5-29-2013

# Mobile GIS: An Economical Approach to View and Edit GIS Data

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# Mobile GIS: An Economical Approach to View and Edit GIS Data

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Capstone Project

for

Master of Science in Geographic Information Science

May 29, 2013

**Abstract**

Faulk's capstone project provides specific instructions for the implementation of the My Maps Editor app that allows the city of Taylorsville, Utah employees and residents the ability to view, create, upload, edit, and share their own geographic data on an iPad or iPhone. The project consists of identifying the city's GIS (Geographic Information System) needs, researching existing GIS capabilities, selecting and installing an app, and providing instructions for system maintenance. The selected app offers many benefits including practical application, functional capabilities, financial feasibility, time saved, and aid in emergency preparedness.

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**Project Definition**

In 2012, the Community Development Department of Taylorsville, Utah expressed a desire to utilize a GIS iPad or iPhone app allowing the city's mayor and other selected city employees easy access to city data. The city currently uses ArcGIS but has no method for remotely retrieving and editing city data on city issued iPads or iPhones. Currently, most city employees choosing to utilize GIS must contact the GIS coordinator to gather, analyze, and provide all geographic information. The city also expressed a concern with not having geographic data in the event of a major power outage. Furthermore, the city has no additional resources to implement GIS systems. The city of Taylorsville will benefit from a mobile GIS application to aid employees in creating, accessing, analyzing, and updating the city's geographic data.

Viewing GIS data through the My Maps Editor app provides an economical solution for a potentially expensive need. Similar GIS apps may cost hundreds of dollars or require an annual subscription. App utilization would allow city employees easy and continual access to important city GIS data. When properly implemented, the app may serve as a tool for emergency preparedness by allowing city employees and residents access to critical geographic information.

The app provides users the ability to select a GIS layer, zoom to any city location, click on a single attribute, and then view, create, upload, edit, and share their GIS data. Upon the request of city residents, the city can provide public data to residents who can also view GIS data on their iPhones or iPads by simply adding a resident's email to the list of viewers with access to a specific data map.

This project provides an innovative process for empowering the My Maps Editor app. In addition to cities, any company, organization, or personal user could implement the app as well as the process for empowering the app to their benefit. One of the implications of this project is that iPads, iPhones, and other mobile devices will become a greater part of the GIS world.

**Project Foundations**

Cloud computing promotes the availability of spatial data and is already an invaluable tool for many GIS users (Kerski and Clark 2012, 295). Cloud computing allows data analysis while not requiring all of the data to exist on a device. As such, GIS has the potential for near infinite amounts of data storage as well as fast, easy, and mobile access and analysis (Kerski and Clark 2012, 294-296).

Kang identifies numerous advantages of cloud computing some of which include the diminishing need for super computers, the ability for sharing and editing data performed by non professionals, and updating a

GIS via Internet connection instead of CD-ROM (Kang 2011, 4-5). These advantages aid in the overall reduction in the cost of GIS.

Gonzales explains that Google Fusion Tables is a cloud-based service for data management and integration and that Google Fusion Tables enable users to upload tabular data such as spreadsheets, CSV, and KML files currently up to 100MB (Gonzales 2010). Google Fusion Tables is an experimental data visualization web application to gather, visualize, and share larger data tables (Google Inc 2013).

Lobeck lists some advantages of mobile GIS for a city including mapping the location of utility infrastructures, helping with improvement projects, reducing paperwork, aiding in public safety (specifically police and firefighters), and even tracking crime (Lobeck 2010, 1). These benefits, as well as many more, will emerge as mobile GIS evolves from a few users to billions of users continuously exploring data. This technology can aid people in solving large scale challenges and even global problems such as natural disasters, pollution, waste, transportation, and diminishing natural resources such as petroleum, natural gas, ores, forests, clean air, and clean water.

Bhat et al. state another advantage of mobile GIS as consisting of a small initial investment in time and cost (Bhat, Shaw, and Ahmad 2011, 4). Organizations may now provide geographic solutions to their customers because costs are at a minimum due to advancing hardware and software, market competition, and more data. Traditional data collection devices and

their accompanying systems were once expensive and required expert knowledge to effectively use. Now, GIS data collection and analysis can take place on user friendly iPads and iPhones.

