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The SaveMyBike Project: ITS Technologies and Rewarding Policies to Improve Sustainable Mobility in Cities

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Abstract

Private car mobility registers a high accident rate and, in addition, in 2014 in the EU-28, around 70% of the overall CO2 emissions from transport were generated by road mode. As a result, a modal shift of at least a part of passenger transport in urban areas, from private car to sustainable transport systems is desirable. Several policies have been adopted in the EU in this direction. The SaveMyBike project regards the development of a rewarding system for sustainable mobility based on an open source platform able to monitor systematically trips in the city, starting to integrate the platform with a service to incentive private bike use by means of UHF-RFID systems, creating secure areas for bike parking and finding stolen bicycles. The real testing application to the Livorno case study from the beginning of 2018. Then, SaveMyBike project introduces four innovations: it's, for the first time, an open source rewarding platform, called GOOD_GO linked to an anti-theft system for private bikes, it is applied to a whole city and it introduces a 'financially hot system' for municipalities able to find financial resource from bike services.

Keywords: RFID, GPS, Smartphone App, Open Source Platform, Rewarding Strategies

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1.Introduction

Private car mobility registers a high accident rate: in 2014 it was responsible for over 25,000 fatalities in the EU-28. In addition, in 2014 in the EU-28, around 70% of the overall CO2 emissions from transport were generated by road mode% (European Commission, 2016). Moreover, in urban areas they occur 38% of the overall fatalities from road transport, and 23% of the overall CO2 emissions (European Commission, 2013) As a result, a modal shift of at least a part of passenger transport in urban areas, from private car to sustainable transport systems is desirable. Several policies have been adopted in the EU in this direction (Petri et al., 2016). Moreover, bike-sharing solutions has a high maintenance costs and, especially in medium size cities, this limits its application.
The SaveMyBike project has been developed in order to improve at first the private bike mobility (Pratelli et al., 2017) and linked to it all other sustainable mobility modes present in urban areas (public transport, electric car-sharing, car-pooling, etc..). However, several factors, currently, limit the bike development. A first factor is the high number of bike thefts in Italy but also in the rest of Europe: in Firenze, 40% of complaints for thefts regard bicycles. Some countermeasures have already been adopted but results have been not relevant. A second factor is the low attitude to bicycles use, even for short trips and the culture of private car usage. The change of mobility attitudes is encouraged also by the European Commission, through the adoption of rewarding policies. However, currently only a few rewarding policies have been performed on occasional basis; moreover they have never been applied to private bikes.
The SaveMyBike project regards the development of a '*space of services*' for sustainable mobility users linked to ITS sensors and an ICT social platform called GOOD_GO capable of:

- monitoring systematically bicycle trips and all the other transport modes by using an APP for smartphone;
- creating secure areas for private bike parking;
- finding stolen bicycles;
- rewarding people who perform sustainable trips in the city;
- generating financial resource for administration coming from the user annual subscription.

In the following paragraph, it is presented the state of art about some of the project key elements and in the third paragraph, it is presented the proposed complete solution and the simplified one to be applied from the beginning of 2018 in the real testing application of Livorno city (Italy). Finally, we present some future developments.

2.The state of the art

In the next paragraphs, they are presented the actual state of the art about the main elements, that's to say the software, hardware used to increase sustainable mobility and the best practices in sustainable mobility rewarding policies. For each element, the actual problems are underlined.

2.1.State of art about bike-linked hardware developments

To insert in the bicycle industry production process and in the existing private bikes an effective anti-theft system the Radio Frequency Identification (RFID) technology represents a good candidate (Lin K., 2011) thank to its capability to realize a low-cost and easy-deployable solution to perform identification of objects without the need of the line-of-sight condition. The main components of an RFID system are the reader, the transponders or tags and the management system (Finkenzeller K., 2000). In passive RFID system the tag is a battery free device composed only by a printed antenna and a microchip which contains the Electronic Product Code (EPC). To choose the best RFID solution in bike scenario, it is necessary to take into account the bicycle metal materials or advanced carbon fiber materials, together with the high temperature paint treatment during the production stage.
In the state of the art, most solutions suggest the employment of Low Frequency (LF, 125 KHz or 134 KHz) or High Frequency (HF, 13.56 MHz) RFID systems since they have good performance in presence of liquids or metal materials. The tag detection occurs in proximity of the reader antenna. On the contrary, the Ultra High Frequency (UHF, 860-960 MHz) RFID systems allow to detect tag at distance of meter and to contemporary manage several tags (Buffi A., 2015). However, such systems suffer of the presence of conducting materials.
In bike sharing application the employment of RFID technology can allow to identify bike during pick up and deposit operation. The bike can be equipped with both the RFID tag or the RFID reader. Among solutions with tagged bike it is worth to mentioned the LF B-cycle system (Bcycle) and the HF systems such as PBSC (PBSC, RFIDJournal), Nextbike (Nextbike, RFIDJournal). In the latter systems, the RFID reader is integrated in the dock and an HF RFID smart card is employed for user identification at the kiosk side. Instead in the Smoove system (Smoove-bike), the RFID reader is directly mounted at the bike side and the RFID tag is applied on the dock.

