We received several suggestions about how to adjust our project report. First, we had TA feedback asking us to add OpenStreetMap results to our collected data. With this suggestion, we added our findings from OpenStreetMap to the final paper.

We also had several suggestions from Group 4. The first was about including another image in the paper to illustrate how we did our accuracy measurements. An image was added to the paper to better demonstrate our methods. They also recommended that we use a more precise definition for accuracy of the result. Since this was a more general analysis and would require that we retake all of our data points, we decided not to apply this suggestion. Group 4 also suggested that we add more metrics, like the consistency of view while doing different operations like panning, and zooming in and out. We also opted to not do this since the further you zoom out, the harder it is to validate how close the marker is to the correct location.

We also received several suggestions from Group 9. The first was to collect data outside of the Twin Cities area. This was a good point, however due to time constraints and the need to visually verify the authenticity of each location, we are not able to do this for this project. We did mention in our future work section that we would like to extend this to other areas both in the state and in the country. They also suggested that we do repeated data measurement at one location (precision vs. accuracy) and see if they show same results. We decided not to do this, as we would be making the same request to the web server for these and this type of measurement would not really show us anything interesting. The same requests going to the server multiple times should return the same result. Group 9 also suggested to survey native apps vs. web-based apps and see if they show any difference in our results accuracy. For our data retrieval, we had used both web apps and native apps and these do not appear to have any effect on the accuracy. This makes sense, as both should be retrieving their data from the same data source.

Revised Report

1. Introduction

At the time of the writing of this paper, Apple Maps had recently replaced Google Maps as the main mapping application on iOS devices. Google Maps is considered by many to be the defacto standard for general user online mapping. Due to this, there have been many concerns and complaints about Apple Maps accuracy in comparison to Google Maps. However, there have been little analytical comparisons to see which mapping tool is more accurate over a wide range of target locations. In this paper, we will be comparing several commonly used, internet driven mapping solutions. We will be focusing on the location data for each of these and will be testing if each mapping system is capable of finding certain locations and how accurate they are able to mark them on a map.
2. Map Comparison

Each of the mapping systems we analyzed are gone over in detail below. We will be going into each map application briefly, covering where they get their data from, and any additional important information about the mapping systems.

2.1 Apple Maps

Apple Maps is a mapping application created by Apple. The mapping system is available exclusively on devices that use the iOS operating system. Apple Maps gets its data from several sources and combines the data together.

Apple Maps uses TomTom and Waze for map data, street data and for driving directions. These appear to be the main sources of map data provided to Apple Maps in the United States [1]. OpenStreetMap is also used by Apple Maps in some parts of the world for its visual map and street data. Although OpenStreetMap has location data available for locations in the United States, Apple Maps appears to only use this data when it does not have data from other mapping sources. As such, we have noticed that locations such as buildings on the University of Minnesota campus are not rendered when on the standard map setting, even though OpenStreetMap has these locations mapped and their location information available. OpenStreetMap is explained in further detail, below.

Yelp, Localeze, and Acxiom are used by Apple Maps for business and point of interest information. Yelp takes precedence over the other sources, as in addition to the name and location data it normally includes the location, ratings, and pictures [1]. Anecdotal evidence suggests a lack of a “live connection” to Yelp, and as such updates to Yelp do not appear in Apple Maps.

Apple Maps claims that it supports crowdsourcing, and that if a location is incorrect or missing that you can submit the location and it will be corrected. The two methods that are commonly mentioned on how to do this is to submit a report directly from the Apple Maps app, or go onto Yelp.com and add the location there. To verify this, we have submitted three separate requests to add missing locations to Apple Maps. One business location was submitted on 9/21/2012 both from within the Apple Maps application and through Yelp.com. Two other locations were submitted for buildings on the U of M campus on 9/30/2012, both through Yelp. One of the locations (Keller Hall) received a rating and a comment, while the other location (Tate Laboratory of Physics) received just a single rating. All three of these locations now show up in a search on Yelp.com, but none of them appear when searching in Apple Maps. Because of this, we have determined that Apple’s current methods for crowdsourcing are ineffective. It should be noted that OpenStreetMap’s data source also contains the two university location’s data and accurately displays them, so it would appear that not all data sources are used in certain situations.

2.2 Google Maps

Google Maps is a mapping application created by Google. The mapping system is accessible on any modern web browser and on most mobile devices. Google does not disclose
where all of their mapping data comes from, but they do mention that the majority of its US data comes from information off of their web search results, data submitted directly by business owners, from different publicly available Yellow Pages sources [2].

Like Apple Maps, Google Maps uses crowdsourcing to improve its location data. Any user is capable of submitting a new location or a correction to an existing location. Unlike Apple Maps, Google Maps does update based on user input. It was more difficult to find locations that we could add to Google Maps, but we were able to test fixing a misspelling of a company name. The submitted correction was visible in Google Maps within one day.

2.3 Bing Maps
Bing Maps is a mapping application create by Microsoft. The mapping system is accessible on any modern web browser and comes as a built in app on Windows Phones and Windows 8. Bing Maps underlying engine is powered by Nokia maps, and most of the user interface in Bing Maps is derived from the Nokia engine as well. Nokia owns their own mapping division and data [3].

Bing maps also partakes in crowdsourcing, though their website was the only location we were able to find to submit this data. Apps on the Windows Phone and Windows 8 did not provide a mechanism to report this data. Since most users will discover that a location is inaccurate while they are away from their desk, not including this capability on a mobile device is a possible hindrance to having people submit data corrections.

