Use of Mobile Application Development Technologies in Capstone Projects

Shuju Wu
Central Connecticut State University
swu@ccsu.edu

Xiaobing Hou
Central Connecticut State University
xhou@ccsu.edu

Karen Coale Tracey
Central Connecticut State University
tracey@ccsu.edu

Abstract

This paper presents the authors' continued efforts to apply mobile application development technologies in our undergraduate and graduate capstone projects in the Department of Computer Electronics and Graphics Technology (CEGT) at Central Connecticut State University (CCSU). Specifically, the efforts are introduced in the context of three graduate and one undergraduate senior capstone project, all of which are closely related to the State of Connecticut's first bus rapid transit system, namely CT*fastrak*. The projects have successfully promoted student engagement in hands-on research, a high impact practice identified by the American Association of Colleges and Universities, enhanced various technological and project management knowledge in their areas of study and skills of collaboration with teammates, other teams, and local government and business. In addition to the bus tracking and trip planning system developed, the success of the projects has also provided a framework for faculty and students to develop similar projects, with components usually available on campus.

Introduction

In engineering and technology education, capstone project experience is a valuable component to increase student motivation and engagement in real life problem solving, as well as to enhance their independent study capability. In CEGT, both undergraduate Computer Engineering Technology students and the graduate Computer Information Technology students are required to take capstone project courses. One of the challenges both students and faculty face is topic selection. A good research project will help faculty explore new research ideas and students gain real-world experience and cutting edge technologies. A common area shared by the two programs is computer application development, and mobile application development is an ideal capstone project topic in this area. Mobile phone industry has been ever growing over the last several years. One study shows that there are more mobile phones in the US than people [1]. A mobile application development project requires project formulation, platform and development tools selection,

application design, application development and debugging, documentation, and presentation. Additionally, various design and development issues must be studied.

Mobile application development is the fruit of technological change and growth in the mobile market, and among the multiple development platforms, iPhone iOS and Google Android are now the dominant market shareholders, together with other mobile operating system such as Blackberry RIM and Windows 8 [2]. It is also estimated to have a huge job market potential worldwide [3]. Our current undergraduate and graduate programs offer some programming courses such as C++, JAVA, and VisualBasic etc.; however, none of them focuses on mobile application development. Therefore, we expose students with opportunities of using such technologies in real-life projects to enrich their experience, and at the same time, enhance faculty collaboration and capstone project advising. We also hope to gain experience and guidance through the capstone projects to enrich the current curriculum with related technologies.

The key of an application development project is to find a target application that solves real life problems. The CT*fastrak* project from the state DOT aims to provide a new bus transit system interconnecting over 60 routes and providing travellers convenient access to work, shopping, universities, downtown and other entertainment destinations. This paper introduces four capstone projects (three graduate and one undergraduate) that use mobile application development and other related technologies to design a bus tracking and trip planning system for the CT*fastrak* project. The projects provide passengers with mobile applications on either iPhones or Android phones that enable them to view real-time bus location, delay information, bus schedules, and points of interest. There is also trip-planning capability in the application. In addition to the passenger-side application, the projects also provide necessary functions on the buses and the transit control center for management purpose. At the end of this paper, guidelines and suggestions are provided to help similar programs develop their own mobile application development projects.

Related Work

Normally, in addition to printed schedules, bus information in a transit system can be accessed through one of two ways: by visiting the system website directly, such as Where's My Bus (WMB) [4], Chicago Transit Authority (CTA) Bus Tracker [5], and NextBus [6], or by running a mobile application on the local smartphone, such as My Nextbus [7] and Centre Area Transportation Authority (CATA) [8], which in turn accesses information from the system and presents the result to users. System such as WMB can be very system-specific and targets a specific city; therefore, most of the applications cannot be easily implanted and they are generally not open-source. NextBus provides service to multiple transportation systems, therefore lacking customization. Commercially available systems are sold or licensed to transportation systems and continuous costs may be incurred. Mobile applications are often free to end users; however, they are generally designed for specific transit authorities and are tied to server-side applications, which, in turn, are not open-source and free.

In addition to the above issues, bus-tracking systems such as WMB and NextBus do not show real-time bus locations on routes, and they also do not provide points of interest service to the end users. CTA Bus Tracker shows the real-time bus location but has no mobile application. Most client-side mobile applications are similar with some providing text-based route information [7] and others providing Google Maps graphic-based route and location information [8].

