Bus Coming: A Service for Tracking Buses in Rural Areas based on Passenger Locations

Arthur Thompson
Department of Computing and Information Technology
University of the West Indies
St. Augustine, Trinidad
arthur.thompson.jr@gmail.com

Wayne Goodridge
Department of Computing and Information Technology
University of the West Indies
St. Augustine, Trinidad
wayne.goodridge@sta.uwi.edu

***Abstract*— The massive influx of programmable smart phones with built in Global Positioning System receivers, provides an opportunity to make the current public transport bus system in Trinidad and Tobago more reliable by providing passengers with information that would allow them to make better travel decisions. A four part system is developed which captures and stores near real time bus location data and provides near real time bus location information visually via a web application and textually via a mobile application. The core communication technology behind the system is based on Web Services and early results demonstrate that this simple approach is very appropriate for rural areas in Trinidad.**

Keywords - *GPS; smart phones; public transport bus system; webservices*

Transport in the West Indies is difficult for many, especially for those that live in rural areas. Many people depend on Government provided buses to get to and from their homes daily. This bus service, however, is not reliable. Buses are scheduled to run at certain times of day but many issues can and usually do account for delays that then cascade down to other scheduled times causing predefined schedules to be useless. Routes to rural areas are assigned few buses and thus if there is a problem with a rural route bus, there are not many buses that can pick up the slack. Currently, there is no way for an individual in a rural area to access the bus transportation options available to him/her at any given time.

This lack of information can lead to long waits or worst waiting in vain for a bus that never arrives. If passengers were provided with near real time information about the location and status of buses servicing their areas then these issues would be alleviated, improving the passenger's travel experience and allowing passengers to make better more efficient use of their time.

Over the past two to three years, BlackBerry smart phones have been introduced to the West Indies on a large scale. Research In Motion (RIM) [1, 2] the company that manufactures BlackBerry smart phones also provides a developer platform that allows application developers to extend the functionality of the BlackBerry smart phone. This platform provides developers with access to build-in devices such as Global Positioning System (GPS)[3] receivers allowing them to utilize the functionality of these built-in devices in the applications that they develop.

The Bus Coming system proposed in this paper uses the BlackBerry developer platform with the built-in GPS receiver in the BlackBerry smart phone to build a relatively cheap bus tracking system. The system will provide passengers with near real time bus location and status information with respect to the passenger's current location, not bus stops as is usually done. This will improve the travel experience of passengers in rural areas (where there are few bus stops) and allow them to make better and more efficient use of their time.

This paper is organized as follows: Section I gives motivation for the approach taken for development the Bus Tracking system which is based on both GPS mobile devices and the mobile cell phone network; Section II briefly describes the components of the Bus Coming System and how accuracy across multiple platforms is achieved.

I. LACK OF BUS TRACKING

Bus tracking services have recently (within the last 2 years) been introduced in some metropolitan areas. Chicago [4], Washington DC [5] and London [6] are a few cities that have implemented some form of advanced bus tracking services. These services are usually comprised of a GPS equipped fleet of buses and these locations are feed to a central server which then makes the locations available to different readers, web sites (basic lists or graphical representations like map overlays), electronic signs at bus stops, SMS for bus locations at particular bus stops and even mobile applications for smart phones that gives the location of buses on a particular route with respect to bus stops.

In the West Indies, however, electronic bus tracking systems are not yet available. Territories like Jamaica [7], Barbados [8] and Trinidad and Tobago [9] have transport authorities who go as far as providing semi-static scheduling

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via hard copy or rarely updated websites. These schedules are seldom exact and thus cannot be relied upon. Especially in rural areas, where there is no assistance or information available from transport authority about bus availability or location thus it is difficult to access bus transport in an efficient manner.

In metropolitan cities like Chicago, Washington DC and London; buses strictly stop at predefined bus stops, because of this the bus tracking systems implemented in these cities are focused on bus locations with respect to bus stops. In the West Indies, especially in rural areas this approach will not work, designated bus stops are few and far between. It would not be practical to expect every person living in these areas to walk to the stop nearest them, as the nearest one can be kilometres away. Due to the scarcity and distance between bus stops, buses do not strictly stop at pre-defined bus stops, in many cases a bus driver will stop for passengers at multiple non bus stop locations along the route. The amount of time for the bus to arrive at the next stop in these areas is much less useful than the time for the bus to arrive at the passenger's location along the route. Therefore, building a bus tracking system based on each passenger's current location would be very useful for rural areas.

