The Role of Vehicular Ad hoc Networks in Future Heterogeneous Networks

Massimo Osella
Lab Group Manager of ECS Architectures and Vehicle Connectivity
Electrical & Controls Integration Lab,
General Motors Global R&D 30500 Mound Road, Warren – MI 48090
Tel: 248-930-4983
Email: massimo.osella@gm.com

Scientific Contributions: Recent developments in the automotive industry point to a new emerging domain of vehicular wireless networks, which include not only vehicle-to-vehicle communications but also vehicle-to-infrastructure communications. Vehicular networks are envisioned to be a critical component of future large-scale, heterogeneous Internet architecture which not only covers traditional cyberspace but also links the physical worlds to cyberspace. In the past few years, several US industry initiatives supported by US Department of Transportation have focused on industry developments and commercialization of safety applications using off-the-shelf technical approaches. At the same time, there is also considerable scope for the development of more sophisticated information-rich applications which can provide more benefit to end users. However, it is increasingly clear that enabling a rich set of vehicular applications requires that peer-to-peer Vehicular Ad hoc Network (VANET) technology be developed beyond the state-of-the-art.

State-of-the-art automotive wireless network systems take such an approach: After collecting sensor data directly from vehicles via cellular connections, cyber-space data aggregation centers process data and then publish analyzed results. Because of its centralized nature, the major effort in this framework is spent on locating relevant vehicles, identifying their IP addresses and maintaining seamless connections between vehicles and data aggregation centers. Such a centralized, end-to-end network framework is appropriate for exchanging *light* data between remote vehicles (or between vehicles and cyberspace); on the other hand, we argue that this purely centralized framework lacks efficiency and flexibility for a number of reasons:

1) The over-the-air communication cost needed for such a centralized system could be expensive for vehicular users if they happen to be nearby;

2) While most information in vehicular applications are of localized nature, the usage of remote data aggregation centers as the intermediate processing agents creates the dilemma of ‘triangle routing’, wasting cherished bandwidth and introducing latency;

3) Gradually upgrading this system needs a close collaboration between wireless ISPs and automotive OEMs.

Recognizing the potential limitation of the cellular-centric vehicular system, we propose a distributed approach called *Information-Centric Networking on Wheel (IC NoW)* to develop a generic network architecture supporting futuristic information-rich VANET applications. This framework focuses on the content and scope of the information, rather than the traditional address-centric end-to-end framework like traditional Internet design. Instead, we argue that a peer-to-peer paradigm is more efficient for developing spatially and temporally localized, data-intensive vehicular applications on the roads.

The key for developing such localized vehicular communication applications is information content itself, rather than addressable vehicle entity like traditional IP networking paradigm. However, we do not advocate that a fully distributed VANET should replace existing cellular systems; instead, distributed VANETs supplement the cellular systems, as part of heterogeneous networks. We believe that the vehicular network should be able to coexist with IP protocols in cellular telephony systems, especially when vehicles need to communicate with servers in cyber space. We envision that an overlay network will be engaged to accomplish this goal, with the gateways (e.g., wireless Access Points or cellular base stations) between the vehicle cloud and the cyber cloud playing active roles.

Technical Background and Benefits of My Participation:

I am an Electronic Engineer with more than 20 years of expertise in research of electronic controls systems for automotive applications. Principal areas of investigations are in intra-vehicle serial communications, safety-critical and fail operational control systems, hardware and software architectures, diagnosis, safety and security, wireless and vehicle to vehicle communications. In my previous employment, with Fiat Research Center, I was leading several joint research projects with other European OEM’s funded by the European Community. After joining GM in 2006, I am leading a research group and managing several collaboration researches with major US and global universities in the area of vehicular information technology.

Vehicular networking has been envisioned as a major component of next-generation Internet and Cyber-physical system. With my technical background covering both intra-vehicle networks and inter-vehicle networks, I believe that my participation could bring unique knowledge of vehicular networking domain from automotive industry to this workshop. On the other hand, learning the latest trend of future network design from generic networking society (e.g., heterogeneous network paradigm), it is very useful for automakers to understand the constraint/requirements of future Internet architecture so that we could design efficient and reliable vehicular network protocols and service as well as properly interfacing our vehicle networks into generic Internet architecture.

NSF Funding Requirements: No.