Assistive Mobile Software for Public Transportation

João de Sousa e Silva, Catarina Silva, Luís Marcelino, Rui Ferreira, António Pereira

Computer Science Communication and Research Centre

School of Technology and Management, Polytechnic Institute of Leiria
Morro do Lena - Alto do Vieiro -2411-901 Leiria - PORTUGAL

joao.sousa.silva@gmail.com, {catarina,luis.marcelino,rui.ferreira,apereira}@ipleiria.pt

***Abstract*— The need of mobility on public transport for persons with visual impairment is mandatory. While traveling on a public transport, the simple ability to know the current location is almost impossible for such persons. To overcome this hurdle, we developed an assistive application that can alert its user to the proximity of all public transportation stops, giving emphasis to the chosen final stop. 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 developed prototype runs on an Android OS device equipped with Global Positioning System (GPS). To ensure the highest possible level of reliability and to make it predictable to users, the application's architecture is free of as much dependencies as possible. Therefore, only GPS, or other localization mechanism, is required. 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. Thus, it was meant to be graphically simple and unobtrusive. It was tested by visual impaired persons leading to the conclusion that it demonstrates an existing need, and opens a new perspective in public transportation's accessibility.**

Keywords: Assistive software, mobility, accessibility, public transportation, Android.

I. Introduction

In today's complex and dynamic world, mobility is crucial to ensure the involvement of an individual in the society. In this context, it is easy to identify many situations where the personal presence is essential. From basic life necessities, such as having a job, shopping, attending medical consultations, and also leisure activities like cultural events, meeting with friends, practicing sport and many more. These are all situations where the bodily presence is mandatory. These notions, which are taken for granted for most population, are actions hardly accomplished for people with some kind of visual impairment.

According with the censuses from 2001[8], in Portugal there were more than 150.000 visual impaired persons. This population typically relies on public transports for mobility. Hence, the user-friendliness of the transportation system should be particularly relevant.

Some problems concerning public transportation's accessibility were identified from the constraints of visually impaired persons. For instance, a blind person, or a person with low vision, may have trouble determining his/her location while traveling in a bus. This hurdle can also be an issue that negatively constraints decisions, degrading life quality.

Although there are some public transportation vehicles with audio systems alerting to the current and the next stops, these are only marginal, and are almost only seen in big cities.

Nowadays, a big part of visual impaired persons already has a smartphone equipped with speech output interface. In this work, we will present an assistive software running Android OS that mitigates the identified problems.

The developed assistive software uses the GPS information to identify the user's location, integrating a database with bus lines and their stops, and allowing the user to define entry and exit stops. Furthermore, the application keeps the user informed about its location, the next stop and alerts him/her when the exit stop is approaching and reached.

The rest of the paper is organized as follows: in the next section, an overview of current assistive systems in public transportation is presented. In the Section III, the proposed approach is described and in Section IV implementation and tests are presented. The paper closes with the main conclusions and some insights on future work.

II. Current Assistive Systems in Public Transportation

Nowadays there are already audio systems installed in the vehicles of some transportation operators with the aim of helping visually impaired people (VIP), which alert, via recorded sounds, the current and the next stops. With this information the VIP may decide independently whether or not to exit the transportation. There are systems [2] where such a system is deployed with the complement of some features such as, while at a bus stop, using a dedicated device, owned by the VIP, it is possible to check the estimated time for arrival of a certain bus.

Another system [3], complements the audio system with two other devices, one at the vehicle and the other with the VIP. The user should select, in his device, the desired line and activate it at the bus stop. The VIP's device's radio emits a low frequency signal that activates the vehicle's one, alerting its driver that a person with visually impairment wants to get on-board. On arrival, the device at the bus announces, using a recorded voice, the line's number until the person gets in.

Another example is described in [4] and is implemented in several cities. It can be used in two different ways, either a dedicated device or an inbuilt device in a white cane. With the simple hit of specific buttons, this system allows the user, not just to check, for example, the number of the bus line and of the vehicle that is arriving at the station, but also, if the vehicle is the desired one, and to alert the driver that a person with visual impairment (VI) wants to get on-board. This system may be complemented with some other technology to increase the independence of the VIP [4].

