Apps influence on urban mobility – improving intelligent cities

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Abstract: - The availability of mobile internet and mobility related apps are changing things on the roads. By using the data available in application software for handheld devices, people are finding more efficient and effective ways to move around, but how could it be accelerated? To answer this question, three main categories of applications were studied due to their impact and scale on urban mobility and its services. This article aims to increase the understanding about these technologies by discussing, based on existing literature and analysis of the three chosen apps, how the usage of these tools can influence the user and traffic in general and by proposing ways to use the capabilities and data available to enhance urban mobility management. In conclusion partnerships and information exchange can provide many effective intelligent mobility contributions and improve life quality in urban centers.

Key-Words: - urban mobility, applications, smart cities

1 Introduction

The proliferation of Smartphone and the broad reach of mobile internet are helping drive the growth of application software for a variety of purposes, from daily games to specialized medical apps. While some apps affect an individual others affect how people relate to the environment and society [1]. Urban mobility apps may influence an entire city dynamic by transforming the paths taken by drivers, public transport uses and transport services such as taxis and shared rides [2].

The wide availability of GPS (Global Positioning System) integrated devices [3] enables apps to access user location information and use information for the app features and also data collection [4].

The data collection is usually voluntary and the information becomes available for features improvement or advertisement [5].

Hundreds of millions of people use application software for handheld devices all over the world [6]. Therefore, it provides a large and rich source of data [7] with significant potential for mobility improvement by the cooperative use between managers and transport suppliers companies [2, 8, 9].

The impact of these apps is not limited to data collection; the main goal is to add value to service performance. By doing so, urban mobility apps affect traffic dynamic and how people move. They can also change secondary streets occupation rates, increase taxis (or similar) occupation and shared rides frequency, among others. On the other hand, these apps may create undesirable situations and rise risks to users [10].

In this context, the aim of this article is to understand how these applications may improve intelligent mobility and suggest guidelines to establish close relationships between users, developers and urban mobility companies and thus provide more accurate and integrated data, with better information about traffic flow in urban centers, driving habits, traffic behaviour and improve its usage. In addition, this article purposes the extension of cooperation through joint actions by adapting apps interfaces and features in order to enable users' communication.

2 Choises justification

This chapter presents the variables analyzed to define the focus of the research.

2.1 Smartphone types

The definition of smartphones analyzed considered the market share of each operational system, presented in Table 1.

Table 1. Operational systems market share [11]

Year	Android (%)	iOS (%)	Windows Phone (%)	BlackBerry OS (%)	Outros (%)
2015	82.80	13.90	2.60	0.30	0.40
2014	84.80	11.60	2.50	0.50	0.70
2013	79.80	12.90	3.40	2.80	1.20
2012	69.30	16.60	3.10	4.90	6.10

With 96.7% of market share in 2015, Android (Google) and IOS (Apple) are the main players and therefore were chosen to enhance the study. The apps and key words related to urban mobility were researched in the available literature and in Play Store (Google) and Apple Store (Apple).

2.2 Transportation modal

São Paulo, the biggest city in Brazil, offers several transportation modals. The options and the choices made by population are shown in Table 2.

Table 2. Transportation modal per reason [12].

	Work	Education	Shopping	Health	Leisure	Others	Total	%
On foot	3.4	7.3	453	204	450	887	12.6	33.1
Car	4980	2.3	587	513	679	1.371	10.4	27.3
Bus	5.2	1.7	319	600	281	949	9.0	23.7
Subway	1.4	368	57	116	62	192	2.2	5.8
Eschoolbus	4	1.3	0	1	5	9	1.3	3.5
Train	615	95	18	22	25	40	815	2.1
Moto	547	97	7	10	21	39	721	1.9
Charter	432	53	2	2	14	11	514	1.4
Bicycle	214	39	4	0	12	35	304	0.8
Taxi	32	7	8	21	8	15	91	0.2
Others	52	1	1	5	1	1	61	0.2
Total	16.9	13.2	1.5	1.4	1.6	3.5	38.1	100

As presented in Table 2, on foot, car and public transportation represents the most common transportation model chosen by São Paulo´s population. Several apps were created to fulfil users demand and improve displacement experiences:

