Smart Cities: How the concept of smart cities can improve urban mobility in the city of Rio de Janeiro

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ABSTRACT

Urban mobility is significantly affected by the disorderly growth of cities. Many problems in urban centers today are caused by the increase in the number of cars on the streets and the few incentives for public transport are just some of these problems. The accelerated urban growth registered in recent years has increased the concern regarding urban mobility in the city of Rio de Janeiro. Smart cities are an alternative to the problems found in cities where, based on Information Technology, search for databases, and thus share important information with the effective participation of the population, helping the management itself to do something for the citizen. In the last eight years, there is an excessive number of people and vehicles on the streets, generating congestion, insecurity and loss of time, based on statistics from the Dutch company Tom Tom, Rio de Janeiro loses an average of 47% more time in traffic compared to the time lost around the world. The objective of this study is to present how the concept of smart cities can influence urban mobility, through sustainability, innovation, research through world statistics, intelligences among world cities, in order to bring improvements to congestion and difficulty of circulation in the city of Rio de Janeiro. Therefore, in this study, in addition to statistical data, it was used materials of Smart cities and urban mobility in the current world, how to demonstrate different forms of urban mobility in smart cities through the use of applications of interaction between people and cities.

Keywords: Smart Cities, Urban Mobility, Internet of Things.

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INTRODUCTION

According to the report *United Nations, Department of Economic and Social Affairs, Population Division* (2015), the world's urban population is already larger than the rural one, as 54% of the inhabitants live in cities. This figure is significantly higher than in the 1950s, when only 30% were in urban areas. Recent data indicate a complete reversal by 2050, suggesting that only 34% will reside in rural regions. The evolution of the world's urban and rural population from 1950 to 2050, according to projections calculated by the United Nations. In 1950, only 700,000 people lived in urban areas; in 2014, about 3.9 billion individuals were in urbanized centers; Finally, it is estimated that this number will reach 6.3 billion by 2050.

According to the IBEU (Urban Well-Being) index, prepared by the observatory of metropolises in 2013, among the 15 metropolitan regions of Brazil, Rio de Janeiro is the one with the worst evaluation in terms of urban mobility, being below the national average in all dimensions analyzed (Ribeiro and Ribeiro, 2013).

The difficulties faced by citizens in their daily commutes create barriers, especially for the poorest and those who live far from the areas that concentrate the best opportunities for study and work. The most notable result of this statement is that the process of social exclusion is further aggravated by the existence of a deficient public transport system (Pero and Mihessen, 2012).

In this context, there are great challenges to face smart city projects, even more so if we understand as "intelligence" the processes that stimulate creativity, criticism, democratization and not only the adoption of digital technologies. The initiatives will not necessarily create a more sensitive and promising metropolis just by offering objects with sensors interconnected to digital networks. Without a political discussion in relation to new informational tools, there is no guarantee that we will have, in the future, smarter cities (Lemos, 2013).

According to Sonda (2017), which is increasingly common worldwide, the concept of *Smart City* is transforming entire cities by using technology and intelligence in public management. The simplest and most direct way to talk about the subject is to consider that smart cities are those that use connected devices to monitor and manage streets and public spaces. The concept, however, goes far beyond that. In its broadest meaning, *Smart Cities* are urban centers that have been incorporating IT (Information Technology) technologies and solutions to integrate and optimize municipal operations, reducing costs and improving the quality of life of their inhabitants, reducing idle time and increasing productivity. A city that reaches this level, therefore, is not only connected, but a living and sustainable region that can use intelligence in favor of administration and resource management, in addition to ensuring more safety and practicality in the use of roads and other public devices.

According to Villarino (2017), when we talk about technological revolution, the notion of the

Internet of Things (*IoT*) is one of the main subjects. And it's not hard to see why. Its possibilities are numerous, such as transforming our relationship with technology, changing the way we interact with the world, and even more, the way the world interacts with us. It is a concept capable of changing not only how we live, but also how we work.

