Its Applied in Bus Rapid Transit

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Abstract: - The BRT (Bus Rapid Transit) is a public transport system of low implementation cost and allowing to offer a quality service, although the BRT should not be seen only as an isolated mobility solution for the areas it serves, butas an inductor axis of urban development capable of contributing to the consolidation of a more fair and balanced city in social and environmental terms. To make one quality of services, BRT needs an efficient automation system, this system called ITS (Intelligent Transportation System), that enables control over the operation and maintenance of the BRT in order to prioritize service and thus bring greater quality in public transport for the population. However, due to system complexity it is necessary to implement a system that can be scalable and receive new features not only connected to the BRT as other systems that need to exchange information. This paper presents architecture to meet the requirements and needs of BRT in Brazil.

Key-Words: - Architecture, BRT, ITS, Brazil, Mobility, Transportation

1 Introduction

The BRT (Bus Rapid Transit) is a mass transportation system for passengers that deliver fast, comfortable, safe and efficient urban mobility through segregated infrastructure with overdrive priority, fast and frequent operation, excellence marketing and customer service.

The BRT system not only proposes a change in the fleet or infrastructure of public transportation. But rather a set of changes that together forms a new concept in urban mobility. The implementation of high-performance transit systems, efficient and environmentally sustainable world consists of the political agenda of urban and environmental planners.

This system should be carried out permanent replacement of individual traffic by an attractive public transport, promoted security and protection for its passengers, the CO^2 reduction and the reduction of congestion.

For this, there is nothing more appropriate than BRT solutions, achievable in the medium and long term with moderate investment. The BRT concepts are integrated homogeneously in urban structures, in a timely manner as full or also stepwise solution.

Deployed pioneered in Curitiba, BRT is a flexible concept that can be configured especially for the market it serves and the physical environment in which it operates. Currently the system exists in more than 160 cities around the world and has become one of the most viable and efficient choices to qualify urban mobility in 38 countries on five continents.

The BRT system has also demonstrated the potential to dramatically reduce CO2 emissions, since for their correct deployment, optimization of existing routes is performed. An example of its impact on climate change is the operation of the

Metrobús (Mexico City BRT), which, with the opening of its fourth line in 2012, is reducing 110,000 tons of CO2 emitted per year, while that improves mobility of 200 million passengers per year. This BRT system was designed and implemented to serve at least 800,000 passengers per day.

The main characteristics of BRT are:

- Dedicated corridors for the movement of public transport;
- Loading and unloading of vehicles on the same level, making the process faster;
- System of pre-charge;
- High-capacity vehicles, modern and cleaner technologies;
- Transfer between routes without incurring cost;
- Integration with other modes of transport;
- Operational control center;
- Prioritizing traffic signal;
- Real-time information to the user;
- Universal accessibility.

The Bus Rapid Transit (BRT) is from one of the engines cost more efficient for cities quickly develop a public transport system that can expand a complete network as well how to promote a speedy service and excellent quality. Still in his early application, the BRT concept offers the potential to revolutionize the way of urban transport.

The BRT basically mimics the characteristics of performance and comfort of modern systems transport on rails, but at a fraction of cost. A BRT system costs typically 4 to20 times less than a tram system or of light rail transit (LRT) system and 10 to 100 times less than a metro system. [01]

Beyond the physical infrastructure, the BRT needs to implement some

In addition to the physical infrastructure to the full functionality of BRT is required to implement automation systems that collaborate in the BRT operation. Such automation systems are known as ITS (Intelligent Transportation System). The ITS are advanced applications that provide innovative services relating to different modes of transport and traffic management and enable various users to be better informed and make safer, also the ITS permit to have more coordinated and smarter transport network in order to reduce congestions, have an efficient use of infrastructure and so on. [02].

2 Problem Formulation

The ITS needed to meet the BRT is complex because the BRT is composed of several elements spread over a city, among them are: Stations, Shared Vias, Restricted roads, buses, besides the maintenance crews and operation.

