# Mobile Access to Real Time Tracking of Public Transports

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**Abstract**

*Nowadays the density of the population in cities is increasing, and that factor coupled with economic difficulties makes public transport extremely important and more used by the population. On the other hand, with the increasing use of mobile technologies, there is a need to get information about public transports in real time to facilitate time management and daily trips. Our approach provides this information in real time using GPS-based mobile applications both for end users and mobile transportation communications via a centralized server. Tests on real users evaluate the usability of the system and allow for the definition of standard functionalities.*

**Keywords**

*Mobile Applications; Public Transports; Monitoring; Android*

## 1. INTRODUCTION

Real-time bus arrival information, immediately available on mobile devices, can significantly enhance the usability of public transit systems. By helping travelers move from single-occupancy vehicles to public transit systems, communities can reduce traffic congestion as well as its environmental impact [1]. In this work, we describe our efforts to increase the satisfaction of current public transit users and help motivate more people to ride.

Nowadays, people have an inescapable need to move either for professional or personal reasons. Moreover, people are aware of the need of using public transports, since it is a cheaper mean of transportation, compared to their personal vehicles. This need has the tendency to increase due to economic factors given the current economic crisis situation that requires cost reductions for families and companies. Additionally, people are also aware that they can reduce the levels of pollution by using public transportation instead of their own vehicles. In this work, we propose a solution that also allows greater comfort for all users, since it facilitates the planning and fulfilling of their trips.

The ease with which the population has access to mobile devices (1,038 billion by the end of the third quarter of 2012 according to CBS News) comes from the fact that their prices have decreased in recent years, due to the growing search for these new technologies. These devices allow a great variety of interactive functions, which may definitively improve applications, based on the many sensors they have, such as GPS or cameras.

The increasing need of using public transports, combined with the diffusion of mobile devices (smartphones, tablets…) in population's daily life, changes the paradigm of using public transports. People, used to control their mobility using personal means of transportation, are now searching for ways of feeling in control of their movements using their mobile devices. This scenario presents a real challenge for researchers and developers in the area of mobile applications and services. We grasp this challenge by proposing a solution of mobile access to real time tracking of public transports. We make use of GPS sensors that users carry in their mobile devices to provide information of the whereabouts of the desired buses. For this to take place, buses must also be equipped with GPS sensors that provide their localization to a central server.

The rest of the paper is organized as follows. Next section will introduce the main context of research in the area. In Section III we detail the proposed approach and in Section IV we present the implementation relevant details. In Section V we analyse the test results and in the last section we present the conclusions and possible lines of future research.

## 2. STATE OF THE ART

Public transport systems are very important under different perspectives [2] [3] [4] and have thus been extensively researched in different fields, e.g. traffic congestion, emission reduction, schedule optimization, and user information systems [5]. Our work focuses on this last point, and in this section we will present recent advances in the area.

There are different mobile applications available for instance on Google Play, e.g. “Madrid Metro”, “IZI Carris”, “Metro Lisboa” and “RATP: Paris Metro” that provide information services. We will focus on positive and negative points of these specific applications for tracking public transports, since it is the main emphasis of this work.

The application "IZI Carris" is designed for Lisbon public transports to give information about the timetables and next buses. IT is relatively easy to use, using lists and it is possible to add descriptions to items. On the other hand, users find the communication capabilities and reliability very low.

The application "Metro Lisbon" was design to give information regarding Lisbon underground. What stood out the most (in an early stage) was the functionality to calculate routes through the choice of start and destination.

The application "Madrid Metro" is similar but targeted to the Madrid underground. In this case, the interface is designed in a simple manner by making use of large buttons, which would be a plus for an application that would be used on the move.

The application "RATP Paris Metro" targeted to the Paris underground exhibits high level of functionalities.