The employment of UHF-RFID technology in bike sharing applications has been proposed in the ZAP system employed for user transit identification (ZAP, RFIDJournal) and in the Synotag system used for user identification in cycling race (Synotag - Synometrix). In the ZAP system the tag is placed on the wheel spokes, while in the Synotag system it is applied directly on the cyclist helmet. It is worth to mentioning also the Cycle Alert system operating at 2.4 GHz (Cycle-Alert, RFIDJournal), that has been proposed to avoid collisions among vehicle.
The above described RFID solutions for bike sharing applications are summarized in Table 1.

Table 1. RFID solution for bike sharing applications.

System	*Operating Freq.*	*Tag location*	*Reader location*	*Applications*
B-cycle	LF-RFID	Bicycle frame	Dock	Identification system for *bike sharing*
PBSC	HF- RFID	Bicycle frame	Dock	Identification system for *bike sharing*
		User card	Totem	
Nextbike	HF- RFID	Bicycle frame	Dock	Identification system for *bike sharing*
		User card	Totem	
EVO-BIKE	HF-RFID	User card	Dock	Identification system for *bike sharing*
		Plug socket (e-bike charging)		
Smoove	HF- RFID	Dock	Bicycle handlebar	Identification system for *bike sharing*
SoBi	HF- RFID	User card	Bicycle' frame	Identification system for *bike sharing* and GPS localization
ZAP	UHF-RFID	Tags on the spokes of the wheels	Pole along the path	Identification system for transit users
Synotag	UHF-RFID	Tag on helmet	Finish line	User identification system in cycling races
Cycle-Alert	UHF-RFID 2.4 GHz	Active Tag on the bicycle handlebar	On the side of a truck	Anti-collision system

2.1.1.Bike innovative anti-theft systems

In the last years, due to the gravity and the growing frequency of bikes thefts, different systems to prevent them have been proposed over time. It is noteworthy that tracking devices are not an anti-theft solution. Because no bike lock can offer total protection, tracking devices/software offer a last-resort, post-theft recovery support. Referring to all the above mentioned aspects, some approaches to bike security can be identified, each with its own strengths and weaknesses:

- Metallic plates: these, reporting unique numbers, can be fixed or welded onto the frame. Similar solutions have been adopted since many years in Switzerland and Denmark. Recently, in some Italian cities (e.g. Pisa), plates have been tested but results have been rather poor.
- Adhesive plates: similarly, some cities in northern Italy have adopted adhesive plates. However, these can be easily removed.
- QR codes: this is a solution that has been tested mostly in northern Europe. Codes can be punched onto the metallic parts of the bicycle, but removal, covering or hiding is almost easy.
- GPS-GPRS and Bluetooth systems: these are advanced and costly solutions (an interesting program using GPS tools has been proposed by both the Taiwan University and the Copenhagen municipality) that allow the identification and also the tracking of the bike within a given area (Bluetooth) or almost without restrictions (GPS). Unfortunately, they are heavily affected by the short life of batteries and by the easiness with which the emitting sources can be removed from the frame. Besides, the cost of the anti-theft system is often burdensome.

2.1.2.Bicycles anti-theft and localization systems with GPS

Most of commercial solutions to perform bicycle anti-theft and localization are based on the employment of GPS systems. Simple solutions suggest to use the GPS module of the cyclist smartphone for applications such as geo-fencing or tracking (referring to a rewarding policy).

As an alternative it is possible to equip the bike with a proper GPS receiver that can be managed through the smartphone. In such case, the bike can be track in real time with the possibility to release an acoustic alarm in case of theft. The GPS module can be installed in the lamp or within the bike frame (saddle tube or handlebar tube) as proposed by the Spybike system. As alternative, the GPS receiver can be integrated within the mechanic lock as in the Deeper solution or in the bottle cage as in the Cyclotrac. Typically, some motion sensors are installed together with the GPS receiver to detect unwanted movements.