The projects introduced in this paper design a complete transit bus tracking and trip planning system for the CT*fastrak* project. It not only includes a mobile application but also the necessary function on the buses as well as the transit control center server application. Unlike most systems that use Google Maps, we adopt OpenStreetMap [9], which is open-source and free. It also allows the user to generate updated and customized maps (e.g., community and local attractions) to reflect map change. Overall, our objective is to design a customized, cost-effective, efficient, and user-friendly bus location and tracking system specifically for the CT*fastrak* project.

Case Studies

This section presents four case studies. The first reviews current mobile technologies aiding transit systems. In addition, both quantitative and qualitative analyses are provided to support the statement that by providing a dependable information system the usability of the CT public transit system can significantly be enhanced. The second presents a user-friendly iPhone application design (called CCSU Go) to provide CCSU students (but not limited to) with an enhanced transit experience that would attract and retain student riders to CT*fastrak*. The third performs similar tasks but in the Android system. The fourth describes the application design, development, and implementation of a bus tracking and planning system. Based on the previous projects, this one is the most complete and fully functioning system.

Bus Rapid Transit (BRT) System

This study investigates current application technologies used in transit systems and the effects they have on commuters. Such technologies include the automated vehicle locator (AVL) and Google Maps, which help increase the users' consciousness about his/her surroundings, survey links to users commentaries and suggestions for improvements, and CT DoT site to keep the user up-to-date on the *CTfastrak* progress, etc. The objective of this study is to provide a solid foundation on a user-friendly AVL application and valuable research for future capstone projects on *CTfastrak.*

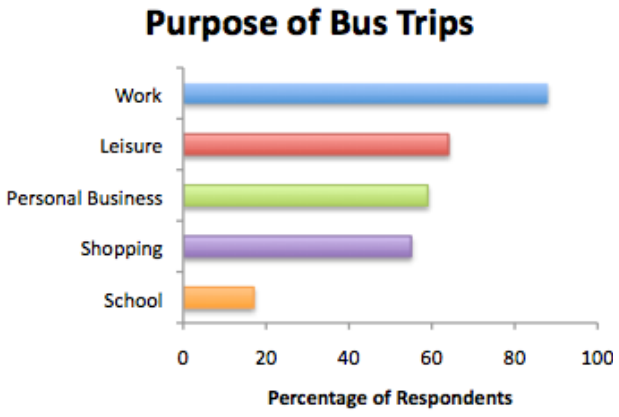

Figure 1. >60% responders indicate the most frequent reason for using it was work related

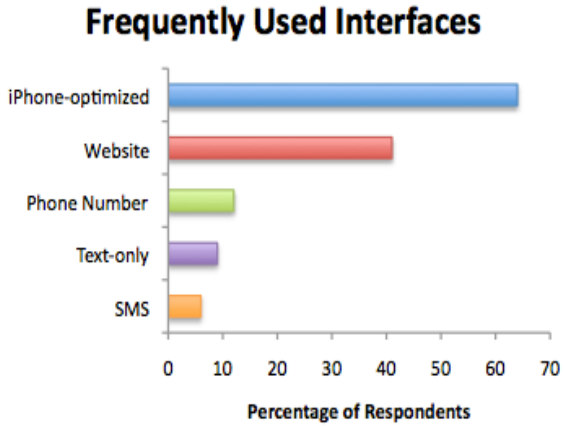

Figure 2. >60% responders use mobile phone (iPhone) for response

Bus passengers prefer to spend as little time as possible waiting for the bus and have safety on and off the transit system. AVL is what will contribute in both areas. An AVL device is composed with hardware, software, and a map system allowing the requester to determine the exact geographical location of the vehicle. One study [10] shows that "travelers may increase their trip-making frequency as a result of real-time transit information use, and positive psychological outcomes are more prominent in both short and longer terms." By providing real-time information, passengers can be assured that the mobile application will minimize the time spent waiting for a specific bus that they need to take to get to their destination, hence assuring safety. Therefore, an AVL is an indispensable component for a successful CT*fastrak* system.