- on foot: the main apps for this modal are the GPS navigation ones;
- car and motorcycle: Likewise on foot, GPS navigation is the most common apps used. Furthermore, drivers may use apps to find parking spaces and organize share rides. Motorcycle drivers may use a microphone integrated to the helmet;
- bus, subway and train: there are two types of apps that are more common in these modals. The schedule transport provides information about availability and time tables in the traditional way, it facilitates data access and the user can choose the best path and/or vehicle. The second type optimizes the route by suggesting transportation modal, schedules and streets. Some navigation apps integrated this service to their features in order to provide a more encompassing displacement service by including directions to drivers, pedestrian and public transport users;
- school bus and charter: due to the necessity of a fixed rout the apps are less common in these modals;
- bicycle: There are several apps made especially for cyclists. Navigation service, cyclists information sharing (bicycle paths, rent, parking places) [13]. This modal has also a range of cycling exercises apps, which are not direct related to mobility;
- taxi: Besides navigation benefits, apps allow a more efficient connection between the taxi driver and passenger, considering their location and a range of payment methods [14]. Nowadays, apps that enable users to share rides and split costs seem to be a new trend.

Among the apps described, the navigation apps are more popular, affecting a large number of people who travel on foot and by car, public transportation and taxi, which represents 92.2% of users.

These apps improve the urban mesh awareness, by indicating alternative and/or with less congested

routes and enable significant impact for users and entrepreneurs [15, 16].

Table 3 presents the apps chosen for functionality discussion. The decision was made based on the amount of users [17] (App Store does not provide this data) and features availability in Brazilian market (as established by application installation).

Table 3. Apps analyzed

Type	Apps	Keywords
Navigation and GPS	Google Maps (500 millions), Apple Maps, Waze (100 millions)	GPS, Maps, Navigation (Portuguese and English)
Public transportation	Cadê o Ônibus (500 thousand), Transit Directions by Moovit (10 millions), CittaMobi (1 million), Google Maps (500 millions), EMTU Oficial (100 thousand), São Paulo Metro Oficial (100 thousand), TRAFI: Bus & Train (1 million)	Bus, Metro, Subway, Public transportation (Portuguese and English)
Taxi request apps	Easy Taxi (10 millions), 99 Taxis (1 million)	Taxi, Taxi Brazil (Portuguese and English)

Therefore, three navigation and GPS apps, seven public transportation apps and two taxi apps were analyzed and compared. It is noteworthy that the literature research was not limited to these apps, as referenced during the article.

3 Navigation and GPS apps

As dedicated GPS devices, mobile GPS apps have a clear function: indicate one or more routes. Since 1999, when the first commercially-available GPS mobile was launched [18], interface, efficiency, features and reliability of these devices made significant progress of both software and hardware issues [18].

Although hardware GPS improvements were developed –especially regarding space, energy consumption and accuracy, software amendments were the main responsible for usage innovation. A new trend of navigation app was developed by connecting access capacity, users' connectivity, data collection from user and networks and communicative interaction.

This new type has not only online and accurate maps, but also thousands (or even millions) of informal contributors and reviewers connected through web networks [19]. It aims to provide reliable information about optimized routes (distance, time or cost optimization). Users may collaborate by informing errors and even temporary events, such as accidents and police blocks.

3.1 Direct advantages

Navigation apps may add value to the user in different forms:

- decrease in journey time: by providing optimized routes, these apps may cause significant reductions in journey time, especially when the user is not aware of the path, is going for the first time or there is an unexpected event on the way;
- reduction in costs: caused by reduction of mistakes and utilization of optimized routes, which represents fuel economies, or by avoiding road fees;
- decrease in congestion: some apps can verify bottlenecks and saturations point in order to suggest faster routes. Users' collaboration may be direct (information provided by the user) or indirect (information collected from devices). Indirect data must be compiled and traffic statistics analyzed [20, 21];
- arrival forecast: some apps inform the arrival time based on route information, speed limits, direct and indirect data and historical data. This information may be useful once the user can better define the schedule, programme the departure time to avoid waiting / being late or choose less congestion hours when the app provides online information [21];
- speeding warnings: by getting information about speed limits, apps may notify the user that he is driving over the limit, through alarms or information on the display.

3.2 Indirect advantages

The benefits provided by the massive use of navigation and GPS apps go beyond the ones observed by the users:

- better exploration of secondary roads: in case of congestion on the main roads, the apps indicate alternative roads, decreasing time in traffic jam and improving utilisation rate. Secondary routes are usually used by drivers familiar with the region; with help of

handheld devices other drivers become aware of these options and other information, such as accidents, floods and constructions. By changing directions, users avoid bigger congestion rates;
- fewer vehicles on the road: the direct consequence of apps use is the journey time reduction. Hence, vehicles spend less time driving, which contributes to the reduction of road system utilization.

