ArcIMS Implementation for San Antonio River Authority

Abstract

The San Antonio River Authority has implemented ArcIMS and Metadata Explorer. The paper will focus on the issues observed when implementing Internet Map Server and Metadata explorer on a completely new and at the time not yet ESRI endorsed platform of Windows 2003 using IIS 6, Tomcat 4.1.12. Evaluation of both HTML based and Java based or custom viewers will be made. The emphasis will be placed on the functionalities needed to make the ArcIMS technology applicable for dynamic, real-time, web based modeling. The methods of customization for ArcIMS and the importance of focusing on ArcIMS design to meet the needs of user will also be explained.

Introduction

The Internet system has undergone explosive development during the past decades. The Internet began to be used extensively by the public, business, and society in 1995 (Castells 2001). In 1995, there were about 16 million users worldwide. Internet usage in 2000 was around 400 million people. The usage is currently around 800 million (InternetWorldStats.com, 2004). It was forecasted to be over one billion by 2005 indicating a 60-fold increase in only a decade.

Internet is a network that connects local, world-wide computer networks (i.e., LAN, WAN). The system was envisioned in the 1960s as a U.S. military "fail-safe" network. Internet development was started by the Advanced Research Projects Agency (ARPA) of the U.S. Department of Defense. The first network, ARPANET, was based on packet switching communications technique.

ARPANET was developed and promoted initially by computer scientists working at research institutions and universities. The goal of the development was to generate a new kind of computer-based, digital communications network for non-military and non-commercial reasons. ARPANET became operational in 1975 when it was transferred to the Defense Communication Agency. The number of Internet host computers reached 10,000 in 1987 (Branscomb 2003).

ARPANET was decommissioned in 1990. National Science Foundation (NSF) completed the privatization of the Internet in 1995. After the privatization internet grew rapidly and today there are millions of Internet host computers and users around the world.

Internet functions on three basic principles (Castells 2001):

- Decentralized network structure, with no single "headquarters" that controls the whole system.
- Distributed computing capabilities throughout many nodes of the network.
- Redundancy of functions and control of the network to minimize risk of disruption in service.

Internet provides a large and rapidly increasing variety of resources and services (i.e., software, data archives, library catalogs, bulletin boards, directory services, interactive applications etc.) The most popular and the most widely used application of the Internet is electronic mail. Other major applications are Telnet (remote login), file transfer (FTP), and the World Wide Web.

The Web is the collection of all information available anywhere within the Internet system. It is a seamless, transparent interface to the entire network. It is also among the newest, most exciting, and rapidly growing developments on the Internet.

The World Wide Web was invented by Berners-Lee, at the European Laboratory for Particle Physics (CERN) in Geneva, Switzerland in 1990. Web function was enhanced enormously in 1993 by Andreessen and Bina at the U.S. National Center for Supercomputing Applications. They incorporated an advanced graphics capability in the first hypermedia browser, Mosaic. In 1994, the World Wide Web Consortium was formed to lead the development of the web on a global and vendor-neutral basis (World Wide Web Consortium, 2004).

The technological basis for the Web is Hypertext Transport Protocol (HTTP), which establishes communication between a browser (client) and a Web server (server) computer. Hypertext Markup Language (HTML) forms the notation for writing documents and creating links on the Web. The locations of files and other resources on remote server computers are identified by a Uniform Resource Locator (URL). Client software opens the window to the Web. Web browsers allow the user to move through the Web with text, graphic, video, audio capabilities. Among these browsers currently Internet Explorer and Netscape are the most widely used. However, Microsoft Internet Explorer has obtained market dominance as the Internet browser in recent years.

Growth of the Web has been phenomenal during the past decade. According to various estimates, the Web doubles in size every nine to 18 months (Gibbs 1996, Hayes 1997). There are probably more than half a million servers worldwide today, and millions of people around the World use the Web.

Development of the Internet is a collective phenomenon, diverse and dynamic in nature. It is not controlled by any one company, country, or social groups, segments. It changes the way people communicate and share information fundamentally.

