

# CNMS - Cross layer design of next generation communications, networking, and computing in connected vehicular environments

## Background

Vehicle to everything (V2X) communications and networking have the potential to provide a considerable contribution to the increase of the sustainability and quality of life in urban and suburban areas, by better control of road traffic, reducing battery drainage of electric powered vehicles, and CO2 emissions of combustion-engine based ones. They are also a means to increase safety, including vehicles' passengers, pedestrians, and items. Efficiency, in terms of both energy consumption and spectrum use, and reliability of vehicular communication and networking solutions can be significantly increased by introducing new networking paradigms, which combine traditional communications in the sub-10-GHz bands (e.g., cellular networks and WiFi), with emerging wireless communication technologies such as visible light communications (VLC) and intelligent reflecting surfaces (IRS). Another dimension along which an increase of efficiency and effectiveness of the V2X-enabled connected vehicles paradigm should be pursued is the interplay between the communication and networking capabilities and the design of tools and algorithms implementing application-level functions that can be executed by the connected vehicles while in traffic. Such functions enable, for instance, collision avoidance, safe overtaking, flow control in crossroads and roundabout crossings, semaphore-vehicles interactions, as well as less locally targeted functions such as traffic-aware route planning.

The UI-IIT research unit of the CNR Institute for Informatics and Telematics is carrying on research activity in the aforementioned domain within the context of the Italian National competence center for suSTainable MObility (MOST) funded by the EU through the Italian National Recovery and Resilience Plan (NRRP).

## Topic description

The research in the cross-layer networking and protocol design along the two dimensions mentioned above, i.e., the combination of different communication and networking technologies and the interplay with the application-level functions, is a challenging task. Within the context of the MOST National competence center, the UI-IIT research unit intends to design and test novel networking and distributed computing schemes which leverage the multiple access technologies available in the next generation vehicular environments, and the computing capabilities in the vehicles to perform assisted or autonomous driving functions. Within the same project, the UI-IIT research unit is involved in the realization of a multi-vehicle reduced-scale testbed with up to 10 vehicles equipped with on board units, LiDar and camera sensors, and powerful GPUs, and vehicular on board units. The testbed development will go hand in hand with the theoretical studies on the networking and computing solutions in such a way that the testbed will be used, along with state of the art simulations tools, for the performance evaluation of the solutions proposed in the research activity.

In summary, the research activities of the group in this area will consist in:

- the definition and solving of optimisation problems related to vehicular networks leveraging multiple medium access technologies, with objectives and constraints pertaining to the different involved domains, i.e., networking, computing, and application level. This activity will follow a strongly experimentally driven approach;
- the development of a reduced-scale testbed which will include the fundamental system elements (vehicles equipped with different types of sensors and on board units, road-side units, etc.);
- the testbed- and simulation-based performance evaluation of the devised solutions.

## Type of prospect positions

On this topic, we plan to open the following positions:

- 1-year Researcher position (ricercatore a tempo determinato)
- 1-year Research Fellow position (assegno di ricerca professionalizzante) , renewable for an additional year.

## Funding and partnerships

*Supported by:* **MOST**: National Competence Center on Smart Mobility (funded by the National Recovery and Resilience Plan (NRRP), European Union - NextGenerationEU)

## Candidate profiles

- For the renewable **1-year Research Fellow position** (assegno di ricerca professionalizzante) - which will be renewable for an additional year, we seek candidates with a MSc degree, or about to obtain it in Computer Science, Computer Engineering, Communications Engineering, Mathematics, or closely related disciplines, and a proven track record of excellent University grades.

The candidate is required to have experience/knowledge/skills in the following topics and/or tools or type of activity:

- wireless access technologies and protocols for mobile networks;
- C++, Java, Javascript, python Programming languages;
- wireless network simulation

Knowledge or experience in machine learning and/or Artificial intelligence algorithms, and in prototyping/testing activity are also welcome.

Good written and spoken communication skills in English are required.

The candidate will contribute to the research on the topic by the involvement in the set-up of a reduced-scale multi-vehicle testbed composed of car-shaped 4-wheel robots and in the design and performance evaluation of communication, networking, and distributed computing algorithms and protocols.

- For the **1-year Researcher position** we seek candidates with a PhD, or about to obtain it in Computer Science, Computer Engineering, Communications Engineering, Mathematics, or closely related disciplines, a proven track record of excellent University grades and publications in relevant top-tier conferences and journals.

The candidate is required to have experience/knowledge in the area of next generation wireless networks, heterogeneous and multi-RAT mobile or vehicular networks. Preferably the MSc/PhD thesis of the candidate should be in this area.

The candidate should have knowledge and be skilled in the use of tools in one (or preferably more) of the following areas

- multi-objective optimization,
- machine learning and Artificial Intelligence,
- statistics and probability,

and have experience in network simulations and/or prototyping/testing.

Good written and spoken communication skills in English are also required.

The research activity to carry out during the contract shall be focused on the topic of the project which funds the position and shall involve the definition of specific research problems pertaining the design of communication, networking, and computing algorithms and protocols in the area of communications, networking, and distributed computing in connected vehicular environments.

## Contacts



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