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Towards the development of real time services for an optimized multimodal mobility supported by cooperative networks and open data - Advances in TIMON project

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Abstract

TIMON project (www.timon-project.eu) aims at providing Real-Time (RT) information and services through a cooperative open web-based platform and a mobile application to different transport users – drivers, Vulnerable Road Users (VRU), and businesses.
Problems such as the traffic congestion and accidents cause cities to be the principal source of pollutant emissions. TIMON provides a solution by creating a cooperative ecosystem which connects people, vehicles, infrastructure and business, with the aim of improving safety, sustainability, flexibility and efficiency of the road transport.
The system collects and stores RT data from infrastructure, cars, VRUs and open data; it processes the information using several innovative technologies, such as open data management, hybrid vehicle communications, artificial intelligence and cooperative positioning; and delivers RT services to drivers, VRUs and business particularly information on nearby accidents, traffic jams or air pollution, a multi-modal commuter and dynamic route planner.

Keywords: RT services, Open Data Management, Artificial Intelligence, Traffic Congestion, Route Planning, Hybrid Networks, Cooperative Positioning.

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1. Introduction

The persisting problems related to congestion make cities the principal source of CO_2 and other pollutant emissions. Vehicle circulation in urban environments is responsible of 40% of CO_2 emissions and for 70% of others as stated by the European Commission (2017a). The need to assist drivers in an intelligent way has become essential since the human factor is predominant in traffic accidents, which are also the main cause of congestion, increase of travel times and air pollution.

Road operators and transport companies are realizing the benefits that the knowledge data can provide and, therefore, they are increasingly sharing part of it. This is, however, causing the existence of huge amounts of data that is disorganized and heterogeneous. This fact is becoming a problem since that noteworthy amount of data cannot be directly used and it needs to go through a process of transformation and analysis in order to obtain useful information out of it.

Several projects at European level have been developed to deal with some of these problems. ICSI project which results are shown in the paper by Moreno et al. (2016), proposed a system to achieve significant energy efficiency in transportation systems through faster, dependable and more accurate sensing cycles and reactions. This, however, do not envisage either services to drivers or vulnerable road users (VRUs). TEAM project coordinated by Fraunhofer-Gesellschaft (2016) developed a collaborative transport solution for increasing traffic and reducing pollution, however no safety services are addressed. GET SERVICE project coordinated by Technische Universiteit Eindhoven (2015) provides transportation planners for a more efficient routing; however, no safety services nor multimodal routing are provided.

This paper presents TIMON project (www.timon-project.eu). TIMON is a research and innovation project supported by the European Union's Horizon 2020 programme and coordinated by the University of Deusto (2017). TIMON tries to give a solution to all these already mentioned problems by connecting people, vehicles, infrastructure and businesses into a cooperative ecosystem composed of an open web-based platform and a mobile application that deliver Real-Time (RT) information and services to all the users of the transport ecosystem – drivers, VRUs, and businesses. The creation of such an ecosystem is one of the key objectives of the project, with the aim, also, of improving safety, sustainability, flexibility and efficiency in road transport.

TIMON deals with a huge and heterogeneous amount of data from many different sources such as infrastructure, cars, pedestrians, cyclists and open data. This data is collected, harmonized, stored and turned into enriched information using several key enabling technologies (hybrid vehicular communications, artificial intelligence and cooperative positioning techniques) to provide RT services to different transport stakeholders.

This project has gone through a first phase of testing in the living lab of Helmond (the Netherlands) where the main technologies have been separately tested obtaining very promising results. A second phase is to be held also in Helmond and in Ljubljana (Slovenia) with the aim of validating the whole system integrated in a controlled environment and in a real scenario, respectively.

