Convergence of LTE-A and DSRC Infrastructure for Intelligent Transportation System

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Abstract: In this paper, we focus on the design of similar physical layer for communication between DSRC(Dedicated short range Communication) and 4G-LTE-A. In LTE-A /DSRC communication, physical layer design which involves all the processing performed on peak data rates (1Gbps for low mobility and 100Mbps for high mobility) of about 1000 times above than the 2G and 3G standards. By using these enabling technologies, we can combine IEEE 802.11P (DSRC) vehicular safety standards and LTE-Advanced (Rel 10) to achieve such a performance of Intelligent transportation system(ITS).

Keywords:- 4G LTE-A, DSRC, IEEE 802.11p, ITS.

I. INTRODUCTION

In this paper we will analyze the LTE mobile communication standard, and particularly it's Physical Layer, in order to accomplish the mathematical foundation of empowering LTE advanced technologies. Such as Orthogonal Frequency Division Multiplexing (OFDM) and Multiple Input Multiple Output (MIMO), to its attain to achieve a optimized performance.

In the empowering technologies of the LTE advanced standard with the joint signal processing of OFDM and MIMO is to achieve a better performance in Vehicular Communication. In point of interest to make models in MATLAB especially in physical layer of LTE PHY focused around these.

As a result of convergence of two different techniques is to provide the optimized data rates, improved coverage, improved spectral efficiency, minimum operating cost, low latency, multi user connectivity and significantly seamless integration of vehicular communication and LTE.

The evolution of 4G LTE mobile technology can be considered an evolution of existing third generation standards(3G). The evolution of wireless communication started from 1G is shown in figure 1.

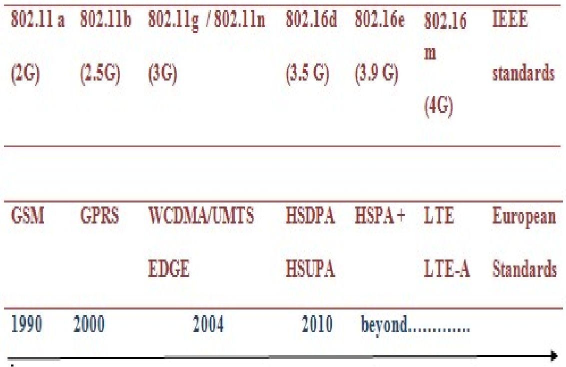

Figure 1. Evolution of LTE Advanced.

One of the prominent feature of LTE-Advanced is optimized peak rates (100 Mbps) for high mobility and (1Gbps) for low mobility[9]. The 4G LTE-A standards will be enabled with IP-Based packet networks and it can support on-demand applications like vehicular safety applications, navigation and video on demand services. Authors aim to achieve a convergence between LTE-A and DSRC for better vehicular communication.

II. LTE-A FOR VEHICULAR COMMUNICATION

In order to support the increasing demand in vehicular communication as well as mobile communication services by providing peak data rates on low mobility condition and to maintain Quality of Services(QoS), LTE-A plays a major role. LTE-A covers the three fundamental components of evolved 3G standard architecture are System Architecture Evolution(SAE), Evolved packet System(EPS) and Evolved Universal Terrestrial Radio Access Network (E-UTRAN)[1].

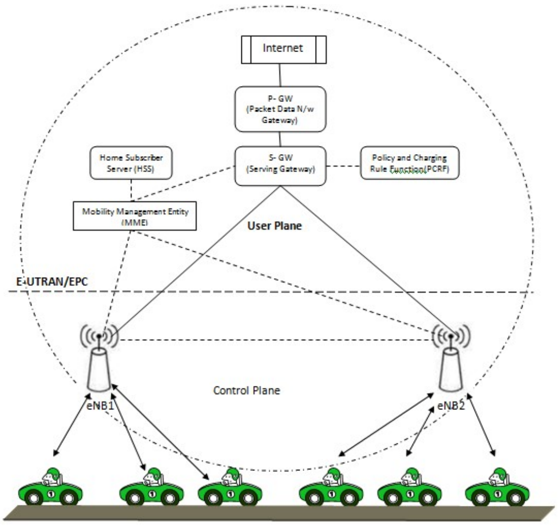

Figure 2. LTE-A Architecture

In Figure 2. Describes the LTE-A working architecture and Those three evolved components are to enhance the overall system performances which includes peak data rates, low latency, improved coverage, multiple antenna support and seamless integration with 3G UMTS and WiMax.

