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Mobile App Development For Bus Monitoring in Macaé-RJ

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RESUMO

Transport is an essential element for urban population activities. The lack of arrival times, itineraries or bus stop information is a significantly recurrent situation in Brazilian cities. Thus, independently of city size, the lack of information stickles mobility and increases locomotion time. This research aims to present a prototype development which monitors Brazilian public transport bus services. This prototype, unlike other known applications, informs which buses are equipped with accessibility facilities, capable of attending limited mobility users. Besides that, the bus monitoring application may be accessed by mobile devices. For that purpose, a survey based on existing application and case use was made detailing the most known bus monitoring mobile application. The mobile application was prototyped using global position system, providing real time geographic information of Macaé city mass transit system. Therefore, buses position information is presented, furnishing benefits for users, especially for whom physical movements are restricted.

PALAVRAS-CHAVE: Accessibility. Collective Transportation. Spatial Information Treatment. Application Prototype.

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INTRODUCTION

The waiting time in a bus stop and terminal, a consequence of jammed traffic in several cities, is according to Andrade et al. (2004) a common problem of urban mass transport. Besides that, Cabral and Garcia (2015) show the bus overcrowding as other a recurrent problem faced by public transportation users. In this scenario, Cavalcanti et al. (2013) and De Araújo et al. (2012) explore the buses precarious conditions for mobility and accessibility. The importance of urban collective transport and issues related to its dynamics, present itself according to Vasconcellos (2012), as determining factors to search transport services efficiency in the city, and consequentially, to reduce barriers which harden the people's activities routines, mainly for those with special locomotion needs.

These users, inserted in a digital society, are familiar with geotechnologies which, nowadays, according to Laudares (2014) are available to all. The smartphones growing the number and the mobile APP popularization redefined according to Meneguette (2012) how people and maps interact, contributing to the people's welfare. In this matter, geography and spatial analysis models application are shown by De Abreu e Barroso (2013 as a relevant approach to solve problems, especially those associated with geographic location which includes the collective transport location, even to determine the bus routes between buses stops, as shown by Lima, Barroso, and Muzzarelli (2003).

In this work, we show that even though bus monitoring APP already exists, authors Lousada et al. (2016) did tests with various applications and testified that such applications don't fully englobe the usability criteria which deserves developer attention. In this context, the objective of this research is to present the steps of developing a prototype in the paper of a public transport monitoring app that can offer accessibility information for buses. Therefore, after a detailed analysis of existing apps, this research should present a solution that works for users with impairments and disabilities and that is capable of reducing the wait time of buses for its users, making lower their second biggest dissatisfaction with collective transport, according to Rodrigues and Sorratini (2008).

For this end, a case study will be made to analyze the real scenery of a city's public transport system. As goals, the app shall monitor the city's public transport in real time; make bus stop queries, itineraries, and routes; allow for bus location monitoring by the user; predict arrival times in bus stops; identify buses with support for users with special needs.

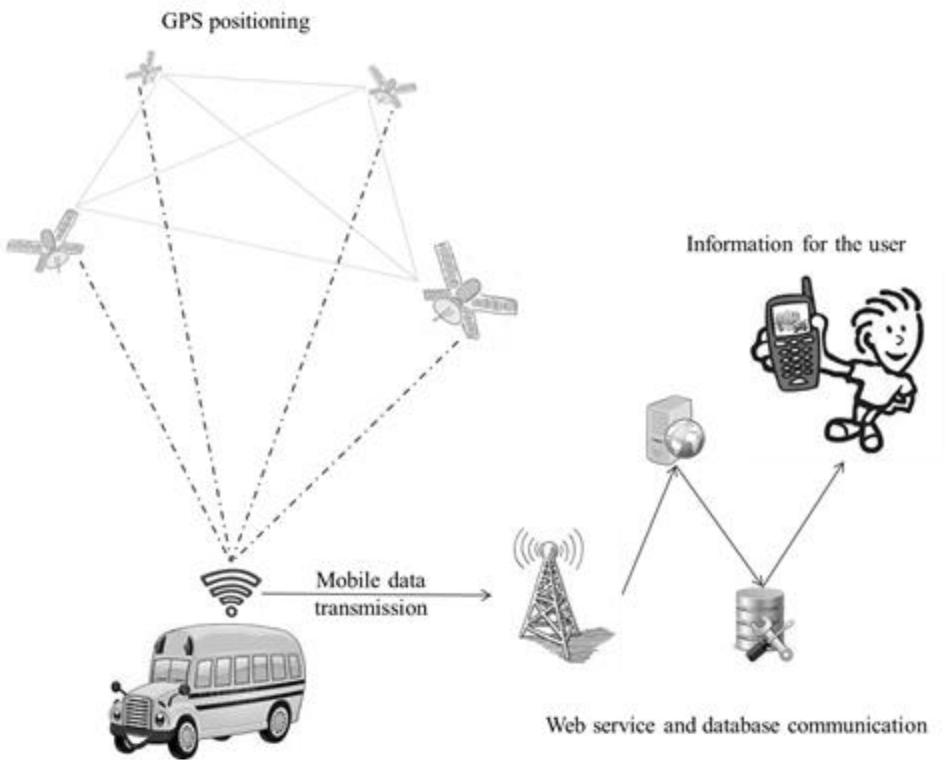
Therefore, the proposed prototype should raise public transportation efficiency, generating benefits, as highlighted by Goldsmith, Killorin, and Larson (2006), as the reduction of costs, noise and atmospheric pollution. Beyond that, the enhancement of public transport operations contributes to the optimization of roads, generating benefits to people, to the economy and to the environment.

