Unit 133 - WebGIS

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Advanced Organizer

Topics covered in this unit

- This unit is an overview of how GIS are being developed to run within the Internet and Worldwide Web, as well as within private intranets
- Included is discussion of strategies for developing GIS functionality within client-server networks
- The overview discusses the rationale behind these strategies, but does not provide programming solutions. Nor does it address the the details of designing a user interface for a WebGIS application.
- Links are provided to examples and to software tools now available to realize the potential of WebGIS

Learning Outcomes

- After learning the material covered in this unit, students should be able to:
  - Explain how GIS functionality can be developed in intranets and the Internet
  - Compare the strengths and weaknesses of different strategies for providing GIS functionality in the Web
  - Choose and defend a strategy for developing a Web-based GIS application

Instructors' Notes

Full Table of Contents

Metadata and Revision History

WebGIS

1. The Potential of WebGIS

- Much recent attention has focused on developing GIS functionality in the Internet, Worldwide Web, and private intranets and is sometimes termed WebGIS.
  - WebGIS holds the potential to make *distributed geographic information* (DGI) available to a very large worldwide audience.
  - Internet users will be able to access GIS applications from their browsers without purchasing proprietary GIS software.
  - WebGIS will make it possible to add GIS functionality to a wide range of network-based applications in business, government, and education. Many of these applications will be run on intranets within businesses and government agencies as a means of distributing and using geospatial data.
  - Many experiments are now underway in WebGIS and related mapserver applications for interactive cartography. One of the important areas of innovation involves "pay-for-use" mapping and GIS services.

- The challenge of WebGIS lies in creating software systems that are platform independent and run on open TCP/IP-based networks, that is on any computer capable of connecting to the Internet (or any TCP/IP-based network) and running a Web browser.
  - This task is different from running proprietary GIS software over local-area networks (LANs) or intranets on just a few types of computer hardware. Such systems already exist.

- Many strategies can be employed to add GIS functionality to the Web:
  - **Server-side** strategies allow users (clients) to submit requests for data and analysis to a Web server. The server processes the requests and returns data or a solution to the remote client.
  - **Client-side** strategies allow the users to perform some data manipulation and analysis locally on their own machines.
  - Server and client processes can be combined in hybrid strategies that optimize performance and meet special user needs.

- Developers can program their applications from scratch or now, more commonly, purchase the necessary GIS modules from commercial vendors.

- The visual design of the WebGIS interface--though not discussed in this unit--requires great care to assure that users can understand and make use of the information and

functions provided by the system.

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2. Server-side Strategies

- These strategies focus on providing GIS data and analysis "on demand" from a primary or *heavy* server that has access both to data and the software needed to process this data.
    - This strategy is comparable to traditional terminal-to-mainframe models for running GIS on local networks.
    - Little processing power is required of the client (a "dumb" terminal in the traditional model), only the ability to submit requests and display responses.

- The following steps summarize the procedure:
    - A user makes a request from a Web browser.
    - The request is sent across the Internet to a server.
    - The server processes the request.
    - The response is returned to the user to be viewed using a Web browser.
    - Figure 1. Server-side strategies.

- The term **map server** is often applied to this sort of server configuration. User requests for maps are "served" by a host.

- Server-side strategies rely on the ability of users to send requests to GIS software through the Internet server.

- The programs that service user requests can be written in a number of widely used languages including Perl, VisualBasic, and C++. Such programs can also be purchased from vendors to tie the Web server directly to an existing GIS.

- CGI (Common Gateway Interface), Java, ISAPI (Internet Server Application Programming Interface), and NSAPI (Netscape Server Application Programming Interface) are common interface standards for allowing the Web server to communicate with needed GIS applications.

- The advantages of server-side strategies include:
    - If a high-performance server is used, users can access large and complex datasets that would be difficult to transfer across the Internet and process locally on the client.
    - If a high-performance server is used, complex GIS analytical routines can be run quickly even by clients who lack access to sophisticated hardware.
    - More control can be exerted over what the user is permitted to do with the data, perhaps also insuring that the data is used correctly.

