Assimilating GIS-Based Voter Districting Processes in Maricopa County, Arizona

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Abstract

Accurate district coding is essential to the proper functioning of the election process. This presents an ever-present challenge to Maricopa County, Arizona, with more than 1.5 million registered voters and an extremely fluid and growing population. GIS-based technologies provide an effective solution. This paper will present a project undertaken by the Maricopa County Recorder/Elections Department to assimilate GIS data and methods into the Department's Voter Registration System to automatically place voters in their proper precincts and districts. The project combines address locations and spatial data maintained by ESRI software with the enterprise system and voter data to derive the proper district codes. The software and technology employed include ESRI ArcGIS and ArcSDE, Microsoft SQL Server and VB. NET, and Open Geospatial Consortium (OGC) compliant methods and spatial data types. The project demonstrates a successful assimilation of GIS technology into an existing system architecture and development environment.

Background

With more than 3.5 million residents, Maricopa County, Arizona is the 4th most populous U.S. County and is the 14th largest in area. Three out of the top ten fastest growing cities & towns in the nation are located here: Gilbert (#1), Chandler (#4), and Peoria (#9). Phoenix, the state's capitol, is located in Maricopa County, along with Mesa, Glendale, Scottsdale, and 19 other cities and towns. The Maricopa County Recorder/Elections Department administers elections for almost 1.7 million registered voters in the County.

Problem Statement

The Department must accurately determine the voting precinct, districts, and jurisdictions for each and every voter. This information defines where to vote, who and what is on the ballot, what schools their children attend, and who represents them. Correctly assigning voters to districts is therefore an essential, critical function of the electoral process. The function must be performed when a voter first registers or moves, as precincts or districts change, and as jurisdictions annex or de-annex. The process is therefore very fluid given the rapid change and growth of Maricopa County.

This function presents a classic spatial problem: given a voter's address, locate it, and discover the precincts and districts it is within. This ability to identify a point's surroundings has been a familiar part of GIS software since its inception. However, assimilating this technology into an enterprise system capable of handling the volume and accuracy required of a Voter Registration System becomes a significant challenge. The purpose of this paper is to describe Maricopa County's approach to leveraging GIS technology within the Voter Registration System as an effective means of determining a voter's precincts and districts.

Traditional Approaches to the Problem

Coding voters into the proper precincts and districts must be accomplished with or without the aid of GIS technology within every county or township within the United States – the problem is not unique to Maricopa County by any means. Some counties may be small enough to handle the process manually. As voters register or changes occur, registration specialists can manually code them into the proper areas. Another common approach is to attach precinct and district codes to street address range records in a table that can be easily queried in a database. For example, a record may exist that places "100 to 199 N Central Ave" into precinct "0001", school district "Maple", city "Anytown", etc. by having those values in fields on the same street record or directly related to it.

The traditional way of handling this within Maricopa County was to store street address ranges and address alignments in one table and boundaries with north, south, east, and west address alignments in another table. Figures 1 and 2 show examples of the streets and boundary tables, respectively.

STDIR	STNAME	STSFX	STTYPE	ALIGN	ADDRFROM	ADDRTO
N	100TH		AVE	10000	4600	4799
N	100TH		AVE	10000	13400	13499
N	100TH		AVE	10000	13000	13099
N	100TH		AVE	10000	13200	13299
N	100TH		AVE	10000	4100	4299
N	100TH		AVE	10160	19820	19839
N	100TH		AVE	10000	4400	4499
N	100TH		DR	10050	4500	4699
N	100TH		DR	10170	19820	19845

Figure 1: the Streets Table

BDVAL	BDTYPE	NALIGN	EALIGN	SALIGN	WALIGN
F05	F	23400	13300	22925	13900
AV	C	6000	13900	7600	14100
AV	C	2300	13100	3600	13900
AV	C	3500	13700	2900	13777
AV	C	3600	13500	5200	13900
AV	C	9200	13100	18800	13900
AV	C	3200	10700	3300	10900
AV	C	1600	9900	300	10700

Figure 2: the Boundary Table

Additional fields in each table define the parity, alignment axis, and address numbering system used. A database query could then be run using an address's house number and street alignment as "X" and "Y" values to find the boundary "boxes" it was within. To maintain the tables, Department staff would draw the boundary "boxes" on graph paper and compare these sketches with various printed reports of the streets table to add or update areas.