Korte provides a breakdown of how to determine if a new GIS solution will outweigh the cost of implementing and maintaining an existing system. An ideal GIS solution uses existing hardware, software, programs, and requires little maintenance after implementation (Korte 1996, 1). Evidence of a GIS system needing updating or replacement include: the system no longer completes desired tasks, requires too much time for processing and maintenance, is not user friendly, or requires continual expert GIS knowledge.

Lidstone et al. argue GIS is useful in addressing a range of real world problems. GIS provides a linkage between science and policy and assists in the search for principles and laws that apply everywhere regardless of the geographic context (Lidstone, John and Joe Stoltman 2006, 205-209).

One of the challenges with mobile GIS is the difficulty of displaying more than one attribute for a single feature. Earthpoint provides two methods for displaying multiple attributes for a single feature in a placemark description box based on a KML file's description box (Earthpoint n.d.).

Zandbergen explains that the iPhone 3G and the iPad Wi-fi + 3G have three techniques for determining location; assisted GPS, WiFi positioning,

and cellular network positioning. These results serve as a baseline for comparison of current device accuracy in the area of study.

Traditionally, people utilize GIS for outdoor use, however, indoor use may soon become an additional GIS feature. Usman's Master's Thesis explains the Design and Implementation of an iPad Web Application for Indoor-Outdoor Navigation and Tracking Locations

*Comparison of Apps*

In 2012, Taylorsville expressed interest in a GIS iPad or iPhone app to aid in multiple city projects. The city conveyed the following app criteria based on the city's needs:

- Free or low cost to install
- Creates and edits features in points, lines, and polygons
- Imports the city's existing GIS data
- Allows data sharing to other mobile devices
- Provides satellite map viewing
- Provides label map viewing
- Allows searching for places
- Stores pictures in the cloud
- Uses GPS or other location based services
- Provides differing placemark icon options
- Is user friendly

Table 1 shows 13 of the most capable GIS apps from the Apple App Store. Many of the apps are highly capable and many are low cost or free, however, the My Maps Editor app is the only app meeting all of Taylorsville's criteria. Question marks in the table represent unknown attributes that could not be determined without purchasing the apps.

Table 1.

| Application | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| GeoMobile for ArcGIS | Free | ✓ | | | ✓ | ✓ | ✓ | | ✓ | | ✓ |
| iGIS | Free | | ✓ | ✓ | ✓ | | | | ✓ | | |
| Google Earth | Free | | ✓ | | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ |
| My Maps Editor | Free | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| zMap | $0.99 | | ✓ | | | ✓ | ✓ | ✓ | ✓ | | ✓ |
| KML Map HD | $3.99 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | | | |
| GlobalScout | $5.99 | | ✓ | ✓ | | ✓ | ✓ | ? | ✓ | ? | ✓ |
| Integrity GIS | $9.99 | | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | |
| Forester GPS GIS | $44.99 | ✓ | ✓ | ✓ | ✓ | ? | ✓ | ? | ✓ | ? | |
| GIS Kit | $99.99 | ✓ | ✓ | | ✓ | ✓ | | | ✓ | ? | ✓ |
| GIS Pro | $399.99 | ✓ | ✓ | ✓ | ✓ | ✓ | | | ✓ | ? | ✓ |
| ArcGIS | License | ✓ | ✓ | | | | | ✓ | ✓ | ? | ✓ |
| Wolf-GIS | Subscription | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ? | ✓ |

**Approach**

The project began with an interview with the city of Taylorsville's GIS Coordinator to identify the city's GIS needs. Various existing GIS iPhone and iPad apps were researched to determine the best solution for the city. Following this research, app testing was performed to determine the app's