The elements that need to exchange information with each other are usually not the same manufacturer, therefore there is a clear need to integrate these systems and propose solutions to facilitate the implementation of any element within the ITS for the BRT.

The general principles relating to the ITS system are as follows:

1) Improvement in the population's quality of life by providing regular public transport service, reliable and secure, allowing the sustainable mobility and accessibility for carrying out activities that modern life imposes;
2) Efficiency in service delivery through integrated transport network rationality operating system, giving priority to collective means;
3) Cost reduction in shifts in public transportation;
4) Provide mobility to people with disabilities or mobility restrictions;
5) Prioritize under road aspect, the use of the collective mode of transport and the integration of its different modes;
6) Improve the management of the services of the Public Mass Transportation System;
7) Provide efficient, integrated and shared solutions to public transportation in the surrounding areas;
8) Integrated management of road systems, transport and transit;
9) Improving quality and reducing cost of travel for the user of public transport services;
10) Deployment of operational control systems, registration, ticketing and information to the user;
11) Rationalization of passenger public transportation system will be achieved through physical, operational and fare integration, should be established from the set of procedures, technologies and infrastructure that constitutes the ITS;
12) Implement efficient system of information to the user in order to allow the understanding of the system and their rational use, with priority given to people with disabilities or reduced mobility;
13) Implement control and operational monitoring through the Intelligent Transport System - ITS;

DOI: 10.37394/23204.2022.21.8

14) Prioritize the movement of collective on the car, with the control system deployment and traffic signal coordination and exclusive tracks and priority to public transport;
15) Adequate supporting infrastructure, with universal accessibility, the operation of public transport;
16) Establish alternatives integration to reduce the cost and travel time for larger numbers of users;
17) Adjust the time intervals between vehicles, adapting capacity to demand;
18) Deployment of Intelligent Transport System;
19) The terminal network must have information system for the user, including accessible to persons with disabilities or reduced mobility, through information panels and variable message, maps, sound and written messages. With the participation of public officials to answer questions and provide information on the BRT conditions;
20) Network terminals must have operational control structure of vehicles operating in the system, aimed at improving the mobility of people and vehicles.

3 Problem Solution

This item present a solution for ITS architecture to solve the problems identified. This article present an overview of possible architecture for ITS.

3.1 About ITS

The ITS system consists of a technology matrix intended for operation and management of urban mobility. It consists of sets of information systems, communication, control, monitoring, sensing, acting, among others. It aims to provide greater operational efficiency to transport and transit operations services as well as provide comfort and safety for users of BRT services.

3.2 Areas of ITS

The ITS deployment strategy should define the situation to be reached by reference to the best practices in the world. Such assessment could be carried out considering the eight areas of ITS to follow the BRT:

- Information for Users: services designed to support users' decisions before and during their displacement.
- Traffic management: services required for the management of traffic flows on the corridor.
- Demand management: services needed to reduce congestion on the roads and in urban areas.
- Advanced service to the driver: automated systems to improve vehicle performance and driver and make driving safer.
- Financial transactions electronically: Services that provide automated fare collection.
- Fleet management: support service necessary to the management of collective public passenger transport service fleet.
- Public Transportation Management: includes services necessary to optimize the public transportation of passengers in terms of convenience and performance.
- occurrences of Service: services needed to meet the occurrences of accidents and other emergencies.

3.3 ITS Architecture

A key point in the ITS system design is the definition of its architecture, and this definition should be made throughout the systemic design process. At the present stage we consider two reference architectures:

- ITS Architecture proposed by ISO 14813;
- American ITS Architecture (Nitsa).

3.3.1 ITS Architecture: ISO 14813

The ITS technical committee of the International Organization for Standardization ISO / TC204) proposed by ISO 14813 standard a reference architecture for ITS. A key feature of the architecture is the ISO reference model and a set of services to the user. Figure 1 below shows a basic representation of the core ISO ITS reference architecture.

