DENVER MAPS:
DENVER'S ARCHITECTURE FOR DELIVERING ACCESSIBLE INTERNET GIS SERVICES

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Abstract

The City and County of Denver provides many location-based services to its residents, businesses, and visitors. Making this information available online and accessible to a broad audience increases the level and quality of services provided to the public. To meet the diverse present and future needs of Denver's many city agencies and departments, an extensible integrated mapping and reporting architecture was created using ASP and ArcIMS. Denver Maps integrates information from multiple sources including other applications, databases, and document collections in an interactive report format. Reports are configured using XML utilizing spatial operations, attribute queries, and a variety of output elements (maps, tables, text, images, links, etc.) without writing code. The object-oriented architecture promotes maintainability and supports accessibility goals including Section 508 guidelines and assistive technologies (screen readers, text browsers, etc.). The architecture and the lessons learned in creating this internet GIS solution will be addressed.

1   Introduction

The DenverGIS is a centralized GIS department supporting over 30 departments and managing 500+ data layers and associated information resources within the City and County of Denver. As a municipality, the City and County of Denver is responsible for providing many geography-related services to its residents, businesses and visitors. In 2004, DenverGIS set out to create an internet GIS site to provide geography-related services to its constituents. DenverGIS spoke to a variety of city agencies and the public to identify their information needs. Next, DenverGIS performed extensive research on existing ArcIMS sites created by other cities and municipalities. How the sites worked, how they provided information and what was liked and disliked about them was analyzed and recorded. Finally DenverGIS spent numerous months planning, analyzing and gathering requirements for the Denver Maps internet site.

Denver Maps is an integrated mapping and reporting web site that provides Denver citizens, businesses and visitors with convenient access to City and County of Denver location-based information. It is designed to allow its users to find public information quickly and easily without having to come down to the city and county offices. Denver Maps provides data from many different agencies ranging from the Mayors Office of Economic Development to Public Works. The data is collected from various databases, citizen records, old hard-copy maps, and new and existing data collection projects. Denver Maps is designed to provide a one stop location where people can access city and county location-based information, download maps and create custom maps.

2   Accessibility

A major goal of Denver Maps is to ensure that Denver Maps remains accessible to all users, including those with disabilities. Denver Maps voluntarily strives for compliance with Federal government Section 508 (1) standards and Double-A (AA) conformance (2) with the W3C Web Content Accessibility Guidelines 1.0 (3).

Providing map-based information in an accessible manner presents many accessibility challenges. Denver Maps allows all searches to be performed without requiring map interpretation or interaction. Search results that are displayed on the map are provided in textual sections below the map. Links are provided to all sections of textual content and the sections of each report are organized into a heading hierarchy to enable quick navigation with a screen reader or other outline capable browser.

The Denver Maps reporting system imposes constraints on all content to enforce accessibility goals. Not all goals can be enforced by the reporting system and additional testing is performed to ensure that these goals are met. This includes both automated testing and user checks on all content.

Automated testing is conducted using Bobby Watchfire (4) for compliance to WCAG AA 1.0 guidelines. User checks are verified by manually reviewing application pages and map content. Content is also tested by using assistive technologies (screen readers, text resizing) and maps are tested for color-blindness problems. Additional tools used for testing Denver Maps accessibility include: W3C Markup Validator (5), W3C CSS Validator (6), Vischeck (7), JAWS (8) and Opera Web Browser (9).

