Open Standards in Practice: An OGC China Forum Initiative

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Abstract. Open standards like OGC standards can be used to improve interoperability and support machine-to-machine interaction over the Web. In the Big Data era, standard-based data and processing services from various vendors could be combined to automate the extraction of information and knowledge from heterogeneous and large volumes of geospatial data. This paper introduces an ongoing OGC China forum initiative, which will demonstrate how OGC standards can benefit the interaction among multiple organizations in China. The ability to share data and processing functions across organizations using standard services could change traditional manual interactions in their business processes, and provide on-demand decision support results by on-line service integration. In the initiative, six organizations are involved in two “MashUp” scenarios on disaster management. One “MashUp” is to derive flood maps in the Poyang Lake, Jiangxi. And the other one is to generate turbidity maps on demand in the East Lake, Wuhan, China. The two scenarios engage different organizations from the Chinese community by integrating sensor observations, data, and processing services from them, and improve the automation of data analysis process using open standards.

1. Introduction
With the advancement of sensor technologies, large volumes of geospatial data are collected every day [1]. Various tools and platforms are developed to access and process these data. The data and software usually have their own proprietary features or operations. For example, it is often a challenge to combine processing functions from different tools/platforms to work collaboratively. Open standards bring an interoperate approach to address such an issue, which allows heterogeneous data and software to work together in an interoperable way. For example, the data service standards like the Open Geospatial Consortium (OGC) Web Map Service (WMS), Web Feature Service (WFS), and Web Coverage Service (WCS) are a set of standard interfaces for finding and accessing data in data archives of varied sizes and sources. The OGC Web Processing Service (WPS) specifies a standard interface and protocol for discovering and executing distributed geoprocessing processes. And the Open Modelling Interface (OpenMI) provides standard interfaces to support data exchange at runtime [2], which enables interoperability across modelling components. The main geospatial standards are provided by ISO/TC
ISO/TC 211 [3] is a standard technical committee in International Organization for Standardization (ISO), which is responsible for ISO series of standards in geographic information. In the geospatial Web services area, OGC is the main organization working on developing geospatial services standards by adapting or extending common Web service standards.

Service Oriented Architecture (SOA) is increasingly popular in recent years, and a large amount of geospatial data and processing functions are available in the form of online Web services. OGC has developed a set of OGC Web Service (OWS) testbeds, through which a set of open standards are developed, such as WMS, WFS, WCS, WPS, Web Coverage Processing Service (WCPS), Web Map Tile Service (WMTS), and Catalogue Service for Web (CSW). WMS provides HTTP interfaces for clients to access to geo-registered map images from distributed geospatial databases on web map server. WFS provides feature operations for clients to communicate with servers on features and feature properties. WCS defines a standard for sharing and interoperability of coverage data. The WCPS defines a protocol-independent language for the extraction, processing, and analysis of multi-dimensional coverage data. WMTS provides an interface for accessing to some map service. The OGC WPS specification makes traditional analysis functions accessible through standard interfaces on the Web. The OGC CSW standard specifies interfaces, bindings, and a framework for metadata catalogues to publish and discover geospatial data, services and related resource information. OGC Sensor Web Enablement (SWE) [4] standards provide a framework for sensor web interoperability. For example, Sensor Observation Service (SOS) specification provides standard interfaces for accessing sensor observations. The Sensor Event Service (SES) performs filtering of sensor data (streams) and sends notifications of events [5].

The distributed services following OGC standards could be combined together as workflows to automate the extraction of information and knowledge from heterogeneous geospatial data. This paper will present an on-going China “MashUp” project that adopts OGC standards to facilitate information interaction among multiple organizations in China. The project is being coordinated by the OGC China Forum. It will provide a demonstration/mashup by organizations in China designed to show exactly how OGC services work using Chinese scenarios and Chinese data. Two scenarios are used to demonstrate the advantages of using standard services and workflow technologies.

The remainder of the article is organized as follows. Section 2 introduces the role of OGC-China Forum. Section 3 presents the OGC China forum initiative. Conclusions and future work are given in Section 4.