As internet became a widely used tool, GIS over the internet became an important component of Enterprise GIS implementation. Some of the reasons necessitating the internet GIS could be summarized as follows:

a. The ability to extend the audience of GIS to a larger circle of users so that a much larger return on investment could be possible through the collaborative use of data, services, and applications for multi-user, multi-agency, cooperative work.
b. The enhancement in customer satisfaction by providing automated information and related services based on visually referenced-spatially enabled databases.
c. Communicating dynamic/interactive spatial information and services to the users (i.e., real-time information dissemination, integration, communication)
d. To support daily or emergency operations of the organizations in a timely and cost effective manner.
e. Incorporation of complex spatial /statistical analysis functionalities, modeling and decision support (ie., data-to-models and data-to-interpretation and others) (Goddard et al. 2002).

2. GIS on the Web

The Web GIS technology opened new paths for disseminating, sharing, displaying, and processing spatial information on the Internet. Web-based solutions provide a low-cost, efficient way to deliver maps, data, metadata and applications to users. Today, Web GIS is used in many areas, including finding locations, obtaining driving directions along the streets, showing dynamic weather or streamflow information, accessing GIS data, maps, applications for various specialized uses-services (i.e., software providing GIS functionality) at the browser end and integrating that with local specialized data, maps or applications residing on the local machine.

GIS subjects are well represented on the web for several reasons. Much GIS data exist in digital format, and many users are familiar and comfortable with working in a networked, computer-based environment. The subject matter is image rich, which lends itself for Web serving (i.e., delivering text and graphic imagery). Internet also has the ability to move large files quickly (FTP); a great advantage for transferring GIS data and databases from one location to another. The Web offers user interaction, so that a distant user can access, manipulate, and display geographic databases from a GIS server computer.

The Xerox web site is one of the first implementations of GIS over the web. It was established in 1993 (mapweb.parc.xerox.com/map). The site had used pre-created image maps for each case scenario for the users to find the particular html page containing the map for display. GRASSLinks was the first fully functional on-line GIService which connects GRASS GIS software developed by US Army Corps of Engineers and the World Wide Web. It was implemented in 1995.

Geographic Information System (GIS) capabilities on the World Wide Web, using the middleware program called as Internet Map Server (IMS), was first commercially launched by ESRI (Environmental Systems Research Institute Inc.). Internet map server was a very efficient way to make live GIS products available to a large population at minimum cost.

ArcIMS is Internet-base GIS allowing users to centrally build and deliver wide range of GIS maps, data and applications to users. ArcIMS accommodates client and server technologies. It extends the web to serve spatial data and limited functionalities. ArcIMS could also work with wide range of clients including desktop and mobile devices. The ArcIMS technology facilitates expansion of GIS technology for the web, integration of data from multiple sources, scaling of the system to meet the user needs, and providing access to data and location services.

3. Internet GIS using ArcIMS

ArcIMS has a multitier architecture consisting of presentation, business logic, data tiers and a set of applications for managing a Web mapping site (ESRI, 2003). The general architecture of the ArcIMS is given in Figure 1.

