5G for the Automotive Domain

Carla Chiasserini, Anthony Magnan

Fifth generation (5G) technology is expected to be a game changer for the automotive industry. The possibility for vehicles to be connected to other vehicles, pedestrians, roadside infrastructure, or application servers enables the development of multiple revolutionary services. As specified in [1], they will include:

- vehicle platooning: vehicles dynamically forming a group, driving together, and proceeding at a very short distance from each other;
- advanced driving: sharing driving intentions, sensor data, and videos gathered through onboard cameras with roadside infrastructure, other vehicles, pedestrians and network servers, for safety and traffic efficiency applications, as well as semi- or fully-automated driving;
- remote/cloud computing driving: a remote driver or a V2X application that operates a remote vehicle traveling in dangerous environments, with impaired passengers onboard, or public transportation vehicles.

The requirements that the 5G technology should fulfill in order to meet the needs of the automotive industry are as follows [1][2][3]:

- Ultra-high availability, namely, 99.9999%;
- Ultra-high reliability, namely, 99.9999%;
- Ultra-high resilience, namely, 99.9999%;
- Low latency, ranging between 1 and 10 ms;
- High data rate, ranging between 0.5 and 50 Mbps, with lower requirements for uplink traffic;
- Many simultaneous connections, namely 2000-4000 vehicles/km^2
- No need for user registration.

Importantly, the first requirement implies that services should be supported also in out-of-coverage conditions, while the latter requirements call for new security mechanisms that provide authentication, authorization and privacy even when registration with a mobile operator is not in place.

Among the key innovations of 5G, it is expected that the following will represent major enabling technologies for automotive services:

1. Network slicing
2. Multi-access edge computing (MEC)
3. eV2X communications
4. mmWave communications

Network slices, namely virtual functions graphs and the corresponding resources needed to implement them, should be easy to configure, re-usable for one or more network services, with an agile lifecycle management, and possibly isolated from other slices for security reasons.

Network slicing can involve resources at the edge of the network, leading to the implementation of the MEC concept. MEC is indeed an effective approach, capable of guaranteeing low end-to-end delays, low bandwidth consumption, low energy consumption and high resilience, which are of critical importance to automotive services.

The idea of exploiting resources at the edge of the network can be then pushed to the extreme case where resources offered by pedestrian and vehicular user equipment are exploited. It is thus fundamental to realize efficient V2X communications so as to enable user equipment to share computing, network and storage resources. While the 3GPP Release 14 has started defining some guidelines along which cellular V2X communication should develop, detailed specifications about radio channel access and synchronization are still missing, as well as how such technology can be enhanced and evolve toward the so-called 5G eV2X.

References

1. 3GPP TS 22.261 V15.1.0 (2017-06) Rel. 15 - Service requirements for the 5G system (eV2X).
2. 5G Automotive Association, "The Case for Cellular V2X for Safety and Cooperative Driving," November 2016.
3. NGMN Alliance, "5G White Paper," Feb. 2015, https://www.ngmn.org/fileadmin/ngmn/content/downloads/Technical/2015/NGMN_5G_White_Paper_V1_0.pdf

Carla-Fabiana Chiasserini (M'98-SM'09-F'18) received her Ph.D. degree from Politecnico di Torino, Italy, in 2000. She worked as a Visiting Researcher at UCSD in 1998-2003, and she is currently an Associate Professor with the Department of Electronic Engineering and Telecommunications, Politecnico di Torino. In 2012 and 2015, she was a Visiting Professor at Monash University (Australia). She is also a Research Associate with CNR-IIET and CNIT, ITaly. Her research interests include architectures, protocols, and performance analysis of wireless and mobile networks. She has published over 290 papers in prestigious journals and leading international conferences, and she serves in the Executive Editorial Committee of IEEE Transactions on Wireless Communications and in the Editorial Board of several journals such as IEEE/ACM Transactions on Networking and IEEE Transactions on Mobile Computing.

Anthony Magnan has more than 10 years of wireless industry experience and is currently working as a Senior RF Planning Engineer at an automobile manufacturer in Detroit, Michigan, USA, integrating 5G use cases and requirements into future vehicle platforms. Prior to his current position, he worked as a Cellular RF Optimization Engineer and an LTE Network Design Engineer. He holds BS/MS engineering degrees from Lawrence Technological University in Southfield, Michigan, USA. Mr. Magnan has several years of experience in 3GPP radio systems, 3G & LTE cell planning and optimization, protocol stack, and system architecture. Mr. Magnan is also a contributing member of the Wi-Fi Alliance, IEEE ComSoc and Society of Automotive Engineers.