Traffic Management Solutions in Large Cities – the Integrated Centre of Urban Mobility (CIMU) in São Paulo

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Abstract— The paper aims at presenting solutions which may tackle one of the major problems of contemporary big cities all over the world – traffic management. It brings into reader’s attention the example of São Paulo. Learning from examples of global cities as London and Chicago where traffic is managed with the use of open protocol solutions such as UTM and NTCP here it is suggested that such a way of facilitating traffic management may also be successful in São Paulo. An answer for contemporary problems may be the Integrated Centre of Urban Mobility (CIMU), which with the use of open protocol communication will help to manage traffic problems of the city.

Keywords—Traffic management, São Paulo, Integrated Centre of Urban Mobility (CIMU), open protocol.

I. INTRODUCTION

An unrestrained development of global urbanization that can be witness all over the world brings numerous challenges which requires joint effort of experts from various disciplines to help develop new ways of dealing with city problems. An array of areas such as demography, infrastructure, climate issues, economy, ecology, social, legal and countless further need to be merged to enable working out solutions for complex and multifaceted challenges which appears on a day-to-day basis in global metropolises.

An effective transport system is a vital element facilitating life in modern cities, its influence on various levels of public life is undeniable (from moving goods and passengers, though improving daily mobility and access to various services and labour market, up to improving social inclusion). The evidence for an existing connection between well-functioning transport and economic development, competitiveness, quality of life in urban areas were provided in number of studies: Wegener [1]; EUNOIA [2]; Llewelyn-Davies, Banister and May [3]; Portuguese [4]; Le Gales [5], Leven [6], OECD [7], CEC [8].

Since the challenges of modern transport systems were enlisted in number of studies, where the authors presented also a number of thematic solutions that help addressing the most vivid issues. Each of the areas presented above has a number of both theoretical and practical solutions that has been developed in various academic and applied studies. The major challenges of transport systems can be organize into six thematic groups: organizational issues, infrastructure, technological (Intelligent Transport System – ITS), environmental, social and spatial issues. The organizational area covers all issues connected to the traffic management [2], [9], [10] which include inter-modality of transport (use and connection of various transport modes like buses, metro, trains, private cars and others; including means like bikes, carpooling, electric vehicles etc.). Other group of answers to modern problems include the use of various tools for organization of traffic within the city such as control and monitoring centres, emergency monitoring, maintenance of traffic management tools, etc. [11]. One of the most important areas here is the creation of new traffic management regulations and holistic solutions [12], [13].

Within the infrastructural area the common problems can be tackled by the improvement of the quality of physical infrastructure such as parking spaces, roads, railways [14], [15] but also pedestrian areas and other type of urban infrastructure like bus stops, traffic controls and other tools for traffic measurement etc. [16]. Besides upgrade and development of traditional infrastructure, it is equally important to develop ITS infrastructure, which will not only facilitate traffic flow on daily basis [17], [18] but also allow to collect data about the traffic to support areas as urban modelling and planning, decision making and other processes [19].
The technological issues are interconnected with the infrastructure, however it covers not only the physical presence of equipment for traffic control and management but also provides structural and software solutions that allows to tackle such issues as automatic collection of traffic data, bulk data (storage and use), spatial and temporal movement of data, achieving transparency and efficiency [2], [18], [19].

Another area of transport challenges which importance is growing in recent years is undoubtedly environmental protection. It is also associated with economic, social and security issues (like shrinking energy resources, alternative/removable energy, contamination, etc.). An increasing air pollution to which transport is one of the major contributors in urban areas, requires far-reaching solutions which are present in our daily life like reduction of private transport use [1], [22], [23] (like plate based rotation scheme for private cars in São Paulo [20], reduction of traffic of heavy utility vehicles [21]). The answers for the environmental issues are sought in alternative transport (both on infrastructural and organizational level), renewable energy resources, sustainable mobility, etc. [24].

The area of social issues connected to traffic problems require highlighting of issues of participation and social inclusion, which influence quality of living but also other aspects of public sphere like safety or accessibility. Changes of mobility of urban population is interconnected with job relocation and settlement patterns.

In this paper, we formulate the basis for building an integrated centre for control of urban traffic in São Paulo city based on the experience of large world metropolises, presenting possible architecture solutions for various traffic management equipment, as well as for communication between existing traffic management centres.

II. SPECIFICITIES OF TRAFFIC IN SÃO PAULO

São Paulo, the largest city of South America, and one of the fifth largest cities of the world, face the same type of problems regarding transportation management as the majority of large world metropolises. With over 11.8 million inhabitants and almost half of this number in cars (see table 1), allow us to expect that solutions used within other cities will be effective in São Paulo as well.

