Managing Car Sharing for Better Urban Mobility through Information Systems

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Abstract—This work brings a consistent analysis based on a systematic review of the literature and using quantitative techniques about that car sharing management (Car Sharing), a trend in the United States and Europe, is capable of promoting a greater sustainable urban mobility in places that use or intend to use this automotive sharing solution, and prove that it is possible and feasible to enhance their functions when managed by information systems, thus being able to reduce passenger travel time, carbon emissions, resulting in a better quality of life in large urban centers. The goal will be exposed through a systematic review about the car sharing with the advent of information systems, and how to bring these trending solutions in other countries to the reality of our country.

Index Terms—Car Sharing, Mobility, Urban Traffic, Vehicle Sharing, Acessibility, Information System Traffic, Car Travel.

1 INTRODUCTION

Urban mobility and its implications are characterized as one of the greatest challenges of this century for sustainability in cities. In Brazil, the daily urban mobility reflects a major dissatisfactions exposed by the population. The year of 2013 was marked by many conflicts that took place simultaneously in major Brazilian cities, and placed urban mobility as a priority in the agenda of negotiations between government and society in seeking solutions to this [1] sector. The divergence of interests and the imbalance of the dimensions of sustainability highlight the inefficiency of urban mobility management mechanisms.

At different scales and levels of complexity, proper management of urban mobility has the potential to produce actions and reflections towards the advancement of sustainability. It assumes that "(....) any policy or technology that reduces traffic by eliminating the trip is beneficial" [2]. Thus, any technology that is able to confirm this assumption will be well accepted. Thus, technologies signal the reduction of travel, even though some critics argue that other trips can be generated on a secondary basis, but certainly many of them will cease to exist, and this is the most important. Congestion in traffic in large cities are a major cause of idleness and fuel wastage worsening air pollution and increasing stress for drivers. The European Union estimates that 1% of GDP is lost in traffic jams. "City Life", a study of ConsumerLab, studying the transport user behavior (whether public or private) in 13 world metropolises, concluded that traffic is the main cause of dissatisfaction of citizens residents of large urban conglomerates [3].

And the problem of urban mobility is only going to get worse, because cities do not stop growing. Every day about 7,500 new residents are added to the population of large cities in the world. In 2050, it is estimated that 70% of the world will be focused on major urban centers. To deal with the commute of large population masses, the solution will prioritize public transport with the application of information and communications technology(ICT) [3].

This article initially addresses urban development followed by the urban mobility and accessibility with a focus on people. Then introduces the concept of Car Sharing and also some references to the proper understanding of sustainability in traffic, bringing finally the management of mobility by information systems, showing and proposing new methods and tools that enable this transformation with the use of telecommunications networks and data transmission means, making it possible to reduce travels or even not generating them at all.

2 BASIC CONCEPTS

2.1 Urban Development

The urban sprawl originated from the 1950s, motivated from technological advances in agriculture and incentives to modernize it, it was then that the rural exodus occurred as a result [4]. Urban expansion in Brazil occurred and still occurs at an accelerated rate and precariousness in the

management measures of their territories, cities, particularly medium-sized, with rare exceptions, end up going through a vertical integration process of getting projects able to produce or attract concomitant travel and an increase in the fleet of vehicles by changing the spatial dynamics, road and environmental. The intensification of the urbanization process in Brazilian cities produces profound changes in the urban environment that affect mainly the political-economic, sociocultural and space sectors. These various changes in the urban environment collaborate to cause reallocation of trade activities and services to other parts of the cities in the process of occupation of surrounding areas, increasing the need and complexity of population displacements, making transport systems in an important variable required for the quality of life in cities. [5] In most western countries about 65% to 70% of the population lives in urban areas [6].

Clearly, the pattern of mobility has an influence on the way of life of modern human, according to Drucker [7], demographic changes are considered sources of innovative opportunity, which of all the external changes, demographic changes are the most obvious, defined as being changes in the population, its greatness, age structure, composition, employment, educational status and income. In general, large cities have as a focal point socio-economic and cultural activities of the majority of the inhabitants who live near the center and that are further apart and are influenced by the communications industry and information. However, modern management business witnessed a trend towards urban decentralization, with the spread of the activities of virtual enterprises and electronic commerce, however, several policies intensify the need for guidance in order to form large urban agglomerations in such a way that travels become short and able to be performed by means other than private cars. Thus, a modern city has displayed a combination of positive and negative economic scales which are directly connected with the transport and land use [8].

