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Abstract:

Location-based mobile applications have been a growing research topic in the field of urbanism due to their potential for transformation to the urban space. This paper raises the issue of urban mobility oriented digital platforms for mobile devices. This work stems from the research carried out in the Graduate Program in Urbanism at the Federal University of Rio de Janeiro (PROURB/UFRJ). This article aims to discuss the construction of information in the contemporary city, presenting as a case study, Caronaê, the official rideshare system of UFRJ. Being created by students for the academic community and launched in 2016, the said application allows the sharing of empty seats on car trips to and from UFRJ campi, increasing the occupancy rate on these trips and encouraging greater integration of the university community.

Keywords: Mobile apps, Urban mobility, Rideshare, Caronae UFRJ

1 Introduction

The ubiquity of information and communication technologies (ICT) has profoundly altered people's relationship with the urban environment – as well as their very experience of the city. A plethora of platforms and applications dealing with transportation and mobility in cities are transforming the way people and objects move around in the urban space, as they emerged with the advancement of location-based technologies, the popularization of mobile devices and widespread wireless Internet connection. The construction of information today largely involves the mediation of various spheres of urban life through digital platforms that enable, among other things, the articulation of community practices and collaborative processes in the search for solutions to many challenges found in contemporary cities.

This article aims to analyze the use of the Caronaê system, understanding the project as an example of a digital platform that seeks to solve an urban issue through collaborative practices mediated by digital communication. The first section discusses the classification of Caronaê in relation to the different platforms dealing with urban mobility, using categories we developed in a previous study. The following section presents the Caronaê project, the context in which it was created and the analysis of the system's user data between 2016, the year in which the project was launched, and 2018, the year the research was conducted. Finally, we present a reflection on the application of these mobility-related technologies in contemporary cities and on the construction of information in digitally mediated collaborative processes.

The issue of urban mobility is a central theme for big cities. The impacts of urban planning directed towards private owned cars, highway-oriented development, and minor investments in public transportation systems are felt everywhere. According to the latest report of the National Association of Public Transport of Brazil (ANTP, 2015), the fleet of private cars had an increase of more than 100% in ten years, from 2002 to 2012, representing about 55% of the total of vehicles in the country. This model has been showing signs of exhaustion, producing several effects on daily life, such as the increase in travel time, with longer and more frequent traffic jams and the increase in the emission of pollutants, which directly impacts the health of inhabitants, as well as the environment and the climate (Andrade and Linke, 2018).

With the development of location-based technologies incorporated into mobile devices, several projects have been developed with the aim of optimizing mobility in the urban territory, as well as reducing the impacts caused on local and global ecosystems. In this paper, the term mobility is used in reference to the physical displacements carried out in the urban space. More specifically, we focus on passenger mobility, leaving aside the transportation and distribution of goods and services.

In recent years, a number of transportation and mobility applications have been - and continue to be - developed based on georeferenced information, such as taxi applications, public transport monitoring, and also bicycle, car and ride-sharing, among which Uber and Waze are perhaps the most well-known. Their popularization among various social groups serves as an important data source on urban dynamics, justifying the study and analysis of both the apps and the data they generate, especially when considering the Brazilian context, where governmental data about transportation is less available and much more dispersed.

In the specific case of Rio de Janeiro, urban mobility has become increasingly relevant as it is one of the main issues when it comes to urban dwellers' well-being and their right to the city. The difficulty of access to the UFRJ main campus makes a large part of the academic community choose to drive to the university (Universidade Federal do Rio de Janeiro, 2011, p. 37) - and, in most trips, having the driver as solo occupant of the vehicle.

2 Digital platforms for urban mobility

According to Adriana de Souza e Silva (2013), mobile devices have always been based on location-aware systems, but only a few years ago this resource became available to ordinary users, disseminating its use in everyday affairs. The diffusion of smartphones, as well as wireless connection technologies (wi-fi, 3G, and 4G) and GPS, enable real-time interactions using information filtered by the user's location in space, using a portable device that is most of the time within an arm's reach of its owner – or actually handheld.

It is not surprising, therefore, that mobility is one of the areas initially most affected by these specific technologies, since it enables the almost instant connection of location data of users and transport vehicles, allowing the dynamic reconfiguration of the system or at least some of its parts using the actual demand as input. On the one hand, these technologies are used to make the existing transport system more efficient; on the other hand, they make it possible to think of different guidelines for public policies and urban mobility planning.

French author Georges Amar says that information has become an essential component of transport systems (Amar, 2016, p. 13) and mobile technologies only enhance their role. In fact, it can be argued that the very concept of "smart cities" (and its most critical counterpart, "smart urbanism"), in its outset, arises from mobility-related applications (Townsend, 2014, p. 17).

