Collaborative Gamified Approach for Transportation

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Abstract. Transportation-related costs are responsible for a large portion of the logistics cost. This is particularly important in city logistics process where it is not easy to aggregate deliveries. Fleet management if often based on efficiency criteria which does not always is compatible with customers' service requests. Models supported by ICT, blockchain and gamification tools are developed to raise collaboration and share of resources in urban logistics process, in a kind of "Logistics-as-uber" concept, where operators share resource and ICT system support than giving advice, handle transactions. The discussion is provided on how such a framework can contribute to simultaneously reduce logistics costs, improve service delivery, reduce traffic in cities and reduce pollution.

Keywords: Fleet management · Logistics · Transportation · Collaboration · Gamification

1 Introduction

In recent years, there has been a great concern of local authorities and the community in general, regarding issues related to the high flow of polluting vehicles circulating in large cities, causing several adverse effects on the quality of life of those who share the urban space. A good percentage of these vehicles are intended for passenger transport (private and collective), although many of the vehicles that circulate every day in cities aim to ensure the distribution of different types of goods in the cities. The growing awareness and concern of local authorities and the general public about the high levels of pollution and noise present in large cities and the resulting health problems, as well as the problems of congestion in urban centers, provides great motivation to question and rethink the way merchandise is transported in the first and last mile of the collection and delivery steps. The activity of urban logistics, which aims to ensure the distribution of goods in cities, has a significant contribution to the quality of life in these places and is also fundamental for the urban economy. In addition, merchandise flows in cities are increasing, with high growth prospects, either because of the growth of the e-commerce business or because of an increase in the population in urban areas.

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In parallel, there are increasing restrictions on accessibility (restrictions on access for certain types of vehicles, establishment of own areas for loading/unloading/transfers, restrictions on access to pedestrian zones, creation of urban tolls, establishment of temporary access windows, among others), often in areas of high concentration of services and commerce, causing many difficulties to urban logistics service providers, among which the uncertainty regarding the service time due to the congestion of the road infrastructure and the difficulties of parking. In practice, the problem of urban logistics is characterized by a rather high degree of complexity. One of the primary sources of complexity is the fact that there are several Stakeholders with different and sometimes contradictory objectives. On the one hand, there are local and central authorities, urban planners and residents whose main concern is centered on sustainability issues in cities. On the other hand, there are customers, suppliers and distribution companies whose focus is on reducing costs and increasing efficiency.

In the current scenario, most of urban logistics cargo are carried by private companies, using dedicated fleets (typically vans and trucks) using with fuels derived from Petroleum, leading to the associated CO_2 emissions. In this context, the problem is exacerbated by a large number of parcels (both in volume and weight) to be collected and/or delivered to a large number of customers (private as well as public/private and/or retail) atomised in the cities, implying a significant challenge to simultaneously optimize daily loads to provide a service adjusted to the needs of the clients and optimize the available resources. In parallel, the transport of passengers in the city is mostly assured by a dedicated public or private network of buses, taxis, electric cars and/or metro. Throughout the daily operation, there are significant variations in the number of passengers using a transport service, although the transport network continues to operate uninterruptedly throughout the day, albeit with less frequency during some periods. This leads to poor performance of the transportation system regarding capacity utilization, creating challenges for fleet and driver management. The need to minimize the negative impacts [1] associated with the traditional distribution of goods within cities motivated the definition of this research work.

Recent data indicate that most of the world's population lives in areas that are considered urban [2]. This situation leads to higher traffic intensity and congestion, which are exponentiated if there are parking difficulties. CO_2 emissions are a direct consequence, and the European Commission [3] estimates that on average 8%–15% of traffic in urban areas is the result of transportation of parcels. One management approach is to postpone or anticipate the movement of at part of this load to periods with lower traffic intensity, usually evening or night periods.