The points of interest supply a user with helpful and interesting information about the route, and passengers can become more familiar with the transit system and the nearby locations. A transit application system should allow the customization of the station and points of interest information, which can provide more convenient service to the bus passengers in the area. This capstone project suggests that the CT*fastrack* mobile application utilizes feature similar to Google Maps, Google Latitude, or other open-source and free software such as OpenStreetMap [9] to provide location-based services.

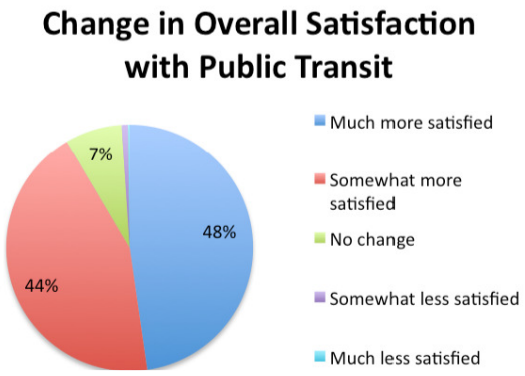

Figure 3. Change in overall satisfaction when using mobile application transit tool

The study also reviews the statistical data from research performed by universities, and public/private organizations on mobile applications that are currently in use and investigates the effects of various mobile application technologies such as OneBusAway [11] (Figures 1-3), TransLoc [12], and Google Transit [13] on commuters. The study helps in demonstrating the overall perception of using public transit with a mobile application, including satisfaction, safety, waiting time, and more versus passenger cars when planning a trip or commuting between cities. The data are derived primarily from surveys taken by both the regular transit and first time or infrequent users. The information provides valuable information as to what should be expected once CT*fastrak* goes into operation. Furthermore, the mobile application will help in addressing the demographics, frequency, and reason of transit usage, reliability, and usability of the mobile application software as to make the CT*fastrak* mobile application more reliable and accommodate passengers' needs. The capstone study shows that if a reliable transit tool and transit system is available, people are more willing to utilize it. In some cases, they can even contribute to a mode of transportation switch once passengers become accustomed to it.

CCSU Go (iOS)

CCSU Go uses students as the general user pool although the application itself can be used by anyone. The motivation for the capstone project is that recent studies [14] shows that millennial generation or those adults between the ages of 18-31 have exhibited a behavior shift when it comes to personal transportation. From 2001 to 2009, the vehicle-miles traveled per person for people between the ages of 16-34 declined by 23 percent. At the same time, the per person miles traveled on transit increased by 40 percent, miles biked increased by 34 percent, and miles walked by this demographic increased 16 percent.

CCSU Go is developed on Apple's iOS. As show in Figure 4, CCSU Go (CCSUtransit App in the figure) allows students to view bus schedules, find fare information, and provides location specific listings of attractions and stations. It also enables the user to access the CT Transit Trip planner website within the application and contains phone numbers for other modes of transportation. CCSU Go also includes links to CCSU Hertz On Demand car sharing service, the NuRide Rewards program, CT ride, and CT*fastrak*. Users are connected

to the webpages without leaving the application. Due to space limitations, the phone application interface will only be presented in the last case study. It should be noted that this study focuses on the functionality specifications and interface design in iOS. GPS, trip planner and points of interest will depend on and need the installation of Google Maps. A later case study in this paper will have all the functions built in the mobile application.