There is a wide range of mobile services offered or powered by mobile apps, from government and corporate initiatives to independent low-cost collaborative platforms. In a previous paper (Teixeira and Paraizo, 2018), we examined different applications for *iOS* and *Android* devices in order to understand how each one deals with urban mobility and also how to categorize them. The systematization was based on some parameters, such as vehicle ownership, uni or multimodality, the presence or absence of ridesharing and the type of payment (when that was the case), in order to understand the benefits of each platform in terms of environmental and social issues.

We proposed four main categories (each with its own subdivisions): 1) mobility orientation, that is, applications that help users navigate the urban environment, such as Google Maps, Waze and the French RATP platform, which can be uni or multimodal; 2) on-demand transport, or e-hailing, such as Uber, Lyft and 99, which essentially provide taxi services managed by a computer server; 3) vehicle sharing, when applications manage vehicle rental, typically for daily short trips such as Vélib and BikeRio for bicycles, and AutoLib and Car2Go for cars; and finally, 4) ridesharing, such as BlaBlaCar and Zimride, which addresses the provision of empty spaces in a vehicle (usually a car) on a particular trip, increasing occupation and optimizing the system as a whole.

This last category is precisely the one where the subject of this article, the Caronaê project, is included. Applications in this category take advantage of existing transport configurations in order to make them more efficient in terms of occupancy of vehicles; they do not create or change modalities of transportation, for instance. This makes bottom-up initiatives easier to appear in this category, as is the case of Caronaê. The inefficient public transportation network to the University's main campus, in the Fundão's island in Rio de Janeiro, ends up leading the academic community to largely opt for individual transportation by car - and, as often happens, with very low occupation. The project, then, was designed to improve car occupancy for these daily trips to and from the *campus*.

3 The Caronaê Project

The Caronaê is a ridesharing system created by students for the academic community of UFRJ, with the purpose of strengthening the culture of carpooling in the university, encouraging the more efficient occupation of available seats in private cars. Originally, the project was carried out on the University's main campus of UFRJ, expanding to other campi after some time of activity.

3.1 The context of the UFRJ campus

The main campus of UFRJ is the University City, located on Fundão's island. It constitutes a neighborhood in Rio de Janeiro, on the West side of the Guanabara Bay, occupying almost all the extension of the city's North Zone coast. Other UFRJ campi include Praia Vermelha campus, in Urca; the Institute of Philosophy and Social Sciences and the Law School, in the downtown Rio; and Macaé campus (a town nearby Rio de Janeiro).

The University City concentrates most of UFRJ's undergraduate and graduate courses and serves as the headquarters of several other research institutions. As it is usual among educational institutions, from the point of view of mobility, it is categorized as a Trip Generation Hub (TGH)[1] (Parra and Portugal, 2007); if we consider only the academic community of the university, the campus has a daily commuting population of about 100 thousand people (Universidade Federal do Rio de Janeiro, 2011).

3.2 Brief history of the project

The "Caronaê" project was conceived by UFRJ students for the "Sustainable Solutions" competition, organized by the Green Fund[2] of UFRJ, in 2014. The original team was formed by undergraduate students of Architecture and Urbanism (namely, one of the authors of this article) and Engineering (from Civil, Computer, Environmental and Materials careers). With the name "Solidary Transport: unifying and expanding the rides in UFRJ", the entry won the "Mobility" category. The main objective of the project was improving access to the University City through an efficient and safe official rideshare system, which would unify initiatives that already existed but were scattered in social networks such as Facebook and WhatsApp.

The proposed system was based on the triad "mobile digital platform - pick up points - cultural change". Therefore, in addition to the digital platform, physical hubs were created to serve as physical meeting points, signaling the implementation of the system in the urban space of the University. Those both represent the connection between virtual and real - and are references for those who schedule the rides departing from the University. Another fundamental characteristic of the system is that, in order to ensure greater security for its users, they are authenticated using UFRJ's Intranet, therefore ensuring only members of the academic community can access the system.

The implementation of the application began with the elaboration of the wireframe indicating the main functionalities and flow of the screens, based on the project sent to the competition. After this first stage, the code development was done by Fluxo Consultoria, junior engineering enterprise of the Technology Center of UFRJ. The team decided to develop two independent codes for the operating systems (iOS and Android). In parallel, the visual identity of the application was elaborated (according to the brand definitions initially created for the project), and incorporated into the code after approval by the team. The app development phase lasted approximately ten months, with several tests conducted with a smaller group of users. The physical meeting points were designed and implemented in the last three months of this period.

