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Comparative Analysis of DSRC and 5G Technologies for Vehicular Communications

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ABSTRACT

Vehicular communication (VC) is a form communication method which allows vehicles (vehicle nodes or on-board unit) to mutual interchange data with other vehicles, nearby vehicle to facilitate safety first and efficient of transportation communication system for drivers, passengers and vehicles. Safety parameters such as vehicle's location (position), vehicle speed, enables the sensing of hazards and traffic congestion in intelligent transport system. In this paper, two vehicular communication standards including Dedicated Short Range Communication (DSRC) based IEEE 802.11p and the cellular based 5G adaptive Gen technologies are compared for vehicular comm. network and safety transport applications. A detailed study of the two technologies and comparative analysis with respective to safety communication measures such as transmission delays and latency, transmission range and coverage, network size and scalability, and dynamic topology changes and pre-defined mobility pattern. The analysis significantly indicate that IEEE 802.11p facilitate acceptable road performance with short coverage and slow mobility in contrast, 5G facilitate lot of applications of vehicular communication (VC) such as round trip time, latency, transmission coverage are, scalability of network, and dynamic changes in mobility. Even though 5G standards are not ratified but the 5G feature changes way people live with technologically, socially and economically.

Key words: DSRC, IEEE 802.11p, V2X Communication, 5G

1. INTRODUCTION

As per Road Transport & Highways authority, India, 4,67k, 464k and 481k accident occurred in 2018, 2017 and 2016 respectively[1]. Based on times of India, 1.5 lakh lives killed in road accidents in 2018, over-speeding main reason and in 2018 WHO reports, India position in first in term of road accident deaths across the 199 countries and also reveals that India contributed 11% road accidents in the world. Nearly 1.25 million passengers die every year from traffic accidents every year, and around 20 million to 50 million affected due non-fatal danger. Technically advanced like U.S, 6 million road accidents in 2016, 40,200 fatalities are estimated and more 1.7 million danger situations. It indicates the some technological solutions to address the challenges in road transport. It should safeguard the lives of drivers, passengers and vehicles. Improve road safety applications and traffic data management have varied around the world. In the U.S., the NHTSA (U.S National Highway Traffic Safety Administration) studied V2V communication possibilities for many years and generated a Notice of Proposal for Rulemaking (NPRM) in safety transportation system.

For vehicles and transportation infrastructure there are many devices in vehicle networks such as V2V, V2I, V2P, V2N & V2X which is active with DSRC as well as LTE cellular network Technologies. DSRC supports short message interchange of traffic data among DSRC node devices and smart handy devices by the pedestrians. It is the main support of Intelligent Transport Systems (ITS). Basically DSRC supports short exchange of traffic data among DSRC node devices per automatic and ITS. DSRC devices includes OBUs, RSUs and handheld devices carried by pedestrians. Set of devices and interfaces have been defined IEEE 802.11p. IEEE 1602 standards for Wireless Access for Vehicular Environment (WAVE) are to be used in DSRC based measurements. NHTSA worked with US Department to enable save behaviour communication. Due to lack of infrastructure and other feature of IEEE 802.11p has challenged researcher to look for other access technologies.

The limitation of DSRC and recent advancements in cellular technology like D2D motivated research work to investigate 4G LTE based V2X communication. LTE V2X uses high volume, large region coverage range and infrastructure services to support vehicular management network. D2D has improved spectrum utilization efficiency. 3rd Generation Partnership Project (3GPP) aim to provide various V2X transport services completed. Journey toward 5G shown in Figure 1.

Release 15, 5G provides complementary transport services and new service and function capabilities. The main challenge is that for supporting v2x, problem related to Doppler Effect and dense UES must be solved. Resource allocation is yet another area where conflicts should be avoided. Another challenge is that of security, broadcast system need to be improved.