- The disadvantages of server-side strategies include:
    - Every request--no matter how small--must be returned to the server and processed. Responses must then be returned to the client across the Internet.
    - Performance will be affected by the bandwidth and network traffic on the Internet

between the server and client particularly when responses involve transferring large files.
    - Applications do not take advantage of the processing power of the user's own "client" computer, which is used merely to submit a request and display the response.

- In general, this strategy is best for mass market applications with thousands or millions of users with little need for GIS analysis capabilities (Plewe 1997, 70).

Server-side Strategies	
Server tasks	**Client tasks**
Map browsing	Display
Query	
Analysis	
Map drawing	

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3. Client-side Strategies

- Client-side applications attempt to shift some of the work of processing requests to the user's computer, sometimes referred to as a *thick client*.

- Instead of forcing the server to do most of the work, some of the GIS capabilities are downloaded to the client, or reside there, and data is processed locally.

- The advantages of client-side strategies include:
    - Applications take advantage of the processing power of the user's own computer.
    - The user can be given greater control of the data analysis process.
    - Once the server has delivered its response, the user can work with the data without having to send and receive messages across the Internet.

- The disadvantages of client-side strategies include:
    - The response from the server may involve transferring large amounts of data as well as applets, causing delays.
    - Large and complex datasets may be hard to process on the client if it is not very powerful.
    - Complex GIS analytical routines may run more slowly on the client if it is not very powerful.
    - Users may not have the training needed to employ the data and analysis functions properly.

- These strategies work well for services used by a smaller set of GIS-savvy users within an intranet (Plewe 1997, 70).

Client-side Strategies	
Server tasks	**Client tasks**
Analysis	Display
Map drawing	Map browsing
	Query

- There are two variations on the client-side strategy:

3.1. GIS Applets Delivered to Client on Demand

- In this variation, GIS capability is provided in the form of small programs, or applets, that can run on the client.
- These applets are delivered to the client "on demand," that is as they are needed by the user.
- Once data and applets have been downloaded from the server, the user has the freedom to work independently of the server. Requests and responses do not have to be passed back and forth across the Internet.
- The following steps summarize the procedure:
  - A user makes a request from a Web browser.
  - The request is sent across the Internet to a server.
  - The server processes the request.
  - The response is returned to the user including both data and applets that allow the user to work with the data.
  - Figure 2. A client-side strategy using GIS applets.
- Applets can be written in Java, JavaScript, or ActiveX.
  - Java and JavaScript are languages developed by Sun Microsystems and Netscape Communication
    - Compilers for Java and Javascript programs run within Web browsers and process the applets as they are needed.
  - ActiveX was developed by Microsoft Corporation
    - ActiveX applications allow users to share programs in the Windows environment

3.2. GIS Applets and Plug-in Applications Reside on Client Permanently or Semi-permanently

- The strategies discussed above involve adding GIS functionality to Web browsers.

    - Moving the necessary data and applets across the Internet can be very time consuming, particularly if the applications are used frequently.

- The alternatives are to:
    - Transfer GIS applets to the client computer on a permanent or semi-permanent basis so that they do not have to be transferred each time they are needed.
    - Download and permanently install a "plug-in" program on the client's browser.
    - Build browser capabilities into existing GIS software that runs on the client.

- Any GIS package that includes a scripting language capable of making external file calls can be programmed to download data from the Internet.
    - Some office productivity packages like MSOffice 97 already allow users to make links between local documents and Internet resources.
    - The same capabilities are being added to some proprietary GIS packages.

- In this strategy, users decide (and program) the links they will make to sources available in the Internet.
    - Servers are called upon by the clients to deliver only the data needed for a particular application

- This strategy allows the user full control of the data they use and how they analyze it.

- Figure 3. A client-side application using the GIS system as a "browser."

3.3. Real-time GIS

- Both variations on the client-side strategy can be used to implement real-time GIS.

