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SMART PARKING FOR THE DELIVERY OF GOODS IN URBAN LOGISTICS

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Abstract
The purpose of this research is to develop an application to reserve slots of loading and unloading activities in urban environment and create a collaborative low cost solution based on BLE (Bluetooth Low Emission) beacons to monitor this process. Violations can be easily detected through a collaborative process among user mobile devices detection and a reward mechanism incentives user participation. This approach allows the implementation of a system to handle parking slots for load and unload of goods, without investments costs using an ad-hoc network of users that sends information to a central system and from this violations were sent to control agents.
This solution allows the coordination of the usage of parking places for load/unload of goods in a city environment following European guidelines. The developed App assists operators towards parking place with routing and traffic advice and collects data for mobility authorities.

INTRODUCTION

According to the European Commission (MDS, 2012), 8-15% of the flow of traffic in urban areas derives from logistical operations involving the movement of goods. Loading and unloading activities are often performed in spaces that are not dedicated to them, causing disruption in the normal flow of traffic and increase in CO_2 emissions (MDS, 2012). Urban goods movement has these negative effects that can occur due to insufficient space infrastructure, presence of large trucks, inefficient use of land used for off-street and on-street loading/unloading of goods on vehicles. The presence of goods transportation trucks parked outside its proper loading/unloading spaces causes congestion and accessibility problems for other road users, since they act as physical obstruction, and they are also a significant cause of accidents, due to their size, adjustability and on-road loading/unloading operations (Awasthi, 2006). Urban freight movements represent a quite low proportion of the total vehicle kilometres (10% -15%), but is one of the top sources of emissions of air pollutants (16% - 50%, depending on the pollutant) (Dablanc, 2008; Dablanc, 2007). Space reservation creates a need of planning on operators and city life benefits from this because distribution is planned to use the available slots distributed in time. Without this planning there is no proper space for logistics activities and high punishment prices should be implemented to prevent misbehaviours. Cities have large populations that share its space and infrastructure for their daily life and for their mobility and for the mobility of goods. Space is limited, which often causes major problems in providing freight transport services. This can lead to a loss of efficiency of urban freight transport operations.
The scientific community already looked at this problem (Allen, 2007) and concluded that there are problems associated with Urban Logistics (UL), such as those related to loading/unloading regulations, fines, lack of unloading space, and handling problems. Also authorities have begun to give a greater importance to urban freight transport measures, which can increase its efficiency and sustainability and the

European Union is aware of the importance of UL and its challenges (several project has been financed in this area under the programs FP7 and H2020). UL has different measurements that can be used to improve the logistics of urban freight transport, and they can be organized according to the following categories: 1) public infrastructure; 2) land use management; 3) access restrictions; 4) traffic management; 5) enforcement and promotion; and 6) sharing approaches (Ferreira, 2017). ICT new tools with IoT (Internet of Things), real time information, mobile devices and data connectivity allow the creation of platform systems that monitor distribution activity integrated in a smart city environment and controls several activities that are occurring at the same time in a whole city. These new systems can provide great efficiency gains in terms of getting data analysed to extract knowledge, integrate information and provide real time guidance towards the optimization of route and process. In spite of this, the efficiency and effectiveness of the urban distribution of goods goes back to the rational use of cargo loading and unloading places in urban centres, as highlighted in the main studies developed by Taniguchi (2002) and Allen (2007). These point out that the type and availability of facilities for loading and unloading operations may impact the total cost of the process.

RELATED WORK

Related work in this field of UL is scarce, possibly because the tests conducted at each location are difficult to extrapolate to other places and difficult to implement because most of them needs to fulfil related laws. Also in this field the Green paper on urban mobility (European Commission, 2007) opens a debate with citizens and all relevant stakeholders and financial incentives to study the problem became available. One outcome was CIVITAS implemented in three phases: CIVITAS I (2002), CIVITAS II (2005) and CIVITAS PLUS (2008) (www.civitas-initiative.net). There is also STRAIGHTSOL (http://www.straightsol.eu) with seven demonstrations about freight initiatives, one of them in Lisbon related with parking for load/unload of goods. This initiative due to missing laws and high investments was stopped. Another project was Short Term Actions to Reorganize Transport of goods (START) (http://www.start-project.org). This project approach is based on close collaboration between the municipality, transport companies and local businesses formalized in local freight networks.

