Towards Dynamic Land-Use Planning Using Geospatial Technology: Conceptual Design of a Collaborative Web-based GIS

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ABSTRACT

This article presents the conceptual design of a collaborative web-based Geographic Information System (GIS) for land use planning in which all parties including land use planners, applicants/developers, and community stakeholders can participate. The approach employs three-tier architecture built in a Java client-server environment, and consists of the ESRI ArcGIS 9.2® Server Advanced Edition and MySQL relational database. The ESRI ArcGIS 9.2® Server Advanced Edition includes a collection of advanced web applications and services. This server edition can be used for web-based delivery of GIS information, hosting GIS web portals, processing of enterprise GIS databases, and distributed GIS data management and analysis. MySQL is a freeware, multi-user SQL Database Management System (DBMS), which is easy to learn than most database applications and is very popular for web applications. Using the system, users can log on and see the proposed site plans overlaid with sensitive environmental areas of concern, new zoning layer, drainage infrastructure, and they can post their comments and concerns. Real stakeholders can interactively post comments, concerns, and create mark-ups on the maps to reference areas of concern. The main applet will have controls so that everyone can view, but only real stakeholders can edit and add comments and mark-ups. The system helps to create a resilient user community that is more environmentally conscious and promote overall process of land use planning that is collaborative and transparent.

Introduction

It is recognized by the profession and the stakeholders that decision support tools based on geospatial technology can support a wide range of land use planning activities. When delivered through a web-based and interactive interface, these tools can facilitate the coordination among different government entities involved in this process much more efficient and faster. Hence, the use of geospatial technology in land use planning process ranging from day-to-day to future planning, would make the process more effective. This is valid since geospatial technology can help to guarantee that the every-day decisions made as part of the land use planning process are consistent with accepted conservation guidelines, environmental regulations, water resources protection policies, and regulatory controls on land uses. Such tools can be institutionalized and further used to support more sophisticated land use planning activities.

Information technology applications built on geospatial databases with or without web capabilities, have a great potential in enhancing decision making processes in many situations ranging from the daily governmental activities to crisis and emergency management. For example, natural conversational interfaces have successfully been built on geospatial databases (Cai et al., 2005), enabling for collaborative geoinformation access and decision-making (MacEachren, 2005). Geospatial tools have been used for geospatial data acquisition through mobile GIS (Montoya, 2003; Nusser et al., 2003), building of geospatial databases for coastal monitoring, integration of web-based GIS and analytical processing (Shan et al., 2000), and digitalization of coastal management and decision making (Li et al., 2003). Through an NSF funded project at the Ohio State University, a geospatial web-based system for coastal management and decision-making has been developed. The system was designed for applications in the Lake Erie area and has the potential to be adapted and applied elsewhere (Ma et al., 2003). The system consists of three components including a shoreline erosion awareness subsystem, a coastal erosion structure permit subsystem, and an on-site mobile spatial data acquisition subsystem.

In the shoreline erosion awareness subsystem, historic and predicted shorelines are organized on top of parcel maps of the town of Painesville in northern Ohio. Coastal residents were able to access the subsystem through the internet and view the current and future impact of shoreline erosion on their properties. Based on historic shorelines, future shorelines were predicted and published in the subsystem using a new shoreline prediction model (Ali, 2003). This allowed coastal residents to inquire about coastal erosion conditions in an extended vicinity of their area, enabling them to make decisions about their need of erosion protection structures. The coastal erosion structure permit subsystem simulates the decision making process for granting erosion structure permits in a GIS environment. The purpose of this subsystem is to help Ohio Department of Natural Resources (ODNR) officials to evaluate the potential impact of the proposed erosion structure efficiently (Xutong et al, 2005). This system allowed local residents to submit permit applications for erosion structures online, and track their application during the review process. This subsystem incorporated geospatial data relevant to ODNR's permit approval process including aerial/IKONOS-derived orthophotos, a coastal terrain model (CTM), a water surface model (WSM), and parcel maps.