The application was launched in April, 2016 and, since then, it has been active in the University. In 2017, it was transformed into an Outreach/Extension Project in order to foster replication of the initiative in other institutions and TGHs, especially other public universities. The main action towards this goal was the release of the source code as open source, made available on the GitHub[3] platform, under the GNU General Public License v3.0[4] license. Therefore, it enabled a simpler and more collaborative system replication, creating a network of contributions to the shared source code, based at UFRJ.

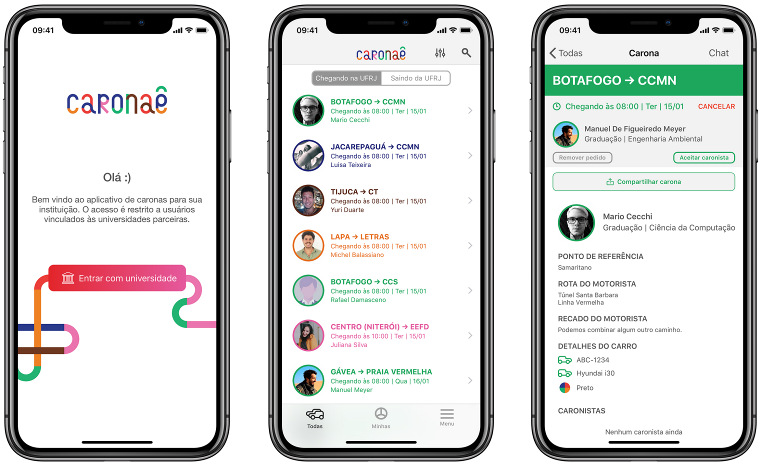

Fig. 1: Caronaê application screenshots (v. 1.5, 2018), showing login, search and ride detail screens. Source: Authors, 2018.

Fig. 2: Physical meeting point at the University City *campus* of UFRJ. Source: Authors, 2017.

3.3 The ridesharing dynamics from the Caronaê database

As a subset, it cannot be said that the users of the Caronaê are representative of the universe of those who offer and take rides in the UFRJ. First, its users represent a very specific demographics; for instance, it corresponds to those willing to install a particular application, go through the entire registration process and actually use the system in their daily routines. Second, many rides in UFRJ happen outside the Caronaê system, in groups of rides from various social networks (already installed in many cellphones prior to ridesharing uses); and also begin to happen in company-owned applications such as Wunder and Waze Carpool – all this in addition to those that happen by traditional personal contacts. It is reasonable to assume that each system, digital or not, has its own dynamics, and Caronaê is no exception. However, this research assumes that Caronaê records might indicate several trends that can help shape transportation policies on campus or more efficient car sharing systems, and are therefore worth analyzing. No only data from Caronaê was available for our research, unlike other active ridesharing systems used in UFRJ, but it was available as structured information coming from a specialized ridesharing system – in contrast with rides arranged using social networks, for example, which would be much harder to aggregate even if we could have access to the data. The time frame for data analysis of the system goes April 2016, corresponding to its launch, to December 2018 when our consultations were actually carried out.

We can separate the information obtained from the Caronaê database data set into two basic categories: *users* and *rides*. The main data on users comes from the authentication of the UFRJ registry, with basic identification information which, in addition to ensuring that the user is an active member of the academic community, also allows the mirroring of some data from the original registry to the profile such as: name, category UFRJ, and course (in case of a student user). This information cannot be changed from within the system, so as to ensure the accuracy of profiles and therefore improving the security of the system for its users. Other data are informed by the user to complete the app registration: e-mail, contact phone number and neighborhood of origin. If the user wants to be able to give rides, then he or she must register also as a driver, and provide the car information, so it can be shared with users who are on the same ride.

The database also stores all the information about the rides: if they are to or from UFRJ, origin, destination, date, time, number of available places, reference points and route. Working with the logic of the Trip Generation Hubs (TGH), the Caronaê works for both inbound and outbound trips from a given institution, in this case UFRJ. On inbound trips, the destination is always a hub of a UFRJ campus, and the origin is always a neighborhood in one of the zones of the city. On outbound trips, the opposite occurs.

3.4 User profile

In December 2018 the Caronaê had 13,635 users with full registration - that is, those who, after accessing and authenticating the profile via UFRJ Intranet, filled in the additional contact information and, when applicable, car info. For the analyses performed here, we consider as active users in the system only those users with full registration.

Of these users, 94% are undergraduate or graduate students. The total number of academic staff (Professors + Administrative Technicians) is only 6%, totaling 677 users. It is a very low proportion, considering that, according to the UFRJ 2020 Master Plan, faculty staff represents 20% of the total academic community.

