature Service Implementation Specification (WFS) [11]

The WCS implementation specification defines required interfaces for a Geospatial Web Service which supports electronic interchange of geospatial data as "coverages" – that is, digital geospatial information representing space-varying phenomena. A WCS Web Service provides access to potentially detailed and rich sets of geospatial information, in forms that are useful for client-side rendering, multi-valued coverages, and input into scientific models and other clients.

The WFS implementation specification defines interfaces for a Geospatial Web Service which represents data access and manipulation operations on geospatial features. Via these interfaces, a web user or service can combine, use and manage geospatial data (the feature information behind a map image) from different sources [11].

The WMS implementation specification defines Open Interfaces which empower a Web Service to produce maps of spatially referenced data from vector geospatial information [7]. WMS implementation specification will be depicted in more details in this paper.

### **3- Development of a basic WMS Service**

Data providers have been sharing their spatial data through online mapping services for years; each of them has implemented a set of proprietary systems for online

mapping purpose. However, as a result of this isolated development, online mapping services from different vendors cannot interoperate.

To resolve this problem, the OGC developed a non-proprietary Web mapping approach based on open interfaces, encodings and schemas. In fact, the OGC Specification Program and Interoperability Program provide an industry consensus process to plan, develop, review and officially adopt OpenGIS Specifications for interfaces, encodings and schemas that enable interoperable geo-services, data, and applications [12]. Based on mentioned program, OGC developed an Open Interface for mapping purpose through the Internet, called Web Map Service (WMS). Using such Interface, Mapping Services empower their client to connect to each service using WMS Interface.

### **3-1- WMS Implementation Specification**

In order to implement WMS Interface, each mapping service has to provide three operations:

- GetCapabilities()
- GetMap()
- GetFeatureInfo()

GetCapabilities() and GetMap() functions are mandatory operations and each WMS service have to implement them. But GetFeatureInfo() is an optional operation which can be refused to develop by Mapping Service.

#### **3-1-1- Describing the Mapping Service through GetCapabilities**

Users can obtain Service Metadata using GetCapabilities() operation. This operation returns a machine and human-readable data about mapping service. In fact user receive an XML file – called Capabilities XML – as a response to GetCapabilities request, which contains general information about Mapping Service, available layers and styles, output map format, and so on. This XML document must be valid based on Capabilities.xsd schema [13] presented by OGC for WMS Capabilities Document.

#### **3-1-2- Serving Maps through GetMap**

GetMap() operation presents an image map with defined spatial parameters. This image is composed of two dimensional array of pixels which presents a specified

region of earth and has pre-determined layers, Geospatial or Projected Coordinate System.

### **3-1-3- Providing Basic Data about Map Layers through GetFeatureInfo**

This function provides required information about features in the map for users. If a WMS Mapping Service implements this operation, the Service is called Queryable WMS Service.

### **3-2- SLD-Enabled WMS Service**

Basic WMS with three above functionalities can only use predefined styles to present different layers of the map. In fact, WMS Implementation Specification has some defined styles which can be used by Mapping Service to portray map layers. Therefore user can not define new styles based on its current need. Also there is no opportunity to view a style output before generating map by WMS Service.

In order to overcome such limitations, OGC defined a new Implementation Specification, called OpenGIS Styled Descriptor (SLD) Specification [14], which provides users with such capabilities.

### **3-3- Distributed Computing Platform (DCP) for WMS**

At present, WMS Implementation Specification only supports World Wide Web (WWW) as Underlying DCP. WWW uses a request and response model using Hyper Text Transfer Protocol (HTTP). HTTP supports two request methods: GET and POST (IETF RFC 2616). WMS Implementation Specification just uses the HTTP GET request method. Based on this, a user, Web application or any client application can use a WMS Service opportunities with sending messages through HTTP GET to the Mapping Service. In addition to this, OGC is developing a new version of WMS Implementation Specification, called Implementation Specification Part2: XML for Requests Using HTTP POST [17], based on HTTP POST and XML encoding.

### **3-4- Development of Typical WMS Service**

Necessary concepts of WMS Implementation Specification were described earlier. This section concentrates on various steps over design and implementation of a typical WMS Service using .Net Technology which is on going in K.N.T. University of Technology.

Considering the bulk of required activities for developing a WMS Service, development process was divided into three iterations that will be described later. UML used as a graphical language to design the software. In addition, Microsoft .Net Platform and Microsoft Web Services Technology was used as Implementation Platform.

### **3-4-1- Software Development Iterations**

Given today's sophisticated software systems, it is not possible to sequentially first define the entire problem, design the entire solution, build the software and then test the product at the end. An iterative approach is required that allows an increasing understanding of the problem through successive refinements, and to incrementally grow an effective solution over multiple iterations [15], [16]. With this in mind, in this project, development of the WMS Service, was divided into three iterations:

1- First Iteration: Development of a basic WMS Service

The first iteration concentrate on development of a basic WMS Service which provides GetCapabilities() and GetMap() operations as two mandatory operations of WMS Interface.

