Application note

A WebGIS and geodatabase for Florida's wetlands

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Abstract

Florida's wetlands are impacted by agricultural, urban, and other human activities. This enrichment effect can be seen in many subtropical freshwater wetlands in Florida, most notably in the Everglades. Given the environmental and political interest in these wetlands, there is urgent need for a centralized repository and mechanism to share geospatial data, information and maps of Florida's wetlands and adjacent agricultural ecosystems. Our objective was to develop an interactive WebGIS and geodatabase for Florida's wetlands providing map and data services. We used ArcIMS, a commercially available software, which was extended using a MSAccess database, Java, Visual Basic and Active Server Pages to customize our application. Our Web-based tool facilitates to share data globally, provide end-users a cost-saving solution to access up-to-date spatial datasets customized for a specific topic to users with limited GIS knowledge.

Staff from state and regional agencies and others are making increased use of our Web-tool to assist in the decision-making process to restore and preserve wetlands in Florida. Our interactive website of Florida's wetlands is accessible at http://www.giswetlands.ifas.ufl.edu.
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1. Introduction

Geographic information technology enables the integration of geospatial datasets of land and water resources and facilitates data sharing via the Internet as outlined in the National Spatial Data Infrastructure (Clinton, 1994), a concept defined as the technologies, policies, and people necessary to promote sharing of geospatial data throughout all levels of government, the private and nonprofit sectors, and the academic community. This concept can be profitably applied to wetland ecosystems. Wetlands are endpoints of hydrologic and nutrient flow patterns accumulating nutrients and contaminants from upland agricultural and urban ecosystems. In the Greater Everglades ecosystem, wetlands form a critical interface between uplands and adjacent water bodies and act as a buffer for retention of phosphorus (P). The subtropical climate, high annual precipitation rates, sand-rich soils, and karst topography cause accelerated transport of nutrients and contaminants into wetlands. Given the environmental and political interest in these wetlands, there is urgent need for a centralized repository and mechanism to share geospatial data, information and maps of Florida's wetlands and adjacent agricultural ecosystems.

Like many other rapidly evolving information technologies there is confusion about the consistent use of terminology when addressing the sharing of geospatial datasets "online" such as Internet GIS (Peng, 1999), GIS online, Distributed Geographic Information (Plewe, 1997), Web-based GIS, or simply Web GIS (Grunwald et al., 2003). Terms are similar but have different meaning. Internet GIS refers to the use of the Internet as a means to exchange data, perform GIS analysis, and present results, whereas Web-based GIS refers to the use of the World Wide Web, i.e., the WWW or the Web. Both Internet GIS and Web-based GIS use the client/server computing model. However, the term Internet has a broader and more enduring meaning than Web-based GIS, because it is any network composed of multiple, geographically dispersed networks connected through communication devices (Hall, 1994). The WWW is a networking application supporting a HyperText Transfer Protocol that runs on top of the Internet (Peng and Tsou, 2003). In other words, the Internet is an infrastructure that hosts many applications including the WWW. Distributed GI refers to the use of Internet technologies to distribute geographic information in a variety of forms, including maps, images, datasets, spatial analysis operations, and reports. Distributed GI is the most encompassing framework including both Internet GIS and mobile GIS (e.g. pocket PCs with wireless connections). Peng and Tsou (2003) points out that a WebGIS is a GIS distributed across a computer network to integrate, disseminate, and communicate geographic information on the WWW. We adopt their definition in this paper.

Commercial desktop GIS softwares such as ArcGIS (ESRI Inc., Redlands, CA) are costly and require extensive training and high-end hardware to get reasonable performance. In contrast, WebGIS provides end-users a cost-saving solution to access up-to-date spatial datasets and information (Horanont et al., 2002; Painho et al., 2001). A WebGIS is designed with tools and features that are common on Web pages and it is therefore easy to understand for users familiar with the Internet (Nelson, 2002). Other advantages of WebGIS include independence of platforms and operating systems. Usually only a simple Web browser is used to establish a client/server connection. Furthermore, WebGIS can be customized to provide specific data and information and/or services to end-users. In this paper we present a WebGIS application customized for Florida's wetland ecosystems. Two distinct types of

WebGIS can be distinguished, data services and map services. Data services allow clients to retrieve spatial data and information from the Internet to local machines. Using the Internet, the latest version of the dataset is accessible to all users immediately when the datasets are updated on the central Web server (Theseira, 2002). In contrast, map services are constrained to online use and no data or information can be retrieved to local client machines.