- Real-time GIS involves feeding data directly into the system from sensors or real-world sources as the data is generated.

- Real-time can used to:
    - Monitor vehicle location or traffic conditions for systems designed to route deliveries.
    - Monitor weather and hydrological conditions for flood-prediction systems.
    - Track tagged animals in habitat monitoring applications.

- The advantage of using Internet-based systems is that data from many sources can be delivered across the open network without the need for dedicated cable, telephone, or radio feeds.

- Figure 4. Configuration of a real-time GIS application.

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4. Combination and Hybrid Strategies

- Pure server-side and client-side strategies have distinct limitations:
    - If server-side strategies involve frequent transfers, their performance is sensitive

to Internet bandwidth and network traffic.
    - Client-side strategies are sensitive to the computational power of the client, meaning some tasks may run slowly if there is mismatch between processing demands and processor power.

- Server-side and client-side strategies can be combined to produce hybrid solutions better matched to capabilities of both the server and client.
    - Tasks that involve heavy database use or complex analyses can be assigned to the faster machine, typically the server.
    - Tasks that involve the greater control by the user can be assigned to the client.

- In this situation, both the client and server share some information about their power and capabilities so data and applets can be assigned to each to maximize performance.

- Figure 5. A hybrid client-server solution.

- Hybrid solutions are also useful for certain "pay for use" and "maps on demand" applications where users would "subscribe" to make periodic or regular use of a server for data or specific types of analyses.

- Designing an effective hybrid solution is most effective if the designer understands in detail the audience for the WebGIS application, the capabilities of the audience's computers, the audience's knowledge of GIS applications.

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5. Summary

- This overview has introduced a number of strategies being employed to offer GIS functionality with the Internet and Worldwide Web and within private intranets.

- These strategies are compared and suggestions are made about how they can be used together to produce hybrid and combination systems.

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6. Review and Study Questions

6.1. Essay and Short Answer Questions

- How might WebGIS expand the audience for GIS?

- Why is WebGIS different from developing networked GIS applications within a single organization using a local area network?

- Compare the advantages and disadvantages of server-side and client-side strategies for developing WebGIS.

- What are the advantages of building Web browser functions into existing GIS software?

- How can hybrid strategies be used to get the most out of the capabilities of both the client and server?

- To what extent must developers consider the needs and abilities of inexperienced users when designing WebGIS?

6.2. Multiple-choice questions

Choose the best or most appropriate answer(s) to the question.

- Which of the following statements are true of WebGIS?
    1. GIS applets must be written in Java
    2. Server-side strategies offer the slowest performance
    3. Client-side applications offer users local control of some GIS processing
    4. Hybrid strategies are determined by server speeds and performance

- Which of the following are disadvantages of server-side strategies?
    1. Large and complex datasets can be processed automatically on the server
    2. Client requests and server responses must be transferred across the Internet no matter how large or small
    3. Complex GIS analytical routines must be run by the client
    4. More control can be exerted over what users are permitted to do with data

- Hybrid strategies involve:
    1. Maximizing data transfer time
    2. Minimizing the use of the client processing power
    3. Converting GIS programs into Java
    4. Optimizing server-client performance

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7. Reference Materials

7.1. Print References

- Plewe, Brandon. 1997. *GIS Online: Information Retrieval, Mapping, and the Interne.* Santa Fe, NM: OnWord Press.

7.2. Web References

7.2.1. Map generators and demonstration projects

- ArcView Internet Map Server Demo - ArcAustria
- Cabarrus County, NC - GIS public access tax information
- Demographic Data Viewer
- ESRI Map Objects IMS and ArcView IMS Demos