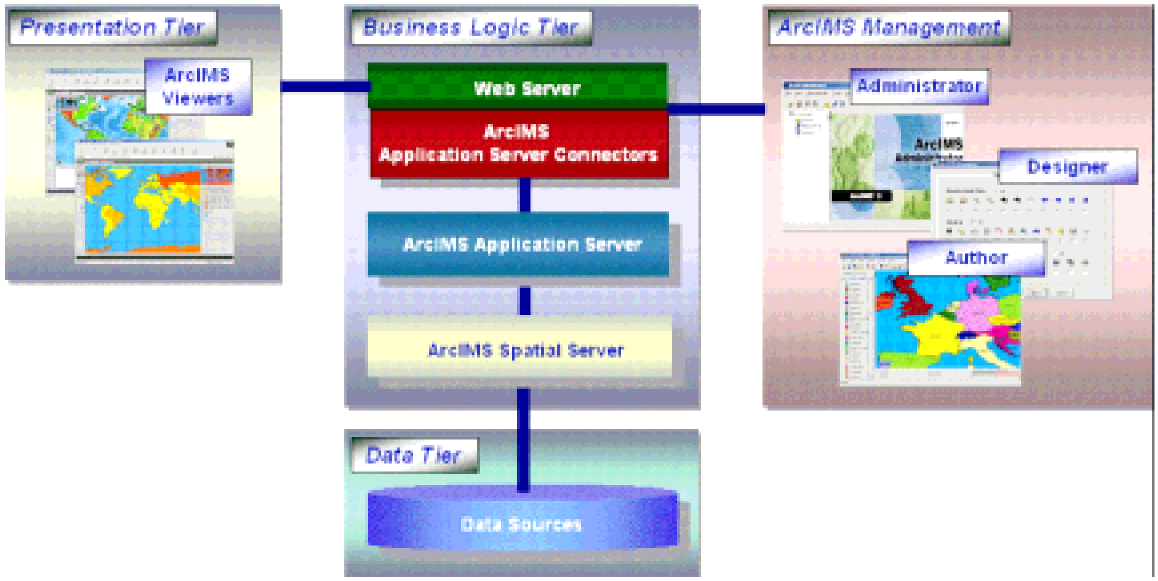

Figure 1. ArcIMS Architecture (ESRI, 2003)

ArcIMS runs in a distributed environment. The presentation tier includes the AcIMS client viewers for accessing, viewing and analyzing geographic data. The ArcIMS business logic tier contains the components needed to run services and process requests and responses. The components include the Application Server Connectors, the ArcIMS Application Server, and the ArcIMS Spatial Server. The data tier includes all data sources available for use with ArcIMS. ArcIMS site management applications provides access to business logic tier applications for authoring, administering ArcIMS services and servers and designing web sites. ArcIMS works in Java 2 environment, and requires web server, JavaVM, and servlet engine. A Web server handles requests from a client using HyperText Transfer Protocol (HTTP). The Web server forwards a request to the appropriate application and sends a response back to the requesting client.

A JavaVM, basic provides application programming interface (API) for running many of the Java 2 components of ArcIMS. ArcIMS requires a JRE to function. A servlet engine is an extension to the JavaVM and provides support for servlets through a servlet API. The servlet engine plugs into a Web server and provides the link between the JavaVM and the Web server (Figure 2.).

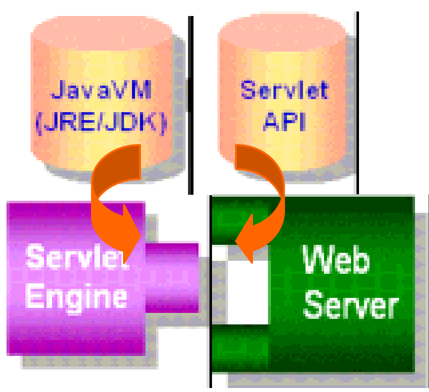

Figure 2. Servlet Engine and Web Server Connection.

The framework requires the Web server, JavaVM, and the servlet engine. When an ArcIMS request is made, it is first handled by the Web server, passed through one of the connectors, and then forwarded to the ArcIMS Application Server. The Application Server, in turn, dispatches the request to an ArcIMS Spatial Server for processing. Below is a diagram showing the business logic tier components.

Communication between components in the business logic tier is handled through ArcXML, an implementation of XML used with ArcIMS. ArcXML elements and attributes provide the structure for Map configuration files which describe how a map should be rendered. ArcMap documents can also be used as map configuration files, and an input to ArcMap Image Services. Metadata configuration files provide instructions on the location of metadata tables and other information needed to support Metadata Services. Requests are sent to an ArcIMS service requesting maps, attribute data, or metadata information and responses return information to the requesting client. All administration such as adding, starting, stopping, and deleting ArcIMS Spatial Servers, Virtual Servers, and services is handled using ArcXML. ArcIMS users have access to some of this functionality using Application Server commands.

