Analyzing the use of blockchain for managing loading zones for urban distribution

Análisis del uso de blockchain para la gestión de zonas de cargas para la distribución urbana

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Summary.- The lack of efficiency in the use of the on-street infrastructure dedicated to loading and unloading freight in the city, with their shortage and inefficient placement, generates congestion and delays during urban freight deliveries. An exploratory study is presented on the feasibility of incorporating technology into the management of dedicated loading/unloading areas for urban logistics in downtown Montevideo (Uruguay). After data of the neighborhood was collected, and the main stakeholder interest gathered, the paper analyzes a feasible technological solution to the problem, considering the restrictions posed by the stakeholders for sharing information. Due to the increasing influence of blockchain and its implementation for specific logistic problems, such as product traceability, the introduction of blockchain as part of the solution is considered and discussed in the system architecture.

Keywords: Blockchain; urban freight transport; loading/unloading areas; urban logistics.

Resumen.- *La falta de eficiencia en el uso de la infraestructura dedicada a la carga y descarga de carga en la ciudad, junto con su escasez y colocación ineficiente, genera congestión y retrasos en las entregas de carga urbana. Este estudio, presenta un estudio exploratorio sobre la viabilidad de incorporar tecnología en la gestión de áreas dedicadas de carga / descarga para logística urbana en el centro de Montevideo (Uruguay). Una vez recopilados los datos del barrio, y recogido el interés principal de los involucrados (stakeholders), este artículo analiza una solución tecnológica factible, considerando las restricciones impuestas por los actores para compartir información. Debido a la creciente influencia de blockchain y su implementación para problemas logísticos específicos, como la trazabilidad del producto, la introducción de blockchain es considerada como parte de la solución y se discute en la arquitectura del sistema.*

Palabras clave: *Blockchain; transporte de carga urbano, zona de carga/descarga, Logística urbana.*

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1. Introduction. - The growth of the world population has brought an increasing percentage of people living in urban centers, in developed as well as undeveloped countries. These highly densely populated areas generate an increase in commercial activity to meet the residents' needs, which enhances the complexity of freight transport needed to distribute and commercialize high volumes of products (Fransoo & Blanco, 2017). Therefore, urban freight becomes a key factor in city dynamics.
In particular, South America has reached 80% of urbanization, a percentage expected to keep growing shortly, causing new challenges for authorities and city logistic stakeholders. Poor planning of urban logistics directly affects regional development, reducing the competitiveness of supply chains. It also generates a negative impact on the quality of life of the citizens through increased risk of accidents, congestion, and noise pollution (Kelli et al., 2018). A consequence of this poor long-term planning is that the transport of consumer products must face the lack of freight-oriented infrastructure.
One example is the shortage of exclusive loading and unloading parking zones (LUPZ) for freight activity. These are zones by the sidewalk, usually identified with painted lines and signs, reserved for freight vehicles to carry out their loading and unloading maneuvers. The saturation of their capacity during peak hours forces trucks to park in double rows, on garage entries, and forbidden zones. Although vehicles are sometimes fined because of these practices, these action does not prevent them from continuing to commit the infractions, because parking far away from retailers (in allowed parking zones) implies loss of time while transporting the load by foot, and risks associated with not being able to keep the vehicle within sight.

One of the main problems faced by local authorities in determining the correct location and number of LUPZ, together with achieving efficient management of these areas. To address this problem, the use of Information and Communication Technologies (ICT) tools is suggested. Kijewska et al. (2018) define telematics systems as "spatially arranged physical information systems with dedicated functionality that, using communication capabilities, enable the recipient to provide designed services". Another problem faced by the government is the lack of empirical information describing the dynamics of urban freight distribution.

In order to present a primary solution for existing problems, the feasibility of incorporating a telematics solution for managing LUPZ is studied. Specifically, the utility and feasibility of using blockchain as a part of the solution are discussed. Moreover, a survey was designed and carried out based on the unified theory of acceptance and use of technology (UTAUT).
The novelty of this article is analysing the possible introduction of blockchain as part of a telematics solution for urban freight logistics. Blockchain has been used for traceability of chains of production and logistical networks involving various companies and means of transport (DHL and Accenture, 2018), but not for urban freight distribution or parking management.

In section 2, a literature review was developed, including the topics of freight parking, existing telematics solutions for managing LUPZ efficiently, and blockchain. Then, in section 3, the adopted methodology is presented. It is followed by the main results obtained from the research in section 4. The use of blockchain to manage LUPZ is discussed and analyzed, and a possible technological solution is presented, with blockchain as a part of the solution but not as its key component. Finally, in section 5, results are discussed, and conclusions are presented regarding future paths of research are drawn.

2. Literature Review. - 'The process for totally optimizing the logistics and transport activities by private companies, with the support of advanced information systems, in urban areas, while considering the traffic environment, the traffic congestion and energy consumption within the framework of a market economy is defined by Taniguchi, Thompson, Yamada and Van Duin (2001) as city logistics. This definition outlines the importance of using advanced information systems as a key support tool to manage city logistics.

