WEB-BASED SPATIAL DECISION SUPPORT: TECHNICAL FOUNDATIONS AND APPLICATIONS

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Summary

This article presents an overview of approaches to support Internet users in different decision situations. Most of these approaches are based on web-compliant geographic information systems (GIS). Therefore, the article starts with a brief introduction to current WebGIS techniques. In subsequent sections, specific requirements imposed on WebGIS by decision support tasks are examined, and sample applications providing decision support at different levels, from individuals' day-to-day decision situations to strategic community decisions, are reviewed.

1. Introduction

Geographic information systems (GIS) are tools to process geographically referenced data, often in order to support decisions in spatial problems. Many GIS applications can be described as spatial decision support systems. However, spatial decision support in a narrower sense requires specialized analytical functions such as optimization and multiple criteria evaluation algorithms. While most GIS functions can implicitly assist decision making, only the specific decision support features result in explicit solutions for a decision problem.

With the appearance of GIS on the Internet (called WebGIS, GIS online, or Internet map servers) there is a need to define the role of spatial decision support systems (WebSDSS) in the context of a global information network. Since explicit decision support functions are rare in today's WebGIS, this article will focus on general decision support aspects of WebGIS.

The article starts with a brief overview of current WebGIS techniques. In the following section specific requirements imposed on WebGIS by decision support aspects are examined. Subsequently, a couple of sample applications are reviewed that provide decision support at different levels: from individuals' day-to-day decision situations up to strategic decisions of communities. The article concludes with a summary and an outlook on the near future of WebSDSS.

2. WebGIS Techniques

GIS applications on the Internet, which date back only to the second half of the 1990s, can be characterized by implementing one of two technical strategies: a server-side approach, or a client-side approach.

Most Internet mapping tools available from commercial vendors follow the server-side approach. This means that a "thin client" sends requests to a powerful GIS server via a standard web server, as sketched in Figure 1.

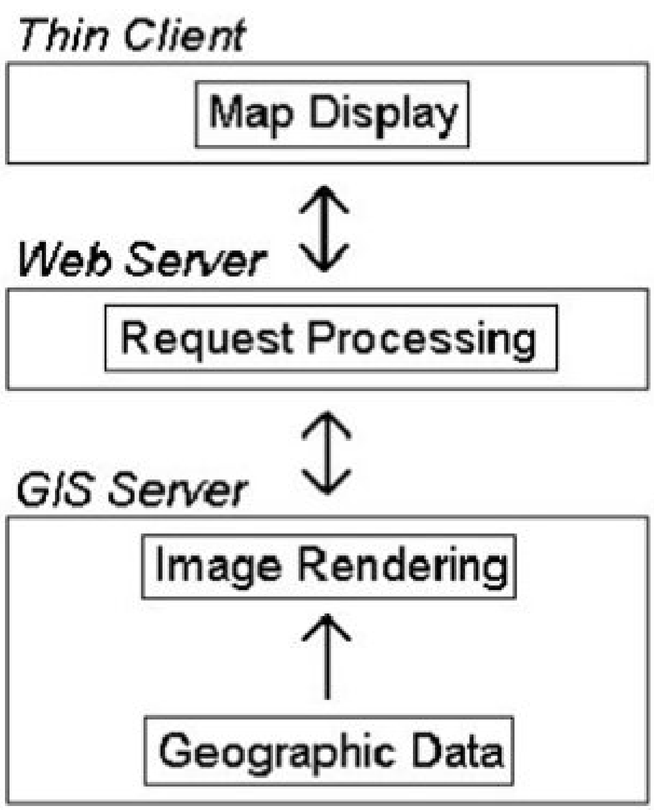

Figure 1. Schema of WebGIS functions in a server-side approach

A typical thin client would be an HTML form with a map image and control buttons, emulating the user interface of a desktop GIS. Geographical data is available at the client side only in the form of the map image. If the user clicks on the map or a button, a script on the web server transmits the input (e.g. a map coordinate, the name of a button) to a fully-fledged server GIS. The GIS server processes the input with respect to its geographical database (e.g. re-centers the map, zooms in, gets information about a location), renders an image of the resulting map, and sends it back to the client via the web server. The Common Gateway Interface (CGI) is a common standard for scripts that link a web server with a server-side GIS. CGI scripts can be developed using the C or Perl programming languages.

Additional functionality, under the server-side approach, can be provided to a client using the Javascript language. For example, the user could switch between different meanings of a click on the map (re-center, zoom in, get information). A hybrid approach between server-side and client-side processing can also be envisioned. Such an approach would provide the client with map display functionality and some geographical data, but would, for example, download additional map layers from the server only when requested.