Structure of geographic monitoring

The technologies in mobile systems, aimed at public transport users, is a common informational tool in various cities, as shown by Lousada et al. (2016). These apps use GPS locators together with an internet connection, present in the buses, that transmit their location, in real time, to a server. This server has a function the sending of this information to the app. Therefore, traffic eventualities that might cause delays can be identified by users. In a broad way, B'Far (2005) shows that geoprocessing allows for the friendly availability of information, through maps, for the regular citizen, and together with mobile systems, guarantee the access to information from anywhere, being GPS the essential component for the working of these apps.

GPS is, according to Maurya, Singh, and Jain (2003), a system of radio navigation based on satellite. This system allows for obtaining location and speed of the monitored object during the day, under any atmospheric conditions and anywhere in the globe. Its working is based on the triangulation, distance measuring and differentiation of transmitting times to a group of satellites, determining a position on earth. The monitoring of vehicles using GPS tech and internet, affirms Padmavathi and Begum (2016), requires four satellites to check the positioning with time precision, but normally it's necessary the usage at least three satellites to calculate positioning. The integration of GPS with mobile systems and its location apps is detailed by Lecheta (2009), is based on the Google Maps API. This API is described by Hu and Dai (2013) as a map and routes supply system for the entire planet. These services allow for the addition of markers, polygons, map overlapping or perspective shifts from an area. Apart from providing a series of native resources for the developer. Figure 1 synthesizes the integration of technologies that, together, form the basic structure for the construction of bus monitoring apps.

Figure 1 - technological structure for bus monitoring



Source: Authors.

The system for bus monitoring is formed by a GPS, an internet modem inside the vehicle, a Web Service that stores info in a Database.

The GPS is, to Rosa (2011), one of the techniques to collect spatial information, is inserted in one of the four categories related to spatial information treatment, and, therefore, to geoprocessing. GPS has the function of capturing the signals of satellite positioning in orbit, extracting the coordinates of latitude and longitude. The internet modem reads and transmits the satellite data to the Web Server that communicates with the database and makes the information available to the users through the app that allows for monitoring bus positioning.

The reproduction of apps that use this technological architecture is recurrent in literature. The research by Lousada et al (2016) presents mobile apps that do the monitoring of buses for Belo Horizonte. In this research apps from Fortaleza, Rio de Janeiro and São Paulo were also analyzed (see table 1).

Table 1 - Analyzed Apps and their Features

Features	App		
	Meu Ônibus Fortaleza[1]	Vá de Ônibus[2]	Cadê o ônibus?[2]
Provide itineraries and routes	0	1	1
Informs start times	0	0	1
Inform the arrival forecast of the bus	1	0	0
Finds the stops closest to the user	1	1	1
News information that affects traffic	0	0	1
View the vehicle's route in real time	1	1	1
Reports presence of accessibility equipment	0	0	0
Number of features	**3**	**3**	**5**

Table Caption:

yes	1
no	0

Source: Authors.

