

The Development and Implementation of an ArcIMS System for City Parcel Mapping

Michael Montemayor, Jr.^{1,2}

¹*Department of Resource Analysis, St. Mary's University of Minnesota, Winona MN 55987.* ²*Engineering Department, City of Winona, Winona MN, 55987.*

Keywords: Geographic Information Systems, Arc Internet Map Server, Internet, Intranet, Active Server Pages, Structured Query Language

Abstract

This paper outlines the exploration of internet based mapping software for municipal government use. Using Geographic Information Systems (GIS) and other mapping software, a land parcel management application was created for the City of Winona. The project's goals were to first implement an intranet based parcel viewing and querying system that would allow city employees to obtain information about city parcel data. Second, to demonstrate the effectiveness and efficiency of internet GIS access to city officials as a means to make city data available to the public.

Introduction

In terms of modern technology, the Internet has transformed and modernized the computer and communications world like nothing before (Cerf, Clark, Kahn, Kleinrock, Leiner, Lynch, Postel, Roberts and Wolff, 2001). What was once an experiment conducted for university and government data transfer, the Internet has evolved into a global resource connecting millions of users. The Internet is the world's largest network and has doubled in size every year since 1988 (Oppliger, 1998). For many, the Internet has become an essential facet of everyday life. It was estimated in January of 2000, there were 242 million internet users worldwide. By 2005, the number of internet users worldwide is projected to reach 765 million (Anonymous, 1994-2002).

One of the most important aspects of the Internet is the near limitless exchange and free flow of data and information that can be distributed.

Building on the exchange of data, the Internet has become an essential source of data for users of geographic data. Geographic data are important because they are information connected to a specific location on earth. Whether or not we may realize it, geography plays a very important role in everyday life. Many decisions we make are often influenced, determined or constrained by some aspect of geography (Environmental Systems Research Institute, 1994). Over the last thirty years, Geographic Information Systems have dramatically evolved into multifaceted computer applications and systems which specialize in the analysis of geographic data. While not available to all, the use of GIS may aid in everyday decision making about geographic phenomena.

Since the beginning of the Internet and the origins of GIS, users of both have recognized the need for the

integration of the two systems. Because of this, the Internet may serve as the ideal location for analyzing, solving and providing solutions for geographic information problems (ESRI, 2001a). Arc Internet Map Server (ArcIMS) is a new and powerful GIS tool that enables an integrated approach for creating and managing geography-based websites.

In the early 1980's there were only several hundred people using GIS. By 1998 there were approximately a quarter million people using GIS (Harder, 1998). While this is an impressive increase, the number of GIS users is dwarfed compared to internet users. ArcIMS may provide the perfect solution by bringing GIS capabilities to non-users of GIS by deploying the power and functionality of GIS over the Internet.

Background

Winona is located in southeastern Minnesota (Figure 1). Nestled in the bluffs along the Mississippi river, Winona is home to some 27,069

residents and 10,666 households. (U.S. Census Bureau, 2000). Within the City limits, these 10,666 households reside on approximately 12,654 different parcels.

Currently all parcel data is gathered and maintained through Winona County. The City of Winona obtains all parcel data and parcel data updates from Winona County. If an individual wishes to obtain information about a land parcel within the city, he/she must visit the engineering department at City hall and meet with a city engineer. This can be time consuming because city engineers may have to access databases, obtain plat maps and or reference legal documents in order to deliver property information desired. Several city employees have access to Winprop, a computerized parcel management system designed by Resource Analysis Projects at St. Mary's University. While Winprop is somewhat user friendly, it was built in ArcView 3.2. This is a problem because many city employees are unfamiliar with GIS software. Also, the number of ArcView licenses is limited.



Figure 1. Location of Study Area

In a GIS needs assessment performed by Resource Analysis Projects, numerous city employees expressed interests in having a city computer available to both employees and the public for access to city parcel data. With this in mind, the City of Winona contracted with the Geospatial Service Center (GSC, Department of Resource Analysis, St. Mary's University) to develop an intranet based parcel mapping system to allow all employees access to parcel data.