2. The role of OGC-China Forum
The OGC-China Forum can be traced back to October 2007, when the OGC China Symposium was held in Wuhan, China. The symposium topics include the OGC standards process and infrastructure, the business and technology environment for OGC standards, overview of OGC standards architecture from business and development perspectives, OGC standards for Location Services, Sensor Webs and spatial-temporal apps [6]. The goals of the symposium aim to introduce OGC to the geospatial community in China and initiate effective communications concerning geospatial standards development. This symposium improved the cooperation between China and OGC. Later, the Asia Forum of the OGC was established in October 2011. China is one of the founding members. The OGC Asia Forum aimed to address OGC outreach in the Asia region [7].

The OGC-China Forum could help improve awareness of geospatial interoperability standards in China and assist in the definition of a set of standards to meet requirements of China. In addition, OGC–China Forum also provides a platform for Chinese developers and users to access the latest products and services of OGC.

3. An OGC-China forum initiative
The “MashUp” project involves six organizations from the Chinese community: 1) Wuhan University (abr. WHU); 2) National Geomatics Center of China (abr. NGCC); 3) Institute of Remote Sensing & Digital Earth, Chinese Academy of Sciences (abr. RADI); 4) Fuzhou University (abr. FZU); 5)
Zhengzhou Institute of Surveying & Mapping (abr. ZISM); and 6) Wuda Geo Information Engineering Technology Co. Ltd. (abr. GEOSTAR). The organizations involved include both OGC members (e.g., WHU, RADI, FZU, ZISM) and non-members (e.g., NGCC, GEOSTAR). They will join the two scenarios on disaster management. In the scenarios, they will work together to integrate sensor observations, data, and processing services, and improve the automation of data analysis process using OGC standards.

3.1. Scenarios

Two motivating scenarios are used to demonstrate how OGC standards benefit the interaction among multiple organizations and how the automation of data analysis process works. The first scenario is to derive flood maps in the Poyang Lake, Jiangxi. And the other one is to generate turbidity maps on demand in the East Lake, Wuhan, China.

(1) Scenario 1

Supposing Mr. Li is a staff member in a disaster monitoring department in China, and he wants to know the situations of flood inundation in a region around the Poyang Lake in China in 2010. One satisfactory result would be a thematic image for the flood area, which renders regions that have different flood situations using different colors.

Mr. Li would like to formulate a geoprocessing task on the flood analysis, which can generate such an image. He finds that a geoprocessing model can perform the flood analysis and output the image (figure 1). The model uses input images in different periods. In each period, there are two images in the first and second wavelength bands of MODIS data respectively. Each group of images goes through Normalized Difference Vegetation Index (NDVI) calculation, binarization, and rendering processes to gain the range of the flood in the same place in each period. Then, the resultant images can be mixed by a blend process to generate the required flood thematic image.

![Figure 1](image)

**Figure 1.** A scientific workflow for change extraction of water coverage area from remote sensing imagery.

In this scenario, the images could be provided by data services following Web Coverage Service (WCS) specification, while the processes could be accessed via OGC WPS interfaces. It is then possible to integrate data and computational resources in a distributed information infrastructure using workflow technologies. In case users want to generate another flood thematic image in other periods, users just need to adjust input parameters. Then time-series maps on demand are produced.

(2) Scenario 2

Suppose Mr. Wang is an employee of the National Disaster Reduction Center (NDRC) in China. He is responsible for monitoring the water quality of East Lake in Wuhan City, Hubei Province. He asked the GEOSTAR company to place a number of water quality sensors in East Lake, which can continuously collect chlorophyll concentration and water turbidity data. When detecting anomaly (e.g., Water turbidity exceeds the threshold), Mr. Wang will collect suitable remote sensing observation covering East Lake, process the data based on a turbidity extraction processing flow (figure 2). The
observation imagery will go through orthorectification, radiometric calibration, atmospheric correction, clipping, Normal Differential Water Index (NDWI) calculation, mask building, silt inversion, and mapping processes to provide decision support on whether pollution happens or the range of pollution.

Traditionally, experts have to check in-situ observation data regularly, and if anomaly is detected, find remote sensing imagery and process the data step by step using an image processing software. With the standard Sensor Web technologies, in-situ observation data is sent to the data center, accessed through the SOS interface, and checked automatically against the threshold. Once an event is detected, the turbidity extraction processes could be triggered automatically. Thus interoperable services and the workflow approach improve the automation of the environment monitoring.