3   Architecture

Denver Maps architecture is designed with a multi-tiered architecture, separating the GUIs, database, and business level objects (Figure 1). Denver Maps GIS data is stored in an Oracle database running ArcSDE. Denver Maps is also able to serve non-Spatial data from SQL Server databases or any other format that can be read through ADO (ActiveX Data Objects). Denver Maps utilizes html templates for its GUI, Active Server Pages with VBScript business objects and XML report configuration files. This makes Denver Maps easy to maintain and allows DenverGIS to quickly add new reports for agency who wish to share their data with the public.
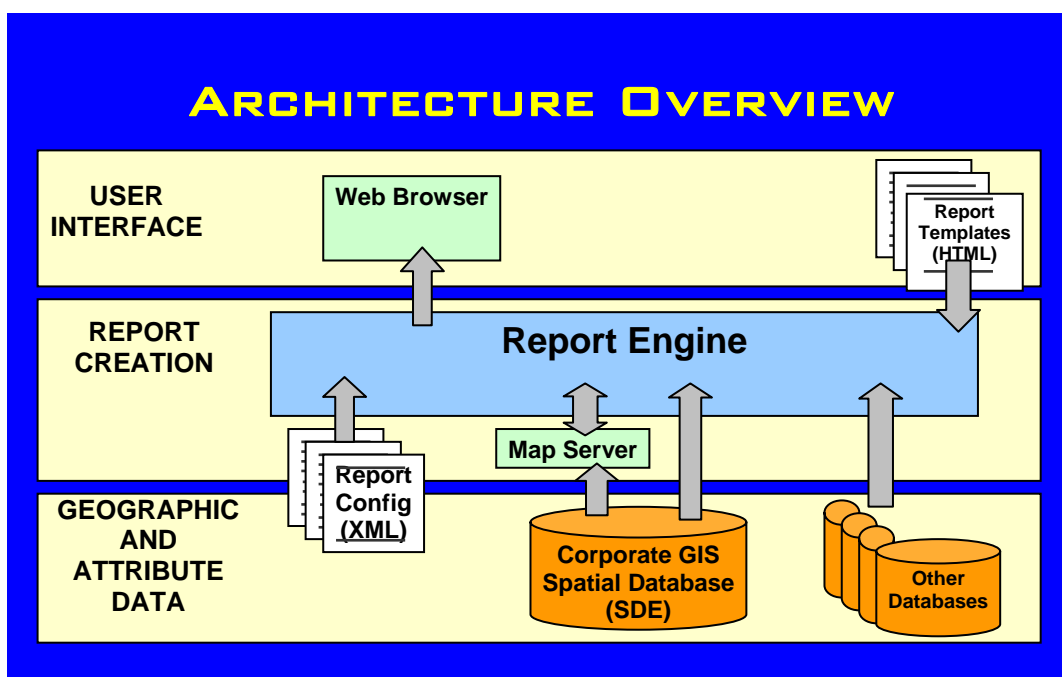

Figure 1: Denver Maps is designed with multi-tiered architecture.

DenverGIS' HTML Template model uses a HTML template engine to turn simple HTML template objects into usable pieces of a report. One benefit of the template system is that the look and feel can be controlled by simply updating the look and feel of the HTML templates. Template objects include items like a table template, a map template a searchoptions template, and other objects included in reports.

Denver Maps Business Objects are written using Active Server Pages (ASP) with VBScript. The business objects are designed to be independent objects. This allows individual objects to be enhanced or new objects to be created without disrupting other objects. The business objects are used for actions such as creating an ArcIMS recordset, performing spatial queries, and translating XML configuration files to build reports dynamically. Business objects are also utilized to read and display the HTML report templates such as table elements, map elements, paragraph elements, etc.

The use of XML for configuration files allows DenverGIS to identify what objects should be included in a report, how a report should behave, and how a report should look. The XML files are used to set constraints on what objects are allowed to interact with other objects and to define how different objects should interact with one another. XML files contain information such as recordset definitions, actions, report sections and other information needed to create a report. Utilizing the XML configuration files, allows new reports to be built in a short amount of time.

4 Denver Maps

Denver Maps allows users a unique way to view the data. Denver Maps is a report based system. Information is presented in an interactive report format. Reports are grouped into logical categories.