II. PROPOSED SOLUTION

Internet access is key component of this system, Trinidad and Tobago like many other countries in the West Indies is seeing consistent positive growth in both fixed and mobile internet access. In Trinidad and Tobago, Q1 2011 almost 50% of households have internet access, with 96% of those having broadband access, this is up 11% over the previous year. Also 36% of the population of Trinidad and Tobago have mobile internet access in Q1 2011 up 9% over the previous year. [10] With mobile internet coverage close to 100% in Trinidad and Tobago and general internet usage trending upwards, an internet based solution to the bus tracking problem in the West Indies is very feasible.

A system is needed that takes the passenger's location into consideration. In order to give information about the bus's location with respect to the passenger's location along the route, the passenger's current location along the route is required. The passenger's location along the route would be treated in much the same way as a bus stop would be, without having to erect an unreasonable number of stops along the route. With the passenger's location along the route, the system can tell the passenger the amount of time to the next bus or buses with respect the passenger's current location.

GPS capable smart phones were used to provide near real time bus location information by placing a GPS capable smart phone on a bus and the phone would submit its current GPS location periodically.

A. *Reference Points*

Google Maps were used to provide a map with near real time bus location overlays. However when the GPS locations generated by the mobile devices were plotted directly onto the Google Map of Trinidad the results were inconsistent. Reference Points were used to help associate the GPS locations generated by the mobile devices with visually consistent positions on the Google Map.

Reference Points are positions along each route that visually correspond to locations on a Google Map of Trinidad. The GPS locations generated by the mobile devices are associated with the reference point nearest it. This allows the system to be consistent with the points that are used to perform calculations like distance to passenger and estimations like time to passenger; while still being able to display visually consistent locations of buses on a Google Map.

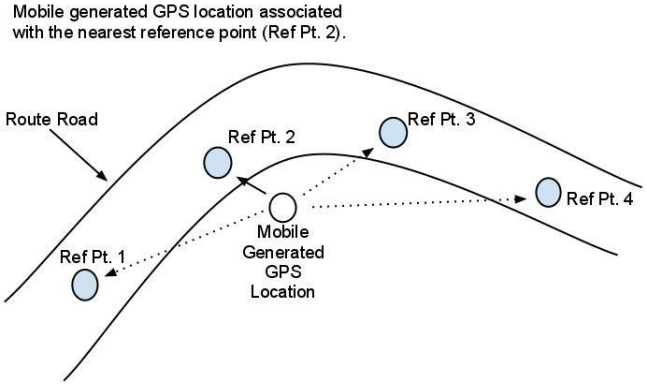

Fig. 1 Mobile GPS location associated with Nearest Reference Point

Reference points provided a solution to the inconsistencies between mobile generated GPS locations and positions on a Google Map. They also provided two benefits as a side effect.

1) Easy calculation of distance between different positions along a route, since a straight line could be drawn from each reference point to the next without going off route. This provided a way of easily calculating distances along winding routes which are common in rural areas.

2) Easily calculate the availability status (coming or gone) of a bus with respect to a passenger along the route. If a passenger is associated with Ref. Pt. 2 and a bus is associated with Ref. Pt. 3, since 3 is greater than 2 we can let the passenger know that that bus has already gone.

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The skills and technology required to produce a system that provides both passengers and bus operators with near real time bus location information can be built using readily available and relatively cheap technology involving programmable GPS devices (BlackBerry smart phones in this case, however any programmable GPS capable device would do, eg: Android, IOS, Symbian devices). The availability of fairly cheap programmable GPS enabled BlackBerry smart phones makes a bus tracking system implementable at a relatively cheap cost and in a relatively short period of time with minimal disruption to the current bus operations.

B. *Components of the BusComing System*

The proposed Bus Coming system consists of four components:

1) Bus Coming Web Service

This is a web service [11] that allows all other parts of Bus Coming System to submit information to the server (for example the Bus Tracker component submits information to this web service) or request information from the server (for example the Bus Coming Web and Mobile Views).

Standardised web services were used to provide the ability for multiple platforms to work within and around the system without any major changes. The BlackBerry smart phones used could easily be replaced by one or more of many other web service compliant GPS capable devices.

Parts of the Bus Coming Web Service could be made public, allowing third party developers to use the data in interesting ways.

2) Bus Tracker

This is an application running on a GPS capable blackberry, the blackberry is placed on a desired bus to track its location. Figure 1, shows the Bus Tracker application and the interface where the bus driver selects the bus and route. Note that the tracker transmits the bus current location of the bus to the server via a web service periodically.

