The Design and Testing of Hand Held Devices to Assist Persons with Disabilities to Navigate Bus Services

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Daniel is a senior majoring in Mathematics and Computer Science. This paper is the result of research conducted through the Adrian Tinsley Program under direction from Dr. Uma Shama and Mr. Lawrence Harman. This research is a continuing project that will be expanded into an Honors Thesis and will be presented in the National Conference of Undergraduate Research in April 2008.

Abstract

Many transit systems around the U.S. are using global positioning systems to track their buses. Some of these systems provide bus locations in real-time on web maps. With internet integration becoming common in portable electronics, this research project analyzed the opportunity to utilize mass market devices to assist the general public and persons with disabilities to access and navigate fixed route bus services. This study has taken advantage of the state of the art automatic vehicle location systems aboard the Cape Cod Regional Transit Authority and MetroWest (Boston) Regional Transit Authority bus services, Microsoft Virtual Earth mapping services and Microsoft MapPoint Web Services to design, build and test hand held device interfaces and powerful web applications on personal computers for transit customer information systems. These technologies can provide all consumers, particularly transit consumers with disabilities, with improved access to mainstream bus services.

Introduction

This report presents the result of an Adrian Tinsley Project Summer Grant to research hand held devices to aid in navigation of bus services sponsored by the Office of Undergraduate Research, the Bridgewater State College Foundation, and the President’s Office. The objective of this research initiative was to research and develop methods for accessible information delivery of transit information to consumers. Specific objectives included:

To conduct a literature survey in order to explore what tools are available to consumers currently for geospatial location of transit systems, both vehicles and routes.

To analyze and make any necessary changes to the information delivery system currently in place at the GeoGraphics Lab receiving current data of vehicle location.

To develop a web interface in order to deliver the information through a highly accessible medium.

To extend the web interface to automatically cycle through the available routes on the transit system in order to be used for a large automated display.

To research hand held device interfaces and to create an interface accessible on hand held devices.
Three primary sites were used for collection and delivery systems. These sites were 1) Bridgewater State College’s (BSC) transit service running routes throughout the BSC campus and a connection route into Brockton, MA; 2) the Cape Cod Regional Transit Authority, (CCRTA), running routes throughout the peninsula of Cape Cod, Massachusetts; and 3) MetroWest Regional Transit Authority, running routes throughout the MetroWest region of Boston, Massachusetts. The use of these sites allowed the study of multiple transit route systems, including fixed route systems and a demand response system provided by the CCRTA’s Flex Route Service. It also enabled a collaborative use of GeoGraphics Lab and CCRTA resources in order to purchase and set up a large flat panel display at the Hyannis Transportation Center to test a large display prototype for information delivery.

There were three main forms of delivery that were designed and tested. These delivery methods were a 1) a personal digital assistant (PDA) powered by the Windows Mobile 5.0 Operating System, 2) Web systems using the Microsoft Virtual Maps Interface readily available through computer web browsers, and 3) a large high-definition flat screen display running at an intermodal transportation center.

Although this project was initially designed to have a primary focus on American with Disabilities Act (ADA) accessibility to be built directly into the programs, however it was later determined that the focus of the development should be to coordinate with existing programs and technologies readily available to those persons with disabilities. These technologies include text reading and magnification programs built into the Microsoft Windows Operating System and more powerful and focused programs. Another focus became ensuring that the information was available through multiple platforms, allowing for the most accessibility regardless of the user’s technological ability or current device availability.

This report will describe the project as well as the methodology used, provide the result of the analysis of the systems, offer lessons learned through the project in the form of a conclusion, and include examples of data received and the systems developed.

**Project Description**

**Task 1: Literature Survey**

**Task Description:** A brief review was conducted on 1) current and upcoming advancements in the transit field with respect to real time positioning and location devices, 2) appropriate mapping interfaces to run such programs on wireless Personal Digital Assistants (PDAs) and smart phones using available mapping software, 3) the programming language of the mapping API to be used for best practices and capabilities and 4) ADA requirements for the communication of transit information.