Etak EZ-Map!
- GeoNorth - Several online GIS applications featuring Anchorage, Alaska
- GeoSolv Corporation examples
- Geosystems Global MapQuest LinkFree
- High Point, North Carolina Street Locator Atlas - First site in the southeast to use the ESRI MapObjects Internet Map Server software
- Interrain Pacific - Conservation organization providing information through its GIS resources
- Montana Natural Resource Information System (NRIS) - Interative mapping applications from the Montana State Library
- Multi-scale maps from Los Alamos
- NAISMap from the National Atlas of Canada
- Resource Data Inc. - Free land data and detailed parcel information for Anchorage, Alaska
- UPS Ground Time-in-Transit Maps
- U.S. Census Bureau Tiger Mapping Service
- Vicinity Corporation MapBlast!
- Xerox PARC Map Server
- Yahoo Address Matching

7.2.2. Software tools

- AutoDesk MapGuide
- ESRI ArcExplorer, MapObjects Internet Map Server
- Etak Map Server
- Intergraph GeoMedia WebMap
- MapInfo ProServer
- University of California at Berkeley GRASSLinks
- University of Minnesota ForNet MapServer

7.2.3. Additional Internet Resources

- *GIS Online* Web Site
- UC-Berkeley Library Web GIS and Interactive Mapping Sites
- The Common Gateway Interface (CGI)
- Java
- ActiveX

Citation

To reference this material use the appropriate variation of the following format:

> Foote, Kenneth E. and Anthony P. Kirvan. (1997) WebGIS, *NCGIA Core Curriculum in GIScience*, http://www.ncgia.ucsb.edu/giscc/units/u133/u133.html, posted July 13, 1998.

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WebGIS (133)

Instructors' Notes

Developing a WebGIS application requires considerable programming skill and is best saved for advanced courses. However, students in introductory and intermediate courses can learn much about the capabilities of such systems by examining in detail some of the examples and demo projects listed in the unit's reference section.

Studying Examples

Have students work individually or in teams to compare and contrast two or three of the examples listed in the module. Have them characterize the strategy being employed, assess its performance, and suggest other strategies for accomplishing the same goals.

Developing a Plan for a WebGIS

Have students consider how they might develop a WebGIS or a local government agency or company that might be interested in providing geospatial data to the general public. What strategy would they employ and why? What steps would they take to guide inexperienced users who might access the system?

Creating a Simple WebGIS

The software tools needed to develop some rudimentary WebGIS are becoming easier and easier to use. If you have time, it is possible to set up some examples with products like ESRI's ArcView IMS (Internet Map Server), Intergraph's GeoMedia Web Map, or with software tools produced by other vendors. Creating or experimenting with a simple, pre-programmed example is a good laboratory exercise.

Back to the Unit

Unit 133 - WebGIS

Table of Contents

Back to the Unit

Unit 133 - WebGIS

Metadata and Revision History

1. About the main contributors

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2. Details about the file

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  - WebGIS

- unit key number:
  - 133

3. Key words

- WebGIS
- Internet
- Worldwide Web
- Real-time GIS
- Map servers

4. Index words

- Client-server strategies
- Java
- JavaScript
- ActiveX

5. Prerequisite units

- 048 - Computer Networks
- 047 - User Interfaces

6. Subsequent units

- 148 - WWW and Digital Libraries

7. Revision history

- 7 December 1997. First draft completed.
- 7 January 1998. Figures completed and added to module.
- 21 January 1998. Additional links added and alphabetized.
- 20 June 1998. Revisions made based on reviewer's comments.
- 13 July 1998 last revision date

