MANAGEMENT SYSTEM FOR A FLEET OF VEHICLES BASED ON GPS

João André Correia Telo de Oliveira

Author Affiliation(s)
Instituto Superior Técnico, University of Lisbon, Portugal

ABSTRACT

This dissertation was based on the development a system that controls the position of smartphones through the GPS system. The system created is based on three main structural items: an application to the Android system, a server that contains a database and a website that allows you to query the information in the database created. The Android application runs as a system that sends information about geographical data and kinematics of the smartphone to the server. With these information, the server update the database contents. Finally we have the website where you can see a map showing the location of smartphones in real time, view the history about the routes made by them and show us a graph about speed. At the end of this work we make some performed tests in order to verify their behavior in different situations.

Keywords: GPS, Mobile Communications, Google Maps API, Android.

1. INTRODUCTION

The global positioning system (GPS) has become, in recent years, a strong ally in the lives of many people around the world. Currently, this system is present in several systems, from the most modern aircraft until the simplest smartphone. Being the GPS system a system of open access, but at the same time very useful, it is interesting develop applications that utilize and take full advantage of the data provided by this system. Combining these data with free digital maps available on various websites allows us to create ever more evolved and interesting applications. This dissertation had as the initial objective the creation of a control system that control a fleet through smartphones because nowadays these mobile devices are increasingly popular around the world, and most of them are equipped with GPS receivers.

In addition, it was also defined as objective, that the solution used to monitor and manage system users be totally realized through a website. Thus, an Android application, a server and a website was developed during this project.

1. TECHNOLOGIES

i. Global Positioning System (GPS)

The GPS (Global Positioning System) is a satellite navigation system that was developed by the United States Department of Defense, over several years, having become fully operational in 1995. The GPS system is nowadays widely used in mapping, localization, navigation applications, etc. This system is composed by three segments which are: Space segment, Control segment and users segment. In Figure 1 are illustrated the three segments that together form the GPS system.

![Figure 1 - Representation of the three segments of GPS system](image-url)
• **Space Segment**

This segment consists in a constellation of satellites responsible for the emission of radio signals to receivers somewhere on planet earth. The base constellation satellites currently have 27 satellites and are positioned in six orbits approximately 22,200 km of the Earth's surface and with an inclination of 55° relative to the plane of the equator. [1]

![Figure 2 - GPS Constellation [1]](image)

• **Control Segment**

The control segment is composed of a network of stations on planet earth that control the satellites of the GPS system. These stations analyze signals transmitted by satellites and send information to them. This segment is composed by One Master Control Station, One Alternate Master Control Station, 12 Antennas and 16 Monitor Stations which are distributed as follows: [1]

![Figure 3 - Distribution of the control segment [1]](image)

• **User Segment**

The segment of the user relates to receivers of GPS signals. These receptors work as a processing unit that decodes and processes the signals received from each satellite space segment, thus allowing to calculate its exact position. Today, the types of receivers ranging from a simple smartphone to the receptor incorporated in a complex navigation systems, for example, an airplane.

**ii. Mobile Communication Systems**

• **GSM**

GSM is, as its name indicates, a Global System for Mobile Communications and is the most widely used standard in the world for mobile phones. The big difference between this system and those that preceded it is that their voice and signaling channels are digital, which has facilitated the sending of SMS, the use of fax services and voice-mail. [2]

• **GPRS**

The growing number of mobile phone users, as well as the number of internet users caused that works on with the goal of combining these two trends. GPRS (General Packet Radio Service) is a service that made this possible, because allows the transmission of data over the GSM network. GPRS uses the concept of packet transmission, instead of GSM networks using the concept of circuit switching, this allows the transfer of data packets between the GSM base stations and other networks that using the IP protocol, as in the case of the Internet. [2]

• **UMTS**

The UMTS is a mobile communication system known as 3rd Generation (3G). In Portugal, this type of network is present
in most of the country and it can reach speeds of 43.2 Mbps. [3]

iii. Programming languages

Regarding the programming languages used in this work it should be noted. The Java language used in the development of smartphone application, the C# language used in programming the server and also the SQL language used by the server in the interaction with the database. To develop the website have been still employed HTML, PHP, JavaScript language, that is the language used by the Google Maps API, and also still the SQL language for interaction with the database server.

