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Lecture 10: Introduction to Internet GIS and ArcIMS

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See: Peng and Tsou, Internet GIS, 2003, John Wiley, ISBN: 0-471-35923-8.

Main Topic: Introduction to Internet GIS and ArcIMS

- Introduction to Internet GIS
- State of the Art of Internet GIS
- Introduction to ArcIMS

The Road Map of GIS

Stand-alone GIS Programs

- Mainframe-based monolithic GIS programs
- Desktop GIS programs
- Limited or no communication with other computers (other than transparently via, for example, use of a network file server)

- Programs need to run on the mainframe or PC where the program resides
- Users need access to that machine via a login or dumb terminal session.
- Examples: early Arc/Info installed on a stand-alone mainframe or PC.

LAN-based GIS Programs

- GIS installed on one or more machines on a Local Area Network (LAN)
- GIS programs run on local machines but can share data and printing facilities from the data server, or
- GIS programs run on a server, user can access it from any machine inside the LAN.
- Typical Client/Server architecture.
- Examples: Most current GIS programs.

Limitations of Stand-Alone and LAN-based GIS Programs

- Difficult for user outside the LAN to access.
- Difficult to directly access data that are available outside the LAN.
- Limited GIS users.
- Difficult to mange, update and extend.

What is Internet GIS?

- Internet GIS is a network-centric GIS tool that uses the *Internet* as a primary means of providing access to the *functionality* (e.g., analysis tools, mapping capability) of GIS and to the spatial *data* and other data needed for various GIS applications.

- Internet GIS is an integrated client/server, and Web/Server application.
- Internet GIS typically uses a Web browser as client.
- Internet GIS can be viewed as a distributed, object-oriented system.
- Internet GIS is portable and cross-platform.

Internet GIS vs Web GIS

- What's the difference between the Internet and the World Wide Web?
- Internet refers to the inter-connected computer network, -- infrastructure.
- Web is one of many applications that are based on the Internet.
- The term Internet GIS focuses the use of a suite of Internet technologies, not only the Web.
- Internet GIS thus has more longevity and is a preferred term.

Features of Internet GIS

- Wide accessibility, users from the world can access GIS data and analysis tools over the Internet.
- No GIS software is required to install locally.
- Takes advantage of the friendly graphic user interface that is provided by the World Wide Web.
- Users can directly manipulate maps and GIS data over the Web.
- Internet-aware GIS software can access remote data anywhere on the Internet.
- Internet GIS can easily incorporate up-to-date, real-time information

Basic Components of the Internet GIS

Internet GIS: State of the Art

- Static Map publishing
- Static Web Mapping
- Interactive Web Mapping
  - Client-side Plug-ins and Helper Program
  - GIS ActiveX Controls
  - Java-based Internet GIS
- Distributed Geographic Information Services

Server-Side and Client-Side Internet GIS

- Server-Side Internet GIS
  - HTML to GIS server via CGI (Common Gateway Interface) script
- Client-Side Internet GIS
  - Client-side Plug-ins and Helper Program
  - GIS ActiveX Controls
  - Java-based Internet GIS
- Hybrid of server- and client-side Internet GIS

Static Map publishing

- Insert Map images in a text file on the Web.
- Not a GIS.

Static Web Mapping

- How does it work?

Common Gateway Interface

- When information is collected by a browser it is sent to a HyperText Transfer Protocol (HTTP) server specified in the HTML form, and that server starts a program, also specified in the HTML form, that can process the collected information. Such programs are known as "Common Gateway Interface" programs, or CGI scripts (E.O. Johnson).
- CGI is a simple interface that links Web browser, server and other external programs.
- CGI or Dynamic Link Library (DLL) has three functions:
  - It receives user inputs and parses them into parameters of variables to be used in GIS programs.
  - It lets Web servers run other GIS programs.
  - It interprets output and sends back to browsers.

Advantages of Static Web Mapping

- A “thin” client (e.g., all data processing is done on the server, while the client is used only for display and user input).
- Takes full advantage of all GIS software functionality at the server.
- Ubiquitously accessible over the Internet.
- Can handle large database to serve spatial queries

Drawbacks of Static Web Mapping

- Every user request has to go through the Internet to activate a CGI script every time.
- Creates heavy traffic over the Internet.

- Operation is slow, because every command (even very simple ones like zoom and pan) has to be operated on the GIS server.
- Maps are static images.
- User cannot draw a box or a circle or select polygons on the map images.

Examples of Static Web Mapping

- VISA International ATM locator (http://www.visa.com/)
- ESRI's MapObjects Internet Map Server (http://metro-trip.ci.waukesha.wi.us/waukesha/)
- Map Quest (http://www.mapquest.com/)

Interactive Web Mapping (Client-Side Internet GIS)

- Interactive Web Mapping programs allow the user to manipulate GIS data and conduct GIS analysis at the client/user side, including:
  - GIS Plug-Ins and Helper Programs
  - GIS Java Applets
  - GIS ActiveX Controls

GIS Plug-Ins or Helper Programs

- GIS plug-ins are software executables that run on the browser and interpret the GIS data received from the server.
- GIS plug-ins are used in extending the browser to process GIS data.
- While GIS plug-ins are small applications, GIS helper programs can be large GIS applications or existing GIS software that is located in the user's local machine.