2.4 OpenStreetMap
OpenStreetMap is a collaborative project, much like Wikipedia, with an overarching goal of creating a free, editable, world-wide map. OpenStreetMap, with over 900,000 contributors, is comprised entirely of crowdsourced GPS data, aerial photography, and other freely available data. These data are available under the Open Database License. Anyone is capable of adding locations or correcting data on OpenStreetMap. Crowdsourcing is a very important part of this mapping solution. OpenStreetMap is primarily concerned with its data and secondarily concerned with a mapping system accessible via its website.

3. Difficulties
Initially, coming up with a valid scale to properly evaluate the different mapping solutions was a challenge. There are many different features that make each solution unique and valuable. We decided that we would evaluate only the data of point of interest locations produced from querying the map application, since this feature is notably the most. Therefore, road data, driving directions, and 3D images were not included in our study.

Another difficulty was our method of validating location accuracy. Since we had to visually verify each location, each data point was very time consuming to obtain. In addition, there was generally only one device that had to take a data point for each mapping application.

One of our data sources, Bing Maps, appears to have a slightly different approach to how they place their location data. The majority of Bing Maps data appears to be displayed by address and not actual building location. Because of this, the majority of their data appears on roads, often times on the wrong side of the street. We noticed this after our data collection metrics had been decided on and our techniques did not favor Bing’s accuracy ratings.
OpenStreetMap was also difficult to query, in general. Both the web browser and the iPhone app do not appear to take your current viewing window into account when you are searching. For instance, if your map is centered and zoomed in on your location and you search for “school”, you will receive results for schools found in several countries.

4. Data Collection

Our data was collected using each mapping solution and was visually verified. Both the existence of the location was tested as well as its accuracy. If a location was not found by a mapping application, that datapoint counted against its ability to find a location but did not count against its location accuracy. We used a three part scale for each accuracy measurement which were: “accurate” meaning that the mapping application correctly indicated the location within its perceivable property lines, “slightly-off” meaning the mapping application did not designate the location to be within the property bounds but was within 100 feet of it, and “way-off” meaning the mapping application indicated that the location was over 100 feet from its actual location.

(Figure #1: The green square indicates where the building’s approximate property line, including its parking lot. Anything inside of this square is counted as “accurate”. Inside the red square is “slightly-off”, and outside of that is “way off”.

Each of our result categories mentioned above were converted into a percentage of the overall data points taken. From these values, we could tell how accurate each mapping system’s location data was for points of interest.

5. Results

We collected data from multiple locations throughout the Twin Cities area, with over 50 locations that we visually verified the location data. We found that Apple Maps data found 86.04% of locations, Google Maps found 90.69%, and Bing Maps found 90.47%. Our data results are shown graphically in Figure #2 below:
For the locations that we surveyed, Google, Apple, and Bing maps all had similar success rates in finding locations. OpenStreetMap however was able to find far fewer locations than the other three solutions. However, the locations that OpenStreetMap did find tended to be very accurate. Bing Maps appeared to be the opposite of OpenStreetMap, with it being able to location almost as many locations as Google Maps, but tending to be very inaccurate with its location data. In our study, Google Maps was determined to be able to find the most locations and was the most accurate about their positions.

6. Reflections

One area that we found interesting was that Bing Maps was able to find more locations than Apple Maps, but the locations that Apple Maps did find were almost always far more accurate than Bing Maps. Bing maps has been around for quite a while, and it is surprising that their have not been as many high profile complaints about its accuracy compared to Google Maps. This could possibly be due to Google Maps not having an app for the Windows Phone devices.

We were quite disappointed with our findings of Apple Maps usage of crowdsourced data. Reporting several missing locations to Apple did not generate any data additions, even over the course of several months. Google Maps however, displaying our update within a day of our submission, appears to respond as fast as could be expected while still retaining some level of backend validity checking. If Apple Maps was able to absorb crowdsourced data as fast as Google Maps currently seems to, we believe that the two's location accuracy would quickly approach a similar value. Bing Maps however seems to require a much larger data adjustment in order to get its data accuracy to the same quality as both Google, OpenStreetMap, and
Apple maps. We believe this is because their data is based more off of street address locations instead of actual building locations.

7. Future Work

There are several portions of this analysis that could be extended in future work. Adding additional data points would be crucial before definitively concluding any map is more accurate than another. All of our data points came from the Twin Cities area in Minnesota, which is not a large enough dataset if one was to try to evaluate the entire United States. However, these trends were fairly consistent throughout the entire data set we collected, and little change in the percentages were observed after the first twenty data points were collected.

Another area of future work would be in usability of the mapping solution. During our usage, Google and Apple Maps appeared to be easier to use than either Bing. However, all three were much easier to use than OpenStreetMap, since sometimes it wanted the location along with the city you were searching, sometimes it wanted the location along with the state, and sometimes it wanted both. Since usability is an important issue surrounding the update of a technology by users, usability will play an important role in future mapping technologies.

8. Conclusions

Our data indicates that Apple Maps does indeed have fewer and less accurate “point of interest” information than Google Maps. Of the data sources compared, Google Maps ranked the highest in both percentage of locations found and their accuracy. We have found that both Apple Maps and Bing Maps have the potential to improve on their accuracy and gain on their rating in comparison to Google Maps, but also that they need to adjust some of their current crowdsourcing techniques in order to be as effective as Google Maps is at incorporating data fixes. OpenStreetMap also does not appear to have as much data as Apple Maps needs to compete with Google Maps, which may be the reason why Apple chose to go with a data mashup instead of a single data source for their mapping data.

9. Sources