Even though these are enormously helpful systems, there are some identified flaws. Those systems are not easy to be adopted since they require specific equipment, which increases its complexity, maintenance and associated costs. For a person with VI it may be a problem to have an extra device to carry and handle. It can be particularly problematic for those that walk with a white cane. Finally, the audio system may be a problem when the noise of the surrounding ambient hinders it.

III. Proposed Approach

After carefully analyzing existing solutions, a solution was devised to overcome most of their handicaps. In this section, we present the proposed approach and architecture and further provide an insight on its deployment.

A. *Introduction*

Our primary goal is to announce the desired final stop to the VI user at a convenient time. The stop alert must be anticipated to allow the user to take the necessary actions, usually to signal the driver with the intention to exit and collect all personal belongings.

Contemporary smartphones have a wide set of features that fulfill the essential conditions to ensure the feasibility of our goal, namely, mobility, GPS antenna and speech output. Moreover, smartphones are widely adopted by the target group, making them a natural choice to deploy the approach.

To successfully achieve our goal, preliminary system requirements were gathered from surveys presented to visual impaired users and professionals in the area of visual impairment. Some of the identified requirements include:

- The VI person should be able to select the desired line number and desired final stop
- To achieve a level of accessibility that makes the application usable to VI people, the graphical interface has to be simple and unobtrusive
- It would be suitable to allow the user to consult, at any time during the way, the next and remaining stops until his final desired one
- The user should be alerted if the GPS signal is lost, since it will make it impossible to accomplish the predefined task

This application may be the first step towards an integrated mobility system for VI people, or a compliment to the research of UbiBus. Such system may have features such as alerting the proximity of the public transportation, giving the stop order from a bus stop or from a bus and consulting the estimated time to arrival of the transportation, among others.

The application may be easily adjusted to any operator with marginal costs. For a user, in case s/he already owns a supported smartphone, the adoption consists simply on the installation of the application and a short training period.

B. *Application usage*

From the identified system requirements we defined what we expected to be the most frequent application usage. This proposed case study was the reference to the initial implementation and tests of the application.

Once the user opens the application, a first screen with the available surface transportations operators' names appears. There s/he has to select the desired operator. Then, a screen with a list of available routes is shown and again s/he has to select the desired route. After that, a list of stops appears, organized by their sequence in the chosen route. Then, the VIP has to select the entrance stop and then his desire final stop. Right after, the navigation screen appears. At this point the smartphone starts searching for GPS signal. Hence, the user should perform this task before arriving to the stop so that when the transportation arrives, the software is ready to track the way. The navigation screen keeps its backlight on, not only to allow the VIP to check it easily, but also to keep updating the location with a required frequency.

While traveling, the list of stops is updated whenever the transportation passes by a stop, by removing it from the list. Thus, the first stop in the list stop is always the next one. This allows the user to check, at any time, the remaining route.

In order to let the user comfortably get ready to exit the transportation, when the transportation reaches two stops before the exit stop, a distinct sound is played to alert him. Upon arrival at the chosen final stop, another distinct sound is played.

There are also specific sounds to alert the user in case the smartphone loses the GPS signal as well as when it gets it back.

After the application detects the arrival at the desired final stop, the navigation screen closes and the first screen (where the operator has to be chosen) reappears.

C. *Architecture*

The system, to be able to be used without network access requires a local database with all operators, lines and stops for a region of interest. The information associated with each stop includes its name and its geographic position (the information about which lines pass at a stop may be obtained from the line's properties).

To determine its current position, the system uses its GPS capability. The current position is then compared to the position of the stops to infer the location of the user in the route.

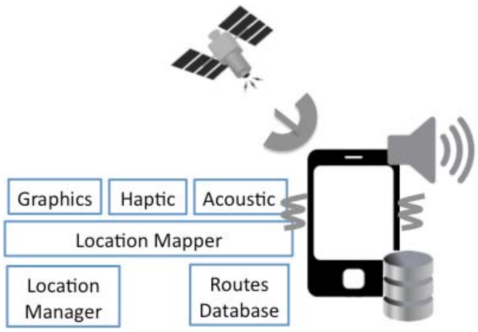

Figure 1. Simplified system architecture.

