Distributed Web GIS

Jihong Guan
Tongji University, China

Shuigeng Zhou
Fudan University, China

Jiaogen Zhou
Wuhan University, China

Fubao Zhu
Wuhan University, China

INTRODUCTION

The popularity of World Wide Web and the diversity of GISs on the Internet have led to an increasing number of geo-referenced information (GRI) sources that spread over the Internet. How to integrate the heterogeneous and autonomous GISs to facilitate GRI accessing, data sharing, and interoperability is still a big challenge. Furthermore, the rapidly emerging mobile Internet and constantly increasing number of wireless subscribers bring new opportunities to geographic information services. Putting the Internet GIS in the palm will enable us to access geographic information with personal devices anytime and anywhere.

In the past decade, a lot of research has been done on designing interoperable systems in which collections of autonomous and heterogeneous GISs can cooperate to carry out query tasks. However, as far as system architecture is concerned, current solutions for integration of distributed GIS applications are mainly based on either C/S or B/S mode. The inherent limitations of these modes—for example, requiring a proper bandwidth, high-quality and stable network connection, less supporting of group awareness, and high-level cooperation—make them incompetent to fulfill various requirements of a dynamic, complicated, and distributed network computing environment, especially the mobile network environment, where the wireless communication networks have low bandwidth, frequent disconnections, and long latency, and the mobile devices (PDAs or mobile phones) have limited power, memory, computational power, and displaying capability. Such a situation calls for a new framework to support globally geographic information accessing and sharing in the (mobile) Internet environment.

The mobile agent is a recently developed computing paradigm that offers a full-featured infrastructure for development and management of network-efficient applications. Mobile agents are processes dispatched from one host to another during its execution on behalf of its owner or creator to accomplish a specified task. Agent-based computing can benefit Internet (especially mobile Internet) applications by *providing asynchronous task execution and more dynamics, supporting flexible and extensible cooperation, reducing communication bandwidth, enhancing real-time abilities and a higher degree of robustness, enabling off-line processing and disconnected operation.* Thus it is natural to introduce mobile agents into accessing and sharing distributed geographic information in a (mobile) Internet environment.

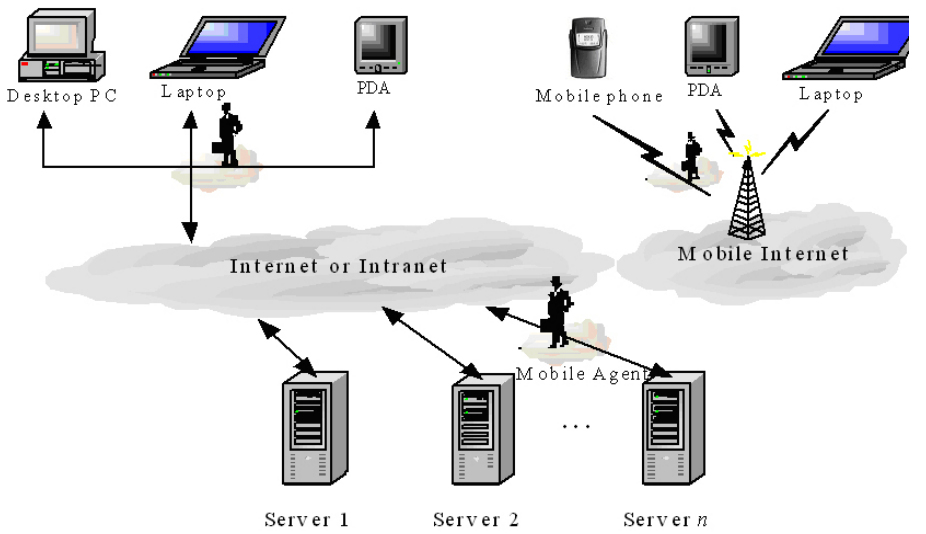
This article presents the MADGIS (Mobile Agent-based Distributed Geographic Information System) project, which aims at integrating distributed Web GIS applications by using mobile agent technologies to overcome the limitations of traditional distributed computing paradigms in a (mobile) Internet context.

MADGIS FRAMEWORK

The MADGIS system consists of client sites (or clients), sever sites (or servers), a (mobile) Internet or intranet connecting these sites, and mobile agents roaming on the Internet/intranet for retrieving information on behalf of the clients. Figure 1 is an overview of MADGIS.

In MADGIS, a client site refers to a client machine, which can be a desktop, a laptop personal computer, a PDA, or a mobile phone used for query submission and results presentation. A server site is also a MADGIS server that provides spatial information services for local or remote requests. A user submits a query from a client machine to a server *via* Web browser. The query is analyzed and optimized by the server, from which one or multiple mobile agents are created and dispatched to accomplish the query task cooperatively. Each mobile agent along with its sub-task travels from one remote server to another to gather the related information. Retrieved information is then taken back to the original site after the mobile agent finishes its mission. All returned

Figure 1. MADGIS overview



information is further merged there and presented to the user. The servers also provide a docking facility for mobile agents in case they cannot travel back to the destinations promptly due to network problems.

The Client Site of MADGIS

A user can access any GISs within the MADGIS system via a client or a local server. First, a user should log into one server in the system. Then the server returns a Web (HTML) page to the client, in which there is a Java Applet termed as Client-Applet composed of one mobile agent environment (MAE), one stationary agent, and one mobile agent. The client-applet is executed at the client site to establish the MAE for the client and to start the stationary agent encoded in the Client-Applet. We call this stationary agent "client-agent", which is responsible for two tasks:

1. To obtain the data sources description information (DSDI) from the visited server, which includes all data sources' metadata (e.g., names, URLs, and schema of each data source). Users submit queries to or browse the MADGIS system according to the DSDI. The client-agent gets DSDI from the stationary agent of the visited server. At each server, DSDI is maintained by the local stationary agent. Besides responsibility for maintaining local DSDI, the stationary agent should also send messages to other servers in the system to notify of updates of DSDI, so as to keep the global DSDI updating simultaneously.
2. To create the query interface (QI) in the Web browser with which the user submits queries and gets retrieved data.

Thus when the query environment is set up at the client site, what a user can see is only the QI, while client-agent, mobile agent, and its execution environment are at the back-end. The user starts his or her query operations via QI, and the server accessed will take charge of query processing and mobile agent manipulation. Typically, a whole query session consists of the following steps:

1. At a client site, a user visits one server *via* Web browser by specifying the server's URL.
2. The accessed server returns a Web page including a client-applet.
3. The client-applet is executed at the client to establish MAE and to start the stationary client-agent.
4. The client-agent obtains the DSDI from the server and creates the QI for the user.
5. The user constructs his or her query and submits it via the QI to the server.
6. When the client-agent gets the user's query, it initiates a mobile agent to take over the query task.
7. The mobile agent with user's query task migrates to the server to which the client first visited for further query processing.
8. After the query task is completed at the server, the mobile agent moves back to the client and returns the results to the user via the browser.

Above, steps 1 to 4 are necessary for a client to access MADGIS. After that, the client can submit queries that are answered by following steps 5 to 8 repeatedly. The process described above and the interaction among client, server, and mobile agent are demonstrated in Figure 2.