In this study will be presented the proposal of the application of the concept of smart cities, using in practice the concept of *Smart City* to improve urban mobility in the city of Rio de Janeiro, through sustainability resources and integrations of smart systems, proposing a *MOBILE URB application* to ensure a better locomotion through the city with quality of life, ease and accessibility to the citizens of Rio de Janeiro.

PROBLEM

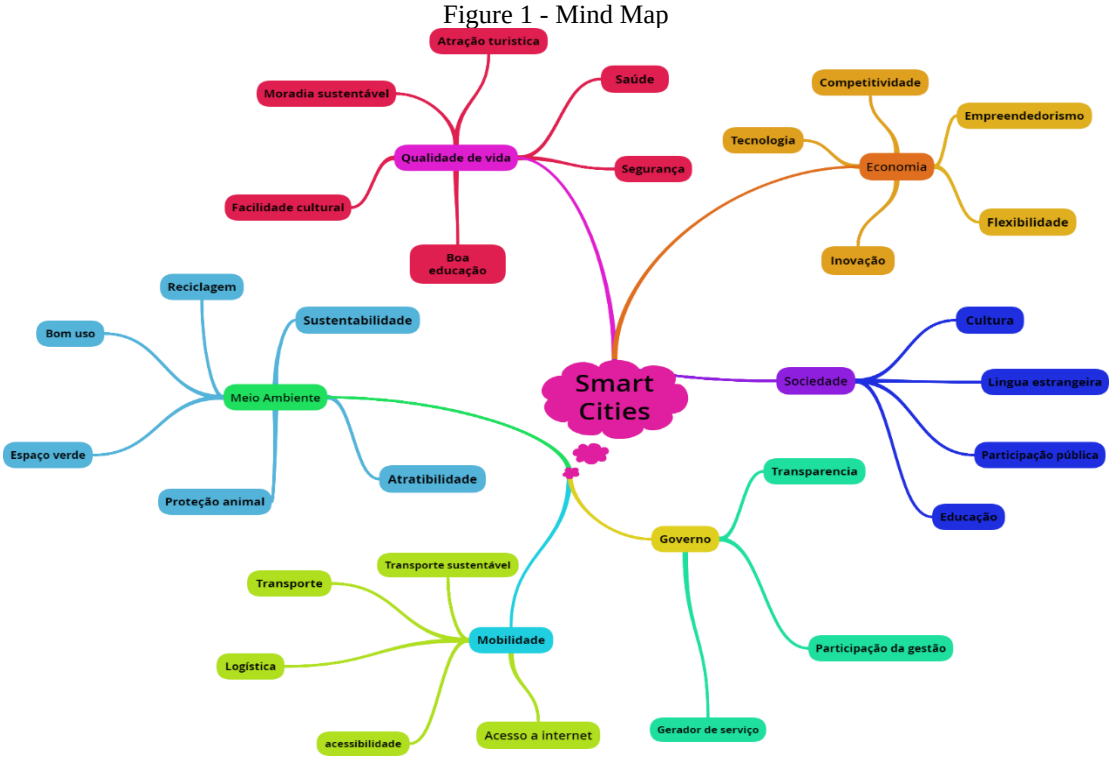
Urban mobility in Brazil has become a great chaos, especially in large metropolises. A problem that worsens over the years and directly affects the population.

Thus, in large cities in Brazil with a population of 3 million people, 6 million trips are made per day. These trips are made with a greater or lesser level of comfort according to the specific conditions in which they are carried out and imply consumption of time, space, energy and financial resources and the generation of negative externalities, such as air pollution, traffic accidents and congestion. Due to the intense urban growth in Brazil, since the 1960s, many cities – and metropolitan regions – have started to have low-quality and high-cost mobility systems, with negative impacts on people's lives and on the economic and environmental costs for society. Thus, the study of the effective conditions of mobility is essential to assess the quality of urban life in the country and to identify public policy actions that can reduce the problems and improve the overall quality of life and the efficiency of the movement of people and goods. (Fernandes, 2015)

According to the Tom *Tom Traffic Index* (2017), Rio de Janeiro is the 8th most congested city in the world and the first in Brazil. Cariocas spend an average of 47% more time stuck in traffic at any time of the day, and up to 81% more at peak periods at the end of the day compared to a free-flowing or uncongested situation – adding up to 164 more hours of travel per year.

