KING FAHAD UNIVERSITY OF PETROLEUM AND MINERASLS

COLLEGE OF ENVIRONMENTAL DESIGN
ARCHITECTURAL ENGINEERING DEPARTMENT

CRP 514 TERM PAPER

DISTRIBUTED AND WEB BASED GEO-INFORMATION SERVICES AND APPLICATIONS

BY

MOHAMMED ABDUL FASI

(ID#: g200904790)

SUBMITTED TO

Dr. BAQER AL-RAMADAN

19th December, 2010

Table of Contents

DISTRIBUTED AND WEB BASED GEO-INFORMATION SERVICES AND APPLICATIONS 1

ABSTRACT 4

1. INTRODUCTION 5

1.1 What is Internet GIS? 5

2. Different Types of Internet GIS 6

3. Recent History and Current State of Internet GIS standards 9

4. Standards for Internet GIS 11

5. The Future of Internet GIS: Services-oriented applications 13

6. References: 15

List of Figures

Figure 1: Three kinds of Internet GIS 6

Figure 2 *: The architecture of three-tier Internet Map Server* 10

ABSTRACT

Distributed and Web based geo-information services is a very hot topic now a days. It has an extremely good potential in almost every subfield of traditional Geographic Information Systems (GIS). It may even change our life style in the next few years. Huge outlays of effort, money, and people have developed the related technologies, software packages and applications. Most GIS professionals expect that the Internet is the future of GIS. This paper provides an introduction to Internet GIS technologies by discussing today's realities and a vision of the future Internet GIS. This paper will also introduce some examples of data standards for the Internet GIS.

1. INTRODUCTION

1.1 What is Internet GIS?

What is Internet GIS? Internet GIS is "network-based geographic information services that utilize both wired and wireless Internet to access geographic information, spatial analytical tools, and GIS web services." [4]. There are a few key concepts in this definition. First, "network-based" indicates that the whole framework of Internet GIS is sharable and exchangeable. Second, the method of telecommunication includes both "wired and wireless". Mobile devices (like PDAs, cellular phones, and Pocket PCs) with wireless communication are an integral part of the Internet GIS framework. Finally, the contents of Internet GIS include not only displaying Internet maps or sharing on-line geospatial information, but also providing advanced GIS analysis functions and new information services. Examples include virtual touring, children location-monitoring, social services, and others.

The distributed Internet GIS framework is an example of the revolution of information systems -- from traditional architecturally closed and centralized information systems to more open and distributed information service architectures [1]. The driving force behind this transformation of GIS architecture is the availability of new technology in network communication and programming. New languages such as Java, Python, and C# (C-sharp) support platform-independent applications across the Internet. Advanced network technologies, such as Microsoft.NET framework, J2EE platform, and Common Object Request Broker Architecture (CORBA) provide a comprehensive scheme for distributed component technology essential to the development of Internet GIS. Distributed component technology allows clients to access heterogeneous servers dynamically, which is an essential feature of distributed GIServices. We foresee a future in which traditional GISystems, designed as isolated islands, will become increasingly less attractive, maybe disappearing altogether. The cost efficiencies and flexibility of reusable and interoperable open and distributed services interfaces will provide greater economies. GIServices focus on open, distributed, task-centered services, which will broaden geographic information uses into an increasingly wide range of on-line geospatial applications These include digital libraries, digital governments, on-line mapping, data clearinghouses, real-time spatial decision support tools, distance learning modules, and so on.

2. Different Types of Internet GIS

Internet GIS has many different faces and alternative names, such as "internet mapping", "distributed GIS", "web-based GIS", "networked GIS", "on-line GIS", etc. To simplify the variety of Internet GIS, we identify three kinds of Internet GIS: Internet GIS for data sharing, Internet GIS for information sharing, and Internet GIS for knowledge sharing (Figure 1).