ArcIMS Application Server runs as a background process and handles the load distribution, and catalogs which services are running on which ArcIMS Spatial Servers to dispatch an incoming request to the appropriate Spatial Server. Connectors are needed to either pass the ArcXML straight through or translate third party syntax such as ColdFusion, Active Server Pages (ASP), or JavaServer Pages (JSP) prior to forwarding the ArcXML request to the Application Server. The server connectors provide a communication pipeline between a Web server or third party application server and the ArcIMS Application Server. ArcIMS has four connectors as ArcIMS Servlet Connector, Java Connector, ActiveX connector and ColdFusion connector. The ArcIMS Servlet Connector is the default connector and uses the servlet engine to provide a communication link between the Web server and the ArcIMS Application Server. A Web Map Server (WMS) connector that processes WMS requests is contained in the ArcIMS Servlet connector, and allows any Open GIS Consortium WMS-compatible browser or client to access an ArcIMS service. ArcIMS ColdFusion connector processes requests from the ColdFusion Server before handing the request to the ArcIMS Application Server. ArcIMS ActiveX Connector is a Component Object Model (COM) DLL that is used in a COM application. The ArcIMS Java Connector is a set of JavaBeans that allows users to create client and server applications, custom servlets, and JSP applications. A JSP tag library is also included for supporting JSP applications.

An ArcIMS Spatial Server provides the functional capabilities for accessing and bundling maps and data into the appropriate format before sending the data back to a Web browser. The Spatial Server is a container for holding components that support different functionality. These components make up a server types inside the ArcIMS Spatial Server. In image server component, maps are generated on the server and sent to clients as JPEG, PNG, or GIF images. Cartographic images can be generated from shapefiles, ArcSDE data sets, and supported image formats. In feature server component vector features from shapefiles and ArcSDE data sets are streamed in a compressed format to a Java Applet in the client Web browser. Feature streaming is a temporary compressed format that remains only as long as the client is open. Feature streaming allows for additional functional capabilities on the client such as clientside labeling, changing the appearance of a map, MapTips, and clientside spatial selection. In query server, the query function is used to return attribute data for spatial and tabular queries. In geocode server, the geocode function is used to locate points on a map based on the address; intersection; or city, state, or place name. In extract server, data extraction is used to return data in shapefile format. The Metadata Server is a repository for documents that contain information about maps, data, and services. The ArcMap Server generates images using an ArcGIS ArcMap document as the input. The behavior and types of requests are similar to the Image Server. The Image, Feature, Metadata, and ArcMap Servers are public and can be accessed through the ArcIMS interface. The Query, Geocode, and Extract Servers are private and are managed automatically by the Spatial Server when they are needed. The ArcIMS Spatial Server also has some supporting components that include weblink. Weblink is the communication gateway between the ArcIMS Application Server and the ArcIMS 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. A Spatial Server instance is a thread that can process one request at a time. Each of the component servers of a Spatial Server, such as an Image Server, comprises one or more instances. Number of instances depends on the type of service and which server components the service accesses. A service provides instructions on how to generate a map when a request is received. ArcIMS supports four types of services as image services, feature Services, ArcMap Image Services, and metadata Services. The Spatial Server configuration will vary among ArcIMS sites depending on the number and size of services, time to process requests, number of requests, Web and network traffic, and other factors specific to the site. A Virtual Server is a grouping of like instances, such as Image Server instances, on one or more Spatial Servers. Grouping ArcIMS Spatial Servers is important not only for administration but also for reliability.

The data tier consists of data sources available for use with ArcIMS. Depending on the type of service, different data formats are available. To access components in the business logic tier, ArcIMS provides a set of management applications.

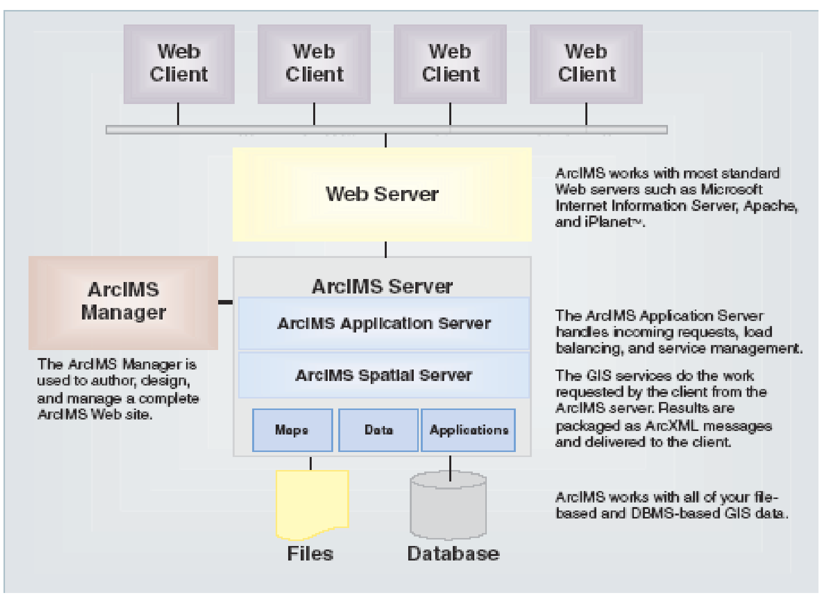

Figure 3. ArcIMS system (ESRI, 2003).

