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Location Broadcasting Using Mobile Push Technology

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Abstract: ***The pace of change brought by new technologies has had a significant effect on the way people live, work and even plays worldwide. New and emerging technologies such as mobile devices now has become part of the daily routine of every human being as their aid or even assistant in whatever things they wish to do. In a progressing country like the Philippines, most likely in one of its highly-urbanized city, Butuan, commuters always have uncertainties on their travel especially the buses. In the daily operation of public transport systems, mainly of buses, the movement of vehicles is affected by different uncertain conditions as the day progresses, such as traffic, congestion, unexpected delays, and randomness in passenger demand, irregular vehicle-dispatching times, and incidents. Location Broadcasting using Mobile Push Technology Mobile Application uses a variety of technologies to track the location of buses at a certain point or station and uses this information to commuters for possible predictions of bus arrivals, route schedule and status of the bus, making time efficient for the riding public to reach the bus stop just before the bus arrives or take an alternate means of transport if the bus is delayed. When properly and appropriately implemented, this can provide competitive enhancement to any transport companies and greater benefits for the community which in turn reduces traffic and pollution.***

Keyword: Mobile Technology, Location broadcasting, Push Technology

1. Introduction

In a progressing country like the Philippines, one of its highly-urbanized southern cities, Butuan, commuters always have uncertainties on their travel especially on buses. In the daily operation of public transport systems, mainly on buses, the movement of vehicles is affected by different uncertain conditions as the day progresses, such as traffic, congestion, unexpected delays, and randomness in passenger demand, irregular vehicle-dispatching times, and incidents [1]. Many passengers are often late for work, students are late for classes because they decide to wait for the bus instead of just simply using an alternate transportation. Most real time arrival systems, currently in use, are completely web-based applications. NextBus, a popular bus tracking service in United States provides the passenger with a website where he/she can login to find out the location of the buses and textual time estimates projecting the next bus arrival at a particular stop. These displays are often misleading since there is no clear indication of where the bus is actually located and whether there are potential delays [3].

With the advent of Internet, GPS and the ubiquitous cellular network, vehicle tracking for better transport system has become possible. These technologies can be applied to public transport systems, especially buses which are not able to adhere to predefined timetables due to reasons like traffic jams, breakdown, etc. [1]. Location broadcasting is an act of sending information from a mobile device to a designated server while Push Technology or Server push is a style of Internet-based communication where the request for a given transaction is initiated by the publisher or server. It is contrasted with pull, where the request for the transmission of information is initiated by the receiver or client.[4].

Location Broadcasting using Mobile Push Technology Mobile Applications uses a variety of technologies such as the Internet, SMS infrastructure to track the location of buses at a certain terminal or station and then, uses this information to commuters for possible predictions of bus arrivals, estimated time of arrival and status of the bus, making time efficient for the riding public to reach the bus stop just before the bus arrives or take an alternate means of transport if the bus is delayed. When properly and appropriately implemented, this can provide competitive enhancement to any transport companies and greater benefits for the community especially the riding public and pedestrians which in turn reduces traffic and pollution.

2. Methodology

The development of this application followed the three phases in a rapid application development; phases include Discovery Phase, Mobile Application Design and Development Phase and Implementation and Testing Phase.

Discovery Phase

Accordingly, all buses are assigned to a designated route and its required time of arrival at the destination. Upon arrival at a certain point, terminal or station, the dispatching bus is allowed to stop for ten – fifteen (10-15) minutes to give ample time for passengers to embark and disembark into and from the bus respectively, unload or load any baggage, and the like, meal allowance is given to all dispatching buses and should not be more than thirty (30) minutes and only allowed to stop at designated and identified food house.

Buses are classified generally as Aircon, Super Deluxe and Regular type. The first type of bus basically has a minimal stop-over since it is not allowed to stop at any non-identified station unless, otherwise when necessary. Super Deluxe buses also had minimal stop-overs since it will load only passengers at a designated station or terminal. Regular types of buses have a lot of stop-overs since it will cater passengers waiting along the bus route regardless of terminal or station stop over. Fare varies from the type of buses; usually the third type is the lowest.

