

Tracking Capital Improvement Projects with ArcIMS and ArcSDE

Capital Improvement Projects (CIP) require sizable investments of time and money from municipal governments. The lifespan of projects may cover several years and costs may exceed several millions of dollars. Other important aspects of a project are the extent and location. Location relative to other projects and surrounding infrastructure elements may determine when and where to proceed. The City of Olathe, Kansas has developed a web-based intranet application for creating and tracking CIP budget and spatial information. This ArcIMS application runs in a web browser and allows the user to digitize new project features directly into ArcSDE feature classes.

Introduction

The City of Olathe Geographic Information Systems (GIS) team has developed a new Capital Improvement Project (CIP) Inventory application. This application features a robust set of tools, many of which are standard offerings among GIS web-based and desktop applications. Custom tools allow users to create and edit feature and attribute data, while form documents load project and budget information into a central database. Powered by internet mapping server software from Environmental Systems Research Institute (ESRI), this web-based application is somewhat unique in its ability to edit feature data in a standard web browser.

Background

Prior to the development of the web-based CIP Inventory Application, the Public Works department used a customized ArcView GIS 3.2 project based on ESRI's CIP template. This project provided a set of custom drawing tools for creating and editing CIP project features, as well as tools for creating CIP budget reports. The budget reports were generated by Crystal Reports using Microsoft Excel spreadsheets, Microsoft Word documents, and map images created by ArcView.

The original CIP application was meant to reside on the network where it could be accessed by the project managers and the CIP project coordinator--the individual responsible for submitting projects to the city council for budget consideration. Unfortunately, the application was never able to function properly over the network and ended up on a single workstation. Having this application on a single workstation meant that one person was responsible for all parts of the CIP submission process.

In 2001, discussion began about creating a new web-based CIP application that would allow all of the

players in the CIP budgeting process to participate in entering and tracking information about proposed projects. At that time the city was just beginning to explore the possibilities offered by ESRI's internet mapping server software, ArcIMS. Building a web-based application was right in line with the GIS division's gradual move toward what some in the GIS community would refer to as an "Enterprise GIS". This term refers to a more centralized distribution of software and data resources. Along with increased focus on intranet and internet applications, the move to a more centralized structure also emphasizes the need to migrate data from shapefiles to ArcSDE geodatabases.

As part of a push toward reducing the number of licenses in use, the new CIP application would be the first in a series of web-based GIS applications meant to replace desktop applications for certain individuals. The employees that would use the new web-based applications did not need the sophisticated set of tools available in the ArcGIS or ArcView GIS software packages. Rather, they need only a few simple tools to view and query specific data sets. While the new CIP application is anything but simple, it does provide specific tools to help users take advantage of existing GIS data and technology.

Development

The CIP Inventory application is built on the concept of creating and editing features using a standard web browser. Creating new features requires a set of drawing tools. This application uses the ArcIMS HTML viewer and the drawing tools were created using HTML, JavaScript, and ArcXML. The HTML viewer displays map images generated by the ArcIMS application server. The client browser communicates with the server through a servlet connector that translates ArcXML requests into the map images that are displayed on screen. ArcXML uses a tag named LAYER to specify how the feature information should be displayed. One particularly important attribute of the LAYER tag is "type". When a request is sent to the application server, type is usually specified as "featureclass" or "image". A third layer type is "acetate". The acetate layer is used to display the new features as they are drawn, before they are inserted into a feature class and become actual features. The acetate layer is displayed in a separate layer of content within an HTML document. This layer is created using the HTML LAYER tag, as opposed to the similar ArcXML tag. The ArcXML LAYER tag simply points to the HTML layer to display graphics.

Creating and editing features in ArcIMS also requires ArcSDE. The City of Olathe has implemented ArcSDE for SQL Server 2000. This application takes advantage of the ArcSDE Java API (Application Programming Interface) to create and edit features in an ArcSDE feature class. Drawing tools create feature shapes on an HTML layer. The geometry for those features is passed to a Java servlet through a URL string. The servlet consists of Java classes that use commands available through the ArcSDE Java API to create, update, and delete features in one of three feature classes, (multipoint, line, and polygon.)

The application was created with the goal of developing a tool that would be easy to use, but that would feature powerful feature and documentation tools. In an attempt to ease the transition from ArcView GIS 3.2 the graphical user interface (GUI) was designed to resemble ArcView GIS and ArcExplorer in both

form and function. For example, in the new application the toolbar uses many of the same or similar icons that are found in the more familiar applications. The different icons are themselves familiar and easily recognized. Also, the table of contents has been modified to look and function similarly when compared to ESRI's desktop offerings. The active layer is selected by clicking on the layer name, in the table of contents. After doing so, the area around the layer name will appear offset from the rest of the list. In addition, the legend has been redesigned to include symbols in the table of contents, rather than creating a separate legend image.

All of the project and budget information is stored in a SQL Server 2000 database. The database is connected to the application using Active Server Pages (ASP). All of the forms used to collect and display project and budget information are created based on the selected project.