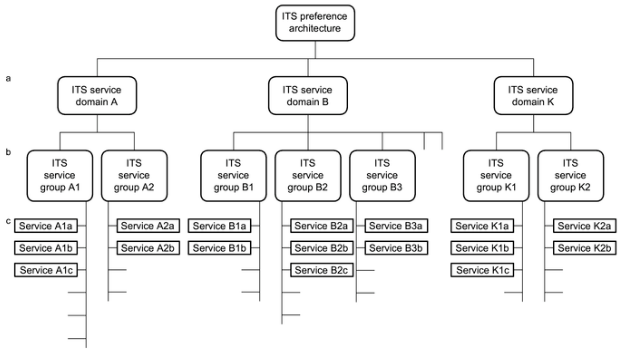

Fig.1: ITS services hierarchy of definitions for ITS

reference Architecture [03]

3.3.2 ITS Architecture: ISO 14813

The US was the first country to develop a national ITS architecture, in the early 1990. The architecture itself consists of a collection of user services (33 services divided into eight domains), each accompanied by a set of requirements a logical architecture and physical architecture, which serves to guide the development of standards. Figure 2 illustrates the logical architecture of the ITS system at various levels of detail, showing the configuration of services without going into details about its operation. The logical architecture illustrates logical processes (shown as circles) entities (rectangles) data flows (arrows) and data storage (logical data files, represented by a name between parallel lines).

3.4 Proposed Architecture

Based on ITS architectures presented on item 3.3, this article propose an possible architecture using SOA (Service Oriented Architecture).

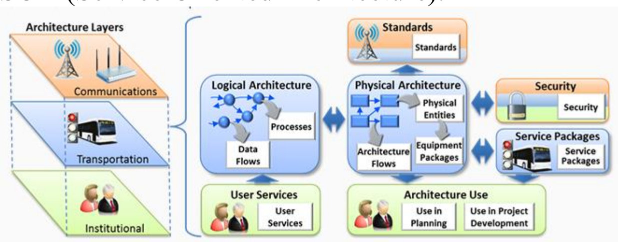

Fig.2: ITS Architecture [04]

The SOA involves the deconstruction of an application in common offices reusable, which can be used by other internal applications the organization or external, independently of the applications and computing platforms adopted the company and its partners. With this approach, companies can assemble again and again these services based on open standards in order to extend and improve collaboration between existing applications, create new possibilities and stimulate creativity at every point in the value chain. The service-oriented approach simplifies communications among IT systems, to the extent that it makes no difference that particular "service" resides in own computers or in their external partners. In essence, SOA delivers the IT systems owners of its verticality and its rigidity, adapting them, so user needs. An SOA approach applied to systems integration requires an elaborate project jointly between business and technology. Among the main benefits of this approach, the most obvious is that it gives more flexibility to the business, but one should also highlight that promotes the construction of new capacity in less time and at lower cost. Moreover, as the services are separated from the applications used to deliver them, companies can extend the life of existing applications and integrate more easily various types of applications and platforms. SOA provides a standards-based structure, in which every participant is inserted in the process can connect to each other regardless of a specific solution, personalized and point to point. Increasing the level of communication, connectivity and flexibility between existing systems, SOA unlocks the power of print services and streamline the system.

The components will be installed in the field, data center and operational control center (OCC). The field will be installed sensors and actuators to be responsible for data collection and due role as business rules that are in various applications of ITS, in addition to information boards and sound equipment.

The data center will be installed servers and equipment responsible for carrying out the backup. The CCO will be workstations installed for the ITS actors, especially the public transport activities connected.

To interconnect all components will be installed routers and data networks that allow them to do proper communication and transparently and with quality.

The architecture planned for the BRT ITS is shown in Figure 3 and consists of four applications: Operational Management, Billing Electronics, Information System of User and Prevention & Security.