Back to the Unit

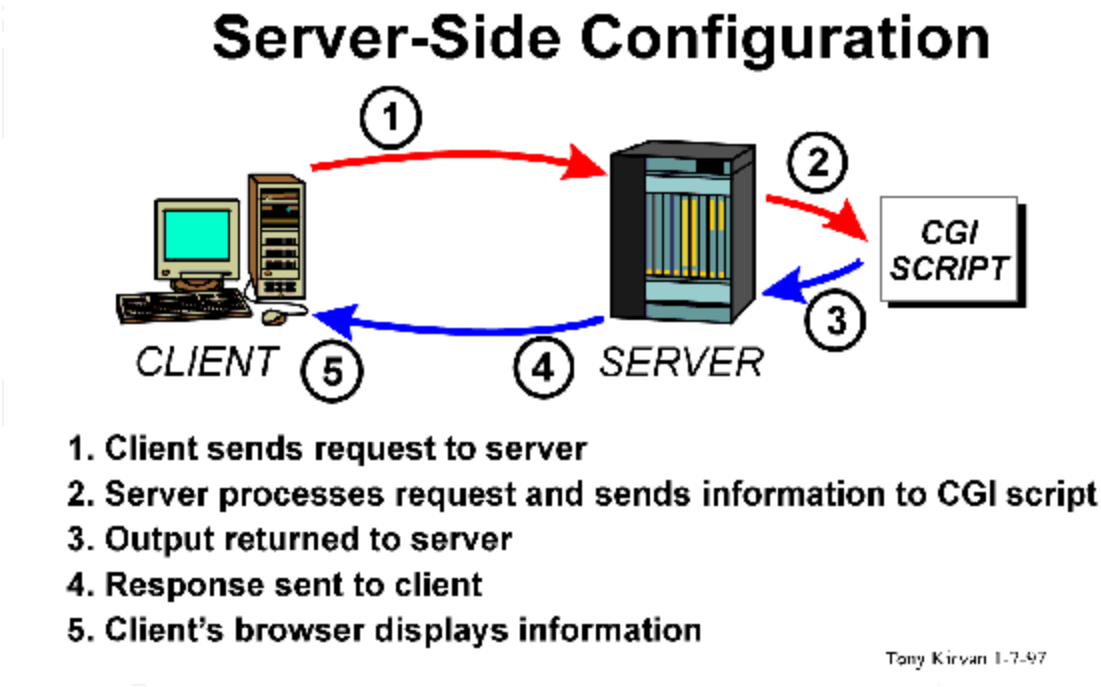

Figure 1. Server-side strategies.

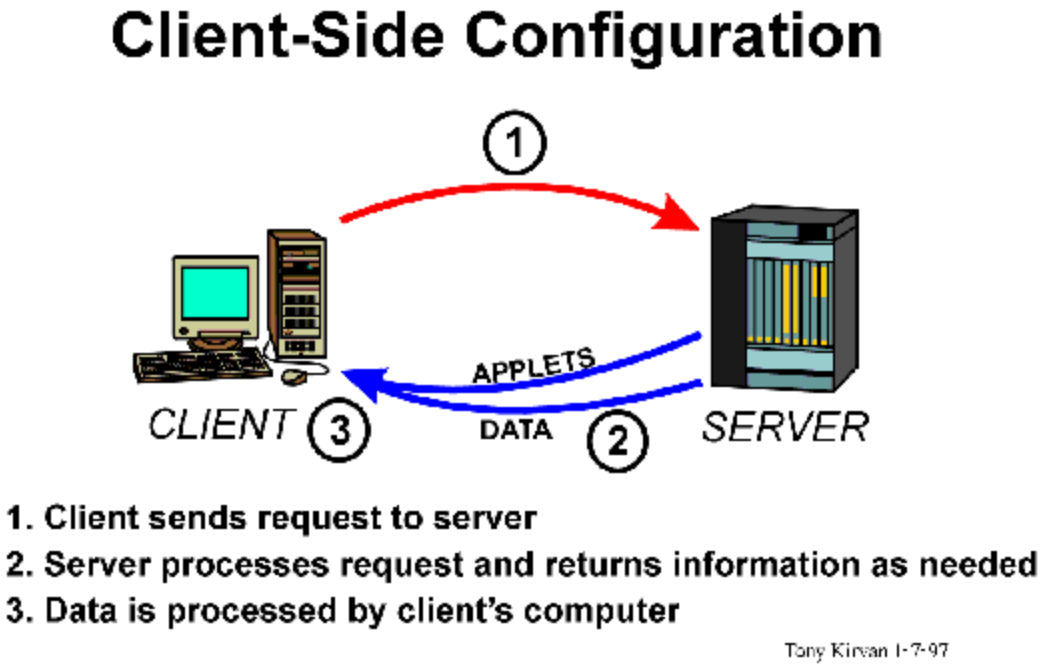

Figure 2. A client-side strategy using GIS applets.