Regarding the academic perspective there are several investigations that are focused on urban freight distribution at the European level. A comparative study of nine countries, contrasting the objectives, methodologies and results obtained in each of them was performed by Ambrosini (2004). This non-extensive review shows that in spite of different framework methods and models, similar trends emerge at the economic and environmental levels. Other initiative has been introduced at Reims, France. This is a time restriction scheme that foresees time delivery windows for each delivery vehicle entering the inner-city area (Littiere, 2006). Rules for delivery times were attempted in Maribor, Slovenia (Politic, 2006). Taking into account the costs and benefits of this measure during only the year of 2005, around 1000 violations with the lower value (85€) would be identified and the total benefits would be 85K€. At Aalborg, Denmark, a pilot oriented time deliveries, more efficient deliveries, improved working conditions for freight distributors, and reduced numbers of freight vehicles in the city centre (Mikkelsen, 2012).

Barcelona is an example that cargo transport management measures can bring effective results and improvement to the process. Through the SMILE (Street Management Improvements for Loading / unloading Enforcement) project, it has been identified that 100,000 deliveries are made using the urban road as a place for loading and unloading the goods, requiring 4,000 additional loading and unloading places to accommodate all this operation. For better management, loading and unloading operations were concentrated from 8 to 14 hours, allowing a maximum period of occupation of 30-minutes per space, thus reducing the average space occupation rate. In addition, the intensive inspection removed 12,370 vehicles parked irregularly while loading and unloading.

Some other studies examine urban logistics centres and try to identify the potential for the development of urban consolidation centres (UCCs) that have as their main objective the alleviation of local environmental and traffic concerns in urban areas (Browne, 2005). These more specific studies have been of great help when planning to implement initiatives in Bilbao (Browne, 2005).
Among the management solutions, there was a study in Winchester of the benefits of offering reservation of loading and unloading places in urban areas (McLeod, 2011). The authors concluded that there is an improvement in the access to the researched region, however, they point out as a weak point of the proposal the operators arrival on time for their reservation, which, in the worst case, could cause congestion in the road when this happens.
In addition, as a solution, it is proposed to create urban logistics spaces for the distribution of goods, as investigated by Oliveira (2012), which can reduce the number of cargo vehicles using the roads in search of a parking space. Also Dablanc (2009) states that these areas are important in urban centres, as few municipalities create organized truck parking centres.

LOW COST MONITOR ACTIVITY USING SENSORS
There is a new type of sensor devices that opened several business opportunities in healthcare, sports, beacons, security, monitor and home entertainment industries. This Bluetooth low energy (BLE) is a wireless personal area network technology that once compared to Classic Bluetooth is intended to provide considerably reduced power consumption and cost while maintaining a similar communication range. Also in this context there are beacons of around 3-5 centimetres, a small hardware radio device that broadcasts data over Bluetooth Low Energy (BLE). Typical ranges of the radio signal are up to 20 or 100 meters (60-300 feet) and they are easy to fit in many applications and contexts. Together with this, they are very easy to interact with mobile devices sensors, like GPS, Accelerometers and gyroscopes creating a continuous monitor process since users carry the mobile devices all the time. This generates massive data (bid Data) through the process identified as Process 1 in Figure 1.

