A User Satisfaction Evaluation of Web GIS Platforms in Public Service Delivery: A Case Study of Winona County

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Abstract

The proliferation of web-based Geographic Information System (GIS) technology over the last decade has led to increased utility of web GIS in all levels of public administration. A potential benefit of this technology is improved data accessibility and decision making for policy makers and stakeholders. City and county administrations in Winona, Minnesota have utilized this technology since 2004, mostly for providing parcel-related data as a free-for-all service. However, online GIS platforms had not kept pace with corresponding changes in Esri's ArcGIS web server technology. Consequently this project was initiated in mid-2012 with the customization and configuration of new Silverlight-based GIS web applications to replace systems that would have been functionally obsolete with the transition from ArcGIS Server versions 9.3 to 10.1. The primary goal of this study was to assess the effectiveness of the new applications for both internal and external customers for both the city and the county. Data were collected by means of an electronic survey. A subsequent analysis of the feedback showed a disparity in expertise and appreciation of geospatial technology and its potential benefits between the two groups. There was also some muted interest in mobile compatible applications as well as a general consensus from the respondents on performance bottlenecks of the current systems.

Introduction

The proliferation of geospatial web technology has precipitated a paradigm shift in geographic content analysis from desktop software toward GIS-centric web applications. Current web systems enable geographic data access on a wide variety of hardware platforms: desktops, smartphones, and tablets (Esri News, 2013).

Geospatial data dissemination has evolved with the corresponding changes in web technologies. Before Web 2.0, Public Web GIS (PWGIS) typically delivered static map content on pre-determined sets of queries and procedures (Esri News, 2013).

The advent of Web 2.0, a dynamic content and rich internet application (RIA) ready platform, has spurred improvements in content delivery via data interchange standards, notably AJAX (Asynchronous JavaScript and XML), Keyhole Markup Language (KML), Simple Object Access Protocol (SOAP), and Representational State Transfer (REST) services (Alexander, 2013). The Web 2.0 era has also simplified GIS data collaboration through freely available mashups, mostly overlays of data from diverse sources like Google Maps, Yahoo Pipes, Bing Maps, and social media feeds. This has opened various opportunities for visualization of geospatial overlays with local data (2D and 3D views, live traffic streams) within simple graphical user interfaces compatible with most web browsers (Figure 1).

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Pre Web 2.0 GIS

- Up to late 90s
- 'Static GIS'
- GRASSLink, TIGER GIS
- Limited concurrent use

GIS 2.0

- 2005 - to date
  - FLEX, Silverlight/WPF, Javascript Web plugins
  - SOAP, REST services, AJAX, GeoJSON
  - Mashup capability
  - ArcGIS online; mobile and desktop systems,
  - Google maps, BING, Virtual Earth, Open Street Map, MapQuest

Figure 1. Summary of web GIS evolution.

Web use in government typically varies locally with mission objectives; some organizations publish data for public awareness and consumption, while others utilize the technology for citizen engagement typically through social media enabled tools. A recent survey of over 586 municipal planning departments with over 50,000 inhabitants indicated that 52% have been utilizing GIS web applications for more than a year (Cowley-Evans and Kitchen, 2011).

History of GIS at Winona County

Geospatial technology was first introduced in the late 1990s at Winona County. PWGIS was implemented in 2004. Prior to the introduction of web GIS, the county relied on three GIS personnel to compile and distribute data to the customers. Data requests in this period mostly consisted of revising plat books and building the current vast inventory of data owned by both the city and the county. Currently the county maintains the following datasets: cadastral (approximately 25,000 records), elevation, emergency, natural resources, very high resolution imagery, transportation, and utilities (Meyers, Hoffmann, Huth, and Zielsdorf, 2011).

Web GIS applications have vastly improved department workflows and data dissemination efficiency for both the county and the city governments. With the decentralization of GIS tools, both the county and city have seen drastic reductions in data requests and the printing of ownership related data, significantly reducing administrative costs. This has enabled GIS personnel to concentrate on building data inventories and producing trend analyses and spatial visualization products for policy makers. Arguably the largest benefit of the PWGIS has been the remediation of cadastral data errors, mostly through public collaboration. Corrections of acreage and ownership errors of commission or omission have routinely been initiated by the public. The county's GIS website is currently among the top 5 most visited pages with an average of over 1,100 visits a month (Figure 2).