TIMON is being funded by Horizon 2020 Societal Challenge 4 “Smart, Green and Integrated Transport “, under the call Mobility for Growth by the European Commission (2017b). This challenge aims to boost the competitiveness of the European transport industries and achieve a European transport system that is resource-efficient, climate-and-environmentally-friendly, safe and seamless for the benefit of all citizens, the economy and society. TIMON project counts with a consortium formed by 11 organizations (Universities, RTOs, SME and big industry) from 8 different European countries (Spain, Italy, Belgium, the United Kingdom, Germany, Hungary, the Netherlands, and Slovenia), and an external panel of experts, composed by vehicles suppliers, road transport experts, City Councils etc.

The objective of this paper is to give an overview of the project and review its progress. The project results will have a direct impact on different aspects related to transport and mobility of people. TIMON will specifically contribute to increase safety thanks to the RT alerts for drivers and the VRU assistance; will improve transport efficiency by offering efficient and cost effective solutions for reducing congestion; will increase flexibility, by providing alternative options to drivers in case of traffic disruptions; and will increase sustainability, by cutting down GHG and other pollutant emissions.

The paper is structured as follows. In Section 2 the main concept of TIMON project is presented. In Section 3, the main subsystems of the project are addressed. Section 4 presents the main services offered by TIMON and Section 5 gives an overview of its general progress. Finally, Section 6 contains the conclusions of this work.

2. TIMON project concept

TIMON project tries to create useful information and services out of the huge amount of heterogeneous accessible data. For that purpose, the project follows three steps: to collect the existing open/close and RT data, to harmonize and process it, and to provide useful RT services using the processed information through an open platform and a mobile application.

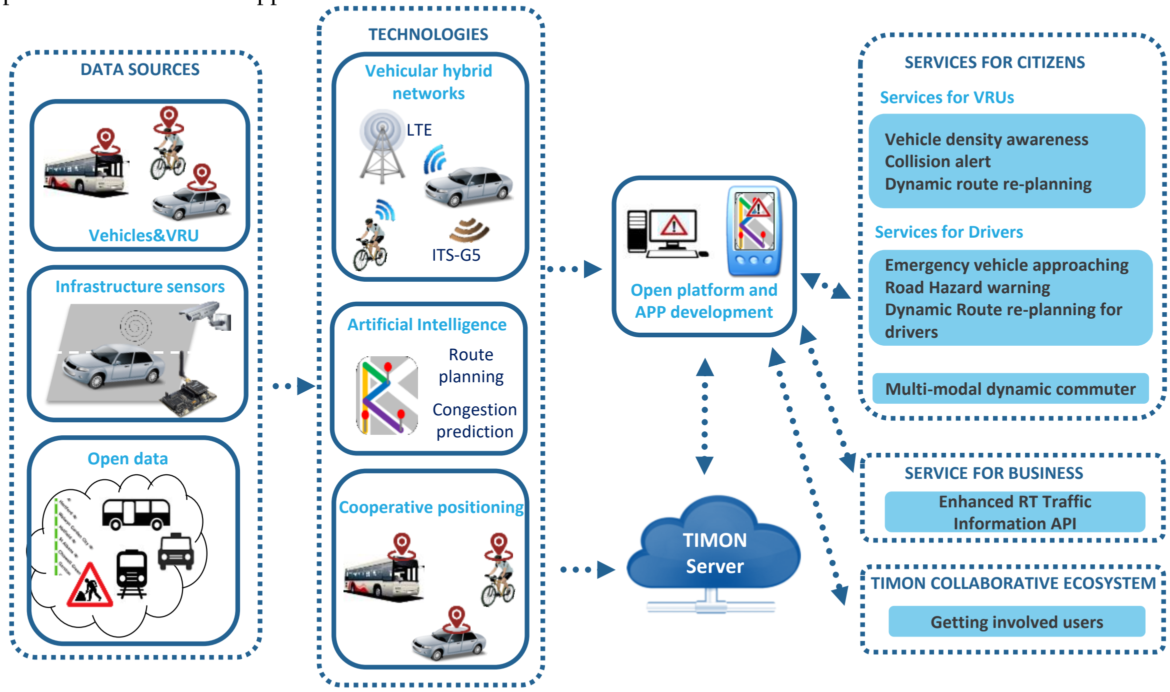

Fig. 1 TIMON project conceptual diagram.