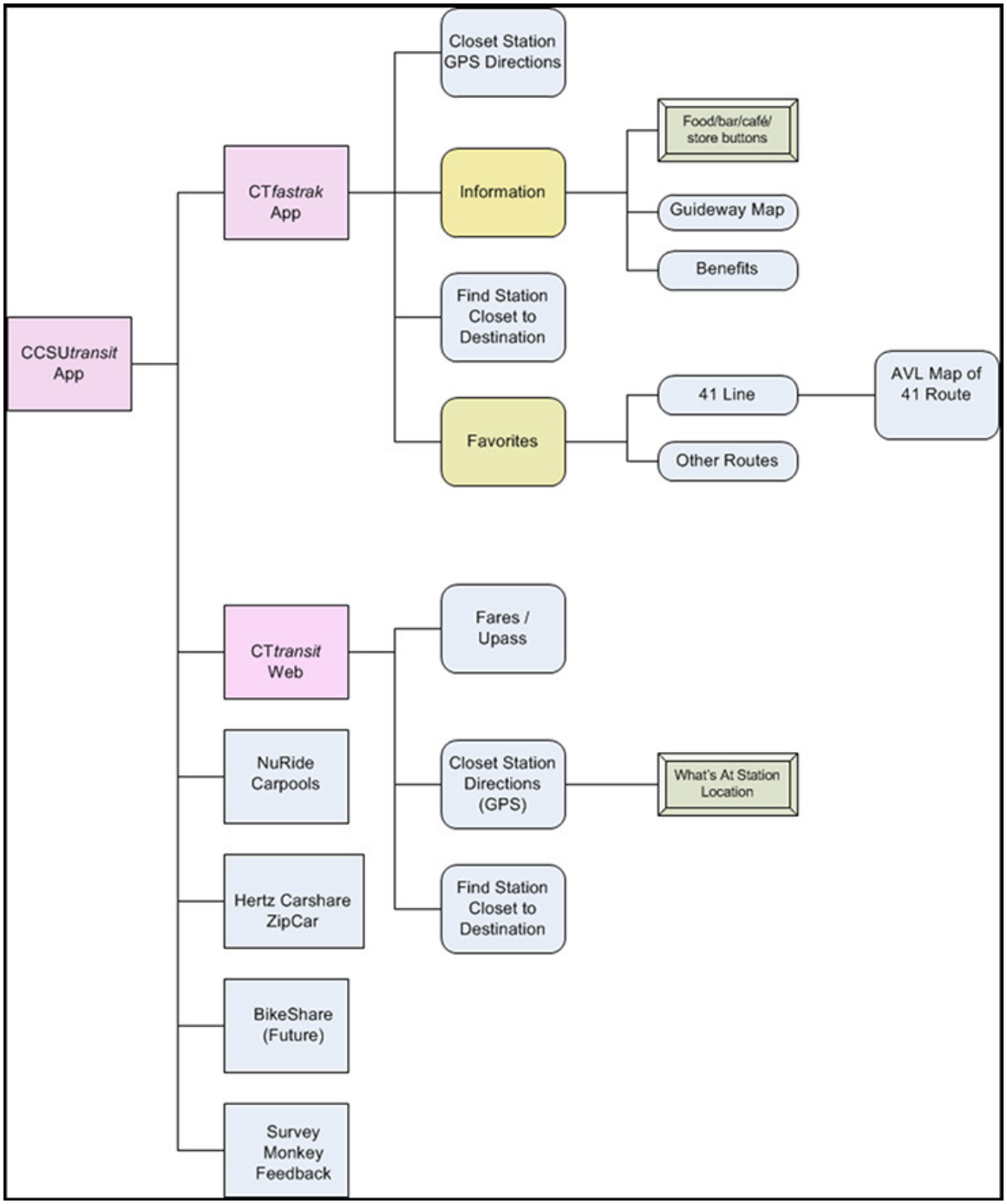

Figure 4. Application flowchart for CCSU Go

ISBN 978-1-60643-379-9

CCSU Go (Android)

The previous case study describes the CCSU GO application in Apple iOS, while this study describes another version of the CCSU Go developed for Android phones. So when looking at the transition of the CCSU Go from Apple to Android, users would prefer that the usability of the application does not change dramatically. As it is, the platforms of iOS and Android are quite different; therefore, the plan is to make the application as similar as possible, considering both appearance and the most important functionality. Figure 5 shows the CCSU Go (Android) application interface and functionality flow chart. Due to the space reason, the phone application interface will only be presented in the last case study.