Increasing the size and density of urban areas raises issues of mobility of people and goods. The concept associated with it, smart mobility, is one of the current topics in international forums and recent studies [1, 4]. Mobility management systems have not kept pace with emerging growth and challenges, leading to longer path times and more congested communication routes. The entry and exit of goods in urban space are usually carried out independently by each issuer or receiver involved. This situation prevents cargo aggregation and rationalization of the number of vehicles in urban space, as well as the use of roads without concern to avoid periods of greater congestion. Within the concept of mobility in zones of high urban density, logistic activity places continuously higher restrictions on other users of the city. Of these, the most important are pollution (sound and atmospheric) associated with transport, the use of infrastructures initially intended for other purposes (roads, car parks), and the resulting congestion caused by loading and unloading activities. Smart goods mobility aims to make more efficient use of means of transport and communication routes, as well as to reduce CO_2 emissions. In order to mitigate these problems, the present project intends to contribute with technological solutions that allow increasing the sustainability of the distribution of goods within the cities, maintaining, however, the service quality of this distribution according to the needs of supply; that is, to rationalize the distribution process - economically, spatially and temporally - by reducing the flow of goods but maintaining the service level of deliveries. The general objective of current work is to create a system of merchandise management, as well as its efficient collection and reception, contributing to increasing the smart mobility of cities. In this context, the aim is to develop a platform to add goods that require to be moved, improve the occupation of the vehicles used and manage the cash flows, in parallel with more efficient and effective management of the loading and unloading places with prior reservation of spaces using a platform created for this purpose.

We developed a collaborative gamified an online platform oriented to logistics in urban areas, as kind of "Logistics-as-uber" concept, which allows:

(1) To operate as a collaborative broker where there are companies with goods transport needs (buyers) and freight companies with space still available in their vehicles (sellers). The buyer defines the nature of the merchandise, the volume and the weight of the goods, the delivery time-window, the point of origin of the goods and the point of delivery of the goods. Then the buyer receives service proposals from sellers (delivery window, price, and type of transport). The platform, taking into account the available transport offers, will determine the best proposal is taking into account the characteristics of the requested service, providing a solution for the transport of goods similar to Uber's passenger transport solution. Associated gamification process has the mission of increasing users' participation.
(2) Companies that offer transportation services to optimize their routes and spaces in vehicles, contributing to the minimization of empty returns and non-complete loads.
(3) Dynamic price setting depending on the supply available and the degree of aggregation of goods achieved.
(4) Developing a solution that allows the management of parking spaces by creating a pre-reservation policy for a particular parking slot by the logistics operator.

2 Literature Review

Since the work is developed under four topics we analyze the state of the art as follows: (1) Collaborative platforms for sharing transport resources; (2) Reservation place loading and unloading; (3) Optimizing Routes; (4) Dynamic prices supply function and demand; (5) blockchain; and (6) gamification platforms.

2.1 Collaborative Platforms for Sharing Transport Resources

Chow et al. [5] provide an informational base model grounded on the collaboration between the different players in the supply chain. This model allows the consolidation of several cargoes and, consequently, rationalization of physical flows of goods. Such an Internet-based logistics information system, called E-logistics [6], allows for greater integration of information and is especially useful in situations involving reduced time windows and small size cargoes [7], i.e. less than full truckload, which is consistent with the moved of cargo in urban areas and for which there is currently no efficient and effective solution. The aggregation of these loads, through an information platform, allows the reduction of transportation costs and the number of vehicles required to handle this load. These aggregation principles are used by large carriers, but not by individual approaches that often do not contemplate urban logistics.

There are already conceptual models for the development of collaborative platforms that allow the integration of loads in urban spaces [4]. However, there are no systems implemented due to the tendency of the market to function individually. Cargo consolidation works well outside the cities where there is a high volume of goods and with individual loads of high dimension for which large carriers have their own systems. However, within the urban environment, this type of approach has not been successful because of the volume of the business is smaller and more atomized and, therefore, not attractive from a commercial point of view. In urban logistics, it is common to have small carriers that often lack information systems because of low levels of activity. It has been proved that collaboration between partners [1] in a supply chain context, aiming at improving collective performance, requires visibility of the system [8]. Therefore, a solution based on collaboration and resource sharing between different carriers could be beneficial for both the carriers and the environment.

Information systems and communication networks are essential factors for the development of collaborative relationships [9]. The degree of collaboration between partners can be diverse, ranging from a simple exchange of information to the development of strategic alliances [9, 10]. The exchange of information online allows for faster coordination between partners or between autonomous players, enabling collaboration and mutual gains even in situations of previous commercial ignorance among these partners. An informational meeting point does not currently exist for goods. However, its absence in the market causes that today loads within the cities end up being moved using inefficient solutions.