Operators did express concern about the bus driver having to initiate the tracking along a journey, so considerations are being made to have the tracking remotely initiated by central operators.

Fig. 2 Bus Tracker Application

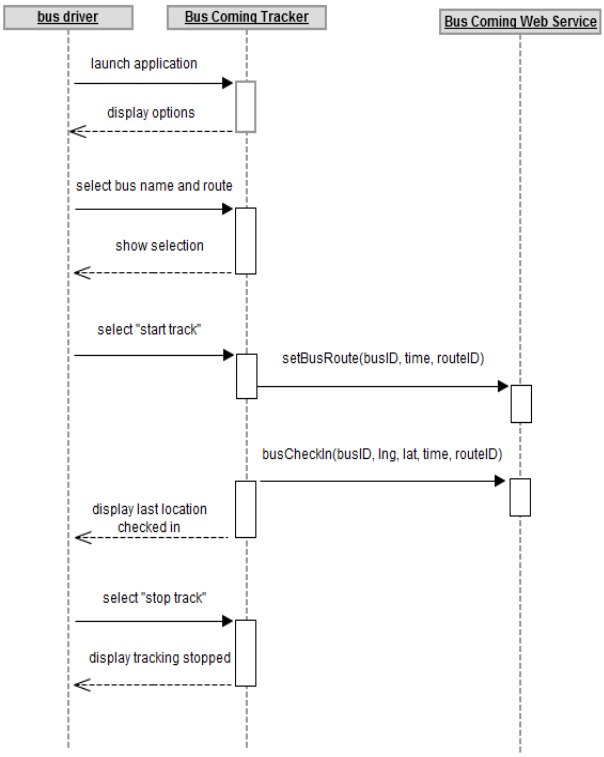

Fig. 3 Bus Tracker Sequence Diagram

Bus Coming Tracker must be given some information before tracking can begin. Figure 2, shows a sequence diagram outlining the steps involved. The user that initiates the tracking (the bus driver) would set the bus name and route before the bus begins to move. Once the bus name and route are set and the bus driver is ready to begin the journey, the driver selects the "Start Track" button and then tracking begins. Bus Coming Tracker lets the Bus Coming Web Service know that it is starting to track by using the ***setBusRoute*** service, which sets the bus's current route and the time at which tracking has begun.

Once tracking has been initiated, Bus Coming Tracker frequently submits, every five seconds or so, the location of the BlackBerry device and thus the location of the bus, via its built in GPS receiver to Bus Coming Web Service via the ***busCheckIn*** service. These frequent submissions are used by Bus Coming Web Service to provide Bus Coming Web View and Bus Coming Mobile View with information about the bus's location.

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3) Bus Coming Web View

This is a web view of all routes in the system and all buses on those routes. Figure 3 shows a Google Map web page of this component which is typically used by passengers using a home computer or can be used by the central control station of the bus service department. This web view is interactive and allows the user to view routes of interest. In addition, the site is updated in near real time, periodic AJAX[12] calls are made to the web service to get new data and update the web view accordingly showing the position of buses as received by Bus Tracker.

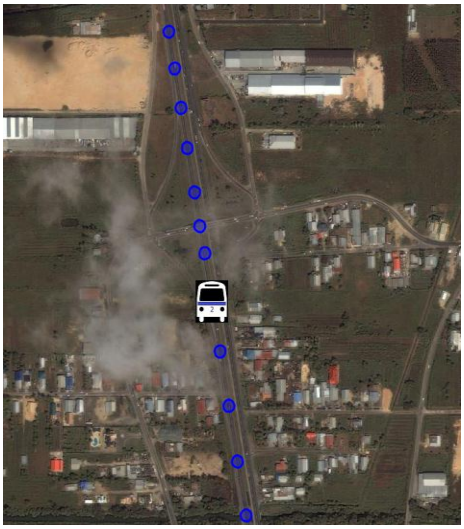

Fig. 4 Google Map showing Bus Locations

Google provides API access to their Google Maps system. Through this API developers can include Google Maps in their web applications. Overlays are added onto the Google Map to show a map with customized information on it, for example reference points along a bus route. Figure 4 shows a sequence diagram which illustrates how the ***getRefPoints*** capability of the web service is used by the web viewer to retrieve latitude and longitude of each reference point along a particular route.