How Do GIS Plug-Ins Work?

Partition Points for GIS Plug-In

Examples of GIS Plug-ins

- Autodesk: MapGuide (http://www.mapguide.com/)
- GeoMedia Web Map (for Netscape browser)

Advantages of GIS Plug-Ins

- GIS plug-ins enable Web browser to interact with GIS data.
- Some GIS functions (i.e., zoom, pan, query) can be conducted by the plug-ins, so it can reduce traffic on the Internet.
- GIS plug-ins can fetch data from the server on demand.
- Plug-ins are easy to control and are not distributed with browsers.

Drawbacks of GIS Plug-Ins

- Plug-ins are not platform-independent. The GIS vendor has to create different plug-ins for different operating systems (Unix, PC).
- Users have to download different plug-ins from different GIS servers.

- GIS plug-ins and helper programs have to be installed in the user's machine.
- Security concerns make users hesitant to download plug-ins.

GIS Applets

- GIS applets are executable code that are downloaded from the server and executed on the browser client at runtime.
- Java applets use an object-oriented language designed to work on a virtual machine and including functionality that is useful for the interface design of GIS mapping and analysis functions.
- Java applets are interpreted locally via tools that are embedded in the most common browsers.

Java-Based Internet GIS

- How does it work?

Examples of Java-Based Internet GIS

- MapXtreme from MapInfo (http://www.mapinfo.com/)
- Google maps (http://maps.google.com/) (using AJAX: asynchronous javascript technology and XML: http://java.sun.com/developer/technicalArticles/J2EE/AJAX)
- ArcIMS from ESRI.

Partition Point for GIS Applets

The applet model moves the partitioning point further to the right.
Applet gives the application designer/developer the flexibility to determine where to split the application.
For example, a Web server may supply different applets depending on the speed of the connection between it and its clients.

Advantages of Java-based Internet GIS

- Java's byte code is platform-neutral, so it can run in any machine without modification.
  - For vendors and developers, it means larger potential market and the elimination of "software porting."
  - For users, it means lower cost and greater interoperability among components.
- Java applet is run on local machine, minimizing through-net traffic, and making better use of local computing resources.
- Java applets are more flexible in creating and displaying graphics and maps.
- Java applets are downloaded from the server at runtime and will disappear when the user quits the application.
- Java is more secure, because applets run on the JVM on the user's local device. Java applets have no access to local system.

Drawbacks of Java Applet

- It takes some time to initially download applets. This is especially problematic for slow connections (e.g., via dialup modems).

- It needs Java-enabled Web browser for Java applets to function.
- It cannot access local files and data (due to security limitations of Java tools).
- Java based Web GIS can not select objects by radius or select object from multiple themes (E.O. Johnson).

Java Plug-In

- Old Java applet relies on the web browser's default virtual machine.
- Java Plug-in software enables enterprise customers to direct applets or JavaBeans on their intranet web pages to run using Sun's Java 2 Runtime Environment, Standard Edition (JRE).
- The Java plug-in allows redistribution of both standalone Java technology-based applications and browser-based applets (http://java.sun.com/products/plugin/).

GIS ActiveX Controls

- An ActiveX control is a piece of executable code that can run on Windows platforms.
- ActiveX controls conform to the COM (Component Object Model) standard.
- They are loaded and executed inside a container (Internet Explorer).

How Do GIS ActiveX Controls Work?

Partition Point for ActiveX Controls

Same as for Java Applet

Example of GIS ActiveX Controls

- Intergraph's GeoMedia Web Map Server (http://imgs.intergraph.com/gmwm/)
- MapGuide (www.mapguide.com)

Advantages of GIS ActiveX Controls

- Offers better performance, because they are compiled to the native executable format.
- Takes full advantage of local machine resources and platform functionality (e.g. files, memory, hardware and software system controls) unavailable to a Java applet.
- Can access to local data.

Advantages of GIS Controls

- Some GIS functions (i.e., zoom, pan, query) can be conducted by the GIS controls.
- GIS controls can fetch data from the server on demand.
- GIS controls can communicate with other ActiveX controls and data locally as well as remotely as long as they conform to the COM standard.

Drawbacks of GIS ActiveX Controls

- Portability: platform dependent, different ActiveX controls need to be created for different platforms.
- Users have to download different GIS controls from different GIS vendors, such as GIS controls from ESRI, Intergraph, etc.
- Not all browsers support ActiveX controls. For example, Netscape needs a plug-in to run ActiveX controls.
- GIS controls have to be installed in the user's machine and lead to a "fat" client.
- Safety: Because ActiveX controls have full access to platform services, they can do great damage to a local system.
- Safety solution: Use verification approach to verify if a control is supplied by a trusted source. The assumption is that if it is supplied by a trusted source, it should be safe to use.