Currently, the sector of WebGIS and Distributed GIServices are growing exponentially. Examples include, the Florida Seminole County Watershed Atlas (http://www.seminole.wateratlas.usf.edu/help/aboutcontent.asp), the Southern California Wetlands Recovery Project Information Station (http://www.eureka.regis.berkeley.edu/wrpinfo/), the Clinch River Environmental Restoration Program (CRERP) (http://www.research.esd.ornl.gov/CRERP/SUB/INDEX.HTM), and the Florida Geographic Data Library (FGDL) (http://www.fgdl.org/). Though numerous Florida specific Web-tools have been developed none is specific to Florida's wetlands which cover approximately 50% of Florida's total area. Our objective was to develop an interactive Web-based tool to integrate and visualize geospatial data and information of Florida's wetlands providing map and data services to end-users. Our Florida Wetland WebGIS provides a centralized repository of soil and environmental datasets that support the documentation of ecosystem quality in Florida's wetlands and adjacent agricultural lands.

2. Methodology

The architecture of our Web-tool is shown in Fig. 1 consisting of map services, data services, meta data and other information (e.g. photographs). We standardized and integrated 2130 georeferenced point observations of 78 different soil physical, chemical, and biological attributes collected in Florida's wetlands from 1987 to the present. These datasets were collected by scientists and staff of the Wetland Biogeochemistry Laboratory, Soil and Water Science Department, University of Florida. It was necessary to standardize the soil attribute data to ensure consistency and to avoid redundancy. Attribute data comprised physical soil properties (e.g. bulk density), chemical properties (e.g. hydrochloric acid extractable P), and biological properties (e.g. microbial biomass). We used the Microsoft Access relational database to store and manage datasets. Auxiliary geodata were used to complement the
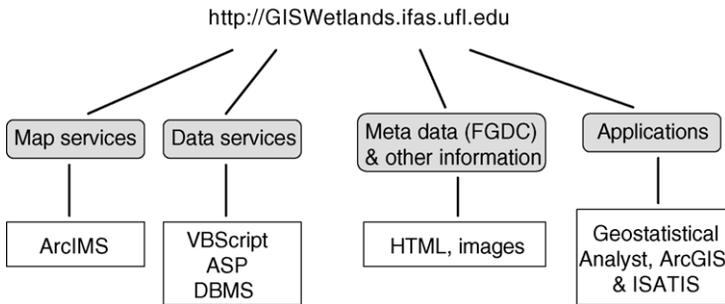

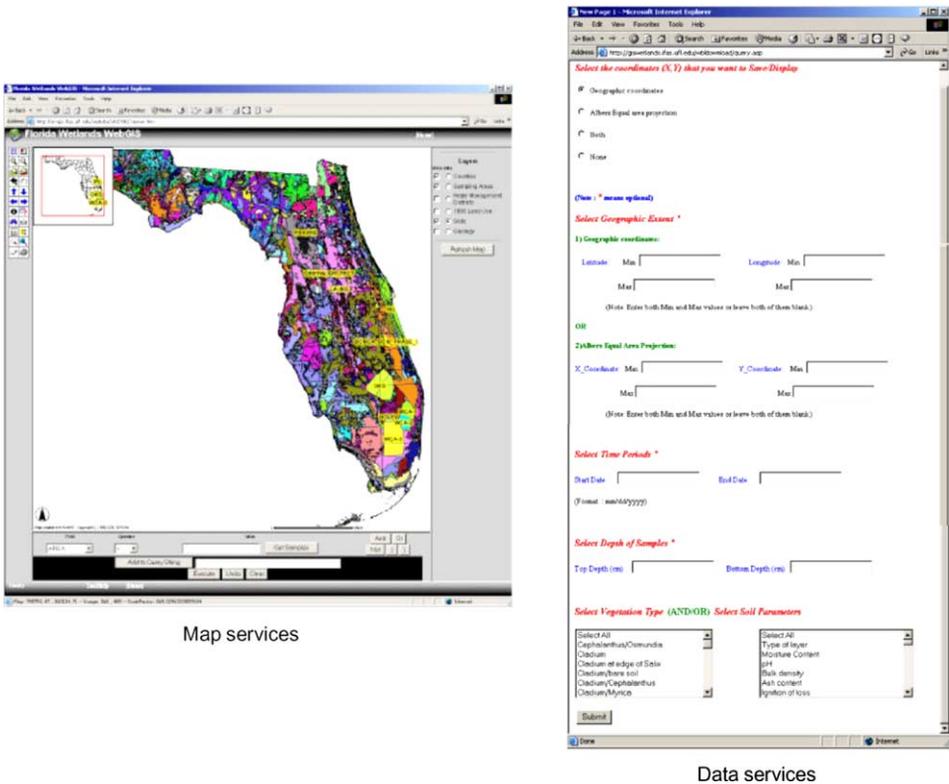Fig. 1. Architecture of the Florida wetland WebGIS and geodatabase.

