Navigation Apps Influence on traffic

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***Abstract*—This work made a study of the influence of navigation apps on traffic conditions. Specifically, it studied the use of applications to aid users' displacement, such as: the suggestion of alternative routes, analysis of traffic variables (average speed, average time of arrival, among others), services near the vehicle (gas stations, restaurants, shops in general), electronic inspection points, comments from previous users, among others.**

The results obtained showed that there is evidence that navigation applications influence both positively and negatively the traffic conditions. The most used algorithm in the apps for route identification is the *Dijkstra* algorithm which is based on the identification of the shortest path between two points. The navigation apps showed good acceptance of 86.2% of users in a survey of 65 participants. Evidence was found in the literature of reduction in average travel time of up to 19% with the use of the apps, but it was also noted evidence of evasion of electronic inspections and increased vehicle flow in residential areas.

Keywords— Aplications, Traffic, Influence

I. INTRODUCTION

Transport networks of different modes are essential to modern society and are responsible for influencing the quality of life and economic flow of cities. The fluidity of the traffic of automotive vehicles is an issue widely discussed in both the public and private spheres, and navigation applications (apps) have become great facilitators for users in the decision making of routes, popularizing the use of wayfinding methods, in the location of service providers during the displacement of users, becoming present in the daily life of users on the transport networks of cities [1].

The traffic of automotive vehicles has become chaotic in large world cities and has become a major challenge to be faced and overcome by today's society. The increase in the fleet of vehicles and the inelasticity of the options of roads has triggered the so-called "mobility crisis", which reflects a decline in the quality of life of society and the economic flow of the metropolis. The use of technologies, mobile communication devices, navigation devices, among others, have been used in order to minimize the problems related to the increase in traffic of automotive vehicles.

Nowadays the use of smartphones, tablets, among other mobile devices, is increasingly present in the daily life of society, enabling the use of technologies embedded in these devices, especially the use of navigation applications to move around the transport networks of cities. The navigation applications present advantageous travel routes when compared to the standard GPS, because they update the traffic conditions through information, coming from the voluntary and involuntary mass collaboration, called crowdsourcing, in real time, offering several services to the user related to the traffic conditions and the characteristics of the surroundings.

II. BIBLIOGRAPHIC REVIEW

A. Mobility Crisis

In the last ten years, the country's vehicle fleet has increased from 30 million to 50 million, showing an increase of 66.6%. The problem of road congestion in large capitals is a consequence of few infrastructure works, the opening of new streets and avenues, an increase in lanes and investment in mass transportation that are not carried out by city halls, states or the federal government. Faced with these facts, our capitals are in the so-called "mobility crisis", which refers to the lack of urban planning and investments in alternatives to the use of roads as a means of transportation, where cities suffer from the overpopulation of automobiles, which in turn are responsible for "swelling the roads", causing congestion and damaging the quality of life of people in society. This situation is not only present in large Brazilian capitals, but also in all world capitals where the flow of vehicles is immense and the high viscosity on the roads generates stress, reduced quality of life and friction with the local economy.

B. Navigation apps types

Applications for mobile devices (smartphones), called "apps", have been used by users to help them navigate traffic. The main function of these navigation apps is to guide the user from one point to another, among other useful services to the user in transit, and they are conquering the mobility market thanks to their easy accessibility. Due to the sharp fall in prices and easy access to the mobile internet network (3G, 4G), the demand for app services through smartphones has grown

exponentially and thus the application market has expanded, especially in the transport segment. [1]

Traffic navigation apps are divided into two groups: informative and guides. The informative apps are those that in detail and through quickly updated images keep the user informed of all traffic conditions and the best route to be traced for the shortest running time, some examples of apps are: *"Sigalert"* and *"Beat the traffic"*. With some diverse features, the guiding function applications are those that through real-time maps, GPS and voice instruction, suggest route direction, location of possible traffic jams, change of routes and others. Some examples: Waze, Google Maps, Trapster, Wisepilot etc.

WAZE is a GPS navigation system available in several countries, including Brazil. It is an application for smartphones based on georeferencing that provides real-time information about traffic conditions. Created in 2008 by Israeli engineers, from the collaboration of users, the app measures the average speed and provides information about obstructions, building works and dangers on the track, being able to calculate the best route to the selected destination.

Google Maps is an application for smartphones that uses information from Google Maps (website) providing guidance of direction, real-time traffic conditions, satellite view, street view, offline maps and local information for people to move around. The application has versions for iOS, Android, Windows Mobile, BlackBerry OS, among others.