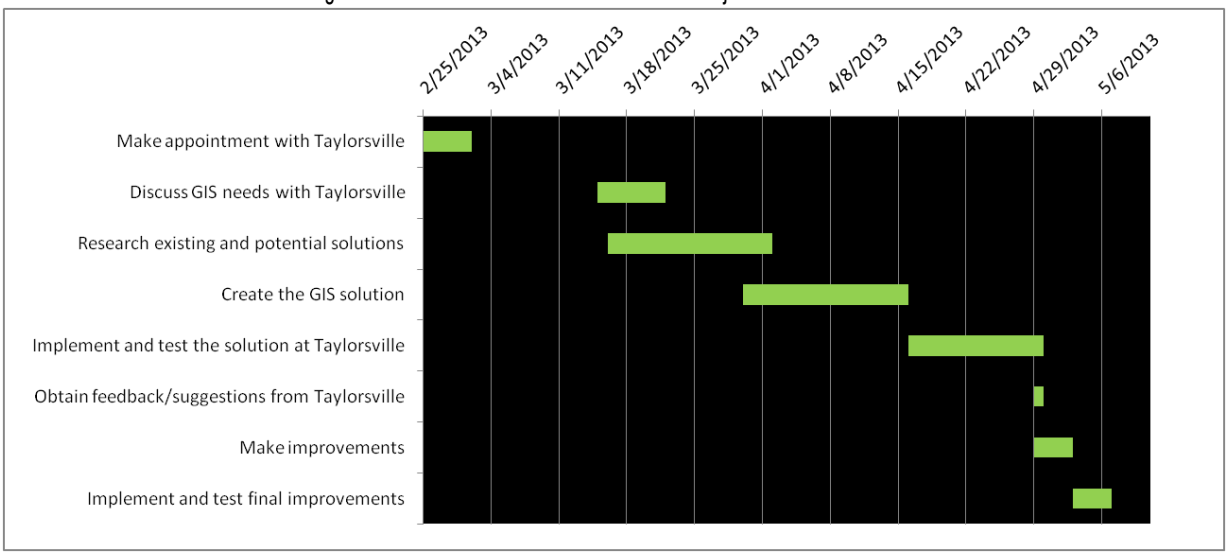
capabilities and limitations after which the app and its system for the city of Taylorsville were implemented. Following the implementation of the app and the system, a meeting with the GIS coordinator transpired to obtain feedback regarding the app, its system, and its use. As discussed, further research and additional improvements were performed for the city.

## Project Solution

### *Project Timeline*

The Gant chart below shows the project timeline. The entire project required just over two months for completion. The timeline allowed adequate time to schedule and begin discussions with the Taylorsville GIS Coordinator regarding the city's GIS needs. The majority of the time spent on the project focused on researching existing and potential solutions, creating the solution, and implementing the solution.

Figure 1. Gant Chart - Project Timeline



**Hardware and Software Requirements**

This project requires an iPhone or iPad Wi-fi + 3G, MS Excel, a Google Account, and the My Maps Editor app.

*Spreadsheet Design*

The project calls for a spreadsheet for each data layer to store city data. Each spreadsheet may contain thousands of records, presumably one record for each placemark, line, or shape, which has several data fields for the end user. The city of Taylorsville has existing databases containing information in the ArcGIS attribute table format. This is an ideal database for this project because the attribute table exports to a .dbf file which MS Excel can import as an .xls spreadsheet. After exporting an attribute table and importing it into MS Excel, it will need to be converted into a .kml for final upload to Google Fusion Tables. Alternatively, the data may be copied to a Google Spreadsheet and formatted as a KML and then imported to Google Fusion Tables. Each record in a spreadsheet requires specific column headers for the Google Fusion tables including “description”, “name”, “geometry”, “style”, and “M_icon_url” as shown in Image 1.

Image 1.

Bus Stops

Imported at Sat Apr 13 08:05:15 PDT 2013 from BusStopsSpreadsheet.
Edited at 9:05 AM

File Edit Tools Help | Rows 1 | Cards 1 | Map of geometry

Filter | No filters applied

1-100 of 210

| description | name | geometry | style | M_icon_url |
|---|---|---|---|---|
| Far Side | 2670 W 4100 S | KML... | <Style><IconStyle><Icon><href>http://maps.gstatic.... | |
| Near Side | 3045 W 4700 S | KML... | <Style><IconStyle><Icon><href>http://maps.gstatic.... | |
| Far Side | 4710 S 3200 W | KML... | <Style><IconStyle><Icon><href>http://maps.gstatic.... | |
| Far Side | 4870 S 3200 W | KML... | <Style><IconStyle><Icon><href>http://maps.gstatic.... | |
| Near Side | 4847 S 3200 W | KML... | <Style><IconStyle><Icon><href>http://maps.gstatic.... | |
| Mid Block | 4779 S 3200 W | KML... | <Style><IconStyle><Icon><href>http://maps.gstatic.... | |

Image 2.


