Yong-Jin Kwon
Alain Bouju
Christophe Claramunt (Eds.)

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Web and Wireless Geographical Information Systems

4th International Workshop, W2GIS 2004
Goyang, Korea, November 2004
Revised Selected Papers

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Preface

The aim of the annual W^{2}GIS workshop is to provide an up-to-date review of advances on recent development of Web and wireless geographical information systems, and new challenges and opportunities for researchers, developers and users in the GIS community. The main topic of the W^{2}GIS workshop is theoretical and technical issues of Web and wireless geographical information systems. This workshop followed the successful 2001, 2002 and 2003 editions, held in Kyoto, Singapore and Rome, respectively. The 2004 edition was held in Goyang, Korea.

In its 4th year, W^{2}GIS reached new heights of recognition as a quality workshop for the dissemination and discussion of new ways of accessing and analyzing geospatial information. This year, 39 papers were submitted from 15 countries, and 20 papers were accepted from 11 countries. Similarly, the Program Committee consisted of 39 members from 16 countries.

We had the privilege of having three distinguished invited talks: "Eliciting User Preferences in Web Urban Spaces," Yanwu Yang and Christophe Claramunt, Naval Academy Research Institute, France; "Discovering Regional Information from Web: Localness and Landmark Computation," Katsumi Tanaka, Department of Social Informatics, Graduate School of Informatics, Kyoto University, Japan; and "Towards Knowing, Always and Everywhere, Where Everything Is, Precisely," Christian S. Jensen, Department of Computer Science, Aalborg University, Denmark.

The workshop was organized by the Internet Information Retrieval Research Center (IRC) of Hankuk Aviation University, Korea. The IRC was established in 2001, sponsored by the Ministry of Science and Technology, Korea, KOSEF (the Korea Science and Engineering Foundation), Gyonggi-do (local government) and various venture companies (over 20). The research term of the IRC is 9 years, and its research fund is 9 million dollars total.

We wish to thank the authors for the high quality of their papers and presentations, and the Program Committee members for their timely and rigorous reviews of the papers. We thank the Steering Committee members for organizing and supporting this event. Finally, special thanks go to Stefano Spaccapietra for his advice and help.

November 2004

Yong-Jin Kwon
Alain Bouju
Christophe Claramunt
Workshop Chairs
W^{2}GIS 2004

In Memory of Prof. Yahiko Kambayashi
(February 15, 1943 – February 6, 2004)

We are deeply saddened by the sudden and untimely passing away of Prof. Yahiko Kambayashi, Dean of the School of Informatics, Kyoto University, Japan. His unexpected departure is a tremendous shock to everyone who knew him. He was 60.

Prof. Kambayashi was one of the pioneers of database research as well as a leader of the international database research community. He published numerous articles in major database journals and conferences such as Information Systems, SIGMOD, VLDB and ICDE. He was also the author and the editor of many books and conference proceedings. Prof. Kambayashi was an IEEE fellow, a trustee of the VLDB Endowment, a member of the SIGMOD Advisory Committee, a vice-chair of the ACM Tokyo/Japan Chapter, the chair of the DASFAA Steering Committee, a co-chair of the WISE Society and the WISE Steering Committee, a member of the W^2GIS Steering Committee, a member of the CODAS Steering Committee, a member of the ER Steering Committee, a member of the RIDE Steering Committee, a co-editor-in-chief of the World Wide Web Journal, an associate editor of ACM TODS, and a member of the editorial board of several international journals. He was a winner of the ACM SIGMOD Contribution Award in 1995 for his many professional services in Japan and worldwide.

Prof. Kambayashi had been making great efforts to organize this W^2GIS 2004 workshop, just before his sudden passing. Together with all the authors and the participants, we are taking this opportunity to express our heartfelt condolence and our deepest sympathy to his family.

November 26th, 2004 W^2GIS 2004 Workshop Committee

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Web Services Framework for Geo-spatial Services

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Abstract. In this paper, we propose a Web Service framework for four kinds of geo-spatial services of GIS, SIIS, ITS, and GNSS. First, we examine what requirements are needed when designing the framework for various kinds of geo-spatial services. Then, we show how the framework can contribute to efficient geo-spatial services on both wired and wireless environment. Main issues in a design of the framework are to define interoperable interfaces, to define standardized metadata, and to design efficient geo-spatial server for various kinds of geo-spatial services. The framework fundamentally adopts international standards such as WMS, WFS, WCS, and WRS announced by OGC. The adoption satisfies the interoperability, extensibility, and standardization of the framework. Especially, we focus on a design of main memory-based GIS server(MM server). The MM server can efficiently serve huge volume of GML documents via Web Service. And experimental results show the effectiveness of the framework and MM server.