Table 1: Bus Schedule

Route	Aircon	Deluxe / Regular
Butuan – Cagayan	1st Trip: 2:00am Last Trip: 10:00pm Interval: every 30 min	24 Hours Interval: every 20 min After 10pm, 1 hour interval
Butuan – Surigao	1st Trip: 3:00am Last Trip: 6:00pm Interval: every 45 min	1st Trip: 2am Last Trip: 10:00pm Interval: every 20 min
Butuan – Davao	1st Trip: 2:00am Last Trip: 9:00pm Interval: every 45 min	24 hours Interval: every 20 min
Butuan – Tandag	1st Trip: 2:00am 2nd and Last Trip: 11:00am	1st Trip: 1:00am Last Trip: 7:00pm Interval: every 30 min
Butuan – Mangagoy	none	1st Trip: 4:00 am Last Trip: 7:00pm Interval: every 30 min

In case of special occasion that needs additional buses, interval and dispatching time will change based on the number of passengers on demand.

Table 2: Bus Routes and its Bus Station/ Terminal

Route	Bus Station/ Terminal
BUTUAN-CAGAYAN	Nasipit*, Magsaysay, Gingoog*, Balingoan*, Salay, Balingasag, Jasaan*, Villanueva, Tagoloan, Cagayan de Oro City*
BUTUAN-SURIGAO	Cabadbaran*, Tubay, Santiago, Jabonga, Kitcharao*, Mainit*, Sison, Surigao City*
BUTUAN-DAVAO	Sibagat, Bayugan*, Prosperidad, San Francisco*, Rosario*, Bunawan*, Trento*, Monkayo, Montevista*, Nabunturan*, Tagum*, Panabo*, Davao City*
BUTUAN-TANDAG	Sibagat, Bayugan*, Prosperidad, San Francisco*, Barobo*, Lianga*, San Agustin, Marihatag, Cagwait, Bayabas, Tago, Tandag City*
BUTUAN-MANGAGOY	Sibagat, Bayugan, Prosperidad, San Francisco, Barobo, Tagbina, Hinatuan, Bislig City

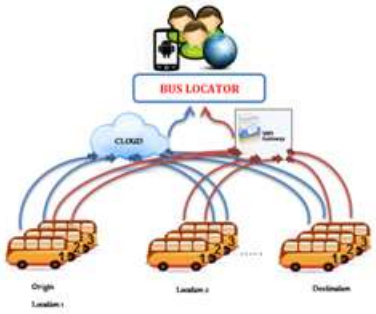
This table presented is a list of routes and its designated or identified bus stop/terminal or station. All Bus station/terminal with an (*) symbol are the terminals where Aircon type of bus should stop to pick up and unload passengers and baggage. All non-air-conditioned buses are thus required to stop at the designated terminals.

Since there are wide array of existing technologies that are new and tested to be of better functionalities to develop bus location, it will then be best to create such application in mobile-based since most people of today are not apart from the recent technologies.

Mobile Application Design and Development

The application is designed and developed using the Android Mobile platform that broadcasted unobtrusively the location of a certain dispatching bus.

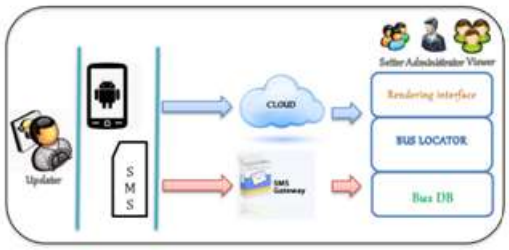
The figure below illustrates the overall system architecture.



Location Broadcasting Model

The figure above shows how the push technology will be used in this study. Every dispatcher bus' current location will be broadcasted or push down to the server. The broadcasting of location will be seamlessly done through Android Mobile connected to the Internet or could be done through SMS unobtrusively. Viewers or Users can locate or view the current broadcasting buses by using the android mobile bus locator application or through the web. Administrators or managers of any transport company could locate the fleet by using the mobile apps or the web.