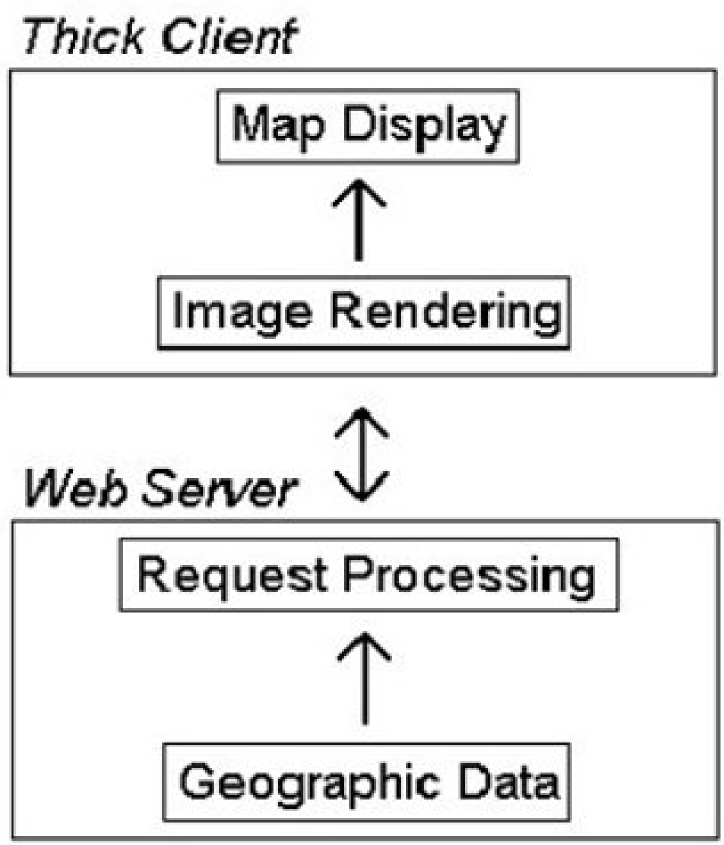

Figure 2. Schema of WebGIS functions in a client-side approach

The client-side approach typically does not require a GIS server component. The functional part of such an application is loaded first (for example, as a Java applet), or is already installed on the client computer (as a web browser plug-in). Then, the client loads geographic data files from one or more web servers and renders a map image, as illustrated in Figure 2. Besides displaying the map, this “thick” client is able to perform mapping operations (zoom, pan) and simple queries (find geographical objects by name or ID).

Server-side WebGIS have the following advantages:

- existing GIS packages with reliable functions can be used on the server;
- powerful server computers are used for complex operations; technical requirements for client computers are small;
- client components are easy to implement, and relatively fast to download; and
- the provider can control access to data and GIS software functions.

The major drawback of thin clients, under the server-side WebGIS architecture, is that every user action requires a communication between client and server via a potentially busy Internet connection

Client-side WebGIS provide the following benefits:

- no client–server communication is required after the initial download;
- clients can be customized to specific user/application needs;
- the client’s computing power is used; and
- costs for a GIS server are reduced.

The major drawback here is the necessity of pre-installing or downloading the thick client software. (For another look at these issues, see ***Geographical Information Applications Over the Net, Interaction Issues, and Decision Support in Intelligent GIS.)***

The server-side versus client-side distinction of WebGIS is useful for classifying applications with respect to technical features such as functional complexity, user interface, and performance. However, this is not the only classification. Alternative classifications emphasize other aspects of WebGIS. For example, one can classify WebGIS according to services delivered into:

- geodata servers, allowing users to search for and download spatial data files,
- map servers, providing online visualization of spatial data in the form of preprocessed or user-defined maps,
- online retrieval systems, providing access to maps and underlying spatial data,
- online GIS, offering full access to data and analysis functions of a remote GIS, and
- GIS function servers, allowing clients to use remote GIS functions on the user-uploaded data.

The OpenGIS Consortium (OGC) is trying to foster standardization in the GIS field (see ***Geospatial Interoperability: The OGC Perspective)***. OGC's WWW Mapping special interest group defined services for web-based access to spatial data and geoprocessing applications. Its Web Mapping Testbed resulted in proposed standards for Web Map Server Interfaces and a Geography Markup Language (GML). The Web Map Server Interface specification defines a standard for retrieving map images and related information from remote servers. The GML provides an encoding syntax for geographic features in the eXtensible Markup Language (XML). GML supports both data storage and data transfer, but in order to display maps a client application has to translate GML features into its own graphic language. The OGC can be expected to play an important role in providing interoperable solutions for web-based GIS applications including SDSS.

WebGIS appear not only in the Internet context but also in Intranets of companies and government agencies. As a general trend, Internet GIS are designed for the mass market, using a server-side approach with a simple client and powerful server component, while Intranet GIS tend to use the client-side approach with a functional client, which is adapted to the specific needs of an organizational environment. Due to the administrative access to every client, the preinstallation of the client software is much easier than in the Internet context, and the performance of clients is well known so that the application can be optimized accordingly.

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Biographical Sketches

Claus Rinner is an assistant professor at the Institute for Geoinformatics of the Westfaelische Wilhelms-Universitaet Muenster, Germany. He specializes in web-based GIS and spatial decision support systems. Claus is a former system developer of interactive Internet mapping tools for exploratory data analysis. He holds a Ph.D. in geography from the University of Bonn. During his doctoral research at GMD, the German National Research Center for Information Technology, he was working on GIS-based discussion support for online planning. Claus graduated in applied systems sciences at the University of Osnabrueck, where he studied environmental modeling and GIS.

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