Here WeGo is a complete and independent navigation map app that has several tools to help users locate themselves in the city, such as point-to-point navigation, interesting places nearby, public transportation schedules and more. The app is an evolution of HERE Maps, Nokia's old GPS service, and is available for free for Android and iPhone (iOS) smartphones [7].

C. Advantages and Disadvantages of navigation apps

Some indirect functions that navigation applications can offer to society are road relaxation, reduced travel time, reduced congestion, and so on.

Some advantages of using navigation apps [2]

- Reduce journey time: by optimizing routes, applications considerably reduce journey time;
- Cost reduction: Reducing route errors and avoiding atypical traffic situations;
- Avoid congestion: Some apps can obtain data on vehicle saturation points and then recalculate the route to optimize it to the maximum;
- Estimated travel time: Some apps can calculate an estimated travel time based on the allowed speeds of the roads to be traveled, route information and history of other trips that have had similar routes;
- Speed alerts: Some applications have in their database information about the allowed speed of the streets to be chosen and then alert the user if they are outside this limit through alerts.

Despite all the advantages that the navigation apps provide to the user there are several disadvantages that the apps can bring to the traffic, because they can create unpleasant congestion situations due to the algorithm not "think" about the consequences of transferring a high volume of vehicles to roads that were not prepared to handle such volume.

Some disadvantages of using navigation apps [2]

- Evade electronic inspections: For signaling possible electronic inspections some types of drivers end up only slowing down their vehicles when arriving at a certain point, disrespecting the speed limit proposed by the road;
- Increased flow of vehicles in residential areas: In order to remove the user from traffic jams, navigation applications drain their users to streets that were not prepared to receive a large volume of vehicles and thus congestion the local streets;
- Evade police roadblocks: Some crowdsourced database applications provide likely police roadblocks, and this may result in some users with multiple claims trying to escape these roadblocks for whatever reason;
- Probable risk routes: Because they work on the basis of route optimization algorithms, applications can end up

leading their users to routes that can put them at risk of life if a particular route is not accessible and perhaps even in violent areas that the user would not like to approach.

D. Navigation Apps Comparison

Table 1
Guidance apps and associated features.

Features	Apps										
	Waze	Trapster	Wisepilot#	Sygic#	Papago#	Scout (Telenav)	Google map	Magellan#	Tomtom#	Garmin#	Here
Real time traffic and road info	✔	✔				✔	✔	✔*	✔*	✔*	
Voice guidance	✔	✔	✔*	✔	✔	✔	✔		✔	✔	✔
3-Dimensional map		✔	✔*	✔	✔	✔	✔	✔	✔	✔	✔
Junction view			✔*	✔	✔					✔	
Live cam real time snapshot	✔									✔	✔
Weather, temperature, and wind speed forecast			✔			✔				✔	✔
Speed limit display		✔	✔*	✔		✔			✔	✔	✔
Speed camera warnings		✔	✔*	✔	✔			✔	✔		
Road alerts	✔	✔						✔*	✔		
POIs	✔		✔	✔	✔	✔		✔		✔	✔
Free lifetime up-to-date maps	✔			✔	✔	✔*		✔*		✔	✔

* Paid feature.
# Paid apps.

Figure 1: Navigation apps features [3].

Figure 1 reveals some features about various navigation apps, both informative and guides. The data analyzed were: Real-time traffic information, voice guidance, 3-dimensional map, route junction visibility, real-time photos, weather conditions, road speed limit, traffic announcements, important points of approach (radars, points of interest), free lifetime updated maps.

Note that any app has all the analyzed functions, because each application has specific characteristics. Some examples: Waze, Google Maps and Garmin whose main objective is to guide the user through voice and maps. Others such as: Magellan and Scout have their focus directed to information about the route and traffic.

E. How works a Navigation App.

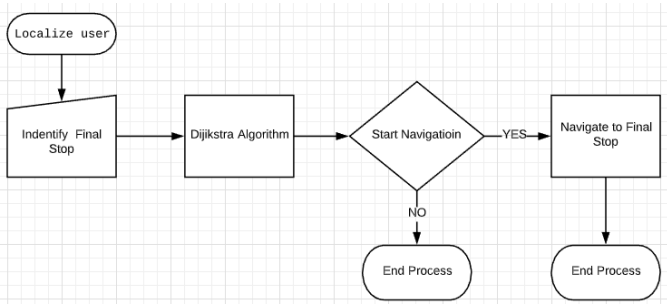

Figure 2: Route search process [5]

Figure 2 shows the basic operating logic diagram of the traffic navigation applications. The location is identified, then the destination is informed to the navigation algorithm, that traces the best route to the destination.

All the navigation apps work on top of an algorithm that is based on the "Shortest path problem" model known as the "Dijkstra algorithm" which consists of a set of vertexes and a set of edges connecting pairs of distinct vertexes (Graph). The algorithm calculates the shortest way to get from one node to another, respecting the conditions imposed [5].