1 Introduction

Recent advance in web-based technology is raising new users' requirements that intend to serve complex and huge volume of information via Web. Especially, in geo-spatial information research field, such requirements that intend to serve huge volume of vector-typed map and satellite imagery map via both wired and wireless network are emerging. Over the past few years, a great deal of attention [1–6] in the Web Service technology has been directed towards efficient service integration among heterogeneous distributed servers. Therefore, it is meaningful to apply the Web Service technology to services integration among heterogeneous geo-spatial servers. However, it is not easy to provide geo-spatial services on Web environment on account of diversity and complexity [7] of geo-spatial data themselves. Actually, there were nearly case studies that can serve huge volume of geo-spatial data owing to the efficiency problem of Web Service so far.

So, in this paper we propose *Web Service framework* for geo-spatial services that has features of interoperability on Web environment, extensibility on various kinds of geo-spatial services, and efficient performance on wired and wireless network. The framework is composed of several kinds of *geo-spatial*

Y.-J. Kwon, A. Bouju, and C. Claramunt (Eds.): W2GIS 2004, LNCS 3428, pp. 1–13, 2005.

servers, *geo-spatial broker*, and *web-based clients*. In order to provide interoperability and extensibility on the geo-spatial services, we basically apply implementation specifications of OpenGIS Consortium (OGC) for designing the Web Service framework [8]. Speaking in detail, *"The Simple Features Specification for OLE/COM"*(SFS) [9], *"Web Map Services Implementation Specification"*(WMS) [10], *"Web Feature Services Implementation Specification"*(WFS) [11], *"Web Coverage Services Implementation Specification"* (WCS) [12], *"Geography Markup Language Implementation Specification"*(GML) [13], and *"Web Registry Services Implementation Specification"*(WRS) [14] are used to build the framework. The framework, actually, uses WMS, WFS, and WCS to build various kinds of geo-spatial servers that can provide image map such as JPG or GIF, vector map such as GML, and coverage information such as GeoTIFF, respectively. WRS is used to build geo-spatial broker that can provide a runtime discovery and registration for geo-spatial services. This Web Service framework can support four kinds of geo-spatial services that GIS server, SIIS (Spatial Imagery Information System) server, ITS server and GNSS server expose. Geo-spatial broker that accommodates WRS and references *"Universal Description, Discovery and Integration"* (UDDI) is a kind of metadata repository for geo-spatial services. So, geo-spatial servers can publish metadata for their services to the geo-spatial broker, and web-based clients can find metadata for their requests from the broker. Especially, the framework includes *MM server* that can give fast responses to clients by removing loading time of geo-spatial data and conversion time for vector data to GML. The main advantages of this Web Service framework are (1) it can efficiently provide the integrated services of various kinds of geo-spatial servers by using OGC and W3C specifications; (2) it can give fast responses to clients by using the MM server.

First, we present an overview of Web Service environment for geo-spatial services in the next section. Then, we present specific requirements of the Web Service framework for geo-spatial services in section 3 and propose our solutions that satisfy those requirements in section 4. Lastly, we show some examples for the framework and conclude our suggestions in the remaining sections.

2 Overview of Web Service Environments for Geo-spatial Services

A Web Service provides a set of protocols that allow applications to expose their functions and data to other applications over the Internet. Also, a Web Service provides a language and platform independent syntax for exchanging complex objects using messages. This Web service architecture has three essential components: *service provider*, *service broker*, and *service requestor*. Service provider publishes an availability of its service resources to service broker using *"Web Service Description Language"*(WSDL) [15] and delivers its services to service requestor when the service requestor wants to bind to its services. Service broker is acting as a registry or clearinghouse of services using UDDI. Service requestor performs discovery operations of services from the service broker and receives

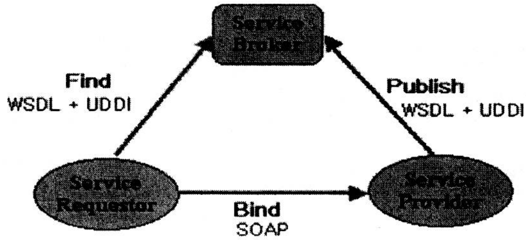

Fig. 1. Web Service Architecture.