A schema of the flow of information in TIMON is shown in Fig. 1. Data is acquired from different data sources such as vehicles and VRUs, infrastructure sensors and open data. Part of this data is collected using hybrid vehicular communications and processed using artificial intelligence and cooperative positioning techniques to produce certain subinformation. This subinformation is later used by the open platform and the mobile app providing services for drivers, VRUs and business.

TIMON consider vehicles and VRUs as sensors that are providing data to the system and return back useful information to those drivers and VRUs. Therefore, this cycle of giving and receiving information is seen as a collaborative ecosystem that brings benefits to the road users in the shape of services. The creation of such an ecosystem is one of the key objectives of the project, bearing in mind the improvement of the safety, sustainability, flexibility and efficiency of the road transport.

3. TIMON subsystems

The TIMON system is constructed over several base subsystems that are all integrated to provide common services for the road users. The main subsystems are associated to a key enabling technology, and are listed below:

3.1. Data acquisition module

The data acquisition module gathers open data related to public transport, multi-modal services, traffic information, weather/pollution data, closed data from infrastructure traffic sensors such as traffic cameras from the city of Helmond, and inductive loops and Bluetooth sensors from the city of Ljubljana. All this data is then harmonised and provided to the system in the form of a REST API using the QuickCode platform (2017), see Fig. 2. The rest of the subsystems in TIMON obtain the data they need from this API following the standard DATEX II by the Directorate General for Mobility and Transport and European Commission (2013).

Additionally, data visualisations are being developed to provide partners and third parties with the ability to monitor the open data sources. This includes a dashboard for data sources with their status and uptime statistics, as well as a Bluetooth traffic sensor uptime and speed measurement system.

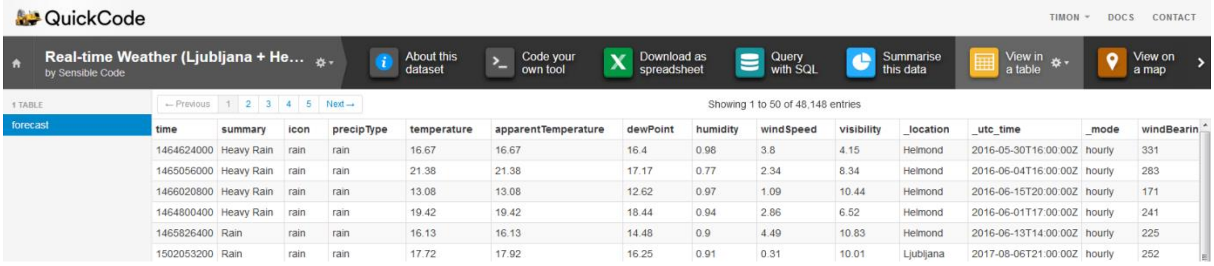

Fig. 2 QuickCode platform to collect and harmonise data.

3.2. Artificial Intelligence module

The Artificial Intelligence (AI) module is used with two main purposes: to make traffic predictions and provide real time traffic measurements (see the papers by Osaba et al. (2017) and (2016)); and second, to provide alternative and conventional multimodal routes based on the inherent flexibility of the users. Both subsystems are explained below.