Collaborative systems use different technologies to support several entities involved in a given process to work together on a specific task within a shared environment. For instance, there are several collaborative CAD-based systems that are in use since the late nineties (Ying-xiu et al., 2004). These systems allow for collaborative design and modeling either though the use of a network or the internet. Existing web-based, collaborative CAD-based systems have been designed in such a way that the server contains a global model, while every client owns a local copy of the shared CAD model. In the system discussed in this article, the server contains the land use planning data along with the site plan under review, which will be available through the internet, but only stakeholders can make markups, comments, and corrections.

The objective of this study is to enhance site plan review procedures by creating a collaborative land use planning system, in which all parties including land use planner, applicant/developer, and community stakeholders can participate. In addition, such a system can be used for educating and building awareness of coastal residents about conservation guidelines, water resource protection policies, and regulatory controls on land use. This system provides transparency to the entire land use planning process and helps to reduce administrative burden to land use officials and enhance communications amongst all parties.

The Review Process

This study deals with the automation of the land use planning activities related to coastal site plans review processes and procedures, and the development of GIS-based internet tools for collaborative planning that

involves the coastal community. It is necessary to present a short overview of the review process here. Site plans are generally reviewed prior to construction or site preparation by the planning department along with other local government departments as needed. The number of the departments and government agencies involved vary from jurisdiction to jurisdiction. Processing is a tedious and long process. It generally takes weeks, months, and in some cases years for major site plans, depending on the quality of the submitted plans, the nature of the proposed development, and the response time of the involved agencies. This long period may cause many adverse effects on the development process including financial damage if loan financing is required for the project development. Major site plans are required for big expansions and for all new construction, and they must be prepared by licensed engineers or architects. Large-scale developments require approval by the planning council in addition to the usual application with the local land use regulating authority. Site plans are required to be drawn to scale and are submitted in hardcopy format in most cases. Then the planning department coordinates a site plan review meeting with other departments including building, engineering, fire, and water departments along with the applicant. Planning department compiles comments and recommendations from other departments in site plan approval package or review letter and sends it to the applicant. If the site plan is approved, the applicant needs to continue through a development review process. The development review committee approves or recommends changes to the submitted site plan, and provides the applicant with information on development regulations and permits. If denied, the applicant needs to rework the proposal and re-submit, or appeal to the zoning commission within a specific period of time.

System Benefits

The system described herein will enhance site-plan review procedures in support of environmental health and environmental health monitoring through the creation of a web-based, interactive, and collaborative land-use planning environment. Such a system is robust, efficient, and much faster than traditional systems used in most places today. System benefits will include, but are not limited to, preserving natural landscape, creating more harmonious environment, managing storm water more efficiently, and minimizing lakeshore pollution, to name a few. This will be facilitated through the collaborative framework in which the proposed site plan is overlaid with the base layers (recent aerial photograph, wetland delineation layer, environmentally sensitive delineation layers, and ecological/hydrological monitoring layers), the zoning map, and the master plan layers (transportation, storm-water, water/sanitary sewer infrastructure). This approach represents an innovative application of technology in two ways. First, the digitalization of the site plans review process will improve the efficiency of the routine land use planning and decision-making. Second, the development of collaborative GIS-based internet tools will help to create a community that is more environmentally-conscious, and promote overall process of land use planning that is collaborative and transparent.

Methodology and Discussions

This approach is based on the assumption that the core land use planning system and the land use planning collaborative web-based GIS system are loosely coupled (see Figure 1), which will help to maintain the separate identity of the two systems. The community master plan as well as environmental quality monitoring parameters will be stored in the relational database (MySQL). The environmental quality monitoring parameters are essential to improve the quality of the output from the core land use planning system, if available. These monitoring activities are essential for building a knowledgebase, which aids in improving future land-use decisions. This will help to educate the stakeholders and the other parties involved in the land use planning process on the effect of new developments (positive, in the case of wide scale closure of septic tanks, as well as possibly neutral, from well-mitigated and Best Management Practices (BMP)-implementing developments).