2- Second Iteration: Development of a Queryable WMS Service

The second iteration intend to improve the first iteration Service to a queryable WMS Service by adding GetFeatureInfo() operation to previous version of service.

3- Third Iteration: Development of an SLD-Enabled WMS Service

The final iteration leads to manufacture a new Service which has the SLD operations as well as two above iterations capabilities.

This paper describes the implementation process until the end of first iteration.

### **3-4-2- Development Process**

In this project for designing the software, UML is used as a graphical language for visualizing, specifying, constructing, and documenting the system. In this respect, the first iteration commenced with architecting the Mapping Service using Use-Case diagrams of UML.

Based on Use-Case diagrams, the service is composed of a Spatial Database, a client application (WMS Client) and WMS Server (WMS Service). Spatial Database maintains Spatial Data layers which WMS Server presents to users.

After that, sequence diagrams of each Use-Case were developed. In fact, each sequence diagram models a specific routine of Use-Case. Using sequence diagrams and considering the WMS Implementation Specification Class Diagrams of the Mapping Service designed completely. Figure 2 shows the main class diagram of the system.

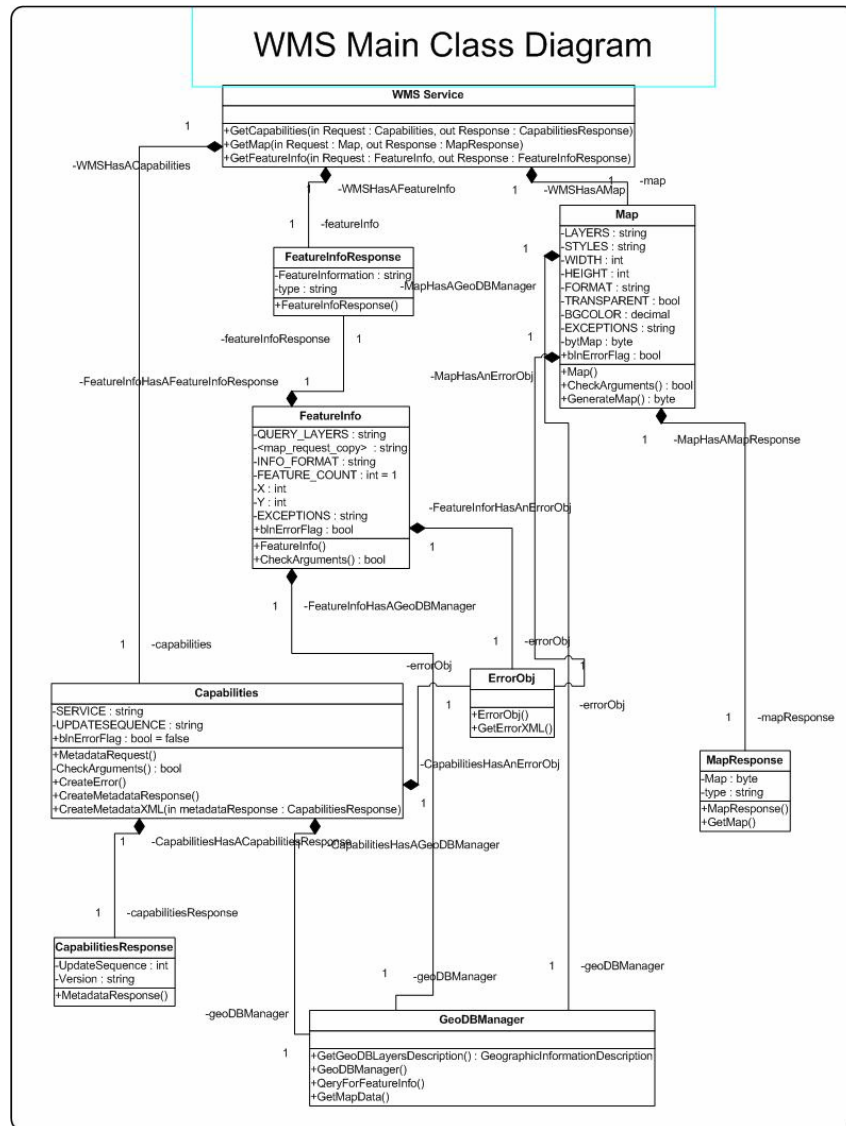


Figure 2: One of the Mapping Service Class Diagram

Mapping service was developed based on the Class Diagrams using ASP.Net Web Services Technology. It is worth to be mentioned that, Microsoft Visio Software was used to generate general codes, relating to class structures. The primary codes was accomplished and the whole system was tested afterward using Visual Studio.Net capabilities to test Web Services. Figure 3 shows the Service response for `GetCapabilities()` and `GetMap()` operations.

```

<?xml version="1.0" encoding="UTF-8" ?>
-<WMS_Capabilities version="1.3.0" xmlns="http://www.opengis.net/wms"
xmlns:xlink="http://www.w3.org/1999/xlink" xmlns: xsi="http://www.w3.org/2001/XMLSchema-
instance" xsi:schemaLocation="http://www.opengis.net/wms
http://schemas.opengis.net/wms/1.3.0/capabilities_1_2_0.xsd">
<!-- Service Metadata -->
-<Service>
<Name>WMS</Name>
<Title>K.N.T.University of Technology - Map Server</Title>
<Abstract>Map Server maintained by Mahdi Farnaghi - MS Student of KNT University of
technology. Contact: m_farnaghi@yahoo.com. Maps are political boundary of Iran and its main
roads and cities</Abstract>
-<KeywordList>
<Keyword>Iran</Keyword>
<Keyword>Political Boundary</Keyword>
<Keyword>roads</Keyword>
<Keyword>cities</Keyword>
</KeywordList>
<OnlineResource xmlns:xlink="http://www.w3.org/1999/xlink" xlink:type="simple"
xlink:href="http://localhost/WMS.asmx/" />
-<ContactInformation>
-<ContactPersonPrimary>
<ContactPerson>Mahdi Farnaghi</ContactPerson>
<ContactOrganization>K.N.T. University of Technology</ContactOrganization>
<ContactPersonPrimary>
<ContactPosition>MS Student</ContactPosition>
-<ContactAddress>
<AddressType>postal</AddressType>
<Address>K.N.T. University of Technology, Vahid-e-asr St, Mirdamad Cross</Address>

```



GetCapabilities() Result

GetMap() Result

Figure 3: GetCapabilities() and GetMap() results