Any of these approaches bring the potential for significant problems and potential catastrophe in the electoral process. Additionally, simple maintenance of the tables is difficult and time consuming. GIS technology can be utilized to either automate the existing task or supersede it with one that replaces address abstracting and modeling with "What You See is What You Get" streets and boundaries. The Department has dabbled in both approaches in its second and fourth generations of GIS applications.

GIS in the Elections Department

The Maricopa County Recorder/Elections Department began formally considering GIS technology as early as 1994. From the beginning, GIS was seen as a logical solution for managing several election tasks such as district mapping, reprecincting, redistricting, and election planning and execution. The primary goal, however, was to integrate the technology into the Voter Registration and Administration System, the enterprise system that manages the voter file and elections. In this way, GIS would serve as an engine for determining a voter's precincts and districts based on their address. A survey of the technology and data available at the time, as well as the cost to implement such an engine, revealed that the project was quite ambitious but could theoretically be accomplished. By far, the biggest obstacle was the need to have reliable and accurate geocoding results for the vast number of addresses in the voter file. After that, adhering to Department IT standards and architecture posed the greatest challenge.

The decision was made that GIS in the department would be phased in over several years. This development can be divided into four distinct generations. The first generation was to create maps and build related datasets to handle the mapping needs of the department. In the second generation, specialized procedures and applications were developed to handle maintaining the street and boundary address tables, election planning, redistricting, and other projects. This generation saw the "ArcVRAS" application – an ArcView 3.x application that modeled and maintained the system tables (see Figure 3).