To ensure interoperability between the ITS systems, legacy systems, AVL, Sensors and Actuators considers the implementation of an integration bus developed with open system, this way you can ensure system growth according to the operational needs of the municipality, as well to reduce dependence on suppliers, as this configuration allows the use of sensors, actuators, systems, AVLS from various manufacturers, and the only requirement is that they meet open communication protocols.

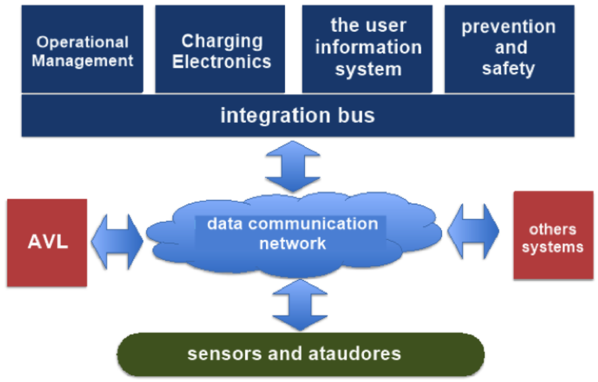

Fig.3: ITS Architecture for BRT using SOA

ITS components will not be in the same location so the communication channel must have adequate response time, and meet the necessary requirements regarding the stability and availability. The proposed architecture solution meets the operational requirements presented in item 3.2 of this document and allows it to receive new features as needed by the BRT operation and maintenance services.

The following are ITS features sets applicable to the BRT system

3.4.1 Operational Management System (SGO)

The SGO allows the operation and maintenance of the BRT corridor to ensure quality in service, bringing resources to the monitoring, corrective maintenance, preventive maintenance, monitoring, control and security. The system also has possibility to store and process historical data to allow those responsible for TP can take the most appropriate decision for each situation.

The SGO is composed of one or more servers, application and database features that can deliver the proposals for the system. The solution proposed by the ITS project, the application will have the following features:

- Planning: Functionality which allows you to plan the operation of the BRT (lines, routes, service offerings, economic and financial analysis) in accordance with the historical use and forecasting, and may include characteristics of the weekdays, holidays, events, among others. The system allows you to model scenarios, evaluating alternatives, structuring actions, establishing routines and procedures with a view to meeting the mobility aspirations of society;
- Service Quality: Monitoring aspects related to standards of care, such as: accessibility, comfort levels, service levels of integration, maximum waiting times, quality indicators / performance and levels of prevention;
- Planning Monitoring: Based on the planning, the system performs monitoring in the hallway, checking the supply and demand, such as amount and allocation line for vehicles, often traveling time, itineraries, timesheet (timetable) and allocation of human resources (driver, marketing agent);
- Supervision, Inspection and Operational Control: Real-time monitoring parameters and events in the hallway (TP System) in order to adapt the operation to set standards and carry out the necessary maintenance. This module also performs the monitoring of the use in the corridor and can identify and generate alerts for unauthorized vehicles to use the corridor;
- Measurement: Functionality related to the acquisition of information from the TP system by AVL and sensors available via the stations.
- Services Management: This feature made the fleet tracking according to plan, as well as quality in providing services and if necessary to generate indicators for the redesign in real time to ensure continuity of services.

3.4.2 Electronics Charging

The electronic charging system aims to manage the flow of credits.Tthis flow includes activities from the generation, distribution, validation, use, storage (ticketing) and compensation (clearing). The features are involved in the system:

- Generation and Distribution of electronic claims: The system performs generating lots of credits that are used by the users for the payment of fares on public transport. The credits will be tracking mechanism to ensure the safety and cloning is not possible, must comply with the principles of Authentication, Authorization and Audit;
- Validation, Use, Storage and Compensation: This module Electronic Billing System checks the validity and the amount of electronic credit available should also include permission. This feature is important for the credit control by holders of benefits users, requiring the use of some form of identification. Use counts the number of passengers in each terminal, identifying whether it is paying or not, in addition to the group to which each user

belongs, for example: normal, old, student, etc. The compensation function generates the result of the collection and distribution for each service making up the public transport system;

- Integration with other storage systems: The system integrates the unified system of the Municipality and / or other storage systems that may exist, such as: integration with other modes of transportation, etc.