From the various problems associated with the complexity of managing city logistics, various studies have identified parking as a key issue within urban freight distribution (ASCE, 1989; Han et. Al., 2005; Manzano dos Santos and Sánchez-Díaz, 2016). Malik, Sánchez-Díaz, Tiwari & Woxenius (2017) carried out a summary of existing studies related to the problem of urban freight parking, classifying them into three categories: those which analyze and quantify the problem, those which propose parking supply and demand simulation models, and those which offer information about public policies to deal with the problem.

2.1. Technological Solutions. - Numerous papers suggest the correct regulatory policy to manage loading zones, but few studies refer to concrete technological innovations conducted by local authorities (Comi, Schiraldi & Buttarazzi, 2018). For example, Muñuzuri, Cortés, Guadix & Onieva (2012) establish that a suitable way for improving the management of LUPZ would be a web application through which freight operators can ensure the availability of a freeloading zone at a given hour. The system would guarantee an adequate rotation of vehicles in the loading zones, avoiding long stays by freight vehicles. The authors mention the use of plate recognition systems to detect infractions such as exceeding the allowed time of use for the zone.

A case of successful implementation of this sort of solution was a pilot test performed in Seville (Spain), where a loading zone booking web application was developed. These systems are feasible in urban areas if there exists regulation that prevents vehicles from parking illegally close to their final destination (Muñuzuri, Larrañeta, Ibáñez & Montero, 2006). A year later, another similar pilot study was carried out in Lugano (Switzerland) with positive results (Stickel & Furmans, 2005).
Similarly, McLeod & Cherret (2011) modeled a loading zone pre-booking system for Winchester (England). They observed that the system helped to distribute the hours of peak demand more evenly, reducing the maximum number of heavy vehicles operating in the area simultaneously. On the other hand, they concluded that a potential disadvantage of a pre-booking system is the uncertainty of whether truck drivers can reach the reserved zones on time. For instance, in case of an externality that affects the whole network (like a traffic accident), the system would collapse. Therefore, a pre-booking system could lack the required flexibility to deal with dynamic situations. Studies by Berenguer, Da Silva, and Balassiano (2004) and Comi et al. (2017), also propose different alternative architectures for a loading zone management system.

Widening the range of study, Perry, Oberhart & Wagner (2015) establish that truck parking management policies (not distinguishing between urban and route) have mainly focused on increasing the number of loading zones, improving the access to information regarding the availability of free zones, and working together with the private sector. Technologies used to detect free zones in the USA and Europe are diverse, including cameras, magnetic, induction, thermal, and infrared sensors, among others. To communicate with the users, variable message signs (VMS) are mainly used, although there also exists communication through web apps, cellphone, radio, and pre-booking systems[6].

[6] The information presented by Perry, Oberhart and Wagner (2015) refers to highway parking. However, it is considered relevant to the problem of urban parking because they share common characteristics.

The latest research found in the literature regarding telematic tools for LUPZ management was by Comi, Schiraldi & Buttarazzi (2018), who merged route planning and LUPZ management by designing a telematic tool prototype that suggests a delivery path and schedule, considering real-time information, and books the required delivery areas for the distribution operation.

2.2. Blockchain. - Blockchain is a type of decentralized ledger with a consensus protocol that allows different participants to share information without needing to trust each other. It was initially theorized in 1991 and implemented for the first time in 2008. Since then, its popularity has grown and it has been implemented for diverse areas worldwide, taking advantage of its potential to solve a wide variety of problems. In the context of financial transactions, blockchain eliminates the need to rely on intermediary institutions such as banks and guarantees the fulfilment of previously established rules through Smart Contracts (Allende, 2017).
Blockchain ledges present specific advantages compared to traditional databases. The information becomes inalterable once it is written in a block. Modifying an existing block would require such a great amount of computational power that it becomes virtually impossible. This is probably the most important characteristic of blockchain, which allows users who do not necessarily trust each other to hold a distributed database and share information without the need for a trusted third party. Smart Contracts also allow the automatized fulfilment of previously agreed terms and conditions for every transaction. According to ISO standards, blockchain ledged can be permissionless public, permissioned private, or permissioned public depending on the degree of decentralization and the existence of nodes which different hierarchies (Allende, 2021).

A report by DHL and Accenture (2018) mentions cases of application in the medical sector, in the creation of digital identities for people without documentation, in the energy industry, and the fabrication and management of car parts. It also refers to its possible application to manage registers and documentation in logistic chains, improving their transparency, efficiency, and traceability. Furthermore, the report mentions smart contracts as valuable tools for automatizing commercial processes, together with IoT (internet of things) technology.
Löf (2017) states that blockchain is beneficial when the intention to keep a database or transfer property exists between different entities who do not trust each other, without a central authority who governs the process. He also refers to it being favourable “if the data benefits from a chronological timeline and is allowed to be public to all participants of the blockchain". On the other hand, he establishes that “it is important to understand the limited domain where the technology adds value”, and that “blockchain technology is not beneficial for many of the usage areas proposed in the blockchain sphere”.