Without the column headers in the spreadsheet, the application will not correctly read the Google Fusion Tables and the application will display an error message (Image 2). In the case of Image 2, the "style" column header did not exist.

*Data Collection*

The application allows users to collect data through an iPhone or iPad only while connected to the Internet. To do so, the user taps the placemark icon in the lower right hand corner of the screen and selects one of the five options to add features. Currently, users can add a placemark, draw a line, draw a line (free-hand), draw a shape, or draw a shape (free-hand). After adding a feature, the user customizes the feature through adding a title as

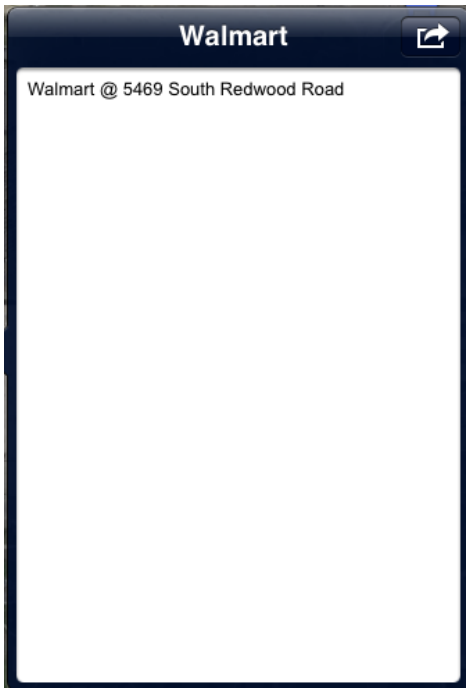
well as an icon, description, or even line color, and then saves the feature. When connected to the Internet, the application automatically updates in Google Fusion Tables. City officials may monitor field data collection as it takes place either in Google Fusion Tables by refreshing the web page or in the app by refreshing the map. City data specialists no longer need to spend time processing collected data or wait for the data collector to complete the entire data collection project before analysis.

*Data Processing*

This app allows users to import existing data into the app through Google Fusion Tables, however, without processing the data first, a feature's description only displays one attribute of the feature. This is because an attribute table uses many cells for a description whereas the app and Google Fusion Tables use one cell for the entire description. An unprocessed description cell generally results in a small amount of visually unappealing and disorganized data whereas a processed description cell may facilitate easy understanding of large amounts of information (Images 3 and 4).

Image 3. (Processed)


Image 4. (Unprocessed)

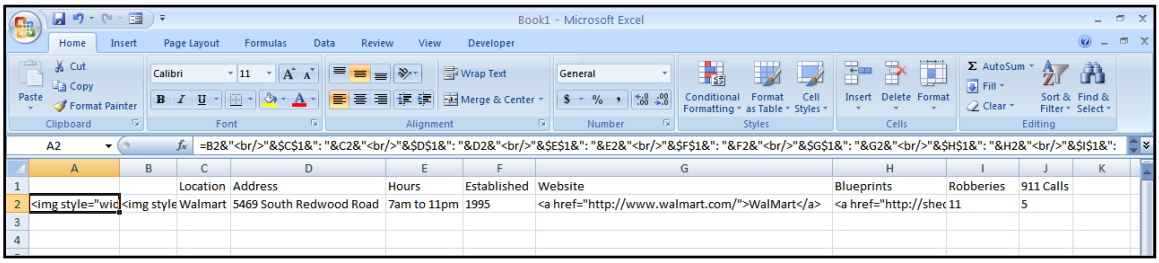



In order to create a processed description box, GIS Specialists can enter the data manually or populate the data using MS Excel.

*Code*

Three methods exist to populate GIS description data into a readable HTML description box format using MS Excel. The first method populates the description box using the AppendDataColumnsToDescription column header. Unfortunately, this system does not work with the My Maps Editor app. The second method, performed by inserting a blank column before the dataset and placing Code A (see Appendix) in cell A2 is compatible with the My Maps Editor (see Image 5). Code A is an improved version of the website's code that enables users to copy the formula down using MS Excel's fill handle tool.

Image 5.