3.4.3 System Information to User

This application is responsible for communicating with users of the transport system, whether they are responsible for operating and maintaining or travelers who are actual users of BRT services, information is generated from the available data in the operational management and prevention system & safety. System features are:

- Planning: helps the user in planning the form of travel to allow a choice of the most efficient and fast itinerary, plus the cost of the trip. The tool will be available through Internet-connected devices.
- Travel: It helps the traveler who needs additional information during the course of the trip. They are usually dynamic information related to travel time, estimated time of the next connection, among others that allows travelers to reschedule the trip if necessary. The information will be available through Internet-connected devices;
- Information to the traveler: At terminals and stations will be available panels with respect to each location information such as: arrival of the next vehicle, estimated time, service suspension of a given line;
- Information on the vehicle: This module provides for AVL information regarding the next season, scheduled to arrive, traffic conditions, weather conditions, among others. Inside the vehicles should be available to a panel presentation of information;
- Post-trip information: This information about the history of travel, as well as data for the SAC (of Customer Service);
- Information to responsible: Those responsible for operation and maintenance will receive information necessary for the performance of its activities. The information will be made available over the Internet or local network and network as the needs of each user.

3.4.3 User Systems Prevention and Safety

The prevention and security system to the traveler / passenger / driver, both in the aspect of preventing the actions of third parties (security), and to guard against operational risks (safety). The planned features are:

- Monitoring of vehicles (internal), surrounding the vehicle (external) of the tracks, stations and terminals: This monitoring is done through images and sensors present in the stations, terminals, stops, ticket offices, ordinances, decks, pathways and patios TP parking of vehicles. Routes in the cameras are designed to verify the existence of elements that might jeopardize the vehicle, driver and passengers in the travel route, as obstacles and action of criminals. Prevent also against the track invasion by unauthorized vehicles and pedestrians;
- Control agglomeration / overcrowding: monitors the number of travelers and passengers present in the stations and vehicles, in order to determine the level of occupation in order to avoid overcrowding and discomfort. May use an imaging monitoring system to meet the goal, as well as turnstiles and automatic access doors to limit the flow of passengers. In panic situations, the turnstiles at entrances / exits should provide a mechanism to facilitate the evacuation (free passage);
- Integration with public security and emergency systems: It consists in sharing information, voice and image with the security and emergency forces in order to prevent and treat critical situations, risks to users and damage to the TP system, caused by offenders and criminals, vandals, weather conditions or accidents.

3.4.3 Integration BUS

Services responsible for the coordination of transport and traffic systems, to improve the services offered is considered:

- Integration between modes: Enables coordination between agents operating in different ways services (intermodal service provider). Aims to provide convenience at the point of transfer, as well as improving the operation of the TP;

- Integration traffic light: Search privilege the movement of vehicles through PT priority at traffic lights.

3.4.3 Data Communication Network

Data communication networks, voice and images consist of two systems: the primary and secondary communication systems perform communication between the various systems and subsystems.

They should enable the transmission and reception of messages in voice formats, data and images in a bidirectional manner, with integrity checking of all incoming and outgoing data as well as the ability to: IP number of the setting, implementing QoS mechanisms (quality of service), emulation private networks, network status management in real time implementation of verification mechanisms and validation of communication and data traffic packages.

The primary communication system should allow the use of at least two concurrent or additional communication technologies, for example: GSM / GPRS / EDGE and digital trunking or GSM / GPRS / EDGE, and WiMAX or WiMAX and WCDMA (3G) to ensure service availability.

To the fullest extent of the BRT corridor will be built an operating fiber optic network connecting the equipment on the road, responsible for communication with the vehicles in operation.