## 4- Results and Future Works

In this paper, the process of development of a basic WMS Service for Iran's SDI was described. It was depicted that interoperability is one of the major problems for data sharing in SDI environment. Using WMS interface can resolve the interoperability problem for dissemination of digital maps through internet.

Microsoft .Net technology has been used to develop the WMS service in this project. Tremendous capabilities of this technology, specially the ASP.Net Web Services technology, can be used to develop other OGC web services.

Development of a queryable WMS service (second iteration) and SLD-Enabled WMS service are ongoing as the future works. In addition a WMS client application will be developed in order to provide users with the capabilities of easy access to WMS servers.

## 5- References

- [1] Farnaghi, M. (2005). Developing an Interoperable Distributed Architecture for Iran's National SDI, A Seminar Submitted in Partial Fulfillment of the Requirement for the Degree of Master of Science (MS) in GIS, K.N.T. University of Technology, Tehran, Iran.
- [2] Mansourian A. (2005). Development of an SDI Conceptual Model and Web-based GIS to Facilitate Disaster Management, PhD Thesis, Faculty of Geodesy & Geomatics Eng., K.N.Toosi University of Technology, Tehran, Iran.
- [3] Albarèdes, G. (1992). A new approach: user oriented GIS, Proceedings of Third European GIS Conference, 23-26 March, Munich, Germany.
- [4] Rajabifard, A., Feeney, M. E. F. and Williamson, I. P. (2002). Future directions for SDI development, International Journal of Applied Earth Observation and Geoinformation, ITC, Vol. 4, No. 1, The Netherlands, pp.11-22.
- [5] Lemmens, M. J. P. M. (2001). An European perspective on Geo-Information Infrastructure (GII) issues, <http://www.GIS Development.net> – visited on February 2002.

- [6] Rhind, D. (1999). Key economic characteristics of information, Ordnance Survey, U.K.
- [7] Beaujardiere, J. (2004). Web Map Service, OGC™ Publicly Available Standard, <http://www.opengeospatial.org/>, Jan 2006.
- [8] Reed, C. (2004), Integrating Geospatial Standards and Standards Strategies into Business Process, An Open GIS Consortium (OGC) White Paper, <http://www.opengeospatial.org/>.
- [9] The Importance of Going Open, An Open Geospatial Consortium White Paper, <http://www.opengeospatial.org/>.
- [10] Evans, J. (2003), Web Coverage Service (WCS), Version 1.0.0, OpenGIS® Publicly Available Standard, <http://...>, visited on Date.
- [11] Vretanos, P. (2005a), Web Feature Service Implementation Specification, OpenGIS® Publicly Available Implementation Specification, <http://www.opengeospatial.org/>, Jan 2006.
- [12] Kolodziej, K. (2004), OpenGIS Web Map Server Cookbook, OpenGIS Consortium Document, <http://www.opengeospatial.org/>.
- [13] [http://schemas.opengis.net/wms/1.3.0/capabilities\\_1\\_3\\_0.xsd](http://schemas.opengis.net/wms/1.3.0/capabilities_1_3_0.xsd).
- [14] Lalonde, W. (2002), Styled Layer Descriptor Implementation Specification, Proposed OpenGIS® OGC Implementation Specification, <http://www.opengeospatial.org/>.
- [15] Barry W. Boehm, A Spiral Model of Software Development and Enhancement, Computer, May 1988, IEEE, pp.61-72.
- [16] Philippe Kruchten, A Rational Development Process, CrossTalk, 9 (7), STSC, Hill AFB, UT, pp.11-16.
- [17] Jeff de La Beaujardière, Web Map Service Implementation Specification Part 2: XML for Requests using HTTP POST, OpenGIS Project Document 02-017r1, <http://www.opengeospatial.org/>.