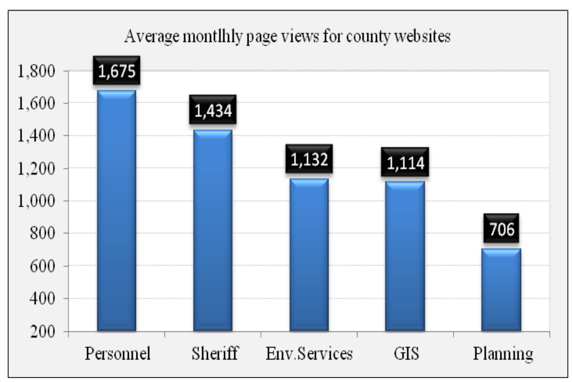

Figure 2. Top 5 most visited websites for the period May 2012 – September 2013. Data courtesy of the Winona County Information Technology Department.

Implementation of GIS 2.0 for the City and County Web Applications

In mid-2012, it was deemed necessary to replace the outdated Web Application Development Framework (WEB ADF) (City) and Internet Mapping Framework (IMF) (County) applications. Web ADF technology had been superseded by Esri's more REST-full capable web mapping application development interfaces (API) with the advent of ArcGIS Server 10.1 (Esri, 2010).

The API and customization tool chosen for this project were Geocortex Essentials from Latitude Geographics®. Geocortex offers several highly configurable RIA-based viewers harnessing Microsoft's Silverlight and Adobe Flex for desktop clients and a Hypertext Markup Language 5 (HTML5) enabled JavaScript viewer optimized for desktops and mobile hardware (Latitude Geographics, 2013). Figure 3 illustrates the main API interfaces utilized.

The Silverlight viewer was chosen as the client-side platform due to the vast integrated out-of-the-box customized libraries it offered. The new client web interface had the following improvements using the built-in API functionality:

- fine-grained map navigation widgets and mouse enabled zoom-scroll functionality;
- user specified text and geometry mark-up and saving capabilities;
- incorporation of spatial query widgets (feature identify and buffering);
- spatial filtering of layers;
- Google (street view) and Bing Map (oblique view) links;
- layer transparency controls;
- user-specified bookmark tool;
- ability to save and reload user sessions as project files on the server or locally;
- thematic layer control based on user preferences;
- collapsible toolbars;
- layers and results panels; and
- parcel feature hyperlinking to the County Assessor's tax roll data.

Custom programming leveraging the Essentials API's workflow designer was used to incorporate parcel feature attribute queries to external database tables: Tax and City Utility Customers. Also, custom parcel reports and mailing labels (based on AVERY 5165 format) were implemented as a custom solution using Essentials report designer.

Several task automation python scripts were developed using ArcGIS Model Builder and deployed on a web server as scheduled tasks.

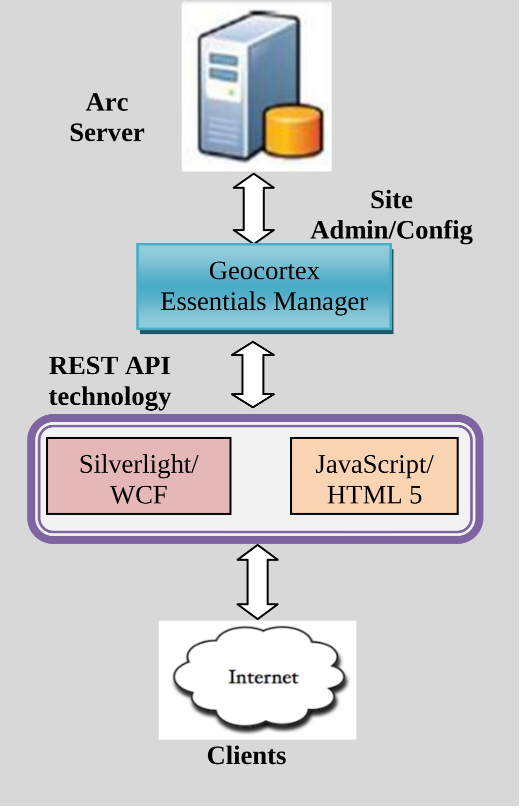

Figure 3. A simplified illustration of the component development framework for the county and city's web GIS client-side applications.