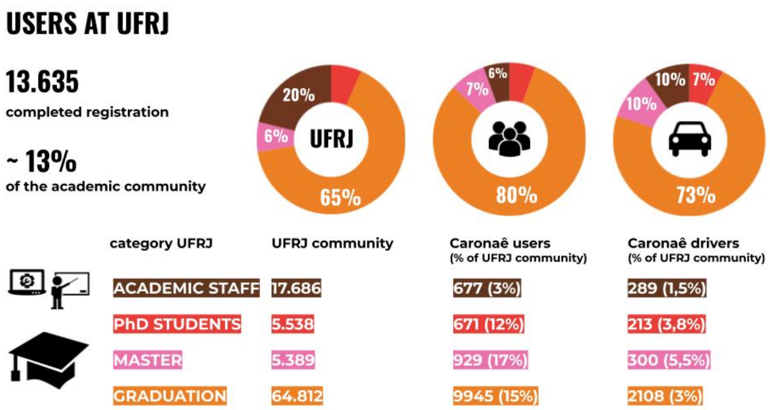

Fig. 3: Users and drivers with complete registration. Source: Authors, 2019.

As previously stated all users are considered potential riders within the system, and those who self-declare as drivers in the registration form can also offer rides. Ideally, with a good offer of rides, a driver can choose to take a ride instead of offering one, leaving his or her car at home. There are 3,094 registered drivers in the system, which represents 22% of all fully registered users. Students represent a total of approximately 90% of the drivers, and the academic staff, 10% - implying the latter tend slightly more to be drivers than riders, when using the system.

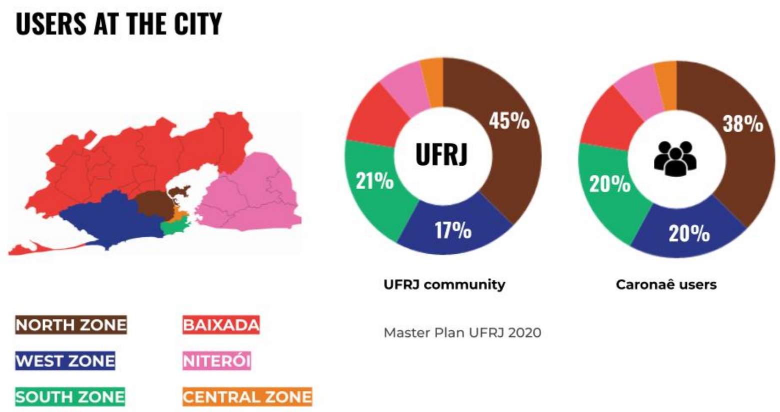

Fig. 4: User distribution throughout the city. Source: Authors, 2019.

The geographic distribution of users throughout the city can be analyzed through the home neighborhood users declare when filling the registration form. Each neighborhood belongs to a zone, that is, a region in the city as defined according to the second level division of the Master Plan UFRJ 2020 (Universidade Federal do Rio de Janeiro, 2011, p. 34), which echoes the official division of zones made by the administration of the city of Rio de Janeiro: North Zone, South Zone, Center, West Zone, Baixada and Niterói region. The region with the highest number of users is the North Zone, with a total of 4621 users, 1027 of which are drivers. In fact, one of its neighborhoods, Tijuca, concentrates alone approximately 7.5% of the total users. The West Zone and the South Zone are practically tied in second place, with only 9 users of difference. On the other hand, as shown in figure 4, the distribution is reasonably similar to that of the UFRJ community.

3.5 Space-time distribution of rides

The registered rides are categorized as *offered* and *completed*. The latter are all rides offered in the system that have received at least one request and have been completed. Every completed ride, therefore, is also an offered ride, but not every offered ride was necessarily completed. A ride can only be completed if it has received at least one accepted request. By December 2018 more than 50,000 rides had been offered and 5,700 (12.5%) had been completed. For most of the analyses performed here we will take into account only the rides actually completed.

To facilitate the organization of the offers in the application the neighborhoods and cities were grouped and advertised in the system by their zones. The decision to use this division as primary filter (instead of the neighborhoods, for example) is justified by the difficulty of getting transportation to leave the University City: quite often a ride that takes one to the desired city zone is considered good enough even if does not get the person to the neighborhood. It is also worth mentioning that Rio's road layout generates many coincidences in trajectories to destinations in the same zones – or even from zone to zone. The separation by zones therefore promotes an initial screening of the demands/offers of rides.