Methods

Data Acquisition

Data for this project were obtained from the City of Winona Engineering Department. The specific coverages used for this project were the Winona County parcels coverage, Winona County roads coverage, Winona City limits coverage, Winona City zoning coverage and the Winona Rivers and Lakes coverage. The coverages were converted into shapefile format available for use in ArcView 3.2 and ArcIMS. As a backdrop to the shapefiles, 11, 1:24,000 Digital Ortho Quarter Quadrangles (DOQQ's) spanning Winona County were obtained from the United States Geologic Survey. In addition to the GIS data, three database tables were acquired containing information relating to the parcels shapefile. These three tables included property, legal and owner information.

Hardware/Software Requirements

This project was completed using a variety of software products. The most important component was ArcIMS developed ESRI. ArcIMS is comprised

of three applications used to create, publish and maintain maps for intranet and internet use. These applications are Administrator, Author and Designer. While each application is separate, for "out of the box" solutions all three are required and work interactively. Author is an application used to create a map configuration file. This file defines the content of an internet map: what features will appear on a map and how those features will be symbolized or rendered. Administrator is an application that is used to convert a map configuration file into a map service which is a file that is readable by a web browser. Designer is an application used to quickly build a website configured to the map service needing to be published. For the end product of this project, only Author and Administrator were needed. For initial testing and product development, Author, Administrator and Designer were all used.

In addition to ArcIMS, ESRI's Site Starters applications were also needed for this project. Site Starters are a set of simple web-based Active Server Pages (ASP) templates that can be manipulated to fit the needs of user datasets (ESRI, 2002). For data development and manipulation, ArcView 3.2 was used as well as Microsoft Access for relational database capability and data management. For final website development, Dreamweaver software was used to create a homepage containing the interactive mapping pages.

ArcIMS is a software package that bridges the gap between two clearly different technologies; the Internet and GIS. Because of this, additional components were needed to allow the two technologies to work interactively. In order to have ArcIMS working

correctly, a servlet engine is required. Servlet engines extend the functionality of web servers by allowing open communication between the ArcIMS Application Server and the Web Server by building servlets (ESRI 2001a). In addition to the servlet engine, a servlet connector is also needed. A servlet connector is a method for getting requests and responses between the web server and the application server.

For this project the ActiveX Connector was used allowing GIS data and maps to be integrated into existing ASP applications. Because the ActiveX Connector uses ActiveX technology, Microsoft's ActiveX controls and Internet Information Services (IIS) were also needed.

Data Development

Before any type of map development could begin for this project, initial data preparation needed to occur. In order to extract only the necessary parcel data, ESRI's *Geoprocessing Wizard* was used to clip the parcels shapefile to the City

Limits shapefile extent. Using the *Edit Tools* extension, attributes from the zoning shapefile were transferred to the parcels shapefile (Tchoukanski, 2002). Numerous unnecessary fields in the parcels shapefile database file were deleted using table editing tools. The final step in data preparation included creating an image catalog of the aerial photographs for Winona County. This was accomplished by using the *Create a Catalog of Images* extension written by Augusto Meriggi (Meriggi, 2001).

Map Development

The content of the internet map that would be seen by a user was developed using the ArcIMS application Author. Similar to other GIS software such as ArcView, data were added as layers to the map frame (Figure 2). The data layers added to the map frame were the parcels, roads, city limits and rivers and lakes shapefiles. The image catalog was added to the map by manually editing the map configuration file in a text editor.

