Quality Assessment for Geographic Web Services

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Abstract

Being able to assess the quality of a service is a significant factor in distinguishing the success of service providers. In this context, the quality of geographic Web services can be measured through the assessment of standard Quality of Service (QoS) parameters (e.g. availability or scalability) plus of other non-standard parameters specific of the domain (e.g. resolution or positional accuracy of the geospatial data). From this perspective, we propose a framework to assess the quality of geographic Web services, as well as the quality of the data that they provide. The proposed framework was implemented in the GeoWatchDog (GWD) system. The GWD was evaluated using services available from the Portuguese Geographic Institute (IGP) and the Spanish IDEE portal. The results of these evaluations are also presented in this paper. Finally, the GWD is all implemented in Java, and will be released as open-source.

Key-words: *GIS, Geographic Web Services, Quality of Service, Data Quality*

INTRODUCTION

The OpenGeospatial Consortium (OGC) developed standards for interoperable geospatial Web services that can be published, discovered and invoked across the Web. Implementing these services and enabling them to integrate with non-spatial Web services will help bring the value of geospatial applications to a much broader community.

Although the importance of geographic Web services is well-established, their quality is often questionable. Moreover, the issue of geospatial data quality has an important role for the adoption of certain geographic Web services. From this perspective, the quality of geographic Web services will become a significant factor in distinguishing the success of service providers. The quality of geographic Web services can be measured through the assessment of standard Quality of Service (QoS) parameters (e.g. availability or scalability), plus of other non-standard parameters specific of the domain (e.g. resolution or positional accuracy of the spatial data).

This work proposes a framework to assess the quality of geographic Web services, as well as the quality of the data that they provide.

The proposed framework allows a human operator to assess the quality of geographic Web services through three main functions: a) monitoring of the service performance and availability, b) test service scalability, c) quality assurance of the spatial data returned by the service. The Web services that can be assessed by this framework are expected to implement open standards such as those provided by the OGC.

The proposed framework was implemented in the GeoWatchDog (GWD) system. The GWD application has three components, one for each assessment function, plus a

specific component for administration and another for testing operations. The **GWD Administrator** component manages the services registered in the GWD application. The **GWD Monitor** component monitors the services performance and availability. The **GWD Load-Tester** component executes load tests in order to assess scalability. The **GWD Data-Tester** component applies data quality algorithms to the data returned by the services. Finally, the **GWD Playground** component is an operational module from where a user can invoke and assess the responses returned by the services.

The GWD was evaluated using services available from the Portuguese Geographic Institute (IGP) and from the Spanish IDEE portal.

The organization of this work is as follows. First, the background and related work that constitutes the basis for the research presented in this paper is described. Next, the requirements of the proposed framework are identified. Next, the implementation of the framework in the GWD system is described. Next, an experimental evaluation of the GWD application and the respective results are described. Finally, the main ideas and conclusions of this work are presented.

RELATED WORK

A geographic information system (GIS) can be defined as a special type of information system tailored to store, process, and manipulate geospatial data [1]. A GIS on the Web are constituted by a set of Web services dealing with data, spatial or not, where the GIS behaviour results from the interoperability between the services [2]. From this perspective the Open Geospatial Consortium (OGC - http://www.opengeospatial.org) encouraged the development and implementation of standards for processing and sharing of geospatial content.

OGC Web service standards

The OGC Web Service (OWS) set of standards defined interoperable geospatial web services that can be published, discovered and invoked across the web. Some of the OWS standards support application developers in integrating a variety of online geoprocessing and location services. Examples of these standards are the OGC Web Feature Service (WFS, ISO/CD 19142) [3] to access and operate on geographic features, and the OGC Web Map Service (WMS, ISO 19128) [4] for accessing map images. A list with the OWS specifications can be found in the site of the OGC. There are several open-source products implementing the OGC specifications. Table 1 lists examples of actual known implementations.

