OGC standards in daily practice: gaps and difficulties found in their use

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Abstract

The Open Geospatial Consortium (OGC) defines standards for the geospatial domain. The purpose of open standards is to provide interoperability. However, in our daily practice of creating web applications based on a service oriented architecture we experienced that problems associated with the application of OGC standards do surface. In this paper, a conceptual model on the use of these standards for further discussion is proposed. Issues associated with the application of OGC standards can surface at three levels: the definition of the standard, the implementation of the standard in software, and the application of this software. The issues can be divided into three categories: semantic issues, organizational issues and technical issues. This leads to a two dimensional matrix which can be used to classify gaps and difficulties encountered when working with OGC standards. The identification of these issues in the right context makes it easier to address the shortcomings and to improve existing standards.

Keywords: OGC, open standards, conceptual model, WMS, WFS, CSW

1 OGC STANDARDS

The purpose of open standards is to provide interoperability. Interoperability refers to the capability of a software product to interact with other systems (ISO/IEC 2001). It should lower development costs, avoid duplication of effort and prevent vendor lock-in (Walker, Chou et al. 2008). Interoperability is based on exchange of reliable and unambiguous data. This is guaranteed typically at the source of the data. The importance of being interoperable is underlined by the first INSPIRE principle which states that data should be collected once and maintained at the level where this can be done most effectively.

The Open Geospatial Consortium (OGC) defines open standards for the geospatial domain. Today's spatial information exchange can be improved by spatial data infrastructures (SDI). An SDI is a commonly recognized set of components that in a coherent way form the infrastructure for exchanging spatial information. These components vary from network access components to the people that form the institutional components. Crucial in that context is that standards are used to guarantee interoperability. The OGC standards of which most are conveyed to the ISO19000-series standards are commonly used in the spatial domain.

The main products of the OGC are implementation specifications and abstract specifications (Open Geospatial Consortium Inc. 2009). Implementation specifications are written for a more technical audience and detail the interface structure between software components. Abstract specifications provide the conceptual foundation for most OGC specification development activities. This paper focuses on implementation specifications since applications developed using OGC standards actually rely on these implementation specifications.

Well known OGC implementation specifications are the Web Map Service (WMS) standard, Web Feature Service (WFS) standard and the catalogue service (CSW) standard. A Web Map Service (WMS) produces maps of spatially referenced data dynamically from geographic information. A "map" is in this case a portrayal of geographic information as a digital image file suitable for display on a computer screen (Open Geospatial Consortium Inc. 2004). The WMS standard is used for data visualization. Optionally, symbolization of a WMS layer can be controlled by a client using a Styled Layer Descriptor (SLD) (Open Geospatial Consortium Inc. 2007). A Web Feature Service (WFS) provides a client with access to the actual features encoded in Geography Markup Language (GML). A transactional WFS (WFS-T) allows a client to both retrieve and update geospatial data (Open Geospatial Consortium Inc. 2005). Both a SLD enabled WMS and WFS use the OGC Filter Encoding to filter spatial data. A SLD can be used to style the features from a WFS. Catalogue Services for the Web (CSW) support the ability to publish and search collections of descriptive information (metadata) for data, services, and related information objects (Open Geospatial Consortium Inc. 2007).

Other examples of OGC implementation specifications typically found in a SDI are the Web Coverage Service (WCS) standard and the Web Processing Service (WPS) standard. A Web Coverage Service (WCS) describes and delivers multi-dimensional coverage data over the World Wide Web. A coverage is a geo-referenced raster, for instance gridded geospatial data or remote sensing images (Open Geospatial Consortium Inc. 2008). Whereas a WFS provides access to vector data, a WCS provides access to geo-referenced raster data. A Web Processing Service (WPS) defines a standardized interface that facilitates the publishing of geospatial processes, and the discovery of and binding to those processes by clients (Open Geospatial Consortium Inc. 2007). Figure 1 depicts the relation between the above mentioned OGC standards. There are numerous other OGC implementation specifications available, but a discussion of all these standards is beyond the scope of this paper.