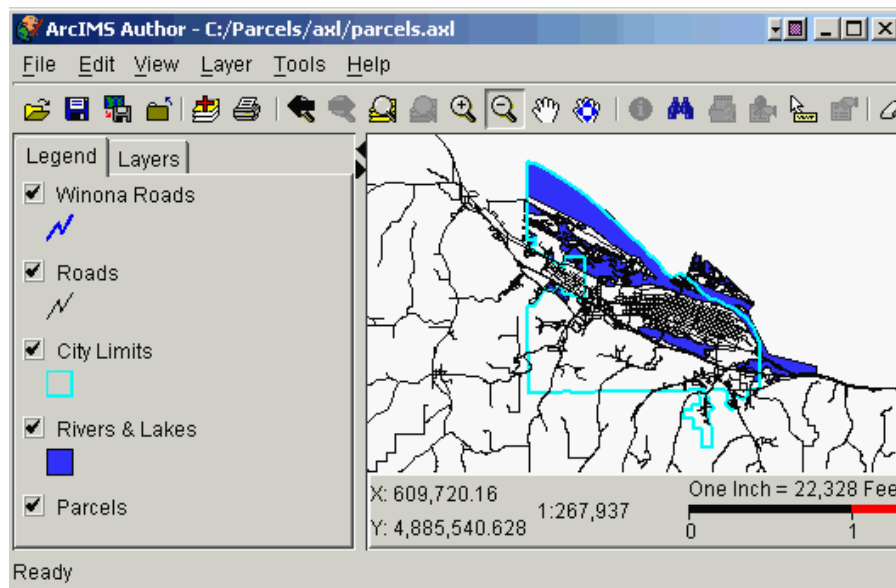


Figure 2. Map Configuration File Development in Author.

In order to build a user friendly interface, scale factoring and scale dependent rendering were used for each of the data layers. Scale factoring is setting a scale range in which a layer will display. Scale dependent rendering is a method used to change map feature symbology with a certain scale range. Before scale factoring and scale dependent rendering could be set, map units were set to meters and scale units were set to miles. Map units defined what the units the data were stored in and scale units defined how the units appeared on the scale bar. The initial extent of the map was set to only show the rivers and lakes and roads shapefiles. Between a scale of 1:23,000 and 1:9,000 the parcels layer was set to be visible and have a solid yellow fill. At a scale less than 1:9,000 the parcels shapefile was set to have a white outline and transparent fill while the roads became blue and increased in size. Finally, at a scale less than 1:5,000 the roads were set to be labeled by name, the rivers and lakes shapefile would not be visible and the image catalog would become visible.

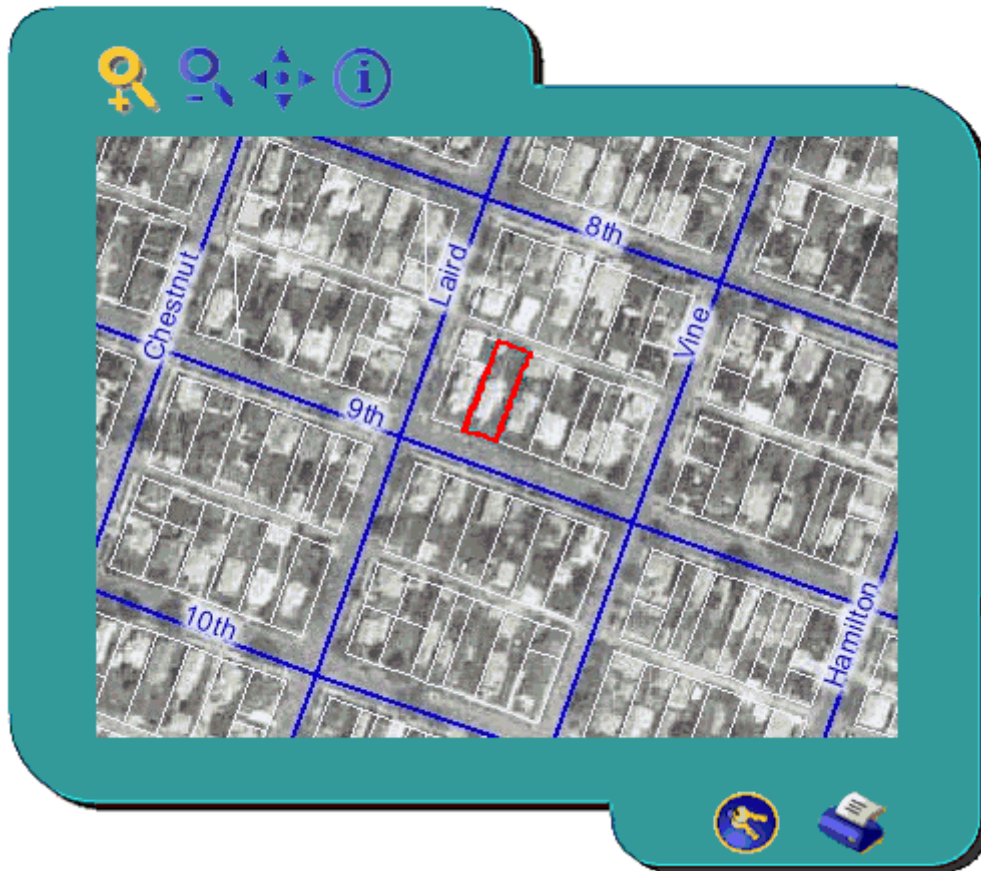
Following the creation of the map configuration file in Author, an image map service for the website was created using Administrator. In order to test the rendering of features and the image catalog visibility of the map configuration file and map service, a test website was set up using Designer. After confirming the correct presentation of the features in the website, adding user interaction capabilities to the website could occur.