![Image 1](image1.png)

**Figure 2.** A scientific workflow for turbidity extraction from remote sensing imagery.

3.2. Architecture

The architecture used in the scenarios follows the publish-find-bind paradigm (shown in figure 3). The various kinds of services (e.g., WCS, WFS) provided by different Chinese organizations are published in a registry (e.g., CSW). The requestors are able to find appropriate services to consume through the registry. After the service discovery, the result services will be bound to specific tasks. For complex spatial problems, distributed services need to work together as service chains, and workflow technologies are employed to accomplish this. The integration environment will provide a user-friendly tool for service composition to support on-demand generation of geospatial data products.

![Image 2](image2.png)

**Figure 3.** Service-oriented architecture using OGC standards.

In scenarios, distributed algorithms are exposed as OGC WPS interfaces, and distributed data (e.g., images, features, observations) are accessible through OGC data service standards (e.g., WCS, WFS,
SOS). All services are published into an OGC CSW. The scenarios adopt the scientific workflow approach for turbidity extraction and flood analysis, in which the workflow-based service chaining is used.

3.3. Implementations
All developed services follow the OGC standards. And, the service integration environment is implemented by extending an existing geoprocessing workflow tool, named GeoJModelBuilder [8].

Table 1 shows services provided by the six organizations. RADI provides processing functions, such as binarization and rendering used in Scenario 1, which follow the WPS specification. The processing functions used in scenario 2 are provided by WHU. The CSW is offered by WHU. FZU provides remote sensing data services. NGCC operates a national geographic information service named the MapWorld, which provides base maps. The feature service is offered by ZISM, which provides the area of interest. GEOSTAR provides a sensor observation service which follow the SOS specification.

**Table 1.** Services provided by six organizations following OGC standards.

| Data/Processing functions                  | Type of services | Organizations |
|-------------------------------------------|------------------|---------------|
| silt inversion, mask building, clipping, etc. | WPS              | WHU           |
| Service registry                          | CSW              | WHU           |
| NDWI, Binarization, Rendering             | WPS              | RADI          |
| Images                                    | WCS              | FZU           |
| Features                                  | WFS              | ZISM          |
| MapWorld                                  | WMTS             | NGCC          |
| Observations                              | SOS              | GEOSTAR       |

![Figure 4. Flood analysis in GeoJModelBuilder.](image-url)
GeoJModelBuilder is a geoprocessing workflow system for environmental monitoring and integrated modelling, which could couple sensor web, geoprocessing services, and data services using workflow technologies. The tool is extended to support the ability to discover appropriate services from a service registry following the OGC CSW specification. Figure 4 shows that the services are integrated for the flood analysis in the GeoJModelBuilder. In the figure, rectangles stand for services and ellipses stand for input or output. When users double click on the rectangle, a dialog is popped up to set parameter values. Users could use the Search button to search for input data from a service registry. Figure 5 shows that GeoJModelBuilder is used for turbidity extraction. Users could specify the threshold of observations to define an event. Once the event happens, the turbidity extraction process will be triggered automatically. The result also could be visualized in the GeoJModelBuilder.

3.4. Result analysis
In the two scenarios, various geospatial data and processing functions from six organizations are coupled into a workflow in a flexible, reusable, and interoperable way using OGC standard services. The first case derives flood maps in the Poyang Lake in China. Once MODIS images in different periods are provided, a thematic map showing the change of water coverage area will be produced. In the second case, SOS and SES are used to support “active” environmental monitoring. When an event is triggered, the turbidity extraction process could be executed automatically. Users don’t need to extract the turbidity maps step by step. The ability to share data and processing functions across organizations using standard services could change traditional manual interactions in their business processes, and provide on-demand decision support results by on-line service integration.

4. Conclusions and future work
In this paper, an ongoing OGC China Forum initiative is introduced. OGC standards are used to share data and processing functions in an interoperable way over the Web. Geospatial services from various organizations could be integrated for the automation of information and knowledge extraction. Two scenarios are developed to demonstrate the advantages of using standard services and workflow technologies to provide on-demand decision support. Six organizations in China are involved in the “Mashup” project. The work is still going on. For example, since the Donghu lake is located inside the city of Wuhan, the second scenario could be extended to support some cases on smart cities. We will have a special OGC-China Forum session to make further planning in the annual conference of Chinese GIS society, which will be held in Shenzhen University, Shenzhen, China in September 2016.

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