Optimization of wireless sensor networks communications within a collaborative intelligent transportation system

Ph.D. candidate: Ali MAMADOU MAMADOU. **Supervisors:** Gérard CHALHOUB[1], Joël TOUSSAINT[1]

[1] ***University of Clermont Auvergne***

UNIVERSITÉ Clermont Auvergne

Ecole doctorale Sciences Pour l'Ingenieur

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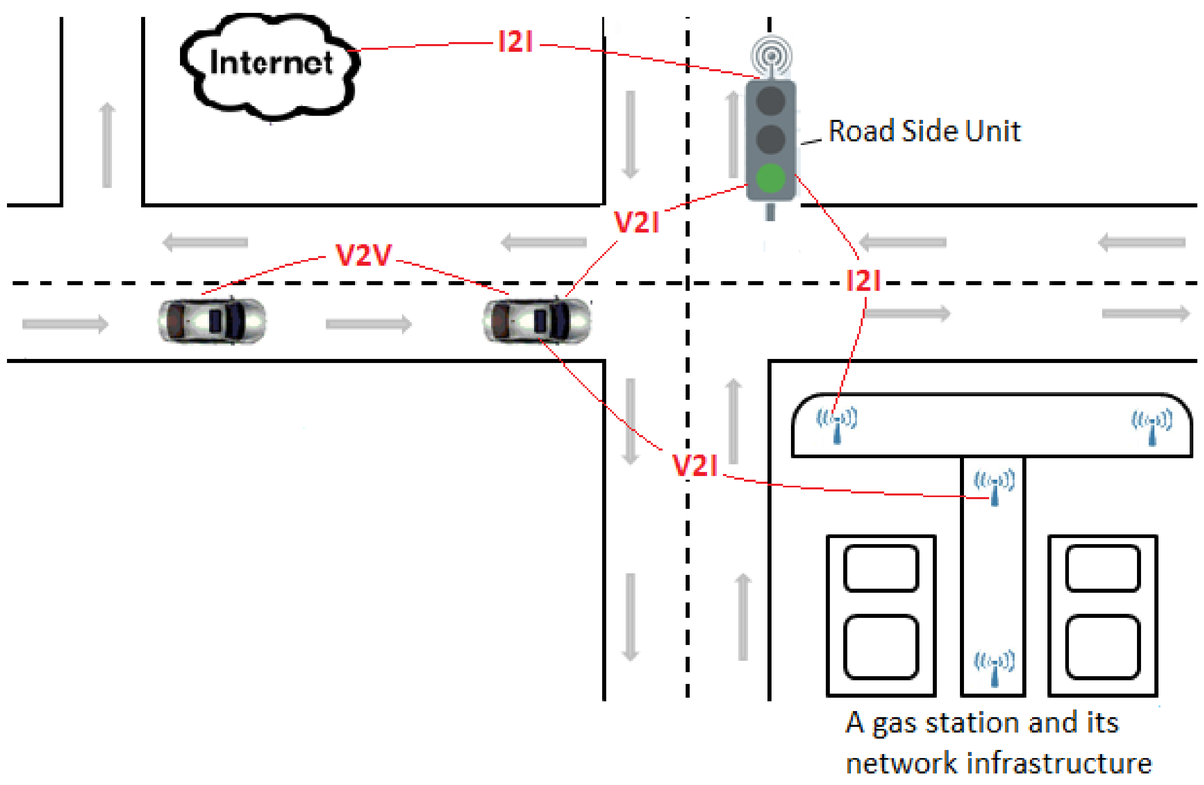
1. General introduction: 5G networking concept

Apart from more throughput and ultra-low latency communication requirements, the wide vision and revolutionary side of the 5G networks are to enable **a seamless society connection** by bringing together all network actors and elements (e.g. people, things, cities, applications, and data) by 2020 and beyond. With 5G on the horizon, the concept of the collaborative intelligent transportation system (C-ITS) also known as the Internet of Vehicles (IoV) which relies on the coexistence and the integration of heterogeneous communication networking technologies and devices is getting a reality.

2. Our working context: connected and smart cities

The networking environment of IoV which is typically a dense urban environment of connected cities should address several communication scenarios such as Vehicle-To-Vehicle (V2V), Vehicle-To-infrastructures (V2I) or Infrastructure-To-infrastructure (I2I) as illustrated in the figure below. Disseminating information in such environment, imply the usage of various access technologies such as Bluetooth, 802.15.4, 802.11p|ac|ax, LTE-U, 802.11ah, LoRa, Sigfox, LTE-M, NB-IoT, etc.



A gas station and its network infrastructure

The information in IoV environment is of various types, from various sources, and for different applications. Applications such as road safety, advanced driving assistance, autonomous vehicles, fluidification/regulation of urban traffic, environmental monitoring for security matters, and so on.

3. Issues

In order to coexist, wireless access technologies have to share the scare and naturally limited radio resource. Hence, appropriate precautions must be taken for a safe, reliable and efficient co-existence of access technologies in IoV environment which have to share very often the limited number of license-free radio bands.

Technology standards toward a 5G networked world are typically in place and some deployments even stated. Nevertheless, every access technology can only optimize the usage of the resources (e.g. the radio) in its homogeneous environment and, heterogeneous networking access technologies have to coexist under the 5G umbrella, particularly in the dense urban environment of connected cities.