In the work elaborated by Souza and Vidal (2015) a prototype to monitor Mossoro's buses is presented, however in this the information for buses with accessibility for people with special needs isn't present The accessibility is also a neglected factor by Gularte, Ribeiro, and Silveira (2016) in the prototype developed to monitor public transport in real time through GPS in Porto Alegre. Therefore the availability of accessibility information is the differential of this research presented prototype. In this case, the research motivation is highlighted by De Araújo et al. (2012) by highlighting that moving around is a necessary act to the realization of the day to day activities, being accessibility a life quality component. In a scenery where only 45% of the bus fleet has the tools for easy access, Cavalcanti et al. (2013) affirm that mobility is fundamental for the realization of Social relations and work and accessibility to the public transport system is a relevant factor to the process of moving around.

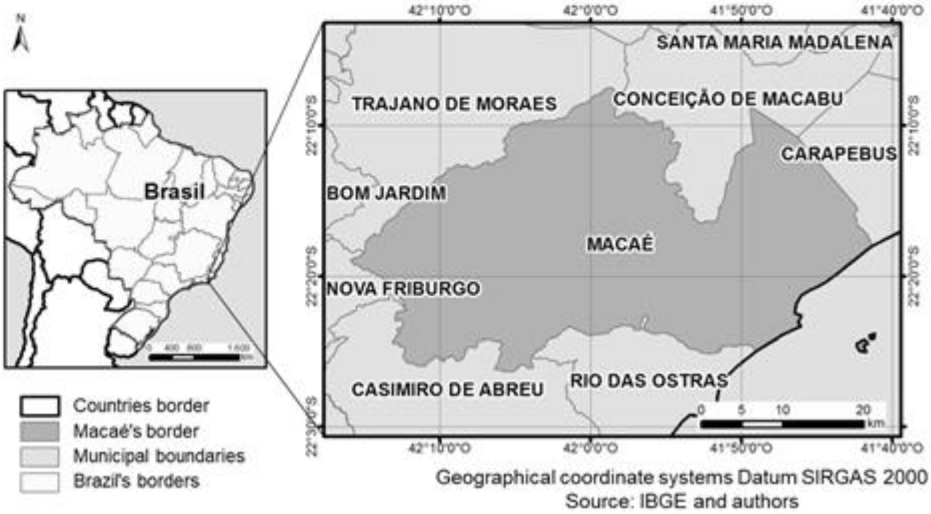
MATERIALS AND METHODS

This article presents an experimental research where a prototype for bus monitoring is developed. To that end, geotechnologies based on the Google Maps API are used in the test environment, in the city of Macaé RJ.

Study Area

The city of Macaé (see figure 2) is internationally known as the petrol capital. The city had, according to IBGE (2016), an estimated population of 234.628 inhabitants by the year of 2015. The settlement of the city of Macaé is, according to Paganoto and Becker (2007), a consequence of the migratory flow influenced by the oil segment. In this segment, only Petrobras employs 6.9 thousand people directly and 28 thousand indirectly.

Figure 2 - Macaé-RJ localization map.



Source: authors.

DENATRAN (2015) calculates that Macaé's traffic moves more than 108 thousand vehicles every day, difficulting the public transport operation. Among the highlighted problems in O Globo (2016) are the recurring lines in bus stops, the big wait time for buses, the overcrowding of buses and the lack of accessibility for people with special needs in the vehicles.

In the news report from O Globo (2016), it is affirmed that: whoever depends on public transport in Macae faces lines in the bus terminals. Still, O Globo (2016) verified that the growth of the buses numbers hasn't followed the 54% increase in population between the years 2000 and 2010.

Research development stages

The approach to the prototype development, according to Pressman (2006), is systematic and disciplined and follows the basis of software engineering. Therefore, a set of linked activities forms a development process. In this case, the prototype development activities is a process that starts in the analysis of requirements and the elaboration of use cases, modeling entities and relationships, the diagramming of classes from the data receiving module and