***2.2.**State of art about rewarding mobility*

Over recent decades, the question of how to motivate voluntary adoption of environmentally sound modes of transportation, as well as other environmentally conscious behaviors, has attracted the attention of social scientists, transportation experts, and behavioral economists. As part of this endeavor, various studies have tried to elicit people's perceptions and attitudes regarding various means of transportation, as well as the normative basis for their use (Ayzen,1991) and several projects developed software/App solutions to experiment in real contexts.
In this section, firstly the policies applied to some urban scenarios are described and after, existing SW solutions are presented with their advantages and disadvantages.

2.2.1.Best practices of rewarding policies

At the moment, real applications of rewarding policies are limited, both in number and in results, and often regard uni-modal systems, such as the application of rewarding policies to bike-sharing systems (performed in Paris and in a few Italian realities, e.g. Massarosa) or the promotion of public transport through free access policies. Several examples are referred to the Netherland reality, where the central administration, after promoting a uniform national policy of road pricing, to which citizens clearly and sharply opposed, decided to try a new branch of mobility management systems, based on rewarding policies (Khademi et al., 2014).
The first application experiences started right from the Netherlands with the Spitsmijden project in 2006, where the reward was applied to disincentive displacements in the morning peak hour, for 341 resident volunteer commuters, who traveled from the town of Zoetermeer to the city of The Hague by motorway. They received monetary prizes (between 3 and 7 euros) if they did not perform their displacements in peak hours or if they decided to travel by train. The results have shown a high level of impact on transport modes (more than 50% of participants modified their travel habits). However, after the reward regime had ended, most participants returned to their old behavior. Other problems associated with this 'real experiment' are the little sample and the high cost of incentives that lead to a poor sustainability of the experiment for any type of municipality.
Starting from the results of the Spitsmijden project, three new projects have been developed, namely SpitsScoren, Spitsvrij and a second Spitsmijden project in several Dutch areas. The largest project is SpitsScoren with the goal of reducing congestion by 5% on the A15 motorway corridor and the parallel roads that connect the city of Vaanplein with Rozenburg. The test results of about 2,000 users, applied for three years (2010-2012), saw a very positive result with a 7% reduction of morning peak traffic, with rewarding rates variable between 1.5 and 3 € /day. Also in this case, in the long term, the effect of incentives decreases with respect to short-term effects. Once again, the issue of economic sustainability of incentives remains.
Another project which is mostly focused on a single action is Travel Smart Rewards, which is ongoing in Singapore and is aimed at encouraging commuters, through cash-back, to travel by public transport or to avoid travelling during peak hours. Providing personalized information on displacement alternatives led, in case studies carried out in Japan, to a reduction in car use (Fuji & Taniguchi, 2006). This technique is typical of Transport Demand Management programs and is often called the Travel Feedback Program-TFP. Fuji and Taniguchi's analysis of some Japanese study cases shows that reduction percentages by more than 15% in the use of the car can be achieved. On the other hand, this analysis has been applied on small samples, often limited to 2-300 families or individuals; another TFP application has been carried out on a ten school student sample in 1997 at Perth in Australia (Department of Transport, Government of Western Australia, 2010).
Another interesting example of TFP was the experiment on a sample of 100 families in Adelaide, Australia where several suggests have been personally provided to each single participant, for example (Rose and Ampt, 2001):

Craig, could you use public transport at least once a week, taking the train at Blaxland station and then the bus

line 301 at Central Station to go to work?
Graham, when choosing whether to use the Commodore Street instead of the Statesman, try to use preferably the first one because it is less polluting.