2.2 Urban Acessibility and Mobility

There are several definitions about the concepts of mobility and accessibility, and sometimes both concepts end up confusing or even complementing each other. Quite simply, urban mobility can be understood as the ease of displacement of people and goods within an urban space and accessibility as the population's access to perform their activities and movements. Personal mobility, according to [9], is interpreted as the individual's ability to get around from place to place and depends mainly on the availability of the different modes of transport, including walking. To [10], this concept is interpreted as the individual's ability to move from one place to another depending on the transport system and individual performance characteristics. The National Policy of Sustainable Urban Mobility, developed by the Ministry of Cities [11], in turn, defines urban mobility as an attribute associated with people and goods, which is related to the displacement needs in urban areas, according to the activities it developed.

According to [12], in the urban geography, displacement in cities is analyzed and interpreted in terms of a conceptual framework that articulates urban mobility, which are the population groups and movements; the network, represented by the infrastructure that channels shifts in space and time; and flows, which are the macro decisions or constraints that guide the process in space.

According to Meira [] In 1998, Kevin Kelly, then editor of Wired, said that …

> *This new economy is defined by three characteristics: it is GLOBAL favors INTANGIBLE such as ideas, information and relationships, and is intensely interconnected. It changes the scope of the place of things to space: physical proximity [or place] is replaced by multiple interactions with anything, anytime, anywhere [space].*
>
> *In other words, Kelly says something more than Bush-Druker-Castells, he concludes that the place [place] interactions of all kinds and at any time and place. Instead of places, all types and in any time and place.*

Instead of places, pure and simple, connected places, their interactions and flows.

2.3 Vehicle Sharing

The shared car system appeared first in Europe. After a few attempts, came the pioneer and most important experiences: Mobility in 1987 in Switzerland and StattAuto in 1988 in Berlin, Germany (current Greenwheels) [13]. In North America the experience was more limited and the best US programs happened in the 90's, originating in "station cars" (vehicles in metropolitan train stations, used by users of public transport), and the first program with molds today was the Carsharing Portland in 1998 [13]. In Canada, it began in 1994 with the Auto-Com in Quebec City and in 1995 with the CommunAuto in Montreal (same group) [13]. Since it was implemented, with a basically commercial and business concept, until now, when it is viewed as a mode of urban transport complementary to public transport [14] [15], the system showed a significant growth in several countries (Figure 1).

The development of new technologies, especially information, had enormous impact on operators because it allowed it to grow and encouraged the adhesion of new customers (flexibility and convenience).

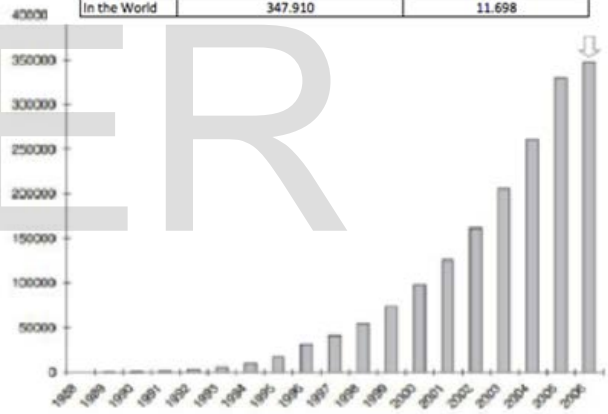
Figure 1. Car Sharing in the World

According to [16], the shared car can be the solution of the future for cities. Realizing that the cars are approximately 90% of its life cycle occupying public spaces and parking lots, sharing is interesting evidence. Car sharing is more effective and attractive when viewed as a "link" between public transport and private car, since it can be integrated with other means of transport and services by strategic alliances combined mobility. [13] [17] [18] [19]

The system in most of the time works as a rental car, with pre-registration, annual fee and fee per hour for the use of vehicles. With the registration, the user receives a card that serves as a key to unlock a car at any distribution point (parking lots located in neighborhoods, businesses, public transportation stations, etc.), provided that a prior reservation is made. After use, the car can be returned in the same or another distribution point, depending on the rules of the operator. Currently vehicles sharing has been deploying in Brazil, specifically in the city of Recife, where after a brief period of testing the electric car sharing system, seeking to improve urban mobility in a sustainable manner, allows any citizen previously registered in the system sharing to enjoy the cars over five stations around the city.