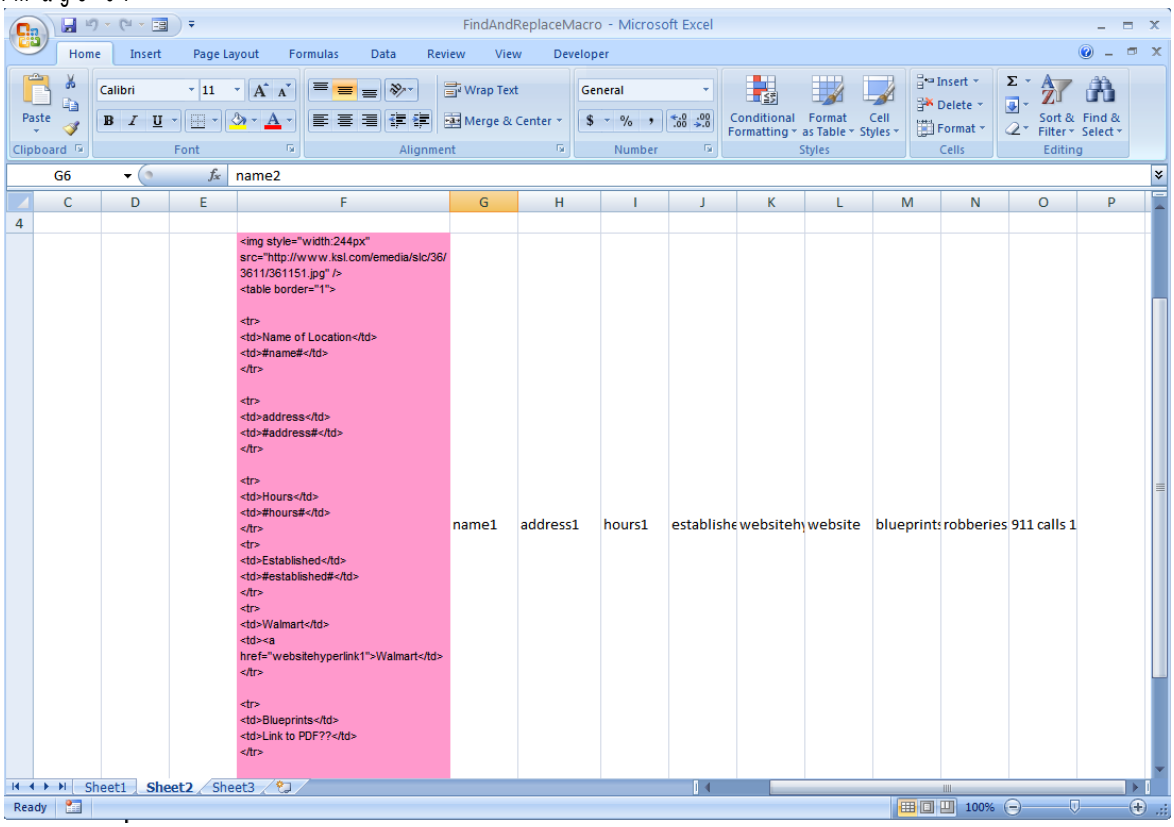

The improvement of this code consists of the use of the "$" symbol. When this symbol is used such as =$C$1 instead of =C1, the MS Excel formula locks the column and row auto fill migration to that specific cell. The F4 key provides a shortcut for this handy capability. This symbol allows users to populate a single cell with each column header. The text shown as ""<br/>"" in the formula is HTML code for a line break. If desired, users may create a tabled look by incorporating HTML table code into the record's description box such as Code B (see Appendix). Benefits of this code include the ability to choose which columns and column data to include in the description box as well as the formatting within the description box. Disadvantages of this code include confusion and discouragement of users from editing the data due to the complexity of the description text while editing as well as the higher likelihood of novice users introducing errors in the description table.

The solution requires a column named "geometry" to visually represent any points, lines, or shapes. Points, lines, and shapes all follow their respective formatting which include longitude and latitude coordinates

(see Appendix Code C). Unlike lines and shapes, placemarks require columns titled "M_icon_url" and "style". The code for these fields follow Appendix Code D. The URL contained in both columns must match.

The third and much more complex option to add attribute data to a description box requires an Excel macro. Code E was used in cell F5, the description box cell, while Code F was used as the macro (see Appendix for Codes E and F). Cells G6 through O5 contain the attribute data (see Image 6).