Information-based systems used by the large carriers allow better utilization of available vehicle capacity, thereby reducing the unit cost of transport [11]. However, this type of optimization requires high volumes of customer orders to be effective regarding delivery windows, a situation that presents itself as a challenge for small, individual companies. One way to overcome this challenge is by being able to aggregate parcels. Reservation os space for loading and unloading cargo

Applied cases in urban logistics are scarce in part because of the difficulty of real tests is performing. Also, there are specific laws that do not allow easy replication. In literature, the Green Paper on Urban Mobility [10] is one of the research work to raise attention to this problem and was the basis for three major initiative: CIVITAS I (2002), CIVITAS II (2005) and CIVITAS PLUS (2008) (www.civitas-initiative.net).

Another example is STRAIGHTSOL project (http://www.straightsol.eu) with seven cases. One of this initiatives took place in Lisbon in the area of parking for load/unload of goods, but unfortunately, this process stopped due to missing laws and high investments.

In terms of academic work, most of the research is oriented to urban freight distribution at European level, most of then oriented to the load/unload process, the need for reservation space to avoid road occupancy and consequently congestion:

- One work of Ambrosi [11] shows a comparative study of nine countries, where is highlighted applied methodologies and results obtained.
- At Reims, France, a project shows the time restriction scheme that foresees time delivery windows for each delivery vehicle entering the inner-city area [12].
- In 20005, rules for delivery times for urban logistics process were attempted in Maribor, Slovenia [13]. Around 1000 violations with the lower value (85€) would be identified, and the total benefits would be 85K€.
- At Aalborg, Denmark, a case-study to improves delivery efficiency and working conditions for freight distributors, and reduced numbers of freight vehicles in the city centre (aggregation process) [14].
- In Spain, Barcelona another study on cargo transport management measures that can bring useful results and improvement to the process. The associated process was SMILE (Street Management Improvements for Loading/unloading Enforcement). About 100,000 urban logistics deliveries are made using the urban road as a place for loading and unloading the goods, requiring four thousand additional loading and unloading places to accommodate all this operation.
- Winchester study was concerning the benefits of offering reservation of loading and unloading places in urban areas [15].
- Also, [16] shows that parking areas are essential in urban centres, but the reality shows that this does not exist in many municipalities.
- In work [17] again the creation of urban logistics spaces for the distribution of goods can reduce the number of cargo vehicles using the roads in search of a parking space.

Some other research works on urban logistics centres were oriented to the identification of urban consolidation centres (UCCs) [18]. These more specific studies have been of great help when planning to implement initiatives has the example in Bilbao [19]. Although still in its infancy, there is already evidence that organizing parking areas in municipalities can lead to the reduction of environmental hazards and the volume of traffic. Nonetheless, the lack of coordinated efforts from the stakeholders involved is limiting the success of these initiatives.

2.2 Optimization of Routes

It is intended to take advantage of the opportunity to apply and adapt academic models of route optimization to the transport situations explored in the project, namely the so-called vehicle routing problem (VRP), usually referred to model and optimize vehicle routes in a logistic context [3]. With adequate optimization, in addition to other benefits, savings of more than 10% in transport costs can be achieved [20].

Among the routing problem approaches, one is focused on defining the route each vehicle has to follow without exceeding its capacity (both regarding cargo and availability of time). The rout is only completed when the vehicle returns to its origin. This routing problem is known as the Vehicle Routing Problem (VRP) and was initially introduced by Dantzig and Ramser [20]. Among these, the improvement heuristic from [21, 22], VRPH, applications using the program made available by [23], is a very recent one regarding the heuristic techniques it uses. This metaheuristic can perform several types of local research in the vicinity of initial solutions generated by the heuristic of Clark and Wright [22] and also to the diversification of solutions, returning, in the end, the best solution found. Because it is a heuristic improvement process, the routes obtained by VRPH are at least as good as Clarke and Wright's. VRPH hs been used to identify the best route for a specific case, minimizing its distance (see, for instance, [24, 25]).