The network must also be both redundant fiber optics segment spread via like in wireless communication with vehicles in operation, stations and garages. The wireless part can be done through a network "Wi-Fi" and have a minimally GPRS communication (or 3G) with fixed IP and contracted service level guarantees through a telephone operator and data as a contingency.

Operational data network should be extended to the garage responsible for the maintenance of vehicles and orders for the line.

The network must also be integrated with traffic control systems or area traffic management systems, integrating traffic signal controllers, VMS (variable message panels), CCTV systems and detection and surveillance, telemetry, etc., with the CCO.

3.4.3 Cameras System

The entire line of BRT and its stations and terminals should be monitored by a fixed camera system and the vehicles must have built-in cameras showing the entire length of the vehicle and a camera facing outside the vehicle showing the driver's vision.

Some fixed cameras should also be able to be moved from the CCO moving in one hundred and eighty degrees (or 360 degrees, depending on the function) and approaching the desirable object, and minimally two internal cameras per station wagon and two outer cameras, in each direction of the line. Fixed cameras should be spread on supports visually cover the whole 100% BRT line.

The system should offer the possibility and show all or certain images captured in real time or retrieved from a recording on an image bank and be digitally available in real time to the CCO and integrated with traffic control systems and CCTV systems city traffic covered by the system, especially in BRT's area of influence.

These cameras are used by centers to help observe the surface transportation system. CCTV devices can be used by centers:

- Check for a reported traffic congestion.
- Determine that assistance may be required for the incident.
- Monitor the progress of incidents, construction and special events.
- Determine when the residual incident congestion is eliminated.
- Provide visual images to the public on the state of the track.
- Determine what types of emergency services need to be dispatched.

3.4.3 AVL

The AVL is a device embedded in the BRT vehicle that aims to track the level of use and performance of each vehicle and the way they are operated. Collects information necessary for the rationalization of equipment, provision of design, safety and comfort of operation. Examples: State monitoring (safety device, opening / closing doors) and as continuous variables (position, velocity, acceleration, occupation and motor functions / body).

The AVL integrates with door station equipment where there, so that they can open at the right time in order to prevent accidents and to increase the commercial speed and the operational flow.

The planned features are:

- Identification of the instant geographical location of bus.
- Capture and transmission of information on demand.
- Monitoring the vehicle on the ground.
- Telemetry vehicle.
- Operating data record.

- Communication with the driver and collector.
- Communication with the central operation and supervision and emergency services (Police, Civil Defense, Municipal Guard, Fire Department, etc.).
- Control communications system and information for the driver and user.
- Generation operating alarms and operation of embedded devices and systems.
- Embedded surveillance.
- Remote intervention on the vehicle and embedded devices.
- Management and processing of data generated by the equipment transmission and / or recording images.
- Data or audio when alarms are triggered.
- Multimedia monitors.
- External displays.
- Automatic counting of passengers on doors or turnstiles.
- Various sensors;
- Onboard computers.

3.4.3 Sensors and Actuators

Associated infrastructure (stations, terminals and tracks), the sensors perform the collection of information for assessing the level of congestion and occupation. Examples: the terminals and on the decks - users / travelers count; the roads - counting and identification of vehicles, speed measurement, light forward and improper occupation.

4 Conclusion

The architecture presented is a proposal for the implementation of ITS in a BRT, the important point of the architecture is to enable the introduction of new services and applications as needed, this enables the architecture to start with only one system and some sensors and it starts to grow according to the need of maintenance and operating staff. Based on service-oriented architecture can sending or receiving external information systems of other bodies within the municipality or external entities.

The architecture is being detailed and the city of Sao Jose dos Campos is considering implementing it in its structure and in the BRT project that is under development.

5 Acknowledge

We appreciate the support of Prefeitura de São José dos Campos - SP - Brazil which enabled this research. The survey results are being applied in city hall of specific projects in infrastructure, traffic and transportation.

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