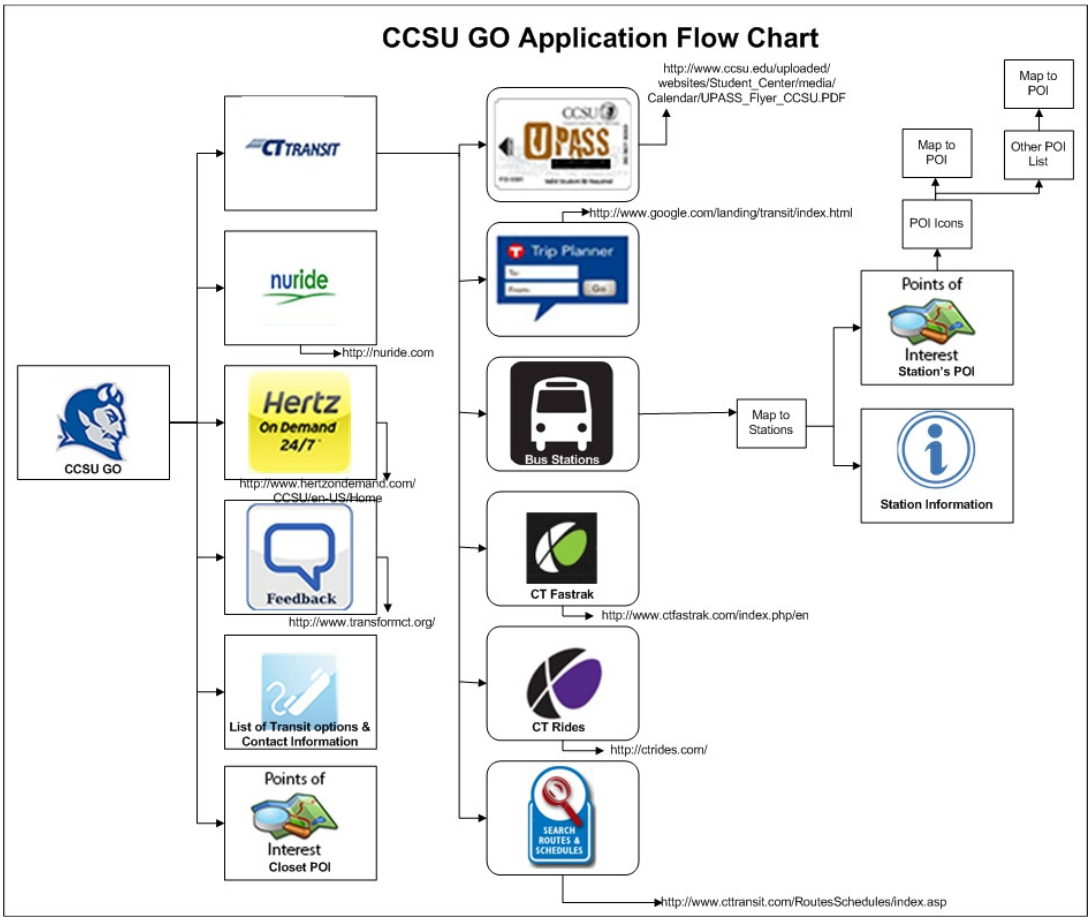

Figure 5. Application flowchart for CCSU Go (Android)

Bus Tracking and Planning System

The detail of the work for this case study is published in [15]. Figure 6 depicts the bus tracking and planning system that consists of three modules: bus-side application, server-side database and client-side (passenger-side) application. The current bus-side application is developed on mobile phone with GPS receiver capability to acquire location information,

calculate delay, and report to the transit center (server-side). The server-side database holds the updated location and delay information for all the buses on the routes and provides response to passenger queries. The user-side mobile application enables the clients to access the bus information from the server to find out bus arrivals, departures, real-time delay, points of interest, and plan their trips.