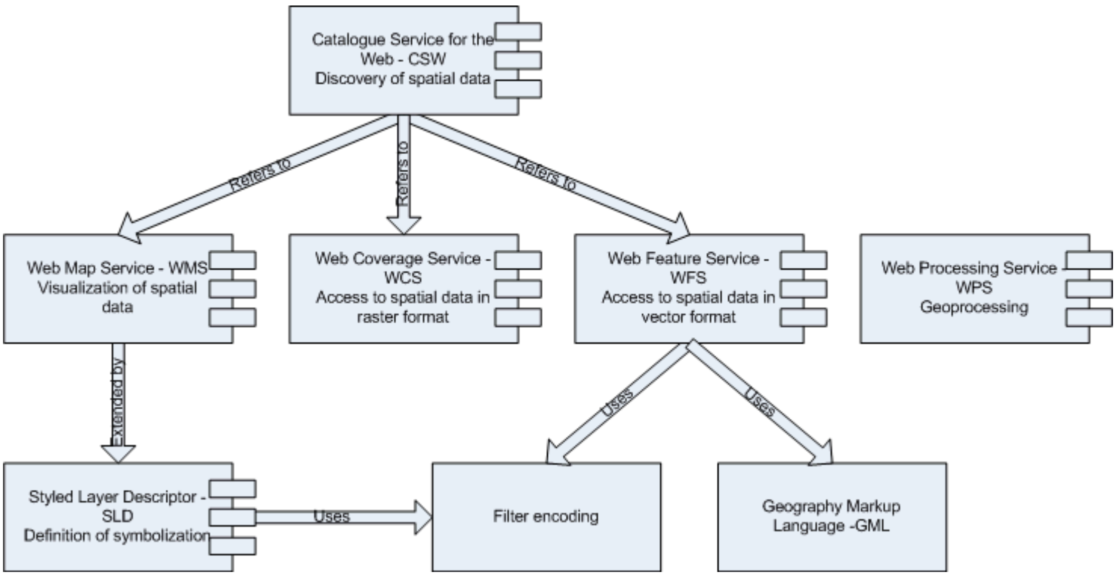

Figure 1 Relation between OGC implementation specifications

Existing research on OGC standards can be divided into two categories. Research in the first category focuses on a particular application which has been based on one or more OGC standards. Song, Rui et al. for instance describe an architecture based on OGC standards for integrating distributed coal mine map services. OGC standards are used to integrate coal mine maps from different sources (Song, Rui et al. 2008). Mansourian, Valadan Zoje et al. describe web services which use feature extraction techniques from satellite images to make spatial data available on demand in a SDI (Mansourian, Valadan Zoje et al. 2008). OGC standards are used to meet interoperability demands in the SDI environment.

Lassoued, Wright et al. demonstrate how the CSW standard can be used to integrate different heterogeneous and autonomous Coastal Web Atlases (Lassoued, Wright et al.). Gao, Mioc et al. describe a loosely coupled, interoperable service oriented architecture for online mapping of spatial-temporal disease information based on OGC standards. According to the authors, such an infrastructure enhances efficiency and effectiveness of public health monitoring (Gao, Mioc et al. 2008). Moreno-Sanchez, Hayden et al. and Moreno-Sanchez, Anderson et al. describe how open source software and OGC standards can be used to develop a health related cross-border web-based spatial information system. The application of open source software and open standards settled issues with regard to differences in health IT infrastructures on both sides of the border (Moreno-Sanchez, Hayden et al. 2006; Moreno-Sanchez, Anderson et al. 2007).

Research in the second category does not entail a particular application, but focuses completely on judging OGC standards themselves. Walker, Chou et al. for instance conclude that the OGC standards have a growing impact on the GIS community, but also that many of the standards and standard groupings are immature and evolving rapidly (Walker, Chou et al. 2008). Michaelis and Ames focus on the WPS standard and find that the WPS standard is workable as currently designed, and is indeed suitable for many GIS tasks, but the authors also identify several opportunities for enhancement (Michaelis and Ames 2009). Lu, Dos Santos et al. have investigated GML. The authors conclude that GML2 is missing functionality. This functionality has been added to GML3, which in turn has become rather elaborate. In addition, the authors raise concerns regarding processing and transport since GML documents can (and often are) very large (Lu, Dos Santos Jr. et al. 2007).