Table 1: Population, area and number of cars in some large cities.

<table>
<thead>
<tr>
<th>Cities</th>
<th>Population (in million)</th>
<th>Area (thus km²)</th>
<th>Number of cars (in million)</th>
</tr>
</thead>
<tbody>
<tr>
<td>London</td>
<td>8.3</td>
<td>1572</td>
<td>2.5</td>
</tr>
<tr>
<td>Chicago</td>
<td>2.7</td>
<td>606</td>
<td>1.5</td>
</tr>
<tr>
<td>São Paulo</td>
<td>11.8</td>
<td>1521</td>
<td>5.0</td>
</tr>
</tbody>
</table>

Source: IBGE, DENATRAN, US Census Bureau, UK National Statistics.

Currently there are already in São Paulo – and metropolitan area – systems and equipment using ITS (Intelligent Transport System) for traffic management, such as: (a) Traffic Signal Control System; (b) Traveller Information Services; (c) Freeway Management; Electronic Toll Payment; (d) Emergency Management Services; (e) Transit Management; (f) Incident Management Systems; and (g) Railroad Grade Crossing Safety, among others.

These systems and equipment are spread around the city and aim to manage and provide specific services to the population or decision-makers. The above mentioned elements of traffic management architecture are shown on Fig. 1.

Since the majority of traffic infrastructure is already present in São Paulo, one may question: is it really necessary to change? There is currently a lack of integration in the systems used in São Paulo. The systems using ITS in São Paulo as well as city general traffic management can profit from complex information from various sources.

Fig. 1: Contemporary traffic management architecture in São Paulo.
The major reason for lack of integration of existing ITS systems can be found in the manner that traffic equipment was built in the city. The majority of traffic infrastructure was built up as a response for growing demands and main problems of the time. In fact, the existing structures for traffic management very often function as isolated and independent systems, including the operational units of two major public companies dealing with mobility in São Paulo: the one responsible for traffic management (Companhia de Engenharia de Tráfego - CET) and the one managing public transport (São Paulo Transporte - SPTRANS).

The first, CET, is not only responsible for management of the transit in the city but also for setting up, maintenance and use of the majority of existing equipment for facilitating traffic. The second public company (SPTRANS) regulates and manages city’s bus operators and the infrastructure of public transport connected to bus transport (such as bus corridors, terminals, bus-stops). Both companies has been traditionally acting independently in the provision of transportation services for the city.

As an attempt to answer to existing problems regarding transport, São Paulo authorities have adopted a few measures to minimize negative impacts on traffic and congestion of roads:

- in 1997 a license-plate-based car rotation scheme, by which 20% of the car fleet is kept off the streets during peak hours on central areas of the city on working days;
- restrictions at certain times of the day to truck traffic were implemented within the geographic area of the expanded CBD (2008);
- maximum speed limit was reduced in a number of city’s streets and avenues, mainly in the centre (2012);
- since 2013 bus-only lanes were intensively created (over 300 km within the city borders), giving clear priority for public transport.

However, despite implementing the measures above and the various types of traffic infrastructures exiting within the city, unforeseen events (such as natural phenomena) and the excessive use of private cars still cause enormous traffic problems in the city, which remain highly jammed. For example, on 21st of March 2014, a normal working day with no special event or holiday eve, the city traffic management service observed the longest traffic jam of the year so far, with a length of 239 km [25]. There was no particular explanation for such a traffic to occur, apart from the excessive use of cars by the city inhabitants. This record was beaten two months later on 23rd of May, a Friday when a traffic jam of length of 344 km was registered; it was the longest traffic jam that São Paulo has ever suffered from [26]. This time, the explanations of the phenomena included such events like: the extreme rain fall that the city had for a period of a few hours; travels of city inhabitants for the weekend; accumulation of personal errands due to two days of strike of public transportation, and remaining strikes in public transport in ten cities of the metropolitan area. Individual accidents worsen traffic conditions, specially due to the relatively long time of reaction of rescue services. This thus increase the disturbance of traffic, like the accident involving a heavy utility vehicle which blocked the crucial Rodovia Castelo Branco for about 5 hours causing traffic jam of 17 km on February 18th 2014 [27].

III. GLOBAL SOLUTIONS

Since various types of equipment are already located in São Paulo, the ideal solution for the city is that which bridges different system and technologies and allows for cooperation and communication between several sorts of traffic equipment. It would accommodate traffic in the city and facilitate movement of its inhabitants.