Denver Maps is organized into categories (Figure 2) that contain similar types of information. Denver Maps also allows for location persistence between reports. This means a user may move seamlessly between categories and reports without losing their location information.
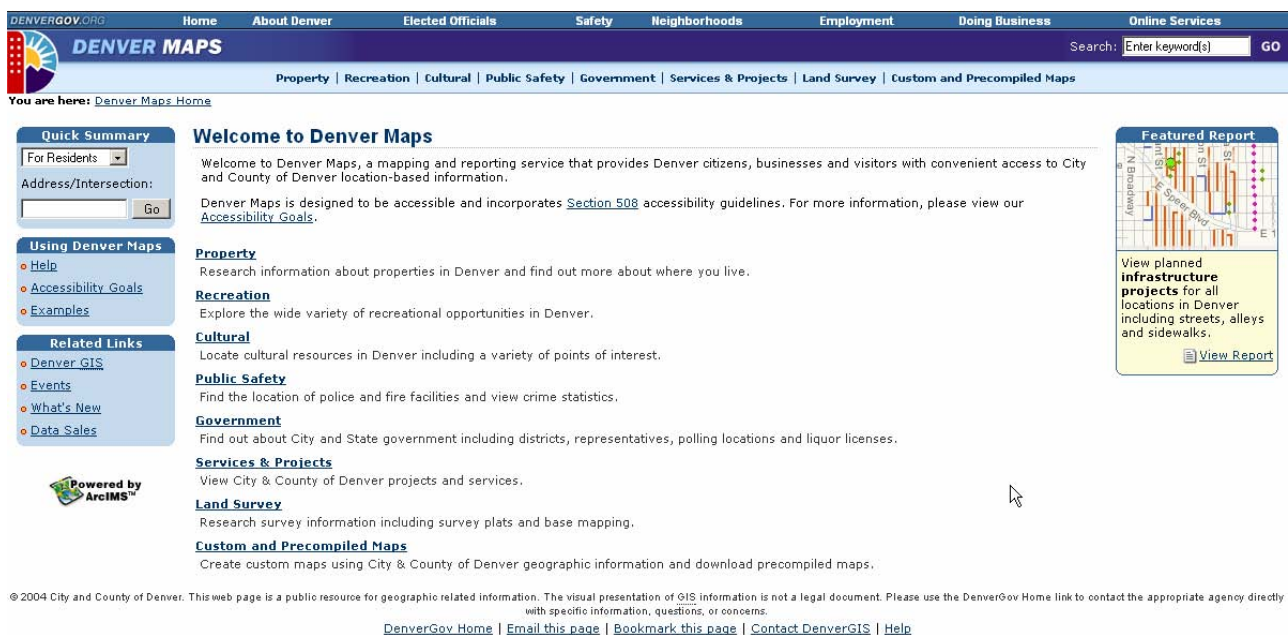

Figure 2: Reports are grouped into logical categories.

Each report provides information about a specific topic and includes search options, map, report and link sections that provide details about features at a location (Figure 3). At the top of a report is the title bar. The title bar contains links to the various categories, a link to DenverMaps home page, links to www.DenverGov.org (10) and a keyword search. The keyword search allows the user to enter a word and find all reports associated with the key word. For instance, if a user typed in the word Park, a list of all reports that contain information about parks would be provided.

Below the title bar is a search option section. This section is designed to allow the user to navigate easily to a specific location such as an address or a specific location such as a neighborhood. One unique aspect of Denver Maps is its location persistence. Denver Maps allows users to jump between reports while maintaining its location reference. For example, if a user entered a specific address on the property report, and then selected the election report, the user would be redirected to the election report zoomed to the election precinct in which the address exists.

The map section includes an interactive map, reference map and a legend. The interactive map allows users to zoom in and out, zoom to full extent, pan, re-center the map at a specific location and select a feature at a specific location. Below the map the user has the ability to toggle on and off additional optional layers. The reference map highlights the users current map location in relation to the City and County of Denver boundary. The legend displays symbology for a select set of layers displayed on the interactive map.