Fig. 2. Architecture of the WebGIS implemented in ArcIMS.

point observations in Florida's wetlands. These included soil data from the Soil Survey Geographic Database (Natural Resource Conservation Service), land use/land cover derived from Landsat Thematic Mapper satellite imagery (Florida's Water Management Districts), county boundaries (U.S. Census Bureau, Tiger line files), geologic data (U.S. Geological Survey), and the National Wetland Inventory developed by the U.S. Fish and Wildlife Service.

We created a WebGIS tool using the ArcIMS (Arc Internet Map Server) software (ESRI Inc., Redlands, CA) to augment point observations with other GIS data layers such as soils, geology, land use, and county boundaries providing map display and interactive query, selection, and navigation functions to users (Fig. 2). The server-side components included the ArcIMS spatial server, application server, application server connectors, and the ArcIMS manager (Fig. 3). The ArcIMS spatial server processes requests for maps and related information. When a request is received, the spatial server performs functions such as creating cartographic map image files (e.g. in JPEG or PNG format), streaming map features, searching to query the database, geocoding for address matching operations, and extracting data to create a subset that can be sent back in shapefile format. Two middleware processes, the ArcIMS monitor and tasker, run in the background to support the ArcIMS spatial server.
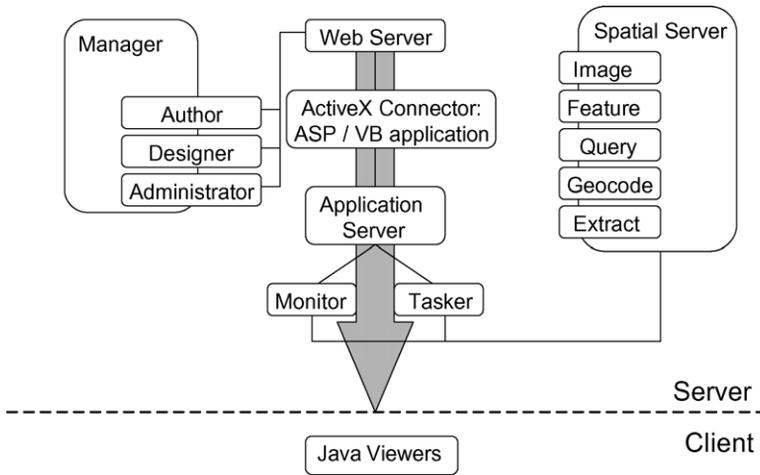
Fig. 3. WebGIS provides map services.

The ArcIMS application server handles the load balancing of incoming requests and tracks what kind of map services are running (ESRI, 2002; Peng and Tsou, 2003).

The ArcIMS application server connectors are used to connect the Web server to the application server. We used the servlet connector which is the standard connector for ArcIMS. The presentation tier provides an interface for users to access, process, and interact with the maps, tools, and geospatial data. It consists of two standard ArcIMS viewers, a Hypertext Markup Language and a Java Viewer which was implemented here because it provided extended viewing capabilities (ESRI, 2003; Peng and Tsou, 2003).

The ArcIMS manager is a suite of tools that provide access to all ArcIMS server-side functions and tools. The manager was used to develop our application. The ArcIMS manager consists of three stand-alone components – the author, designer, and administrator. The ArcIMS author defines the mapping application content. The ArcIMS designer generates the Web services that the end-user can view (e.g. design of legend, colors of map, etc.). The ArcIMS administrator console controls the operation of the Web mapping site including load balancing, management of the spatial server(s), monitoring of the client/server communication, compiling statistical information, and more (ESRI, 2003; Peng and Tsou, 2003).