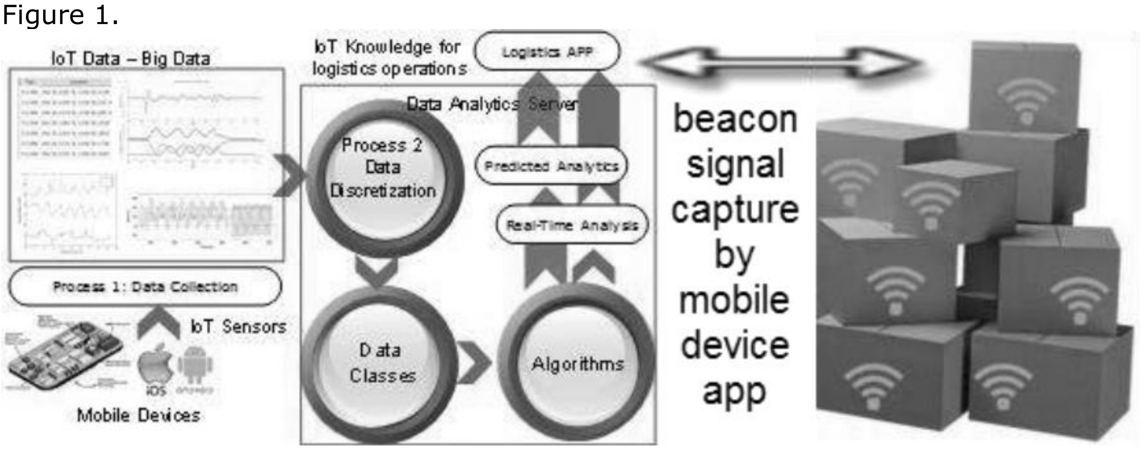

Figure 1. Overview of the proposed system based on sensor data acquisition and manipulation

This collected data can be transformed into information that allows passively tracking the users' mobility or track logistics distribution route process at low cost. Passive tracking of users' activities using mobile devices (Ferreira, 2016) has been assessed in a diversity of studies applied to activity recognition (Turaga, 2008) and transportation mode detection (Reddy, 2010), among others (Patterson, 2003) and our work shows other approach to this in public transportation area (Baeta, 2016). With the Figure 2 we developed an approach for mobile device application. By using it it is possible to track logistics distribution routes and times. Also with the use of beacons at packages it is possible to trace these packages through the interaction of beacons with mobile devices. Clients can track their packages without big investments because mobile devices capture beacon signal adds position and transmit it to a central system.

To monitor parking activity our proposal is to instal of a beacon in each delivery truck (costs around 3€, with battery life span of 2 years). These requirements should be reinforced by law and each logistics provider should be responsible for its maintenance. This would works like an electronic plate number that allows vehicle identification.
To avoid the creation of infrastructure and networking, our approach is innovative by the usage of citizens and their mobile devices. In this model users get rewards for each beacon signal picked and transmitted to the central parking application. This reward could translate in free parking time and the reward could be increased if an infraction is identified. This reward is based on transmittion performed in a price that could be establish as 0,05€.
This process is performed centrally, where the beacon ID is used to check if the truck place was reserved or not. Infraction data can the immediately send to nearest parking agent who would issue the infraction ticket or the central system can send the invoice directly to the logistics operator. Delays to reach reservation slot, or longer times to unload the goods could happened, but they are responsibility of logistic operator.
The reservation system (available in web and mobile interface) sells slots of 15 minutes parking for the identified places, which logistics operator should reserve in advance. The mobile application gives guidance towards parking and alerts of traffic situations. Figure 2 shows the main working idea for the main system with beacon signals captured by mobile devices and truck position is added and transmitted to a central server. This information is proceeded to check if the parking was reserved or not. In order to avoid errors that can result from users receiving beacon signals from a moving truck passing in front of the parking place the system will wait from two notifications of different users before proceeding for infraction identification.

