INTERNET OF THINGS (IoT) IN URBAN MOBILITY: THE CASE OF BUS RAPID TRANSIT (BRT) OF SÃO JOSÉ DOS CAMPOS CITY

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Abstract: - The implementation of the Bus Rapid Transit (BRT) in São José dos Campos - SP, aims to improve urban mobility and quality of life. The search for improvement in technologies that assist in the population's daily life is achieved through something known as the Internet of Things (IoT) in the case called ITS, which connects objects and provides fast communication between a system and operator, providing information that enable monitoring of equipment use within the BRT.

Key-Words: - Internet of Things, Bus Rapid Transit, Urban Mobility

1 Introduction

Mark Weiser was the first to propose solutions similar to what we call today's Internet of Things (IOT), titled Ubiquitous Computing in 1991, in his article, The Computer for the 21st Century. Begins with a comparison using the term "Literacy Technology", which means nothing beyond the writing spread in our society, as the primary means of transmitting information as street signs, billboards, newspapers and documents.

Ubiquitous computing Weiser is to have a network of computers that communicate between them and us, so natural and everyday way that goes unnoticed, as well as writing, making or assisting humans in their daily activities. [1]

According to Weiser, the non-perception of technology is a fundamental consequence of human psychology, not a technological need, exemplifying the following passage:

"When you look at a street sign, for example, you absorb its information without consciously performing the act of reading ..."

The term Internet of Things, created by Kevin Ashton in 1999, has as its main concept, communication between different everyday objects, through the internet. Connection may be through networks, for example, Radio Frequency Identification (RFID), WiFi, Bluetooth, among others. [2]

Thinking that way 25 years ago, the interaction between computers and humans was still very recent. However, currently we have a lot of growth in this area. We can find in almost any pocket a smartphone. In many establishments, intelligent monitoring and connected to a network. Our daily life begins to be surrounded by a lot of technologies, which facilitate our communication with the environment, whether at home, in a company, on a highway or even in your vehicle. [1]

2 IOT in transport

One way of applying the IOT is in interaction with vehicles and roads, for example, the connections between a car audio systems and smart phone owners.
latest innovations give the first steps in automation. An example of this are the cars that do not require the driver to perform any task, as in the case of car manufactured by Tesla brand. Elucidating the concept of IOT on transport, where you need a whole mapping performed by sensors, so that the car does not collide with obstacles. And also the simultaneous interaction with GPS so that passengers reach their destination, and software that makes the car is connected to the internet and do a mapping of paths, choosing thus the road safer. Among other features that the model can offer. [3]
In addition to personal use as mentioned above, we also have the applications of IOT in a wider perspective when thinking about solutions for transport and logistics in a region. With the possibility of exchanging considerably faster information, this kind of development certainly contributes to that deliveries come increasingly within the prescribed period, the collective are able to improve their paths, thereby relieving traffic congestion in large cities . The IoT can contribute, too, in order to have greater oversight of vehicles, using as an example the National System for Automatic Vehicle Identification (SINIAV) which assists both in traffic organization, such as the inspection of irregular or stolen vehicles. Its operation has communication antennas and radio frequency identification portals (RFID). [4]

See basic scheme of system operation:

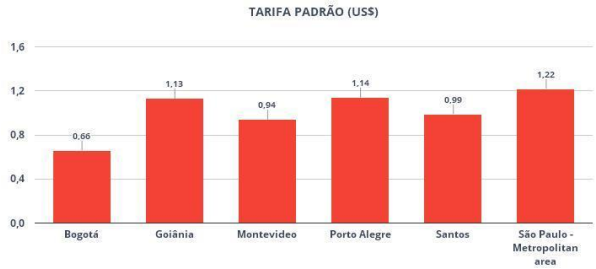
Fig. 1: Basic elements that make up the system

3 *Bus Rapid Transit* (BRT)

The Bus Rapid Transit (BRT) is a public transportation system of low cost and high efficiency standard, consists of exclusive lanes for articulated buses with closed seasons. Thus creating a pattern that resembles the transport on rails, as trains and subways. Unlike conventional collective bus, BRT has closed breakpoints, called stations, thus enabling the collection of tickets is made at the station before boarding passenger in the vehicle. It collaborates with the agility in the boarding process, since all ports are available for such functions, and provides greater comfort to users, not to have an exclusive space for the collector. Traffic routes are separated from conventional transport, either individual or collective transport, thus improving the flow of traffic, being positive for both users of public transport such as private transport. [5]

3.1 The Global BRT Date

The BrTData is a site that was developed by Across Latitudes and Cultures - Bus Rapid Transit (BRT-LAC) and aims to encourage projects providing guidance on when and how the implementation of BRT can improve urban mobility in a city. [6]
The site has a huge BRT systems database or corridors priority to bus 207 cities. Separating the data by region and enabling the comparison of cities with the help of interactive graphics. [6]



Graphic. 1: standard rate of BRT systems and priority corridors.