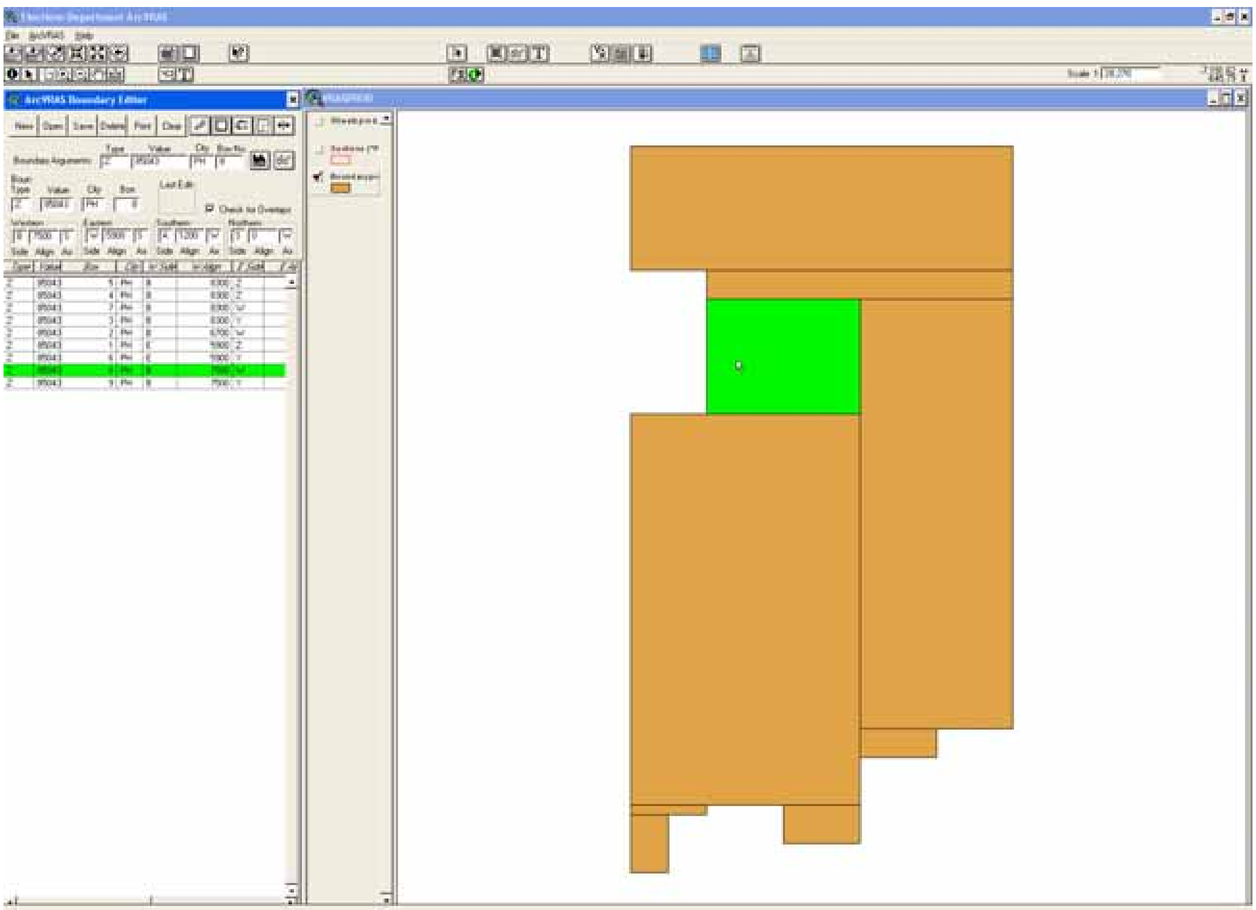

Figure 3: the ArcVRAS street and boundary application

This application eliminated hand drawn district graphs, saved hundreds of man hours in maintenance and troubleshooting, and proved that GIS could smoothly mesh with the existing Department applications. Third, the Department deployed internet and intranet applications with ArcIMS to allow district viewing, election analysis, and several specialized applications. Finally, voter address geocoding would be tackled, and the results would be integrated into the department's systems and processes. This would also enable the use of GIS-based district coding.

The Elections Department System Design

The Recorder / Elections Department has standardized its Voter Registration System on the Microsoft SQL Server database with applications designed in 100% managed Microsoft .NET. Although a few legacy applications written in VB6 exist, these will soon be migrated to .NET. Therefore, it was decided that new applications must adhere to managed .NET.

Numerous commercially available COM and Java controls exist to perform GIS tasks, many relational databases support spatial data types natively or through extensions or middleware, and a few managed .NET components are beginning to appear on the market. Additionally, the GIS industry has made significant progress in web based technologies for distributing spatial services. Unfortunately, none of the readily available solutions fit into the Department's design strategy. Each of them require unacceptable changes or additions to the system design and development environment, additional layers of system resources and infrastructure, or increased management and maintenance considerations. The few available .NET components, in particular, still rely on COM interop or can only operate on shapefiles. Due to the extremely rapid rate of change to the underlying data, a shapefile based solution will falter on multi-user editing.

In order to meet the design requirements without adding extra complexity, the Department decided to utilize distributed computing: ArcGIS, ArcSDE, and SQL Server would be used within the GIS section and to power the ArcIMS internet maps, but Open Geospatial Consortium (OGC) Well-Known Text (WKT) spatial data in the enterprise SQL Server database and an open source C# component would be used to power the Department's district coding application. An interface was built to leverage the advanced editing and display of the ArcGIS system with the simple, flexible, and scalable design of the OGC WKT standards.

Under the spatially-enabled database design, a "Geometry" column was added to the "Streets" and "Boundaries" tables that stores each feature as a properly represented text string in WKT. Four fields are added to define the extent of each feature as numeric values that can be queried with x and y coordinates in SQL. The spatially enabled Streets and Boundaries tables are shown in figures four and five, respectively.