These examples show it is possible to design and implement SDI's based on OGC standards and that the OGC standards do live up to their promises regarding interoperability. However, issues regarding the application of open standards are also present and these issues endanger interoperability (Geonovum 2007). Furthermore, most of the above mentioned authors focus on issues regarding the standards themselves. In our daily practice of creating web applications based on a service oriented architecture we experienced that problems associated with the application of open standards do surface on other levels as well.

Therefore, a conceptual model on the use of OGC standards is proposed. Purpose of this model is to classify issues associated with the application of OGC standards. Such a classification may help to identify possible solutions for the issues encountered and who is responsible for solving the problem. Focus will be on WMS, WFS and CSW standards since the applications which are used as input for the design of the conceptual model mainly evolve around SDI's based on these standards.

2 APPLICATIONS ON WHICH THE CONCEPTUAL MODEL HAS BEEN BASED

This conceptual model is based on experiences gained during the development of several internet GIS applications. The first step of the development of these internet GIS applications consisted of setting up a framework for the integration of geospatial web services (Vanmeulebrouk, Lokers et al. 2008). This framework has been used to create several user friendly internet GIS applications. Some of these applications are listed below. A short description of each application is given, it is indicated which OGC implementation specifications have been applied and which software implementation(s) of these specifications is/are used server side. Furthermore, the issues associated with the use of OGC standards are listed.

Name	Atlas Demonstrator
Description	The Atlas Demonstrator is meant to demonstrate the use of distributed web services from national, regional and local governmental organizations to bring together data sources regarding the living environment. Purpose of the Atlas Demonstrator is to provide citizens with adequate, up-to-data spatial information on their living environment. The Ministry of Housing, Spatial planning and the Environment also uses the project to fulfill their obligation to provide the people with information on the environment, according to the Aarhus convention and other EU directives (Bulens, Vanmeulebrouk et al. 2009). Providing information on the living environment is an ongoing project and 2008 was a reconnaissance phase to explore together with pilot partners (provinces and municipalities) ways to provide information on air quality, noise and green areas.
Implementation specifications	WMS, CSW
Server software	ArcIMS, ArcGIS Server, MapServer, GeoServer, eXcat
Issues	• Integration of spatial data from different sources proved cumbersome since different suppliers of spatial data used different symbolization for similar data • This symbolization could not be harmonized since not all WMS implementations support SLD • Similar phenomena are calculated using different methods which leads to features which are hard to explain to end users • Lack of adequate metadata • Monitoring of service uptime is difficult since OGC standards do not use standard HTTP error codes • Different versions of standards and different versions of software. • Not all WMS provide a legend graphic • Not all WMS layers advertise the scale range in which they are visible • Service uptime

Table 1 Atlas Demonstrator factsheet

Name	Geoportalul Romàn
Description	The Geoportalul Romàn is a prototype for a national geoportal for Romania (Bulens, Schram et al. 2009). It depends on the CSW

	standard for discovery of spatial data and on the WMS standard for previewing spatial data found. The prototype is set up in a Twinning project of the Romanian and Dutch Cadastres to gain experience in implementing a National Spatial Data Infrastructure (NSDI) in Romania according to the INSPIRE directive (Schram, de Bree et al.). The prototype is set up for a small number of datasets in a province in Romania and the prototype consists of a discovery geo-portal and a web shop geo-portal (Bulens, Vanmeulebrouk et al. 2008).
Implementation specifications	WMS, CSW
Server software	GeoServer, eXcat
Issues	• Additional, more concise, arrangements on how to refer to layers available in web services in the metadata were necessary.

