Social and Smart Mobility for Future Cities: the S^2-Move project

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Abstract. *The main idea behind S2-Move, a social innovation project financed by the Italian Ministry of Education, Research and University, is to supply soft real-time information exchange among citizens, public administrations and transportation systems by exploiting Information and Communication Technologies. In this paper, we describe the technological S2-Move infrastructure and the mobility services used to demonstrate the potentialities of the project.*

Keywords: smart mobility, fleet control, traffic monitoring.

1. The project S^2-Move

The main idea behind S2-Move [Marchetta et al., 2012], a project financed by the Italian Ministry of Education, Research and University, is to supply soft-realtime information exchange among citizens, public administrations and transportation systems. As shown in literature [Schaffers et al., 2011], to this aim ICT plays an essential role and, currently, several projects investigate the potentialities of similar approaches ([Bakıcı et al., 2012] and references therein). In our view, the urban mobility represents a complex and ever-evolving ecosystem that can be just partially measured through a widely and well distributed set of probes. In this scenario, it is essential to exploit at best the forcedly limited information collected form the urban environment: a set of different types of elaboration may allow to gather accurate knowledge on the current status of the urban mobility and supply citizens with a set of different services. In order to maximize the quality of experience of the citizens as well as the impact of the project, we identified the mechanism of customized maps as the most user-friendly and intuitive approach to supply urban mobility services. In order to meet this underlying philosophy, we designed an architecture consisting of two main components, described as follows. The urban probes represent a heterogeneous set of devices/sensors deployed in the urban environment. Within the project, we also designed and developed a prototype of On Board Unit (hereafter simply OBU): a smart electronic device, installed into a vehicle, that is able to collect and send information, to process data by applying filtering techniques and communicate with the other components of the architecture. The OBU is responsible for both vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communications. In particular, this device is able, through the CAN (Controller Area Network) bus, to take a set of information from the different electronic control units in vehicles. By analysing the data collected from the CAN bus, it is possible to monitor the vehicle and, indirectly, the urban environment by crossing the data provided by multiple sources of information. Finally, we are currently implementing mobile apps to encourage citizens to actively collaborate toward a more effective and efficient urban mobility by reporting mobility-related events to the central system. The Central Processing System (hereafter simply CPS) represents the core of our architecture. This component has three main responsibilities: (a.) it permanently stores the information collected by the urban probes (Data layer); (b.) it hosts all the data-processing algorithms part of the services at the basis of the project (Core layer); (c.) it implements all the mechanisms for the interaction with the final users through customized maps (Presentation layer). In our current prototype, we adopted the Play! Java Framework [Reelsen, 2011] for the implementation of most modules, Geoserver [Deoliveria, 2008] to generate annotated maps, and PostgreSQL [Stonebraker,1986] extended with PostGIS to persistently store the collected data. The data cycle of the project can be described as follows. A generic urban probe collects an information about a parameter of interest (e.g. a car park has been released), this bit of information is pre-processed by the urban probe and sent to the CPS via the Internet, to be permanently stored by the data layer. From now on, this information is available to all the mobility services to be exploited for totally different purposes, such as updating the information about a specific parking lot. Few moments later, when the map manager refreshes the map, the number of free parks is updated.

2. S^2-Move Applications

While the platform at the basis of the project is purposely defined to be easily extended with always new and more sophisticated services, we considered a set of applications as a valuable proof of concept of the potentialities of our approach. In particular, in this work we describe Traffic Monitoring and Fleet Control.

Traffic monitoring aims at determining an accurate and complete knowledge on the traffic in the city by exploiting the limited information collected from the urban environment. Since traditional traffic monitoring systems based on heterogeneous traffic detectors (inductive loops, video camera, etc.) are particularly expensive, the S2-Move traffic monitoring service mainly relies on the information provided by OBU devices and collected thanks to the GPS (Global Positioning System), an approach already proposed in literature [Barbagli et al., 2011] [Hadachi, 2012] [Yang et al., 2005]. The idea is to infer the traffic condition by observing the speed of the monitored vehicles along the urban routes. To this end, a data collection module hosted on the OBU device samples and filters kinematics information coming from the CAN bus. On the CPS, two main modules are responsible for the data processing phase. The

Map Matching Module associates data and coordinates to the involved streets. Currently the algorithms used in project are based on geometric relations between the GPS coordinates and the position of the closest street. The Speed Estimation Module extracts a representative value for each street from the speed occurrences provided by the monitored vehicles travelling across the city.

Fleet management can be divided in two main action: Fleet Monitoring and Fleet Control. Fleet monitoring aims at tracking group of vehicles moving in the urban environment. Fleet Control, instead, allows to manage vehicle fleets such that vehicles travel in the same direction, one behind another; moreover vehicles are equipped with a longitudinal control law in order to guarantee that vehicles travel with a common velocity and a predefined intra-vehicular distance [Hedrick et al., 1994]. The platform includes the Communication Module, letting the on-board collected data to be shared between all the vehicles in the fleet (i.e. GPS, target position and speed) and includes both V2I [Belanovic et al., 2010] and V2V [Sichitiu, 2008]) communications. In this context, heterogeneous wireless communication technologies and their performance and quality of service must be carefully taken into account [Bernaschi et al., 2005],[Iannello et al., 2004],[Karres et al., 2006],[Botta et al., 2008]. The Coordination Module coordinates operations between adjacent vehicles in order to guarantee the safety for drivers. The Regulation Module collects and processes information coming from the on-board sensors in order to compute the right control effort on the vehicle actuators (i.e. throttle, braking and steering control). A more detailed description of the control law used in the simulated scenario can be found in [Marchetta et al., 2012]. A possible advancement of this control strategy is under investigation [Di Bernardo et al., 2010] (recently used to control mechanical automotive and power electronic systems in canonical forms [Di Bernardo et al., 2008],[Salvi et al., 2013]) to guarantee robustness with respect to noise and non modeled dynamics as well as rapid adaptation to changes of road conditions. Finally, the Vehicle Dynamics Module is the physical layer providing information about the vehicle motion.

3. Conclusion

The social innovation projects financed by the Italian Ministry of Education demonstrate a particular attention to the quality of life in the urban environment. In this context, S2-Move aims to contribute towards a more effective and efficient urban mobility thanks to an ICT-powered architecture able to collect and process soft-real time data. By using the collected information and applying the most innovative data analysis techniques, it is possible to derive new information that may help citizens and public administrations to develop new management strategies. The modular architecture behind the project is designed to allow the integration of new mobility services that, using the information gathered and made available at the storage level, would be able to determine new information for the end user. Accordingly, the services described in the work aim at demonstrating the potentialities of this approach.

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