The North Zone has the largest number of rides offered, totaling 16,778, 9,690 inbound and 7,088 outbound. The South Zone comes next, with 12,149 rides offered in total, 6,844 inbound and 5,305 outbound. In figure 5, we have the percentage distribution between the rides offered and rides completed by zone and center, both discriminated by whether they are coming to and returning from the University City. When compared to figure 7, it is interesting to note that, although there are more rides offered on the way out than on the way back, the absolute number of completed rides is approximately the same in both situations - which makes a ride more likely to be completed when outbound from UFRJ than inbound, for most areas of the city. We speculate it is probably easier to schedule rides within a TGH, as it concentrates the demand for travel in a specific location, in this case reinforced by the presence of physical meeting points.

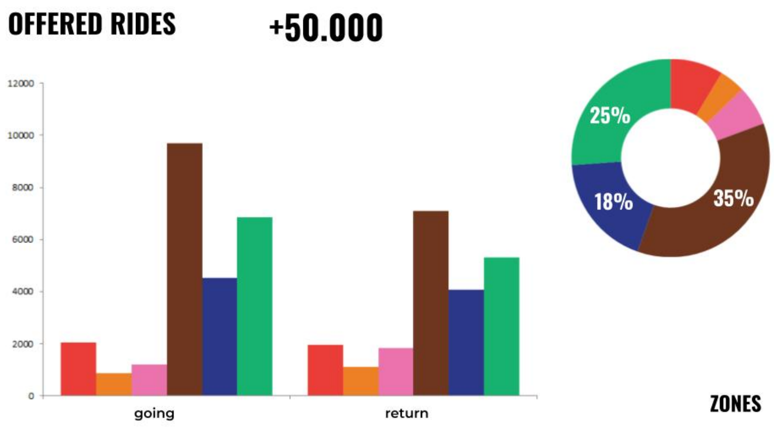

Fig. 5: Rides offered by city zones. Source: Authors, 2019.

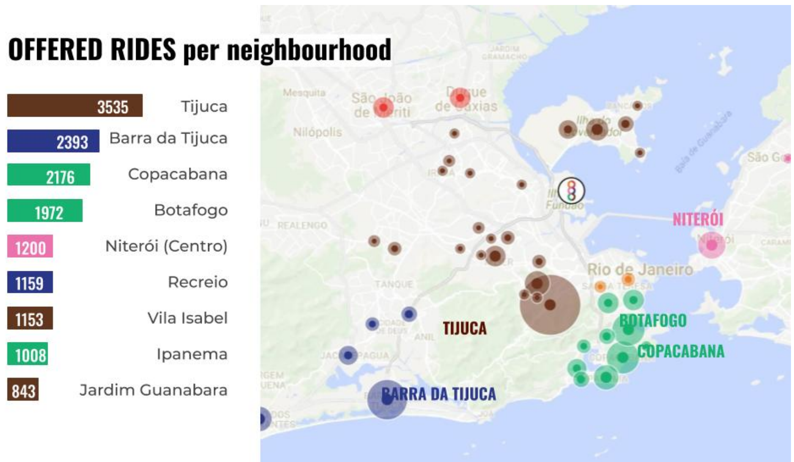

Fig. 6: Rides offered by city neighborhood. Source: Authors, 2019.

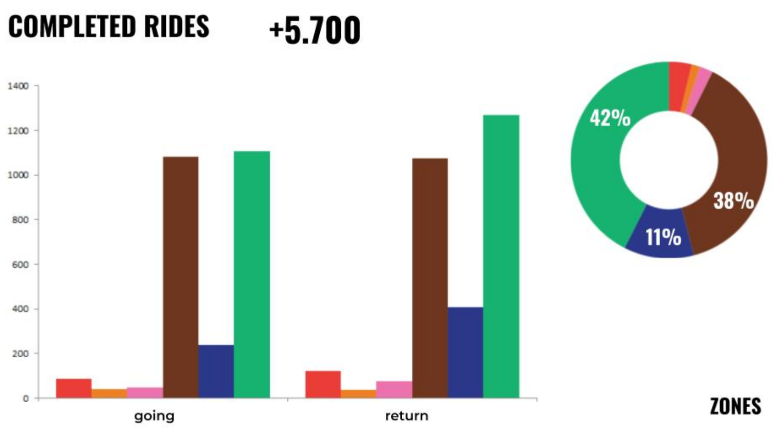

Fig. 7: Complete rides by city zones. Source: Authors, 2019.

Figure 8 shows that the South Zone is the area of the city that has the highest number of completed rides, with 19.5% completed rides, against 12.8% in the North Zone. That is, although the number of rides offered in the North Zone is higher, it has fewer completed rides.

