INNOSOC Case Study

(selected for Zagreb 2016; extended version)

Case Study title:

Intelligent Transport Systems and Vehicular Ad hoc Networks

Keywords: Intelligent transport systems; Vehicular ad hoc networks; Car-to-car communications

H2020 challenge addressed by the Case Study: Smart, green and integrated transport

Introduction to the Case Study

Increasing demands for different kind of **transportations** (road, railways, air) will generate higher density of vehicles, traffic jams, high number of fatal accidents and high level of environmental risks. The **Intelligent Transport Systems (ITS)** add information and communication technology (ICT) for elements of transportation systems to ensure new challenges in fields of **safety, economy, reliability and efficiency**.

In the near future the ITS will focus on the road transport, enabling introduction of different services from toll collection to driver assistant systems [2]. Subsystems of ITS will later act as the base of the autonomous car, or a "driverless car". The ITS communication system in case of road transport is based on wireless ad-hoc communication [1], called **vehicular ad hoc networks (VANETs)**.

The concept of leveraging wireless communication in vehicles has fascinated researchers since the 1980s. The last few years have witnessed a large increase in research and development in this area. Several factors have led to this development, including the wide adoption (and subsequent drop in cost) of IEEE 802.11 technologies, the embrace of vehicle manufactures of information technology to address **safety, environmental, and comfort issues** of their vehicles, and the commitment of large national and regional governments to allocate **wireless spectrum** for vehicular wireless communication. While cellular networks enable convenient voice communication and simple infotainment services to drivers and passengers, they are not well suited for certain direct **Vehicle-to-Vehicle** or **Vehicle-to-Infrastructure** communications. On the other hand VANETs, a direct communication between vehicles and to and from **roadside units** (RSU), can send and receive hazard warnings or information on the current traffic situation with minimal latency.

The major goals of these activities are to **increase road safety** and **transportation efficiency** as well as to **reduce the impact of transportation on the environment**. These three classes of applications of VANET technology are not completely orthogonal: for example, reducing the number of accidents can in turn reduce the number of traffic jams which could reduce the level of

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environmental impact. Due to the importance of these goals for both the individual and the nations, various projects are underway, or recently completed.

Five INNOSOC students, supervised by two INNOSOC lecturers, will collaborate on answering how intelligent transport systems and vehicular ad hoc networks can contribute to building sustainable transport systems of the future. These activities will be conducted as a part of the ERASMUS+ blended mobility and will be finalized during INNOSOC Zagreb 2016 workshop in late April 2016.

How this Case Study is related to the selected H2020 challenge?

The future **smart, green and integrated transportation** is a very important challenge of the Horizon 2020, which reflects the policy priorities of the Europe 2020 strategy.

This Case Study deals with Intelligent Transportation Systems (ITS) and with Vehicular Ad-hoc Networks (VANET), which will be the technical background of the **green, safe and economical road traffic** in the future. Nevertheless, introducing elements of ITS requires international standardization, frequency management considerations and usage of interference resistant radio communication technologies.

The term VANET was originally adopted to reflect the “ad hoc” nature of these highly dynamic networks. However, since the term “ad hoc networks” has widely been associated with unicast routing related research, there is currently a debate among the pioneers of this field about redefining the acronym “VANET” to deemphasize ad hoc networking. Since this discussion is not yet reached consensus, we will continue to refer to **Vehicle-to-Vehicle** and **Vehicle-to-Roadside** communication based on wireless local area networking technology as a VANET.

Typically, applications are categorized as:

1. **“safety” applications** (examples: traffic signal violation warning, curve speed warning, emergency electronic brake light, pre-crash sensing, cooperative forward collision warning, left-turn assistant, lane change warning and stop sign movement assistant);
2. **“transport efficiency” applications** (examples: enhanced route guidance and navigation, green light optimal speed advisory and lane merging assistants);
3. **“information/entertainment” applications** (examples: remote wireless diagnosis, tolling, point-of-interest notifications, fuel consumption management, podcasting and multi-hop wireless Internet access).

How this Case Study is related to the INNOSOC project?