In order to assist in the unfolding of the subjects to be addressed in this study, the mental map represented in Figure 1 below was elaborated, where it presents the unfolding of the problem and the proposal for the implementation of the concept of *Smart Cities* to help in urban mobility in the city of Rio de Janeiro.

Figure 1 - Mind Map



Source: Authors (2018)

THEORETICAL BACKGROUND

SMART CITIES

Smart Cities are a mix of human capital and technology that aim to improve the development of a city in a sustainable way. Information and Communication Technologies (ICT) are used to enable economic growth and an improvement in the quality of life, a good management of natural and energy resources, with the participation of the State. The investments are five main areas: environment, mobility, citizen-government interaction, quality of life and economy/creative people. (EU, 2017)

Giffnger et al. (2007) provided a Smart *City* model, understood as a city composed of six features built on the intelligent combination of donations and self-management activities, conscious and independent citizens, and a method for measuring and comparing urban intelligence. The six characteristics or sectors in which a *Smart City* has to ensure high *performance*, according to the authors, can be identified as: smart economy; smart people; smart governance; smart mobility; smart environment and smart life.

URBAN MOBILITY

For decades, cars have been at the center of big city planning. As a result, urban mobility was synonymous with road infrastructure for motor vehicles. The result? Stratospheric traffic jams, road saturation and severe pollution. But, thanks to the advancement of technology, Digital

Transformation in urban mobility is expanding solutions and allowing a new look at the chaotic planning of urban areas (TD Team, 2018).

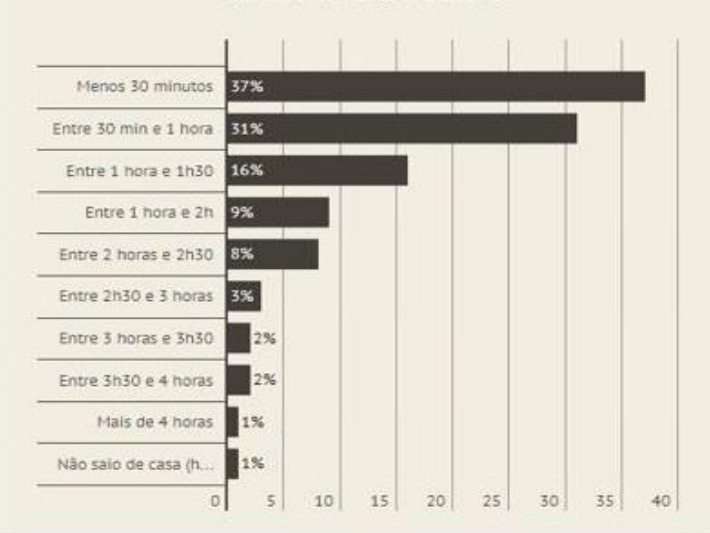
The lack of urban mobility is considered one of the biggest problems faced by large metropolises. The problems encountered in the urban mobility of a city can derive from several factors, among them: disorderly and accelerated population growth combined with an unprepared infrastructure, incentive to the use of individual cars and lack of quality in public transport (Ximenes, 2016).

Many of the challenges encountered in urban mobility in developing countries, such as Brazil, are a combination of historical problems and the belief that the main way to make citizens' mobility better is individual transport, the automobile (Silva, Costa and Macedo, 2008).

According to Silva, Costa and Macedo (2008), the issue of mobility in Brazil is treated as a question of the supply of transport services, that is, the provision of automobile infrastructure to the detriment of public transport, non-motorized transport and the separation of urban planning from transport planning.

According to Exame magazine (2016), about 41% of the population spends around 1 to 4 hours in traffic to commute from home to work, as can be seen in Figure 2 below.

Figure 2 - Travel time in traffic



Source: Exame (2016)

INTERNET OF THINGS

According to Werkema (1995), IoT or Internet of Things refers to the interconnection of embedded computing identifiable solely as a device within the existing Internet infrastructure. IoT typically offers advanced device, system, and service connectivity that goes beyond machine-to-machine (M2M) communications and spans a variety of protocols, domains, and applications. The interconnection of these embedded devices (including smart objects) is expected to dominate

automation in almost every field and enable advanced applications such as *Smart Grids*.