OBJECTID	GEOMETRY	LENGTH	ADD1_L	ADD1_R	ADD2_L	ADD2_R	STDIR	STNAME	STTYPE	STSUFX	ZIP_LE
0	MULTILINESTRING ((577823.0805592502 891580.43...	285.563	11994	11995	11976	11975	W	POLK	ST		85323
34	MULTILINESTRING ((630643.21255925 1109354.325...	1602.887	56906	56907	58698	58699	N	BLACK CANYON	HWY		85087
35	MULTILINESTRING ((629804.0095592502 1106033.2...	5043.801	59200	59201	59698	59699	N	BLACK CANYON	FWY		85087
36	MULTILINESTRING ((629804.0095592502 1106033.2...	3774.754	59200	59201	59698	59699	N	BLACK CANYON	RAMP		85087
38	MULTILINESTRING ((629823.15255924989 1098084....	8102.669	56000	56001	58698	58699	N	BLACK CANYON	HWY		85087
41	MULTILINESTRING ((430298.85355925024 1101196....	6794.437	1846	1845	3898	3897	N	TEGNER	ST		85390
46	MULTILINESTRING ((633210.53255925025 1096409....	13655.506	56906	56907	61100	61099	N	BLACK CANYON	HWY		85087

Figure 4: the spatially enabled Streets table

OBJECTID	GEOMETRY	A	P	BDTYPE	BDVAL	ST...	ROWDATE	MinimumX	MinimumY	MaximumX	MaximumY
1	POLYGON ((639115.125 951605.5625, 639095.2110...	.	.	P	0001	0	2005-05-09 11:30:00	633900	949838	639115	952349
2	POLYGON ((612839.888326708 952749.055218149, ...	.	.	P	0002	0	2005-05-09 11:30:00	606254	949709	612994	955120
3	POLYGON ((625878.867 901089.765, 625874.41408...	.	.	P	0003	0	2005-05-09 11:30:00	623037	898891	625878	901591
4	POLYGON ((638937.5221084794 986977.8289567001...	.	.	P	0004	0	2005-05-09 11:30:00	631098	976208	640410	987214
5	POLYGON ((591580.56097738491 958397.811689294...	.	.	P	0005	0	2005-05-09 11:30:00	579756	956159	591580	960163
6	POLYGON ((360314.625 1093215.125, 360213.8125...	.	.	P	0006	0	2005-05-09 11:30:00	268725	961172	423145	1094229
7	POLYGON ((680532.34839023172 854511.504296959...	.	.	P	0007	0	2005-05-09 11:30:00	676371	847892	680539	854511

Figure 5: the spatially enabled boundaries table

An additional polyline table was created to store street exceptions and alternate names. Point tables with "X" and "Y" fields were created to store "found" addresses for faster joining, address exceptions, and the centroid of the Assessor's parcel feature layer. Another point layer was created to store edits and corrections to the Assessor data, and yet another table was created to store address exceptions and special cases.

These tables are used in a geocoding function to find an address location according to a predefined hierarchy. The hierarchy arranges the address sources in order of preference to ensure the best match possible is used. If the match source is a line table, the function will locate the point along the line appropriately and offset it based on the even or odd side of the road it's on. This part of the function closely mimics the "geocoding" and composite locator styles in ArcGIS.

Once a point is found, its location is used to query the possible surrounding boundaries based on their extent. This recordset is then tested with a point in polygon function to determine the collection of boundaries it is actually within. Figure six shows an example of an address and the resulting districts.