Main goal of this Case Study is to give opportunity for students coming from different countries to work on an **innovative problem** and work together through the **blended mobility** teaching and learning instrument. The intercultural part of the project focuses on **multicultural team**

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building, teamwork using telecommunication facilities, presentation of results as well as **exchange of good practices** from different cultures.

While working on this Case Study students will get familiar with up to date radio communication technologies and their application in the road traffic. They will study advantages and disadvantages of wireless telecommunication technologies, impacts of Intelligent Transportation Systems (ITS) and with Vehicular Ad-hoc Networks (VANET) to road safety, economics and logistics. The Case Study will give a traffic coordination systems overview for students studying in different countries of the EU.

Questions that need answers during the Case Study development

- Which kind of sensor and telecommunication networks we need for application of driverless car in the future?
- Which type of information we should transmit in the Intelligent Transport Systems? What is the needed bit rate for different services?
- Which propagation properties have frequency bands allocated to ITS systems? Which telecom technologies are deployed on these frequencies? [3]
- What are properties of wave propagation in the road environment with obstacles and/or reflection?
- How can we calculate interference in Car-to-Car communications?
- What are properties of the Cooperative Forward Collision Warning service?
- What are options for Internet access in vehicles?
- What are potential applications for the Vehicle-to-Infrastructure opportunistic communications?

References

[1] Advanced intelligent transport systems radiocommunications ITU Report ITU-R M.2228-1(07/2015)
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[3] Technical characteristics for communications equipment in the frequency band from 63GHz to 64 GHz; System Reference Document ETSI Technical Report TR 102 400
[4] B. Ducourthial: A Tutorial on Vehicular Networks. https://www.hds.utc.fr/~ducourth/dokuwiki/_media/fr/t-tutorial-vanet-jnctt2011-bducourthial.pdf
[5] G. Karagiannis, O. Altintas, E. Ekici, G. Heijenk, B. Jarupan, K. Lin, T. Weil: Vehicular Networking: A Survey and Tutorial on Requirements, Architectures, Challenges, Standards and Solutions. Communications Surveys & Tutorials, IEEE (Volume:13, Issue: 4), 2011, pp 584-616.

Knowledge and skills needed for developing the Case Study

(P: prerequisite; D: desirable, but not necessary)

- Basic knowledge in field of radio communications (P)
- Wireless communications basics (P)

- Interest in smart car systems(D)
- Mobile communications system basics (D)

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Figures describing this Case Study

