

Titre de la thèse – PhD Title:

Hybridation de la 5G-V2X avec d'autres technologies de communication dans le contexte des ITS coopératifs

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Hybridization of 5G-V2X with other communication technologies in the context of cooperative ITS

Collaboration- Partnership: *IMT Atlantique / SRCD*

IMT Atlantique : Campus Brest Nantes Rennes

Laboratory : IRISA

École doctorale : SPIN 3MG

Financement - Funding: PEPR 5G (Fitness)

**Context:**

IMT Atlantique, internationally recognised for the quality of its research, is a leading general engineering school under the aegis of the Ministry of Industry and Digital Technology, ranked in the three main international rankings (THE, SHANGHAI, QS).

Located on three campuses, Brest, Nantes and Rennes, IMT Atlantique aims to combine digital technology and energy to transform society and industry through training, research and innovation. It aims to be the leading French higher education and research institution in this field on an international scale. With 290 researchers and permanent lecturers, 1000 publications and 18 M€ of contracts, it supervises 2300 students each year and its training courses are based on cutting-edge research carried out within 6 joint research units: GEPEA, IRISA, LATIM, LABSTICC, LS2N and SUBATECH.

The proposed thesis is part of the research activities of the team: EASE (Enable Affordable Smart Environment) and of the laboratory IRISA (<http://irisa.fr>) and the department SRCD (Système Réseaux, Cybersécurité et Droit du numérique). The scientific activities of this department are related to networks and telecommunications.

The IRISA EASE research group aim to ease development, deployment, evolution and maintenance of pervasive applications in complex environments with a strong focus on smart cities and smart agriculture. We are especially interested in cooperative autonomy applied to autonomous vehicles. We develop a comprehensive set of new interaction models and we are interested in new communication technologies that could support such local ephemeral interactions. 5G-V2X is one of these technologies.

The project takes place in a larger project (<https://www.cnrs.fr/en/pepr/pepr-dacceleration-5g>) launched by the French government in order to responds to the challenges of 5G and the networks of the future.

Scientific and technological context:

V2X (Vehicle to Everything) technology is pivotal in reducing road accidents, offering real-time communication among vehicles and infrastructure to enhance situational awareness and prevent collisions, aligning with the European Union's strategy to improve road safety and move towards a vision of zero road fatalities. Indeed, in order to decrease fatalities on roads while maintaining efficiency, vehicles will have to cooperate together and with roadside infrastructure using V2X communication technologies. Several technologies are in competition to gain access to the 5 GHz ITS bands, and other mass-market communication technologies could be used in order, for example, to cooperate with other devices (smartphone). The ITS (Intelligent Transportation Systems) communication architecture has to evolve to allow the cohabitation of multiple incompatible communication technologies and their unavoidable evolutions.

In the context of V2X communication, the team is interested in the way information is exchanged to enhance the various involved devices (vehicles, smartphone, roadside equipment, ...) making safety related decisions. Awareness information is to be broadcast by all allowed to use reserved channels. For these basic use cases, ITS-G5 - an evolution of WiFi technology - has been designed, experimented and validated for more than ten years. It is now ready to be deployed on a large scale.

Unfortunately, deployment of V2X has been delayed by uncertainties over the communication technology to be chosen by the market or the regulator. It is very likely that several technologies will coexist to meet the needs of basic services and advanced services, which are much more restrictive in terms of delay and bandwidth.

In this context, the development of 5G-V2X offers many opportunities but introducing a new V2X mode ready to operate in the 5 GHz ITS band, 3GPP, raised the question of which technology - ITS-G5, LTE-V2X or future NR- V2X - should be deployed for which services and hybridizing 5G-V2X with other communication technologies in the context of cooperative-ITS have to be studied and developed.

Beyond the choice of the V2X technology, it is obvious that several technologies will have to coexist in the same 5 GHz frequency band or in different channels, and even more could have to cooperate to share the spectrum or to allow building interoperable ITS service on top of these multiple technologies with or without the support of a multi-technology infrastructure.

This hybridization of V2X technologies mix has to be considered and this work aims at exploring the conditions and mechanisms necessary to allow such hybridization in the ITS communication stack. Moreover, new radio technologies take advantage of active antennas to improve radio efficiency. The broadcasting zone could then be finely tuned according to each message purpose. The communication architecture has to be evolved to allow upper layer (Facilities layer) to control beamforming and transmission power in order to optimize spectrum consumption without preventing ITS services to work properly, ie. according to their requirements.

Expected contributions of the Thesis:

On its side, IMT Atlantique will study cross-layer mechanisms allowing cooperation through multiple V2X technologies and evaluate them through simulations and proof-of-concept. The cross-layer approach will allow us to take into account high level requirements (from ITS services) in the way communication layer are used, without modifying standard network API. We, then include mass-market communication technologies in order to include smart-phones and low energy devices into safety-related service scenario.

For each message/application, the decision mechanism will choose the most suitable communication interface and its configuration, using the infrastructure (roadside, 5G) when available. The work will be first applied within a more controlled environment (AGV in industry) prior to a generalization in Cooperative ITS context.

Profil du candidat – Required skills:

- Network architecture and protocols
- 4G and ideally 5G technologies (3GPP)
- Simulation
- Standard soft skills for a doctoral thesis (imagination, precision, tenacity, listening, team spirit)
- Fluent English

Plan de travail – Work Plan:

- Skill development: 3GPP standard (5G), V2X communication technologies, ITS services
- State-of-the-art on multi-interface management
- Definition of target scenarios and KPIs
- Implementation of the simulation platform
- Definition of the selection algorithms and the cross-layer mechanisms
- Evaluation of the proposed solutions
- Possible participation to standardization bodies (ETSI, ISO)

Candidature – Application:

To apply for this position, please send a detailed application including a cover letter, an up-to date CV, transcripts of grades and reference letters will be addressed to: Jean-Marie Bonnin (jm.bonnin@imt-atlantique.fr)

Renseignements complémentaires - Additional Informations :

- Date de fin de candidature - Application deadline : April 30th 2024

- Date de démarrage de la thèse- Start date : September-October 2024
- Durée du contrat- Contract duration: 36 months
- Localisation - Location :
 - IMT Atlantique, campus de Rennes, 2 rue de la Chataigneraie, 35510 Cesson Sévigné
 - The thesis will be in IMT Atlantique (campus of Rennes) premises and bound to IRISA Lab (<https://www.irisa.fr/>).
 - The doctorale school is SPIN: <https://ed-spin.doctorat-bretagne.fr/fr/lecole-doctorale>
- Contact(s) : jm.bonnin@imt-atlantique.fr