Figure 3: Denver Maps reports are include map and report information.

Below the map is the report section. The report section contains attribute information associated with the selected location. The attribute information is displayed utilizing various objects including tables, paragraphs, links, images and precompiled documents.

At the bottom of each report is the related links section of the report. The related links section includes links to associated web sites, phone numbers and precompiled documents.

5 Report Definition

Denver Maps Reports are made up of objects. Each object exists as a stand alone element that can exist independently or can have objects nested within other objects (Figure 4). The first level of a report consists of the root section. A section is an element that separates different parts of a report. A report can have one or many sections. Sections can contain additional sections or various report elements. The elements include searchoption elements, map elements, table elements, paragraph elements, link elements, etc. Elements can also contain other elements. For instance, a table element may contain a paragraph element that contains a link element. By nesting elements, we increase the flexibility and extensibility of the reports. Report elements support conditions. Conditions are actions that determine whether an element should be displayed. For example, a table element may only display if a particular feature is selected. Conditions allow DenverGIS to change the content of a report based upon the selected features.
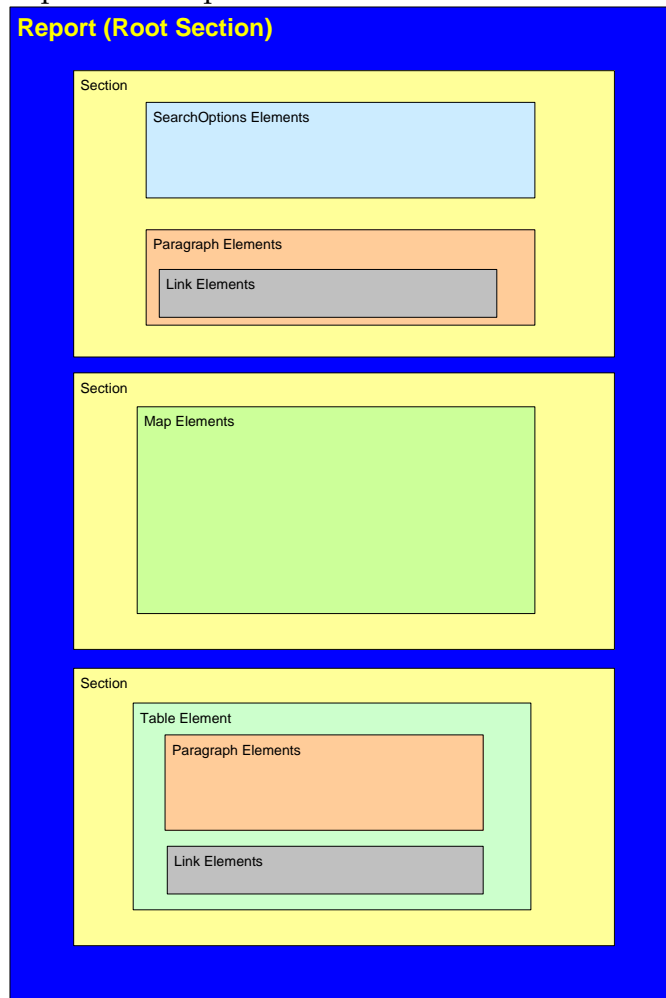

Figure 4: Reports include nested objects such as sections and elements.

6 Lessons Learned

Many lessons were learned through the Denver Maps development process. The first lesson learned was the importance of proper planning and design. Following a standard Software

Development Life Cycle, almost 1/2 of our time was spent on planning the design. This allowed us to create a prototype that was eventually morphed into a working framework for Denver Maps. It was important to take the time to prototype and test our concepts to avoid the common practice completely changing our design once in development.