Historically, one of the first online bus tracking systems was developed by Maclean & in 2002 [6]. More recently, Google Transit, which was started as a Google Labs project in December 2005, is now directly integrated into Google Maps on many mobile phones and provides transit trip planning for more than 400 cities around the world (http://maps.google.com/help/maps/transit/partners/faq.html) Interfaces to Google Transit exist on a variety of mobile devices, making use of location sensors such as GPS and WiFi localization on the device to determine a starting location for trip planning.

While Google Transit has been useful to transit riders around the world, it is also significant for establishing a common standard for exchanging transit schedule data: the Google Transit Feed Specification (GTFS).

A number of researchers have also focused on how mobile applications might improve the usability of public transit, both for the general users [7] [8], and for targeted groups such as those with impairments [8].

In this later scenario, in [10] an assistive application that can alert the user to the proximity of all public transportation stops, giving emphasis to the chosen final stop is presented. The application is adjustable to any transportation system and is particularly relevant to use in public transports that do not have any audio system available. The interface was designed to be suitable not only for talkback (Android’s inbuilt screen-reader) aimed at blind users, but also for people with low vision that can still use their sight to check the screen.

Our approach is not specifically targeted at users with impairments, but instead aims for general usability by providing a broad set of interface options, with particular focus on pre-trip information as well as in-trip guidance.

## 3. PROPOSED APPROACH

To implement a mobile system to access public transport information in real-time we propose a client-server architecture with three components: a mobile application for the public transport users, the transport information server and another mobile application, located in the bus to update its position. This proposed architecture is illustrated in Figure 1.

The application available to the public transport user queries the server for position of transports on a route, specifying the stop for the user to get into the transport. The server provides the ETA for all buses that are due to pass through the provided stop.

Attached to the public transport, a mobile application frequently contacts the server to report its position. The contact may be triggered by: the distance from its last position, the time since its last update or the approach to a stop.

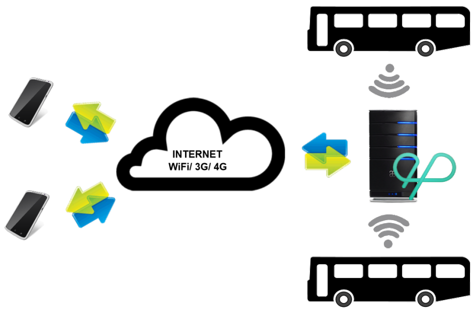


**Figure 1: Service Architecture**

The server authenticates the drivers’ client application and stores the geo-coordinate position of the public transport. This information is then used to compute the estimated time of arrival (ETA) to the public transport’s next stop. The server stores the position of all circulating transports over time and not just the current position. Besides logging the position of public transport, the server also provides information about routes, stops, timetables and fares.

The data model involved in this system must be flexible and support partial routes, route detours, services unscheduled start and stop (for example when a vehicle breaks down, it stops its service, and a replacing vehicle may stops its current service to migrate to a more needed one) and exception non stopping (when a transport is full and cannot accept more passengers).

## 4. IMPLEMENTATION

To verify the application a mobile application was implemented that connected to a transport information server. The mobile application, named BusToGo, aims to enable its users to access public transport information provided by the server that contains the information for a local bus transport network. This includes the access to buses' timetables, location of stops, routes and location of buses in real time.

To assist these tasks, the application may use the GPS sensor to identify the user position and search for a nearby stop. Alternatively, the camera may be used to decode a QRCode with the position of the stop.

This information and the approximated position of the public transport are overlaid on a Google Map to display the location of stops and buses.

The client application and the server communicate over the Internet, available through a Wi-Fi connection or data service from he mobile phone operator.

To maximize the potential of adoption, the client was implemented on the Android platforms, as it is currently the one with biggest market share.

Furthermore, to include almost all Android users, the application is backward compatible with versions starting from 2.2. The application can also be used with tablets, even though it has not been designed to take advantage of those screen dimensions.

### 4.1 Data Persistence

The application uses an Internet connection to get the data in real time. All of this data is stored in a local database and application data can be classified as a "short term" and "long term" data.