4. San Antonio River Basin and River Authority

The San Antonio River Basin is located between 96.51, 99. 35 degrees longitudes, and 28.27, 29.57 degrees latitudes in south central Texas. The river basin area is approximately 11380 square kilometers (Figure 4.). The basin is bordered on the west by the Nueces River Basin and on the east by the Guadalupe River Basin. Most of the San Antonio River Basin is rural, particularly in the southern half.

The San Antonio River Authority (SARA) plans, manages and implements programs and projects to preserve, and protect the resources and environment of the San Antonio River Basin. The river authority's responsibilities include flood control, environmental services, water resources, utility services, and park services. The authority's district consists of Bexar, Wilson, Karnes, and Goliad counties.

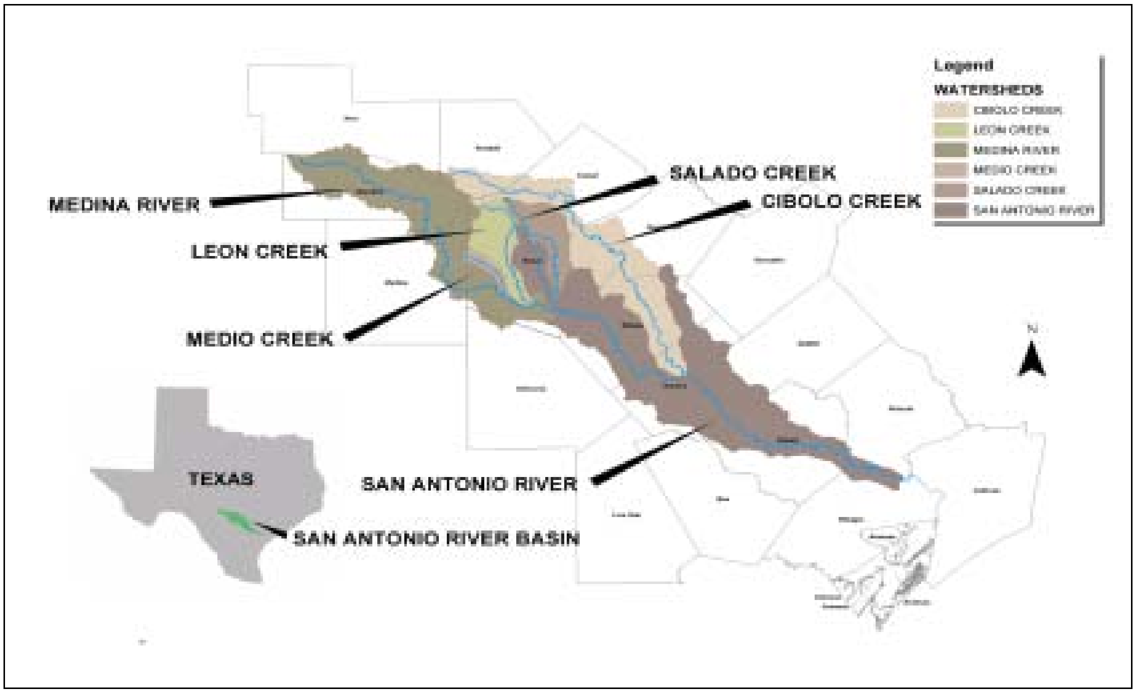

Figure 4. San Antonio River Basin Map.

5. SARA GIS Internet Map Server

The GIS organization and Enterprise GIS implementation including intranet/internet map services for SARA has begun with establishing general guidelines for GIS, organizational structure, spatial data, standards, technology and their use in SARA. This is documented in the SARA GIS Policy. The policy stated the vision, objectives, organization, general standards for data quality/consistency, metadata, software, hardware requirements, accessibility, technical support, and funding sources for SARA GIS.