Table 1: Open-source products that implements OGC specifications

Product	URL
Deegree	http://www.deegree.org
MapServer	http://mapserver.gis.umn.edu
GeoServer	http://geoserver.org
OpenLayers	http://openlayers.org

Quality of Service

Quality of service (QoS) refers to non-functional properties of Web services such as performance, availability, integrity, etc. The QoS dimensions are detailed in [5].

Geospatial data quality

Verifying the quality of geospatial data is essential to data sharing. The ISO 19113 and ISO 19114 standards embody principles and evaluation procedures for geographic information [6]. The main elements of geospatial data quality were recently summarized in [7].

INSPIRE issues for quality of geographic Web services

The INSPIRE (http://inspire.jrc.ec.europa.eu), a directive to build an infrastructure for spatial information in Europe, established QoS criteria which shall be ensured by geographic Web services. Those criteria can be expressed in terms as, for example, *"the response time for sending the initial response to a discovery service request shall be maximum 3 seconds in normal situation"*.

Assessing the quality of OGC Web services - Deegree owsWatch

The Deegree project [8] implemented OGC/ISO standards in open-source solutions. Deegree integrates the owsWatch, a Web-based application for monitoring the availability of different OGC Web services.

REQUIREMENTS FOR ASSESSING THE QUALITY OF GEOGRAPHIC WEB SERVICES

This research proposes a system framework to assess the quality of geographic Web services, as well as the quality of the data that they provide.

With the proposed framework, a human operator can assess the quality of geographic Web services through the following five main functions: a) administrate operations, b) monitor performance and availability, c) test scalability, d) assess data quality and e) test services. The following sub-sections describe the requirements identified for each of these functions.

Administrating the system

- Support the registry of services (including editing of the details and deleting of the full record);
- Support the querying of geographic service catalogues, in order to register their published services.

Monitoring the Performance and Availability of Geographic Web Services

- Support the monitoring of the performance and availability by periodically sending requests and measuring response times;
- Support the configuration of the monitoring function;
- Provide an interface to visualize the monitoring results through histograms;
- Support the comparison of the monitoring results with reference values specified by the operator;

Testing the Scalability of Geographic Web Services

- Execute load-tests by periodically sending request batches;
- Support the configuration of load-tests;
- Provide an interface to visualize the load-tests results.

Assessing Geospatial Data Quality

- Support the addition of algorithms for assessing spatial data quality;
- Apply algorithms to the data returned by geographic Web services;
- Provide an interface to visualize the results of the applied algorithms.

Testing Geographic Web Services

- Support the configuration of requests to send to geographic Web services;
- Send requests to services to assess the quality of their responses;
- Visualize responses returned by the services, over reference maps;
- Give example of requests in order to facilitate the users task;
- Check the logical consistency of XML responses in order to give a first and automatic assessment of the returned data.

THE GEOWATCHDOG APPLICATION

In order to accomplish the requirements established in the previous section, a prototype was developed in the context of this work, namely the GeoWatchDog (GWD). The GWD application has the following components:

- **GWD Administrator** component responsible for **system administration**;
- **GWD Monitor** component responsible for **services monitoring**;
- **GWD Load-Tester** component responsible for **testing the services scalability**;
- **GWD Data-Tester** component responsible for **data quality assessment**;
- **GWD Playground** component responsible for **testing the services**.

Taking as basis the architecture of the owsWatch, the GWD application implements the Java Model 2 architecture. The Model 2 promotes the use of the Model-View-Controller (MVC) design pattern for the development of Web-based applications, by integrating the use of both servlets and JSP pages.

GWD Model

The GWD model is constituted by a set of files that store the data of the GWD application. The essential information to run the GWD application is held in the configuration and services. The configuration file specifies the service types supported by the application. The services file stores information about the services registered in the application.

GWD Controller

The GWD controller implements the behaviour of the GWD components which ensure the functionalities of the GWD application. The GWD controller functions are the following:

- Process the actions of the GWD operator;
- Forward the results to the appropriate GWD views;
- Send requests to geographic services and receive the responses;

- Save the results produced by the GWD components in log files;
- Load model files.