The main parts of Location Broadcasting using Mobile Push Technology use a mechanism to determine the vehicle location, a communication or location broadcasting mechanism, location display mechanism and a data server.



Bus Locator Architecture

Effective communication between all the components involved will guarantee the success of the whole system; this is achieved using the following platforms:

i. Mobile platform

An android mobile phone hosts the mobile applications for the administrator, basically the setter, updater and the client. The mobile application is developed using the Android SDK (Software Development Kit), Java software, Eclipse with Java IDE and JSON (JavaScript Object Notation) for parsing data from the android to the database.

For the relational database, SQLite is used, since this software is a self-contained, serverless SQL database engine and this enables the setter and updater to set the route and schedule of travel and broadcast the current location of the vehicle, respectively, and that generated information is used in viewing the bus routes and schedules by the users or viewers.

ii. SMS-based platform

For updaters and client without an internet connection-enabled mobile android device, an SMS-based platform is used as a gateway to update and retrieve the vehicle location information respectively. No need of sending a keyword in a specific format; just using the mobile application in an offline mode and unobtrusively it will broadcast the location from the updater mobile application, and in a likewise manner from the viewer/client, but the information generated is in a form of an SMS. The SMS gateway used in the development was SMSLibX gateway.

iii. Web-based platform

The web application as featured on the system is developed using the Google MAP API version 3 and HTML 5. This is intended for viewing vehicle, route information, bus description and possible list of routes and schedules for the client that accessed the web.

To display the location of a vehicle, a mapping technology is used. Despite the fact that there is much free mapping software on the net, most of this mapping software does not fully represent all the needed locations and road networks. But with the aid of Google maker the freely available maps can be edited to suite the purpose. Google Map API [22] is used in this system and is also integrated by programming languages such as PHP, jQuery and Ajax used to query in the database and display the results on the map.

Since the system is currently developed for Butuan City based locations, all routes are predefined and stored in the database server. The Butuan City Bus Terminal is the source or destination of all routes, thus reflecting the possible station that a bus would stop. Each bus stop or station has a corresponding route ID, and each route has a predefined set of buses.

Estimated Time of Arrival

Arrival time prediction forms the important part of the system. An estimated time of arrival is computed using the time formula and summation notation for all distances:

$\mathbf{t = D / r}$ *(Equation 1)*
where
t: the time required to ride a fixed distance in a given average speed.
D: fixed given distance
r: average speed

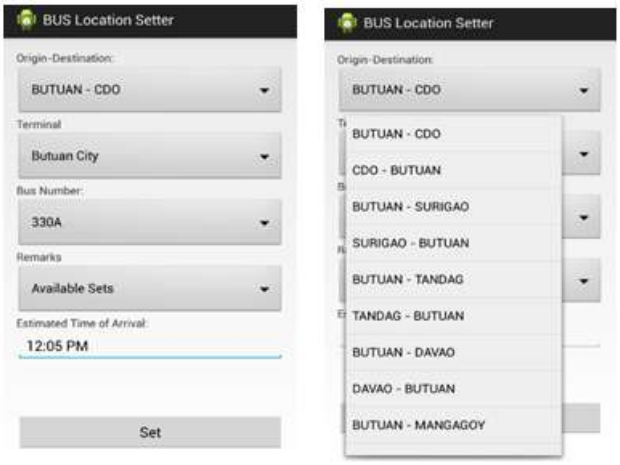
This system computes the time ***t,*** considering that a moving vehicle has an average speed ***r,*** and the given distance ***D,*** from the source location to the final destination.

Another formula used in the system is the computation for an estimated time of arrival from its origin to destination.