Graphic. 2: operating speed of BRT corridors and priority systems.

3.2 The BRT São José dos Campos

The proposed Bus Rapid Transit (BRT) in São José dos Campos, came based on Urban Mobility Act, with the Director of Integrated Development Plan of São José dos Campos (Complementary Law 306/2006). The modal main gear used in the city for something more agile and comfortable, is aimed at

attraction of individual passenger transport, since most of the trips made by the population of São José dos Campos is made through car according to Search Origin destination (OD) made in 2011.

The BRT system, introduced previously in the case of São José dos Campos, will include extension of 195 km of lines, 61 stations, 6 transfer stations and two new terminals. [7]

As shown in the following figure:

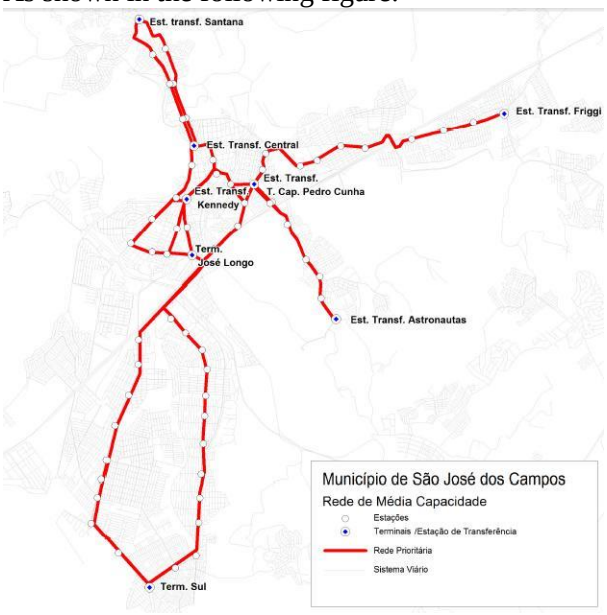


Fig. 2 Network first phase BRT São José dos Campos

Featuring 106 vehicles, articulated buses, which carried over with average intervals of 7 minutes, its biggest line is Andromeda, via St. John and via Adhemar de Barros, which will have a total length of 57 km. [7]

Linha	Comprimento (km)	Tempo de Ciclo (minutos)	Passageiros	Trecho Crítico	Intervalo (minutos)	Frota Veículos
Andrômedra, via São João	29	78	3,207	1,846	4	21
Andrômedra, via Adhemar de Barros	28	76	3,222	1,846	4	20
Santana	12	34	2,430	1,682	4	8
Frigi, via João Guilhermino	22	59	3,197	1,704	4	14
Frigi, via Madre Tereza	23	62	2,755	1,854	4	16
Astronautas, via João Guilhermino	15	42	1,433	509	14	3
Astronautas, via Madre Tereza	16	43	641	466	15	3
Estrada Velha, via São João	24	65	2,802	1,123	6	11
Estrada Velha, via Adhemar de Barros	27	75	2,440	894	8	10
Total	195		22,127			106

Tab. 1 Summary of the proposed network, BRT São José dos Campos.

4 Urban mobility

The movement of people is needed throughout the city, whether for leisure, work or study. The Brazil had a rapid urban growth due to industrialization, it made it to grow the need for transport, they are individual or collective. [8] However, there was an investment by the government, through an incentive policy so that valued cars. [9] The consequence of this is the car overcrowded streets, causing traffic jams that were seen as progress, but today, there is the awareness that it is necessary for measures to be reversed this situation. Since, in addition to the environmental consequences, not all of the population benefits from this progress said. [8]

4.1 National Policy on Urban Mobility

Since the 1988 Constitution, urban policy measures are discussed. However, the latest Mobility Act, 2012 Urbana, is that in fact brought the National Policy to be taken. The law states that cities with over 20,000 inhabitants, has the obligation to present and implement a proposal for mobility that prioritize public transport or non-motorized, and which affects the planning of the city's growth.