**Methodology:** This review was undertaken using internet search engines (e.g. the National Academies’ Transportation Research Board on-line transportation information research database, TRIS online) to find current technical and news web sites of these issues and capabilities. I was also able to use quite a few current texts on the issues and programming methodologies provided under the grant stipend.

**Task 2: Analysis of Information Delivery Systems**

**Task Description:** An analysis of Assisted Global Positioning System (A-GPS) data from the busses being received prompted modifications to the software programs of the Nextel/Motorola i355 cell phone so the geographic information would be received at an extremely high refresh rate (2 – 4 seconds) with improved reliability. This provided the most accurate and up to date information to the consumer.

**Methodology:** The researcher worked collaboratively with other GeoGraphics Lab staff in order to improve two systems. The first was a Mobile Data Terminal (MDT) program developed for the Motorola i355 cell phone using the Nextel iDen network for data transmission. Data refresh rates were somewhat unreliable on what was called the MDT 2.0 program. With the development of MDT 2.1, refresh rates were consistently under 5 seconds. The second system used data being received from Mentor mobile data terminals to a central server at the Cape Cod Regional Transit Authority Operations Center. A program was developed that utilized Structured Query Language (SQL) Stored Procedures and C# libraries for data transmission on the web in order to extract the data from the SQL Server located at the Operations Center and transmit it to a SQL Server housed at the GeoGraphics Lab in order for plotting and analysis purposes. Prior to research work this summer, the GeoGraphics Lab was only receiving geographic data from the buses equipped with mobile data computer transmitting over a private radio network using a BSC-developed Java program. A C# program developed by the Lab during the summer transmitted GPS locations from a new fleet of buses using a new sophisticated mobile data computer over a public data network (PDN) operated by Sprint™. Data from these two “legacy” systems were combined with the A-GPS automatic vehicle location (AVL) data on three “trolleys” running in Wood’s Hole on one integrated intermodal “Cape Cod Transportation Partners” web mapping application at the GeoGraphics Labs www.geolabvirtualmaps.com using Microsoft’s Virtual Earth mapping platform.
Task 3: Develop a Web Interface

Task Description: The researcher then used the information collected in Task 2 to create a web interface for the Bridgewater State College transit system, MetroWest Regional Transit Authority, and Cape Cod Regional Transit Authority that can be used by consumers for tracking real-time spatial information on the operation of the respective bus system.

Methodology: Microsoft Active Server Pages (ASP.Net) 2.0, Javascript, Microsoft Virtual Earth, Microsoft MapPoint and the C# Programming Language technologies were used in the Microsoft Visual Studio 2005 Integrated Development Environment (IDE) to program a web mapping interface that is able to take the Latitude Longitude information that is being received by the buses, translate it into a nearby street address (reverse geocoding), and plot the information on a map that uses high resolution imagery and has route data programmed. This information is then hosted on an Internet Information Services (IIS) Web Server located in the GeoGraphics Lab that is widely available for anyone with internet connectivity.

Task 4: Extend the Web Interface for an Automated Display

Task Description: In order for the web interface to be widely available to those who may not have internet connectivity or are uncomfortable with the web interface as well as for those with mild visual impairments, an automated display of the information was to be developed.

Methodology: A display was strategically placed in the Hyannis Transportation Center that utilized an extension program of the web interface to cycle through the available routes of the Cape Cod Transit System, showing the real time locations of the buses as they traveled. A large screen (46") Liquid Crystal Display (LCD) flat panel display attached to a computer was used to show this modified program. The program demonstrated all the mapping features of the Cape Cod Transportation Partners real-time AVL web mapping application, including 1) map display at small and large scale; 2) map display of roads, aerial/satellite photography and hybrid combinations of the two; 3) a display of the area covered by each route, then display of the route using the road map, and a display of the route using the high resolution vertical imagery, 4) then a display of the route from a “bird’s eye” perspective of 45 degrees from an elevation of 450 feet, and 5) in all cases the real-time location of the buses were being displayed at a refresh rate of 5 seconds. The software program for the Hyannis Transportation Center displays all the routes on Cape Cod in this manner; ending with the Hyannis Transportation Center location and high-resolution oblique photograph of the HTC with real-time display of buses at that particular moment in time. Please see the appendices for pictures of this display.