Image 6.




This code requires advanced Excel user skills and requires modifications to both codes for each imported dataset. One advantage of this method includes the creation of a template for future data imports.

Disadvantages of this method include expert knowledge to use, frequent code modifications, a lengthy initial time investment, and a higher probability of minor mistakes.

*Data Editing*

Users may delete or edit points, lines, or shapes through the mobile device or through Google Fusion Tables. By default, lines and shapes do not display their icons. When a user desires to edit a line or shape, the user must first enable the line or shape icon from the options menu in the My Maps Editor app. Before a user may see updated edits from another user modifying the same dataset, the user must refresh the data by tapping the refresh button in the map options in the app or by refreshing the browser data for a user viewing the Google Fusion Tables.

*Data Sharing*

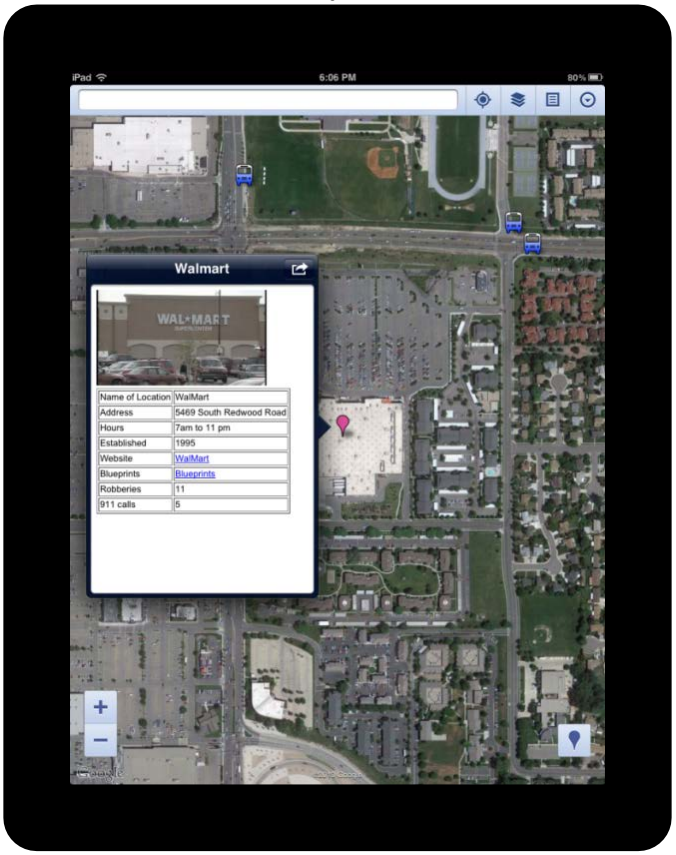
Google Fusion Tables provide the owner of a dataset with several options for sharing data including making the data completely private, making the data completely public, or specifying specific users with permission to "view only" or "view and edit" the data. The owner of a dataset also has the option of transferring ownership and the accompanying privileges to another user. Owners of proprietary data should be aware that any user with permission to view a dataset also has the ability to share the data via email in a .kml file through Google Fusion Tables or through the My

Maps Editor App. The city of Taylorsville may choose to benefit from these data sharing capabilities by sharing data with city employees, contractors, or residents which would reduce trips to field site locations, paper maps, and phone calls.

*Final Product*

The final application stores and displays geographic data in points, lines, or shapes. The application proves visually appealing, mobile, secure, highly capable, and easy to use. The application requires work for proper installation, data processing, and maintenance but is otherwise free for the end-user. Image 7 is an illustration of the final product.

Image 7.



**Discussion and Recommendations**

This project identified a solution for the City of Taylorsville that enabled city officials to view their GIS data on an iPhone or iPad. The project proved beneficial as it identified a solution that met the needs of the city but this solution may also have applicability and prove beneficial for counties, states, federal governments, and other public and private organizations.

Although the solution was quite economical for the city of Taylorsville, actual savings from the solution proves difficult to quantify because of the unknown cost of an alternative solution if it were implemented instead as well as the inability to quantify convenience or the happiness of employees or residents using the solution that previously did not exist.