A total of five web GIS tools were developed: two public viewers available for both the city and county and three internal viewers (two for the county, one for the city) for use primarily by recorders, assessors, and city utility managers. The internal web clients had minor design and functional differences from the external systems; internal web clients typically had secure service layers (non-public map services such as utility location information) and some custom functionality specifically targeting the aforementioned departments (mailing label generator and limited editing functionality for the County Assessors' GIS). Therefore, for the purposes of this study, it was assumed that there were no significant differences between the internal and external GIS web applications being reviewed.

The change in viewer platforms (Web ADF to Silverlight web mapping interface) necessitated a review of user adaptation to the new applications.

Methods

Data Collection

The purpose of the project was to obtain feedback from the users of the county and city's web GIS applications with the primary goal of incorporating feedback into future releases of client-side tools to better serve all stakeholders. Furthermore, the county needed to gauge web application adaptation: a characteristic best measured from user attitudes to technology (Obermeyer and Pinto, 2008).

There are numerous methods for evaluating the user experience of internet based applications. Common industry methods include: comparison of design elements, user experience (UX) evaluations, a priori experimental designs, and case study methodology (Plaisant, 2004).

A posteriori UX design evaluation methodology was adopted for this project utilizing a web form survey. The electronic questionnaire was designed with Google Docs, a freeware tool. A link to the questionnaire was then embedded in the county and city's public websites in June, 2013. The same link was also emailed to county and city GIS data users (approximately 50 employees). Data were collected over a three month period.

Questionnaire Content

The web form was designed with seven questions containing standardized responses (excluding the comment sections). The first two questions were modeled after Skelton (2010). These were intended to gauge overall quality of the user experience and satisfaction with aesthetics, functionality, intuitiveness, and system performance (Figure 4). The next five questions were designed to collect user type, hardware platform preferences, most utilized GIS tools, and user suggestion information.


2a.Rate App on Ease of Use/Intuitiveness
Scale of 1 - 5 (5 being the highest)
1
2
3
4
5

2b. Overall design (placement of toolbars, skinning, screen size)
Scale of 1 - 5 (5 being the highest)
1
2
3
4
5

2c. Rate App on response time (queries, rendering, etcetera)
Scale of 1 - 5 (5 being the highest)
1
2
3
4
5

Figure 4. A sample of the qualitative ratings section of the electronic GIS viewer surveys.

A total of twenty-five respondents provided feedback in the three-month period that was considered for the analysis. They were grouped into two categories: public employees (n=14) and external customers (n=11). The goal was to ascertain whether there were significant differences between the two sampled groups. The web survey results were exported to Microsoft Excel spreadsheets for further analysis. Tools utilized included pivot tables, descriptive statistics (box plots), Pearson's correlation coefficients, student t-test two sample analysis, and creation of visual aids using charts and graphs.

Results

Viewer Scores

Results indicated a contrast between the public employees (P.Es) and external customers (E.Xs). The former gave the GIS web applications higher ratings than the latter. Additionally, the box plots for both groups revealed more diverse scoring ranges. Furthermore, application response times were the lowest scored attribute of the viewer (Figure 5).