Regarding the limited usefulness of blockchain technology, Wüst & Gervais (2017) created a decision tree to determine whether blockchain is the appropriate technological solution for a given problem. According to the authors, the use of blockchain is only justified if all the following conditions are met:

A) There is a need to store data representing the state of a system. Otherwise, no database is required, and a blockchain is a form of a database.

B) There are multiple writers of the database. If only one exists, “a blockchain does not provide additional guarantees and a regular database is better suited because it provides better performance […]” (Wurst & Gervais, 2017).

C) There is not an always online trusted third party (TTP). That is a person or entity with access to the database who is trusted by all participants. “If the TTP is always online, write operations can be delegated to it and it can function as a verifier for state transactions”.

D) Not all writers are known and trusted. If there exists mutual trust between the participants of the database, “a database with shared access is likely the best solution”.

Although blockchain has become increasingly popular across different areas of activity, its usefulness depends on the problem being tackled and should not be assumed without a proper evaluation.

3. Methodology. - The main objective of this study is to analyze the feasibility of incorporating a technological solution that includes blockchain for managing LUPZ in downtown Montevideo (capital city of Uruguay). To achieve this, three research questions were formulated:

- H1: Can blockchain be incorporated as part of the solution?
- H2: Does blockchain add value to the solution?
- H3: To which extent does the reluctance to share information affect the implementation of a solution for managing loading and unloading parking zones?

To give answers to these questions, as a first phase, a bibliographic review was carried out. Based on Ballantyne et al. (2013), the main stakeholders and actors involved in freight transport were identified and later confirmed through surveys and interviews. The research showed the following results about the situation of the different actors involved.

Shippers (senders of goods), shop owners, freight transport companies, and authorities were determined as the main relevant actors for this paper. The interaction between these different groups determines urban freight activity. To optimise freight distribution in cities, the contribution of these actors to the final solution proposed is fundamental.

As a second phase, seeking the development of an integrated solution, the different actors involved were included in the research through the following three activities:

- A workshop with managers and owners of freight transport companies, trade unions, and municipal authorities' representatives was conducted with the help of an international expert researcher in urban freight logistics. The goal of the workshop was to encourage cooperation between the different sectors and contribute ideas towards possible technological solutions for problems caused by urban delivery.
- Surveys aimed at haulers were carried out. The questions were designed based on the unified theory of acceptance and use of technology (UTAUT) and using the questions proposed in Venkatesh et. Al. (2003) as a guide. The goal was to measure the potential users' intention to embrace a technological solution for managing freight loading and unloading in the area, as well as obtaining their points of view of the issue. The UTAUT determines four main constructs which predict user acceptance of new technology; these are performance expectancy, effort expectancy, social influence, and facilitating conditions (Venkatesh, Morris, Hall, Davis, & Davis, 2003). A total of 25 answers were obtained from managers, logistics directors and drivers, and urban truck owners.
- Surveys to shop owners and employees from the neighborhood were carried out also using the UTAUT model, to determine their acceptance of the use of a technological solution for freight transport problems. In this case, 57 surveys were carried out. This number of surveys was limited to the hours that the team spent on the street visiting shops and to the fact that not everyone accepted to collaborate and answer the questions.
- An interview with representatives from the city's municipal government, to obtain their view and evaluation of the problem was conducted.