3.3 Disadvantages

Despite the positive effects, navigation and GPS apps may also generate disadvantages to urban mobility and life quality. Although the negative aspects are not related to all apps, understanding them is important and may help to mitigate risks involved:

- electronic control evasion: apps may use database and users information to notify users through audio and visual warnings about electronic controls. By doing so, reckless drivers may drive in a high speed and jus slow down when notified, increasing impunity and reducing traffic safety. Some apps have online information which also reduces mobile speed camera effectiveness [22];
- increase of traffic flow in residential neighbourhoods: in order to provide faster routes, apps suggest secondary routes (especially in rush hour), affecting residential neighbourhoods [23]. This increase of traffic flow means more noise and wear in these neighbourhoods and higher journey times for residents and local traders;
- police block evasion: one of the most negative effects of collaborative navigation apps, it may facilitate police block evasion by informing users about the exact location. Although the legality of the feature is very questionable, there are examples [24, 25] when these information were used for criminal acts, including kidnappings and thefts;
- regions at risk routes: apps may indicate itineraries through areas at risk and put lives in danger [10]. The entry of regions at risk data is a difficult solution, because people that live in these regions may also be users.

3.4 Integration with urban mobility management

The article proposes two major collaboration approaches for navigation apps and urban mobility management, both related to information. The first refers to the use of information collected and the second concerns the app utilization as a mean of communication with the end user.

The use of information collected through these apps could contribute in researches and improvement projects implementations in public transportation system. The data collected present valuable information, by presenting individual journey times, common routes and their link with existing urban mesh, bottlenecks and seasonal routines. Although most centers responsible for urban mobility in developed cities have access to the database, the enormous amount of available data is already a challenge. But this granularity can be of great value for traffic engineering and public transport secretariat.

The second contribution of the article is deals with the possibility of using the apps as a mean of communication with the end user. This may help the app to notify avoided routes and unexpected (or expected) events.

4 Public transportation apps

In big urban centers, more than one mean of transportation may be necessary to reach destination, which may include displacement between stations and bus stops. These apps usually provide information about schedules and timetables and route options. There are several apps with these functionalities with different quality levels, features and objectives. While some of them are mere reproductions of timetables and maps, others include even waiting time forecast based on the user location.

4.1 Direct advantages

Public transportation apps may add value to the user in different forms:

- schedules, availability and fares: almost all apps analyzed contained direct or indirect information about lines and timetable. In some apps it was a table query, in others, user was supposed to fill departure and destination address and the app presented the possibilities (lines, transports). This may also help to increase awareness of lines and public transportation options [26];

- ease of finding the correct route: some apps work directly with addresses, which facilitates the use of public transport and the identification of stations and bus stops. In Brazil it is hard to find the bus itinerary in bus stops, thus it is necessary to know in advance the route or trust in other users' information;
- route optimization: especially in big cities, some apps indicate alternative routes that may be faster depending on schedule and traffic jam;
- arrival forecast: like in navigation apps, users may use this information to programme themselves;
- information regarding rush hour: users may choose hours or routes to avoid congestions.

4.2 Indirect advantages

The benefits provided by the massive use of public transportation apps may include other benefits:

- encourage of public transportation use: public transportation apps may facilitate and as a consequence increase the use of public transportation;
- reduction of unnecessary occupation: the optimization of routes may contribute, in a limited way, to the reduction of passengers in an amount of travels through the optimization of individual routes.

4.3 Disadvantages

The only adverse effect mapped is a possible increase in levels of public transportation overcrowding. However, this effect is less harmful for urban mobility than the use of private vehicles [27].

4.4 Integration with urban mobility management

Companies that work with public transportation apps are really interested in strengthen relationships with urban mobility managers due to the interest in obtaining accurate information regarding lines availability, schedule and foreseen changes and also users' location and position.

Vehicle maintenance could also be improved by focusing control and maintenance efforts where it is urgent, based on the current state of conservation estimated from users' feedbacks. The necessity of maintenance and fleet increase can also be better understood.

The set of traffic engineering software allows more efficient public transportation systems.

5 Taxi request apps

One of the apps which have the greatest market penetration is the taxi request. It changed significantly users and professional routines [16].

Drivers and users start by registering a profile and usually is required a tracking system, such as GPS. The user requests a taxi through the app, the service notify the closest drivers until the ride is accepted. The user receives a notification with driver location and information.