Figure 2. Overview of the proposed approach to create parking monitor facilities without investments costs using an ad-hoc network of user mobile devices in a collaborative process

LISBON PILOT AND DISCUSSION OF RESULTS

It is clear that there is lack of spaces for freight deliveries in Lisbon and also that there is an abusive occupancy of the available spaces by private vehicles. These lead to road congestion problems and often blockage of roads (when trucks often stop at narrow streets for quick deliveries) and generalisation of illegal parking – such as: freight vehicles parked on sidewalks, double-parking or parked on regular parking spaces, and private cars parked on load/unload parking areas (Andersen, 2012). In spite legislation to regulate loading/unloading activities, there is still lack of rules because most of these places are illegally occupied by vehicles for normal parking. A previous test was performed by EMEL five years ago, but without great results because there was a lack of control mechanisms. To overcame this previous problems, a discussion group was created by a local Portuguese project (Intelligence logistics for urban environments), where several entities studied the problems and advise on change on law to allow an easier implementation of the proposed approach. Each truck receives a beacon that is placed at its cockpit. It is configured with a number that is linked centrally with the corresponding truck. This beacon was configured to transmit signal if the truck is stopped (no movement is detected). This avoid false detection of movement's vehicles. Operators reserve places in times windows with associated prices. These prices (slots of 15 minutes) should be adjusted to avoid a large number of slot reservations that operators might not be using.
To perform a concept proof before real time installation in 2018, we use the 2012 testing street with 10 truck that use this area to distributed goods. Users park the vehicle with beacon and 25 mobile devices of 25 students and professors were used to collect data for a period of 10 weeks. For the testing of the proposed concept, 10 beacon were bought for 30€ (3€/each) and collected 1454 users beacon data transmitted to whom we gave 0,25€ as reward if there is a violation or 0,05€ per transmition. This information allowed identifying 364 infractions (vehicle parked in a different slot from the reserved one), each one leading to a 0,25€ reward to the user. These rewards are used only for parking purposes in the city. This is a small scale pilot was mainly to proof the control mechanism based on this collaborative network of mobile devices. People involved in the test pilot was a mixture of drivers and pedestrian. The pedestrians claim about the energy consumption regarding the App running but always catch beacon signal in their mobile device. Some drivers could not catch beacons because movement process versus short communication range (around 50-70 meters). Data signal transmition at the beacon can be configured, low pooling data transmition means more energy consumption at beacon. From our testing pilot we define a pooling time of 5 seconds. With this rate beacon battery life time decrease to one year.
It is expected that the ITS used allows traffic and CO2 reduction by managing city spaces for load/unload of goods. Travel average times were compared in a month period and a reduction of 5% in peak times was estimated. This process were based on the traffic monitorization without the solution implemented in one month period and compared to one month period of running proposed solution. This monitor process were based on Bluetooth signal capture by 2 master BLE devices installed in the begin and end of the street. With this solution we were able to measure the time that drivers takes to go through the street. Average speed can give an indication of street congestion (Barata, 2014).

IMPACTS IN LOGISTICS DISTRIBUTION AND TRAFFIC

The pilot allowed some preliminary reading from which consequences at different levels can be elaborated: 1) at the level of the service delivery of the logistics companies; 2) at the level of the flow of merchandise and cars in the city; and 3) at the ecological level. These are as follows.
From the perspective of the quality of the logistical service provided by the logistic companies to its costumers it is mostly focussed on on-time and error free deliveries. Being able to keep parking spaces available to pre-scheduled loading and unloading of parcels and general cargo will prevent trucks from having to double line park during their activities and to drive around searching for a parking spot. The extra travel will

reduce on time deliveries and will increase average travelling time, and the double line parking can endanger the physical integrity of the products involved as they will have to overcome additional physical obstacles getting to and from where they should be. Both these aspects contribute to improved logistics service (Grant, 2012).

The ability to park in pre-booked spaces can also have visible impact in the overall flow of traffic in the city. Not only double line parking is prevented, avoiding bottlenecks on the streets, but also the consequent reduction in transit time allows reducing the average number of trucks in the city per period of time. As a consequence all other traffic flows that share the same resources (parking spaces and streets) will be enhanced and will flow more easily. The pre-booked parking policy along with eventual fluctuation of costs for usage at different times of the day will have immediate impacts in the use of capacity available. Although capacity is constant throughout the day demand is not. Price fluctuation for the parking spaces allows transforming the level of demand to be more in line with the level approach of how capacity is made available as it can lead part of the trucks to enter the city at periods of lower traffic intensity (flattening the demand curve for parking spaces). By itself this characteristic will already reduce the flows during traditional heavy traffic hours.