GWD View

The GWD views are a set of Java Server Pages (JSP) which retrieve beans created by the GWD controller and present the information to the users. Moreover, the GWD view layer recognizes the user's actions, such as registering a new service, and sends requests with an associated action to be executed by the GWD controller.

Although each GWD component has a specific interface, there are two common views which are used by all of them. These are the service details view and the request details view that are used by the GWD operator to configure the respective details.

Figure 1 presents the service details view with the details of a WMS 1.1.0 service, called “ESRI Map”. This view shows the service details, namely, the name, the type, the version and the URL.

Figure 2 presents the request details view where is being presented the details of a “GetMap” request.

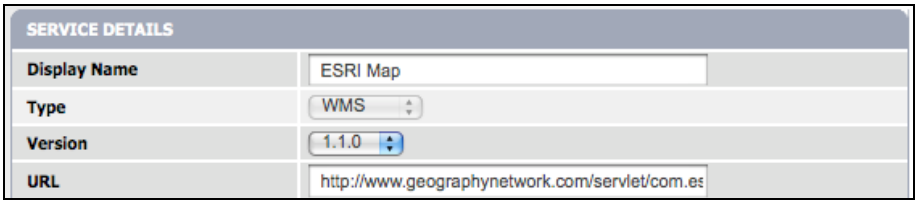

Figure 1: Service details view

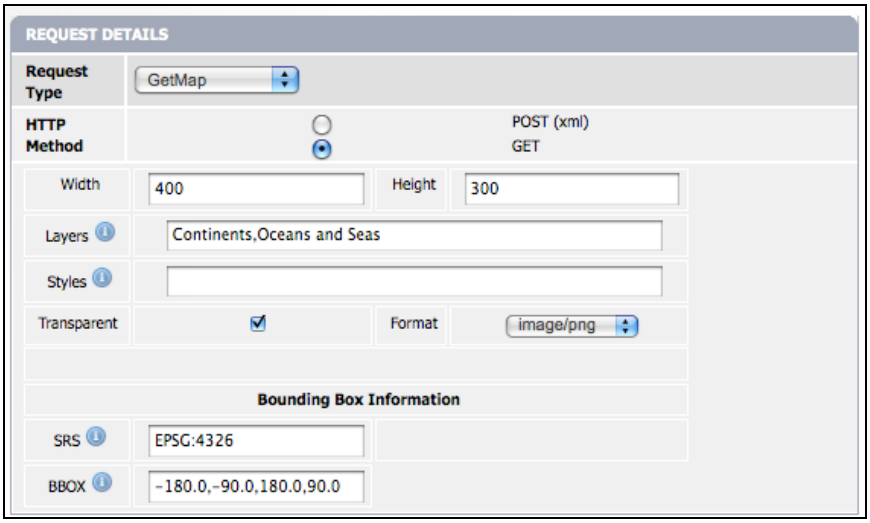

Figure 2: Request details view

EVALUATION

This section describes the experiments made in order to evaluate the ability of the GWD application to be used for assessing the quality of geographic Web services.

The experiments used services available from the Portuguese Geographic Institute (IGP) and from the Spanish IDEE portal. Table 2 lists the IGP services, obtained by querying the catalogue of that organization. Table 3 lists the IDEE services.

Table 2: IGP services registered in the GWD application

Name	Type	URL
CAOP Continente	WMS	http://mapas.igeo.pt/ows/caop2008.1/continente
Vertices Geodesicos	WFS	http://mapas.igeo.pt/pws/vgs

Table 3: IDEE services registered in the GWD application

Name	Type	URL
Mapa Base	WMS	http://www.idee.es/wms/IDEE-Base/IDEE-Base
Nomenclatura C.P.	WFS	http://www.cartociudad.es/wfs-codigo/services

Each registered service has an associated request that is used by the GWD components to realize their functionalities. Table 4 describes the parameters of the "GetMap" requests associated to the registered WMS. Table 5 describes the parameters of the "GetFeature" requests associated to the registered WFS.