The M2M architecture is superseded by the *Internet of Things* (IoT), that is, electronic devices start to add not only communication capacity, but also processing capacity, becoming intelligent agents. With the dominance of Asian countries in the globalized market of commodity production and distribution, the prices of these smart sensors, smartphones and other artifacts become more accessible to the masses and available for composition, by smart city architects, in various arrangements, forming platforms of increasingly sophisticated solutions (Holler, 2014).

APPS AND URBAN MOBILITY

According to Statista (2014), from 2000 to 2014, there was a 1000% increase in people with access to the internet. In addition, it should be noted the increase in the use of mobile devices, which, due to the ease of mobility, help in consultations and production of content about cities. These devices usually have GPS, which allows interaction with others in the area, providing route tracings, traffic time estimates and other important information for the user. These advances have facilitated the population's access to applications, which can entertain and inform about various sectors of the city, including urban mobility. Today, it is possible to get around with ease anywhere in the world with the help of an app. It is also possible to know the traffic conditions even before leaving home, making it possible to choose better and emptier routes. These facilities, which are part of the concept of *smart cities*, empower the user, since, with their use, it is possible to program the time, the places they want to pass through and how these paths will be made.

According to the website O Dia (2016), mobile applications and other technological advances have transformed the ways of coming and going of the population and can be great allies in improving urban mobility. The third and final article in the 'Transport Trends' series shows the potential of these new tools, especially those for car, bike and carpooling, to create smart and more connected cities.

According to the International Union of Public Transport (UITP), simulations carried out in the capitals of European Union countries show that the combination of high-capacity public transport and car-sharing and carpooling could remove up to 65 out of every 100 cars at peak times. (The Day, 2016)

SOLUTION PROPOSAL

THE CITY

Rio de Janeiro is a metropolis known worldwide for its exceptional interaction between culture and nature and a destination desired by tourists from Brazil and the world. The intense cultural life and the exuberant historic center join the natural landscape with many urban attractions.

Icons of Rio's tourist itinerary are: the Tijuca Forest (considered the largest urban forest in the world), the beaches of Copacabana, Ipanema and Leblon, as well as the world-famous Sugar Loaf with the coming-and-going of its cable car and Corcovado with the giant statue of Christ the Redeemer. In addition to being one of the most beautiful sceneries in Brazil and the world, the cultural manifestations of Rio de Janeiro express the synthesis of the carioca lifestyle, internationally known, and marked by samba, bossa nova, soccer, carnival and religiosity - Catholic and of African origin. Lapa with its famous arches, in the Historic Center, is one of the most visited regions by tourists, both for the cultural integration between visitors and cariocas and for the bohemian life and nightlife of the city (Gurgel, 2018).

With 453 years and about 17.2 million inhabitants, Rio de Janeiro, as shown in Figure 3 below, is the third most populous state in the country, according to the population estimate released by the Brazilian Institute of Geography and Statistics (IBGE). It is second only to São Paulo, with 45.5 million inhabitants, and Minas Gerais, with 21 million. The population of Rio de Janeiro corresponds to approximately 8% of the entire population of the country, estimated by the IBGE at 208.5 million people. The estimate considers all people who lived in the country until July 1, 2018 (Globo, 2018).

Figure 3 - Photograph of the city of Rio de Janeiro

Source: Exame (2017)

CONTEXTUALIZATION OF THE PROBLEM

The problem of urban mobility in large cities is one of the main challenges to improve the quality of life of the population, according to a public hearing by the Senate of the Future Commission (CSF). Residents of metropolitan areas spend up to four hours commuting from home to work. They advocated greater integration between municipalities and popular participation in the search for solutions. (News, 2018)

Still Notícias (2018), mobility is a broad topic that goes beyond the discussion on traffic, involving issues related to the history of the occupation of territories, the country's economic and social growth, and public policies. It has a direct impact on people's health and quality of life through

major problems such as congestion, conflicts of different modes of transport, reduced safety for pedestrians, increased air and noise pollution, reduction of green areas due to parking space and expansion of roads for the circulation of motor vehicles. Suggesting, in addition to urbanization without planning, one of the reasons that led Brazil to reach this critical point in mobility was the adoption of public policies such as the reduction of the tax for the purchase of vehicles, favoring individual motorized transport.