According to [13], for long distances, they use a private car, plane, train, bus or rental car; for short distances, you can walk, ride or take a cab; as for longer travels, or even

Continent	Number of members (estimated)	Estimated number of vehicles
Europe	213.424	7.686
North America	117.656	3.337
Asia	15.700	608
Australia	1.130	65
In the World	347.910	11.698



for daily activities, occasional needs for a vehicle and specific situations, one can use a shared car (Figure 2).

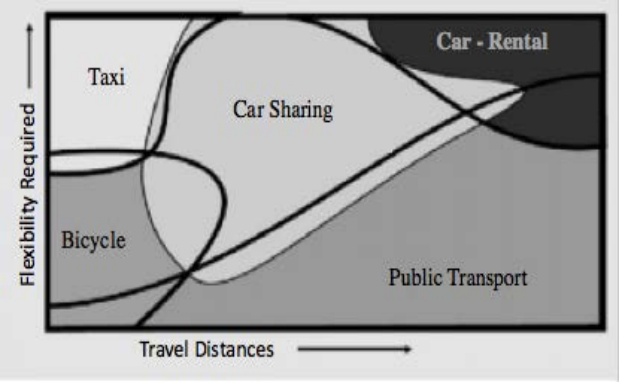


Figure 2. Flexibility x Distance

To [20], each shared car removes between 9 and 12 private cars from the streets. Currently there are several methods developed by car-sharing companies in the industry that have created their own ways to provide the system, as it gained popularity. To generalize, he sums it in three types, which describes like a taxonomy of shared car models: Round trip, One-way + Open End (a path with unlimited end) and Bundled pricing (price package)[21].

2.4 Information Systems Traffic

By 1976, in São Paulo, the Traffic Engineering Company was established (CET, portuguese acronym) responsible for the management, operation and supervision of the entire road system. However, at that time, they used agents to calculate the city traffic congestion rate, pens and a map. The agents scattered in buildings informed the congested streets to the center, where employees with green or red pens painted the map to indicate slow or quiet points. Everything was measured with tape to calculate the traffic congestion rate.

But times have changed, and the CET started using the technology in this procedure, but without giving up the traffic technicians. They work in cars or on top of strategic buildings and transmit information about delays and events to Operations Center, now with cell phones and handheld computers. In addition to the agents, the CET uses radar, cameras and sensors to know everything that goes on. The city is divided into five regions:. Central, East, North, West and South [22] Some key roads to the city can be part of more than one region, each region has a ATC, Area Traffic Control.

According to the CET site, the city of São Paulo is deploying Traffic Lights Modernization Program SEMIN, popularly known as "smart lights". The volume of traffic is calculated with sensors under the asphalt of the streets. The computerized control of each CTA reprograms the time of green and red traffic lights as needed. In addition to the intelligent traffic lights, closed-circuit TV cameras installed at strategic points send images to the corresponding CTA. The cameras may, in the near future, replace the sensors in the asphalt, since these sensors are susceptible to damage. The measurements in this case would be taken within the camera software itself. This information is the basis for the reduction of congestion, immediate identification of slow points, traffic light settings and immediate detection of accidents, among others. In addition to public initiatives to promote the use of technology to aid urban mobility in large cities, there are several types of free software with the same purpose. A good example is *Waze*, a free application that monitors traffic in real time, based on data provided by the users on the traffic. thus providing information for users such as average speed of vehicles on a road, the degree of slow minute by minute, average length of a route, delays caused by congestion, traffic accidents and incidents on the road, such as holes for example.