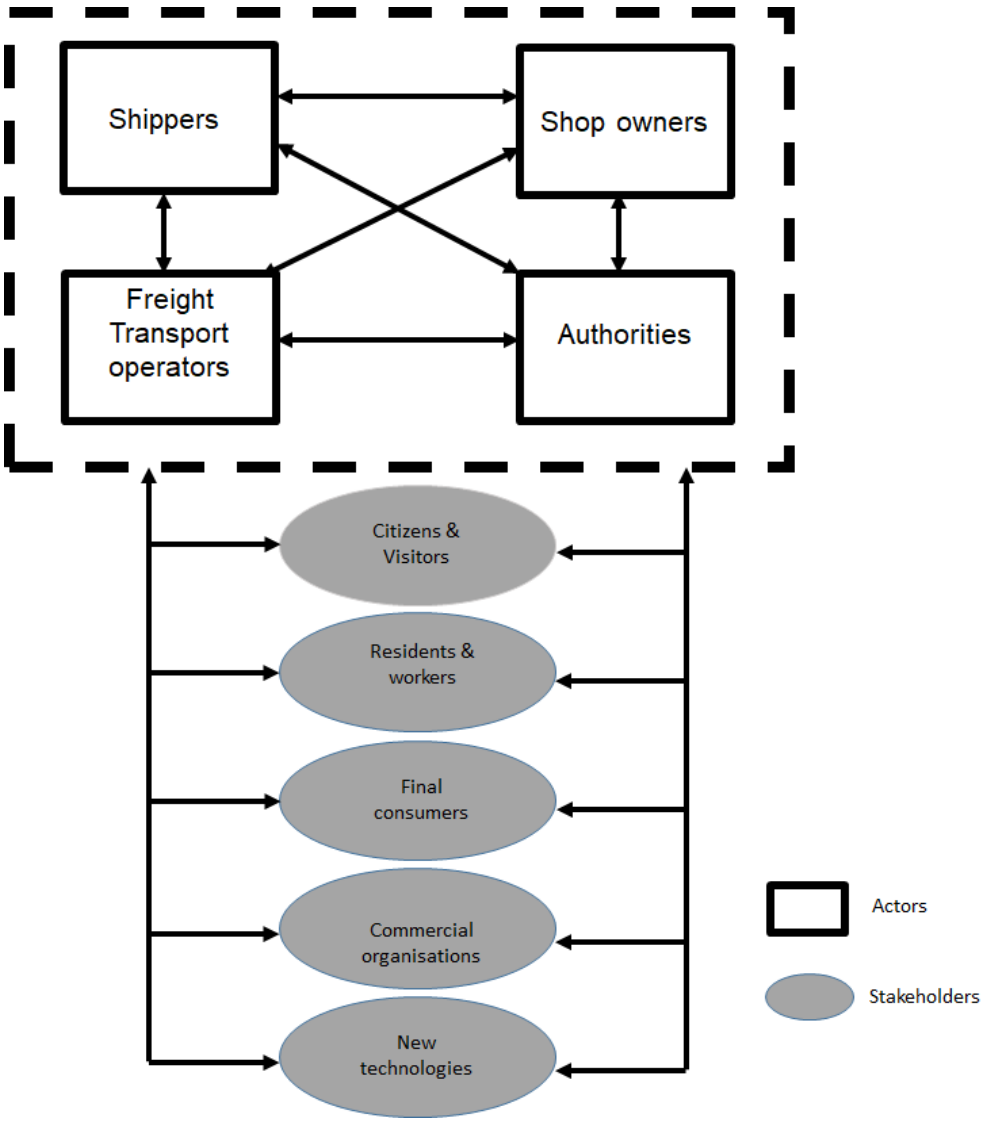

Figure 1. Urban freight stakeholders and actors. Adapted from Ballantyne et al. (2013).

The third phase of this research included a field study for determining the quantity and location of existing LUPZ in the neighbourhood. The register of the necessary data obtained from the field study was carried out using Fulcrum® app. Information about the location (coordinates), size, orientation, and main characteristics of the LUPZ were gathered. The information was displayed using Power BI ®.

Figure 2. Location of public loading and unloading areas in downtown Montevideo (powered by Fulcrum® and Power Bi®).

Finally, the fourth phase in this research included a study on the feasibility of including blockchain for the proposed telematics solution in order to evaluate if a blockchain with shared access was the best solution for the identified problem. For this purpose, interviews with three Uruguayan blockchain experts were carried out.

3.1. Downtown Montevideo. - Downtown Montevideo (Ciudad Vieja) is a neighborhood distinguished for its historical relevance. It presents relevant characteristics for the investigation. First, in this part of the city, the streets are narrow, most of them with just one lane of circulation. Also, it has specific pedestrian and automobile restrictions to favor tourism. For example, the entry of specific large cargo vehicles is prohibited. Moreover, it contains a high number of businesses and companies, which demand large volumes of freight delivery over a small geographical area (around 1 km^2), and some of these entities have private parking zones to develop their activities.

Moreover, the distribution of the public LUPZ was not properly planned, and they were situated randomly. According to local authorities, there was no previous research done about the correct methodology to determine the proper number and location of the LUPZ. Relevant parameters such as the location and concentration of retailers were not taken into consideration.

In downtown Montevideo, there are 390 shops and restaurants that receive commodities once or more times per day, on average. These businesses are normally of small size and they have limited places to store products. These results were obtained from field research carried out during this investigation.

4. Results. –

4.1. Involvement of Actors. - According to the first phase, the literature review was performed to generate the research framework. In the second phase, as mentioned, the different stakeholders and actors were involved during the research through different activities. Through interviews with five private logistic managers, their views concerning the problems related to urban distribution occurring in downtown Montevideo were obtained. The main identified problems were:

- Traffic jams caused by the congestion of freight and private vehicles.
- LUPZ not being enough.
- The time designated for the use of a LUPZ not being enough.
- Lack of control by authorities.
- Private vehicles often occupying LUPZ.

During these interviews, private managers reported that a telematics solution that provides the opportunity to pre-reserve loading zones would not offer much utility, because it would require high levels of coordination between shops and transport operators. As most of them are small shops and often do not possess adequate technological devices, this is a restriction for efficient coordination. On the other hand, a mobile app or a webpage that shows the live availability of LUPZ could help optimise freight distribution times and reduce traffic, as it would allow the transport operators to modify their route according to the loading zones that are available in a dynamic way, thus making better-informed decisions. The telematics system would need to be compatible with the routing programs used today by some freight companies.