The collaborative system described herein will be built in a Java client/server environment. Figure 1 shows the conceptual design of the system, which will manage geospatial information access between the entities involved in the day-to-day land use planning process, and handles user input through a collaborative environment. The approach employs three-tier architecture; a server-side, a client-side, and a database. The proposed system consists of an ESRI ® ArcGIS 9.2 Server Advanced Edition, and MySQL relational database. MySQL is a relational, multi-user SQL Database Management System (DBMS) that is very popular for web applications, and always claimed to be easier to learn and use than most database applications. Relational and object-relational database systems provide a number of functions that are critical to the operation of a GIS including fast storage and retrieval of large volumes of geospatial information, and a Structured Query Language (SQL) interface for manipulating and extracting GIS data. SQL is the most popular computer language used to create, modify, retrieve and manipulate data from relational and object-relational database management systems.

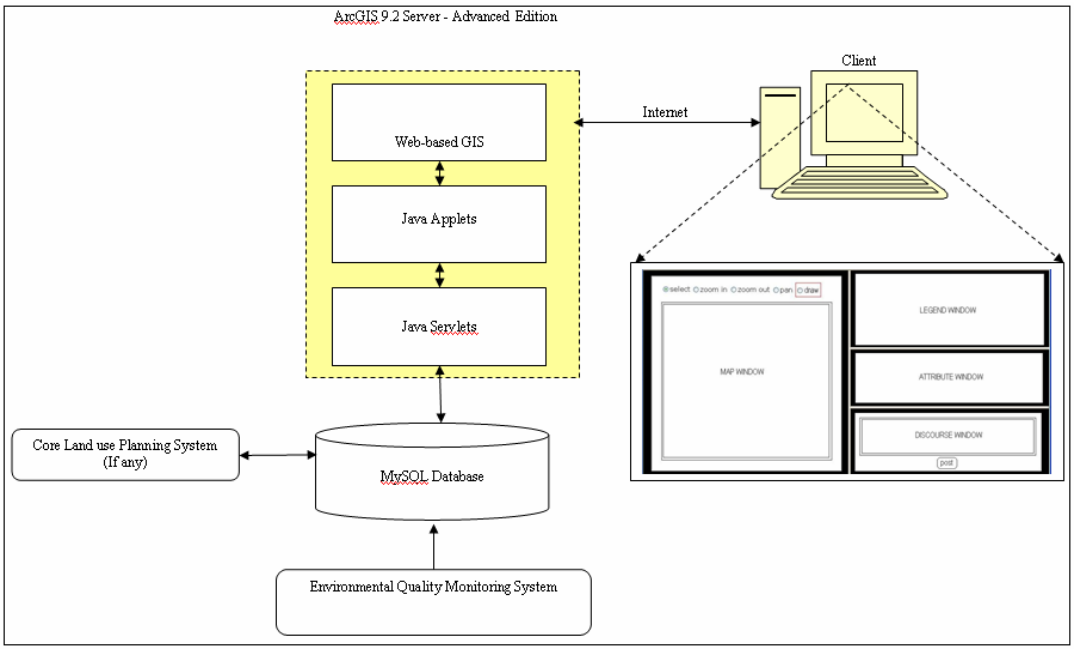

Figure 1: The conceptual design of the Land use Planning Collaborative Web Portal

The ESRI ® ArcGIS 9.2 Server Advanced Edition includes a collection of advanced web services and can be used for many centrally hosted GIS applications (ESRI, 2006). Server-based GIS can be used for web-based delivery of GIS information, hosting GIS web portals, processing of enterprise GIS databases, and distributed GIS data management and analysis. This ArcGIS server version delivers comprehensive web-based GIS services that support geographic data management, mapping, spatial analysis, editing, and other GIS functionality across distributed systems. This server provides a central, server-based GIS for distributing GIS services across an organization or over the Internet (ESRI, 2006). This server also includes multi-tiered components for building and deploying Java 2 Platform Enterprise Edition (J2EE) applications and services for traditional desktop, mobile, smart client, and enterprise deployments. J2EE is a platform-independent, Java-centric environment from Sun ® for developing, building and deploying web-based enterprise applications. The J2EE platform consists of a set of services and protocols that provide the functionality for developing multi-tiered, web-based applications. Some of the key features

and services of J2EE include the following: 1) Enterprise JavaBeans (EJBs), which provides functions such as threading, concurrency, and security. 2) Java Database Connectivity (JDBC), which is the Java equivalent to Open Database Connectivity (ODBC); the standard interface for Java databases. 3) The Java servlet Application Programming Interface (API), which provides enhanced consistency for developers without requiring a graphical user interface.