Task 5: Research and Create Methods to Deliver Information Over Hand Held Devices

Task Description: The researcher then looked into ways to deliver the information to personal hand held devices for accessibility using the Microsoft Windows Mobile 5.0 Operating System and Personal Digital Assistants (PDAs), however, future applications using “smart phones” was included in the research conducted on this task.

Methodology: Microsoft’s ASP.Net 2.0 and SQL technologies were used to create web pages that would follow high web standards and be only text and table based so that such pages would be accessible on multiple hand held devices with web browsers that are capable of interpretation of ASP pages. The same reverse geocoding technology was incorporated into these pages for ease of use. These pages were then tested using a PDA purchased through the summer grant material stipend. Other accessibility programs were also researched for the Windows Mobile Operating System, such as magnifier programs and text to speech programs.

Analysis

The Federal Transportation Administration (FTA) recognizes that public transit serves many public purposes, but cites the most fundamental of them to be what they call “affordable mobility”. They state that “All transit systems provide low cost mobility for people who do not, or cannot, operate a motor vehicle because of personal preference, low income, disability, youth or old age. An important characteristic of low cost affordable mobility service is that regular access is provided to as many destinations as possible. Trip types include, school, medical, business, shopping, recreation, social, etc. It is estimated that these types of trips comprise about 65 percent of total transit ridership.1 The interfaces created under this project serve as tools in order to navigate the services available to all people in a more effective manner. Knowing where the buses are in real time helps consumers to know when they need to be at their bus stops and if the buses that they will need to take in order to reach their destination are on time. By creating three different platforms to deliver this information, all consumers regardless of their current technical knowledge and equipment are able to utilize the service in some way or another, whether it be from home before they start their trip, while they are navigating the services by themselves, or while inside transfer stations or other strategic locations for heads up displays. For future work and resources, it may be able to be possible to have one of these automated displays at every stop, especially with the reduction of display prices. For the handhelds, it was surprising that they were still not able to handle the full Microsoft Virtual Earth or Google Maps platforms. Thus, highly accessible text

based pages were created. With more powerful handheld devices increasingly available (such as the Palm Treo running Windows Mobile or the Apple iPhone running a modified version of OS X) it is only a matter of time before handhelds will have the capabilities to support full mapping platforms. Until that day, the text based page solution, developed by this research, provides the transit consumer with a PDA with precise and timely real-time information on bus locations in the palm of their hand. Thanks to the effort by Microsoft and Apple to adapt their devices for use by individuals with visual impairments there are many available text to speech programs.

**Conclusion**

There were many more projects than initially considered in order to achieve highly reliable and constant data from all of the transit information systems. A workflow of the data transmission can be found in the appendices. Currently, geospatial data is received and mapped in the range of 2 sec – 2 min depending on the devices capabilities and transmission times that are used to collect it.\(^2\) For transit vehicles using the BSC A-GPS AVL cell phones, the refresh rate is a world class 2-4 seconds. This information is then plotted on the Microsoft Virtual Earth platform. The Virtual Earth platform was chosen for this project because of its integration with the C# and ASP languages, the availability of the MapPoint Services for reverse geocoding purposes, the quality of the high resolution birds eye aerial and Pictometry imagery, and the commitment that Microsoft has made to its platform. For fiscal year 2007 for example, Microsoft is spending upwards of $500 million on its Live platform, which includes Virtual Earth.

There are multiple benefits of a web system deployment for this project. This includes providing spatial information to the visually impaired with the proper software, being able to have large displays for visibility anywhere that can handle a computer, display, and internet connectivity hookup as well as being accessible on mobile devices that continue to grow in power and extensibility.

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2. TCRP Synthesis #70 Study on MDTS, Dr. Uma Shama and Mr. Lawrence Harman