2. SYSTEM DEVELOPED

i. System architecture

The architecture of this system is essentially composed of three items. One or more smartphones, one server and one or more computers. The smartphones get the information about the position, velocity, etc. through the GPS system and sends them to the server using the GSM network. The server receives the information and is responsible for filling a database. Finally, computers access the website, to consult the information contained in the database.

![System architecture](image1)

**Figure 4 - System architecture**

ii. Client Application

The client application of this system was designed to run on the Android system. The main functions of this application are the authentication of smartphone in the system and sending the NMEA sentences collected by GPS integrated receiver to the server.

![Android application interface](image2)

**Figure 5 - Android application interface**

After the user data to be entered in the fields, the application sends them to the server and await a response from this. In case of successful authentication, the application immediately begins to collect information from the GPS receiver and send it to the server.

iii. Server

The server was developed in C# and runs on multithreading mode because has a thread with the function to always keep listening for new clients and others that are being launched as new clients connect to the server. When execute, the program server shows an interface for the users similar to that shown in the Figure 6.

![Server interface](image3)

**Figure 6 - Server interface**

To start the server is necessary that the user specify the port where it will be listening. If a port is not specified, the server starts listening to port 2222.
iv. Website

The features that was considered to be necessary to implement such a system were: the possibility of viewing the positions of users in real time, consult a history path taken by each user on a given day and the possibility of observing a graph of the speed of users throughout each day.

- Real time page

On the "Real Time" page it is possible to observe the updated map of the user’s position. The users appear in this map represented by the icon that was defined by the administrator at the time of registration. On this page, it is possible to observe the existence of left side menu that lets you choose to view or not the different user groups on the map.

![Real time page example](image7)

To conclude the server chapter it is noteworthy that by clicking on a user icon, a window with information about the speed, date and time comes up.

![Window with details about a user](image8)

- Path taken page

The page of the website where you can see the path taken by the system users on a given day, is presented in this section. In Figure 9 it is possible to observe a red line that represents the path taken by the user and the points represent the various positions that have been collected by the system.

![Path taken page](image9)

- Velocity graph page

Another possibility to represent the information contained in the database, it is the possibility to observe a graph of the speed of each user over a given date. The chart is created using the Google Charts API. This API allows you to create graphs dynamically and is very useful in building websites.

![Velocity graph page](image10)

- Administration page

In addition to set the username, the password and the user group, on this page the administrator also sets the icon that will represent each user on the map in real-time and if or not this is your group administrator. Through this page it is also possible to delete users of this system.

![Administration page](image11)
3. TESTS

Aiming to test the performance of the system developed some tests were performed. In this chapter, will be explained all the tests that were performed, and the results obtained in each of them. The smartphone used in these tests was a Motorola Moto G represented in Figure 12. This smartphone is equipped with a Qualcomm integrated GPS receiver.

Figure 12 - Smartphone used in the tests

i. Position update frequency test

The first test was used to test different time intervals between sending information of the client application to the server. The test was performed with the smartphone in a car and was made three times the same path with different update frequencies. The path that has been traveled is represented in Figure 13. To begin the test an interval of 10 seconds between updates was set. After this, interval was decreased to 5 and finally to 3 seconds.

Figure 13 - Path traveled during the test

The results reached were:

- Interval of 10 seconds

Figure 14 - Result with an interval of 10 seconds
• Interval of 5 Seconds

![Figure 15 - Result with an interval of 5 seconds](image1)

• Interval of 3 Seconds

![Figure 16 - Result with an interval of 3 seconds](image2)

After performing this test we concluded that the shorter interval gives a better estimate of the path. Even so, although the 3-second interval be one that gives us a better perspective about the path taken by the user, is also the one which overloads more the database.

**ii. System precision testing**

Another parameter that was tested is the precision of the system. This test consisted in positioning the smartphone, at a fixed location with known coordinates, and registering the positions that reported for 2 minutes with an interval of updating equal to 5 seconds.

In Figure 17 is shown the position where the smartphone was placed together with the coordinates of this position.