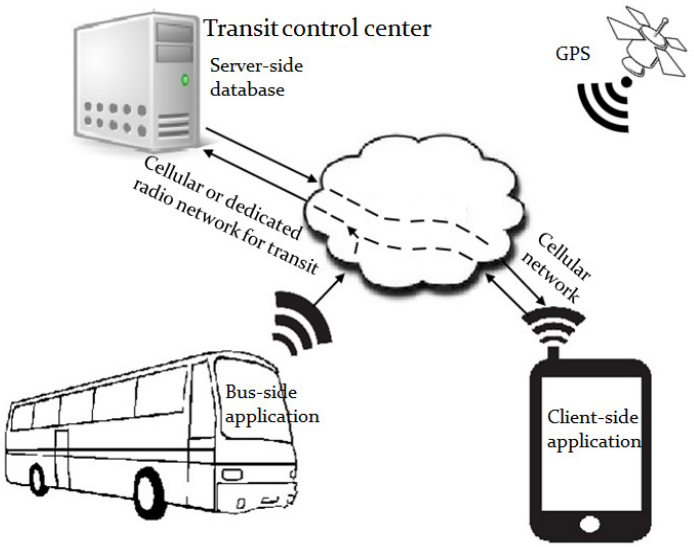

Figure 6. Bus tracking and trip planning system architecture

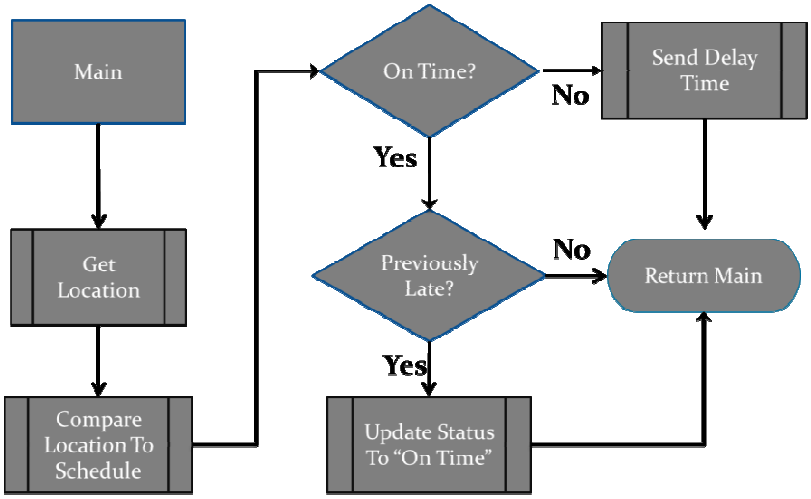

Figure 7. Bus-side application flowchart

The mobile application design for the bus-side is shown in Figure 7. The bus-side application tracks the bus location via GPS and periodically sends location update and delay (if any) to the server. When the user-side application sends a request for location and delay, the server will reply to the request. The user-side application provides the following tasks:

- Provides detailed bus route information, including route overview and information about each stop. Client users can download the client-side application and have the route and stop information updated.

- Provides interactive map-based trip planning service. Client users can input the desired destination, and based on the current location of the user (through the phone's GPS module similar to the bus-side application), the system will provide a calculated route and display the route on the map.

- Provides a user with turn-by-turn navigation to any desired bus stop. This helps a client to arrive the nearest bus stop from the current location.

- Displays points of interest near the bus route

- Shows clients the real-time locations of buses

Figure 8 shows the home screen of the client-side applications. By extending the menu on the home screen, clients can track the buses on route, plan a bus trip, browse the available stops and find points of interest near the bus stops. Figure 9 shows the two buses that are currently on the queried bus route and the related information such as stop name and arriving time. Figure 10 shows the trip planning function of the system. Clients can select a destination, and, based on the current location, the system will be able to find a route with departure and destination stops as well as the path to get to the departure stop from the client's current location.