- Traffic State Prediction (TSP) and Real-Time Traffic (RTT) system. On the one hand, TSP system aims to predict future states of the traffic at specified time horizons. On the other hand, RTT provides traffic information in RT. It is important to highlight that TSP uses a modification of FARCHD algorithm, by Alcala-Fdez, J. et al. (2011) to work with imbalanced data. The TSP provides traffic congestion predictions for four different time horizons (15, 30, 45 and 60 minutes). Both TSP and RTT use several types of data sources available through the data acquisition module.
- Multimodal route planning system (MRPS). Using a differential evolutionary algorithm, MRPS provides alternative routes taking advantage of the user’s inherent flexibility. The provided alternative route improves at least one aspect of the default routes, supports the optimization of citizen’s individual transport, and delivers information on various modes of transport, even in the same route. The system computes and suggests itineraries optimizing different criteria, such as the cost, the time, the length, the environmental friendliness or the safety. In this sense, every time a user asks for the planning of a route, TIMON explores the possibility of offering alternative routes which improve at least one aspect of the default routes given by the planning system. These alternative itineraries will be performed based on slight modifications in the client's preferences.

The provided AI module has been constructed using several existing tools in OpenTripPlanner (OTP) and Open Traffic (OT) such as the routing algorithm, the communication between this algorithm and the TSP and RTT, and the procedure to build the street network.

3.3. Enhanced positioning module

A standalone GNSS-based vehicle positioning prototype with sensor fusion techniques and cooperative positioning has been implemented to provide accurate positioning especially in the urban canyon environment. Additionally, this algorithm has been prepared to receive cooperative signals from the environment to improve its positioning accuracy and provide a better positioning system to the services in TIMON.

The prototype contains an Inertial Measurement Unit (IMU), a Global Navigation Satellite System (GNSS). A hybridization algorithm has been developed to increase accuracy and availability on the position of vehicles and VRUs, see Fig. 3.

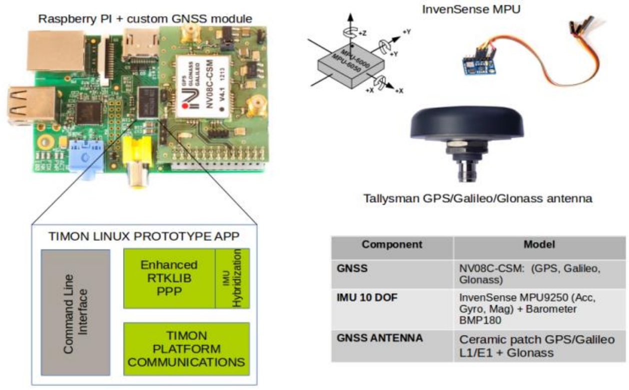

Fig. 3 TIMON positioning prototype platform.

3.4. Hybrid vehicular communications module

This module provides a reliable communication using an ITS-G5 and LTE capable hybrid communication system solution with low latency. A detailed description of this module can be found in the paper by Roscher (2016). Hybrid communications are used, in this case, for enabling communication between vehicles and VRUs, communicating vehicular network context to the TIMON cloud for traffic analysis. The TIMON cloud can also forward information about road hazards and VRUs to the GeoMessagingServer so that this information could be disseminated to the vehicular network. The communications architecture is shown in Fig. 4.