After giving several of these tips, a further monitoring of daily travel diaries has been made, which has shown a 10% reduction in car usage.
After these goal-oriented applications, the first projects based on a general platform and award system have been developed, such as the Sunset project of 2011 (Utwente, 2011) or the Sharing Cities project of 2015. With regard to incentives, the SUNSET project assigns points without linking them in any way to prizes, leads to see the system as a game and to make it interesting only for a small range of users.
In detail, the project is focused on four types of incentives, real time travel information, feedback and self-monitoring, rewards and credits/points and social network.
These different types of incentives have been adopted in three Living Labs but have been applied to a too restricted population (less than 100 users for application case study).
The 2015 Sharing Cities project involved the cities of London, Milan, Lisbon, Warsaw, Bordeaux and Burgas with the target of creating new digital services for citizens in order to stimulate them to use sustainable mobility. It introduced the concept of MarketPlace, where, based on own score, one can book prizes or discounts on products offered by local businesses. On the other hand, the Administration has the "power" of setting the rules to assign to each mobility behavior (rewarding strategies), the rewarding thresholds, and the final targets / goals. Other projects that develop similar platforms are ISUMO (Herrador et al., 2015), 2Move2 (Barsky and Galtzur, 2016), MoveUs (Rossa, 2016).
Another recent project about rewarding activities is the Empower. Funded by the European Commission's Horizon2020 programme, EMPOWER consortium concerns the reduction of conventionally fueled vehicles (CFV) in cities, adopting a 'reward rather than punishment' approach, and exploring the use of positive incentives delivered through smart phone technologies and the web to persuade people to make modest shifts in their transport choices. EMPOWER triggered initiatives combine empirical research with practical implementation in four Living Lab Cities (Milton Keynes, Enschede, Gothenburg, Helsinki) where new tools, concepts and organizational business models are going to be tested. The Living Labs are actually ongoing and the Empower Toolkit (www.empowertoolkit.eu) will enable a wide set of cities and organizations to implement the project concept and will be designed to be flexible for use in several cities, but, at the moment, the toolkit resources are not available and only some APPs for smartphone are developed, with some redundancy which will be better analyzed in the following paragraph.

2.2.2.State of art about rewarding mobility software

Several online tools, apps, ITS technologies embedded in web platforms have been built, aimed to improve the quality of life of people dealing with daily commuting in congested cities and to reduce the social costs of mobility, by encouraging sustainable mobility behaviors using reward. The technical term for these technologies is CAPTOlogy, an acronym for Computers As Persuasive TecnOlogy: this is becoming a new field of research since the years 2000 (Fogg, 2002). This section describes some recent examples of computer-based technologies as a mean of persuading to change behaviors (websites, smartphones, video games, smart environments, virtual reality, etc.).
Common requirements of such ICT product for mobility services may be big data system coupled with data mining, data analytics and decision support intelligence, based on data collected from ITS sensors, from public administration, from social media, participative portals, and crowd sourcing from personal devices, mainly sensor-enabled smartphones, and other communication infrastructures. These platforms include usually also the ability to accept the submission (from public administration and private enterprises) of additional algorithms and content, that can add further services provided by other Smart City control centers, by public transport platforms, for the final users, which may be interested in behavior monitoring dashboards, smart ticketing, e-commerce initiatives and marketplace discounts.
The availability of localization sensors to the mass public is crucial to build big databases enabling the possibility to perform analyses not possible in the past. An example of such a new opportunity provided by the spreading of sensing technologies is the "TomTom Traffic Index", developed by the Dutch company as by product of their navigation and location-aware mobile apps and connected devices (see https://www.tomtom.com/). This Index is based on 19 trillion data points collected over nine years from 390 cities, and allows to build a ranking of the most congested cities in the world. This analysis has been developed at the Tom Tom with the aim to help drivers, cities and transport planners to understand traffic congestion and, most importantly, how to reduce it. This is a relatively old issue, but before the wide diffusion of GPS sensors in the smartphone, it wouldn't be possible to get the