We developed a geodatabase providing data services. The overall functionality and services that are provided is divided into client and server functions. The client/server model has a three-level architecture and efficiently manages the database. The three-tier client/server architecture consists of the following:

- An Internet client and Web browser, which provides the user interface in which the user can select the parameters. The client also captures and displays the results of the queries from a Web/application server. This acts as the application logic layer of this architecture.
- Web/application server. The data processing layer provides the connection to the database. Based on the selection of parameters by the user, a Structured Query Language (SQL)

query is built and sent to the database server for execution. The results of the execution are obtained by the Web/application server and converted into HTML format to display in the client-side Web browser. We used Active Server Pages (ASP) with Visual Basic (VB) script to provide these functionalities to the Web/application server.

- Database server, which provides the Database Management System functionalities, which includes query optimization, query processing, transaction management and database management. It is responsible for searching the database and retrieving the results from it.

The results of the query from the database can either be displayed in the Web browser on the client-side or downloaded to the local machine by the client. Users can activate SQL-based queries and filter specific data records using one or all of the following constraints: (i) geographic location, (ii) map projection (geographic coordinate system/Albers Equal Area Conic projection), (iii) time period, (iv) depth of sample, (v) vegetation type, and (vi) soil property. Either single, multiple, or all soil parameters can be selected.

3. Conclusions

We presented the implementation of a WebGIS and geodatabase for Florida's wetlands using ArcIMS, a commercially available software, which was extended using a MSAccess database, Java, VB and ASP to provide data and map services. This is the first repository for Florida's wetlands and we expect that the sharing of historic, current, and future geospatial wetland datasets will reduce costs, avoid funding of redundant research projects, and enable continuous documentation of environmental health in Florida's wetlands. Staff from state and regional agencies such as the South Florida Water Management District, Army Corp of Engineers and Florida Environmental Protection Agency and others are making increased use of our Web-tool to assist in the decision-making process to restore wetlands in Florida. The Greater Everglades has been point of interest nationally and internationally and the Comprehensive Everglades Restoration Plan coordinates activities to restore and preserve such unique ecosystem. There is need to develop more Web-based tools to share environmental datasets and information. Decision-makers and administrators often have limited expertise in GIS and complex spatial analyses. WebGIS has the potential to share data, provide easy access for users with limited GIS knowledge, and assemble data and information customized for specific topics, such as wetlands, that support informed decision-making.

References

Clinton, W.J., 1994. Executive Order 12906 – Edition of the Federal Register 59 (71) 17671–17674. Available at: http://www.fgdc.gov/nsdi/nsdi.html.

ESRI (Environmental Systems Research Institute), 2002. ArcIMS 4 Architecture and Functionality (http://www.esri.com/library/whitepapers/pdfs/arcims4_architeture.pdf).

ESRI (Environmental Systems Research Institute), 2003. ArcIMS Architecture. ArcNews Online (http://www.esri.com/news/arcnews/summer00articles/arcims-arch.html).

Grunwald, S., Reddy, K.R., Mathiyalagan, V., Bloom, S.A., 2003. Florida's wetland WebGIS. In: Proceedings of the ESRI User Conference, San Diego, CA, July 7–11.

Hall, C.L., 1994. Technical Foundation of Client/Server Systems, New York.

Horanont, T., Tripathi, N., Raghavana, V., Santitamnont, P., 2002. A Comparative Assessment of Internet GIS Server Systems. Map Asia, Hotel Shangri-La, Bangkok, Thailand, August 7–9, 2002.

Nelson, E., 2002. Low cost options for creating a GIS. American City and County, p. 10.

Painho, M., Peixoto, M., Cabral, P., Sena, R., 2001. WebGIS as a teaching tool. In: Proceedings of the ESRI UC 2001, San Diego, CA, USA, July 9–13.

Peng, Z.R., 1999. An assessment framework of the development strategies of Internet GIS. Environ. Plan. B: Plan. Des. 26 (1), 117–132.

Peng, Z.R., Tsou, M.H., 2003. Internet GIS – Distributed Geographic Information Services for the Internet and Wireless Networks. Wiley, Hoboken, NJ.

Plewe, B., 1997. GIS Online: Information Retrieval, Mapping and the Internet. OnWord Press, Santa Fe, NM.

Theseira, M., 2002. Using Internet GIS technology for sharing health and health related data for the West Midlands Region. Health Place 8 (1), 37–46.