Using the ***getBus*** capability of the Web Service, information containing the latitude, longitude and area of each bus currently on a particular route is retrieved. Google Maps is then instructed to display the bus.

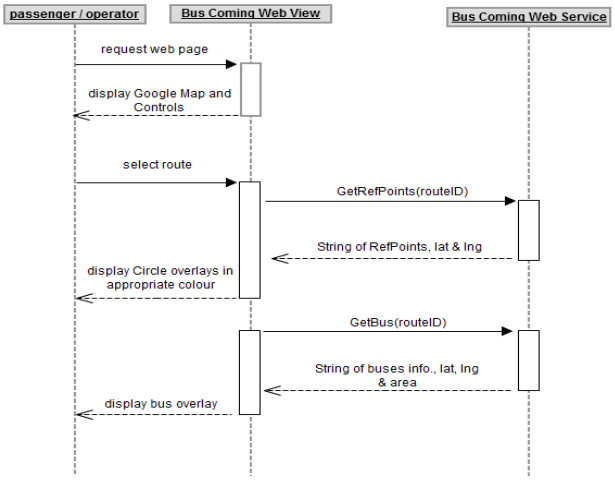

Fig. 5 Bus Coming Web View Sequence Diagram

4) Bus Coming Mobile View

This is an application running a GPS capable blackberry, the application allows the user to select a route and view all buses on the route and see whether or not those buses are coming towards them or if they have already gone past. Figure 5, illustrates that the bus is 20 minutes away from the position of the passenger who requested the service.

From the list of routes the passenger can select the route that the passenger is on. Once the route selection has taken place Bus Coming Mobile View will get the passengers location from the GPS receiver, this location along with the ID of the selected route is submitted to Web Service using a call to ***getBusesOnRoute***. The Bus Coming Web Service then returns a string array containing information about all the buses currently servicing the selected route. This information is initially displayed to the passenger as a button list with the name of the bus and its coming or gone status on the button. If one of the buttons representing a bus is selected more detailed information about the bus will be presented to the passenger with respect to the passenger's current location. This detailed information includes the current area of the bus, the bus's distance away from the passenger, the bus's current speed, the estimated amount of time it will take the bus to get to the passenger, the distance of the bus from its final destination and the estimated amount of time it will take the bus to get to its final destination.

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Fig. 6. Mobile View for Passengers

The location of the passenger that is calculated by the device's GPS receiver and submitted to Bus Coming Web Service, is, as with buses, associated with the closest reference point along the route. All calculations with respect to the user are really taking place with respect to a reference point along a selected route. As with buses this is done to account for any inaccuracy of the GPS receiver. If a passenger lives down a street of the route and uses Bus Coming Mobile View, the passenger will get information as if the passenger was standing on the route at the top of the passenger's street.

III. DISCUSSION

During development and initial testing only two mobile phones were available. The results of this limited testing demonstrate that the Bus Coming System was able to meet all objectives set out. However, it is desirable that a larger scale test be performed.

Currently, requests are being made to mobile operators to supply GPS enabled mobile units to perform larger scale testing of the system. Permission has already been granted by the local Bus Authority of Trinidad and Tobago to perform tests once mobile units are acquired.

REFERENCES

[1] RIM GPS capable BlackBerry smart phone list 2011 http://us.blackberry.com/smartphones/features/gps.jsp
[2] RIM how to deploy on BlackBerry 2011 http://devblog.blackberry.com/2010/06/how-can-i-deploy-my-blackberry-widget/
[3] Global Positioning System 2011, http://www.gps.gov
[4] Chicago Transit Authority 2011 http://www.ctabustracker.com/bustime/eta/eta.jsp
[5] Washington Metropolitan Area Transit Authority 2011 http://www.wmata.com/rider_tools/nextbus/about_nextbus.cfm
[6] Transport For London 2011 http://www.tfl.gov.uk/corporate/projectsandschemes/11560.aspx
[7] Jamaican Urban Transport Company Limited http://www.jutc.com/timetables.php
[8] Barbados Transport Board 2011 http://www.transportboard.com/schedule.php
[9] Public Transport Service Commission, Trinidad and Tobago 2011 http://www.ptsc.co.tt/
[10] http://www.tatt.org.tt/LinkClick.aspx?fileticket=3ORrNw9rKbo%3D&tabid=120
[11] World Wide Web Consortium 2011 Web Services http://www.w3.org/TR/ws-arch/#whatis
[12] http://www.w3.org/standards/webdesign/script.html

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