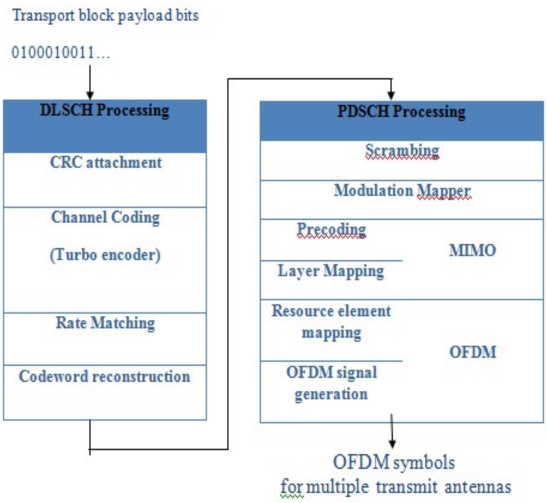

Figure 3: LTE-A Physical layer

In this paper, authors reviewed some of the latest trends in communication research as well as theoretical and mathematical considerations related to integration of Physical layer (PHY) design for such combined system. In LTE PHY layer is integrated with OFDM and MIMO technologies. The details of LTE-A physical layer is shown in figure 3.

III. DSRC FOR VEHICULAR COMMUNICATION

DSRC is one-way or two-way short- to medium-range wireless communication and it works with 5.9 GHz RF frequency. DSRC supports 1000 m range with vehicle speeds up to 120 mph. DSRC, which provides point-to-point communication has two modes of operations:

a. Ad hoc mode characterized by distributed multi-hop networking (vehicle-vehicle),

b. Infrastructure mode characterized by a centralized mobile single hop network (vehicle-gateway).

In 1999, the United states FCC Federal Communication Commission allocated at 5.9 GHz of 75MHz spectrum bandwidth for DSRC system which can be involved in vehicle-to-vehicle (V2V) and vehicle-to-roadside(V2R) communications. The DSRC channel structures are shown in figure 4[2,3,4,5,6,7]. The first channel of DSRC having 5 MHz transmission capacity is held. This held channel approximately 5.850 – 5.855 GHz can be utilized for other purpose which includes Spread Spectrum(SS) based Digital RADAR Technology[8].

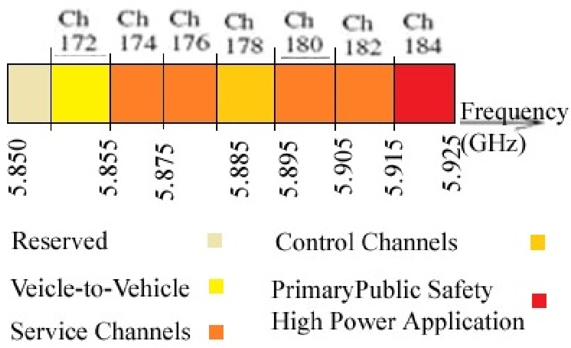

Figure 4: DSRC Channel Structure

IV. LTE/ DSRC COMMUNICATION SYSTEM PHYSICAL LAYER

To improve the network stability and minimize the control overhead of node handovers, Bases on the factors of vehicle parameters and the CH selection protocol will evaluate the speed and destination of vehicle. In this paper we proposed a new approach of convergence of DSRC and LTE-A technology for future ITS.

We assume that all vehicles are integrated with both 4G LTE-A and DSRC radios. For short range car to car (within 1 Km) communication can be established by DSRC techniques. DSRC unit installed on car (DSRC mobile unit) can communicate with other car in ad hoc mode. The DSRC/LTE communication system architecture is shown in figure 4.

