



ERCIM "ALAIN BENSOUSSAN"
FELLOWSHIP PROGRAMME



Scientific Report

First name / Family name	Ali Balador
Nationality	Iranian
Name of the <i>Host Organisation</i>	SICS Swedish ICT AB
First Name / family name of the <i>Scientific Coordinator</i>	Hans Hansson
Period of the fellowship	01/04/2016 to 31/03/2017

I – SCIENTIFIC ACTIVITY DURING YOUR FELLOWSHIP

The fellow studied available protocols and standards, such as IEEE 802.11p and cellular standards, for vehicular communication especially for platooning application, and proposed enhancements or new solutions to improve the total performance. For evaluation purposes, different performance metrics have been studied and optimal metrics selected to compare existing solutions against our own. To simulate different communication protocols and environments, including highway, urban, and platooning scenarios, the fellow studied different available simulators and selected Veins and Plexe simulator platforms (a bidirectional coupled simulator, including OMNeT++ and SUMO), which are used especially for vehicular scenarios and platooning applications. Veins couples SUMO and the INET framework from OMNeT++ through a TCP connection. OMNeT++ is therefore able to send commands to vehicles from the network simulator, influencing their speed or path. Plexe is an extension of Veins which permits the realistic simulation of platooning application. It features realistic vehicle dynamics and several cruise control models, permitting the analysis of control systems, large-scale and mixed scenario, as well as networking protocols and cooperative maneuvers.

During the fellowship period, the fellow presented his research outcomes in several workshops, conferences, and seminars and attended several meetings to extend his network and gain contacts in both academia and industry.

II – PUBLICATION(S) DURING YOUR FELLOWSHIP

Unpublished Papers:

1. Communication Middleware Technologies for Industrial Distributed Control Systems: A Literature Review, **Ali Balador**, Ready to Submit to 22nd IEEE International Conference on Emerging Technologies and Factory Automation, September 12-15, 2017, Limassol, Cyprus.
2. A Reliable Token-Based MAC Protocol Supporting Beacons and Event-Driven Messages in Platooning Applications, **Ali Balador**, Annette Bohm, Elisabeth Uhlemann, Carlos T. Calafate, Yusheng Ji and Juan-Carlos Cano, Ready to Submit to IEEE Transactions on Intelligent Transportation Systems.
3. An anomaly based Intrusion Detection System for MANETs: Reducing Detection Cost using a Neural Network Scheme, Samira Hosseini Talari, Sam Jabbehdari, **Ali Balador** and Dimitris N. Kanellopoulos, Ready to Submit to International Journal of Information Security and Privacy (IJISP).

Published Papers:

4. A Density-Based Contention Window Control Scheme for Unicast Communications in Vehicular Ad Hoc Networks, **Ali Balador**, Carlos T. Calafate, Juan-Carlos Cano and Pietro Manzoni, International Journal of Ad Hoc and Ubiquitous Computing, 24(1-2): 65-75, 2017. **Abstract:** Achieving a well-designed medium access control (MAC) protocol is a challenging issue to improve communications efficiency due to the dynamic nature of vehicular ad hoc networks (VANETs). IEEE 802.11p standard was selected as the best choice for vehicular environments considering its availability, maturity, and cost. The common problem in all IEEE 802.11 based protocols is scalability, exhibiting performance degradation in highly variable network scenarios. Experimental results for the IEEE 802.11-based MAC protocol show the importance of contention window adjustment on communications performance; however the vehicular communications community has not yet addressed this issue in unicast communication environments. This paper proposes a novel contention window control scheme for VANET environments based on estimating the network density, which is then used to dynamically adapt the CW size. Analysis and simulation results show that our proposal provides better overall performance compared with previous proposals, even in high network density scenarios.
5. A Reliable Token-Based MAC Protocol for V2V Communication in Urban VANET, **Ali Balador**, Annette Bohm, Carlos T. Calafate and Juan-Carlos Cano, IEEE PIMRC 2016, Valencia, Spain, 4-7 September, 2016. **Abstract:** Safety applications developed for vehicular environments require every vehicle to periodically broadcast its status information (beacon) to all other vehicles, thereby avoiding the risk of car accidents in the road. Due to the high requirements on timing and reliability posed by traffic safety applications, the current IEEE 802.11p standard, which uses a random access Medium Access Control (MAC) protocol, faces difficulties to support timely and reliable data dissemination in vehicular environments where no acknowledgement or RTS/CTS (Request-to-Send/Clear-to-