It can be said that the absence of more efficient mobility not only generates negative consequences on people's quality of life, but also on the country's economy due to the increase in commuting time from home to work, a factor that generates losses for companies due to the reduction in employee performance, either due to delay or fatigue. And in view of all this information, the city that was chosen to represent all these challenges of Urban Mobility was Rio de Janeiro, which, despite the crisis it has been experiencing, has also adopted solutions to improve the population's commuting and standard of living.

The main problems that occur in the city frequently are:

- Time spent waiting for public transport;
- Distance traveled;
- Public transport users who need to make more than one modal change in a single journey;
- High cost of public transportation compared to monthly income;
- Time spent in congestion;
- High number of cars on the street;
- Lack of public transport policies;
- High air pollution and risks to the health of the population.

THE *URB MOBILE APP*

In order to provide society with better locomotion and interactivity, in order to improve the quality of life for the citizens of Rio de Janeiro, with less time in traffic, and with better mobility to circulate over the city, the idea of developing an application for smartphones arises, available for the Android, *iOS* and *Windows Phone* operating systems is able to interact with the ERP system, which is an information system that integrates all the data and processes of an organization into a single system that will be used for the mobility of Rio de Janeiro.

Access to Mobile Urb

To access the *Mobile Urb application*, it is necessary to search for it in the virtual store of the smartphone's operating system. After requesting its free installation, upon completion of this process,

just access it on the device.

In figure 4 below, the initial screen is presented to the user to register a personal e-mail and password, then the user is directed to register with information such as: home address, work address, contact phone numbers and credit, debit or cash card registration. After the first time the customer accesses this screen, *Mobile Urb* will store their information, and when they activate the app, they will have direct access to the main menu.

Figure 4 - Application Splash Screen

Source: Authors (2018)

Menu principal

On the screen you will have 5 locomotion options: "Cyclist", "Public Transport", "Private Transport", "Pedestrian" and "Info RIO" just "press" the desired service to navigate and get all the necessary information or enter your "origin" and "destination", and the application itself directs you which transport is best to use. The app even ranks as the cheapest, fastest, and smartest route (convenience vs. itinerary expense), as illustrated in Figure 5 below.

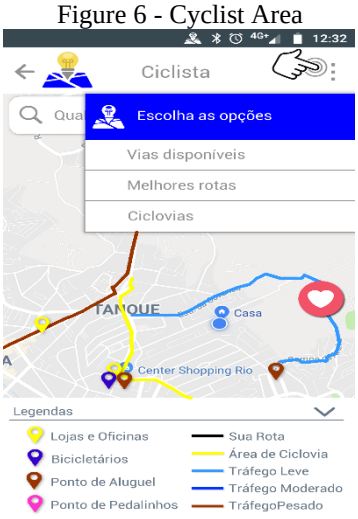
Figure 5 - Application Main Menu

Source: Authors (2018)

Cyclist

By "clicking" on the cyclists button, he will be directed to all the important options for people who choose to move around through this transport, the user is forwarded the following requests, illustrated in Figure 6 below:

Figure 6 - Cyclist Area



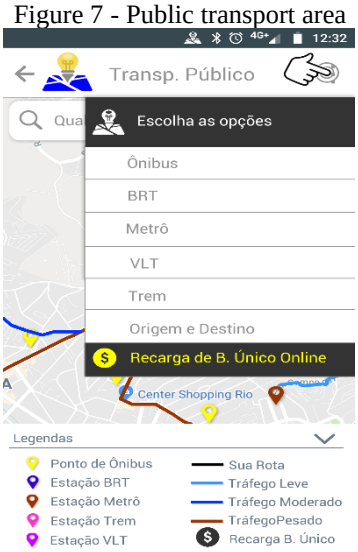
Source: Authors (2018)

- Which roads are available for access;
- Which route to take to get to your destination;
- The app itself calculates the routes taken by cyclists;
- Which places have availability for bike rental and how many bikes are available;
- Bike racks and paracycles;
- Bicycle shops and workshops;
- Recreational bike lanes / quieter lanes for cycling;
- Collects data from bicycle routes, feeding a database that crosses information with existing infrastructure;
- It measures altimetry, average speed, calories burned during pedaling, time, distance and pace.