Table 2 Geoportalul Romàn factsheet

Name	MARSOP3 Viewers
Description	The MARS crop yield forecasting system consists of an ensemble of methodologies and tools to provide early information on crops (Micale and Genovese). The latest version of the system contains a GIS viewer which has been based on OGC standards. This viewer relies on SLD enabled WMS-s for rendering of maps and on WFS for the selection of geographical features.
Implementation specifications	WMS, WFS
Server software	GeoServer
Issues	• The MARSOP3 viewers need to download the geometry of some geographical objects in GML. This download can be rather large which compromises performance of the application

Table 3 MarsOP3 Geographically Linked Windows factsheet

Name	KICH
Description	KICH is a web portal concerning cultural-historical information for the Netherlands. KICH depends on a datawarehouse which is opened up using WFS. Maps are produced using WMS.
Implementation specifications	WMS, WFS
Server software	ArcIMS, SnowFlake
Issues	• Snowflake may generate a GML3 response for a GML2 request • GML3 is very elaborate. Implementation of all possible geometry types stored in the datawarehouse took a lot of time.

Table 4 KICH factsheet

Name	Meadow bird application
Description	The Meadow bird application is an internet GIS application used to manage information with regard to nature conservation aimed at

	meadow birds in the Netherlands (Vanmeulebrouk, Melman et al. 2008). WMS is used to produce maps and WFS-T provides read-write access to the spatial database for authorized users.
Implementation specifications	WMS, WFS-T
Server software	GeoServer
Issues	• Lack of standardized authorization/authentication mechanism in OGC standards.

Table 5 Meadow bird application factsheet

Name	Designer
Description	Designer is a service chaining environment for geo-spatial web-services developed within the frame of the “Geoportals: liberty united” project (Vanmeulebrouk, van Swol et al. 2009). It allows users to compile a services-based internet GIS application. Users have a palette at their disposition from which components can be selected. The palette contains visual components such as a map component, a legend component and a navigation map component. In addition components encapsulating Open Geospatial web-services such as WMS, WFS and CSW are available and the palette contains one example of a processing web-service: a coordinate transformation service (CTS).
Implementation specifications	WMS, WFS, CSW
Server software	ArcIMS, ArcGIS Server, MapServer, GeoServer, SnowFlake, eXcat, GeoNetwork Open Source
Issues	• Version proliferation of both standards and software implementations of standards. • Bugs in software implementation • Errors in configuration of software implementation

Table 6 Designer factsheet

2.1 Issues

From the factsheets in the previous paragraph, it can be concluded that several issues regarding the application of open standards in daily practice surfaced while carrying out these projects. These issues are summarized in Table 7. The order in this table is arbitrary, it does not indicate importance.

1. The OGC standards do not prescribe a standardized authorization/authentication mechanism. As a consequence, users have implemented proprietary authorization/authentication mechanisms in their applications of OGC standards.
2. The OGC standards do not use HTTP error codes according to the W3C standard, but service exception reports or error messages displayed in images instead. This hampers the implementation of error handling in client software and the use of out of the box software for automated monitoring of services.
3. OGC standards suffer from version proliferation. A lot of versions of the implementation specification and of software in which the specifications are