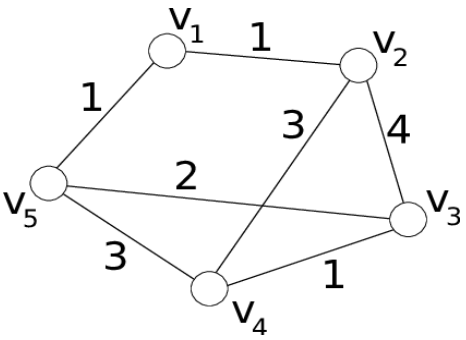

Figure 3: Shortest path problem graph [9]

The algorithm works by pointing the shortest way to get from one vertex to another, however, considering the weight of the edges, which is extremely important for navigation. The user does not search for the vertices in his route search, that searches for the edges. The distance of the route, the possible routes and mainly the time of arrival. The algorithm then returns the weight (distance) of the edges that make up the path **(Figure 3 and 4).**

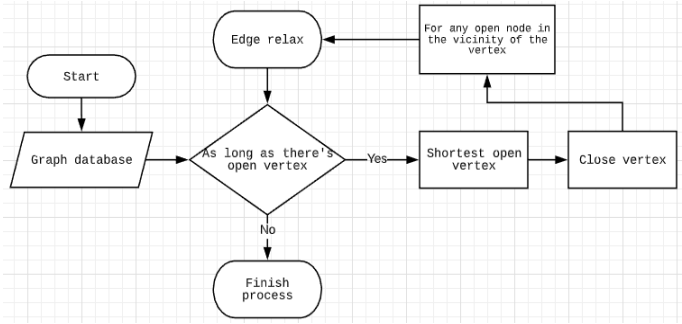

Figure 4: Dijikstra algorithm [8]

F. Navigation apps traffic interferences

Adoko (2014) analyzed the effects of the use of applications with georeferencing in road traffic from the modeling of equations that represent the behavior of drivers. The authors first described two different profiles of drivers: equipped (they used applications with LBS (Location Based Services) and not equipped (they followed known routes and the individual perception of traffic). They then evaluated the interaction of these two types of users by Stakelberg, an application that models the interaction between the two types of drivers and their objectives by providing a non-analytical solution using the "The Augmented Lagrangian" method. This method uses algorithms to solve restricted optimization problems, in which the resolution can be transformed into a single minimization problem without iterative procedures. The work has resulted in comparative graphs between the performances of two types of drivers highlighting the efficiency of traffic applications and has potentially reduced average travel time by up to 19% [4].

Bosch (2011) evaluated the main influences of the use of social navigation for car traffic from the VBSim simulator. Assuming a reference situation with vehicle flow values (cars per hour), distance and time between destinations, the study was able to conclude that the use of applications in traffic can improve performance by 10%, compared with drivers who do not use this technology [6].

III. Methodology

The research had as pillars for its elaboration: study of scientific articles, interviews with users, data collection and visits to control centers.

The studies of the concepts related to the use of navigation apps were made through the reading of several scientific articles followed by discussions of the contents with the supervisor.

The data collection was fully done online through Google Forms, with simple and direct questions, and data were obtained that even in a low quantity behaves in a similar way to much information made available in national and international papers. The form begins with a term of clarification and free consent for the participant not to feel exposed to any kind of charging or exposure of any personal data such as: name, age, gender, e-mail, etc. Be disclosed without your permission. Then the questions were presented and can be seen below:

4. Which navigation application do you use the most?

( ) WAZE ( ) Google Maps ( ) Here we Go etc..

7. For what reason(s) do you use navigation applications?

( ) Find routes to my destination ( ) Escape traffic jams etc.

9. Do you belive that navigation apps can influence the traffic flow in your city?

( ) Yes, positively ( ) Yes, negatively ( ) No

In addition to the public questionnaire, visits were also made to two control centers, one of which was made at EMDEC (Municipal Development Company of Campinas) located in Campinas-SP and the other was made at CET SP (Traffic Engineering Company of São Paulo) located in São Paulo-SP.

IV. Results and Discussion

The results of the survey conducted with 65 participants on the use of navigation apps showed that:

- 86.2% of the users use navigation apps to find routes to their destination or escape traffic jams;
- 12.3% use the app to learn about new routes, which shows that the greatest interest among users of navigation apps is finding the fastest way to reach their destination;
- 53.8% of users feel safer driving when guided by an app, and since most users use apps to find routes to their destination, it is common that much of them feel safer travelling under real-time voice command and image guidance;
- 76.9% of participants consider that navigation apps have a positive influence on traffic and 7.7% believe they have a negative influence.