The app works well in its current state, however, some recommendations that would enhance this app include additional functions such as a measuring distance tool, a compass, user-defined map caching, offline feature storing capabilities, a manual geographic coordinate input tool, some basic GIS analysis functionality such as creating buffers, and an ability to obtain imagery from different time periods especially the most recent imagery. App users will find that if they try to create a feature such as a placemark while not connected to the Internet, the app will display a network connection error. The user must then cancel and lose that feature's data. Additionally, users would benefit from a one-stop location where they could import KML data directly from the app.

The app currently caches map data of the last area of use. This feature in the app is somewhat unstable. If a larger and more consistent caching method were used, the caching feature could easily become one of the app's greatest strengths instead of a limitation because users could still view placemark data as well as map imagery offline. Such a feature would hold great value in the event of a power or Internet connectivity outage.

However, one limitation of this project is the size of a single layer. For example, Microsoft Excel only allows for 1,048,576 rows and 16,348 columns for data attributes. Any layer exceeding these limits requires separation into two layers which can be viewed simultaneously once in the final application.

Data processing could be made even easier by using a program that accepts all sizes of data and formats it correctly to the description column. The current solution is limited to datasets that MS Excel may import or open.

The final product image shows a picture of a Wal-Mart. This picture includes its own URL which is referenced in the Fusion Tables in HTML format. Any picture may be displayed here by adding a picture from the user's iPhone or iPad, or the user may simply take a photo.

This solution could play a role in enhancing coordination of community projects. For example, one possible application of the proposed GIS solution involves the community by providing weekly details, including locations, about community projects such as service projects, parties, sporting events, parades, etc.

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bergen&rft.date=2009-06-01&rft.pub=Blackwell+Publishing+Ltd&rft.issn=1361-1682&rft.eissn=1467-9671&rft.volume=13&rft.issue=s1&rft.spage=5&rft_id=info:doi/10.1111%2Fj.1467-9671.2009.01152.x&rft.externalDocID=1769208521 (accessed April 29, 2013).

# Appendix

**Code A**. *MS Excel code to populate a cell with column headers and column data into a single cell.*

```
=B2&"<br/>"&$C$1&": "&C2&"<br/>"&$D$1&": "&D2&"<br/>"&$E$1&": "&E2&"<br/>"&$F$1&":
"&F2&"<br/>"&$G$1&": "&G2&"<br/>"&$H$1&": "&H2&"<br/>"&$I$1&": "&I2&"<br/>"&$J$1&": "&J2&"<br/>"
```

**Code B.** *HTML code to create a table in a feature's description box.*

```
<table border="1"> <tbody><tr> <td>Location</td></td> <td>WalMart</td></td> </tr></tr>
```

**Code C.** *Google Fusion Table formatting for points lines and polygons*

```
<Point><coordinates>-111.936905,40.650528</coordinates></Point>

<LineString><tessellate>0</tessellate><coordinates>-111.937859,40.650459,0 -
111.935883,40.650455,0</coordinates></LineString>

<Polygon><outerBoundaryIs><LinearRing><tessellate>0</tessellate><coordinates>-111.938820,40.649361,0 -
111.934036,40.649368,0 -111.934059,40.653072,0 -111.938812,40.653168,0 -
111.938820,40.649361,0</coordinates></LinearRing></outerBoundaryIs></Polygon>
```

**Code D.** *Required placemark code for the My Maps Editor App*

```
http://maps.gstatic.com/intl/en_ALL/mapfiles/ms/micons/yellow-dot.png

<Style><IconStyle><Icon><href>http://maps.gstatic.com/intl/en_ALL/mapfiles/ms/micons/yellow-
dot.png</href></Icon></IconStyle></Style>
```

**Code E.** *Tabled formatted description box cell code for data processing using a Macro*

```
<img style="width:244px" src="http://www.ksl.com/emedia/slc/36/3611/361151.jpg" />
<table border="1">

<tr>
<td>Name of Location</td>
<td>#name#</td>
</tr>

<tr>
<td>address</td>
<td>#address#</td>
</tr>

<tr>
<td>Hours</td>
<td>#hours#</td>
</tr>

<tr>
<td>Established</td>
<td>#established#</td>
</tr>

<tr>
<td>Walmart</td>
<td><a href="websitehyperlink1">Walmart</td>
</tr>
```

```
<tr>
<td>Blueprints</td>
<td><a href=#blueprintshyperlink#</td>
</tr>

<tr>
<td>Robberies</td>
<td>#robberies#</td>
</tr>

<tr>
<td>911 calls</td>
<td>#911calls#</td>
</tr>

</table>
```