2.3 Dynamic Prices Supply Function and Demand

There is a decision support system for the dynamic calculation of prices and promotions for stocks [1]. These authors created mathematical models that satisfactorily covered the interdependencies between products and the modeling and optimization of the demand in support systems decision to calculate prices. Setting prices dynamically, due to its non-deterministic nature, is complex. Several models can be found in the literature to address these issues [26–31].

Transportation is the logistic activity that directly impacts on-time delivery and customer service quality, but at the same time, it can strongly influence logistical costs. Setting prices in freight transportation involve trade-offs between these issues and models are required to address them simultaneously.

2.4 Blockchain

Blockchain can play an important role in this collaborative process taking into account that is able to handle distributed transactions without a central supervision entity. This approach has been applied with success in several areas, as for example microgrid, addressing incentive issues while respecting operational constraints [32] and on the management of complex system without centralized supervision [33]. Also blockchains supports monetary transactions based on the concept of cryptocurrencies, such as Bitcoin [33], giving in this case the possibility of performing transportation payments based on agreed conditions without the intervention of a central entity, based on a shared list of blocks of transactions [32], with resilience because there is not a central structure and low cost there is no third parties with commissions involved. Blockchain also can handle cyber-attacks, communication dropouts, and participants joining/departing the network.

In our case the collaborative negotiation can be programmed and handle in the associated smart contract supports monetary transactions in a transparent based on pre-defined rules. This smart contract tries to reflect prices based on aggregation level and changes on distribution timeline and distance based on pre-defined heuristics. The first step is the transportation operator defines the transportation price based on time and distance covered. Based on the aggregation to define a price point agreement, and then the defined amount of money (digital money) is sent to a predefined address that works as an escrow account.

Blockchain creates a security measurement environment using the Trusted Platform Module (TPM), Trusted Execution Environment (TEE), Secure Element (SE), or any similar component could be introduced in smart meters supported by a remote verification service [32].

2.5 Gamification Platforms

Gamification is the strategy of interaction between people towards a pre-defined goal based on the offer of incentives that stimulate the engagement of the public. In this collaborative is important to motive the user under the pre-defined goal and gamification approaches with monetary rewards play an important role. It rewards collaborative behavior with recognition and visibility within the community [34, 35]. The community is maintained under pre-defined goals through users' high engagement and flexibility behavior. We use our experience in several fields applied, energy to motivate user behavior change towards sharing available resources.

3 Platform

The proposed platform in this project is intended to fill the gap in the solutions available in the market, either in the lack of simultaneous integration of several actors, (TMS) used for transport management and planning [36], planning loads and looking for possibilities of consolidation of these for later coordination of loads and discharges [37].

This limitation is exceeded by the present project because, although it is intended for the aggregation of parcels, these are originated in a multiplicity of simultaneous actors generating an aggregate volume with sufficient scale to generate efficient movements of goods. The collaborative solution represented by the platform will allow small players to be integrated that would otherwise be separated from the possibility of goods integration.

The relationship between the logistical integration systems referred to above is centered on the sharing of information and resources between operators. Consequently, the position of this proposal is as follows:

1. A modeling solution that follows the above principles can be found in Leung et al. [38], who proposed a virtual market for operators in the air transport sector where there is logistical integration. This model has no direct application to the problem that is addressed in the present work since it is limited to the aggregation of the load in a controlled environment but can be a partial reference for the solution to be developed. This project will overcome this gap in the market, allowing consolidation with other modules and the possibility of a larger scale use than the current models.

2. Reinheimer and Bodendorf [39] addressed the integration of information between elements of the supply chain and advocate that access to the system should be decentralized, i.e. it should allow access by all players (load transmitters and carriers) individually and easy way. This access is not easy and is limited in the current solutions, intending the present project to fill this absence of solutions in the market.
3. Logistics Brokerage Systems (LBS) is another variety of logistics integration system, in which there is the open integration of information for the transport of goods, and that offers its users financial links, prices, an indication of available space, reservation of transport capacity of door-to-door goods and a single payment point [1]. This model, however, in essence, does not involve the possibility of coordination with entities in the destination of the flow for scheduling of temporal slots of space for loads and discharges. The platform to be developed with this project will overcome this limitation by providing a transportation solution that also integrates coordination with spaces for loading and unloading.
4. While TMS is a more closed system for individual firms, Chen et al. [36] introduced a road freight transport platform (HFTP), which is operated by a fourth party logistics player and is open to industry. Applied in the technical scope, HFTP intends to serve as a network between the owners of the cargoes to be handled and the transport companies (not necessarily logistics operators). This is a feature that will be included in the platform resulting from this project, making it possible to fill a gap in the market.