Public transport

By "clicking" on the Public Transport button, he will be directed to all existing public transport options such as: "train", "subway", "bus", "BRT" and "VLT" and "origin and destination" after filling in the field the application will answer the best route and transport to be used, as illustrated in Figure 7 below:

Figure 7 - Public transport area



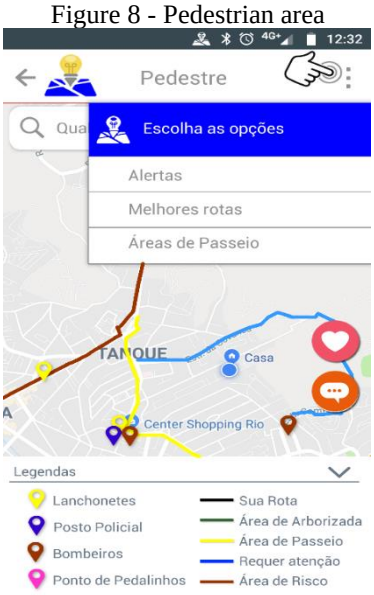
Source: Authors (2018)

- Recharge a single ticket online;
- Which lines are available to follow your destination;
- What transportation options;
- Schedules and routes (shorter routes, lower costs);
- Guide to the transport point and the time to get off from the same transport;
- Advance notification so as not to miss the transport;
- Operating situation;
- Display on the map the position of the buses and more than one line;
- Real-time commute;
- Map of bus stops, train stations, subways, BRT'S and VLT'S.

Pedestrian

By "clicking" on the pedestrian button, he will be directed to all the entertainment, accessibility and safety options that the application offers to the citizen, the user will have the following options as illustrated in Figure 8 below:

Figure 8 - Pedestrian area



Source: Authors (2018)

- Best walking paths (Green space, commercial areas, areas with less slope, less dangerous areas);
- Provides conversation with other users;
- It provides the ranking of everyone who went through that stretch;
- Make direct calls to: Police, SAMU, Firefighter, Civil Defense, among others.

Private transport

By "clicking" on the Private Transportation button, he will be directed to all existing transportation options such as: "Uber", "taxi", "shared car", the user is forwarded to the "origin and destination" field after filling in the field the application will answer the best route and transportation to be used, as illustrated in Figure 9 below:

Figure 9 - Private transport area

Source: Authors (2018)

- Map of the best routes to follow with all the prices described;
- Identification of all vehicles available to share, located in the vicinity of the user;
- Location sharing;
- Reverse for immediate use of vehicle.

Info Rio

By "clicking" on the traffic button, you will have all the information a citizen wanted to know about traffic, as illustrated in Figure 10 below:

Figure 10: InfoRio Area

Source: Authors (2018)

- Real-time information about flooding or natural disaster;
- Blocked roads;
- Risk Areas;
- Shows traffic information;
- Monitors the driver's driving habits (without additional equipment) and encourages safer driving;
- It offers the option of designing the route in the most pleasant way;
- Indicates nearby parking such as the amount to be charged and hours of operation;
- It has integration with apps such as *WhatsApp*, *Telegram* and *Skype*, as well as integration with *music apps*, avoiding the use of your hands even to change music. It has intuitive and functional voice commands;
- Allows you to calculate fuel expenses and repairs. In addition, it has supply records and reminders of future maintenance;
- Travel planning;

- Route information;
- *QR Code*.

Each transport will have a *QR-Code* (identification label), to allow access to the user, it is necessary to activate the *QR-Code* scanner and scan, through the mobile phone camera, this identification label will be at the access to the transport.

When the user accesses the *"QR-Code"* icon and scans it, it will be directed to "Route Information" and will have a history of the routes taken, payments made, as shown in Figure 11 below.