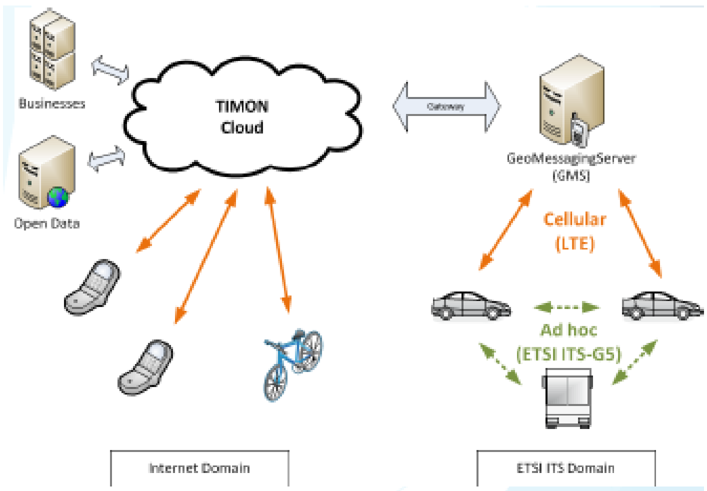

Fig. 4 Architecture of the communications in TIMON

The hybrid system enables geo-localized message distribution via cellular networks in addition to the ad hoc mode of operation using ITS-G5. This was enabled by the deployment of a dedicated server/node in the cloud responsible of managing the connected users and forwarding messages on their behalf to their destination. Protocol stack architecture of the ITS stations was also required to be extended/amended so as to support the tunnelling of messages through the LTE network to the server. A basic hybrid On Board Unit (OBU) for rapid prototyping has been developed using a Cohda MK5 for ITS-G5 and a Nexcom VTC 1010 for LTE communications, see Fig. 5.

Fig. 5 Cohda MK5 for ETSI ITS-G5 communications and Nexcom VTC 1010 for LTE communications.

For systems capable of hybrid communication, it also is significant for each station to select the most appropriate technology/technologies for message distribution. To this end, adaptive heterogeneous networking algorithms were designed/developed which will enable the cooperation of both radio technologies for better satisfying the QoS requirements of ITS applications. A simulator, show in Fig. 6, has been used to evaluate the algorithms developed which encompass different approaches ranging from estimating the availability of the underlying radio access technologies for satisfying the application requirements, rule-based algorithms based on pre-defined policies to self-learning methods adapting the technology selection online based on success/error feedback of previous attempts.

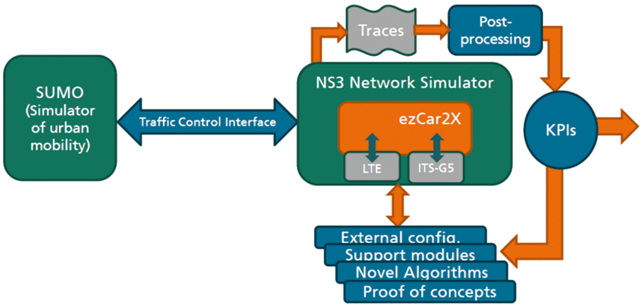

Fig. 6 Schematic of the simulators used in the testing of the hybrid communications

4. TIMON services

TIMON will deliver some information services basing on the RT data gathered and processed. The technologies explained in the previous section are integrated using a common cloud to deliver RT services. These services provide information, driver assistance and some tools for VRUs to improve their safety and provide information on nearby accidents, traffic jams and air pollution. The proposed services are classified in: services for VRUs, driver assistance services, a multi-modal dynamic commuter, an enhanced RT traffic information API and a collaborative ecosystem.

4.1. Services for Vulnerable Road Users (VRUs)

TIMON provides three services mainly focused on assisting VRUs by providing them with RT information or specific routing services. These services are listed below:

- *Vehicle density awareness*. This service provides VRUs with information regarding the density of traffic in a map based application, see Fig. 7. The information provided contains the average speed of vehicles on specific road stretches, the traffic flow for different types of vehicles (heavy duty vehicles, passenger cars, etc.) and the risk of traffic congestion on specific road stretches.
- *Collision alert*. This service warns VRUs and vehicles about their respective presence on a determined road. Hybrid communications are used to communicate vehicles' OBUs with VRUs' smartphones in order to distribute information from/to other vehicles nearby, i.e. thus providing vehicles and VRUs with a complete overview of the traffic situation.
- *Dynamic route re-planning for cyclists*. VRUs have available a fully functional dynamic route re-planning, which accounts for their particular needs and preferences: cycle lanes, roads with low traffic rates, road junction hazard levels, road inclination, preferred routes for cyclist, and traffic predictions. The re-planning of the routes is based on events that alter the initial conditions assumed for the route (e.g. accidents, increased vehicle density, etc.).

Fig. 7 Traffic density map view. Green represents light, orange medium, and red dense traffic density.