Table 4: parameters of the "GetMap" requests

Parameters	CAOP Continente	IDEE Mapa Base
Width, Height	400,300	1000,1000
Layers	CAOP	Relieve,Hidrografia,transporte
Transparent	False	True
Format	Image/	Image/jpeg
SRS	EPSG:4326	EPSG:4320
BBOX	-10.1905,36.8994, -5.71298,42.1896	-3.4650655,40.4137, 3.62939155,44.13107

Table 5: parameters of the "GetFeature" requests

Parameters	Vertices Geodesicos	Nomenclatura C.P.
Typename	vg	app:Entidad
Namespace	CAOP	xmlns(app=http://www.deegree.org/app)

Services Monitoring

This experiment consisted in using the GWD Monitor component to activate and configure the monitoring function for the registered services. The requests periodically sent by the monitoring function were those associated to the services. The time between each sent request was 1 (one) minute. The time that the application waits for a response from the service was 30 (thirty) seconds.

After two weeks monitoring the services, the results were analysed and we concluded that all the services were successfully monitored.

Table 6 summarizes the monitoring results where it can be seen, for each service, the sent request, the average performance, the availability percentage and the number of sent requests.

Table 6: Results of the services monitoring

Service	Performance (ms)	Availability (%)	Sent Requests
CAOP Continente	10926	99.18	21600
Mapa Base	1754	99.27	21600
Vertices Geodesicos	2719	99.30	21600
Nomenclatura C.P.	26867	99.65	21600

Services Load-Testing

This experiment consisted in using the GWD Load-Tester component to specify and execute load test-plans for the registered services. The requests sent in high volume were those associated to the services. The number of simulated users per iteration was 90 (ninety). The period for the sending of requests was 2 (two) seconds and the number of iterations was 3 (three).

Table 7 summarizes the results obtained with the services load-testing, where it can be seen the number of tests, the success rate, the average time to respond to the sent requests and the average bytes of each response.

Table 7: Results of the services load-testing

Service	Tests	Success Rate (%)	Avg Time (ms)	Avg Bytes
CAOP Continente	270	100	3555	13679
Mapa Base	270	100	4945	146834
Vertices Geodesicos	270	100	5074	551
Nomenclatura C.P.	270	100	21	211

Data Quality Assessment

This experiment consisted in using the GWD Data-Tester component to apply two algorithms to assess the quality of the data delivered by the registered services. Therefore the requests associated to the services were sent and the detail of their responses was measured.

In the case of the WFS registered, it was measured the precision of the coordinates returned in response to the “GetFeature” requests. In the case of the WMS registered, it was measured the detail of the map images returned in response to the “GetMap” requests.

Table 8 presents the average (Avg), the maximum (Max), the minimum (Min) and the standard deviation (SD) for the number of non-zero algorisms found in the integer and decimal parts of the coordinates.

Table 8: Results of the algorithm to assess the coordinates precision

	Integer				Decimal			
Service	Avg	Max	Min	SD	Avg	Max	Min	SD
Vertices Geodesicos	3	6	4	0.0	6	6	6	0.74
Nomenclatura C.P.	1	2	1	0.82	13	14	11	0.73

Table 9 presents the results for each tested service, where the pixels field is the size of the minimum area of the image with pixels of different colours. The resolution indicates, in kilometres, the real distance for which it is possible to distinguish information in the map.

Table 9: Results of the algorithm to assess the map image resolution

Service	Pixels	Resolution (km)
CAOP Continente	3 x 2	4.77
Mapa Base	3 x 2	4.96

Services Testing

The experiment consisted in using the GWD Playground component to configure and send requests to geographic Web services and to visualize the returned responses.