Having J2EE environment within the ArcGIS 9.2 Server Advanced Edition is a unique characteristic. This is true as Java is increasingly adopted by developers and information technology professionals as the preferred software development platform for web applications. A Java application runs in a platform-common environment known as Java Virtual Machine (JVM). In this environment, each platform translates the Java functionality to machine-specific calls. A unique characteristic of Java is its ability to generate applets, which are small programs with a compact executable code that can be incorporated into a web page. When the applet code gets to the client from the server, it gets executed by the local browser. The applet is also capable of displaying dynamic graphics on the web, allowing for user interaction, and connecting back to the server to download further information. Other unique features of Java that run on the server side are the Java Servlets, which are dynamic module that run in the JVM environment and serve requests from a server. Servlets have many capabilities such as: 1) they can be used for any number of web-based applications. 2) They can handle multiple requests concurrently. 3) They can synchronize requests. 4) They can forward requests to other servers. 5) They can establish a communication medium through an applet interface embedded in any HyperText Markup Language (HTML) page through HyperText Transfer Protocol (HTTP).

The collaborative system described here will be controlled by a set of servlets and applets, which will be designed within the ArcGIS 9.2 Server Advanced Edition. The servlets that will be developed for the proposed system including a main servlet, a ContextListener which will allow for reloading objects on the server, a DiscourseServlet which will upload the collaborative communication to the MySQL server, and an UploadServlet which will upload GIS layers to MySQL database and register the GIS datasets. Using the UpLoadServlet, GIS information will be uploaded to MySQL database, which will store it as an XML layers. Discourse information at the server end will be handled by the DiscourseServlet, which will be developed and housed in the ArcGIS 9.2 server. The main web page for the proposed system will have four windows: a map window, a legend window, an attribute window, and a discourse window (Figure 2). The map window will display the map of the area of the submitted site plan overlaid with all of the data layers mentioned previously. The legend window will show the layers displayed on the map, and the attribute window will display the available attribute information of the features of interest to the user. The discourse window will display both posted and new comments and concerns, which will be handled using an applet that will be designed using a multi-channel chat component. The user community can log on, see the GIS maps displayed and post their comments and concerns. The real stakeholders can post comments and concerns, and create mark ups on the maps using tools, which will allow for interactive drawing to reference locations or areas of concern. The main applet will have controls so that everyone can view and post comments, but only the real stakeholders can add mark-ups.

Figure 2: The Graphic User Interface (GUI) of the proposed Land use Planning Collaborative Web Portal

Conclusion

Encapsulated in this paper is a conceptual design of a web-based and interactive collaborative GIS for land use planning in which all stakeholders and government parties can easily participate. If implemented, this design provides many advantages. Major advantages include time-saving, robustness, efficiency, and effectiveness. Such automated system conceptually discussed in this paper will substantially increase the capabilities and quality of the traditional systems still in use by many government agencies and municipalities worldwide. Automation of such traditional systems will reduce the likelihood of errors and it will help with the ease of accessibility to the plans and the documents required throughout the review and approval processes. It will also help with document and drawings submission process, and make the process transparent. The approach employs three-tier architecture built in a Java client-server environment, and consists of the ESRI ArcGIS 9.2® Server Advanced Edition and MySQL relational database. The conceptual design reported in this paper is a work in progress. More information on the final design stages and implementation will become available in the future. In the mean time, the authors feel that this information should be disseminated as such to the interested audience.

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