Viewer Application Development

The next stage of the project involved creating an intranet viewer application that would allow a user to obtain parcel information by clicking a feature on a map. When a parcel is clicked on a map, Parcel Identification Number, Address, Owner Name, Legal Description, Zoning Code and Zoning Description would be returned. In order for this to function correctly, several edits were needed in the parcels shapefile. Using ArcView, the property, owner and legal tables were joined to the parcels shapefile attribute table using Parcel Identification Number (PIN) as a join field. Three new fields were created in the parcel database table: address, owner and legal. These new fields were populated using the field calculator and data for these fields were obtained through the three joined tables. After the new fields were populated, the address, owner and legal table joins were removed.

Subsequently, modifications needed to be made in order for the Viewer application to function correctly. The viewer application ASP files were unzipped and extracted to a new folder (viewer). Within the extracted files, the application configuration file needed to be tailored in order for the image map service and the data to interact correctly in a web browser. Edits made included pointing to the correct map service, identifying which layer was the identify layer (parcels) and specifying which fields would be returned to a user. Using Microsoft's Internet Information Services Manager (IIS), a virtual directory (viewer) was created hosting the viewer data folder containing all of the viewer files. The viewer application can be seen in figure 3.

Parcel Viewer Application



Identify Results

1 Feature Found

Feature 1	
PIN	321050130
Owner	COLLINS, CHARLES R
Address	456 KING E.
Zoning Code	R-2
Zoning Description	residence - 1 to 4 family dwellings, community development projects, fraternities.etc.

Figure 3. Viewer Application and Identification Results

Search Application Development

The next phase of this project involved creating an intranet based application that would allow a user to search for a parcel based on Parcel Identification Number, owner name or address. Because three different types of searches would be allowed, the Site Starters search application files were unzipped and extracted to three different folders (pin, owner and address).

Using Microsoft Access, the property and owner tables were imported

into a database using the get external data function. Using the make new table function query, a table was created containing attributes for PIN, Owner Name, Legal Description and Address. After creating a database, a System Data Source Name (DSN) was created for the database using Microsoft's Open Database Connectivity Administrator (ODBC). By creating an ODBC connection, the correct interaction between the parcels shapefile and the associated table within the database could occur.

Next, each of the application configuration files for each type of search was modified in order to facilitate the interaction between the database and the parcels shapefile. There were many constants within each application configuration file that needed to be edited. These constants were broken down into three categories: general constants, table constants and map constants.

The general constants specified the name of the map service used, the database connect string (referring to the system DSN set up in ODBC) and general map display features. The same image map service used in the viewer application was used for all three types of search applications.