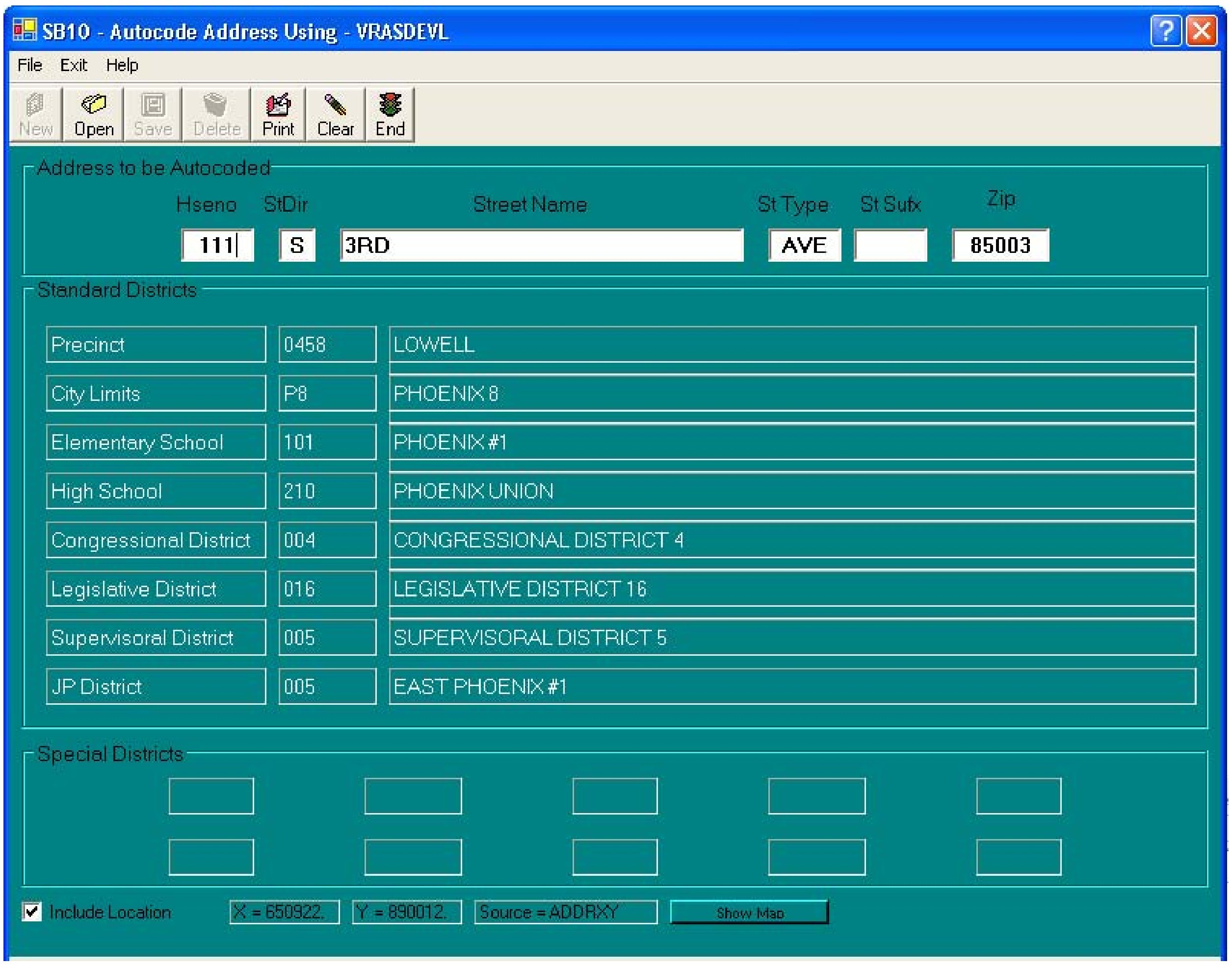

Figure 6: example address input and output

Great care was taken to ensure that the new process was called and returned its results in exactly the same manner as the existing process. Some optional parameters were built into the new district coding such as including the location in the returned values. This could then be used to store into the "found" table or to map the voter's location. The design of the enterprise part of the application was therefore able to meet the requirements and could be freely distributed onto as many client desktops as needed.

The final piece of the puzzle was leveraging the strengths of ArcGIS and ArcSDE to maintain the system. To accomplish this, a custom process was developed in ArcMap that discovered features added, updated, or deleted on reconciling a versioned edit session. These changes are then applied to the enterprise database to ensure the data used is live. This allows the department to use the advanced multi-user editing and data integrity tools in ArcGIS as a means to maintain the data. It also allows greater flexibility in leveraging versioning to handle election setup tasks. For example, a new district or precinct alternative can be developed as a separate version in the ArcSDE geodatabase. Many versions may exist, but when one is selected it can be reconciled and posted into the GIS and enterprise databases simultaneously. A batch process handles bulk updates of voters to ensure the district assignments change when districts do.

Conclusion

More than ten years ago, the Maricopa County Recorder / Elections Department identified a need for embedding GIS technology into its Voter Registration System. By faithfully adhering to standards and careful system design, the Department will be able to improve the services it provides to voters and provide the most accurate district assignments possible.

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