3 METHODOLOGY

3.1 Research Problem

An ineffective urban planning in conjunction with long commutes of its inhabitants leads to the emergence of an informal transport services market that often evade regulation and public planning. Vans offer services that buses do not realize, at lower prices, but creating professionals who work illegally and outside the rules to meet this deficiency observed in cities. Many residents also choose not

to return to their homes during the weekdays to avoid the drama of the great congestion. [24]

A large portion of mobility problems are also due to incentives in the automotive sector for expansion of private car fleet, having the effect of an increase in travel time, increase in congestion (higher vehicle number for the same amount of urban roads), and strong impact on greenhouse gas emissions. The main form of pollution to the environment of the cities occurs because of displacement. A correction in public policies, improving the infrastructure of public transport and penalizing the acquisition or use of private vehicles would naturally lead to a decrease in the number of cars on the streets, leading to a lower amount of pollutants emitted into the atmosphere. [25] The impact on the environment can also be reduced by switching fuels for less polluting ones in all transports generating significant impacts. For example, researchers [26] calculated that the benefits of a possible substitution of diesel for compressed natural gas in buses in Greater São Paulo outweigh 2 to 3 times the vehicle conversion costs, since it would significantly reduce contamination air for inhalable particulate material. [26]

Vehicle emissions also have global effects that contribute to increasing the concentration of greenhouse gases. In large urban centers, the use of fuels is a major contributor to this effect - in the city of Rio de Janeiro, 48.3% of CO2 emissions in 2005 (5478.2 Gg CO2 eq) were produced by transport, with 38.7 % product of road transport. [27]

Noise pollution is also exacerbated by congestion in traffic. With more noise in the streets, worse quality of life for those who live around busy areas and suffers with constant uncomfortable car noises during most of the day especially in rush hours. For this reason, fewer cars on the streets and less traffic also imply in an improvement in overall well-being provided that there is adequate provision of public transport. Wasting time for commuting is usually negative for the individual utilities. If this time decreases, the overall usefulness increases. The reduction in stress contributes equally to improvement in quality of life. [25]

3.2Research Method

Initially it was performed a systematic review, which like other review study, is a form of research that uses literature on a given topic as a source of data where this type of research provides a summary of evidence related to a specific intervention strategy, by applying explicit methods and systematic research, critical analysis and synthesis of selected information. Systematic reviews are particularly useful to integrate information from a number of studies carried out separately on specific therapeutic / intervention, which may present conflicting results and / or coincident, and identify issues that need evidence, assisting in guidance for future research. The overview of the process of systematic review of the literature follows below. [28]

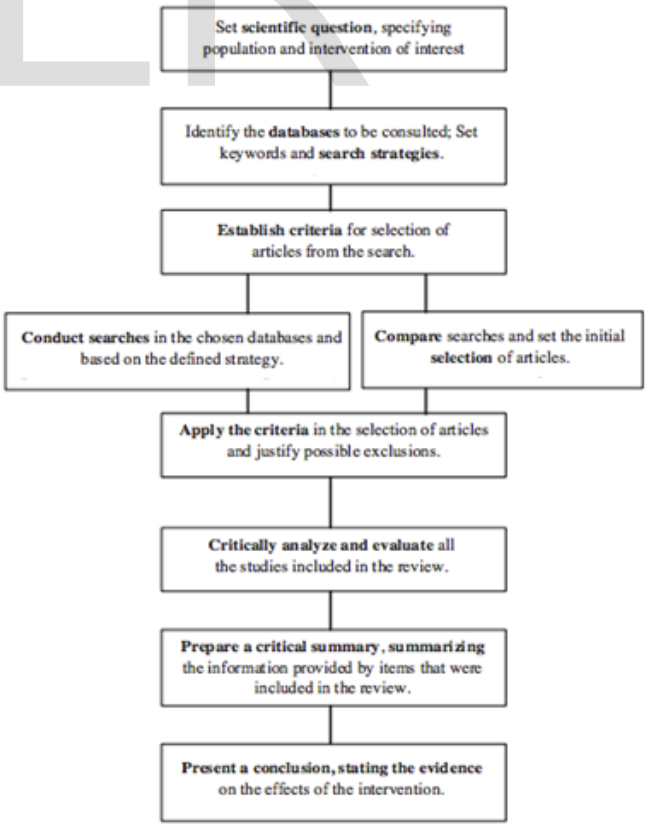


Figure 3: Systematica Review Method, adapted from [29], [30] and [31].