As to the workshop conducted, this experience allowed an opportunity to generate an open discussion space between the public and private sectors and to present the different perspectives of the problem. Some remarkable points of view about the introduction of technology for the management of LUPZ emerged in this instance. For example, the private sector expressed being willing to share information to an authority or a mediator that manages the information if confidentiality is ensured, and it is only used for the optimization of urban distribution logistics. Moreover, the proposed solution would need to be flexible and adaptable to future demand volume shifts.
An interesting opinion obtained in the workshop was that, before the enforcement of a telematics solution, it is necessary to study the location and the assigned time of use of the existing LUPZ in the city where it is going to be implemented, as well as the main sources of demand. Quantifying the problem is essential to identify the origin of traffic jams and externalities caused by inefficient freight activity.

Another point to take into consideration is a survey oriented to haulers about the acceptance of new technologies. The questions of the survey were based on the UTAUT model. Although the model has not yet been validated specifically for the management of LUPZ, it is expected to predict reasonably well the acceptance of this kind of technology. The survey showed that the 4 constructs included in the UTAUT model were evaluated positively. Out of 5 points as the maximum, 3.9 was the minimum value obtained. Moreover, almost all questions included in the questionnaire scored above the mean value (3).

Taking into consideration the perspective and knowledge of the different actors and stakeholders, the solution should involve an app that registers the usage of the LUPZ. This information allows users to know whether the LUPZ is available or not apart from giving the authorities valuable information about the usage of these areas. Information such as frequency and rush hours of usage

can help to manage the location and quantity of these areas in a more efficient way. As described in the third phase of the methodology, the LUPZ were identified and described.

UTAUT	Question	Result	UTAUT variable result
Performance Expectancy	The APP would help me find a loading and unloading area faster	4.3	**4.1**
	The APP would reduce risks while unloading	3.7	
	The APP would reduce the irregular parking situations (double row parking, parking in unassigned areas, etc)	4.3	
Social Influence	The company where I work encourages de use of new technology	4.2	**3.9**
	I would be willing to use new technology if the company where I work requires it	3.9	
	My co-worker's opinion affects my decision towards using the APP	3.7	
Effort expectancy	I periodically use mobile applications	4.6	**4.1**
	I periodically use the computer	4.0	
	I usually learn to use a new program or application easily	4.7	
	Using the application during working hours would not be a distraction	2.9	
	Learning how to use de application would require a short period of training time.	4.2	
Facilitating Conditions	I have good access to the internet in the place I work	4.3	**4.1**
	The company where I work has specialized staff to help me with the application	3.8	
	The company where I work supplies me with the technological devices, I need to complete my tasks	4.2	
	The application would be compatible with the actual programs the company uses	3.9	

Table 1. Survey results.

4.2. Proposed Solution. - To start with, the telematic tool must provide a way of detecting the live occupation of the LUPZ. This would provide users information about the availability of LUPZ, allowing them to make better-informed route choices. A first method would be freight transporters validating their use by SMS when they stop in a LUPZ. Its principal advantage is the easy and quick implementation, as it is a technology that is already being used in the country for managing private vehicle parking zones. Another option is using sensors or cameras that automatically detect if the LUPZ is available or not. In both cases, this information could be later used to measure to which extent the areas cover the demand and whether they are placed inefficient locations.

Moreover, it would be interesting that, through a mobile application or web page, users could access information about location, schedule, size, and vehicles authorized for the LUPZ apart from their availability.

Furthermore, another way of managing LUPZ more effectively is authorities improving their control over them. In many cases, unauthorized vehicles use the areas. It would be useful if the system controlled the vehicles that park on LUPZ. Besides, it might also be of interest to control whether the trucks and vehicles that use LUPZ have the corresponding authorization to enter downtown, have paid their taxes and circulation fees, and other related regulatory verifications.

In order to save all this information, a registry is needed. This database should be actualized automatically in case the technology used makes it possible, or manually actualized if the stakeholders involved cooperate to send and validate the information required. The following figure visually covers the mentioned points.