The next step was to formalize the regional GIS database implementation process, necessary steps, funding and other issues using project management principles. Formal project documents were prepared and approved by the SARA management. After this approval, the next step taken was to determine the requirements for GIS, and the collection of federal, state, local data for SARA.

The Enterprise GIS Database is set-up and configured using MS SQL 2000 and ArcSDE 8.3. First, the general database storage structure, filegroups, security and backup mechanisms were explored, identified and implemented. Test data was standardized using developed SOPs, modeled using Visio, and loaded into the database using simple or object loader tools of ArcGIS. Database and operating system tuning were carried out by adjusting parameters specifically related to buffer size and checking for CPU usage and disk I/O, for better performance with the sample data and limited users.

The ArcIMS, and metadata server web sites together with associated tools-utilities has been set-up using ArcIMS, Tomcat, IIS 6, over the Windows 2003 Enterprise server. The enterprise server is a dual-Xeon Dell server with 3.00 GHz processor speed and a 4 GB RAM, and 600 GB storage space, hosts ArcIMS and ArcSDE. The Internet Information Services 6 (IIS6) web server, Tomcat 4.1.12 Java servlet engine and Java SDK 1.4.0 were chosen for performance, reliability, and consistency. Currently, all the possible technology options for ArcIMS implementation were enabled for SARA and public (SARA's constituent's) users to try different versions for ArcIMS implementation and to have feedback with their experience on the technology of choice to be implemented. ArcIMS and Metadata Server has been customized to a certain degree specifically to serve ArcGIS 9.0 Map2Map Model over the internet. Access control list (ACL) based security was implemented as well. The SARA GIS Web site, ArcIMS and Metadata Server sites are shown in Figures 5-7.

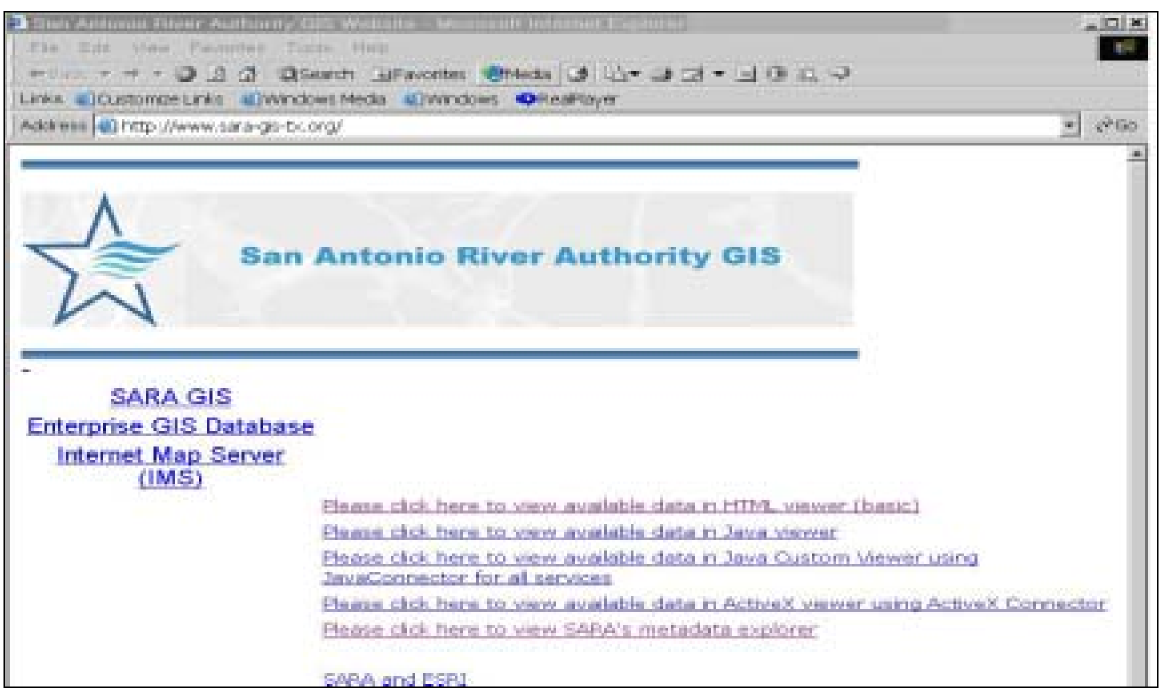

Figure 5. SARA GIS Web Site (SARA GIS Website, 2004).