Basic Mapping and GIS Tools

The CIP Inventory Application uses a basic set of mapping and GIS tools common to most web-based and desktop ESRI applications. Some of the tool functions include map navigation, address location, and feature identification or selection.

Map navigation tools allow users to move around the map at different scales. Several of the map layers are scale-dependent, meaning that they are not available above or below a set scale value. More detailed layers are better viewed at smaller scales. A good example might be streets or address points. Pan slides the map in any direction to view the adjacent areas.

Address location, in this case, is based on the city street map layer. This tool can locate an address or intersection, based on input from the user. Addresses are matched and scored based on the similarity between the desired address and the possible matches. If the address is a perfect match it will have a score of 100.

Feature identification and selection tools provide access to feature attributes. The difference between feature identification and selection is that selection tools actually return the feature and will highlight the selected feature for reference. The identification will return a list of feature attributes, but does not capture the feature itself. Feature selection tools can only select features in one layer at a time. However, the buffer tool uses selected features in one layer to create an area used to select features in another layer.

Other tools offered in this application include measuring and printing tools. The measure tool is used to measure distance on the map and uses the current map units. Click once to begin measuring and continue clicking along the measure path. At the top of the map frame a guide displays the total length of the path as well as the length of the current segment. Users can also change the units that are used. The printing tool located on the toolbar is used to create a print page that features the current map image, a legend, and the application logo. This print page is designed to fit on regular letter-size paper.

Creating and Editing Features

Six tools are included on the drawing tools menu, but only five actually create new features. The sixth tool is used to create city-wide projects. This tool creates a new record for the project but no map feature. All of the city-wide projects refer to the city as a whole, rather than pointing to a specific location. Of the five remaining tools on the drawing tools menu, each creates features that fit into one of three feature classes: multipoint, line, and polygon.

The Point tool creates single or multipoint features. Click on the map once for each new point and click the submit button after all points have been added. The Line tool creates single part line features. Click on the map at each vertex, similar to drawing a line feature in other ESRI GIS software products. Each of the other three drawing tools creates single part polygon features. Features drawn with any of the polygon tools create features in the polygon feature class. Of the three polygon drawing tools, the first tool creates polygon shapes with any number of sides. Click on the map at each vertex. Polygons can have as few as three sides, and when the third vertex is drawn the shape will be visible. Each time a new vertex is added the shape will change. When the desired shape is drawn click the submit button to create the feature. The Point, Line, and Polygon tools allow users to delete the last point or vertex drawn, or start over completely, by clicking on the appropriate button. The next polygon drawing tool is the Rectangle tool. Click on the map and hold down the mouse button. Drag in any direction away from the starting point. Release the mouse button to draw the rectangle. The last drawing tool and the third polygon drawing tool is the Circle tool. Click on the map once at the center of the new circle and again at the desired radius length. A text box at the top of the map display indicates the radius distance after the center point is drawn. Move the mouse in any direction from the center and the distance will be displayed as a positive number accurate to two decimal places.

After the new feature is drawn, click the Submit button. A new window will open with the Enter Attribute Information form. The form lists the attributes and provides spaces for the user to enter the corresponding values. Click Continue to accept the attribute information. The information is validated to ensure that the values meet data type and length restrictions. At the same time, the date and time are captured to mark when the feature was created. In the future, user name will also be recorded for accountability.

In addition to drawing tools, feature editing tools are also available. A feature selection tool located below the drawing tool set is used for selecting features to edit. This tool will only select features in the three layers that represent the three ArcSDE feature classes. The three feature types are listed next to the selection tool. Click on the button associated with a specific feature type to make that feature class the active layer. If another layer is active when the user chooses the feature selection tool, the active layer will change to match the selected feature type. When a feature is selected using this tool, the Object ID is attached to the record for that feature in the results table below the map frame. This allows the application to retrieve the geometric properties of the feature for editing. After clicking on the map with the feature selection tool, select a feature from the result table below the map frame. At the beginning of each row in the result table there is a Record Number hyperlink. Click on the hyperlink to select that

feature. If more than one feature was selected with the feature selection tool, selecting a feature from the table will ensure that the correct feature is edited.

Selecting a feature from the result table will open the feature editing menu. The edit menu allows users to edit feature shapes and attributes or delete features. Editing features requires the user to interact with the map. Deleting features removes the elected feature from the feature class by clicking the Delete Feature button.

To access the feature editing tools, click the Edit Feature button. Before editing, select the desired edit mode by clicking the appropriate button. The list of available edit modes will differ according to the feature type. If the selected feature is a point feature, three edit modes are available: Add Points, Delete Points, and Move Points. Add Points allows users to create additional points in a multi-point feature. Click at the location of the new point and then click on the submit button. Delete Points removes points from a multi-point feature, but will not delete the feature. Click on the point to remove. Move Points does just what it suggests. Click once on the point to move and again at the new location. If the selected feature is a line or polygon feature, four edit modes are available: Insert Points, Move Lines, Delete Points, and Move Points. Insert Points is different than Add Points because Insert Points will only add new points along a line segment, (between two existing vertices.) Click on a line segment to insert a new vertex. Move Lines allows the user to move line segments in line and polygon features. Click once on the line segment to be moved and again at the new location of the line segment. Delete Points and Move Points edit modes are used to manipulate the vertices of lines and polygons. These edit modes function the same whether editing vertices or point features.