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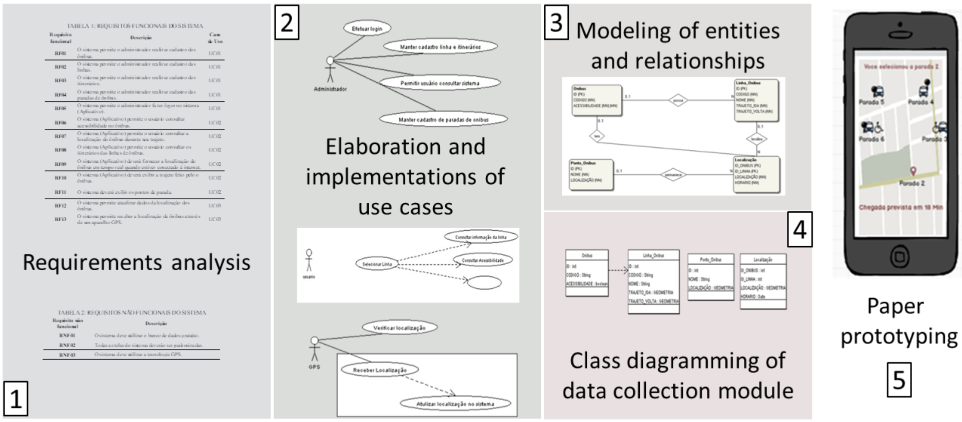
finally the paper prototype. Figure 3 synthesizes the prototype development process.

Figure 3 - Prototype development stages.



Source: Authors.

On Stage 1 the requirement analysis is realized which, according to Jalote (2005), is the detailing of the knowledge related to the problem to which the software is being developed. The focus of this activity is to prepare a formal project of the system development, with quality and adequate costs. In this stage, a document is presented, contemplating functional and not functional software requirements. These requirements are conceptualized by Paula Filho (2000), being the functional ones the description of the functionalities and services expected by users that will work the system. These requirements may vary according to the development. The not functional requirements are requirements, albeit more critical, present in the whole system or in parts of it, defining the properties and restrictions of the system.

Stage 2 consists of the elaboration of use cases: by the end of the requirement analysis, with the body of the specification ready, the functional and nonfunctional requirements are described through use cases. The use cases build the first overview of an analysis model. The diagrams of use cases were produced in the program ArgoCASEGEO v3.0.

In Stage 3 the model diagram of entities and relationships is produced, describing the logical structure of the database. Conceptually, Silberschatz (1999) affirms that the diagram of entity-relationships is a perception of the real world through basic objects relating. The basic objects are entities described by attributes, being those quantized through cardinality mapping. The graphical representation of the entity model through diagrams allow for the communication of information from a specialist to lay users. In Stage 4 the data receiving module class diagram is elaborated. This diagram, according to Rob and Coronel (2011), allows for the visual representation of different data visualizations, meaning, the vision through the point of view of developers, programmers, and final users. The tool used for the modeling of these diagrams was the ArgoCASEGEO v3.0.

In Stage 5 the paper prototype is made. A prototype is, according to Corais (2016), the product in phase, which can be understood as a partially functional model, built based on the defined requirements. The prototype simulates the software workings and allows for software interactions. The paper prototype is a fast way of visualization and test of software design, simplifying its understanding by users. Paper prototyping occurs at the beginning of the development project with the objective to point problems related to name comprehension, terms, messages, content navigation, interface workings and task completion.

RESULTS

Stage 1 results, the requirements making, is subdivided into functional and nonfunctional requirement makings. The results of these sub stages are presented in tables. The main functional requirements foreseen to the system and its respective use cases are shown in Table 2.

Table 2 - Functional System Requirements

Functional requirement	Description	Use case
RF01	The system allows the administrator to register buses.	UC01
RF02	The system allows the administrator to register the lines.	UC01
RF03	The system allows the administrator to register the itineraries.	UC01
RF04	The system allows the administrator to register bus stops.	UC01
RF05	The system allows the administrator to log in to the system (Application).	UC01
RF06	The system (Application) allows the user to consult accessibility on the bus.	UC02
RF07	The system (Application) allows the user to consult the location of the bus during its route.	UC02
RF08	The system (Application) allows the user to consult the itineraries of the bus lines.	UC02
RF09	The system (Application) should provide the location of the bus in real time when connected to the internet.	UC02
RF10	The system (Application) should display the route made by the bus.	UC02
RF11	The system should display the breakpoints.	UC02
RF12	The system allows you to update bus location data.	UC03
RF13	The system allows you to receive the bus location through a GPS device.	UC03

Source: Authors.

The main nonfunctional requirements foreseen to the system and its respective use cases are presented in Table 3.