The table constants were set up to define the search criteria for the search table stored in the Microsoft Access database. These constants defined the table to be searched (depending on search type), the unique identification field, the feature identification field and the fields that

would be returned after the search was complete. As a design requirement to the search application, the search table needed to have a primary key. The primary key field for each of the search tables was PIN and this was referenced as the unique identification field. As a second design requirement, the search layer (shapefile) table needed to have a foreign key (feature identification field) that would relate to the unique identification field. This field was also set to PIN.

The map constants were set up to relate the search table to the search layer in order to select the correct features on the map. The first constant specified that the parcels shapefile as the search layer. Similar to the table constants, the map constants needed a unique identification field and a feature identification field. PIN was again used for both of these fields. Finally, using Microsoft's Internet Information Manager (IIS), three virtual directories were created pointing to the three different search application folders. The search dialog, report results and map results can be seen in figures 4, 5, 6 and 7 respectively.

Using Dreamweaver website development software, a homepage containing the viewer and search applications was created. The intent of the homepage was to create an application that would host the interactive mapping pages in a formal presentation. The homepage was also designed to create an easy to use interface and help dialog for those not familiar with GIS.

Search

Owner: [Search](#)

Figure 4. Initial Search Dialog

Owner	Address	PIN	
ROBERTSON, BRIAN W & JEANETTE S	479 OLMSTEAD	320009890	Map Report
ROBERTSON, CHARLES W & AMY B (O)	566 BROADWAY E.	322001900	Map Report
ROBERTSON, KATHLEEN A	1411 MCNALLY DR.	323320060	Map Report

Figure 5. List of Matching Results

Report	
Owner	ROBERTSON, BRIAN W & JEANETTE S
Address	479 OLMSTEAD
PIN	320009890
Zoning Code	R-2
Zoning Description	residence - 1 to 4 family dwellings, community development projects, fraternities.etc.

Figure 6. Report for first matching Record

Analysis

Search Application Development

During initial testing of the search application, problems were encountered which caused the application not to work. Each time the application failed to start, an error message stating

problems with Object Linking and Embedding (OLE DB) and ODBC connections was generated. After reviewing the specific content of the error message, steps were taken to determine possible sources of error in the application configuration file and in the datasets.