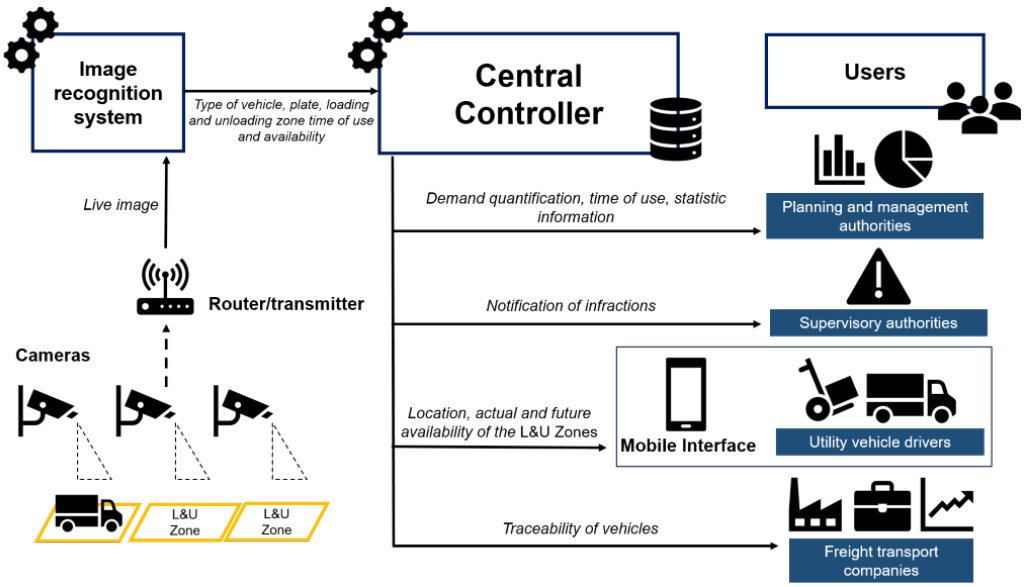

Figure 3. Proposed solution diagram.

For the management of the areas, there are two different options. The first one involves users booking LUPZ in advance (pre-booking). The transport companies would have to plan their distribution routes according to the schedules of the areas. The second option is to book only when the truck arrives at the LUPZ.

During interviews and discussion instances, freight companies and authorities ruled out pre-booking. Principally this was because of the continuous delays and reschedules that occur during distribution. This makes it very difficult to comply with strict and unalterable routes. If this type of system was implemented, it would need a high degree of coordination between the merchants and the drivers of the trucks. In the case of the second option, the reschedules would not be a problem. This system would enable the users to modify their routes in case one nearby LUPZ becomes available, thus providing better flexibility.

The platform for the users could be a mobile app or a web page that enables them to access different information. To start with, it would show a map of the downtown with all the LUPZ and its availability. For example, a green area is a freeloading zone while a red area is occupied. If pre-booking is used, it would have to include a timetable with the hour hand of every LUPZ, showing when it is available or occupied. In this timetable, each user can reserve a period to use the LUPZ. Different types of users for the different stakeholders and actors may be necessary. For example, a type of user for senders of goods and freight transport operators and a different type of user for authorities. While the first ones should have access to information such as hours and quantity of areas used by their company's trucks the authorities may need information about where and when someone committed a traffic offense.

4.3. Blockchain. - In the fourth phase of the methodology, the possibility of including blockchain in the aforementioned technological solution applied to the management of LUPZ was evaluated through interviews with three Uruguayan experts in the blockchain field.

The three of them argued that it would be reasonable to use a permissioned private blockchain. This type of blockchain consists of a central group of entities that deploy, run, and maintain all nodes. In that way, individual peers are given permission to participate in the blockchain's read or write operations. These kinds of networks are generally developed and maintained by a blockchain service provider. Moreover, permissioned private networks are not decentralized nor transparent, and the scalability is very limited, they are usually designed for a single use case or application. (Allende, 2021).

Therefore, data such as the place, date, and identifier of the video recordings made by the camera system could be saved in a blockchain. The video files per se should still be stored inside a physical server, as blocks cannot hold such big chunks of information.

Any conflict which arises due to the lack of trust between users and authorities could be solved by looking for the information in the blockchain. For example, if a private vehicle owner is fined for parking on a LUPZ and requests proof, arguing that the sanction was wrongly imposed, the blockchain holds the inalterable information which can trace the sanction back to the corresponding video file, with its date and location. This constitutes indisputable proof; thus, the complaint can be settled.

If a traditional database was used for this purpose, the veracity of the information could not be completely guaranteed (consider the case of a malignant writer who manipulates the data stored in the database). According to one of the experts interviewed, this type of complaint is very usual, especially regarding fines for excess speed controlled by cameras and radars.

According to the proposed solution, the following system architecture was developed. As it is shown, cameras would record the LUPZ activity. Then, the image is processed and, together with a plate recognition system, information of when, where, and who used the areas is stored. To access this data, there are two important aspects to consider. Firstly, the recordings of the cameras would be saved in a database such as MySQL. In order to make these recordings confidential and inalterable blockchain would be part of the solution. As previously mentioned, the place, date, identity code, and other important information of the recordings made by the different cameras would be saved in a blockchain. All the access to this data is controlled by the business logic which manages the exchange of information. The estimated cost of the project is USD 10000 per LUPZ, including installation of hardware and software, added to 500 USD per month for maintenance.