The importance of taxi request apps for the driver depends on the penetration. 99Taxi has a penetration rate of 88% among taxi drivers in São Paulo [28] and the financial benefit reported may reach 20% [15].

5.1 Direct advantages

Besides the direct benefits, taxi apps add value in other ways:

- time economy: because the app look for free drivers located around the user, it is normally faster than searching for a taxi on the street or calling a central;
- payment methods: the main apps offer different payment methods, which is informed in the moment of taxi request;
- ease of planning: by knowing the estimated arrival time of the taxi the user can avoid wait.
- security: the location of driver and passenger and the feedback system based on profile registration contribute to safety of all users;
- decrease in idle time: the taxi driver can wait for his next passenger in his last stop, preventing unnecessary moves and enhancing occupied time [16].

5.2 Indirect advantages

Besides improving taxi occupation, some side effects can be mentioned:

- • quality improvement: the taxi driver is stimulated to perform a high quality of service in order to receive better feedbacks. The increase in speed service is also seen as quality improvement;
- • reduction of unnecessary roads utilization: since it is not necessary to return to a specific

location to wait for the next customer, unnecessary movements are prevented.

5.3 Disadvantages

Taxi cooperatives may not survive the expansion of these apps [16]. The necessity of calling call centers is decreasing, which reduces backoffice activities and make the taxi drivers more independent from cooperatives.

5.4 Integration with urban mobility management

The existing taxi apps are helping the sector regulation and enabling analysis on taxi offer and demand needs.

6 Conclusion

By analyzing the three app types: navigation and GPS, public transportation and taxi request, is possible to verify the deployment of the Intelligent Transport System (ITS) concepts.

Taxi request apps are reducing wait and are being used by most of taxi drivers in the biggest Brazilian city. They provide more intelligent taxi services by connecting supply and demand online. As consequence, less fuel is spent, vehicles occupation rate increase, quality of service improves and taxi drivers earn more money.

Public transportation apps enable a more rational search for means of transportation and a better journey plan. However, the impacts are not so direct than the ones observed in taxi apps, because the information provided by public transportation apps do not directly affect cities' operation.

GPS and navigation systems also contribute to improve intelligence in urban mobility, by enabling drivers to readjust the journey online considering available information about traffic and other events.

The integration of these apps to a robust data structure, which supports decision-making process, is a huge challenge for urban mobility managers. The use of these apps should be more than data collection; it should work as a platform that allows communication and enquiry of measurement results in order to provide a rapid response system with positive impact in urban mobility.

References:

[1] A. Fonseca, Não dá mais para viver sem os aplicativos. 2015. Available at: <http://www.valor.com.br/carreira/4072960/nao-da-mais-para-viver-sem-os-aplicativos>. Access: 04/26/2016.

[2] E. Goldwyn, The Most Important Transportation Innovation of the Decade Is the Smartphone (2014). Available at: <http://www.citylab.com/commute/2014/09/the-most-important-transportation-innovation-of-this-decade-is-the-smartphone/379525/>. Access: 04/26/2016.

[3] K. Zickuhr, Three-quarters of smartphone owners use location-based services. Washington: PewResearchCenter (2012).

[4] H. Almuhimedi, F. Schaub, N. Sadeh, Your Location has been Shared 5398 Times ! A Field Study on Mobile App Privacy Nudging. In: *Proceedings of the 33rd annual ACM conference on Human Factors in Computing System*, New York, USA, **33**, 787-796 (2015).

[5] T. T. C. Lin, F. Paragas, D. Goh, J. Robert, Technological Forecasting & Social Change Developing location-based mobile advertising in Singapore : A socio-technical perspective. Technological Forecasting & Social Change (2016).

[6] M. Li, H. Zuh, Z. Gao, S. Chen, K. Ren, L. Yu, S. Hu, All Your Location are Belong to Us : Breaking Mobile Social Networks for Automated User Location Tracking. Arxiv, **2** (2013).

[7] H. Dediu, Where are Maps going? (2015). Available at: <http://www.asymco.com/2015/06/15/where-are-maps-going/> Access: 04/20/2016.

[8] C. Aoun, V. Buscher, L. Doody, M. Web, Urban mobility in the smart city age. In: *Smart cities cornerstone series* (2014).