Parcel Owner Search

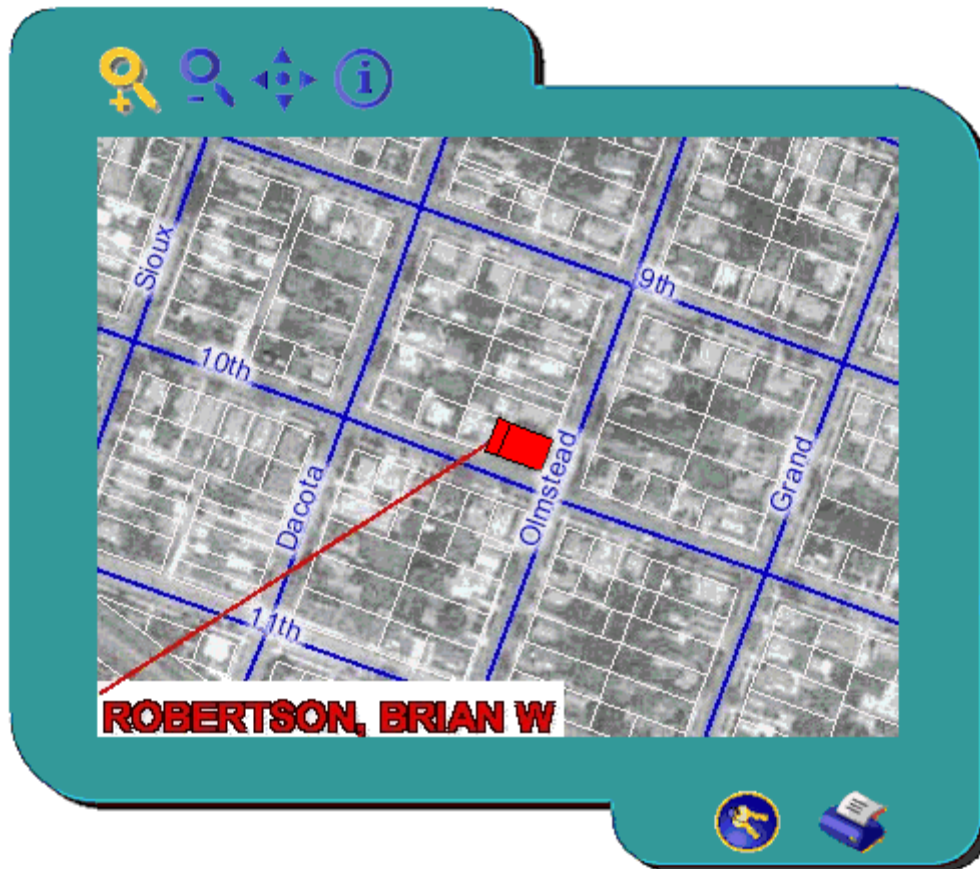


Figure 7. Map with matching parcel for first record.

The first consideration for possible sources of error were mistakes in the constants section in the application configuration file. After carefully reviewing the constants and spelling, the application was run but failed again.

After reviewing the constants as a source of error, the application configuration file was closely examined in response to an error message generated pointing to a specific section of code in the configuration file. When the search application is called to start, the application does a series of tests in order to determine if all settings are

correct. The application 1) Test for necessary components, 2) Test the table constants, 3) Test the map constants and 4) Reads all constants into application variables (ESRI, 2002). The error message generated pointed to the section of code that tested the table constants. When this test occurs, a bogus query is run to test the ability to get a record set. For this application, the query was failing generating a runtime error because of two possible problems. Either the table did not exist or there were locking issues.

Locking issues were thought to be a problem because during the building and designing of the website and the creation of the database, administrative privileges were not given. The authoring of the website and creation of the database occurred using a normal network profile while the ODBC connection and the IIS set up occurred when an administrator was logged on to a computer. The entire rebuilding of the website including all phases of development then occurred under an administrative profile. Following the recreation of the website, the application still failed. This eliminated the possibility of locking issues which then caused the focus to change to examining errors in the datasets.

Focusing on possible errors in the datasets, the bogus query in the application configuration file was more closely scrutinized. Careful examination revealed a Structured Query Language (SQL) query being run to see if a record in the property database had a matching record or records in the parcels shapefile. The next logical step was to determine whether a one to one or a one to many relationship was occurring between the records in the Access database and the parcels shapefile. In order to test this, the tables in the Access database were exported and then imported into ArcView. Using tools from the table menu, the parcels database table was linked to the property table. The same link was also set up for the owner table. To test for the correct relationship between tables, all of the records were selected in the property table. When this occurred, 221 of the records in the parcels database were not selected. These records not being selected accounted for the problems that occurred when trying to run the

application. In order to correct the problem, the records that were not selected in the parcel database file were deleted. After these records were deleted, a true one to one or one to many relationship would occur between the tables in Access and the parcels shapefile. This appeared to be the solution to allow the application to function correctly. Later in the study, changes in datasets would reveal that this would not be the ultimate solution.

Website Enhancement

Several improvements were made to the website in order to increase processing speed when viewed in a browser. The first enhancement made was choosing to use scale factoring and scale dependent rendering. This was a very logical step in that if a user zoomed in to a large scale, small scale layers would not be drawn. This was most evident with using the image catalog of the DOQQ's. Each of the DOQQ's was approximately 42 megabytes (MB) in size. For the application and spatial servers, this would be an enormous amount of data to interpret and draw. Because of this, the image catalog was set to only be visible at a very large scale. Other changes made to the datasets included deleting unnecessary fields and shortening field names within attribute and data tables.

Analysis of Data Manipulation

Several edits were needed in the datasets in order to make the website function correctly. One of the biggest things deliberated over in the project was deleting the 221 records in the parcels shapefile without matching records in the Access tables. This became a cause for concern because one could view this

decision as poor data maintenance. One idea suggested that the Access tables be populated with matching PIN records even if there was not any data to populate with. While a valid idea, this would complicate updating records within the Access tables in the future.