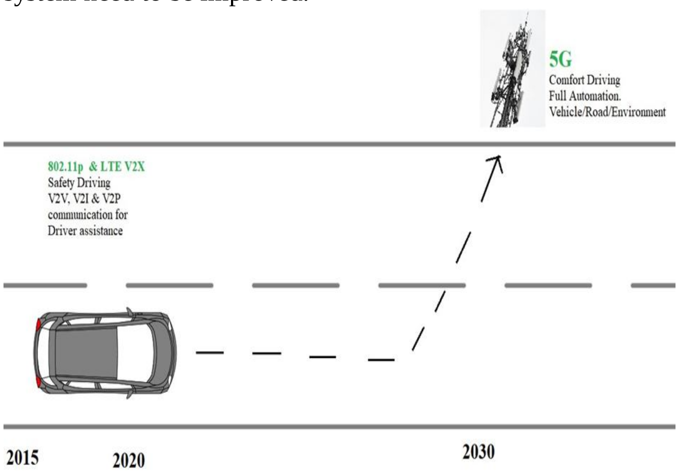

Figure 1: vehicular communication toward 5G

2. RELATED WORK

Guiyang Luo et al.[2] focus on many 5G vehicular network applications that rely on the efficient content sharing among mobile vehicles that challenges rapid changing topology. Authors initiated hierarchical architecture based on an edge computing for efficient allocation of large volume data generated from vehicles. A novel stochastic geometry-based simulation for MIMO vehicle to vehicle communication performed by Yiran Li et at. [3] . Their focus is on the V2V channel estimation modeling and dimensions. Authors derived some equations of channel probabilities and properties including space –time correlation function. Interference zero pilot based design of channel prediction using ZCZ approach investigated by Haibin Chen et al[4]. Investigation on pilot crystal design and channel predication and estimation problems in MIMO based OFDM based on C-V2X system with severe co-channel interference due to lack of spectrum frequency re-using for various vehicle nodes.

In the vehicular network and communication side, authors Zahid Khan et al. [5] proposed multi-vehicle moving zone (MMZ) grouping scheme using cellular-V2X. authors combined IEEE 802.11p and cellular technology 3GPP. In MMZ, vehicle clusters are formed up to three hops using V2V communication.

3. VEHICULAR COMMUNICATION USING IEEE 802.11P

Vehicular ad-hoc networks (VANET)s are advancing the technically with interest due to their influence in safety of people and reducing traffic congestion and improving the life style of people and also alternatively acts as emergency transport system as alternative to disasters (natural) in the society, when there is lack of normal communication systems. Wireless Access for Vehicular Environment (WAVE) protocol stack shown in Figure 2. The hierarchical layers of WAVE protocol includes PHY (Physical) layer, MAC (Medium Access Control) layer, LLC (Logical Link & Control) layer, Transport Layer and Safety application layer.

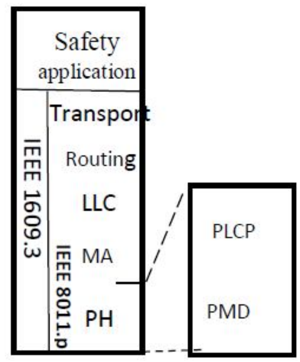

Figure 2:WAVE Protocol stack

WAVE stack consists PHY layer DSRC based IEEE 802.11p protocol the benefit of short latency make it suitable for V2X applications. The IEEE 802.11p std allows the usage of 5.9GHz operating frequency in the band in between of 5.850 GHz to 5.925 GHz with spacing between channels includes 20 MHz, 10 MHz and 5 MHz band. It operates in the DSRC spectrum, which communication technology is based on IEEE 802.11a with 5.9 GHz band in U.S. It overs data exchange between vehicle to vehicle and vehicles to infrastructure (V2I) within a coverage range of one kilo meter using transmission data rate from 3 Mbps to 27 Mbps and also 200 km/h vehicle speed[6].