Figure 1 illustrates the capabilities explored by the proposed system and their basic architecture. The system must be able to function as a stand-alone device: GPS connection, database integration, and visual, tactile and audible feedback. To implement these functionalities a location mapper layer uses the information from the location manager and queries the routes' database for the stops on a given route.

IV. IMPLEMENTATION

This section presents some considerations about developing application for VIPs on the Android's platform. The used technologies include: SQLite, Location Manager and Graphical user elements. Besides all the factors that must be considered when developing mobile applications [7], this section points some additional barriers to the development of applications to VIPs.

A. *Database*

SQLite database is cross-platform, which confers it significant flexibility that helps to its maintenance and provides the chance to create and load the database in a friendly environment, such as desk or laptop computer. Since the result is a single file that is often small and it does not need configuration, the portability to the target device is stress-free. At runtime, the system handles the database easily, since SQLite is an embedded SQL database engine. Furthermore, SQLite has a constant team that upkeeps its development. Therefore it is robust and fast, which is possible to confirm by its smoothness while retrieving information at runtime, even in devices with memory limitations such as smartphones.

Given its simplicity, SQLite database has easy implementation. Moreover since its features are the most suitable for smartphones, it is the chosen databases engine for this application [6].

B. *GPS Location*

The main classes of Android to manage GPS, were explored and tested in order to build an assistant manager class to deal with it. After researching, only LocationManager and LocationListener are being use, since those are adequate for setting triggers for proximity and fire sounds when the GPS state changes.

In order to save battery, the location updates are required just when the navigation screen appears. Even there the updates are made just every 4 seconds. This value was chosen according with the following: the proximity alert has a distance of the major point of 40m, so the diameter is 80m. If the transportation crosses the stop event at 60km/h, or 16,67m/s, so it means that theoretically the location update from 4 to 4 seconds will be enough as the covered distance will be 66,67m in 4 seconds.

KML (Keyhole Markup Language) is an Extensible Markup Language (XML) schema, developed by Keyhole, Inc., used for expressing geographic annotation that is used with Google Earth [5]. These features made this format the right source for the required information.

To extract the desired information from the file, such as stops' names, their coordinates, the route they belong to, etc., manual parsing procedures were used. After the treatment a CSV file was generated, from where SQLite Administrator could load the database.

Through the use of KML, there is the possibility to automate the addition of routes to the application in a future iteration.

C. *User Interface*

The graphical user interface is built over ListActivities, as shown in Figure 2. The best attention was taken while developing it in order to keep it as simple as possible. However, to navigate within these lists a trackball is required as the touch screen is barelly usable for a VIP and, among these, especially blind people.

Also the size of the font is increased, letting people with low vision to manage the software using their sight. Furthermore the screen orientation is locked at portrayed position, with the aim of being more predictable for blind people.

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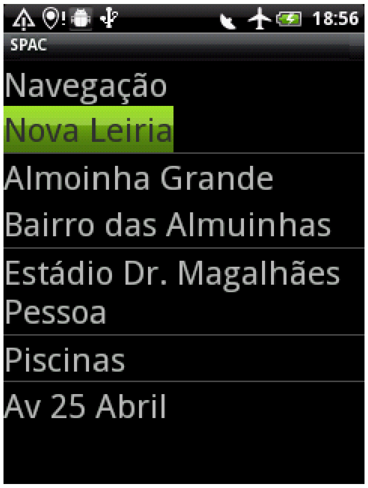

Figure 2: List Activity with Bus stops

Using simple and standard OS graphical components, the software is intrinsically talkback compliant by default. Talkback is an application, which runs as a service and converts text-to-speech, natively available for Android OS since version 1.6 [10].

D. *Accessibility*

The touch screen of smartphones may become a significant obstacle to the adoption of smartphones from VIPs. The unintentionally touch on the screen may trigger events that make the smartphone unusable.