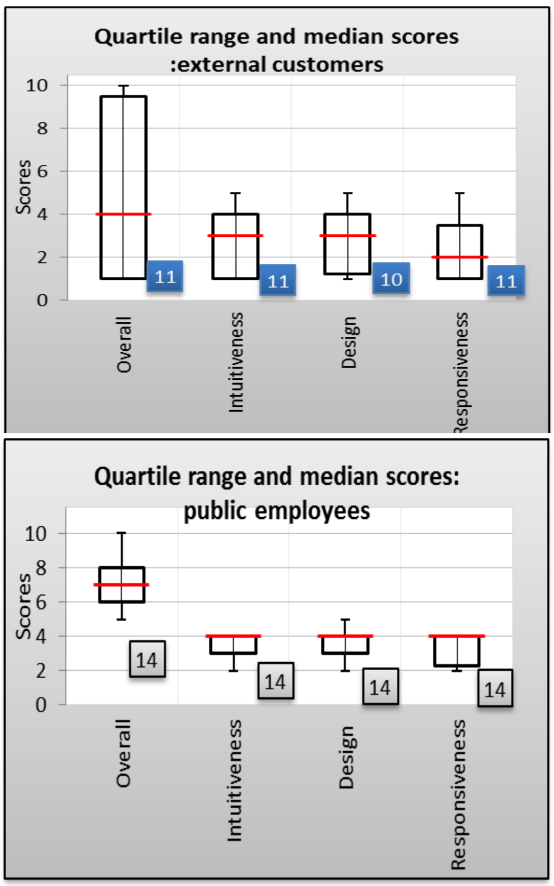

Figure 5. Boxplots show P.Es were more consistent than E.Xs in scoring the viewers. The maximum score for the overall rating was 10. The maximum score for intuitiveness, design, and responsiveness was 5.

Correlation Results

The correlation test was utilized to verify the co-variability of the overall scores against the other three performance scores (intuitiveness, design, and responsiveness). Simple correlation moments were computed using the 'CORREL' formula in Microsoft Excel. Results obtained indicated positive relationship. Subsequent significance testing of the correlation value "r" using the F-test proved the results significant at the 95% confidence interval (Tables 1 and 2). Consequently, it was deemed adequate to utilize the overall scores for hypothesis testing between the two groups.

Table 1. Pearson correlation coefficient matrix for P.Es. An asterisk (*) denotes significance at the 95% confidence level.

	Overall Scores	Intuitiveness	Design	Responsiveness
Overall Scores	1			
Intuitiveness	0.78*	1		
Design	0.91*	0.87*	1	
Responsiveness	0.83*	0.83*	0.87*	1

Table 2. Pearson correlation coefficient matrix for E.Xs. An asterisk (*) denotes significance at the 95% confidence level.

	Overall Scores	Intuitiveness	Design	Responsiveness
Overall Scores	1			
Intuitiveness	0.96*	1		
Design	0.90*	0.95*	1	
Responsiveness	0.96*	0.96*	0.91*	1

Hypothesis Testing

A two-sample t-test was utilized to test the assumption that the two sampled groups were from statistically dissimilar populations of P.Es and E.Xs. Results revealed that there was no significant difference between the P.Es ($M = 6.923$, $SD = 1.439$) and E.Xs ($M = 4.818$, $SD = 4.143$); $t(12) = 1.615$, $p = 0.0662$. However, a subsequent check of the optimal sample size using Equation 1 found that a sample size of at least 378 respondents was required at the stated 95% confidence level and pooled sample variance ($S_p^2 = 48.9565$, d = 2). Guidelines for crosschecking optimal sample size were drawn from Zar (1998).

Equation 1. Estimation of the required optimum sample size "N" for a given confidence interval.

$$n = \frac{2S_p^2 t_{\propto(2),2(n-1)}^2}{d^2}$$
$$d = t_{\propto(2),v} S_{\bar{X}}$$

Where d = 1/2 width of confidence interval; t = critical value of the t-distribution at α confidence interval; and S_p^2 = pooled sample variance.

Other Findings

Results of the survey also conveyed the following:

- E.Xs required assistance navigating the viewer more frequently than P.Es (Figure 6).
- There were more E.Xs that found the applications 'almost always' helpful than P.Es (Figure 7).
- Respondents generally used the viewer for parcel information, zoning, and tax information. Also P.Es showed more diverse application utilization than E.Xs (Figure 8).
- Only 3 of 25 respondents (all E.Xs) indicated an interest in mobile applications (tablets and smartphones).

Conclusions

The study yielded useful feedback on the current generation of web GIS applications. The most important observation was a noticeable knowledge and skills gap between public employees and external customers, hence the need for a less sophisticated system for the latter group. Another area of concern was the slow application response times: both P.Es and E.Xs found the applications too slow.