The positions acquired during this test are shown in Figure 18. Some positions are not shown on the map because they became superposed. Still, it is possible to obtain an idea of the positions that were sent by the client application to the server.

![Figure 17 - Smartphone position for precision test](image3)

![Figure 18 - Positions collected in precision test](image4)

In the Figure 19 we can still observe the latitude and longitude of the positions collected by the server. Thus we can have a better perception of the difference obtained.
Position coordinates of the smartphone in degrees:
Latitude: 38.73679º, Longitude: -9.13857º

<table>
<thead>
<tr>
<th>Time</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Distance [m]</th>
</tr>
</thead>
<tbody>
<tr>
<td>14:31:30</td>
<td>38.73679º</td>
<td>-9.13854º</td>
<td>2.96</td>
</tr>
<tr>
<td>14:31:31</td>
<td>38.73679º</td>
<td>-9.13854º</td>
<td>2.92</td>
</tr>
<tr>
<td>14:31:32</td>
<td>38.73679º</td>
<td>-9.13854º</td>
<td>2.92</td>
</tr>
<tr>
<td>14:31:33</td>
<td>38.73679º</td>
<td>-9.13854º</td>
<td>2.92</td>
</tr>
<tr>
<td>14:31:34</td>
<td>38.73679º</td>
<td>-9.13854º</td>
<td>2.92</td>
</tr>
<tr>
<td>14:31:35</td>
<td>38.73679º</td>
<td>-9.13854º</td>
<td>2.92</td>
</tr>
<tr>
<td>14:31:36</td>
<td>38.73679º</td>
<td>-9.13854º</td>
<td>2.92</td>
</tr>
<tr>
<td>14:31:37</td>
<td>38.73679º</td>
<td>-9.13854º</td>
<td>2.92</td>
</tr>
</tbody>
</table>

Figure 19 - Table with the results obtained in the precision test

In the table we observe that the variation of the latitude and longitude is rather small, which is reflected in small shifts of around 2 to 3 meters.

iii. System multiple users test

The purpose of this test is verify the server’s ability to manage multiple client-server connections.

For this, we created an application that simulates the connection of 10 users. Once connected, users sent NMEA sentences to the server with coordinates that correspond to positions around the campus of Instituto Superior Técnico.

Figure 20 - Test with 10 users

After performing this test, we can say that the system is prepared to handle multiple client access. When the users were launched, the server responded correctly surpassing the test in the best way.

4. FINAL REMARKS AND FUTURE WORK

At the end of this dissertation it is possible to state that the objectives proposed at the beginning were successfully achieved.

A system that can be used to control a fleet was developed and tested to verify that it is working completely.

Throughout the development of this system, it was found that it could become a much more extensive tool, and that its use could go beyond just a control system of a fleet. As it allows you to monitor in real time the location of a smartphone, this system can even be used, for example, for parents who want to track the location of their children in real time.

As the base technology of the developed system is the GPS system, the limitations inherent in the GPS system are also transported to the system developed in this dissertation. For example, the possibility of using this system in an indoor environment is considered null since the GPS system does not allow it. In addition, we must also take into account that the use of the developed system is dependent on the cellular network. This and the GPS system are the two most important technologies for the overall effectiveness of the developed system.

Although the system is fully functional there are certain items that could have been more developed or improved. As this is an academic work, the main concern was to get a working system being remitted to future work these improvements to the system.

In the server, can be added functionalities for managing the same, such as the possibility of view of the users connected at any time, or the possibility to make changes to the database server through the application interface.

The management of the database is also important to be taken into account in future work because with the passing of time this will become much overloaded and there is a need to delete some data considered expendable because of their antiquity. In this case, to ensure that all records of each user are not lost, can be implemented a solution that delete records of some positions and instead of have registers 5 in 5 seconds has been records for example 10 to 10 seconds.

Regarding the website, in future work new features that are useful in the management of the users of this system can be implemented. One such feature is the creation of geographical barriers used to check whether users abandoned a certain geographical area.

Finally, it is also pertinent to point out how future work the possibility to implement a function in Android application that consists of varying the update interval of the position as, for example, the speed with which the user moves.

5. REFERENCES