Given the specificities of the collaborative platform for sharing transport resources, we aim to create open services that optimize transport routes and the packaging of the goods to be transported, depending on the volume and weight, taking into account the diversity of transport vehicles). To this problem, to treat as a whole using multiobjective optimization functions, we want to combine the temporal constraints of the deliveries (defined by the clients) and the traffic restrictions in the cities (a type of vehicles and eventual temporal windows). The heuristic algorithms to be developed and incorporated in the platform, capable of providing efficient routes in real time, will also have to consider the fact that the same route has associated several loading and unloading operations (collection and delivery). This particularity constitutes additional difficulties in the planning of the different loading and unloading periods and in the occupation of packing space. We will apply a decision system to the calculation of the price. Although the authors do not know of the existence of a decision support system for the calculation of dynamic prices applied to the freight transport theme, there are, however, in the literature examples of similarly complex challenges.

It is in this perspective that we intend to develop a model-oriented decision support system, emphasized in statistical access and manipulation and optimized for the dynamic calculation of prices. The goal is for the system to define a strategy (dynamic price determination) that assists decision making that maximizes utility over time. In order to do this, it will be necessary to describe the complexity of the reality of price formulation through specially designed mathematical models. Dynamic pricing, given its complex and non-deterministic nature, will be addressed through the most appropriate techniques and modeling and analysis tools available [30, 31]. This approach will aim to build a model that satisfies the requirements and can be integrated into the platform. This dynamism of prices will tend to lower the values and the consequent demand for the customer of this type of services. This process will work in a similar way to Uber's prices, where price is a function of demand. In this process, the price will be a function of the integration achieved.

Figure 1 illustrates our approach. It is grounded on an installation of steemit (https://steemit.com), where an aggregated system based on an intelligent decision support system (SIAD) collect users' goods transportation needs and operators' offers. A BID system calculates pricing and a gamified approach tries to incentive users' flexibility with lower prices.

In order for the proposed distribution channel to ensure the distribution of the goods, after the request of the service by a customer that intends to send merchandise to one or more locations within the city, the provider platform (the service provider that is the owner of the system that will be developed in the project) should allocate the goods to a passenger transport operator and define, among other issues, where it should be delivered (from a set of strategically pre-defined locations in the outskirts of the city or a reduced set of locations in the city, such as terminals of passenger transport operators), assuring this way the first transfer of the goods from a delivery perspective. In the next step, the goods are transported by the passenger transport operator to a location inside the city and as close as possible to its final destination (at a stopping point for the transportation operator) to be collected by micro-logistics operators, that (e.g. standard bicycles and/or electric bicycles, electric trailers, electric logistic trains and minivans) will move the goods from that location to their final destination using a fleet of electric vehicles), thus verifying the second transfer of the goods. To physically collect the goods, the same system can be used, in reverse order, or the customer can make arrangements to have them available at the location of the logistics operator. It is emphasized that in this last stage of the journey, the merchandise to be delivered to the various endpoints will be integrated into the daily operations of the micro-logistics company, and it can be delivered shortly after its collection or not, depending on the operational arrangements that are made by the micro-logistics company. However, the micro-logistics company is responsible for assuring the service level agreed upon with the end customer. It is also important to mention that, in addition to the fleet to be used by the micro-logistics operator, this more ecologically friendly solution is much more beneficial in terms of environmental impact and noise levels than the traditional fleets, has fewer access restrictions and usually is better accepted by the population that interacts with it.