To edit the attributes of a feature, click on the Edit button to the right of the edit mode lists. The Enter Attribute Information form will open in a new window. This is the same form used to enter attributes when features are initially created. Click Continue to accept the changes. The form will validate the information and inform the user if an error occurs. Otherwise the form will close and the user can continue editing the feature or submit the changes. Changes made to attribute information while editing are only kept after the user clicks the Submit button. When the changes are submitted, an edit date is captured and stored. A feature that has been edited will have both an add date and an edit date. This lets other users know how current the information is.

Project and Budget Information

CIP project and budget information is accessed one of two ways. Users can switch between the map and project information by clicking on the tab buttons in the upper-left corner of the browser window. Click on the Project Info button to view the project and budget information. Another way to access this information is by clicking the Edit CIP Info button below the feature editing tools.

On the left side of the project information screen, drop-down lists allow users to select CIP projects according to the feature type. Selecting a project from the list loads the project information and selects the project feature on the map side. Click on the Project Maps button to switch back to the map and edit

the selected feature.

Project information includes description, justification, and any comments. Other information includes the page number and rank order. The budget information includes inflation tables and inflated budget values calculated from information entered as present-day dollars.

The inflation table information section allows users to create new inflation tables, view and edit existing tables, or remove tables that are no longer used. Tables are created and edited by setting a rate for the table or by editing each year's rate individually. Users enter budget information as present-day dollars and those values are inflated according to the rate table.

When the budget information is entered and submitted, inflation is calculated based on the inflation table associated with the selected project. The present-day dollar values and inflated dollar values are both stored so that the present-day values can be retrieved when editing the budget information. In addition, inflated dollar values can be edited individually by clicking the Edit This Sheet button. These edits are not inflated, but are stored with the inflated values and are included in the budget report. This feature is designed specifically for cases in which the budget values are determined based on factors other than the assigned inflation table.

Reporting

Once a project is selected, users can create project reports from both the mapping and project information areas. At the bottom of the edit tool menu, click on the Create Report button. Doing so will generate a new report document in a separate window. The report document contains CIP project and budget information, as well as a map showing the project feature and surrounding area. Another way to create a report is found by clicking on View CIP Budget Info, in the project information area. Click on Print Report to generate the same report found on the map side.

Users can also view and print a variety of summary reports. These reports can only be accessed by selecting a report type from drop-down lists in the project information area. The Project Summary list consists of project category names. Select a category name to create a report that lists the total budget values for each year by project name. The Project Summary reports also provide the total budget information as expenditure and funding items for all projects, by year. The Summary Reports list consists of four different report types: Grand Total, Fund Summary, Cash Fund, and G.O. Bonds. The Grand Total report lists the totals for each year by project. Projects are grouped by category. Fund Summary consists of funding totals for each year by project category, as well as expenditure and funding totals for all projects, by year. The last two summary reports, Cash Fund and G. O. Bonds, report the totals from a particular funding source for each year by project. The Cash Fund report draws information from the CIP Fund line of the budget information table. G. O. Bonds uses information from the source of the same name. Projects are grouped by category in both reports, but the G. O. Bonds report also groups projects according to whether or not they are ranked.

City-wide Projects

Due to the fact that the city-wide projects are not represented graphically, editing and deleting city-wide project information is handled differently. City-wide projects are added on the map side, but the information is edited in the project information area. When a city-wide project is selected from the drop-down list, the project information screen has two extra buttons—one for editing the project attributes and another for delete the project. Click on Edit Citywide Project Info and the default project information screen is replaced by the Enter Attribute Information form. This is the same form that opens in a separate window when creating and editing map feature attributes. Click Continue to submit changes, or Cancel to return to the project information screen. Click on Delete Citywide Project to remove the project and all of its information.

Future Enhancements

At this time, development is nearing the end of Phase One. Three phases of development are planned. The first phase involves the development of a base application. Much of the administration is still handled as a support issue, rather than giving administrative responsibilities to someone who is directly involved in the CIP budget process. Phase Two is the creation of administration tools. These tools will include an archive capability to package and store information for past years when the process is ready to start again. Other administration tools will allow a supervisor to set up users and change table headers. Phase Three is the development of a public website to access the CIP project information. Conceptually, this would allow citizens to find their house and view the project information for projects near them, or anywhere in the city.

Summary

The CIP Inventory application leverages existing GIS technology to provide the tools needed for tracking and budgeting capital improvement project information. From feature creation and editing to reporting, this application provides a set of tools that rival any desktop application. By taking advantage of existing technology, the City of Olathe has been able to create a new application that is accessible and accurate. It is accessible because it is available to intranet users through a standard web browser—a piece of software that very few computers are lack. It is accurate because all of the data, spatial data included, is stored in central location. No matter where the application is accessed, it is always hitting the same information. Accessibility and accuracy are what GIS is all about.

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