[9] Samsung, How Smartphones Will Transform the Future of Public Transportation (2016). Available at: <http://www.samsung.com/be_fr/business/insights/others/how-smartphones-will-transform-the-future-of-transportation>. Access: 04/20/2016.

[10] G1. Mulher morre após casal entrar por engano em comunidade em Niterói (2015). Available at: <http://g1.globo.com/rio-de-janeiro/noticia/2015/10/mulher-morre-apos-entrar-por-engano-em-comunidade-em-niteroi-rj.html>. Access: 05/05/2016.

[11] IDC, Smartphone OS Market Share 2015 (2015).

[12] Pesquisa Origem e Destino Região Metropolitana de São Paulo. São Paulo (2008).

[13] Y. M. Lin, C. J. Lin, J. S. Peng, C. Cheng, An Effective Integration of Smart Phone APPs for

Bicycle Riders. *Advanced Science Letters*, **19**, 7, 1823-1829 (2013).

[14] A. Jesus, Easy Taxi: baixe e use para conseguir táxi em poucos cliques (2014). Available at: <http://www.techtudo.com.br/tudo-sobre/easy-taxi.html>. Access: 04/22/2016.

[15] M. Lima, A. P. Silva, Taxistas ganham até 20% a mais com uso de aplicativos (2013). Available at: <http://economia.ig.com.br/2013-09-27/taxistas-ganham-ate-20-mais-com-uso-de-aplicativos.html>. Access: 04/22/2016.

[16] G1. Sobe uso de aplicativos para táxi e cooperativas pedem regulamentação (2014). Available at: <http://g1.globo.com/economia/noticia/2014/02/sobe-uso-de-aplicativos-para-taxi-e-cooperativas-pedem-regulamentacao.html>. Access: 04/22/2016.

[17] Play Store. Available at: < https://play.google.com/store/apps?hl=en>. Access: 04/26/2016.

[18] M. Sullivan, A brief history of GPS (2012). Available at: <http://www.pcworld.com/article/2000276/a-brief-history-of-gps.html>. Access: 04/23/2016.

[19] Get the best route, every day, with real–time help from other drivers (2016). Available at: <https://www.waze.com/>. Access: 04/30/2016.

[20] P. Barker, How Traffic Impacts our Everyday Life, an Expert Tells all (2015). Available at: <http://360.here.com/2015/07/28/how-traffic-impacts-our-everyday-lives-an-expert-tells-all/>. Access: 04/20/2016.

[21] T. Stenovec, Google has gotten incredibly good at predicting traffic — here's how (2015). Available at: <http://www.techinsider.io/how-google-maps-knows-about-traffic-2015-11>. Access: 04/23/2016.

[22] L. L. Baroni, Aplicativos podem ajudar você a fugir do trânsito neste feriado; veja (2014). Available at: <http://tecnologia.uol.com.br/noticias/redacao/2014/11/19/aplicativos-podem-ajudar-voce-a-fugir-do-transito-neste-feriado-veja.htm>. Access: 06/25/2015.

[23] M. Williams, Residents of upscale LA neighborhoods pissed at Waze. They're fighting back in the most passive-aggressive way possible (2014). Available at: <http://boingboing.net/2014/11/14/upscale-la-neighborhoods-disru.html>. Access: 04/21/2016.

[24] N. de C. Alves, PM alerta sobre desserviço no uso de aplicativos em celulares (2015). Available at: <http://www.pm.go.gov.br/index.php?link=2&idc=86506&idt=2>. Access: 06/26/2015.

[25] K. Reis, Aplicativos que permitem alertar sobre blitz no trânsito preocupam a polícia (2015). Available at: <http://dc.clicrbs.com.br/sc/noticias/noticia/2015/01/aplicativos-que-permitem-alertar-sobre-blitz-no-transito-preocupam-a-policia-4689398.html>. Access: 04/26/2016.

[26] C. de C. de Oliveira, Estudo sobre a utilização de mapas em android para itinerários de ônibus, 2012. *Universidade Tecnológica Federal do Paraná* (2012).

[27] T. Mazzella, Prioritizing public transit for speed, reliability, and rider satisfaction (2013).

[28] G. Felitti, Para rivalizar com Uber, 99Taxis e Easy Taxi planejam serviço só com melhores taxistas (2015). Available at: <http://colunas.revistaepocanegocios.globo.com/tecneira/2015/08/13/para-rivalizar-com-uber-99taxis-e-easy-taxis-planejam-servico-so-com-melhores-taxistas/>. Access: 04/23/2016.