$\mathbf{ETA}_{\mathbf{O\text{-}D} \approx t + \sum_{i=1}^{n}(s.o * 10)}$ *(Equation 2)*
where:
t: time computed using Equation 1
n: number of big terminal / station designated for stop over
s.o: stop over
i: number of terminal / station

3. Results and Discussion

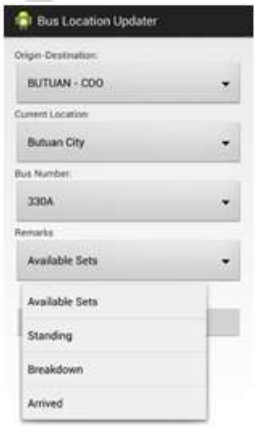
The following are the results of the development of location broadcasting using mobile push technology application; various technologies are used in the integration of this system such as: mobile platform, web-based platform and SMS-based framework.



Bus Location Setter

In the figure above, every departure of a certain bus, the administrator or any assigned personnel of a public transport system must select a route consisting of the origin and destination or simple the route, once route is selected, the spinner will list down the terminals or stations based on the route selected.

And in every route, there are assigned buses, only those assigned buses are listed down in the Bus Number spinner. A button captioned as 'Set' once pressed, will automatically create the set travel. The current time of that bus is then pushed to the server, thus calculating the estimated time of arrival (ETA). ETA calculation is presented in the following section.



Bus Location Updater

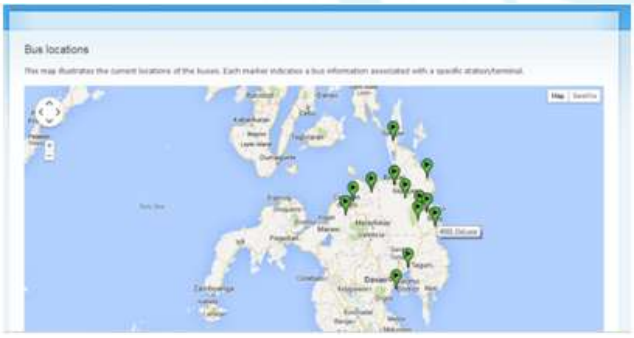
This application is mainly for the dispatchers positioned in a certain terminal or station or even the authorized driver or conductor. Once a bus arrives at a certain location, the updater will then select route in the Origin-Destination field

or drop down list; the Current Location List will generate terminal or station list based on that selected Origin-Destination and then select the bus number in the third spinner or drop down list. Lastly, it will update the status of the bus by selecting the type of Remark in the fourth spinner.

Once, the updater will press the Update button, information of that certain bus such as, the current location, the latitude and longitude, the arrival time and status will be updated in the database server.

Bus Location Client

The figure above displayed the graphical user interface for the Client or Viewer; it has two options in searching or locating bus description. First, it is the 'View Buses' button and second is the 'Search Buses' button below a Search Route Spinner. Clicking View Buses will display all dispatching buses that include the name of the bus, the route and the estimated time of arrival at a certain destination. The user or client can also search for a certain bus by selecting the route in the spinner and clicking the Search Buses; it will display all dispatching buses on that selected route.



Location Map

In the figure, the Google Map API is integrated to illustrate the current locations of the buses. Each of the markers indicates a bus information associated with a specific station or terminal currently positioned. It has two (2) Navigation menus, namely Bus Locations and Location Table. Selecting Bus locations menu displays this homepage, and each marker when clicked, detailed information regarding that particular bus will be displayed in popup menu. The application is built using HTML 5 and Google MAP API version 3.

SMS-based Application

To provide the unobtrusively broadcasting of location, an SMS gateway is modified and used for the SMS-based transmission.

The SMS gateway used in this application is the SMSLibX. The software has built-in functions that are modified to function as a middleware of the system. Another hardware requirement for the transmission of SMS is a GSM Modem configured and connected to the gateway. The modem used is a Globe Tattoo broadband which has a maximum speed of 7.2 mbps transmission.