Three Kinds of Internet GIS	
Data *Sharing*	***Applications*** • On-line data warehouses (data archive) • On-line data clearinghouse (metadata)
Information *Sharing*	***Applications*** • Web-based map display • Navigation Services
Knowledge *Sharing*	***Applications*** • On-line GIS models • Web-based spatial analysis tools

Figure 1: Three kinds of Internet GIS

The first type of Internet GIS is for data sharing. Data sharing combines with the functions of on-line data archive and data search services. Two typical applications are on-line data warehouses (or data archive centers) and on-line data clearinghouse. An on-line data warehouse is for archiving, accessing and downloading both GIS databases and/or remotely sensed imagery. For example, the USGS ***National Map*** Seamless Data Distribution System is an example of an on-line GIS data discovery service. A web-based data clearinghouse can help users to search and index the contents of metadata, and then access the actual data through the descriptions of metadata. Clearinghouses may access dataset or inventory detail. The premier dataset clearinghouse portal for federally acquired data is the Federal Geographic Data Committee (FGDC)'s data clearinghouse. Clients can access descriptions of datasets, and may be redirected to the dataset holder to access individual dataset granules. NASA's Earth Science Data Information System (ESDIS) Project's new ECHO system is an example of an inventory clearinghouse. Clients of an inventory clearinghouse can access descriptions of individual dataset granules and can broker data orders to providers on behalf of users [1].

The second type is for information sharing. Multiple interactive map servers and mobile navigation services are the typical applications. Web-based mapping functions include the display, zoom-in/out, query of spatial information. The major requirement of information sharing services is to provide effective web-based display mechanisms and client/server communication protocols [3]. One on-line mapping example can be found at the U.S. Census Bureau American Fact finder. The reference and thematic maps provided by the Fact finder are built on the OGC standards and use data represented in the Geography Markup Language (GML) standard.

The third kind of Internet GIS focuses on the sharing of knowledge. This is the most challenging task for the development of Internet GIS and only few applications available today. The goal is to provide on-line GIS modeling and spatial analysis functions without running GIS engines or software packages locally. Some Internet GIS applications utilize Java language or other distributed component technologies, (like .NET or web services) to develop on-line GIS functions. The implementation of these web-based software components can provide ubiquitous access for all different types of GIS applications, from environmental monitoring, emergency response, urban planning, spatial decision support systems, media press, etc. One example can be found at the web site of San Diego State University, Geography Department, which created an on-line Java-based analysis toolbox for remotely sensed imagery.

Internet GIS allow easy access to GIS functions using a standard Internet web browser. These interfaces provide a flexible way to access both spatial information and powerful, geospatial analytical tools. Today, almost everyone has experienced the advantages of Internet GIS, such as using MapQuest.Com or Yahoo! Map. The next section will review the recent development history of Internet GIS and give a reality check of today's Internet GIS technologies.

3. Recent History and Current State of Internet GIS standards

To establish comprehensive web-based remote sensing tools and internet mapping services, many new web technologies were adopted currently in the GIS community, including new programming languages, new software architectures, and new communication protocols. This paper will only focus on two representative web technologies: Internet Map Servers and Java programming language. The establishment of Internet Map Servers provides integrated web-based map browsing, spatial query, and map overlaying capabilities [5]. Java language is commonly used for the development of on-line GIS tools and spatial analytical functions. The Xerox Map Viewer was using the Web Browser via Hypertext Markup Language (HTML) format and Common Gateway Interface (CGI) programs to provide interactive mapping functions via the Internet. The technical framework of the Map Viewer is followed by many early on-line GIServices applications.

In general, most Internet map servers adopt three-tier architecture for the system implementation (Figure 2). The first tier is called "the client tier" which includes the user-side web browser and user-resident Java applets/HTML documents. The client tier is used by the user to make requests and to view maps and remote sensing data. The second tier is the middleware tier that includes the Web Server and the Server Connectors (such as Servlet connectors or ASP connectors) to bridge the communication between clients and the map servers. The third tier is the data storage tier that includes the map server and the database server. The three-tier software architecture of web-based GIS provides customizable functions for different mapping applications and scalable implementation for different hardware.