Send) mechanisms are adopted. In this paper, we propose the Dynamic Token-Based MAC (DTB-MAC) protocol. It implements a token passing approach on top of a random access MAC protocol to prevent channel contention as much as possible, thereby improving the reliability of safety message transmissions. Our proposed protocol selects one of the neighbouring nodes as the next transmitter; this selection accounts for the need to avoid beacon lifetime expiration. Therefore, it automatically offers retransmission opportunities to allow vehicles to successfully transmit their beacons before the next beacon is generated whenever time and bandwidth are available. Based on simulation experiments, we show that the DTB-MAC protocol can achieve better performance than IEEE 802.11p in terms of channel utilization and beacon delivery ratio for urban scenarios.

6. A Token-Based MAC Protocol for Achieving High Reliability in VANET, **Ali Balador**, BMW Summer School, Lake Tegernsee, Bavaria, Germany, July 18-23, 2016.
7. A Reliable and Efficient Token-Based MAC Protocol for Platooning Applications, **Ali Balador**, Annette Bohm, **Elisabeth Uhlemann**, Carlos T. Calafate, and Juan-Carlos Cano, SNCNW 2016, Sundsvall, Sweden, 1-2 June, 2016. **Abstract:** Platooning is both a challenging and rewarding application. Challenging since strict timing and reliability requirements are imposed by the distributed control system required to operate the platoon. Rewarding since considerable fuel reductions are possible. As platooning takes place in a vehicular ad hoc network, the use of IEEE 802.11p is close to mandatory. However, the 802.11p medium access method suffers from packet collisions and random delays. Most ongoing research suggests using TDMA on top of 802.11p as a potential remedy. However, TDMA requires synchronization and is not very flexible if the beacon frequency needs to be updated, the number of platoon members changes, or if retransmissions for increased reliability are required. We therefore suggest a token-passing medium access method where the next token holder is selected based on beacon data age. This has the advantage of allowing beacons to be re-broadcasted in each beacon interval whenever time and bandwidth are available. We show that our token-based method is able to reduce the data age and considerably increase reliability compared to pure 802.11p.

III – ATTENDED SEMINARS, WORKHOPS, CONFERENCES

1. SICS Open House Seminar, Stockholm, Sweden, April 15, 2016.
2. SafeCOP kickoff meeting, Milan, Italy, April 19-22, 2016.
3. SICS Vasteras workshop, Vasteras, Sweden, May 15, 2016.
4. SNCNW 2016 conference, June 1-2, 2016.
5. BMW Summer School, Lake Tegernsee, Bavaria, Germany, July 18-23, 2016.
6. IEEE PIMRC 2016 conference, Valencia, Spain, September 4-7, 2016.
7. Workshop on Wireless Communication in Automotive Environment, Goteborg, Sweden, September 28-29, 2016.
8. AUTONET2030 Final Workshop, AstaZero, Sandhult, Sweden, October 27, 2016.
9. Workshop on Wireless Vehicular Communications, Halmstad, Sweden, November 2, 2016.

10. SafeCOP workshop, Copenhagen, Denmark, November 14-15, 2016.
11. Industrial Internet of Things (IIoT), Stockholm, Sweden, December 2, 2016.
12. Indoor and Outdoor Positioning in the Internet of Moving Things, Stockholm, Sweden, March 10, 2017.
13. Why WiFi?, Stockholm, Sweden, March 17, 2017.
14. European Truck Platooning, Brussels, Belgium, March 21, 2017.
15. Digitalization and Industry 4.0, Stockholm, Sweden, March 27-28, 2017.

IV – RESEARCH EXCHANGE PROGRAMME (REP)

The fellow visited the Italian National Research Council (CNR) in Bologna, Italy for a duration of two weeks from November 16 to November 30 of 2016. The fellow together with the research group members at CNR, including Dr. Alessandro Bazzi, Dr. Barbara Masini, and Dr. Alberto Zanella focused on wireless communication for platooning application. Several meetings took place with the research group to find out potential future collaborations and to know about each member's research activities and results. At the end of the exchange programme, both sides agreed on a plan for studying platooning applications and providing a set of minimum communication requirements for this application to be published as a journal or magazine paper. The work is continuing after the termination of the exchange period to prepare a paper to be published in the vehicular communication magazine in 2017.