Simulation Results

A series of tests are conducted to check the data transmission using the SMS Gateway and the GSM Modem. The results are represented in the following;

Table 4: Simulation of the Updater using SMS

Current Location	Time Duration	No. of Updater	Sent SMS	Received SMS	Undelivered SMS
Cabadbaran	48 min	4	44	44	0
Tubay	15 min	4	40	38	2
Santiago	26 min	4	42	39	3
Jabonga	12 min	4	40	37	3
Kitcharao	28 min	4	40	36	4
Mainit	28 min	4	40	39	1
Sison	45 min	4	40	38	2
Surigao	35 min	4	42	41	1

The simulation is conducted wherein the correspondents ride a regular type of bus bound for Surigao City. The travel resulted to 3 hours and 31 minutes from the origin of travel in Butuan City at 3:05pm and arrived at Surigao City Transport Integrated Terminal at 6:36pm. The time duration is completed using the Equation 2. The SMS sent by the updaters in every terminal has a minimum of ten (10) SMS as described on the figure below, Simulation Log.

The Simulation Log figure is a sample data received from the user that sends an updated information. Every correspondent will update at most 10 different buses per current location. The result shows that undelivered messages is minimal. This was due to some factors that would possibly affect the transmission such as poor signal or connectivity, software error, GSM connectivity and even human itervention. The total number of sent SMS resulted

to 328 and only 310 SMS received, differencing to 18 undelivered SMS. In percentage, 94.50 % SMS Received and only 5.50% unreceived SMS.

4. Summary, Conclusion and Recommendation

The developed mobile applications track the current location of all dispatching bus from the setting of route down to generation of information to the client. Updating of current station or terminal location is done by the designated dispatcher, and then forwards this information to passengers or commuters using the user's mobile application or web-based GUI. In the case of no internet connection, the updater broadcasts data using the SMS gateway and GSM modem, making it unobtrusive in transmission. With the simulations presented, there are 94.50% of SMS received from the client and only 5.50% of undelivered SMS. And for the viewers or client's mobile application that use SMS as a way of requesting information, 78.22% SMS are forwarded to the SMS gateway for querying the data server and 21.78% SMS are not delivered to the client. Possible reasons for undelivered transmission could be on the cellular site signals, poor connectivity of the mobile unit, unstable SMS gateway, limited capability of the GSM modem and even human intervention. Also, in the simulation, the computed estimated time of arrival using Equation 1 varies from Equation 2 that applies the stopover interval time in major terminals only.For the internet-based connection, a guaranteed 100 % connectivity has tested.

With the advent of Internet and ubiquitous cellular network, vehicle tracking for better transport management has become possible; and will serve as a viable notification system that will effectively assist pedestrians in making the decision of whether to wait for the bus or take an alternate transportation.

Recommendations

It is recommended to implement this using a GPS-based application so as to generate real-time broadcasting and exact computation of estimated time of arrival. It is also recommended to provide possible LED screen display at designated waiting area for the commuter to see bus routes and schedules. And an enhancement in GUI is also recommended. It is also recommended that the client/viewer's mobile application should have functionality to generate type of dispatching buses based on its class when searched.

It is also highly recommended for future work to develop or use a stable SMS gateway framework or another way to connect SMS and android infrastructure and the GSM modem should have a greater capacity to receive data and higher transmission speed.

It is further suggested for further studies that calculation of the estimated time of arrival should include the normalize formula given below where c is the computed number of uncertainties that a dispatching bus could have.

$$\text{ETA}_{\text{O-D}} \approx \text{t} + \sum_{i=1}^{n}(s.o * 10) + c$$

The system is quite generic in nature and it is possible to extend the methodology for other type of fleet movement where security is of paramount importance. *Dey, (2007)*[24] proposes a novel data hiding technique, based on Steganographic mechanism. Here, the advantage lies in the fact that computationally costly encryption-decryption mechanism is avoided. It is also recommended to future researchers to improve the functionalities and add additional enhancement that would be attractive to any sort of users.

Also, the system uses a combination of processing elements, such as PC's and Mobile Phones. There is a possibility of the overall system malfunction due to a particular type of attack. By this, any similar methodology will be studied to make this system more robust. *Gada,et.al,* (2004) [24] describes a Distributed Security Scheme for Ad Hoc Networks and it also proposes a proactive scheme to prevent Denial of Service Attack.

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