implemented are available. Issues are often solved in a new version of a standard or a software implementation. However, it may take a while before new versions of a standard are implemented in software and it also may take a while before new versions of software implementations are used in production environments.
4. Bugs are found in software implementations of the standards. Examples of bugs found while carrying out the above mentioned projects include: a. The ArcIMS 9.1 GetFeatureInfo buffer used when identifying point features is far too small making it virtually impose to click a point. b. The Dutch national grid (Rijksdriehoekstelsel or RD) implementation in ArcGIS introduces an offset of around 110 meters when converting from WGS84 to RD. c. Snowflake may produce a GML3 response when GML 2 is requested. d. GeoNetwork Open Source uses “any” instead of “AnyText” in CSW queries.
5. OGC implementation specifications distinguish mandatory and optional requests. In some software implementations optional requests have not been implemented, even though these optional request may greatly enhance the practicability of a software implementation of a standard. Examples include: a. Missing SLD support in WMS b. Missing legend graphic in WMS
6. Some OGC implementation specifications provide a lot of degrees of freedom: a. The WMS GetFeatureInfo response is very loosely defined b. CSW GetRecordByID response is very loosely defined
7. Often similar phenomena are portrayed using heterogeneous data. For real interoperability information should be consistent and unambiguous. However, the current international standards like the OGC standards do not transcend the technical domain.
8. Heterogeneous symbolization is used for homogeneous data. To be able to meaningfully integrate spatial data from different sources, a uniform representation of spatial objects is required. Each organization wants to convey a certain message using its spatial data and adjusts the presentation of these data accordingly. Often, organizations will not be willing to modify the presentation (or facilitate modification of the presentation by a third party) of spatial data to fit another purpose.
9. Lack of adequate metadata.
10. GML2 lacks functionality, for instance no topology or support for 3D data
11. GML3 is very comprehensive
12. A GML download is potentially large
13. It would be convenient if the standards allowed for additional functionality. For instance: a. WFS 1.0 does not support coordinate transformations. Data are always delivered in the coordinate reference system of the source data. WFS 1.1 does support this functionality. b. There is no implementation of metadata for services available in CSW, only of metadata for data (ISO19139)
14. Administrators of the software in which standards have been implemented

can introduce errors in the configuration of the software.

Table 7 Issues regarding the application of open standards in daily practice

The issues summarized in Table 7 are by nature quite heterogeneous and they require different solutions which have to be implemented by different organizations or persons. Therefore, arranging of the issues may be useful.

3 THE CONCEPTUAL MODEL

The issues associated with the application of open standards listed in Table 7 can surface at three levels: the definition of the standard as laid down in the implementation specification, the implementation of the standard in software, and the application of this software. The issues can be divided into three categories: semantic issues, organizational issues and technical issues. This leads to a two dimensional matrix which can be used to classify gaps and difficulties encountered when working with open standards. This two dimensional matrix is presented in Table 8. The numbers inside the matrix refer to the issues listed in Table 7.

	Semantic	Organization	Technical
Implementation specification	6, 13, 10	1, 3, 11	2, 12
Software implementation	5	3	4
Application	7, 8	9	14

Table 8 Two dimensional matrix

Semantic issues relate to the contents of the spatial data offered by the web-services. Semantic issues at implementation specifications level relate to the degrees of freedom present in OGC implementation specifications. Degrees of freedom may lead to multiple implementations and interpretations of a standard, thus endangering interoperability. Degrees of freedom can be limited by defining profiles, for instance the Dutch WMS profile (Geonovum 2007). Our experience shows that profiles enhance the practicality of standards by reducing some of the degrees of freedom. However, these profiles can also limit the number of available software implementations of a standard (if a software implementation cannot meet the requirements imposed by the profile) or complicate the configuration of the software.

Semantic issues at implementation level relate to lack of implementation of optional features of a standard. Not all requests described in the OGC standards are mandatory. This is understandable (some requests are not applicable in some situations), but in some software implementations of OGC standards optional requests have not been implemented, even though these optional request would actually enhance the practicability of a software implementation of a standard.

Semantic issues at application level include heterogeneous data for homogeneous phenomena. Semantics and harmonization are keywords here. For real interoperability, information should be consistent and unambiguous. For that purpose data should be translated into meaningful objects to be able to exchange information, not only between the different application domains, but also across borders. Information or semantic models will support this process. On a European level, this process has commenced with the implementation of the INSPIRE directive. However the current international standards like the OGC standards, do not transcend the technical domain.

On top of semantics stands visualization. In this domain harmonization will improve interoperability as well. Within application domains the process is started to standardize representation of spatial objects. A complicating factor in this field is that web cartography is still a very young specialism. Compared to Bertin's theory in his framework for cartographic representation of data on paper, web cartography offers many more variables to add to the framework. Also for representation standards like the OGC standards offer a base for technical exchange but are lacking rules related to content.