**Code F.** *MS Excel macro code to replace contents of a cell based on another cell*

```
Sub ReplaceTextMacro()
' This macro replaces a specific word in cell F5 as specified by cells G5 through O5.
' The macro then increments the rows and repeats the process until it completes 100 rows.


Dim ColumnGRow As Integer, ColumnHRow As Integer, ColumnIRow As Integer, ColumnJRow As Integer,
ColumnKRow As Integer, ColumnLRow As Integer, ColumnMRow As Integer, ColumnNRow As Integer,
ColumnORow As Integer
Dim WhatRow As Integer

ActiveCell.FormulaR1C1 = ""

ColumnGRow = 5
ColumnHRow = 5
ColumnIRow = 5
ColumnJRow = 5
ColumnKRow = 5
ColumnLRow = 5
ColumnMRow = 5
ColumnNRow = 5
ColumnORow = 5
WhatRow = 5

 Do

 Rows(WhatRow).Select
 Selection.Replace What:="#name#", Replacement:=Range("G" & ColumnGRow), LookAt:= _
 xlPart, SearchOrder:=xlByRows, MatchCase:=False, SearchFormat:=False, _
 ReplaceFormat:=False

 Rows(WhatRow).Select
 Selection.Replace What:="#address#", Replacement:=Range("H" & ColumnHRow), LookAt:= _
 xlPart, SearchOrder:=xlByRows, MatchCase:=False, SearchFormat:=False, _
 ReplaceFormat:=False

 Rows(WhatRow).Select
 Selection.Replace What:="#hours#", Replacement:=Range("I" & ColumnIRow), LookAt:= _
 xlPart, SearchOrder:=xlByRows, MatchCase:=False, SearchFormat:=False, _
 ReplaceFormat:=False

 Rows(WhatRow).Select
 Selection.Replace What:="#established#", Replacement:=Range("J" & ColumnJRow), LookAt:= _
 xlPart, SearchOrder:=xlByRows, MatchCase:=False, SearchFormat:=False, _
 ReplaceFormat:=False

 Rows(WhatRow).Select
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Selection.Replace What:="#websitehyperlink#", Replacement:=Range("K" & ColumnKRow), LookAt:= _
xlPart, SearchOrder:=xlByRows, MatchCase:=False, SearchFormat:=False, _
ReplaceFormat:=False

Rows(WhatRow).Select
Selection.Replace What:="#website#", Replacement:=Range("L" & ColumnLRow), LookAt:= _
xlPart, SearchOrder:=xlByRows, MatchCase:=False, SearchFormat:=False, _
ReplaceFormat:=False

Rows(WhatRow).Select
Selection.Replace What:="#blueprintshyperlink#", Replacement:=Range("M" & ColumnMRow), LookAt:= _xlPart,
SearchOrder:=xlByRows, MatchCase:=False, SearchFormat:=False, _
ReplaceFormat:=False

Rows(WhatRow).Select
Selection.Replace What:="#robberies#", Replacement:=Range("N" & ColumnNRow), LookAt:= _
xlPart, SearchOrder:=xlByRows, MatchCase:=False, SearchFormat:=False, _
ReplaceFormat:=False

Rows(WhatRow).Select
Selection.Replace What:="#911calls#", Replacement:=Range("O" & ColumnORow), LookAt:= _
xlPart, SearchOrder:=xlByRows, MatchCase:=False, SearchFormat:=False, _
ReplaceFormat:=False

ColumnGRow = ColumnGRow + 1
ColumnHRow = ColumnHRow + 1
ColumnIRow = ColumnIRow + 1
ColumnJRow = ColumnJRow + 1
ColumnKRow = ColumnKRow + 1
ColumnLRow = ColumnLRow + 1
ColumnMRow = ColumnMRow + 1
ColumnNRow = ColumnNRow + 1
ColumnORow = ColumnORow + 1
WhatRow = WhatRow + 1
Loop Until ColumnGRow > 100

End Sub
```