4.2. *Driver Assistance Services*

The driver assistance services consist of RT alerts that aim to increase safety and decrease the emissions of the vehicles. Drivers are informed about nearby vehicles, high traffic density situations, road works, stationary vehicles and approaching emergency vehicles. These services are listed below:

- *Emergency vehicle approaching*. This service manages the generation of warnings for all the road users that are on the proximity of an emergency vehicle. When an emergency vehicle is approaching with high speed, the road users are informed with enough time to react in leaving the path free.
- *Road hazard warning*. This service involves informing vehicle users about risky situations that might appear on the road. Examples of such situations are a stationary vehicle on the road, adverse weather conditions or road works ahead. These risky situations can be obtained from the road authorities that provide this information or can be generated by TIMON users.
- *Dynamic route re-planning applied to drivers*. This service is analogous to the one described for cyclists but adapted to the particularities of the drivers, and also including a navigation environment.

4.3. *Multimodal Dynamic Commuter Service*

The Multimodal Dynamic Commuter Service supports optimisation of citizen’s individual transport. It computes and suggests the most optimised transport route that best fits the individual citizen’s needs using RT data. The dynamism can cause the re-planning of the route due to delays, accidents, unexpected meteorological phenomena, etc.

4.4. *Enhanced RT Traffic Information API*

The Enhanced RT Traffic Information API service improves functionalities of other smartphone applications focused on enhancing road transport efficiency. This service, also business oriented, aims to provide information related to the density of traffic in areas of interest and highly accurate predictions on traffic congestion, information on road issues, etc. It is intended to be used by fleet management companies, logistics companies, etc.

4.5. *Collaborative ecosystem*

The community of TIMON users are part of an ecosystem where they provide and receive information through the services. TIMON end users are prone to share their experience on a social network based application using gamification techniques that will incentivise data sharing and good practices on the road.

5. Current state of the project and next steps

TIMON project has already been running for 28 months since June 2015. The main research technologies of the project have finished their developments and they are facing the integration phase now. The TIMON cloud is being settled to establish the communications among the involved sub-systems, the open-platform and the TIMON APP in the smartphone.

At this point of the project, the individual technologies have been tested at a living lab in Helmond (The Netherlands). During the first trials, all the subsystems and some interconnections between them have been tested using 3 vehicles, 1 motorbike and 2 bicycle. A first attempt of results has been obtained with very promising quality. However, the whole system still needs to be tested, first, in the same living lab in Helmond, and then in the city of Ljubljana encouraging local citizens to be part of the pilot.

All the subsystems have been tested in the living lab of Helmond. Here the following subsystems are presented:

5.1. RTT and TSP subsystems

Using the existing traffic cameras in the A270 road of the living lab in Helmond, the TSP and the RTT subsystems for calculation of the traffic congestion prediction and the traffic density have been tested. In addition to the traffic cameras, further data sources have been considered, such as weather forecast data and floating data coming from the TIMON APP, the OBUs installed into the 3 vehicles.

Fig. 8 Position of the traffic cameras used in the testing of the RTT system.

5.2. The enhanced positioning subsystem

The enhanced positioning subsystem has been installed into one of the testing vehicles and has been tested against an OXTS RT3003 high-precision positioning system ("RT3003," 2017) with promising results. Several testing experiments have been performed along different scenarios such as open sky or urban canyon. The OXTS system provided very good results at open sky scenarios; however, the TIMON positioning subsystem improved the OXTS in urban canyon scenarios. The track of the route proposed by the enhanced positioning subsystem in an urban canyon in Eindhoven is shown in Fig. 9.