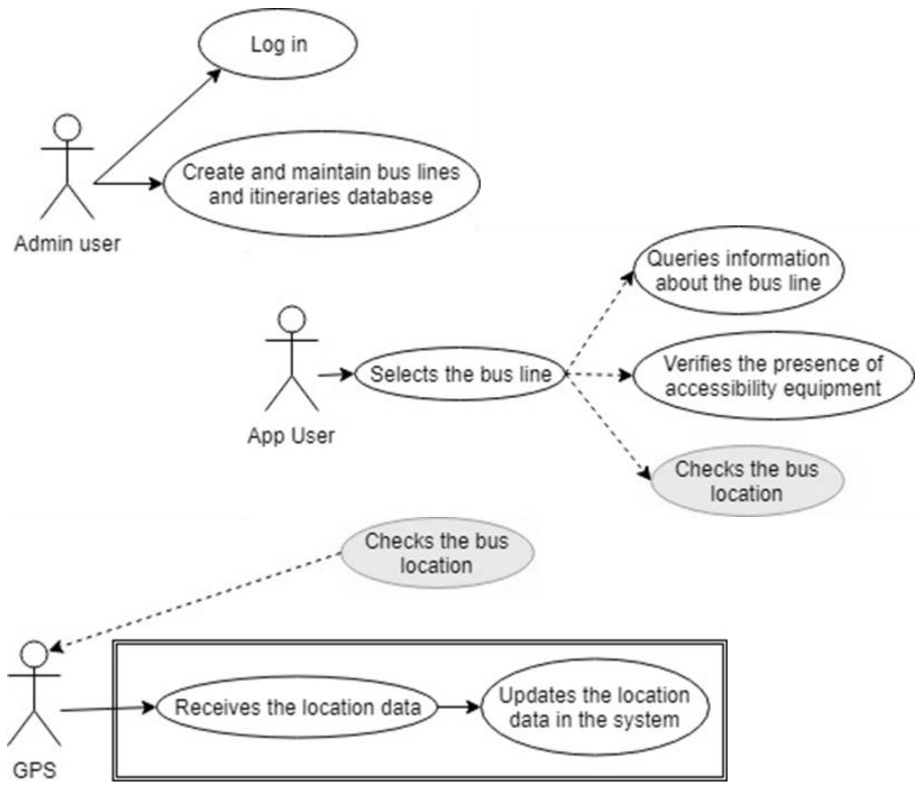
Table 3 - Non-Functional System Requirements

Nonfunctional requirement	Description
RNF01	The system must use the free database.
RNF02	All system screens should be standardized.
RNF03	The system must use GPS technology.

Source: Authors.

The result of Stage 2 is presented in the form of use cases diagrams. These diagrams show the system's activity flow as presented in Figure 4.

Figure 4 - Use cases.

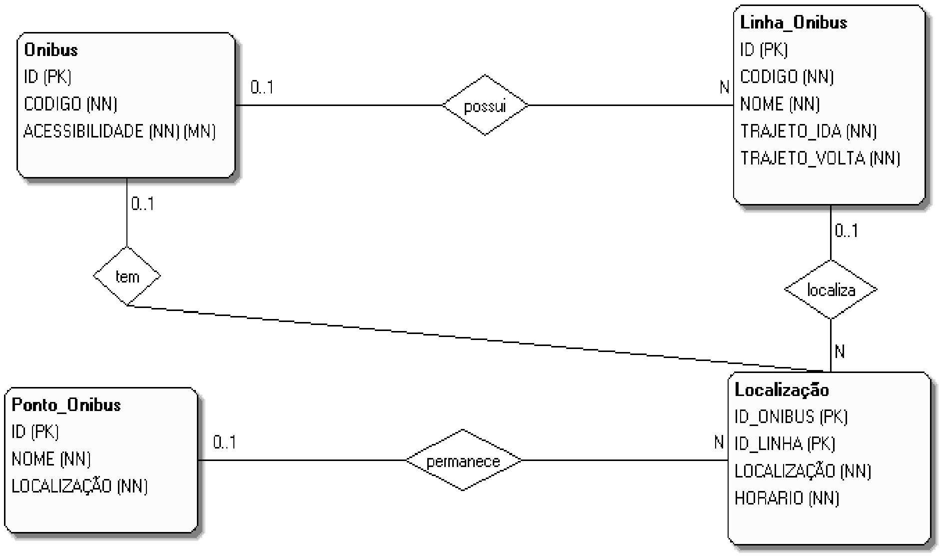


Source: authors.

In the use case diagrams the registering process, the system query, and location identification are exemplified. In UC01, the actor is the admin. The admin is responsible for all registers and alterations of system data referring to buses, routes, and stops. In UC02, the actor is the user. The user is who does the search for system info, being able to identify, bus routes, itineraries, vehicles with accessibility equipment, bus locations, and its trajectory. The use case that describes how to work the location and following of the bus trajectory is UC03. In it, the actor is the GPS, which receives the location of the bus and transmits the update of its bus to the system.