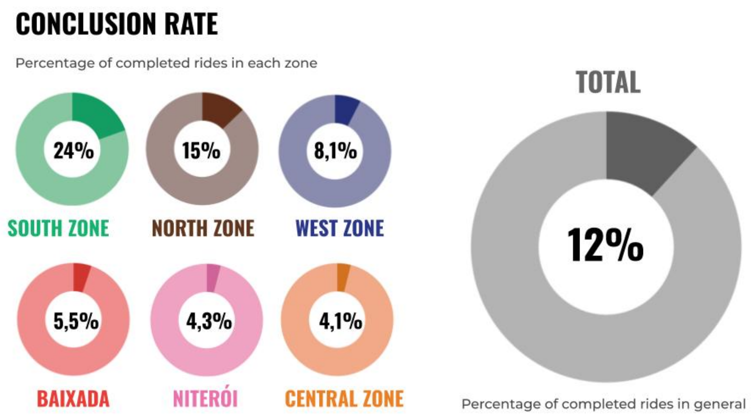

Fig. 8: Conclusion rate of rides by city zones and in general. Source: Authors, 2019.

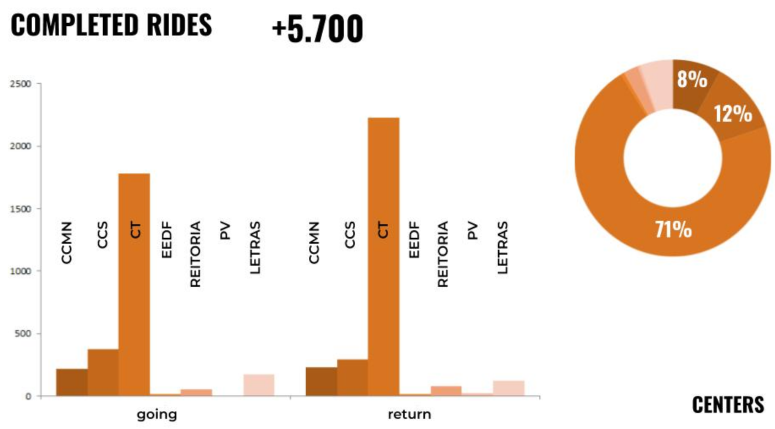

Fig. 9: Rides offered per university centers. Source: Authors, 2019.

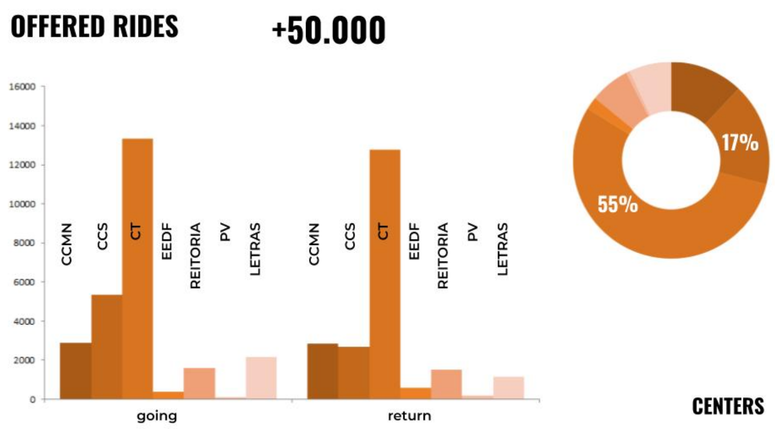

Fig. 10: Rides completed per university centers. Source: Authors, 2019.

As the analyzed TGH in this case is a university, the rides take place mainly on weekdays, at peak arrival and departure times from the *campi*, depending on the class schedule. This time schedule coincides with the peak traffic time in Rio, reinforcing the importance of the system to help mitigate traffic volume.

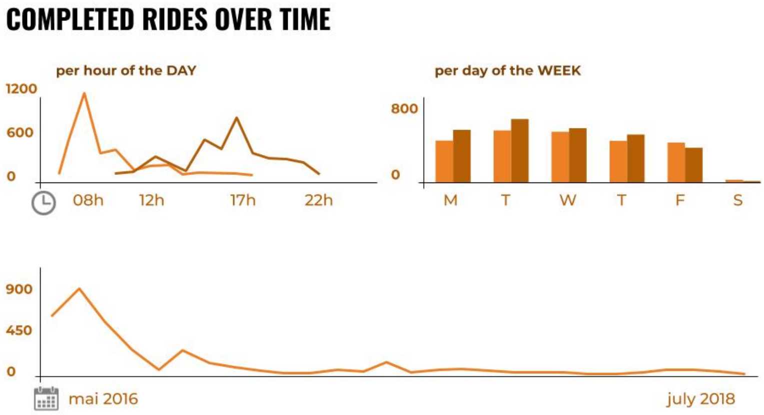

Fig. 11: Average number of rides completed per time of the day, day of the week and per month. Source: Authors, 2019.