Safety Concerns of ActiveX Controls

- Problems with the verification approach
  - To be safe, users would have to reject all ActiveX controls not signed by an authority.
  - Even if the user can verify the ActiveX control comes from a reliable source, there is still no way to tell if executing the control will cause damage.

Data Streaming on the Internet

- Streaming subset of data to the client.
- Full data set stored in the data server.
- The client has the capability to replicate and cache data on the client side.
- The presentation (display and visualization) and logic components (map rendering) of the application reside

on the client side in order to intelligently display the data.
- Example: Google Earth's client: (http://earth.google.com)

Partition Point for Data Streaming

Advantages of Interactive Web Mapping

- Interactive Web mapping enables Web browser to interact with vector data rather than static map images.
- Some GIS functions (i.e., zoom, pan, query) can be conducted by the client-side programs, so it can reduce traffic on the Internet.
- Client-Side programs can fetch data from the server at runtime.

Drawbacks of Interactive Web mapping

- It takes some time to initially download client-side Internet GIS programs.
- Some client-side Internet GIS programs are not platform-independent.
- Limited functionality
- Difficult to handle very large database, since the transport of large amounts of data over the Internet is slow.

Introduction to ArcIMS

ArcIMS Architecture

ArcIMS Components

ArcIMS Client Viewers

- HTML/DHTML Viewer
  - written using HTML, DHTML (dynamic HTML), and JavaScript.
  - A thin client that only supports map images on the Web browser.
  - Only one image can be displayed at a time.
- ColdFusion and ActiveX Viewers
  - Similar to HTML/DHTML Viewer, but thinner
- Java Viewer
  - support both Image and Feature streaming

ArcIMS Business Logic Tier

ArcIMS Web Server

- Receives request from Web Client.
- Communicates with the Web client (browser) through HTTP.
- Forwards client request to Application Server via Application Server Connector.
- Communicates with Application Server through either a Java Servlet, or ColdFusion or the Active Server Pages (ASP).

Application Server Connector

- The connectors provide a communication channel between a Web Server or a third party application server and the Application Server.
- The connectors establish a socket connection with the Application Server for each request.
- Once the communication channel is established, requests are sent to and responses are received from the Application Server.

ArcIMS Application Server

- Manages load and assigns tasks to spatial servers.
- Serves as a bookkeeper for keeping track of which MapServices are running on which ArcIMS Spatial Servers.
- Allocates an incoming request to the appropriate Spatial Server.
- The Application Server can communicate with Multiple Web Servers.

ArcIMS Spatial Server

- This is the backbone of ArcIMS.
- It can produce maps, access data, and bundle maps into an appropriate format based on the user requests.
- It contains several supporting components: Weblink, the XML parser, and the Data Access Manager.
- Weblink is the communication gateway between the ArcIMS Application Server and the Spatial Server.
- The XML parser is used for parsing ArcXML requests.
- The Data Access Manager provides a link between the Spatial Server and any data sources.

Functions of ArcIMS Spatial Server

- Image rendering – generates map images
- Feature streaming – streams feature data
- Geocoding – locates addresses on maps
- Query – returns associated data for spatial and tabular queries
- Data extraction – returns data in Shapefile format to the client

ArcIMS Virtual Server

- It is a grouping of one or more Spatial Servers; it is not a physical entity.
- It is created to better manage distributed Spatial Servers.
- To improve service reliability and scalability
- Five Virtual Servers: ImageServer, FeatureServer, QueryServer, GeocodeServer, and ExtractServer.

Feature Streaming (Java clients only)

- Streams vectors and attributes
- Locally cached
- Compressed binary / XML
- Java clients
- Local geoprocessing
  - Buffer, MapTips, Query, Map Symbolization, ...

Internet Feature Streaming

Thin Client vs. Thicker Client

- Thin Client - Image Streaming
  - Server-side processing
  - GIF/JPEG/PNG images
  - Faster Loading
- Thicker Client - Feature Streaming (java only)
  - Vector / Raster / Attribute Data
  - More Client-side Functions
  - Robust Development Environment
  -

Examples: (how do they split client/server tasks, what protocols are used,...)

- Running ArcMap on the 37-312 lab machines
- Running ArcGIS on MIT's Citrix server
- Using the MITOrthoServer via a browser (http://ortho.mit.edu)
- Using the MITOrthoTools button from within ArcMap
- Running Google Earth (http://earth.google.com)
- The MassGIS data viewer: Oliver (http://maps.massgis.state.ma.us/massgis_viewer/index.htm)
- Shown in lab next Monday:
  - ArcIMS server for (optional) Lab #9 (running on a Linux PC)
  - 'Intelligent Middleware' project: web services using Minnesota Map Server + PostgreSQL and PostGIS (running on a Linux PC)

Written by Zhong-Ren Peng, Fall, 2003

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