Prior to deployment of Denver Maps, the application was put through extensive User Testing. We spent a significant amount of time and resources testing the application both with City and County Employees, as well as residents of Denver. This helped to identify how general users actually use our software and see flaws in the layout design. Users were provided a set of questions regarding data that could be found in Denver Maps. Without ever seeing the application they were asked to complete tasks to find the answers. How they went about answering the questions was recorded by several members of the development team. Several rounds of test occurred with changes and modifications to the application made before each round.

Before User Testing was complete, it was important to test accessibility of Denver Maps. This included running Denver Maps through a series of tests. The Bobby Watchfire (4) application was used to help identify barriers to accessibility and encourage compliance with existing accessibility guidelines, including Section 508 and the W3C's Web Content Accessibility Guidelines (WCAG). Denver Maps also used Vischeck (7) to test how report would look to an individual who was color blind. Denver Maps invited several sight impaired people to participate in user testing Denver Maps utilizing screen readers. This helped identify where additional tags and descriptive text and links needed to be added to Denver Maps reports.

How to market Denver Maps was a question asked many times prior to deployment. The site was marketed internally to the City and County of Denver. Discussion of Denver Maps in meetings, emails and demos created a buzz about Denver Maps. Flyers were distributed to the public from counters where customer interaction occurs. Once deployed, we relied heavily on employees to tell their customers about Denver Maps. Denver Maps has replaced almost all geographic mapping links previously available on www.DenverGov.org (10). Many Agencies have placed links to Denver Maps on their websites, and we made sure that Denver Maps was deployed several months prior to GIS Day 2004. We then used GIS Day to show off Denver Maps and provide Denver Maps training to people visiting our first "Open to the Public" GIS Day celebration. Another significant marketing windfall occurred in November 2004. The election commission placed a link on their website pointing to our election report. This report tells customers where they can find their polling location. This exposed thousands of people to Denver Maps.

One area that must not be overlooked when developing an Internet GIS site is Content Management. It is important to make sure that the data that is presented to the public is up to date and accurate. Denver Maps relies on the agencies to update and maintain their data. DenverGIS has developed GIS data standards that are provided to all agencies wishing to provide data to the Corporate GIS. Utilizing standards and a thorough data maintenance plan, protects Denver Maps and other GIS applications found within the City and County of Denver from failing due to data fields changing or bad data being published to ArcSDE.

7   Conclusion

Denver Maps has become one of the most frequently visited sites in the City and County of Denver. Currently Denver Maps averages over 30,000 visits per month, with more than 80,000 unique visitors through the first 6 months of 2005. Denver Maps received an honorable mention

from the Public Technology Institutes 2004 Top 25 Technology Solutions awards, and will be included in the Applications Fair at the 2005 ESRI User Conference. For more information on Denver Maps please visit the website at www.denvergov.org/denvermaps.

8   Acknowledgements

Denver Maps was developed by DenverGIS in cooperation with Customer Information Services of the City and County of Denver.

For more information about Denver Maps please contact:
>   David Luhan
>   City and County of Denver
>   denvergis@ci.denver.co.us

9   References

1   Section 508, Center for IT Accomodation (CITA), www.section508.gov

2   Double-A (AA) conformance, W3C, www.w3.org/WAI/WCAG1AA-Conformance

3   W3C Web Content Accessibility Guidelines 1.0, W3C, www.w3.org/TR/WAI-WEBCONTENT/

4   Bobby Watchfire, Watchfire Corporation, www.watchfire.com/products/desktop/bobby/default.aspx

5   W3C MarkUp Validator, W3C, http://validator.w3.org/

6   W3C CSS Validator, W3C, http://jigsaw.w3.org/css-validator/

7   Vischeck, http://www.vischeck.com/vischeck/

8   Jaws, Freedom Scientific Home, http://www.freedomscientific.com/fs_products/software_jaws.asp

9   Opera Web Browser, Opera Software, http://www.opera.com/

10   City and County of Denver, http://www.denvergov.org