Because of limitations with the viewer application, data from the owner, legal and property tables were joined with the parcels shapefile instead of remaining separate in an Access database. Attempts were made in having the tables remain separate in an Access database using an ODBC connection. Due to time constraints and programmer limitations, allowing the tables to remain separate was not feasible.

Data Maintenance

While problems were encountered with data, software and programmer limitations, data maintenance should not prove to be a problem. If changes are made to records within the Access tables, the viewer application shapefile should be simple to update. In order to update the address, legal and owner name fields, the property table in Access would have to be joined to the shapefile and values would simply be updated by using ArcView's field calculator. For the search application, if updates were to occur, a table update query was created in order to simplify attribute updates. When updates occur, the city data manager will run a pre-existing update query in Access that will pull attributes from each of the separate tables into the main property table.

If changes were to occur to the map configuration file in Author, problems might arise. As stated earlier in this paper, software limitations would

only allow for the image catalog to be added to the map configuration file manually in a text editor. This creates a problem if there is an attempt to reopen the map configuration file in Author. Author has the ability to delete any code that it deems not fit. This project found that reopening the map configuration file in Author for changes would cause the deletion of all code created using tools in Author. Even though this code was deleted, correct rendering and map interaction still occurred in the web browser. This was still a problem because no changes to the map configuration file could then be made. In order to facilitate this problem, two solutions were found. The first solution would be to remove the lines of code for the image catalog using a text editor. Following this, the map configuration file could then be opened in Author successfully. The second alternative was to create a copy of the map configuration not containing the code for the image catalog.

Further Analysis and Manipulation

Following initial website development, city officials requested to use the original parcels shapefile containing features and attributes extending beyond the city boundary. This further complicated the development process because there are many parcels outside of the city boundary without matching records in the property tables. After reviewing the data numerous times, it was found that there were parcels without matching property records and property records without matching parcels. This problem was further complicated after carefully reviewing the legal records. This project found that there were records in the property table

with multiple legal descriptions for multiple parcels with the same PIN. Within the property table and parcel attribute, there were no unique identifiers to delineate multiple legal descriptions relating to multiple parcels with the same PIN. Because of this, it was determined that it was not plausible to include legal descriptions within the website.

As stated earlier, the application failed to work because a one to one or a one to many relationship was not occurring. This solution became negated after re-adding the parcels shapefile to the application with parcel features extending beyond the city boundary. While the application works, without this true relationship there are still errors generated when executing a search or when the application cannot find a feature. Features beyond the city boundary cannot be found through a search because they do not have matching records in the Access Database. On the contrary, there are property attributes within the Access database without matching parcels within the parcels shapefile. When a search occurs for one of these properties, the search generates errors when trying to link to the map display. This suggests that there were unexplained occurrences within the development of this website. Possible explanations could be that the software does not function correctly all the time or there were problems with the specific computer on which this application was built. Whatever the case may be, this project found that there are errors with the City data that need to be addressed.

Security

During the course of this project, many individuals expressed concerns over security issues associated with the publishing of city data over the Internet. This is a very valid concern because the Internet has become a very popular target to attack (Oppliger, 1998). Because this application was developed for intranet use, security issues and concerns are the responsibility of those in charge of creating and maintaining the city network.

ArcIMS uses Arc Extensible Markup Language (ArcXML), thus ArcXML does not allow for requests that can cause data corruption or illegal data access (ESRI, 2001b). By using ASP and IIS in this project, the administrator has the ability to determine which users to restrict from accessing scripts or directories. If the city decided to make this application available to the public through the Internet, additional measures may need to be taken to tighten the security of this application.

Results

Over the course of this project, many problems with data, software and programmer limitations were encountered. Even though these problems were encountered, the initial delivery of the city's intranet GIS infrastructure proved to be successful. In terms of product development, this project found that using the intranet as a forum for GIS to be very effective and efficient by providing GIS functionality without the logistical costs. Only one license of ArcIMS software is required for the city drastically reducing the price of traditional GIS tools.