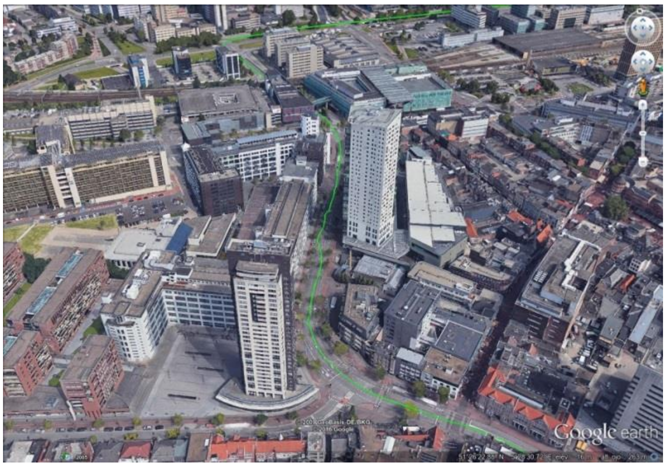

Fig. 9 Google Earth 3D representation of the selected urban canyon situation in Eindhoven.

5.3. Multimodal route planning service

Several routes have been validated and experimented in the living lab of Helmond and also through the city using cars, motorbikes and bicycles. TIMON provides more eco-friendly routes for drivers and safer routes for VRUs. Additionally, the multimodal route planning service provides alternative routes to the ones provided by OTP. These alternatives are based on slight modifications of certain parameters such as the starting time of the route, the walking speed or maximum distance, etc. In Fig. 10, an alternative route (no. 4) is provided by slightly changing the starting time to find a more suitable bus line that allows the user to reduce the waiting time in the line transfer and arrive earlier at the end of the route.

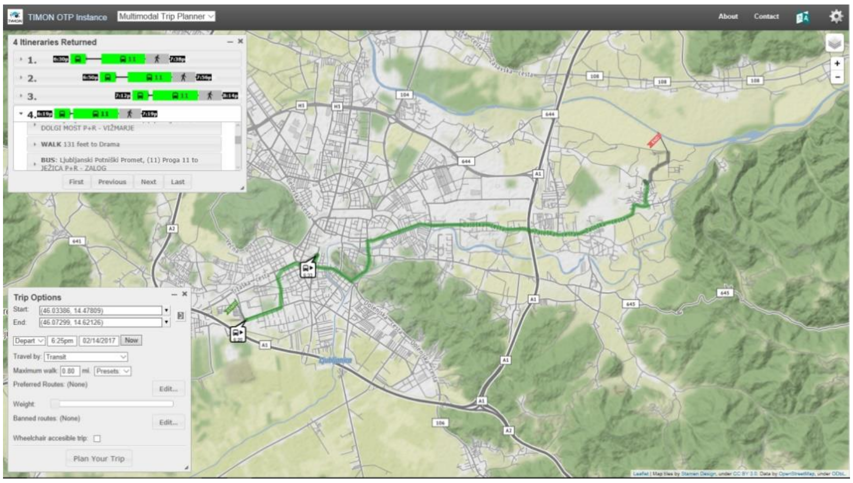

Fig. 10 Public transport route considering the alternative route provided by TIMON (No. 4) based on the flexibility of the user

5.4. Road hazard warning service

The road hazard warning service has been tested using the hybrid communications, the TIMON cloud where the road hazards are stored and the TIMON smartphone APP. The testing consisted in generating warning messages from the TIMON APP that was connected to the cloud and to the OBUs in one of the vehicles which was parked in the road. The other two vehicles were circulating around it. On this manner, both ITS-G5 and LTE communications were tested so that vehicles could interchange messages between them. The whole process was supervised from two smartphones, one at the stationary vehicle, and another one in one of the moving vehicles. In Fig. 11, the TIMON APP visualizing the results of the moving vehicle is shown. The self-position is depicted using the white arrow, the blue icon represents the two other vehicles, and the warning signal represents each of the warning messages received by the moving vehicle.