The National Transport Communication for ITS Protocol (NTCIP) is a group of standards for electronic communication protocols used for transportation (by traffic management agencies, producers, etc.). The protocols aim at providing solutions for communication between various tools and organizational units, and does not covers areas of functionality of the products. It covers communication between such groups of actors as: traffic operational centres (centre-to-centre communication C2C) and centre-to-field equipment communication (C2F). It, however, also provide information for various other participants of traffic activity as: vehicles users, travellers (by use of remote traveller support, personal information access), emergency services, payment administration, maintenance and construction services, fleet and freight management, emissions management, information service provides, archive data management, etc. [28].

![NTCIP Diagram](image)

**Fig. 2. Architecture of NTCIP**

Source: Authors’ elaboration

The C2F covers the exchange of information between such areas as (see Fig. 2):
- Actuated Signal Controllers
Apart from offering specific communication solutions between various types of equipment, the NTCIP provides the possibility of global solutions such as time adjustment, scheduling of various events between different elements of the system, etc.

The Urban Traffic Management and Control (UTMC) initiative was developed at the end of 1990’s in the United Kingdom, initially aiming to point out, multiply and spread good practises and effective solutions among the many authorities involved in public transport. Since that time open standard protocols were the core activity of the initiative, as it was observed that interoperability between various elements of transport control systems were difficult due to the diverse standards of operation which resulted in a lack of a common platform between the many producers and specifications of equipment functioning both in the field and operational centres [13].

The works around UTMC open framework focus on developing the set of specifications for interfaces which allow communication between various systems, especially in manner of problems anticipation. The UTMC covers the interaction of various tools of traffic management such as: Closed Circuit Television (CCTV) which monitors roads, parking areas and highways; traffic signal management (such as Split Cycle Offset Optimization Technique – SCOOT used mainly in urban areas); car park management and guidance; air quality control (including wide range of vehicle emission data); access control (such as automatic number plate recognition or Vessel Monitoring System); travel info services (covering information channels on motorways, public transport and urban areas); infrastructure for Urban Traffic Control (UTC) and provides inputs of for planning and strategy making on various spatial level (starting from municipal, inter-municipal, regional or national) [29]. The scheme of UTMC coverage areas can be seen on Fig. 3.

The use of open protocols such as NTCIP and UTMC offers a wide array of advantages. Among the examples of what open protocols can help with, they allow systems of several different producers to interoperate, while reducing the danger of depending of solutions that are ‘locked into’ one specific supplier; therefore fostering competition, economic efficiency and quality assurance. This is a basic important condition to enable connecting diverse systems and expanding existing solutions.

IV. CIMU

Since the beginning of 2013 a new direction was given to traffic management in São Paulo by the new mandate of city administration. It was emphasizing the integration of the agencies for traffic management (CET) and public transport by bus (SPTrans); innovation and the use of open protocols.

A solution that was thought to solve several traffic and transport problems was to create a unique database that integrates all the information about traffic and transport through a system based on open standards and open protocols, allowing different systems to benefit from the diverse gross data that up to now remained disperse and very much underused.

Therefore, the concept of the CIMU Centro Integrado de Mobilidade Urbana (Integrated Centre for Urban Mobility) was elaborated to address the government emphasis above cited.
The major purposes of CIMU are: (a) to visualize, in a compete and whole way, the information of all different components and sources to support strategic decision-making; (b) automate processes; (c) implement new functionalities; (d) provide information to users; (e) share resources; shrink costs.

The architecture of CIMU is described in Fig. 4. As it is possible to see at the Fig., all data will be collected at field. Data from different sources is integrated in a data network of open protocols which enables control centres to use any information from the field. The data will be then transmitted by network though specific control and coordination centres provided that all data from the specific centres will be replicated in CIMU.

By this design, field data is integrated and support many specific centres, and also, all the centres are integrated themselves, enabling decision-makers to get a whole picture of the city situation regarding mobility at a certain point and interfere in specific cases in real time.
V. CONCLUSION

Although it is well known that the simple fact of integrating technologies with open protocols will not be, just by itself, the solution for all mobility problems of São Paulo, one can assume that if such a centre as CIMU is accordingly associated with a proper infrastructure and organization, it can give more safety to users, allow more control, reduce time of journey, give accuracy, allow users to program their journey, reduce the damages to environment, give more information and predictability.

UTMC and NTCIP are not complete solutions, in the sense that they do not cover all systems and technologies, but they allow the incorporation of systems already existing in the city for traffic management and control. They can be considered as a starting point, a valuable one, indeed. Using open protocols to build the concept of CIMU is the way to combine and put together various solutions without the need of creating everything from scratch. It provides the framework that allows integrating the diversity of field data found in a diverse city as São Paulo, with a modern technology that eventually will permit city authorities to respond to mobility problems with the speed of the challenges that the city faces.

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