Organizational issues relate to institutional aspects surrounding web-services. Both implementation specifications and implementations of standards in software suffer from version proliferation. Issues are often solved in a new version of a standard or a software implementation. However, it takes a while before new versions of a standard are implemented in software and it also takes a while before new versions of software implementations are used in production.

At application level, an important organizational problem is the lack of adequate metadata. Metadata in itself is not difficult, but the complexity and the extensiveness of the standard on the other hand is hard to see through. Also the lack of adequate standards compliant metadata editors hampers a proper use of metadata. An important aspect is that the lack of metadata may result in a downward spiral. Lack of metadata will result in a poor performance in finding information, which is the purpose of metadata. Poor performance will lower commitment in creating and maintaining metadata properly, which in turn will effect performance again. This can only be reversed by showing the added value of available and complete metadata for all data sources

A technical issue at standard level is that OGC standards only conform to W3C standards up to a certain extent. For instance, OGC implementation specifications do not use standard HTTP error codes, which complicates error handling in OGC clients and automated monitoring of services. At implementation level, an obvious issue is bugs in software implementations of standards. Similarly, at application level, errors can be made in the configuration of software. For a consumer of a web-service, it is difficult to discern between a bug in the implementation or an error in the configuration of this software, they both lead to similar results in a client.

4 DISCUSSION

Practical experiences like the ones on which the conceptual model described in this paper has been based are valuable for the development of OGC standards. The applications which have been used to design the conceptual model can roughly be divided into two categories: a category in which a single organization controls both the client application and the server application and spatial data from a limited number of different sources are used (Geoportalul Romàn, KICH, Meadow bird application and the MarsOP3 viewer) and a category in which an organization only controls the client application but depends on other organization’s server applications and spatial data from a variety of sources are used (Atlas Demonstrator and Designer).

During the implementation of the applications in both categories, issues relating to the use of OGC standards were encountered, but solving issues encountered while working on applications in the first category was much easier than solving the issues found while working on the applications in the second category. To solve issues regarding applications in the first category, workarounds could easily be found by either modifying the client software, modifying the configuration of the server software, the application of other versions of server software or relying on optional features in the standards since we were certain that the server software supported these optional features. For the applications in the second category, the number of available workarounds was much more constrained, only the client software could be modified.

These findings are consistent with findings of other research discussed earlier in this paper. Design and implementation of a specific application based on OGC standards is not a problem, but issues related to the application of OGC standards tend to become more of a problem when a system has to be generic.

The OGC standards themselves and the software in which they have been implemented have reached a stage which makes them very suitable for the implementation of SDI's, but there are still issues associated with the application of open standards. The most important issues are related to content, and this demonstrates that standardization should be brought to the next level from data to information. In implementing the INSPIRE directive in Europe, first efforts are made to move into that direction. The Conceptual Generic Model (INSPIRE 2008) is a sound base for further harmonization. The work carried out on data specifications for the themes mentioned in the directive is a difficult step, but a necessary step to bring standardization from the data to the information level.

Identification of issues using a conceptual model as the one proposed in this paper may be a first step towards solving the issues. The model is particularly useful for classification of issues encountered during the implementation of an application which relies on OGC web-services of different kinds. The conceptual model itself will not solve the issues, but it may help to identify whether the problem is associated with the implementation specification, the implementation of the implementation specification in software or the application of this software.

5 CONCLUSION

The OGC standards themselves and the software in which they have been implemented have reached a stage which makes them very suitable for the implementation of SDI's, but there are still issues associated with the application of open standards. The conceptual model proposed in this paper can be used to classify these issues. The issues related to the application of OGC standards in daily practice can be divided into three categories: semantic issues, organizational issues and technical issues. Issues can surface at three levels: the standard itself, the implementation of the standard in software or the application of this software. This classification may help people working together in a project to identify possible solutions for the issue at hand.

The model also shows that OGC standards so far do not transcend the technical domain. The be able to solve semantic issues, the standard have to brought to a next level. Standards on how to turn data into information need to be developed in order to facilitate integration of information from different sources.

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