Systematic reviews allow us to incorporate a wider range of relevant results, rather than to limit our conclusions to reading only a few articles. It is important to note that this is a kind of retrospective and secondary study, ie the review is usually designed and conducted after the publication of many experimental studies on a topic. Therefore, a systematic review depends on the quality of the primary source. [32]

4 RESULTS

Although all data and variables discussed in this article show that the most developed nations use car sharing models widespread among them, Brazil through public and private initiative, has developed many ways to spread the concept in accordance with the economic reality of the country. An example that Brazil is adopting this initiative is the Autolib car sharing service created by the Paris City Hall that has different characteristics from the usual: a fleet of electric cars, with stations around the city. According to its creators, each Autolib in circulation takes seven common cars from the streets of Paris [33], the Autolib is quite similar to the project *CarroLeve* (light car) created by *Porto Digital* in Recife, differing in small ways, but keeping the essence. The development of new technologies for the sustained improvement of traffic, either through applications for real-time monitoring, GPS, among others, had an enormous impact in the current scenario, it allowed its growth through social networks and encouraged the entry of new customers combining the flexibility and convenience to its operators.

In the state of Rio Grande do Sul, more specifically in the city of Porto Alegre, it was developed an electric car sharing project, the *Sistema VeicularInteligente (Sivi) (Smart Vehicular System)* to serve the university community as there is only one bus station at the UFRGS Valley Campus and another at the Campus Center. Projects like Sivi and *CarroLeve*, both have direct management of information systems, Sivi fleet cars for example are equipped with GPS that detects diversion and alerts the driver. *CarroLeve on the other hand* provides a lift system, to trigger the same in mobile application design, if someone who is also linked the initiative accepts the ride, a discount of 50% is given to use the vehicle in the given time. In the same application one can also access the sustainable data, such as the amount of carbon gas not emitted due to use of the electric car within the traveled route.

5CONCLUSIONS

This article aims to expose, facing the literature and the facts explored in previous sections, how car sharing with the management of information systems has become a great ally to optimize short trips, both in major world cities, as well as in Brazil in which it is possible to find successful initiatives in some states where raffic has been hampered due to the high amount of vehicles. High costs of acquisition and maintenance of vehicles, deficiencies in urban mobility infrastructure, lack of public transport policy and prioritizing individual transport are equal to the inevitable and annoying traffic jams, are also factors that favor increasing car sharing. According to *AgênciaAutoInforme* (2013) that accompanies every month spare parts prices, automotive services, fuel, road taxes, parking and insurance in order to measure Car Inflation rate, analyzed the average cost to have your own car was R$ 12,600. Costs of acquisition and maintenance of vehicles are high for vehicle owners and to the entire population. More cars on the streets, issues in urban mobility infrastructure, lack of public transport policy and priority to individual transport entails the inevitable jams that cause losses of about R$ 50 billion only in São Paulo, losses mainly caused by the opportunity cost of idle time people lost in traffic and, secondly, due to the monetary expenditures caused by slowness, specifically the additional fuel costs, transportation of goods and pollutant emissions. [34]

According to the results expressed in this work, one can realize the importance that car sharing may reflect on how the contemporary society makes small trips in their day-to-day. And through the examples already mentioned in many first

world countries can attest the viability of car sharing system, since it has already been tested, implemented and even improved on other continents according the specific needs of each culture. All types of car sharing, regardless of their specificities, bring the same kinds of benefits to the society. Today, Brazil has an ideal conjuncture for the implementation of this type of service due to its economic instability and the lack of urban mobility policies, whether sustainable or not, provide the ideal setting for this type of initiative that will bring great improvements for the local population ranging from statistics ones, such as those mentioned in the previous section that addressed the cost of maintaining a vehicle, to a more subjective one as the individual quality of life.

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