In order to minimize the possibility of mistakes while using the software, a double tap - where the second tap should be kept pressed – was initially defined as necessary to select an item. After this procedure a button to confirm the selection appears. This restriction was implemented with context menus, changing the normal selection behavior for this platform.

With the exception of the font size that is increased, none of the graphical components of the software was changed with the aim of maintaining the software's graphical user interface akin the operating system's graphical standards. This favors usability and accessibility, by conserving an assured level of regularity, at expenses of fancy designs. To improve the predictability of the interface, the screen is set not to react to smartphone's orientation changes. Therefore, it is locked at portrait position.

V. TESTS

To test to the developed prototype we invited 4 VIP to try to use the application on a real scenario. Therefore the tests were conducted on urban lines of a local bus company.

We asked users to select itineraries that would take approximately 10 minutes because the greatest challenge for this application's users is the selection of the desired route.

All the 4 test subjects were blind and regular users of Nokia mobile phones. These devices are significantly different from the selected touch screen Android devices, as they have physical keyboard and no touch screen. Subjects were all male with ages between 30 and 50 years old and half of them are regular users of computers.

The experiment script was defined to ask similar tasks to all the test users. While at a bus stop, they were asked to select the bus operator line and the entrance and exit stops. They would have to identify the stops in the itinerary and recognize the exit stop. The devices used for these tests were HTC Wildfire smartphones. This device has a capacitive touch screen with a small trackball and runs Android 2.2. The physical buttons, namely Home, Menu, Back and Search buttons, of this device are also capacitive with no distinctive feature that enables their identification (using touch is not possible to distinguish the screen from these buttons).

The Android platform has a Home Shell for VI users denominated Eyes Free [9]. This speech enabled home application uses the concept of a matrix where the user can navigate through menus sliding the finger through one of the nine areas of the screen. The focused menu is vocalized with a built-in text to speech and the user may select it by lifting the finger.

This matrix paradigm was completely new to all the test subjects and they required frequent assistance to be able to navigate and select our prototype application.

During the first trial the menu navigation experiment was so challenging that we had to provide the device with the application already on screen. Even so, the back button was not recognizable and the user could not correct his mistakes while selecting the stops. For the remaining experiments we used a screen protector film with marks on the buttons.

The built-in text to speech (TTS) capability supports English, French, Spanish and German. Unfortunately it does not support the Portuguese language (native language to all test users). An external TTS engine that supports Portuguese is available on the Android Market. However with this engine the application became very slow and irresponsive. For this reason the TTS engine read Portuguese text as it were English. Therefore, users had an additional effort to try to understand what was spoken, which they usually succeeded.

A significant change carried out by user's feedback was to alter the initially defined double tap to select an option followed by a second tap. Instead, users suggested the use of a single long pressing, which was implemented, since it was deemed extremely relevant.

The software has shown its capabilities in real environment and testers successfully accomplish the preset task (choose a concrete entrance and exit stop from a concrete route and operator) in a time that often was less than one minute.

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As the accessibility is a priority for this software, it was taken into account at each step of testing, even in low level tests. A failure on this area could nullify the whole project.

VI. Conclusions and Future Work

The major objective of this work was to provide a higher level of independency to people with visual impairment. To achieve this goal includes also trying to increase the privacy of this group of people.

Often a big issue to be handled when referring to reduced mobility is also that when a person with disability wants to go somewhere, in order to be possible to provide help, someone will have to know where that person would like to go.

This paper presents an assistive software for visually impaired people in surface public transportation, improving the mobility of people with visual impairment. The application receives the route and initial and final stops and proceeds by identifying the current stop and alerting the user of the proximity of his final desired stop. This information is available at any time of the route.

The tests performed so far have shown that the application works in real contexts. The main constraints of the application are the devices where it can run on, as the usability of the devices that runs Android OS is often visually orientated.

The usability test results provide support for further improvements, not only in the graphical interface, but also for new features that may be useful in large cities with a big number of lines and stops, such as auto selection of routes that may include connections between routes, set the order of stop in alphabetical order. System and acceptances tests should be performed to insure the reliability and usability of the software.

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