Figura 11 - Manual do *QR- Code*

Source: Authors (2018)

The *QR-Code*

By elaborating the applicability of the project in a complex area consisting of a mileage of 1,255 km², where they have:

- Bike path with a length of 450 km;
- 440 Articulated BRT fleets and covers 125 km in length;
- 204 trains through a network of 270 km and 102 stations;
- Metrô Rio has 41 stations, three lines in operation and 14 integration points with 58 km of extension;
- Rio bus has around 4625 buses throughout the city of Rio de Janeiro;
- VLT consists of 32 trains, 44 meters long;
- 33,000 taxis;
- 50,000 Uber.

One of the solutions capable of regardless of the degree of complexity is the *QR-Code technology*. To carry out this step, it was necessary to access Fetranspor's database, mapped in an

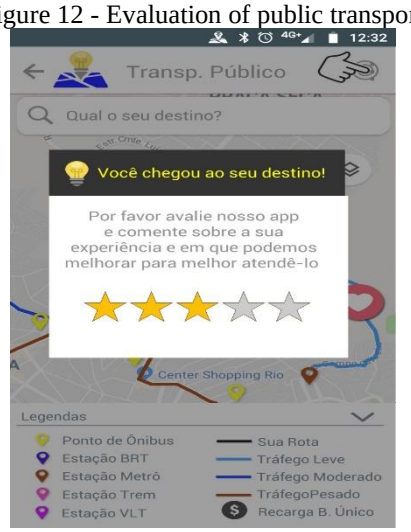
internal system. All it took was for the Information Technology team, responsible for the development of the application, to generate a *QR-Code* equivalent to each of these transports.

Evaluation of App Usage

In order to measure, in real time, customer satisfaction, an option will be made available, below in the "information about routes", for the user to evaluate the performance of the application, public transport, private transport, urban mobility and safety by choosing between none to five stars and, optionally, a summary text for more details.

At the end of the use of the application, each user who uses the service will evaluate with a grade and/or inform an important piece of data to the application so that users are increasingly satisfied and safe, as shown in Figure 12 below.

Figure 12 - Evaluation of public transport



Source: Authors (2018)

EXPECTED OUTCOMES

With the constant advancements in technology and the ease of access to smartphones, more and more people are connected. In the current context, cell phones are not only a practical and fast way to communicate. The main advantages of the proposed actions will be described below:

- Greater incentive to public transport;
- Increased security;
- Reduction of private cars on the streets;
- Reduction of operational failures;
- Reduction of time in traffic;
- Increased reliability;
- Convenience;
- Accessibility in the palm of your hands;

- Easier to get around;
- Greater practicality;
- Greater possibilities;

In view of the expected results with the application of the proposal, the advantages were considered as a real gain for urban mobility.

FINAL THOUGHTS

This work contemplated several aspects focused on the urban management strategies of Rio de Janeiro by improving accessibility that aim to ensure the best locomotion of the entire city, as well as ensuring the well-being and quality of life of citizens.

It is believed that the urb mobile application is a big step, in order to measure the need of the citizen, making the trip easier and faster, in addition to showing that the tool can seek important information from public management, in order to bring improvements to the city.

Smart cities is a concept that is on the rise when it comes to city planning, yet it still causes divergence in the academic world and has a great potential for growth, in fact, it can be realized for cities to be increasingly efficient with the use of information technology, *big data* and the internet of things.

However, it is important to point out that the simple implementation of these concepts does not solve all the problems that exist in a city. On the other hand, the concept of urban mobility is very old and familiar to many, even if not known by this specific term, and even so, it is a topic that needs studies and solutions to face problems that plague, mainly, developing cities, such as the case of Rio de Janeiro, which have suffered an accelerated process of urbanization without the necessary infrastructure to support it.

The authors believe that research on feasibility should continue and delve into ways of financing these initiatives, whether through Public-Private Partnerships or simple financing of companies or public tenders. In addition, to carry out tests in controlled environments of these initiatives in order to better understand the bottlenecks and possible consequences that they would lead to the city as a whole.

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