The PHY IEEE 802.11p has 2 sub parts shown in Figure 2.

a) PLCP:- the physical layer (PHY) convergence protocol responsible for communication packet data (PDU) receiving from the MAC layer to move up Orthogonal frame.

b) PMD:- Physical (PHY) Media Access is the connecting to the physical channel medium (channel radio and linkage) and manage the data encoding for modulation. And Bandwidth of 75 MHz in that 5.9GHz is divided into 10 MHz channels. The first 5 MHz is reserved fixed for Gaud Band.. Transmission CHs 1, 2, 3, 5, 6, 7 are the service channels and remain channels is control channel. For grater throughput channels are mixed and utilized as channel with maximum bandwidth channel of 20MHz. The transmission bit rate is reduced to each channel based OFDM to manage ICI. Due to Doppler span among moving vehicles.

c) CSMA/CA:- the MAC protocol, Carrier Sense Multiple Access and Collision Avoidance, channel access via DCF (Distributed Coordination Function). The principle has 3 fold bases:

1) Stations monitor the channel for actives like energy detection and clear channel assessment.

2) When channel becomes clear STAs enter a contention phase

3) When Stations back-off timer expires, STA transmits.

MAC layer parameter:

There are two major parameters:-

1) DIFS 64µs (32 µs for use with QoS time of signalling. For forward error correction in IEEE 802.11p transmission, a convolution encode is enabled at the beginning to coded data incorporated to reduce burst error due to channel dynamic noises. For OFDM, a 64 part IFFT is used. In the 64 sub carriers, 48 informative subcarriers and 4 are channel phase impulse tracking subcarriers using pilot [7].

2) BSS (Basic Service Set) is defined as a collection of station and obtained bullets to transport / communicate with one another over air connect interface. For V2X networks, dense in IEEE 802.11p are needed to become a member sub of a BSS

When a vehicle node or OBU communicate other OBU (OBU to OBU), it can be organized as a specific single mode directly, i.e OBU or infrastructure setup. Enhance Distributed Channel Access (EDCA) is used for the medium access. EDCS consists of CSMA/CA because of a special contention based origin.

If OBU is busy, the vehicle node transmission delay is by generate random. Station distinguished data by assigning data to access categories (CAs) with other CSMA & CA related specifications which allow effective traffic congestion. The lack of backbone infrastructure may raise the maximum deference.

4. VEHICULAR COMMUNICATION USING 5G

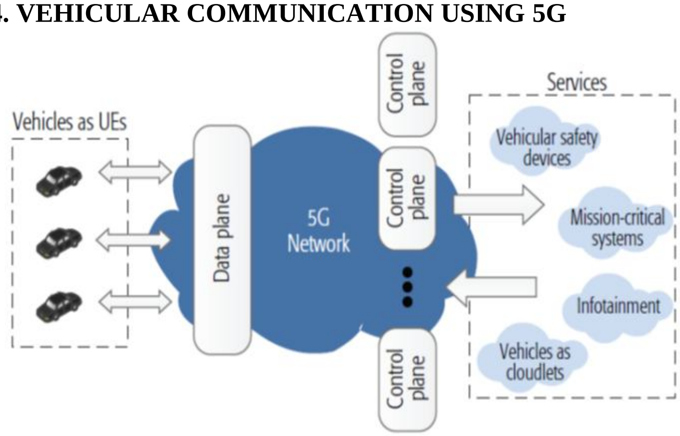

Figure 3: 5G Architecture for vehicular communication

Another alternative is well established 4G LTE. 5G technology can be built on 4G LTE communication technologies may extend the services of cellular communication.

5G is the promising technological breakthrough for vehicular networks. 5G offers

a) 1000 times higher system capacity

b) Size of network increases 100 times higher more existing size.

c) Long Battery life due to mm commutation.

d) Below 1ms latency [4], very much important in safety communications.