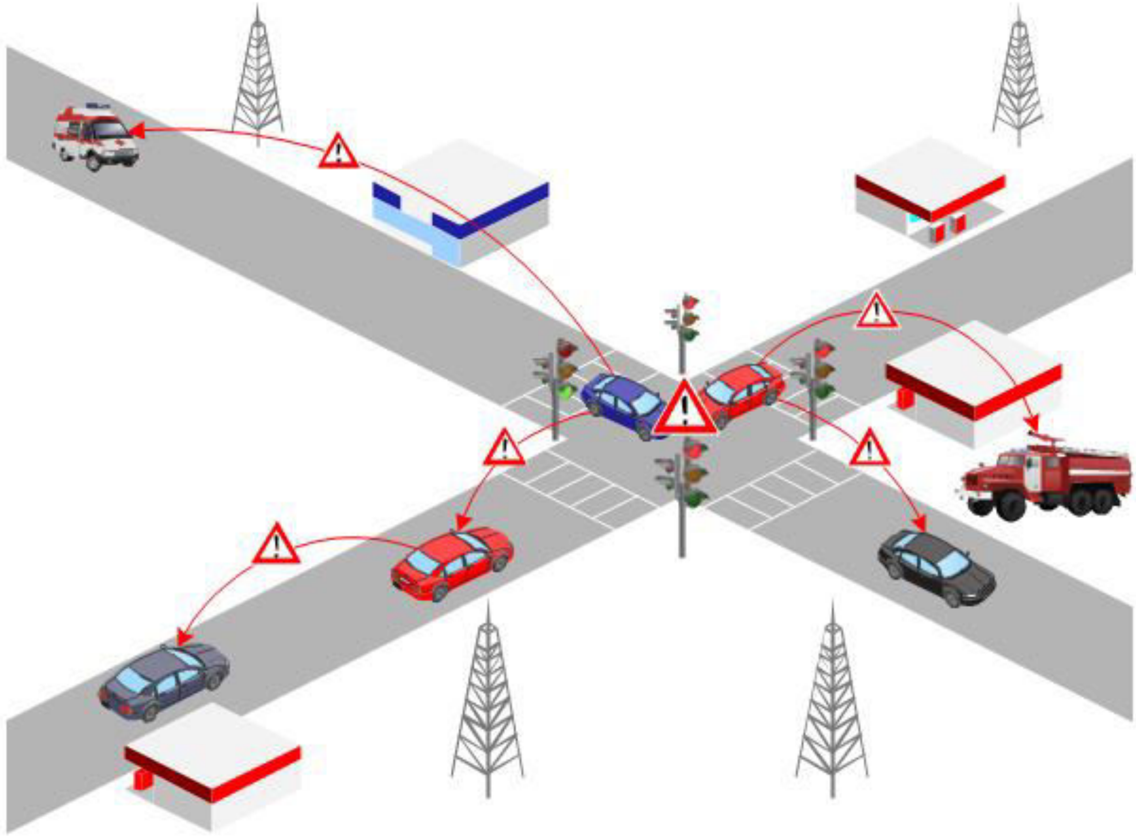

Figure 1. Examples of Vehicular Ad-hoc Network (VANET) Applications

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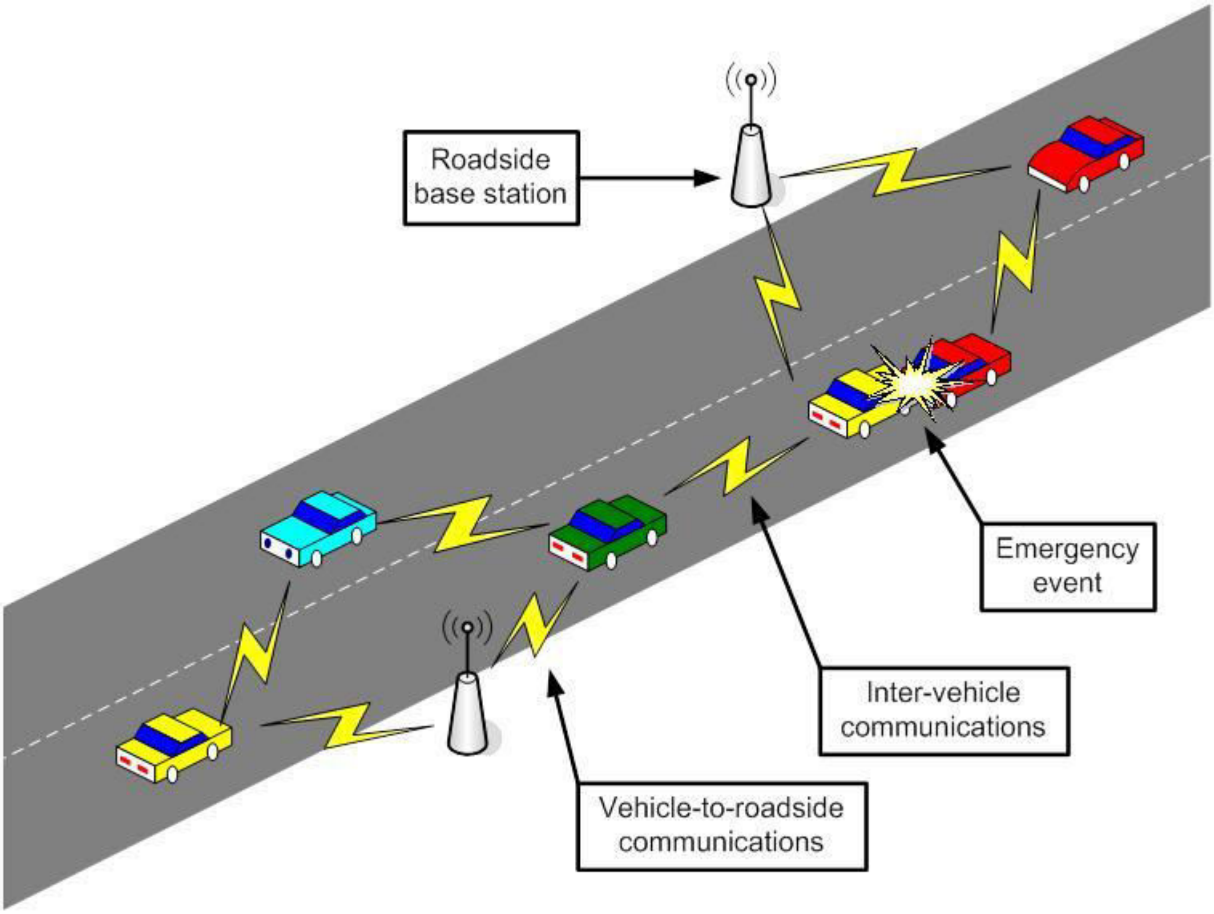