adequate amount of information, neither for a world leader in consumer market of GPS enabled devices!
With the increase of awareness, triggered by such a sort of technological applications, citizen is paying much more attention to methods for satisfying its own mobility needs which at the same time can improve wellbeing and reduce air quality impact. In this context, an individual using best practices for commuting gets gratification by itself and by the community.
MVMANT project's slogan is "Smart Mobility on demand for Smart Cities" and "he finds out how to make traffic congestion a thing of the past and create a win-win ecosystem" (http://www.mvmant.com). It represents an example of Mobility-as-a-Service (MaaS) solution, a sort of 2.0 version of carpooling systems, became well known by after UBER app (https://www.uber.com/), just better integrated with on place taxi services. It is based on machine learning mobility demand and logistic optimization and on a city loyalty platform to engage and reward customers with free bonus trips.
The company performed a first operational street pilot test in Ragusa town (Sicily, Italy) and it is deploying a commercial service between the cities of Venezia and Mestre, where it will cover 3 routes, in cooperation with the local taxi company Cooperativa Radiotaxi. The limit of such a sort of solution is that it supports only car-based mobility, whereas residents of smart cities for their daily commuting want to use a variety of different transport modes, getting some exercise along the way and arriving quicker and weather than if they'd just jumped in a car, even if shared (Neckermann, 2017). The complexity of the ICT backend components for the provision of informations and services to citizens by mobile apps, has to be totally transparent to the service provider, either public administration or private company, flexible enough to be scalable to fast growing demand and expandable to integrate further commercial opportunities.
Nowadays something corresponding to these requirements is already available as proprietary solution, with an adequate level of readiness, also thanks to development paid by public funding on Smart Cities - Smart Mobility programs. Most of them are available as Software-sa-a-Service (SaaS) on monthly or annual fee plan, such as the solutions developed within the scope of aforementioned EMPOWER project: CommuteGreener!, SMART and *ZWITCH. All of them run on the "Mobility Service Infrastructure" (MSI) developed within the scope of EMPOWER project itself, and represent the "customized" software platform implemented for 3 of its 4 Living Labs, based at Helsinki, Gothenburg and Enschede, respectively. Both the front-end as well as the MSI functionalities are based on the existing components and tools of the EMPOWER partners, so it has been possible to create stable ICT components that have already proven to function and deliver. The MSI makes possible to create positive incentives schemes, distributed by ICT. Its functionalities take care of social sharing, track-and trace/monitoring, personal mobility profile and questionnaires/experience sampling.

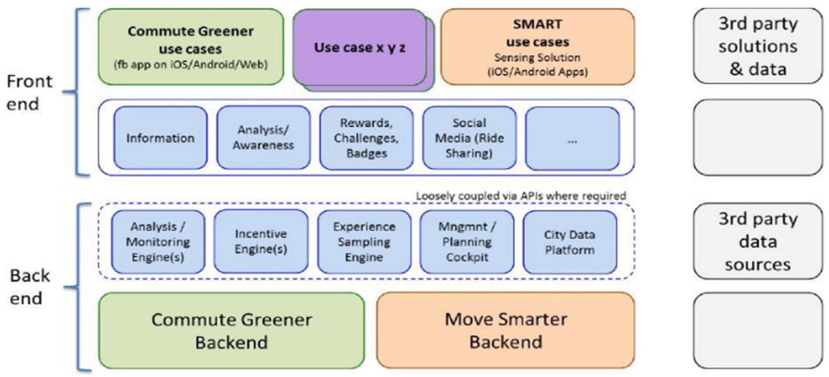

Fig. 1: EMPOWER MSI illustrating the architecture integrating existing backend and frontend tiers of mobility solutions: here "Commute Greener" and "Move Smarter" (source: Vreeswijk, 2015)

An important aspect of the MSI is also that (parts of) it can be connected to 3rd party applications. This means that an existing application in a city can be connected with, for example the track and trace functionality. This means that a contributor can make better use of existing components instead of developing the same kind of functionalities over and over again. Table 2 summarizes the main elements of the three software solutions offered.
Despite, the general objective to EMPOWER MSI, the platforms deployed for the Living Labs are affected by a sort of complexity and fragmentation due to probably case uses implementation excessively influenced by local needs and local culture, therefore their implementation and transferability is very difficult. This limit is particularly evident if medium-sized municipality (i.e. most of Tuscany towns and the majority of European urban realities) needs are taken into account. The analysis shows that the applications are currently not very significant from several points of view (statistical significance, economic sustainability, etc.) whereas, thanks to the common software framework provided by the EMPOWER MSI, the rewarding solutions converge towards a similar structure (platform to design the rewarding system and to have a general dashboard with game / social elements, app for subscribers and marketplaces).

Table 2. The main elements of the three Software solution of Empower project.

System	*Incentive*	*Admin. Dashboard*	*Rewarding rules*	*Auto-tracking*	*MarketPlace*	*Social Env.*
Commute Greener	Yes	No	No	No	No	Yes
SMART	Yes	Yes	Yes	Yes	Yes	No
*Zwitch	Yes	Yes	Yes	Yes	No	No