The intelligent decision support system (SIAD) that it is proposed in this project will allow the management of real-time transport operations in a coordinated and synchronized way, in time and space, of the whole network of vehicles in operation. This synchronization assumes a preponderant role in cargo loading/unloading/transfer points. In addition, this system also ensures real-time re-planning of transport operations in order to respond to extraordinary events or incidents (such as the micro-logistics operator is not at the place of unloading of the goods when of the arrival of the

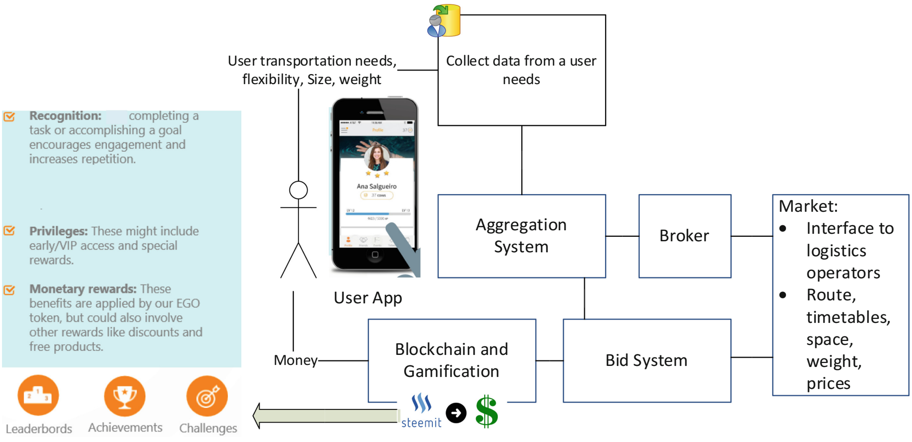

Fig. 1. Overview of main platform modules

transport operator's vehicle in the event of a breakdown or accident, or if the customer for whom the goods are intended to is not at the place of delivery at the time of delivery). To this end, it will be necessary to ensure the continuous monitoring of the whole network of vehicles [1] involved in the process (both the vehicles of the transport operators and those of the micro-logistics operators).

4 BID System and Smart Contract

Transportation publicity their offer based on available space and weight associated time window and route. This could be pre-defined transportation that does not go fully or new ones. The BID price is also defined and the availability to perform a change on original route and times. This is a basis to load gamified platform, where end-users express their transportation needs (space, weight, time and destination). The system tries to fit and suggests possible operators routes with availability and cost. End-user needs to check the availability the best to fit their needs, usually with a need of change time. This part is accounted on this platform where behavior change is quantified in a gamified approach of points. Operators receive request about the possibility of route changes. This is done in a pre-defined time windows. After an agreement, the system quantifies behavior change from operators and end-user towards the common goal of sharing transportation resources. This approach is implemented in the Steemit platform module. To ensure users' data privacy, data is stored without being directly related to the user. Those users who change behavior towards the aggregation win points that can be used on this dynamic pricing creation and this gives a price reduction [1]. After this process, the blockchain accounts the transactions between several possible end-users towards some transportation.

5 Use Case

Since this initial set up, a city distribution process was not possible to come live yet, we apply the current approach to a sharing approach in the automotive industry in Portugal. As most of the logistics flows are inbound, and outbound trucks go less full. Consequently, the goal was to invite other companies to share transportation synergies mainly those that use outbound flows (export companies). A set of potential companies was invited to use the platform in a shared transportation approach. In a first phase, potential partners were contacted directly and invited to upload their transportation needs to the system. Example of these suppliers are: (1) Colepccl; (2) Corticeira Amorim; (3) Grohe; (4) Karmann Ghia; (5) Simoldes; (6) Labsfal, among others. A detailed information about this process can be found at [40]. Transactions were performed on Steemit, and prices were calculated based on the aggregation and initial transportation pricing.

This collaborative approach allowed a reduction in transportation cost of by one quarter in 2014. Some of the procedures used can be applied to city logistics. A pilot in Lisbon is intended to go live next year.

6 Conclusion

In this research work a new paradigm for the transportation of goods taking into account the power of ICT platforms mainly blockchain and gamification platforms to raise collaboration towards the sharing of transportation resources. Sharing approach is fundamental to savings, sustainable approaches. In spite of this ICT approach, this type of collaboration system works well with a considerable number of users to increase matching possibilities. It is our intention to add an interface to include commercial delivery companies, to be used in the case of having a limited number of users present and no matching is possible. In addition, this approach can be used to fulfill this dedicated transportation.

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