In addition, the law requires that all projects are transparent and clear about their costs and utilities, in order that the population has access to this data. In order to inspect and complain in court if something is not within the measures of the law 12.587 / 12.

The law aims at the integration of all sectors of the population so that it is not actually targeted and exclusions. Improving the offsets in order to minimize them and shorten them. For this to be achieved, it is necessary to plan the use of city roads also sustainably. With the prioritization of public transport, more people will use it, occupying the same space. What will result also benefits the environment due to fewer contaminating transport by eliminating their gases. [10]

5 Internet of Things (IOT) applied in Bus Rapid Transit (BRT): Case of São José dos Campos

The IoT concepts applied in public transport, are present in the projects presented by the city of São José dos Campos. Which are inserted in a context that is called Intelligent Tranport Systems (ITS), a concept used to describe the modeling of an interconnected system that collects data from traffic flow conditions, and conditions of the roads. It presents the information to a control system, and this, in turn, manages the received data and provides solutions that are optimized such conditions,

ensuring the quality of transport in question, and all other means of locomotion that can be influenced at the time. [11]

Within the concept applications in the case of BRT São José dos Campos, they are:

• Operational Management System (SGO)
• prevention and security system
• Integration Bus

Working together hows systems presented above, we have also the architecture of the Management Information System (GIS) which is part of the Central Operation and Control (CCO) and Closed Circuit Television System (CCTV). [12]

5.2 Communication with users of the BRT system

The architecture of the Traffic Management System (TMS), also administered by the SIG, is the system that will enable communication between the BRT and the end user. With a display of travel conditions in real time through the web, with information available as track closing conditions, travel time, congestion level, on operating hours, operating status, among others. With this the user can better plan your route by choosing best station to board or transfer, and better landing place as well. [12]

Provided also with other types of communication such as:

• Variable message signs
• Loudspeakers
• Interactive maps
• Online Applications
• Radio and Digital TV

5.3 Descriptions of sensors / detectors

Sensors / traffic detectors are those located by the way, in or on the track, and is one that has the function of detecting the presence or passage of the buses being used in are traffic. They can be used to measure the flow of vehicles, analyze environmental issues, assist in the development control decisions, update information for travelers in stations. The sensor system will be responsible for reading the plates of vehicles and the conversion of Optical Character Recognition (OCR) and virtual links to count the fleet. [12]

Unlike traffic sensors have those who will compose the system storing and transmitting information of the bus, they are:

• door opening sensors

Responsible for allowing the doors to be opened only when positioned and properly aligned with the doors of the seasons.

• sensors fuel consumption, braking and acceleration

Helping the driver maintain a driver with less environmental and economic impact. also keeping track so there is always a safe driving of vehicles.

• Internal temperature sensors

To be monitored temperature in order to increase passenger comfort, and detection of possible incidents, as the focus of fire.

• Equipment for collecting vehicle data

For storage, and transmission of information on vehicle conditions.

4 Final considerations

Analyzing the advantages of installing a standard BRT bus system in a city, it can be noted that it is an economically viable alternative and provide back well with the proposal to be a public transportation system of average capacity. Comprising a highly integrated and intelligent system, it can be said that the Bus Rapid Transit (BRT) is an alternative that will favor the development of a city or region, the urban mobility aspect. Since, it prioritizes and encourages citizens to seek getting collectively, leaving the individual transport to the background. Technological point of view, BRT brings a modern look which currently seeks to improve, both in the areas of Intelligent Transport Systems (ITS), such as Internet in the Things (Iot), which are concepts that are in early stages of a revolutionary process.

The BRT system, in addition to providing a highly efficient platform with intelligent traffic and passenger management systems, leaves a good foundation for new ideas to be implemented in the future. These ideas that can contribute to the optimization of the operational process or contributing to the promotion of new public transport systems implementations more sustainable, viable, comfortable and reflect the social and economic development of a city or region.

Are suggestions for future implementations in BRT São José dos Campos, an economic feasibility analysis to obtain electric vehicles, making the collaborative project with the local and global environment.

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