It was made technical visit to the Traffic Engineering Company of São Paulo (CET-SP) where it was verified the existence of a partnership with WAZE through a program called "Waze connected citizens" with the main objective to make all the data provided by the users be used by traffic engineering companies to find solutions for the intense traffic of the big cities. The fact that São Paulo has an exorbitant number of Waze users allows CET-SP to have access to the "Waze Map Editor". This tool allows the professional, enabled, to make changes in the map that Waze uses as reference to calculate its routes, allowing the professional to block and enable streets and avenues that are used by the algorithm. From this tool CET-SP can make a direct relationship between Waze and the flow of vehicles in the city.

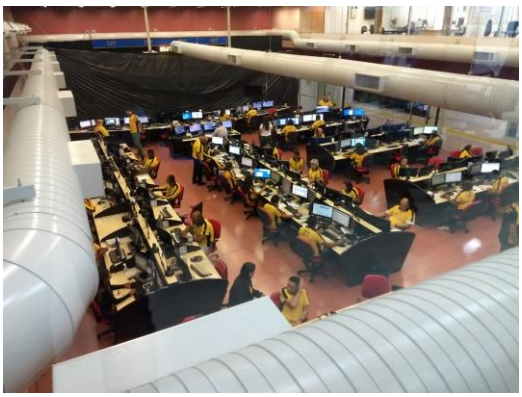

Figure 5: CET-SP traffic control dep.

V. Conclusion

As observed, there is evidence that navigation apps influence both positively and negatively the traffic conditions. The relationship of positive or negative influence is quite relative since the infrastructure, culture and traffic legislation of each city is different. The most used algorithm in the apps for route identification is the Dijkstra algorithm which is based on the identification of the shortest path between two points. Evidence was found in the literature of reduction in average travel time of up to 19% with the use of apps, but it was also noted evidence of evasion of electronic inspections and increased vehicle flow in residential areas. The navigation apps showed good acceptance of 86.2% of users in a survey made with 65 participants, showing that this theme should be studied deeper not only by the academy but also by competent organizations of infrastructure and transport in order to integrate new technologies to the urban environment, optimizing and streamlining all road processes.

VI. References

[1] FRANÇOSO; MELLO. 7º Congresso Luso Brasileiro para o Planejamento Urbano, Regional, Integrado e Sustentavel Contrastes Contradiçoes e Complexidades. “Influência dos aplicativos de smartphones para transporte urbano no trânsito”, 2016.

[2] GONÇALO; DIAS. International Journal of Transportation Systems “Apps influence on urban mobility – improving intelligent cities”, file:///D:/IC%20Aplicativos/3%20Influencia%20da%20tecnologia%20no%20transito/INFLUÊNCIA%20DOS%20APLICATIVOS%20DE%20SMARTPHONES%20PARA%20TRANSPORTE%20URBANO%20NO%20TRANSITO/Apps%20influence%20on%20urban%20mobility%20–%20improving%20intelligent%20cities.pdf 2016.

[3] LING KHOO; “User Requirements and Route Choice Response to smart phone Traffic Applications”) Hong Kong Society for Transportation Studies. Published by Elsevier Ltd, 2015.

[4] ADOKO; KAKPO H. C. “Modelling Effects of Social Navigation on Road Traffic: The Influence of Penetration Rates, Altruism, and Compliance” Delft University of TechnologyFaculty of Civil Engineering and Geosciences Department of Transport & Planning Delft, 2014.

[5] CHANG; “A VANET-Based A∗ Route Planning Algorithm for Travelling Time- and Energy-Efficient GPS Navigation App” International Journal of Distributed Sensor Networks Volume 2013, Article ID 794521, 2013.

[6] BOSCH; ALJE VAN DEN. “Reducing Time Delays on Congested Road Networks using Social Navigation”, 2011.

[7] CARDOSO; Navegue pelos principais pontos da cidade com o app de mapas Here WeGo. https://www.techtudo.com.br/tudo-sobre/here-maps.html 2017.

[8] TORRUBIA; “Algoritmo de Dijkstra. Un Tutorial Interactivo” http://bioinfo.uib.es/~joemiro/aenui/procJenui/ProcWeb/actas2001/saalg223.pdf 2012.

[9] OLIVEIRA; Reduçoes de Problemas em grafos com soluçoes conexas para (MAX) sat e adaptação de um resolvedor sat clausal e Maxsat não clasual para as instancias obtidas. https://www.researchgate.net/figure/Figura-23-Representacao-de-um-grafo-ponderado-Hamiltoniano_fig1_267774928 2013.