More than half of all rides completed (61%) have only one rider (in addition to the driver). On the other hand, full 5 seat rides, with four riders and one driver, represent only 2.7% of the total. This data shows us that it is important to encourage an increase in this occupation, so that more trips can be used efficiently. As it is, however, the average occupancy rate of cars on completed rides is 2.53 when outbound and 2.56 when inbound. If compared to the 1.4 people per car average occupancy rate of cars in large Brazilian cities (CET-SP, 2011), we have that the Caronaê already does have an effect in improving ride sharing by the more efficient occupation of idle seats, rationalizing the use of private automobiles.

An effective improvement in urban mobility, in turn, is promoted by a ridesharing system when a driver decides to leave the car at home and take a ride, reducing the number of cars on the streets and, consequently, reducing the emission of pollutants and allowing better use of the roads. In this sense, one of the most significant data provided by the system is the number of times a registered driver has taken a ride, because it implies one less car in the streets. This has happened 908 times; in previous studies (Teixeira *et al.*, 2018), it was estimated that this corresponds to 2982 kg of CO2 not emitted into the atmosphere.

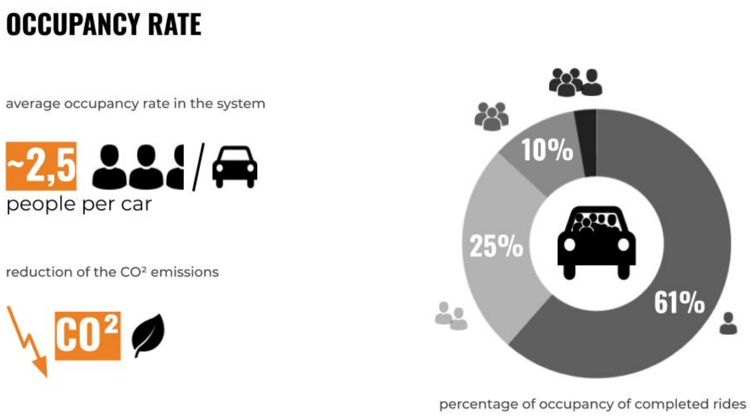

Fig. 12: Average occupancy rate of rides and occupancy percentage of completed rides. Source: Authors, 2019.

Despite the good results of the project from the point of view of urban mobility, with the reduction in the number of trips and emission of pollutants, the use of the system decreased significantly over the months since it started. One of the main downturns happened just a few months after its launch. It can be explained by technical problems encountered at the beginning of the project, such as the instability of the university servers and the lack of funding and staff - at first, it was not clear how the project would be maintained within the administrative structure of UFRJ, and it was also difficult to keep a dedicated stable team for the project. Whether for technical and material issues, or for political and administrative reasons, it stresses the importance of institutional support for projects of this nature.

On the other hand, the first version of the system still needed a number of modifications, and it is possible to observe an increase in usage during the first half of 2017, when those initial bugs were corrected, a permanent team was formed and the application was relaunched. However, a new problem with the server did not allow proper operation in the second half of 2017, causing a further drop in users. The rapid success, followed by the rapid abandonment, illustrates the need for testing, distribution and scalability strategies that allows problems to be fixed with minimal interruptions. Since then, mainly due to the lack of financial support, it has been difficult to gather a permanent team for the project, either to deal with the technical aspects of the system or to its management and publicity tasks. Hence, in spite the good performance of the actual application in 2018 and 2019, the system remains largely underused by the end of 2019. Since a good number of As most potential users are students, it is necessary to consider that there is a high turnover of users, which requires continuous half-yearly efforts of presentation and dissemination of the system to capture this new audience and foster the culture of use of the application. The team often discussed the possible gamification of the system, with some form of ranking or classification that would strengthen user engagement, but the initiative remains on its early draft stages.

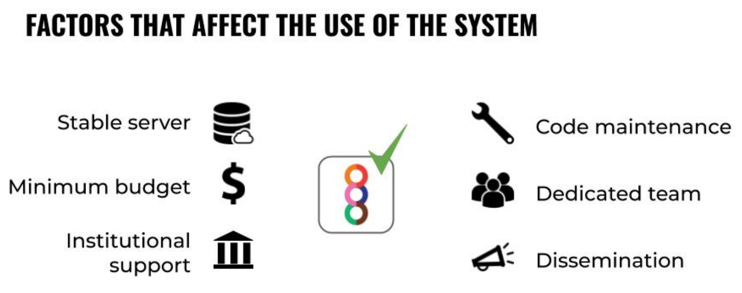

Fig. 13: Factors that affect the use of the system. Source: Authors, 2019.

