Closed User Group Automotive Communication Network Based on Addressing at Physical Layer

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ABSTRACT

Intelligent Vehicle communication is the keyword for the emerging vehicular technologies such as group cooperative driving, real time Engine Operating parameters (EOP) monitoring, collision warning, geo location based mobility applications, and classical voice and data conveyance. The technologies require extensive interaction between the peers which mostly use the framework of the state of the art cellular or radio trunking networks. This may vitiate the network performance due to the surge in mobility management messages originated by the devices plugged in the vehicles. The performance may be severely impacted due to the unique characteristics of vehicular networks e.g., high mobility. Due to the high proliferation of these Machine to Machine (M2M) and Machine to Application (M2A) devices in near future, the cell sizes will shrink, resulting in more signalling messages in the network. Considering classical voice communication services for typical car fleet implementations, the radio trunking networks have capacity constrains due to inability of frequency reuse and absence of mobility management techniques. The alternative is to seek out an access technology considering the fact that a more intelligent physical layer can be employed directly for addressing and mobility management. In this paper the authors address a Closed User Group network implementation for Vehicle to Vehicle/central office communication which can actuate voice and data communication without incorporating any application layer.

Keywords: Absolute Radio-Frequency Channel Number (AFCRN), Coordination Processor, Dedicated Omni-Purpose Inter-Vehicle Communication Linkage Protocol for Highway Automation (DOLPHIN), Engine Operating Parameters (EOP), Home Location Register (HLR), Home Subscriber Servicer (HSS), Inter Vehicle Communication (IVC), Long Term Evolution (LTE), Machine to Application (M2A), Mobility Management Entity (MME), Network Mobility (NEMO), Smart Mobile Network Access Topology (SMNAT)

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INTRODUCTION AND PROBLEM STATEMENT

There has been vested interest in automotive communication systems for the past few years. ITU has formalised the body ‘Collaboration on Intelligent Transport Systems Communication Standards.’ TIA came up TR-48 Engineer- ing Committee on Vehicular Telematics. ISO brought out a special issue (ISO Focus +, February 2012) discussing intelligent transport telecommunication systems for accident reduction, driver assistance systems and on-board diagnostics. This trend stems from the fact that vehicles are evolving to be more intelligent instigated by proliferation of on-board sensors and electronic controls for safety and performance, and increasing demand for integrated and wirelessly connected communication and infotainment devices. Many of these capabilities are being introduced as key product differentiators, only to become ‘must-have’ features within just a few short years. These devices will thrive on unremitting intercommunication framework for voice and data peering, storage, cloud computing. The primary objective is to exchange data and intelligence with the network or other vehicles. These will include ultra-high-speed communication between vehicles and with critical roadway infrastructure, to improve safety, reduce traffic congestion and delays, and to provide operators and passengers with easy access to a plethora of remote and location-specific services.

Considerable emphasis is provided by automobile companies to design a system of Real Time centralised monitoring of the Engine Operating Parameters (EOP). With more and more stringent emission standards, future engine technologies will need to incorporate advanced combustion strategies with optimized engine operating parameters for achieving low emissions while maintaining fuel economy and power density. Genetic algorithms (GA) are being used by engine researchers to optimize engine design and operating parameters to achieve these goals. The Genetic algorithm to determine the engine performance may reside on the cloud in case there is a need to interact with a centralised database registering the performance parameters.

With a considerable penetration of these automotive communication devices in coming years, we anticipate an avalanche of signalling messages in the network. The 3G and 4G core network elements should be re-dimensioned accordingly (Simon et al., 2008; Paint et al., 2002). Capacity augmentation of the access network elements and spectrum needs to be considered. The network will need to serve heterogeneous mobile applications used by man or machine and the key challenge there will be to consistently render the desired quality of service. The wide implementation of automotive telematics can lead to service disruptions in the network if appropriate measures to scale up the network are not taken up.

With the present day network topologies, we need an elaborate arrangement of the core and the access network elements to facilitate communication between the mobile nodes. In a 4G network or its predecessors (namely 2G, 3G), the mobile network tracks the handset continuously to be aware of its presence and location (Kumar et al., 2010). Handset initiates a Location Update process in a given time periodicity, or during network acquisition. Network and Handset manages the handover to another cell when location is changed during a call. All these network activities are managed by Application layer signalling processes at the radio network. So the Network Equipments and the handset need to be intelligent enough to compute and process continuously the signalling messages for mobility and location management. The Network Equipment actuates these processor intensive activities, thus contributing to an increase in capital and operational expenditure of the network. From the device perspective, these processes drain lot of power and impose load on its network processor, just to maintain its ‘presence’ in the network. Signaling mes-
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