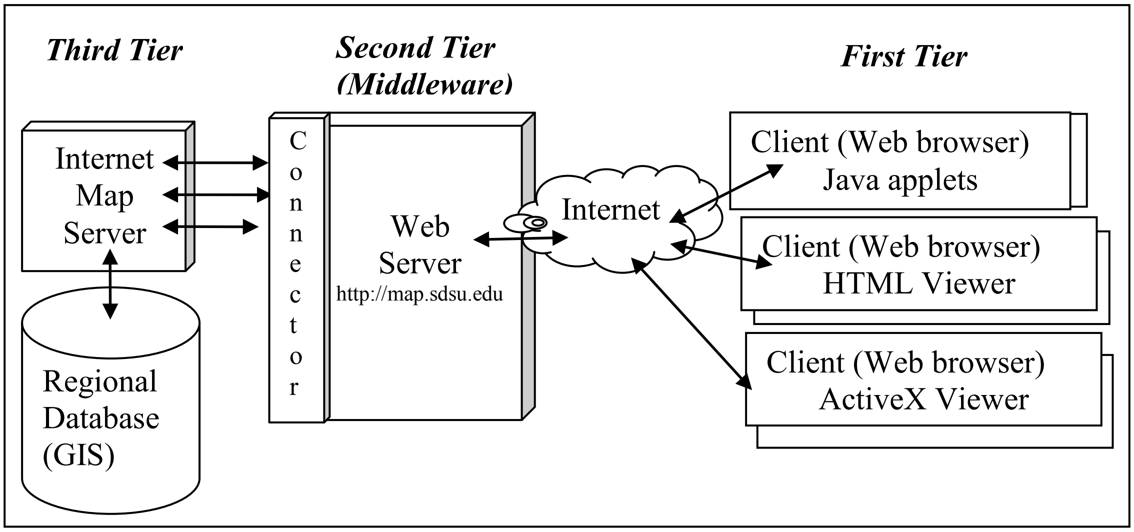

Figure 2 ***: The architecture of three-tier Internet Map Server***

Another contributing web technology is the Java language for developing on-line remote sensing analytical and change detection functions. The Java language is a pure object-oriented language, designed to enable the development of secure, high performance, and highly robust applications on multiple platforms in heterogeneous, distributed networks. From the computer programming perspective, Java is similar to C and C++ programming languages which are capable of advanced functions, such as preprocessor, unions, pointers, and multiple inheritances.

Current Java System Development Toolkits (JDK) provides a series of well-defined Application Programming Interfaces (API) for image processing and display, such as Java 2D API and Java Advanced Imaging (JAI). The Java 2D API is a set of object classes for advanced 2D graphics and imaging, encompassing line art, text, and images in a single comprehensive model. The Java Advanced Imaging APIs are used for manipulating and displaying images and range in complexity from simple operations such as contrast enhancement, cropping, and scaling to more complex operations such as advanced geometric warping and frequency domain processing.

These APIs are used in a variety of applications including geospatial data processing, medical imaging, and photography.

On the other hand, there are also several limitations in Java applets. First, the Application Programming Interfaces (API) of Java applets can not provide a data streaming functions from servers to web browsers. The I/O functions of Java applets can not handle external events outside the web browsers or applets. Also, there are not effective data compression tools or formats in the Java API, which may cause a very long download time for large-size remotely sensed imagery. An alternative solution is to create Java applications rather than Java applets.

4. Standards for Internet GIS

"Sharing" is the major concept of Internet GIS. To sharing data, information, and knowledge among the GIS community, a standardized communication protocol, standardized metadata contents, and interoperable programming interfaces are essential for the success of Internet GIS applications. With the comprehensive architecture for bridging heterogeneous GIServices, researchers and scientists can easily share their geospatial data, GIS models, and knowledge. There are two major organizations that set standards for the development of Internet GIS now.

1. The Open GIS Consortium, Inc. (OGC) (http://www.opengis.org) and

2. The Technical Committee tasked by the International Standards Organization (ISO/TC211). (http://www.isotc211.org)

Both organizations are founded in 1994. ISO is an international organization and its members are mainly from the public sector, including national standards bodies and organizations. For example, the US national standard body is American National Standards Institute

(ANSI). OGC's members come mainly from the private sector, including software vendors and GIS companies, such as ESRI Inc., ERDAS Inc., INTERGRAPH Corp., AutoDesk Inc., etc. OGC puts a great emphasis on working prototype implementations as validation for the effectiveness of a given standard whereas TC211 uses international representative consensus and review. OGC has a cooperative relationship to ISO such that OGC standards can become ISO standards (such as GML, location-based services, and metadata contents). More information can be found on their websites.