Discussion

When Winona County makes updates to parcel information, the city receives these updates on paper. These updates can often be delayed because the County will only give the updates to the City by paper. Once the updates are received by the City, further delay may occur because there is only one city employee handling these updates. Current political boundaries and discrepancies cause the City and County data to not be linked electronically. If the City of Winona and Winona County were to make a concerted effort to resolve these issues, the linking of the datasets on servers would allow for a much more efficient way of managing parcel data.

The city of Winona is currently working on updating and bringing utility and other property information into Access databases. If the city could bring all of its property information up to date within its infrastructure, a much more efficient work environment could be created. City employees could have the ability to provide fast and friendly service to the public. Ultimately, if the city decided to put this application on the Internet, the public could access parcel information right from their desks or from their homes. This would intern lower the burden for city employees while making the city of Winona a much more efficient community.

Conclusion

This paper examines the use of internet based mapping software for local government use. This study found that there were both advantages and disadvantages in using internet mapping software. The biggest disadvantage found in this project is that this type of

software is limited in its spatial analysis capabilities. Another disadvantage found that the traditional GIS analyst may have to learn several internet programming languages in order to extend the functionality of the software. The biggest advantage of the software is its potential. This software is still somewhat primitive and future versions will provide more powerful analytical and spatial tools. For this project the software proved to be very successful and allowed for the creation of a user friendly website for city employees. As future generations of this software emerge, more and more internet users will be given the ability to have GIS functionality at their hands through their web browsers. By the beginning of the next century, tens of millions of people around the world will be using GIS (Harder, 1998).

Acknowledgements

First and foremost, I would like to thank Dr. David McConville for his enthusiasm and support in allowing this non-traditional type of project to occur. I would also like to express my gratitude to Mr. Barry Draskowski for his excitement and support in my exploration of this project. I would like to thank John Gabbert, Martha Roldan and Matthew Johnson for their expertise in helping me with web page design. Special thanks go to Tracy Trole for her overall support and help through the course of my study and this project. I would like to thank Jim Bloedorn for his support as an administrator for fixing my computer numerous times. Finally, I would like to thank Jeanne Franz and the City of Winona for their interest and patience through the development of this project.

References

- Anonymous. 1994-2002. Industry Statistics - Worldwide Internet Population. <http://www.commerce.net/research/stats/wwstats.html>.
- Cerf, Vinton G., D.D. Clark, R.E. Kahn, L. Kleinrock, B.M. Leiner, D.C. Lynch, J. Postel, L.G. Roberts and S. Wolff. 2001. A Brief History of the Internet. Internet Society. Reston, VA. <http://www.isoc.org/internet/history/brief.shtml>.
- Environmental Systems Research Institute. 1994. Understanding GIS: The ArcInfo Method. ESRI: Redlands, CA.
- Environmental Systems Research Institute. 2001a. ESRI Virtual Campus. Learning ArcIMS. ESRI: Redlands, CA. <http://campus.esri.com/courses/learnarcims>.
- Environmental Systems Research Institute. 2001b. Security and ArcIMS. An ESRI White Paper. ESRI: Redlands, CA.
- Environmental Systems Research Institute. 2002. ArcIMS Site Starter Applications (version 1.1). ESRI: Redlands, CA.
- Harder, C. 1998: Serving Maps on the Internet. Geographic Information on the World Wide Web. ESRI: Redlands, CA.
- Meriggi, A. 2001. Environmental Systems Research Institute ArcScripts Homepage. ESRI: Redlands, CA. <http://arcscripts.esri.com/details.asp?dbid=11624>.
- Oppliger, R. 1998. Internet and Intranet Security. Artech House: Norwood, MA.
- Tchoukanski, I. 2002. Environmental Systems Research Institute ArcScripts Homepage. ESRI: Redlands, CA. <http://arcscripts.esri.com/details.asp?dbid=11648>.
- U.S. Census Bureau. 2000. DP-1. Profile of General Demographic Characteristics: 2000. <http://factfinder.census.gov>.