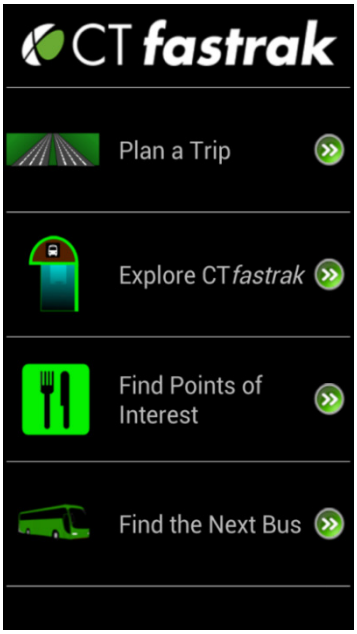

Figure 8. Home screen

Figure 9. Bus tracking

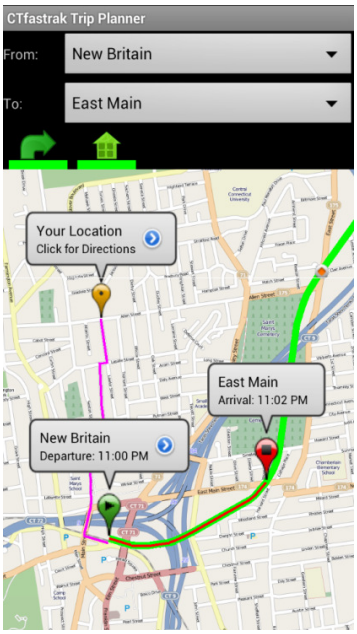

Figure 10. Trip planner

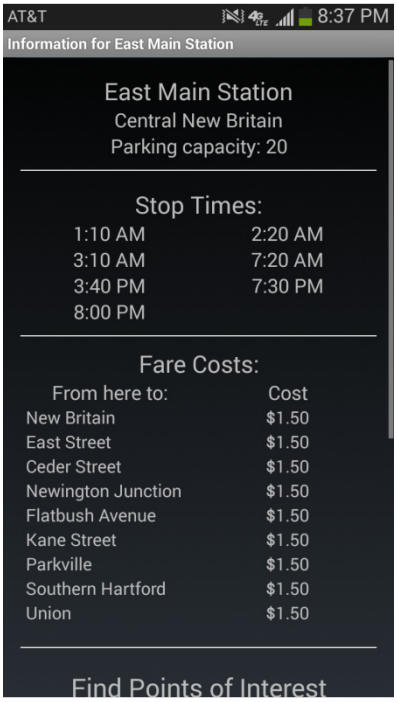

Figure 11. Station information

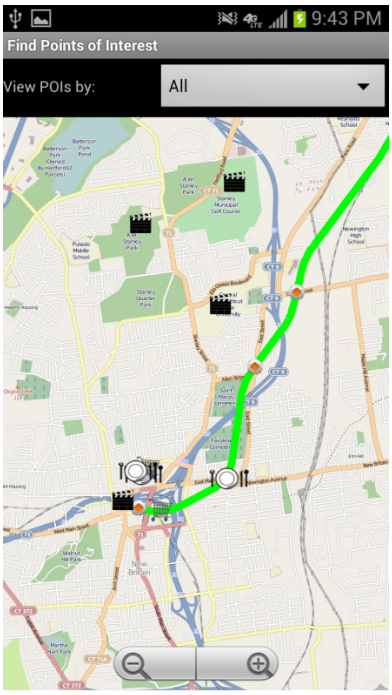

Figure 12. Points of interest

As shown in Figure 11, the system also allows clients to check the bus station information including the parking lot size, departure times and fare costs. Client can also find the points of interest of each station, as shown in Figure 12. The points of interest are intended to supply a user with helpful and interesting information about the route and passengers can become more familiar with the CT*fastrak* system and the nearby locations.

Summary

The work introduced in this paper is the continued effort based on a previous work on mobile application development [16]. The success of the four projects demonstrates the feasibility of a framework of student hands-on research projects in this fast growing area. Similar projects can be developed for undergraduate or graduate capstone projects. Using the similar devices and application development tools, different mobile applications can be developed. The applications can be realistic if faculty and students collaborate with various departments or organizations on or off campus. The following are the components required for such projects:

- *Devices*: Different devices are needed for developing mobile applications on different platforms. Since iPhone iOS and Google Android are used in the four projects, the devices used are listed below.
  - An Apple Mac computer (Mac Pro, Macbook Pro, Mac mini, etc.) is required for programming, and an iPhone or iPad is used for testing.
  - A PC is required for programming, and an Android phone or tablet is used for testing.

- *Development tools*: Same as the devices, different software tools are required by the two platforms.
  ○ Apple Xcode is used to invoke iPhone and iOS internal functionality and HTML/CSS/JavaScript for web application development. Optionally, independent third-party development environments such as MonoTouch can be used instead of Apple Xcode.
  ○ Eclipse is an open-source software and extensible integrated development environment (IDE). It incorporates Android development tool (ADT) plug-in to build android applications. JQuery is a user interface (UI) framework, that helps build a web application to integrate that in Android application. MySQL is an open-source database that helps store, manage, and manipulates data.

- *Curriculum*: Before starting the research work, students should equip themselves with knowledge from areas including collaborative project development, information systems in business, research skills, Internet technology, foundations in computer science for arrays and dictionary used to store data, stacks used in view management, and software engineering for the design and development processes. In addition, to support remote server and database access, students must have a good understanding of networking technology, network application development, server administration, database management, and information security.