By the experience of Softeco Sismat, a digital company Ternienergia Group, and the Municipality of Genova in the MoveUs project (http://www.moveus-project.eu), another proprietary platform, namely myEPPI, has been developed, which comprises several ICT tools specifically tailored for the citizens and the stakeholders. The system has still limited access and documentation in the web (http://www.myeppi.com).
MyEPPI's ICT tools (e.g. mobile apps) are used to inform the citizens, promote the incentives, measure the citizens' behaviours and distribute the incentives. The "Incentives package" like discounts, access to special facilities or services etc. can be easily defined and associated to the rules. Thanks to a comprehensive Data Model it's possible to define the behavior that the users should follow to achieve the goals. As stated in its main webpage, outcomes of the MoveUs project have been especially used as a basis for the development of this product.
At the present only Km4City (http://www.km4city.org) represents an Open Source smart mobility and Smart City management framework alternative, but it is still in a prototypal stage as product of "SiiMobility" (http://www.sii-mobility.org/), an Italian strategic project funded by University and Research Ministry in 2016, in the area of Terrestrial Transportation and Mobility (Badii et al., 2017).
This platform should enable technologies for smart cities and mobility: big data system for decision support, monitoring interface, ticketing, etc.., and support for Data Analytics and Intelligence based on data collected from local data station, from Public Administration, from social media, participative portals, and crowd sourcing, etc. Additional technical elements developed in Sii-Mobility will be: data mining and aggregation modules, sensors and actuators, vehicular kits, participative platform for final users, mobiles applications, API for exploiting the framework, totem and applications for info-mobility and innovative smart city application exploiting the Sii-Mobility data framework and tool.

3.The general SaveMyBike framework

The general idea of SaveMyBike project is to join service for private bikes (and in the future other modes) with a social rewarding platform, called GOOD_GO, to increase sustainable mobility in the city. Then, it integrates hardware and software development with innovative measures regarding transport demand management and, mainly, with rewarding measures.
Firstly, a platform will be developed to take data mainly from an app for smartphone; and a service for private bikes, based on a RFID low-cost equipment, installed on private bikes, capable of:

- discouraging the bikes theft, through the development of "secure areas" where bicycles could be parked safely: if a bike is stolen, an alarm signal, directed to the bike owner, to all other clients of the platform, and to the police, is activated with a local acoustic alarm;
- allowing, in case of theft, the recovery of bicycles thanks to mobile detectors provided to policemen and parking enforcement officers;

Moreover, in order to increase the sustainable mobility 'incentive power', the platform develops a social space where people can: denounce the theft of their bike, post any information about events or any other news related to sustainable mobility, and participate to a competition based on points collected from the monitoring of their own daily trips. Actually it is present a smartphone app able to monitor the users trips and to provide some credits which could be spent in a rewarding system.
In the following sections the three main parts, of the system introduced above, will be presented: the rewarding management platform, called Good_Go; the prototypical solution with the UHF-RFID system connected with private bicycles and the reward management system. In each section, it will be described: firstly, the final target, afterwards the application to the real test case of Livorno: this application will be simplified in some parts for budget reasons.

3.1.The Good_Go Platform

Analyzing the products developed and tested during the aforementioned existing projects, one can infer that:

- the mobile app is a fundamental tool for any sort of initiative in this field, whereas the web app should consist in the portal mainly aimed to manage the content provided by the service provider to the engaged community;
- the ICT system has to be able to ingest and process a relatively limited sort of data, related mainly to GPS tracks, but predisposed to provide a very wide range of feedbacks, based on relatively simple processing;
- the most appreciated products include decision support systems, at least for provisional services in deferred time.

Those previous experiences also taught that to attract more users and to be effective in changing mobility behavior with citizen categories different by age, interests and social classes, at least 3 elements are fundamental:

- to promote a multi-modal approach for daily mobility,
- to engage different type of "contributors", i.e. enterprises and service providers able to manage different sort of economic advantages, including discounts on goods, services and even local taxes,
- to propose the services using a gamification approach, and dominant link to social networking, environmental awareness, safety, health and wellbeing in general.

The entities resulting more interested in contribute to these sort of initiates are public administration, mostly at municipal level, public transportation companies, sharing mobility service providers, insurance companies.

It is worthwhile to remind that for an effective involvement of a contributor, either public or private entity, it is important first to analyze the real scope he wants to satisfy by the ICT solution, in a win-win perspective for both the citizens user and the provider, as the platform success depends at the first by the resources the latter spent in its initial stages.

Within the scope of SaveMyBike project, the rewarding mobility prototypal platform will integrate only a subset of features and options. A diagrammatic representation of main components constituting the Good_Go platform is represented in Fig. 2.

The main differences among Good_Go and the other Smart Mobility platforms reviewed so far, are:

- the platform is entirely developed and based on Open Source software,
- it will offer community based functions to help individuals to find back their bicycle in case of theft and, optionally, to register and integrate the RFID based anti-theft system specifically developed within the project.

