Ultra-Reliable Low-Latency 5G Communications in Autonomous Vehicular Networks

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Abstract. Fifth generation mobile networks (5G) will be a paradigm shift in mobile and object (things) communications. 5G will propose new services that require large broadband data rates and ultra-reliable latency. Unlike the previous generations, advanced 5G concepts aim to integrate multiple radio technologies thanks to software defined radio, software defined network and network slicing concepts. New URLLC services are characterized by the need to support ultra-reliable communication, where successful data transmission can be guaranteed within low (deterministic) latency. In this study, we propose a reliability and latency joint function to evaluate the joint impact of these two metrics in 5G autonomous vehicular networks. The interactions between reliability and latency are illustrated via simulations of 5G autonomous vehicular networks. System level scenarios with Manhattan grid networks will be used to emulate large urban deployments with hundreds or thousands of vehicle platoons, interferers, detailed propagation models and interactions between the fixed road side infrastructure and the vehicular mobile nodes. A new solution that improve both the reliability and latency performance and ensure URLLC is presented for 5G autonomous vehicular networks. Finally, implement a set of promising algorithms in a software defined radio platform and evaluate at the system level a full version of the proposed algorithms.

Keywords: 5G networks, Autonomous Vehicular Networks, URLLC.

1 Motivation and Background

5G is regarded as one of the main enablers of highly critical industrial applications of the Internet of things (IoT) over wider geographical areas and potentially at lower costs. Therefore, this proposal is directly correlated with an enabling technology of the IoT, Internet of everything and industrial IoT. 5G is expected to be spectrum-agile, self-organized, cooperative, software-defined, and cognitive.

Compared with previous manned vehicles, autonomous vehicles are highly dependent on ultra-reliable low-latency communication (URLLC) in 5G vehicular networks, while lower end to end latency with cloud infrastructure cause faster decision making and traffic control[1]. Moreover, increase the safety of vehicles, pedestrians, users, and urban infrastructure, avoid collisions, and reduce safety hazards by better traffic issues prediction and faster decision making due to ultra-reliable low-latency communication. Since, current wireless access technologies cannot meet all the requirements of future vehicular networks, 5G enabling super-fast, reliable, and low latency connections that could provide a solution to these limitations.

Many studies have focused on investigating methods to enhance the latency or reliability performance in vehicular networks. To improve the latency performance of mobility management, a mechanism for inter-cell handover was proposed for vehicles in [2] which considered as a mobile-edge computing (MEC) architecture for cellular vehicular networks. In [3], MEC supported an SDN-enabled network architecture to reduce the latency in vehicular networks based on software-defined networks (SDNs) and OpenFlow technologies. A new method to improve the one hop transmission range based on a genetic algorithm with the approach of reducing the latency in multi-hop vehicular networks was proposed [4].

2 Realization objective and Methodology

The main contribution of this research is the use of radio resource management (RRM) and innovative signal processing for 5G wireless networks to apply in V2X and vehicle platooning services. One of the goals is to evaluate the main candidates of PHY-layer of 5G network for upper layer management and V2X applications. PHY layer design will be closely conducted together with MAC (medium access control) layer to achieve convenient framework design, conflict resolution, error retransmission control, and cooperation between nodes. This also leads to the concept of self-organization and cognitive radio, where resources of the network will be used opportunistically thanks to highly intelligent, adaptive radio technology. Nodes will form coalitions that will optimize network performance. In the end, software defined network will allow us to change network and radio settings on-the-fly and be able to optimize performance in 5G vehicular networks. Self-organization also needs game theoretic concepts to avoid misbehaviours and security threats that need to be reduced. New methods for evaluation of ultra-reliable low-latency in distributed queuing systems.

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