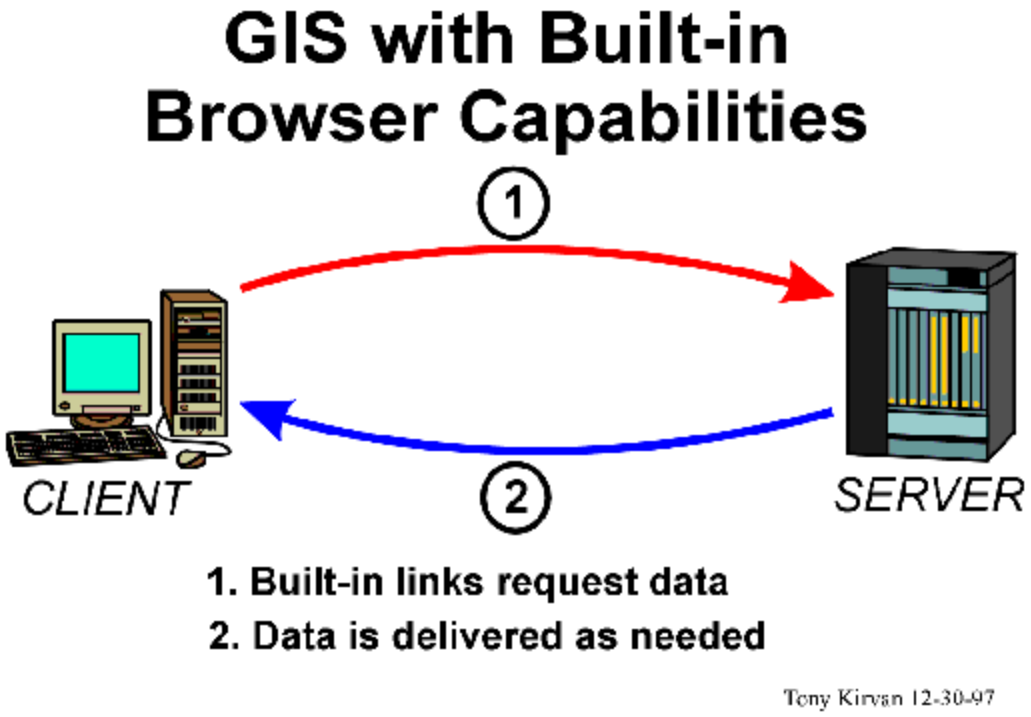

Figure 3. A client-side application using the GIS system as a "browser."