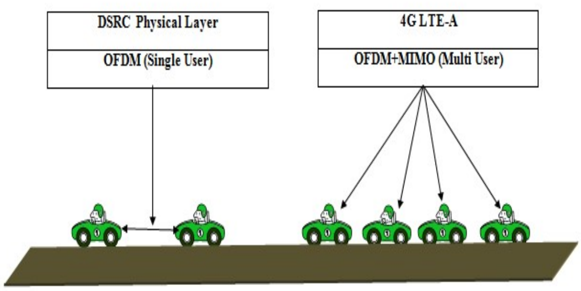

Figure 5. Communication Environment model of 4G LTE and DSRC

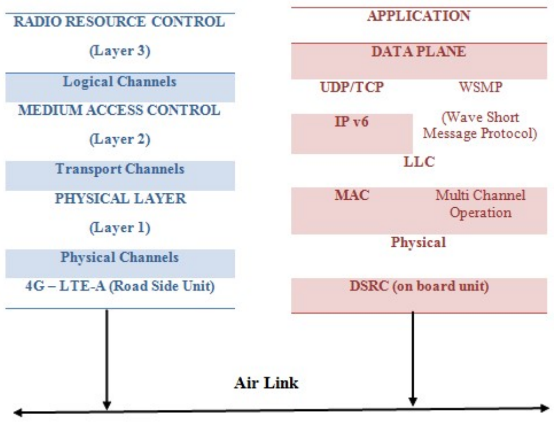

Figure 6. Physical layer Design on LTE-A and DSRC

For long distance communication (above 50 Km), one Mobile Unit (MU) communicates another unit through Road Side Units (RSU). LTE access point is installed in RSUs. It Provides IP-Connectivity between User Equipment(On Board Unit) and E-UTRAN. It Corresponds Radio Access network and Core Network, which are acting as Base Stations (BS). MUs, RSUs can support both LTE as well DSRC system. The diagram of physical layer design on DSRC-LTE communication is shown in figure 6.

Feature	802.11p DSRC	LTE-A
Channel width	10 MHz	Up to 100 MHz
Frequency band(s)	5.86-5.92 GHz	450 MHz-4.99 GHz
Bit rate	3-27 Mbps	Up to 1 Gbps
Range	Up to 1 km	Up to 50 km
Capacity	Medium	Very High
Coverage	Intermittent	Ubiquitous
Mobility support	Medium	Very high (up to 350 km/h)
QoS support	Enhanced Distributed Channel Access (EDCA)	QCI and bearer selection
Broadcast/ Multicast support	Native broadcast	Through eMBMS
V2I support	Yes	Yes
V2V support	Native (ad hoc)	Potentially, through D2D

Table 1. DSRC and LTE-A Parameters

Spectrum allocation is one of the major issues [10] for such combined system. Table 1. Refers the possible parameters of converging DSRC and LTE-A. In spite of the fact that DSRC and LTE both can support multimedia and safety application. While transmitting signals between vehicles to vehicles need single OFDM for connectivity as well as DSRC required around 6 MHz bandwidth of signal transmission. LTE required single OFDM and MIMO to create a multi user environment by communicating multiple vehicles simultaneously as well as long range communication between vehicles. The seamless integration of OFDM and MIMO technologies is used to avoid the inter symbol interference and delivering streams of data in a spatially multiplexed fashion to the different users.

V. IMPLEMENTATION AND RESULTS

Authors have implemented OFDM frame structure shown in fig.7 of DSRC and LTE-A, and evaluated the performance by calculating Bit Error ratio (BER).

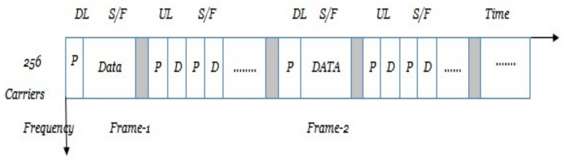

Figure 7. OFDM Frame Structure

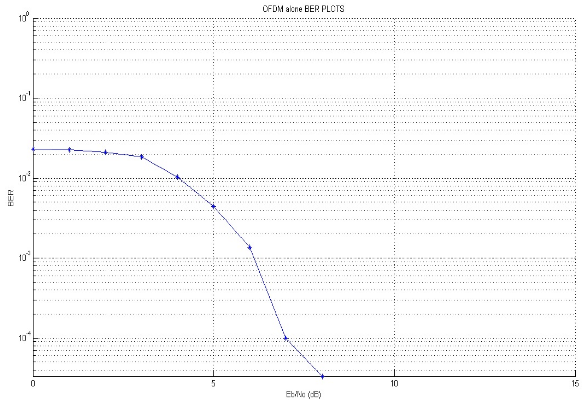

Figure 8.OFDM Bit Error Ratio(BER)

Fig. 8 illustrate the OFDM Bit error ratio(BER), Downlink and Uplink sub frame transmitted by multiple signal subcarriers to the road side unit base stations. DSRC and LTE eNb frame set is composed of more than one subcarriers by generating OFDM symbols. In order to support the multiple subcarriers for multiple access scheme is the fact of multiple vehicular communication simultaneously.

VI. CONCLUSION

The development and integration of this physical layer design of LTE and DSRC proposed the potential improvement of ITS to increased Coverage, Higher data rates and optimize QoS Performance in vehicular safety communication. Authors designed the physical layer to combine DSRC and LTE aims to provide a highly efficient, Low latency, packet optimization and more secure service of future intelligent transportation system.

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