Figure 2. Vehicular Ad-Hoc Networks (Car-to-Car communications)

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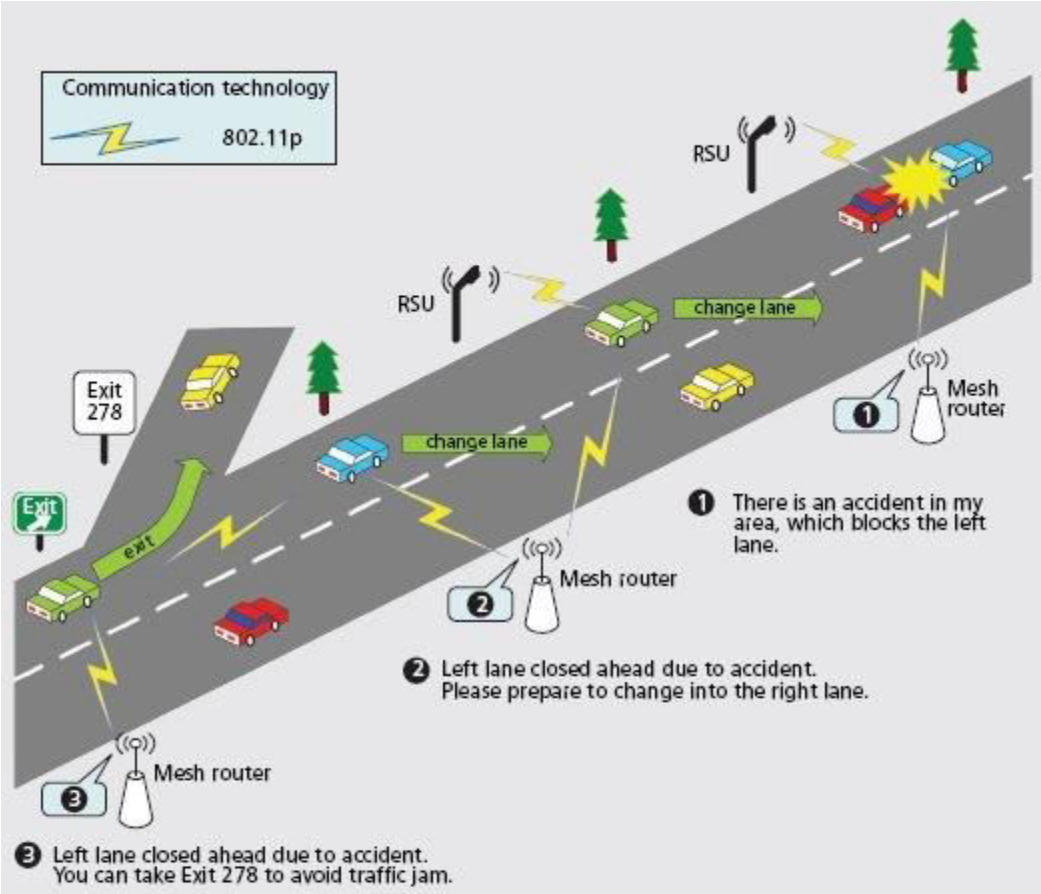

Figure 3. Car-to-Infrastructure communications

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