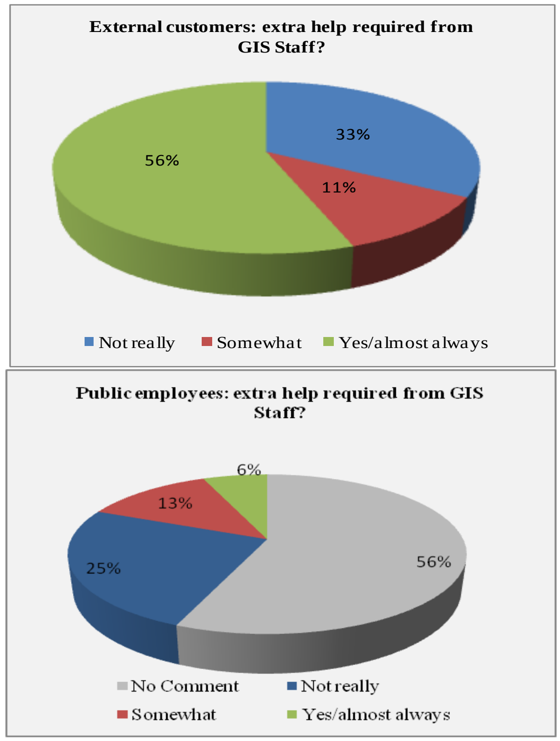

Figure 6. Routine users (P.Es) had better tool familiarity than occasional users (E.Xs).

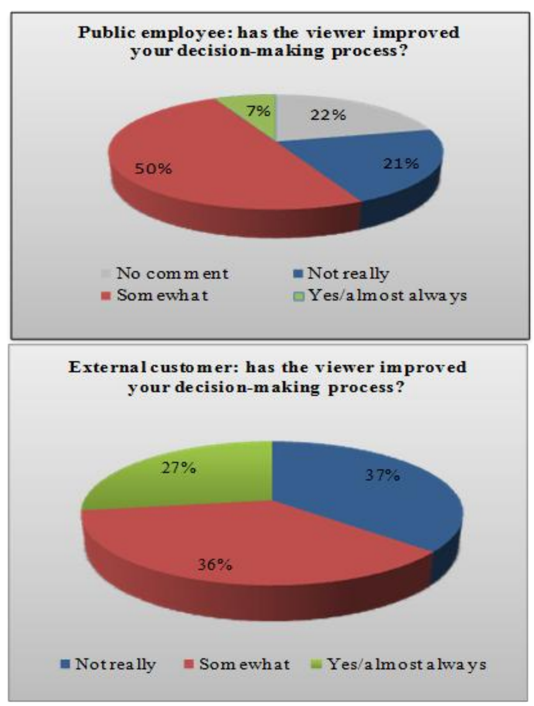

Figure 7. Routine users (P.Es) had better tool familiarity than occasional users (E.Xs).

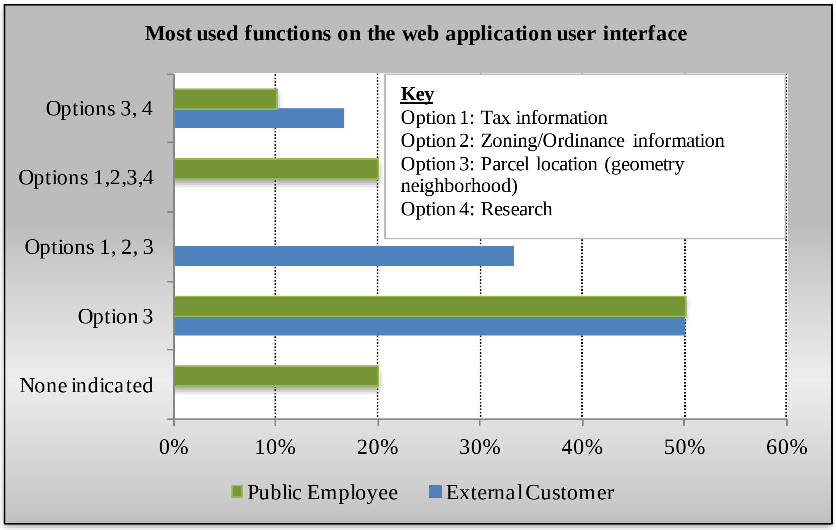

Figure 8. Parcel queries were the most used tools in the web viewers per the survey. P.Es had more diverse task use than E.Xs.

These findings were forwarded to appropriate administrators for incorporation into future releases of the web GIS applications.

Overall, UX surveys have proven to be very useful in articulating customer needs. Knowledge accrued from UX design feedback is a critical ingredient in successful implementation of PWGIS systems.

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