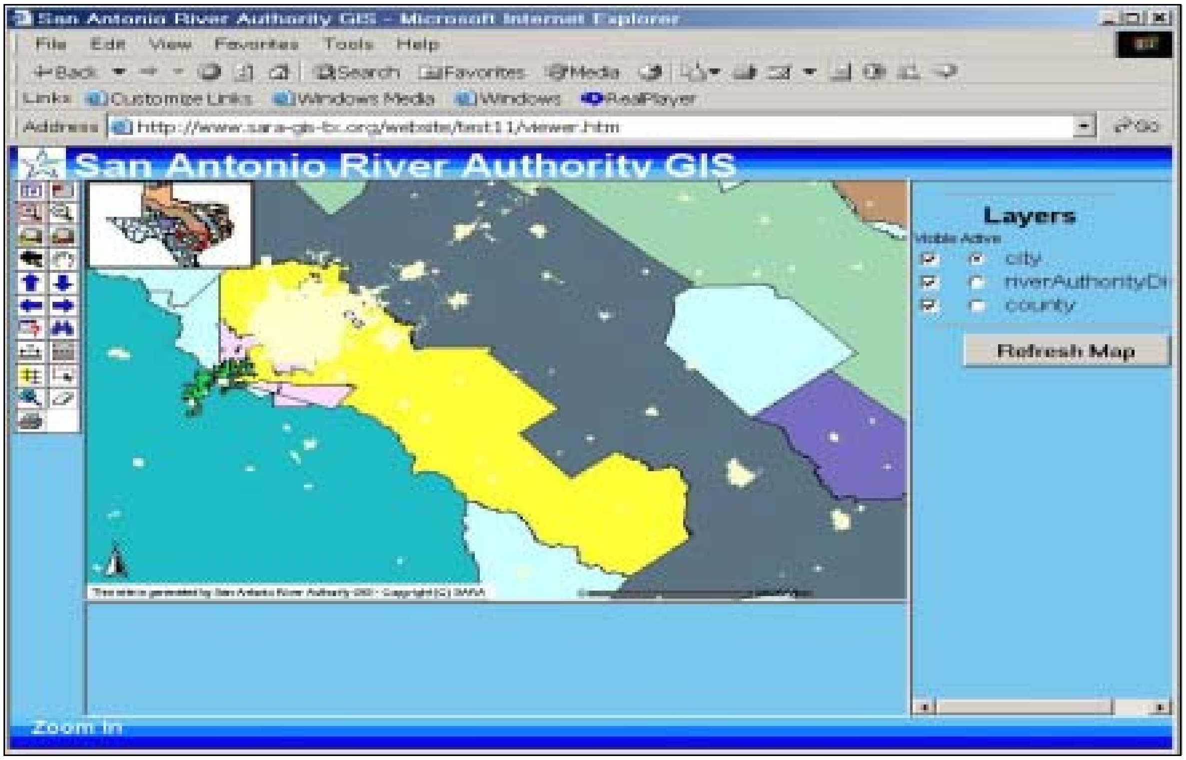

Figure 6. SARA GIS Web Site HTML Viewer Trial Version (SARA GIS Website, 2004).