Thus, the challenge is to efficiently cohabit heterogeneous access technologies for IoV applications, without removing the standard aspects of these technologies which guarantee the interoperability of devices.

Spectrum efficiency in 5G networks

5. Opportunities and Challenges

In a dense urban environment, one can imagine the deployment scenario illustrated in the figure below, where the resources of hotspots having multi-access technology are pooled by other nodes in the vicinity (e.g. connected vehicles, surrounding sensors or mobile users). This deployment scenario implementing a resource mutualization approach would allow to increase the connectivity of the network nodes and avoid harmful interference between the devices through common radio management components within the hotspots. Thus, this would allow to efficiently cohabit the underlying access technologies. Nevertheless, these immediate questions remain open research problems: 1) the appropriate access technologies to deploy within the mutualized hotspots in order to get a maximum of efficiency of the resources. Efficiency, e.g., in terms of satisfaction of latency and throughput requirements of the underlying supported applications. 2) Scenarios (e.g. expected node density, coverage needs) for which to add more such a mutualize hotspots or to add mobility to some of them.

Performance evaluation in this context is usually made through computer simulations because of expensiveness and difficulty of field tests. To the best of our knowledge, to date, there is no a platform that models and brings together all the access technologies expected under the 5G umbrella.

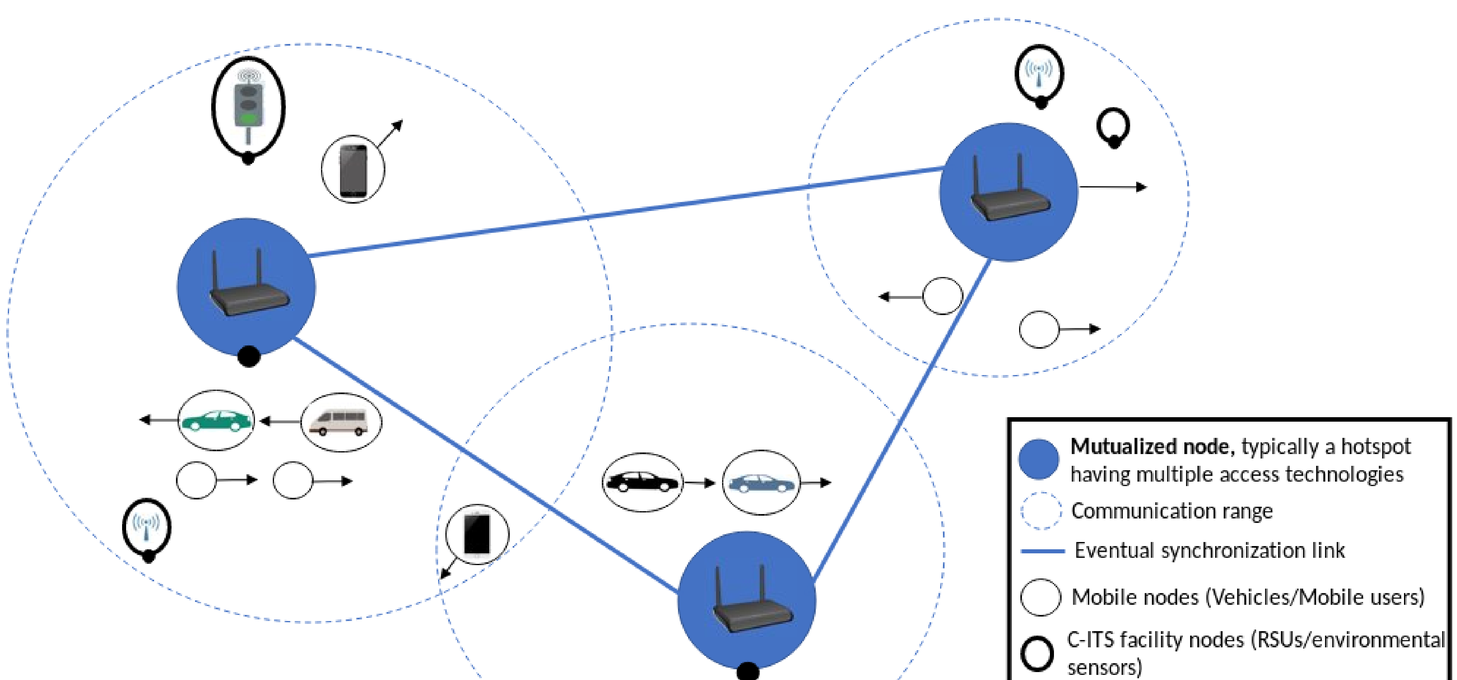


Illustration of a scenario implementing a resource mutualization approach.

4. Our solution approach

To deal with this aspect of wireless access technologies coexistence issue, we rely on **a framework of the mutualization of network resources of a connected city** to efficiently cohabit heterogeneous access technologies in IoV environment. In this framework, the resources are mainly the access devices within the connected vehicles, Road Side Units (RSU), and those of eventual surrounding hotspots, sensors and sensor networks. We reasonably assume that such network resources do not necessarily belong to a single entity. Thus, resource management architecture in this mutualization framework should be decentralized because the deployment of a centralized solution should be practically difficult.

This concept of resource mutualization is not completely new in the field of computer networks in general. For example in Internet Exchange Points, many Internet Service Providers mutualize and share the same routing and switching infrastructures for the sake of cost and resource efficiency.

Toward a resource mutualization

Contact

Ali.MAMADOU_MAMADOU@uca.fr