- *Collaboration* :To target at a real life application, it is critical for the team to work with users in other departments on campus, state and local government, businesses, and various organizations. Students understand their own life and local business or government, and such projects would benefit them in a long run by networking with their potential employers and colleagues. On the other hand, mobile applications are a new and fast growing market. Such applications are in great need. Therefore students can easily find users and develop them a mobile app for free or at very low cost.

Conclusions

This paper introduces four capstone projects, including both graduate and undergraduate, that target at a state bus rapid transit system and focus on different aspects. Together, they successfully developed a bus tracking and trip planning system. The experience achieved from these four projects is very beneficial for both the students and faculty members. As a direct result, the faculty members have organized a series of workshops on Microsoft Windows mobile application development to extend the horizon. With enough feedback and support, future seminar or special topic courses could be developed on mobile application development. The paper also summarized the experience achieved and the components required to develop a similar capstone project targeting at various applications. The components are usually available on campus, if not free.

References

[1] CTIA Wireless Quick Facts. (2014). Retrieved from http://www.ctia.org /advocacy/research/index.cfm/aid/10323

[2] Mobile Application Development. (2014). Retrieved from http://www.bbconsult.co.uk/Expertise/MobileApplications.aspx
[3] VisionMobile and Plum Consulting. (2014). The European App Economy: Creating jobs and Driving Growth. Retrieved from http://www.visionmobile.com/product/the-european-app-economy/
[4] WMB: Where's My Bus. (2014). Retrieved from http://wmb.unm.edu/
[5] CTA Bus Tracker. (2014). Retrieved from http://www.ctabustracker.com/bustime/home.jsp
[6] Real-time Passenger Information. (2014). Retrieved from http://cts.cubic.com/solutions /realtimepassengerinformation/nextbus,inc.aspx
[7] My Nextbus. (2014). Retrieved from https://play.google.com/store/apps/details?id=com.blogspot.msandroid.mynextbus&hl=en
[8] Centre Area Transportation Authority (CATA). (2014). Retrieved from http://www.catabus.com/Announcements/Mobileapps.html
[9] OpenStreetMap. (2014). Retrieved from http://www.openstreetmap.org
[10] Zhang, F. (2013). Traveler Responses to Real-Time Transit Passenger Information Systems. Retrived from http://hdl.handle.net/1903/11168
[11] Ferris, B., Watkins, K., & Borning, A. (2011). OneBusAway: Behavioral and Satisfaction Changes Resulting from Providing Real-Time Arrival Information for Public Transit. *Proceedings of the 2011 Transportation Research Board Annual Meeting.Paper #11-0440-2*., (pp. 1-15). Washington, D.C.
[12] Hundson, K. (2013). Blackboard Mobile Central Adds Transit Info Partner to Platform. Retrieved from http://campustechnology.com/articles/013/02/28/blackboard-mobile-central-adds-transit-info-partner-to-platform.aspx?=CTNU
[13] Google Developers. (2013). Google Transit. Retrieved from https://developers.google.com/transit/gtfs/.
[14] Federal Highway Administration. (2013) . National Household Travel Survey. Retrived from http://nhts.ornl.gov/det
[15] Wu, S., Carroll, S., Krostoski, J., & Boyd-Carter, K. (2014). A Bus Tracking and Planning System for CT*fastrak*. *Proceedings of the ASEE Annual Conference. Paper #10612*, (pp. 1-11). Indianapolis, IN.
[16] Hou, X., Schaefer, R., & Brown, R. (2012). Development of an iPhone Application and a Study of Its Design Issues. *Technology Interface International Journal*, *13*(1), 81-87.

Biographies

SHUJU WU is currently an associate professor in the Department of Computer Electronics and Graphics Technology at Central Connecticut State University. She received her Ph.D. degree in Information Science from the University of Pittsburgh in 2004. She is a member of IEEE. Dr. Wu may be reached at swu@ccsu.edu.

XIAOBING HOU is currently an assistant professor in the Department of Computer Electronics and Graphics Technology at Central Connecticut State University. He received his Ph.D. degree in Information Science from the University of Pittsburgh in 2006. He is a member of IEEE and ACM. Dr. Hou may be reached at xhou@ccsu.edu.

KAREN COALE TRACEY is currently a professor and department head for Computer Electronics and Graphics Technology at Central Connecticut State University. Dr. Tracey may be reached at tracey@ccsu.edu.