4 Conclusions

During this research, it was possible to observe numerous changes triggered by the expansion of network communication in contemporary urban life. From new urban models to the proliferation of mobile applications, we sought to understand the relationships that emerge from the increasingly ubiquitous presence of socio-technical infocommunicational devices in the urban environment. From the organization of work to social relations, including the processes of production of subjectivities, the various dimensions of human sociability are transformed by ICT with unprecedented speed and intensity. Evidently, the spatial experience in the metropolis does not dissociate itself from the mentioned phenomena, being so intertwined that it no longer makes sense to think of urban space as independent from virtual space. Space, sociability and information and communication technologies become, thus, inseparable, forming hybrid spatialities and net localities (de Souza e Silva, 2006, 2013).

At the same time, we realize that these processes are inserted in a socio-political context that offers, on the one hand, hegemonic, functionalist and deterministic views to be replicated in cities, under the discourse of intelligence and efficiency. On the other hand, they also enable alternatives to flourish, with new concepts and ways of thinking about urbanism emerging as a response to the various challenges facing contemporary cities. From smart cities to open source urbanism (Sassen, 2011; Sá, 2014), these alternatives seek to improve the lives of city dwellers through digital tools; their study helps us glimpse ways to build not an intelligent model city, but an urbanism focused on an intelligent – and adaptable – citizenship.

The advent of the smartphone and its enormous popularization is one of the most powerful tools of transformation within this process. The continuous proliferation of mobile apps that operate in the urban environment is one of the main reasons that justify this research. We have seen that urban mobility is one of the main challenges for large cities today and that several digital platforms have emerged that operate in this field. Its comparative study made it possible to understand its most diverse applications and how they interfere in mobility, creating or not more favorable conditions for the development of the paradigm of sustainable mobility (Boareto, 2003).

The realization of this research also led to some conclusions that subside the development of new functionalities for the improvement of the analyzed system. We identified, for example, fields that could be included in the user profiles to enable more detailed analysis on the dynamics of rides. Here, it is interesting to reflect on the perception of the database as a form of expression, in which the organization of information interferes in the narrative to be presented. The great challenge is to create a structure of records that allows exercising greater creativity on its manipulation, facilitating, especially to the researcher, the construction and analysis of data relationships (Paraizo, 2014).

The analysis of Caronaê's database, along with the reported experience in the conduction of the project helped us have a better understanding on how these apps operate socially, at least in the context of the University. One particular element is the importance of continually advertise the system for both newcomers and regular users, in order to keep the system alive in people's minds; and the need for testing and safe incremental updates that can be implemented without interruption of the service. The relatively low adoption of the system among faculty staff remains an item for further research – as regular workers of the place, they tend to use less formal means for schedule ridesharing. However, envisaging ways to foster ridesharing itself in this group is very important, as there are relatively more car owners among them.

As a main conclusion, we have that the Caronaê, an online mobile platform for ride sharing, created and maintained by graduate students, can also be understood as social technology within the environment of a public university. It also meets both falls within the paradigm of sustainable mobility, proposing more balanced and collaborative ways of thinking about the flow of daily commuting of a city. It can also be considered as an example of , and the notion of open source urbanism application, as a bottom-up solution developed as public open platform that was incorporated by the institution as a University Outreach Project. The team's efforts to institutionalize and open the code so far reinforce the public and collaborative nature of the project, as well as its potential for replicability, which expands its benefits in terms of sustainable urban mobility. The project demonstrates and reinforces that the construction of information in the contemporary city, where the fabric of social life is increasingly intertwined with digital networks, can and should be tensioned for the creation of more participatory, collaborative processes that articulate the production of knowledge, teaching and research, in the pursuit of solutions to various urban challenges.

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1 According to the Ibero-American Trip Generation Hubs Study Network, the TGHs are places or institutions of distinct nature, with size and scale capable of attracting a significant number of people and generating a large number of trips, that is, they concentrate a large amount of commuting. Available at: http://redpgv.coppe.ufrj.br/index.php/pt-BR/conceitos/o-que-e-um-pgv. Accessed on 18/10/2019

2 "The Green Development and Energy Fund for the University City of the Federal University of Rio de Janeiro receives funds from the ICMS tax exemption rate, charged by the Rio de Janeiro state government on the electricity bill of the University City campus - UFRJ, to invest in projects to improve mobility, energy efficiency, reduce water and waste consumption, and data monitoring and generation of indicators on the University City campus." (www.fundoverde.ufrj.br , own translation)

3 GitHub is a source code hosting platform. It allows programmers, utilities or any user registered in the platform to contribute to private and/or open source projects from anywhere in the world.

4 GNU General Public License is an open source software license that allows the distribution and modification of the original code. Available at: https://www.gnu.org/licenses/gpl-3.0.en.html. Accessed on 18/10/2019.