Stage 3 shows the results of the elaboration of the entity-relationship diagram. Figure 5 shows this diagram of the system prototype and from it, the tables are generated and its respective relationships in the database.

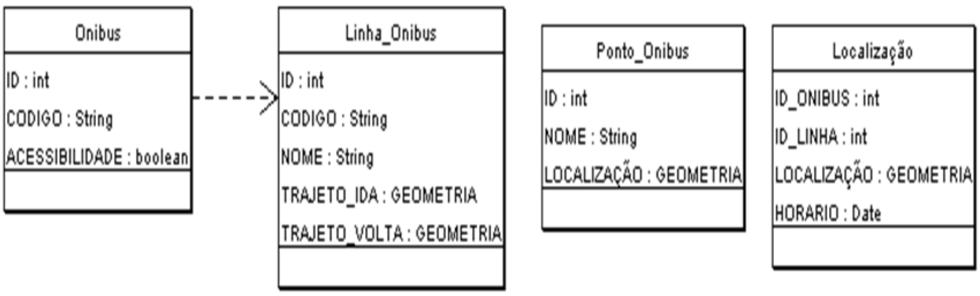
Figure 5 – ERD, Entity and Relationship Diagram.



Source: Authors.

The result of Stage 4 is the receiving data module classes diagram. Figure 6 shows a relationship database diagram model. In this model, the user receives and stores data in tables, then those are related among themselves through attributes and common values.

Figure 6 - Modeling Entity and Relationship.



Source: Authors.

As the result of stage 5, the paper prototyping is executed. This prototype, presented in Figure 7, is a quick way to project and visualize the proposed solution.

Figure 7 - Buses monitoring application Prototype for Macaé-RJ.

Source: Authors.

CONCLUSION

The technology and innovation of the devices and mobile systems have attracted more and more the quest for creative solutions. Based on the study realized in this work it's notable the need of keeping the public transport informed through georeferenced apps, seen that the society already possesses an inclination for the usage of mobile tech.

Aiming to facilitate the life of bus users, this study has as an objective contribute and propose, through modeling, the development of apps for public transport, making it possible so that the population has access to the information about the itinerary or the foreseen bus times. The study also proposes the real time monitoring and location of buses in a certain bus stop, identifying also buses that have equipment for reduced mobility users.

This work provided an understanding related to the importance of georeferenced technology and motivated the realization of new research for the public transportation monitoring.

A public transport monitoring system doesn't solve all the problems, even so, it starts a solution process that aims for the comfort and commodity of the public transport user and incentivizes its utilization.

A point that might be used as a future research is the integration with the app Waze in order to visualize the occurrences of a route in the map, accessible bus stops mapping and utilization of the app in a collaborative way by users.

Desenvolvimento de protótipo de aplicativo para monitoramento de ônibus em Macaé-RJ

ABSTRACT

O transporte é um elemento essencial para a realização das atividades cotidianas das populações das cidades. A ausência de informações de horários de chegada, de itinerários ou dos locais de parada é recorrente nas cidades brasileiras. Assim, independentemente do tamanho da cidade, a desinformação dificulta a mobilidade e aumenta o tempo de deslocamento dos cidadãos. O objetivo desta pesquisa é apresentar as etapas de desenvolvimento de um protótipo que monitora o transporte coletivo de uma cidade brasileira. Esse protótipo, diferentemente dos aplicativos conhecidos, disponibiliza também informações sobre os ônibus com equipamentos de acessibilidade, que atendem usuários com dificuldades de locomoção, sendo acessível por meio de dispositivos móveis. Para isto, um levantamento de funcionalidades dos aplicativos existentes e casos de uso foram elaborados para desenvolver um protótipo de um aplicativo móvel aprimorado, baseado em sistema de posicionamento global, capaz de disponibilizar informações geográficas relacionadas ao sistema de transporte coletivo da cidade de Macaé-RJ. Dessa forma, informações sobre o deslocamento dos ônibus da cidade são disponibilizadas, trazendo benefícios para os seus usuários, especialmente para aqueles com dificuldade de locomoção.

KEY-WORDS: Acessibilidade. Transporte Coletivo. Tratamento da Informação Espacial. Protótipo de Aplicativo.

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