4.4. System Architecture. –

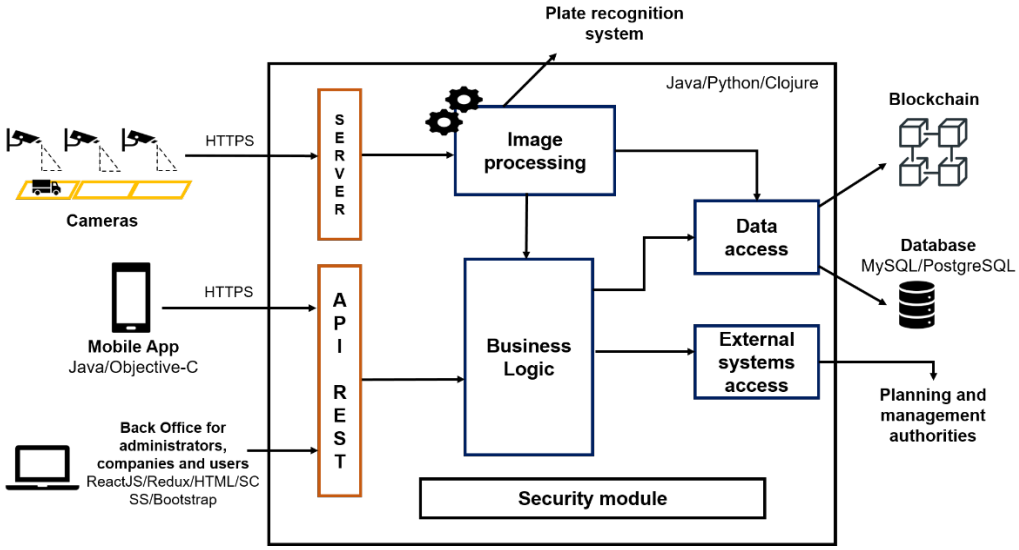

Figure 4. System architecture.

5. Discussion and Conclusion. - In the following section, the results of the investigation are discussed considering to which extent the research questions were answered. Moreover, the limitations of the study are presented together with future needed research.

Results during research showed that shop owners are not necessarily concerned about freight transport problems, which contradicts what is stated by Ballantyne et al. (2013). This attitude is mainly explained by the fact that they are not directly affected by the timing of inefficiencies if the goods are delivered. However, it must be noted that they are probably affected indirectly, as traffic jams and congestions make the neighbourhood less attractive for potential consumers.

Moreover, the problems identified during research are in accordance with what the local authority had previously established, as well as the negative consequences of urban freight distribution mentioned in the literature. Additionally, as established by Malik, Sánchez-Díaz, Tiwari & Woxenius (2017), parking was identified as a key issue within urban freight distribution.

Regarding the hypothesis of to which extent does the reluctance to share information affect the implementation of a solution for managing the LUPZ, results showed that managers and owners of transportation companies are willing to share part of their operational information with a trusted third party (TTP) if it was necessary to develop an information system which improves the dynamics of urban distribution. This TTP could be the local authorities or a private agent who manages the system. The security of the data could be guaranteed via a contract that prohibits the TTP from selling or distributing the shared information. This system may not be enough for countries or cities where businesses trust the government to a lesser extent.

Besides, the applied UTAUT model confirmed that a technological solution for managing the loading and unloading zones would be well accepted by freight transport operators, which are relevant stakeholders of the problem and final users of the system.

The proposed solution would enable haulers to optimize their tasks. By knowing the availability of the LUPZ in the area they can modify their route towards the free zones which not only saves time but also reduces congestions and the consumption of fuel. Moreover, the information on the demand of the LUPZ would help authorities to control their quantity and location.

Regarding blockchain, the research concludes that it could only be useful in ensuring one specific function of the telematic system: the veracity of the information. In accordance with literature and opinions shared by the interviewed blockchain experts, the main and most important characteristics of blockchain regarding its possible implementation for logistical chains are the inalterability of information and chronological traceability. In conclusion, and related to the research questions formulated, blockchain can be incorporated as part of the solution adding value up to a certain extent, being useful especially for keeping a timestamp and ensuring the veracity of important information, e.g. time, place, and date in which a video was recorded, to avoid trust problems when the system provides proof of disobedience of loading zones' rules of use.

According to the four conditions established by Wüst & Gervais (2017) for determining whether blockchain is useful for a given problem, the problem discussed in this paper does not need blockchain, since the database would have only one writer (the municipal authority) which is generally trusted for being a governmental entity. It must be noted that the authors' methodology for answering the question "do you need blockchain?" is rather simplistic since it tries to answer a complex question through a few simple steps, and the presented research has shown that there could be some utility in incorporating blockchain to the telematics solution for managing LUPZ. The municipal authority could even be considered a non-trusted party in some cases.

Future research is needed to determine the freight transport demand of LUPZ. Together with this, a methodology for determining the optimum quantity and location of LUPZ for downtown Montevideo should be designed. This would enable local authorities to have a clear perspective of whether a change in their actual location can generate a positive impact in reducing traffic jams. Moreover, it helps the different stakeholders and actors to have a clearer scale of the problem.

In order to introduce the technological solution, the exact quantity, location, and conditions of the cameras relative to the loading zones should be studied. Apart from the telematics system, human supervision would be necessary to control unauthorized utilization of the LUPZ and deal with problems of the system, both hardware, and software.

One of the most important future challenges in developing the mobile application. It should acquire the functions mentioned in the proposed solution apart from future improvements.