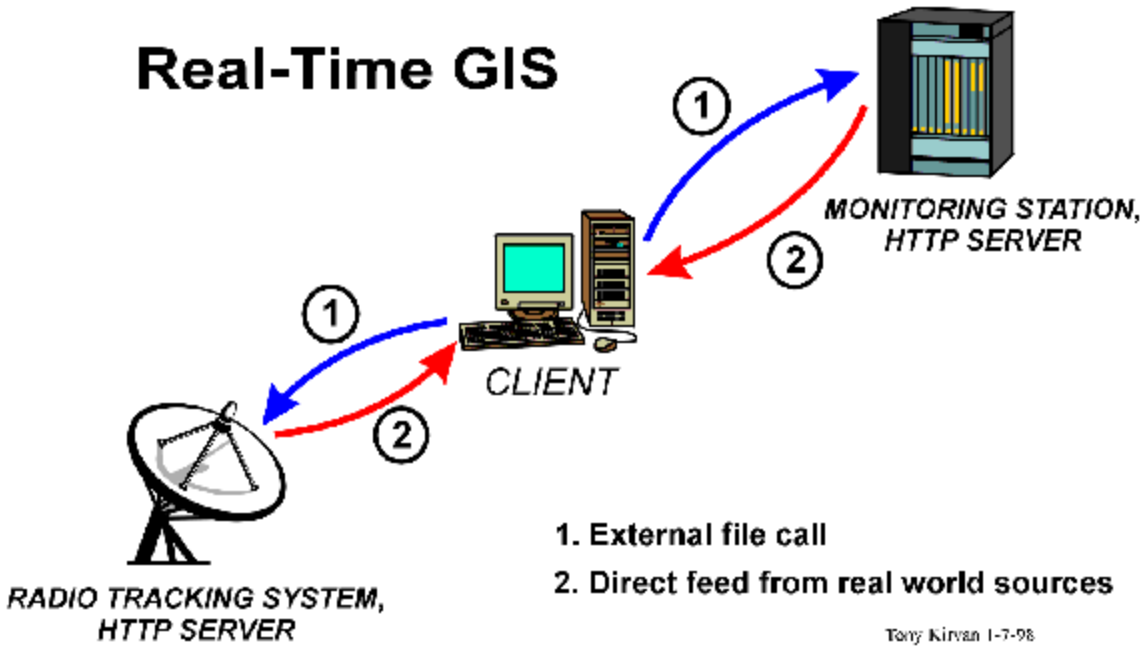

Figure 4. Configuration of a real-time GIS application.

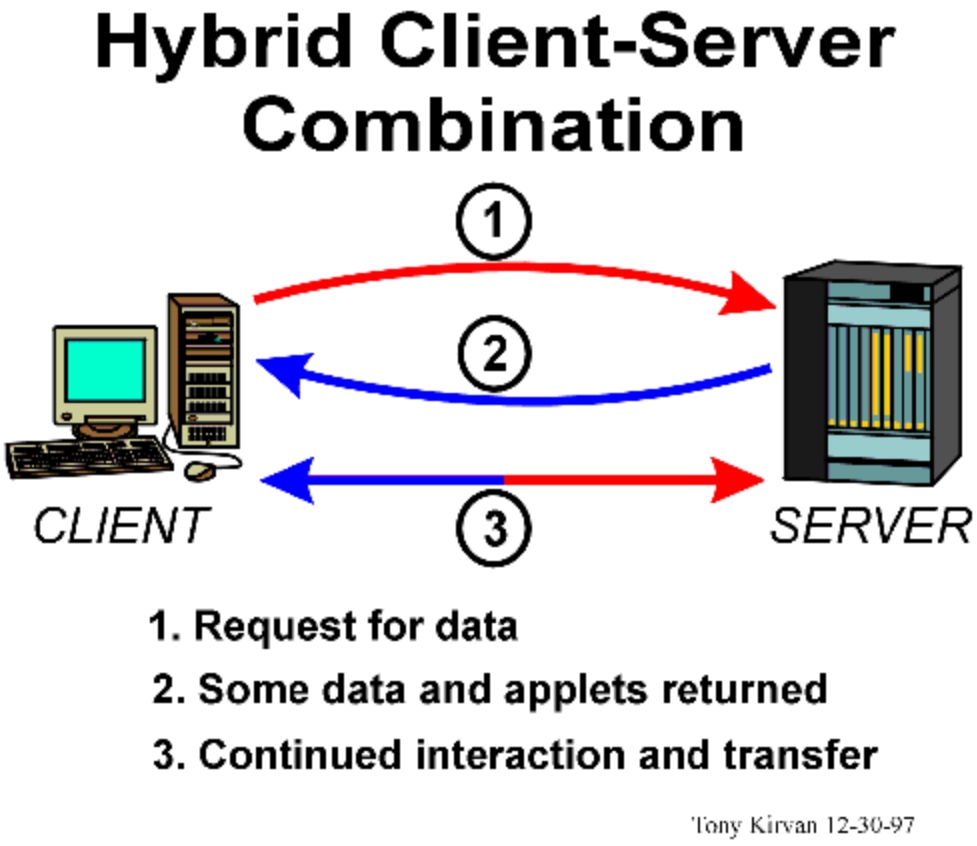

Figure 5. A hybrid client-server solution.