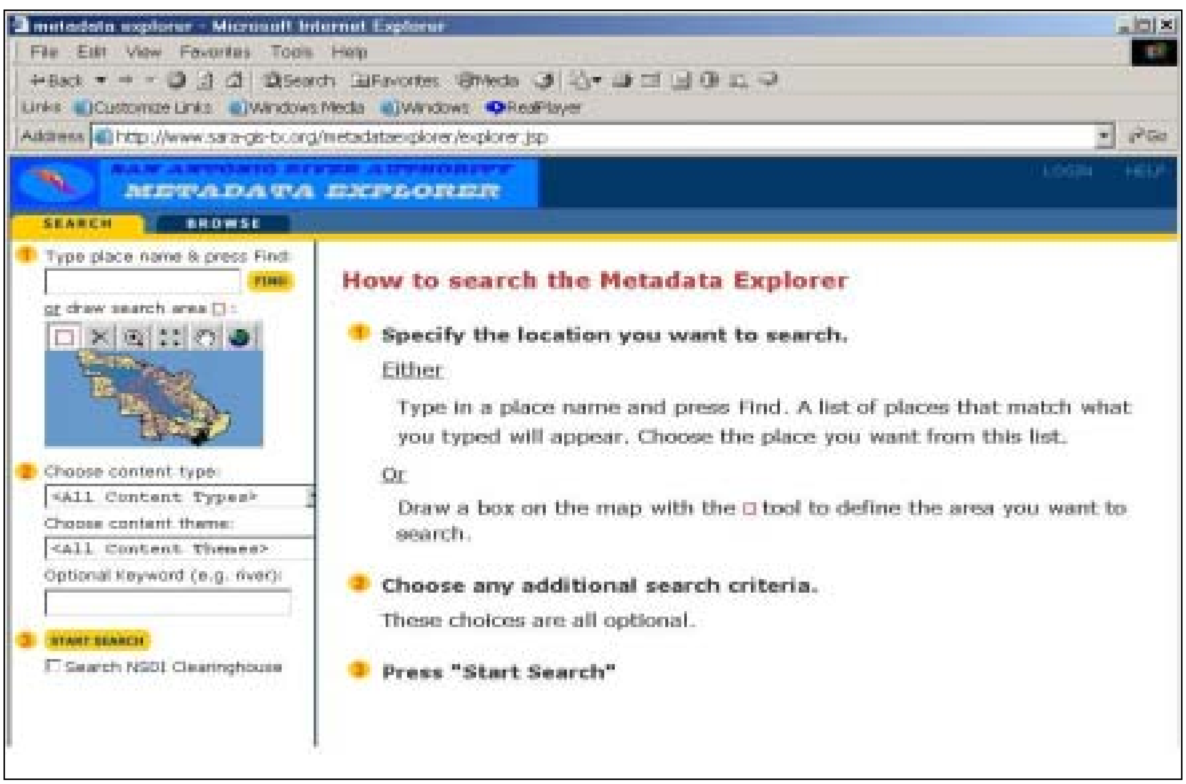

Figure 7. SARA Metadata Explorer Web Site (SARA GIS Website, 2004).

When SARA established the ArcIMS and Metadata Server Web sites, the operating system, internet information services platform and additional software components (Tomcat, JavaVM) used to establish these web sites were not being tested or endorsed by ESRI. Specifically, security enhancements made to IIS 6 and the finding the ways around it made the implementation quite challenging. Additionally, after the web site establishment, SARA has served the Map2Map application and relevant documentation developed using Beta/Prerelease ArcGIS 9. geoprocessing toolbox tools/Map Builder/VBA/VB and scripting and US Army Corps of Engineers HEC-HMS and HEC-RAS core library functions collection (i.e., HECLIB) using modified Metadata Explorer web site.

6. Discussions and Conclusions

From SARA's implementation regarding the making the real-time modeling over the internet possible, the following issues found to be critical and need further enhancement and improvements.

1. Incorporation of multiple data sources (direct live data feeds) and applications with possible diverse formats to enterprise, integrated real-time internet modeling systems. This issue specifically needs to be addressed from the point of interoperability and how the best over the internet interoperability schemes could be employed for real-time modeling (Anderson and Moreno-Sanchez 2003, Abel et al. 1998, ESRI 2003, Uitermark et al. 1999).
2. Incorporating possible task/work sharing between server and client computers, and reduction of the network flows and enhancements in the network infrastructures to facilitate participation of the users by low-end technology and capabilities (Gibbs 1996, Limps 1999, McGovern 2001).
3. Incorporating the mobile data and services for field and reference data collection.
4. Provision of full-blown GIS analysis/processing capabilities for users to interact with the system and for fully automated system related tasks/checks

As technology matures, and technical background for massive data transfers made possible through the availability of high speed network, and common, standardized interoperability schemes implemented, real-time modeling with intelligent GIS/data processing would become a feasible option

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