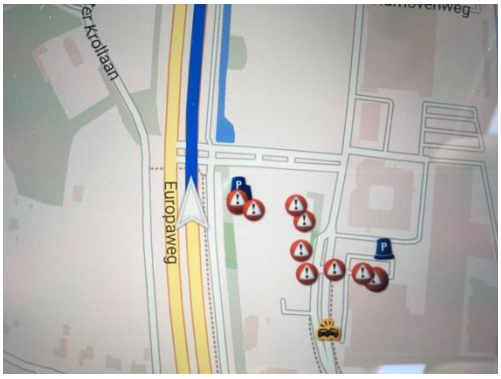

Fig. 11 Visualization of several road events on TIMON APP.

6. Conclusions

This paper presents an overview of TIMON, an H2020 research and innovation project that tries to increase safety, sustainability, flexibility and efficiency of the road transport by connecting people, vehicles, infrastructure and businesses into a cooperative ecosystem. This project presents open web-based platform and a mobile application that deliver real-time (RT) information and services to all the users of the transport ecosystem – drivers, vulnerable road users (VRU), and businesses.

The paper shows the main features of the project and the progress the 28 months it has been executed. The main technologies and services have been presented and some of the testing performed in the living lab of Helmond (The Netherlands) have been gathered and explained.

Acknowledgements

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7. References

Alcala-Fdez, J., Alcala, R., Herrera, F., 2011. A fuzzy association rule-based classification model for high-dimensional problems with genetic rule selection and lateral tuning. IEEE Trans. Fuzzy Syst. 19, 857–872. doi:10.1109/TFUZZ.2011.2147794

Directorate General for Mobility and Transport, European Commission, 2013. DATEX II V2.2 USER GUIDE.

European Commission, 2017a. Clean transport, Urban transport. Urban mobility [WWW Document]. URL https://ec.europa.eu/transport/themes/urban/urban_mobility_en

European Commission, 2017b. Smart, Green and Integrated Transport [WWW Document]. URL https://ec.europa.eu/programmes/horizon2020/en/h2020-section/smart-green-and-integrated-transport

Fraunhofer-Gesellschaft, 2016. Tomorrow's Elastic, Adaptive Mobility [WWW Document]. URL http://cordis.europa.eu/project/rcn/105873_en.html

Moreno, A., Osaba, E., Onieva, E., Perallos, A., Iovino, G., Fernández, P., 2016. Design and Field Experimentation of a Cooperative ITS Architecture Based on Distributed RSUs. Sensors 16, 1147. doi:10.3390/s16071147

RT3003 [WWW Document], 2017. . OxTS. URL http://www.oxts.com/product/rt3003/ (accessed 9.5.17).

Roscher, K., 2016. TIMON: Enhanced real time services for an optimized multimodal mobility relying on cooperative networks and open data (Presentation). Presented at the IEEE Workshop on Cooperative Communication and Positioning (IV CCP), Göteborg, Sweden.

Osaba E., Lopez-Garcia P., Onieva E., Masegosa A.D., Serrano L., Landaluce H., 2017. Application of Artificial Intelligence Techniques to Traffic Prediction and Route Planning, the vision of TIMON project. Presented at the 12th ITS European Congress, Strasbourg, France. doi:10.5281/zenodo.894076

Osaba, E., Lopez-Garcia, P., Masegosa, A.D., Onieva, E., Landaluce, H., Perallos, A., 2016. TIMON Project: Description and Preliminary Tests for Traffic Prediction Using Evolutionary Techniques. Presented at the Genetic and Evolutionary Computation Conference (GECCO 2017), Denver, USA.

QuickCode — Solve data problems + Boost coding skills [WWW Document], 2017. . QuickCode. URL http://quickcode.io/ (accessed 9.18.17)

Technische Universiteit Eindhoven, 2015. Service Platform for Green European Transportation [WWW Document]. URL http://cordis.europa.eu/project/rcn/105698_en.html

University of Deusto, 2017. Enhanced real time services for an optimized multimodal mobility relying on cooperative networks and open data [WWW Document]. URL http://cordis.europa.eu/project/rcn/193386_es.html