NASA has been active in the OGC and the ISO/TC 211. The goal of NASA activity has been to assure that NASA data and data services are compatible with emerging national and international standards. The Earth Science Data Information Systems (ESDIS) Project that is charged with implementing the major components of the Earth Observing System Data Information System (EOSDIS) and the Geospatial Interoperability Office (GIO) of the Earth Science Enterprise charged with ensuring that NASA Earth science data can be employed in information, analysis and decision support applications have directed this activity.

Earth Observation data from NASA satellites is engineered for global Earth systems science research and climate studies, but it has ancillary value to a variety of GIS applications. While the detail of resolution and feature extraction from NASA Earth observations is relatively course compared to other data sources, satellite based observations augment other GIS sources to provide coverage and feature layers essential to a variety of applications from land use planning to disaster management. NASA earth observations provide global, regional and local coverage with repeated observations on regular intervals. They cover the whole of the globe including remote areas for which satellite observations are the only reliable source.

5. The Future of Internet GIS: Services-oriented applications

The future applications of Internet GIS will highlight the concept of "service-oriented" rather than "system-oriented". This term, service-oriented, indicates that geographic information services are provided to help people accomplish their works and meet the needs of the public. We suggest that three criteria for the future Internet GIS applications in order to characterize the service perspective.

1. Internet GIServices are user-centered. In the past GIS users were forced to rely on GIS professionals to interface with geographic information sources. Misuse of geographic information results from miscommunication between the GIS users and the GIS professionals. Future GIS service interactions will reduce miscommunication by giving end-users direct access to GIS components and service agents tailored to the particular task.

2. Internet GIServices focus on long-term, evolution-type operations. Distributed GIServices will emphasize long-term information services rather than project-based, short-term GIS solutions. Traditional GIS are difficult to be migrated and upgraded into a new system. Internet GIS with dynamic architecture can easily be upgraded to a new framework and continue their services in the long run.

3. Diversified GIServices are required. In the demanding applications of the future, different users will require different information services, different tasks require different information sources, and different countries require different information interfaces. Internet GIS will provide a dynamic architecture and customizable GIS components in order to create the diversified, customizable information services necessary for diverse situations.

To summarize, Internet geographic information services will be integrated with many types of on-line information services. The integration will be seamless transparent and expected. For example, customers of on-line hotel reservation service will assume on-line mapping service; in-car navigation and virtual touring services are simply part of the way that the hospitality industry works. In the future, integrated electronic services will be ubiquitous in our daily lives, transforming our experiences in transportation, financial management, shopping, and entertainment. GIS is the compass of e-services, providing directions and location functions for these multitude services. Internet GIS will also affect the way that Earth system scientists use, collect and share data. These changes will dramatically alter the ways that provide a synergy for GIS professionals and researchers by sharing data, information, and knowledge together and provide us better services and better life.

6. References:

[1] Pfister, R., Ullman, R., and Wichmann K. (2001). ECHO Responds to NASA's Earth Science User Community, *Proceedings HCI International 2001: 9th International Conference on Human-Computer Interaction*, New Orleans, LA.

[2] Plewe, B (1997) *GIS Online: Information Retrieval, Mapping, and the Internet*. Santa Fe, New Mexico, OnWord Press.

[3] Peng, Z.R. and Tsou, M.H. (2003). *Internet GIS: distributed geographic information services for the Internet and wireless networks*. New York, John Wiley & Sons, Inc.

[4] Tsou, M.H. (2004 in press). Integrating Web-based GIS and On-line Remote Sensing Facilities for Environmental Monitoring and Management. In special issue on the potential of web-based GIS*, the Journal of Geographical Systems*. (In press).

[5] Tsou, M. H. and Buttenfield, B. P. (2002). A Dynamic Architecture for Distributing Geographic Information Services. *Transactions in GIS,* 6(4), pp. 355-381.