result metadata. Using the metadata, service requestor binds to services of service provider and performs services. Such mechanism of Web Service is termed as *"Publish-Find-Bind"* and can be depicted as Fig. 1. Web environments for geo-spatial data are mostly researched and standardized by OGC. The OGC has announced many implementation specifications for Internet service of various kinds of geo-spatial data. However, the old specifications that have already announced by OGC considered only Internet services for geo-spatial data on web browser. In the beginning, OGC announced WMS, WFS, WCS, and Catalog services specification [16] to easily provide geo-spatial data on web browser. They did not consider the Web Service architecture that can expose geo-spatial services directly using XML. However, OGC began to cooperate with W3C recently, and OGC is announcing new specifications such as WRS, GML, and *"OpenGIS Reference Model"*(ORM) [17] for Web Service. Although the new specifications are not perfectly conformed to Web Service architecture, OGC are making all efforts to confirm the new specifications to Web Service specifications. Speaking in detail, WMS only defines interfaces that can transmit simple image map for web browser based on server-side mapping. On the contrary, WFS defines more complex interfaces than WMS, which can transmit GML documents and can perform spatial operators based on client-side mapping. WCS is similar to WFS except that it transmits satellite imagery data instead of vector-typed map. GeoTIFF, HDF-EOS, DTED, and NITF are widely used as encoding formats for the satellite imagery data. There are additional specifications of *"Styled Layer Descriptor"*(SLD) [18] and *"Coverage Portrayal Service"*(CPS), which define interfaces to change client-side mapping into server-side mapping in case of WFS and WCS servers. In other words, SLD and CPS can convert GML and GeoTIFF typed data that are generated in server side mapping into image map that can be used in client. Such conversions are needed in case of thin clients that can only visualize image map. Fig. 2 shows relations between OGC specifications that serve various kinds of geo-spatial data. In this paper, the Web Service framework adopts OGC specifications of WMS, WFS, WCS, and WRS as a basic architecture. Therefore, the framework can serve all kinds of geo-spatial data that OGC defines. Additionally, we upgrades and modifies the basic framework in order to efficiently serve huge volume of geo-spatial services on both wired and wireless network environment, which will be discussed in section 4.

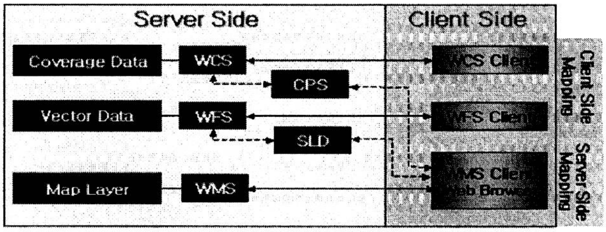

Fig. 2. Relation between OGC Specifications for Geo-spatial Data.

3 Requirements and Problems for Web Service Framework

In this section, we focus on the properties of various kinds of geo-spatial data and services that should be considered when we design the Web Service framework.

3.1 Huge Volume of Geo-spatial Data

Huge volume problem is an inherent property of geo-spatial data. Generally, the size of one geo-spatial object varies from tens of bytes to thousands of Kbytes in the real world applications. Because of huge volume of objects and large number of objects, it is almost impossible to efficiently transmit them to web clients on Web Service environment. General geo-spatial servers, for example Microsoft TerraServer [19], need three steps to provide huge volume of geo-spatial data using Web Service: (1) load geo-spatial objects from the persistent storage such as file system or database system; (2) make XML documents, GML document in this case, for loaded objects; and (3) transmit huge volume of GML documents. Most geo-spatial servers that mainly handle huge volume and large number of objects consume too much time in the three steps. We think it is very difficult to provide geo-spatial data using Web Service on wired and wireless network, so we propose MM server as a solution to solve the time constraint. The MM server is explained in detail in the next section.

3.2 GML-Typed Geo-spatial Data

For the purpose of satisfying Web Service architecture, it is also an important requirement for GIS server to convert original geo-spatial objects into GML documents on-line. Unfortunately the GML conversion consumes too much time, which often becomes major cause of late response to clients. Moreover, as the size of GML document increases, the response time to clients is getting worse and worse. So, we propose preprocessing of GML conversion as a solution for that problem. The preprocessing can give fast response to clients by saving the time consumed by on-line GML conversion. We will discuss more details about this in the next section.