The "long term" is downloaded for the first time during the first use of the application, such as information about the companies and their services, routes and stops. Because these data are rarely changed, the server provides methods with last update timestamp so users may be notified if updated data exists.

On the other hand, "short term" data are those who suffer constant changes such as the location of a transport. If the user wants to know which bus is coming next, the information is also discharged through a data connection or Wi-Fi.

While off-line the user has access to all "long term" information. To limit the amount of information on the device, only routes accessed by the user are stored in the local database.

The users can change the application settings according to their needs. It is possible to enable or disable notifications, automatic updates and the time between them, the type of Internet connection (3G, Wi-Fi, Wi-Fi + 3G) and the route services on which the application provides information.

### 4.2 Features

The interface was designed with the goal of being simple and intuitive. As one purpose of the application is to show bus schedules and ETAs, it is reasonable to expect that application users may be on the move while interacting with it. Therefore, the interface includes large menu buttons and a system of notifications, as shown in Figure 2.

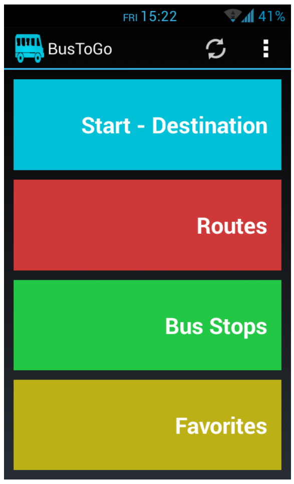


**Figure 2: Main Menu**

Since there are different routes in distinct companies, and there many possible combinations of moving from a point "A" to a point "B", we provide the user with a system of favourites that allows regular users to easily access stops of interest of a route. For casual users, the search for stops and routes is important as it provides easy access to points with a known keyword such as the user destination.

The client application is also able to search for stops on a route and identify connecting stops with other routes of given an origin and destination stops to search for routes that serve those. Figure 3 shows a screen capture by the route calculator, performed from the client application, from the available routes.


**Figure 3: Route Calculator**

The client application includes a QRCode identification feature, which allows users to point the camera to the code at the stop to access all of its details. This functionality is a shortcut for a user to access the information about his or her local stop, as shown in Figure 4.

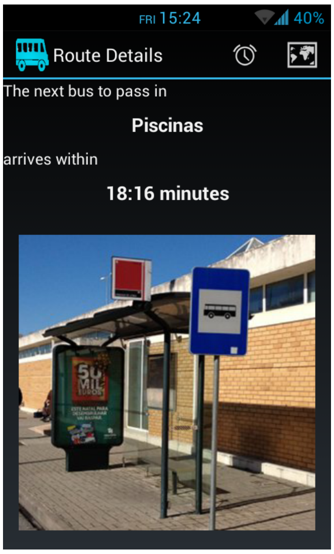


**Figure 4: Next bus at Piscinas stop**

### 4.3 Social Networks

Knowing that most smartphone users have a constant presence on social networks, the client application enables users to share their location at a particular bus stop, through the social networks Twitter (http://www.twitter.com) and Facebook (http://www.facebook.com).

These updates can be automatic or manual, i.e., the user can set in preferences the interval for the automatic updates, or he or she can manually update their position.

## 5. TESTS

The implemented system was tested at two distinct moments with anonymous persons, unfamiliar with the system. These tests were designed to cover the most important features of the application providing some insight on possible improvements.

Both rounds of tests were performed at a bus stop. Users had no previous contact with the system, with ages between fifteen and thirty-one years old of both sexes.

At the bus stop, users were provided with an Android Smartphone with the application installed. During the execution of the task, we recorded the time and number of errors to complete the task and comments from users.