Figure 3 presents the response of the “CAOP Continente”, where is being showed the map of Portugal with the boundaries of districts at yellow. This map is showed over a reference map through an OpenLayers client that was included in the GWD Playground component.

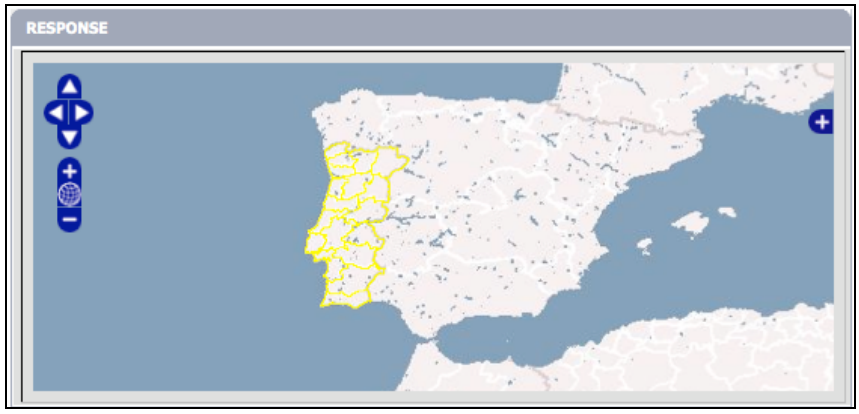

Figure 3: Map returned by the service “CAOP Continente”

Figure 4 presents the response of the “Vertices Geodesicos”, where is being showed an example of feature’s coordinates.

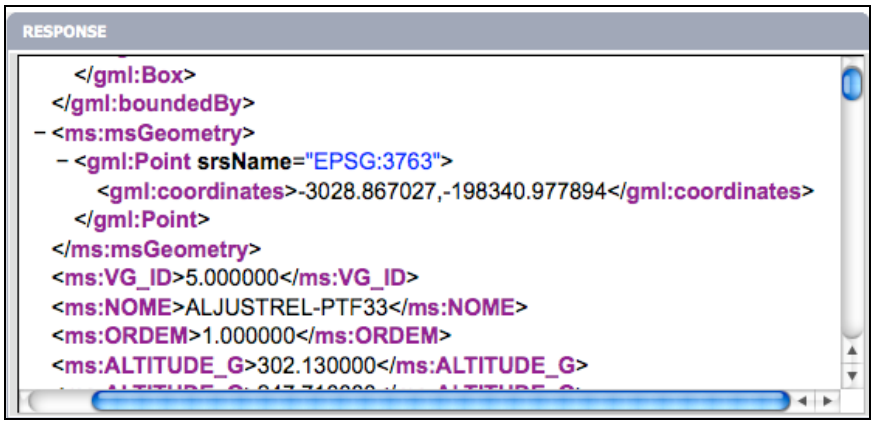

Figure 4: Response returned by the service “Vertices Geodesicos”

CONCLUSIONS

This work proved that the quality of geographic Web services can be analysed from three different perspectives, namely 1) performance and availability monitoring, 2) scalability testing, 3) data quality assurance. A software framework capable of supporting all the perspectives was designed and evaluated with services from two national providers.

The GWD application was submitted to a set of experiments to prove its ability for assessing the quality of geographic Web services. The experiments consisted in using the GWD components to evaluate each function of the GWD application. Therefore, a set of services available from the IGP and the IDEE were tested and the results analyzed. These experiments proof that the GWD application provides quality estimates to potential users or owners of geographic services, helping to determine if the service is suitable for their needs.

The GWD application provides the following functionalities:

- Administration of the GWD system, by adding, editing and deleting services;
- Configuration of the performance and availability monitoring;
- Configuration of test-plans for the scalability testing;
- Assessment of the geospatial data quality;
- A component for testing operations where the operator can experiment and invoke the services by editing or creating requests;

In terms of the development, the owsWatch, was an important role as the basis for the GWD architecture. Moreover, the monitoring function of the owsWatch was the basis for the development of the GWD Monitor component.

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