Paying for parking space to load or unload cargo or parcels represents an additional logistic cost for the companies using it. Nonetheless, at the same time it leads to reduction of transit time in the city, reduction of consumption of fuel and reduction of products damaged during the operations. Overall, it can lead a reduction in the overall logistic costs of the operation.

The ecological perspective is very relevant for the Lisbon municipality as recently the city received severe penalty for the intense traffic in some of the roads. Since then the municipality has made large efforts to reduce pollution and improve quality of the air in the city. It is expected from this project that when it goes live there will be a reduction of traffic congestions in the city, therefore lowering CO_2 emissions.

Also in our pilot, we perform the testing of goods tracking systems, where goods beacons are captured by mobile devices this devices add GPS position and send this information to a cloud server for processing, see Figure 3 illustration. This can be used for tracking purposes without cost and to sending customers alerts about deliver time. This approach needs to study a reward mechanism for users perform these actions (perhaps money from logistic operator, because we can give client additional services without infrastructure investment costs. The test performed, there was a missing of mobile device through the route path, but when there is a mobile device running the App in background mode the beacon signal is captured and transmitted and tracking it is possible.

CONCLUSIONS

This platform innovated by allowing a pre-reservation policy for a given parking slot in a city and created a low-cost inspection procedure that can be integrated with the different parking space management systems. Violations can be easy detected and data is integrated in mobile devices used by control agents. The usage of this type of ITS in urban areas impact urban mobility globally by allowing operators to react to urban traffic conditions in real time and coordinate their deliveries and consequently reduce road congestion and CO_2 emissions.

This system can be financially self-sustained as a pay per use method can be used without installation fee. Considering an average of 100 seats marketed in 30-minute time slots, it is possible to reach about 3000 transactions per day (estimated value of 15 hours per day), or 1,000,000 per year per city. Taking into account an estimate fee of 0,1€/use this gives 100K€ in a year.

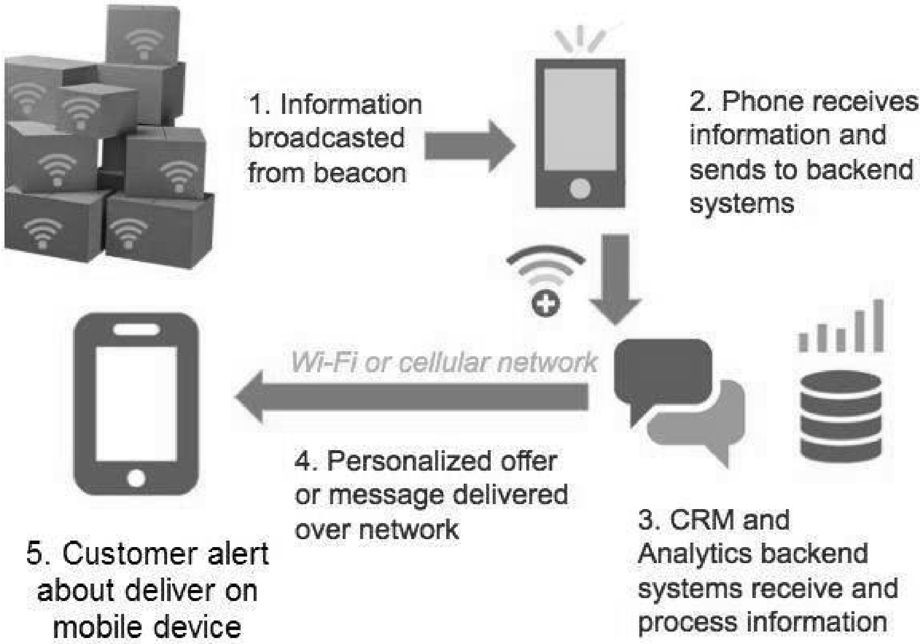

Figure 3. Proposed approach to alert costumers about deliver process.

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