To cover the most important features of the mobile application, each test asked the user to performed two tasks:

T1. Find a public transport that goes from a specified origin to a destination;

T2. Find all the routes that pass through a specified bus-stop (distinct from the bus stop where the test is performed)

### 5.1 Round 1

The exact questions for the tasks of first round of tests were

T1. *Please indicate the time it takes to reach the next bus that lets you travel from the stop "Avenida Heróis de Angola" to the stop " Prisão Escola".*

T2. *What are the routes that pass through the bus stop "Hospital 1"?*

During the execution of the test, some users were confused by the purpose of some main menu option, misinterpreting the options and selecting options that were not adequate for the task being performed. The early menu options were: Calculator, Routes, Favourites and Bus Stops.

Since the errors were due to misinterpretation of the title in the main menu options it was decided to clarify those in order to reduce the number of errors and the time taken to perform this task, as illustrated in figure 2.

After the tests were performed we verified that users that used the menu option to the effect proposed, completed the task with an acceptable time. To find a service that travels between two stops, some users selected the list of existing routes stops and could not identify the services with the desired destination. These users had to go to the initial screen of the application and try the route menu.

Users also had some difficulty in finding the desired functionality inside the menu of bus stops, since this is "hidden" in the "More" option.

As the titles of the main menu options were not clear they were changed. Since the users who used the correct option had a hard time finding the option that was "hidden", it was decided to put this option visible in order to facilitate their access.

### 5.2 Round 2

A second round of tests was made to verify if the problems listed by the users were corrected, and to verify if the time to complete a task has decreased.

Some question details were changed to reflect some of the performed changes on the application. The questions asked for each task were:

*T1. Please indicate the time it takes to reach the next bus that lets you travel from the stop "Avenida Heróis de Angola" to the stop " Prisão Escola" through route "Mobilis 1".*

*T2. What are the routes that pass through the bus stop "Hospital 1"?*

### 5.3 Results and Discussion

The mean time to complete the tasks and its standard deviation for second round of tests decreased significantly when compared with the time required to perform identical tasks before changing the system. Figure 5 shows these values. This improvement is due to the fact that the main menu options have been renamed to be more close to the purpose of the task.

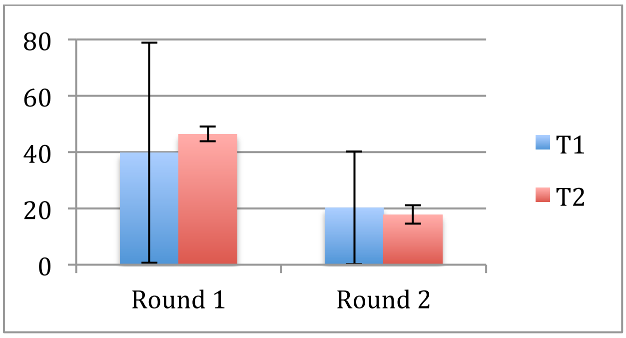


**Figure 5: Test results for tass T1 and T2**

Such as the test to identify a route with service (T1), users began to choose the right option first because the names of the menus have been clarified.

Once users began to choose the correct menu option (Bus Stops) and the "Routes" option has become visible in the ActionBar, the overwhelming majority of users started to perform the task without any error so we can conclude that the change brought improvements in performance of this task.

## 6. CONCLUSIONS AND FUTURE WORK

Mobile devices are becoming increasingly important in day-to-day life of the population that are making use of them to plan and to simplify their daily tasks.

In this work we proposed a solution of mobile access to real time tracking of public transports. We make use of GPS sensors that users carry in their mobile devices to provide information of the whereabouts of the desired buses. For this to take place, buses must also be equipped with GPS sensors that provide their localization to a central server. The proposed solution is found to answer to users and companies requirements.

Tests were carried out in different developing phases, which was revealed of outmost importance to understand how user thinks / acts during the use of an application, making it possible to adjust it to make it more intuitive, improving user experience.

Different future work approaches can be pursued. A strong possibility is in its adaption to different mobile platforms to be more accessible to all. Additionally, more online information regarding traffic congestions, weather conditions or strikes could also be interesting.

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