6. References

[1] Allende, M. (2021). Blockchain - LACCHAIN FRAMEWORK FOR PERMISSIONED PUBLIC BLOCKCHAIN NETWORKS. IDB. Obtained from: https://publications.iadb.org/publications/english/document/LACChain-Framework-for-Permissioned-Public-Blockchain-Networks-From-Blockchain-Technology-to-Blockchain-Networks.pdf

[2] Ballantyne, E. E., Maria, L., & Wheiteing Anthony. (2013). A comparative study of urban freight transport planning: addressing stakeholder needs. Journal of Transport Geography. Obtenido de https://www.sciencedirect.com/science/article/pii/S0966692313001671

[3] Berenguer, M., Da Silva, L., & Balassiano, R. (2004). Intelligent transportation systems and parking management: implementation potential in a Brazilian city. Cities, 21(2), 137-148. doi: https://doi.org/10.1016/j.cities.2004.01.001

[4] Comi, A., Buttarazzi, B., Schiraldi, M. (2018). Smart urban freight transport: tools for planning and optimising delivery operations. Simulation Modelling Practice and Theory, 88, 48-61.

DHL, & Accenture. (2018). Blockchain in Logistics - Perspectives on the upcoming impact of blockchain technology and use cases for the logistics industry. Retrieved from https://www.logistics.dhl/content/dam/dhl/global/core/documents/pdf/glo-core-blockchaintrend-report.pdf

[5] Fransoo, Jan C., Blanco, E. and Mejia-Argueta, C. (Eds.) (2017). Reaching 50 Million Nanostores: Retail Distribution in Emerging Megacities, CreateSpace Independent Publishing Platform, 440 pp.

[6] Han, L., Chin, S., Franzese, O., & Hwang, H. (2005). Estimating the impact of pickup and delivery-related illegal parking activities on traffic. Transportation Research Record: Journal of the Transportation Research Board, 1906, 49–55

[7] Innarella, R., Varisco, M., & Rosati, L. (2017). DynaLOAD: a simulation framework for planning, managing, and controlling urban delivery bays. Transportation Research Procedia, 22, 335-344. doi: https://doi.org/10.1016/j.trpro.2017.03.049Allende

[8] Instituto Nacional de Estadística, Uruguay. (2011). Censos 2011. Retrieved 28 June 2018, from http://www.ine.gub.uy/web/guest/censos-2011

[9] Kelli, L., Abreu, B., Dablanc, L., Ribeiro, K., Setsumb S. (2018) Distribuição Urbana de Mercadorias e Planos de Mobilidade de Carga Oportunidades para municípios brasileiros. BID. Doi: http://dx.doi.org/10.18235/0001169

[10] Kijewska, K., Iwan, S., Nurnberg, M., Malecki, K. (2018) Telematic tools as the support for unloading bays utilization. Archives of Transport System Telematics.

Löf, M. (2017). Decentralized Transactions in a Centralized Environment. A Blockchain Study Within the Transport Industry.

[11] Malik, L., Sánchez-Díaz, I., Tiwari, G., & Woxenius, J. (2017). Urban freight-parking practices: The cases of Gothenburg (Sweden) and Delhi (India). Research In Transportation Business & Management, 24(1), 37-48. doi: https://doi.org/10.1016/j.rtbm.2017.05.002

[12] Manzano dos Santos, E., & Sánchez-Díaz, I. (2016). Exploring Carriers' perceptions about City logistics initiatives. Transportation Research Record: Journal of Transportation Research Board, 2547, 66–73

[13] McLeod, F., & Cherrett, T. (2011). Loading Bay Booking and Control for Urban Freight. Recuperado de https://doi.org/10.1080/13675567.2011.641525

[14] Muñuzuri, J., Cortés, P., Guadix, J., & Onieva, L. (2012). City logistics in Spain: Why it might never work. Cities, 29(2), 133-141. doi: https://doi.org/10.1016/j.cities.2011.03.004

[15] Muñuzuri, J., Larrañeta, J., Ibáñez, J. N., & Montero, G. (2006). Pilot demonstration of a web-based loading zone reservation system. Recent advances in city logistics (pp. 401–415). Oxford: Elsevier

[16] Perry, E., Oberhart, E., & Wagner, S. (2015). Truck Parking Management Systems: A Synthesis of Projects, Research, and Resources for MAASTO Decision Makers. Recuperado de http://docplayer.net/14911143-Truck-parking-management-systems-a-synthesis-of-projectsresearch-and-resources-for-maasto-decision-makers.html
[17] Stickel, M., & Furmans, K. (2005). A web-based support tool to coordinate logistic activities in densely populated areas using auctions. Recuperado de https://www.witpress.com/elibrary/wit-transactionson-the-built-environment/77/14638
[18] Taniguchi, E., Thompson, R. G., Yamada, T. y Van Duin, J. H. (2001) City logistics: Network modeling and intelligent transport systems. Elsevier Science
[19] Venkatesh, V., Morris, M. G., Hall, M., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. MIS Quarterly, 27(3), 425–478. https://doi.org/10.2307/30036540