The citizen, after the registration to the web portal, will have access to the mobile app for the track record and monitoring. He will also be chance to save a personal profile including description and pictures of his own bicycles. On the base of mobility behavior, the user will gain badges allowing discount for public transport tickets or subscriptions. Once the user will reach an adequate badge amount will have chance to request an offered discount, or to accumulate more badges to access at a superior discount level.

In case of theft of his bike, the user can immediately send a geocoded notice with all description and pictures of his bike he previously registered. The members of Good_Go community will have the possibility to reply it in case of retrieval, giving the position and a short note. In case the user is using also the RFID ~~anti-theft~~ system, the RFID code is marked in a "blacklist" and notified also to local authorities which are provided with a RFID reader able to detect and recognize the stolen bike during their routine activities. Also in this case, the bicycle owner will be automatically notified in case of retrieval. According to the level of publication chosen by the user, his history can be shared with friends and public, for a community contest regarding km run wealthy and contribution to air pollution reduction. The reward provider, i.e. the local transportation service enterprise, will have access to a specific section of Good_Go portal, in order to manage and publish their discount campaign. This specific content management web tool will allow to easily manage the value for money of the discount and the categories of user that will have access to each offer, according to their profile and mobility habits, other than the offer expiration. Moreover, they will chance to monitor in a dashboard basic result of track data processing and aggregation, useful to improve their service offer and timetable, as such as follow the evolution of habits changes within the community engaged in the initiative.

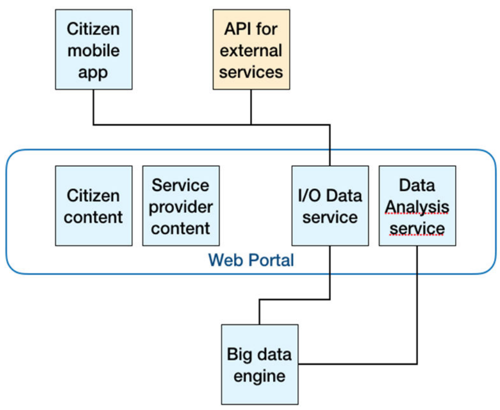

Fig. 2: Main components of the GOOD_GO platform

3.2.UHF-RFID prototypical solution

The solution proposed in this project consists of the employment of UHF-RFID technology to realize an identification system in cycling applications with the aim to contemporary manage multiple bicycles within the parking area. To discourage the bike theft 2 shrewdness are adopted:

i) The bicycle is equipped with passive RFID tags allowing the bike identification after a theft from an operator equipped with a portable RFID reader.

ii) The user has an RFID smart card in such a way that the reader has to contemporary recognize the bike tags and the user tag during the input and output operations within the parking area. Any unauthorized removal may be notified to the bike owner GOOD_GO App or with an acoustic alarm.

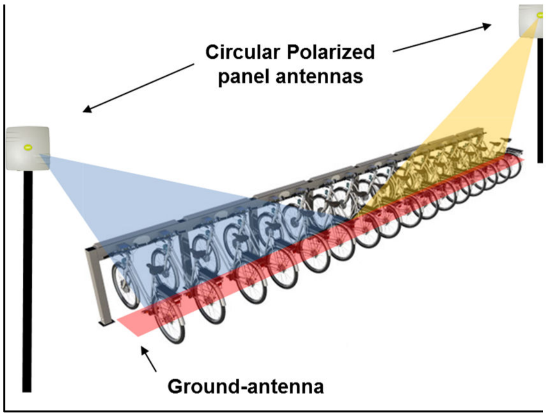

Fig. 3 UHF-RFID system with multiple panel antennas at the side of the rack and ground antenna underneath the rack

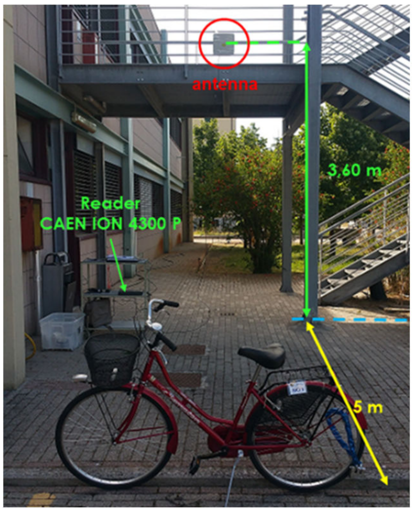

Fig. 4 Measurement setup illustration

To ensure tags detection for several bicycles within the parking area and independently on the tag position on the bike, the UHF-RFID reader is connected to panel antennas at the side of the rack, and to ground antennas (also named mat antennas), namely a thin antenna placed on the ground underneath the rack with a sturdy radome (Fig. 3). A mat antenna can be also installed on the parking area input to record bicycle transit.

A preliminary experimental setup has been realized at the Department of Information Engineering of the University of Pisa where a five-seater bike parking area is available. Five bicycles have been tagged with multiple on-metal tags. In details, five Intermec IT65 tags have been employed. For the measurement campaign, the CAEN ION 4300P reader operating in UHF RFID (865 - 868 MHz) band has been employed (Michel A., 2014) together with the CAEN WANTENNAX019 circularly polarized antenna. Such an antenna has been placed downward and 3.6 m apart from the ground (Fig. 4). An input power of 28 dBm has been used. The bicycles have been placed 30 cm apart each other by occupying an area of about 4 m. The closer bike to the reader antenna is at a distance of about 4 m, while the farer bicycle is at about 6 m. The reader has been able to detect tags fixed on the first three bikes namely up to a distance less than 5 m. It has been noticed that the central section of the bicycle frame is a good installation position to ensure tag detection. Additional measurements have been carried out by using the CAEN R1240IE portable reader connected to a smartphone via Bluetooth, with the aim to verify the possibility of an operator to detect bikes during its daily working activity. The portable reader has been able to detect the bicycle tag at a distance of around 1 m by employing an input power of 27 dBm. It is worth noting that the material of bicycle frames influenced measurements scenario (multipath phenomena).

3.3. The rewarding policies

At the level of rewarding policies, the goal of the SaveMyBike project is to develop a real multi-modal reward management system, which is able of introducing several incentive systems for sustainable mobility, based on the following: punctual measures (e.g. reward for crossing given road sections), linear measures (e.g. reward for travelling along given roads), or areal-based measures (e.g. rewards for parking or travelling in a specific area). All these incentive systems can differ in the level of rewards / credits provided, and can vary according to the time of day, the travel direction (in-out), the journey performed, the type of vehicle, etc.

The general idea is to develop an open system, where each public administration can set up their own rewarding strategies, with the help of stakeholders they consider important for the outcome of their measures/actions.

In addition, the choice of the prototypal application to be carried out in the city of Livorno (Italy), arises from the need to simplify and study a prototype easily replicable in other urban realities, even in the search for potential users. Actually, it is not always possible: to obtain a collection of user license plates, from which a list of commuters can be extracted; or to have the resources to make interviews at a population sample.

In our case, we have set up a multimodal connection between the bicycle system and the local public transport system allowing to identify potential customers of the public transport system with ad hoc rewards. For example, it is possible: to offer single tickets at a reduced price for those who never use public transport but perform compatible routes, or to provide subscriptions to those who only occasionally use public transport. In this way, a reward is offered to everyone, since public transport is attractive for everyone, while a high level of reward personalization is maintained and the reward system is simplified as much as possible, making it easier its broadcasting to people. On the other hand, we are contacting the institutional actors and stakeholders, able to help us in the dissemination of the prototype launch event, scheduled for the beginning of 2018: the Chamber of Commerce, the Municipality, FIAB (Italian Bicycle Friends Association), etc. In this way the whole population will be involved; in addition it will be tested: the attractiveness that this simple system can have to citizens, and the attractiveness of monitoring services, such as RFID, together with the other services offered. In this way they will be experienced: not only the effects of rewarding at urban level, but also the attractiveness of a rewarding offer to the population, the citizens' response will be verified.

4.Future developments

The future development of the project consists of the completion of the multimodal platform with the possibility of setting up rewarding strategies by the administrations, reconstructing a real visual language / wizard to set and customize the rewarding policies. This multimodal system will be linked to a MarketPlace with an increase in the economic viability of the project as the companies subscribed will pay an annual fee (similar to the Nuride system). In addition, a real and proper wizard will be implemented, for the guided upload of the data about the urban reality under consideration: a very important step for the sustainability of the project. In fact, all existing and tested systems are, currently, valid only for single realities and do not contain automatic setup elements for their application to other cities. Within this development, they will be integrated a system able: to monitor transport modes chosen to perform the displacements, and to analyze their possible replacements with more sustainable transport modes, in order to activate the related rule like a Travel FeedBack Program.

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