Sophisticated Industry supported device such as massive-MIMO, Cognitive Radio, millimetre wave communication, Heterogeneity Networks (Het-Nets) which like to meet the research challenging or problem domains requirement of vehicular communication (VC). Real time services of the vehicular communication will be empowered. Millimetre wave links can address the Line of Site (LoS) connection where D2D communication can maintain direct connection in ad-hoc mode between communicating devices. Vehicular Communication Networks has required the multi-tier and Het-Net kind of architecture with collection of various communicational components would help to attain the goal of 5G vehicular network shown in Figure 3.

5. COMPARISON BETWEEN 5G AND DSRC

Table 1: Comparison of 5G and DSRC for Vehicular Networks

5G	DSRC
Builds upon existing, ubiquitous LTE Infrastructure	Build on DSRC (based on IEEE 802.11p standards)
5G will standardize post, 2030 (Release 16 and above)	Multiple field trails / 10 yr testing auto industry support, DoT Cert.
MNOs play critical leading roles	Vehicle OEMs / Transport Agencies leading roles
Enhanced range over 802.11p, from 300 m to serveral km	100s of meters
High throughtput suitable for connected car applications (entertainment, navigation etc)	Limited high-speed mobility support
Some apps, need ubiquitous RSEs	Could leverage DSRC PKI standards for security and privacy, service and application layers
6G Hz range and millimeter wave range 24.25GHz and above	Operating at 5.9 GHz (5.850-5.925) GHz
Support Bandwidth of 20,10 & 5 MHz	< 100 M Hz
< 1 ms	< 1 00ms
99.999 % hard real time receiption	90 % receiption

Table 1 shows the comparison summary of suitability of 5G and DSRC for vehicular network.

Comparison between DSRC and 5G :

1) **Licensed Band:** Most of 5G will exists in licence spectrum, the advantage being good QoS without interference. With no limitation for transmission power, many number of vehicles or OBUs can be supported even in limited coverage and connectivity regions.. The proposed 5G have diverse set of

spectrum bands at lowest frequency for large area connectivity range and coverage, high frequencies with large bandwidth to support high number of vehicle density, operations above 2.4GHz for providing high capacity range and low latency for safety data transmission.

2) **Coverage:** In urban region, due to complex building and obstacles, NLOS propagation affected. 5G offers good performance scale in NLOS as D2D or V2V link can function with small number LOS basis. In limited or less connectivity. Slow varying information in Channel State Information (CSI) are context aware information utilized[16].
3) **Scalability:** Broadcast communication allows IEEE 802.11p to broadcast beacon message and safety messages to large range of vehicle. On the other hand, 5G D2D facilitate large number of device in the network for exchange safety data. Moreover, D2D in 5G also support road speed up to 350 km/h.
4) **Cost- CAPEX/OPEX**: Base level stations in 5G technology, reduce the setup/install and maintenance price to extend the existing 4G technology, so one base network station can cover vehicles with in 1000 m unidirectional. In DSRC based IEEE 802.11p safety, many RSUs are required for average and hence the cost factor CAPEX-OPEX increases.
5) **Capacity:** With help of effective encoding modulation mechanisms and antenna models, the safety data rates can be improved which is target to provide at least 20 Gbps to 100 Gpbs The down side of IEEE 802.11p is that it can facilitate data transmission rate for 3 Mpbs to 27 Mbps.
6) **Infotainment:** With enhancements of high data rates and more bandwidth, 5G offers high quality video and multimedia communication, vehicles nodes can interchange or exchange vehicle data such as position, direction, sensor data like emergency messages and warning messages in addition to safety data. Passengers utilizes the high speed live video streams, email update, software updates etc. In IEEE 802.11p, Low data rates (3-27) Mbps, transmission is limited to safety messages only.
7) **Latency**: In 5G, delay of below 1 mille seconds with 99.9% reliability transmission provided whereas CSMA/CA in MAC cause latency in channel access and it supports latency of 100ms) [17]

5. CONCLUSION

DSRC technology specifically designed for Vehicular Network and facilitate the safety services, driver assistance devices, traffic analysis, mitigate the road accidents whereas 5G technology supports multi-services including vehicle communication. Safety related application works on strict time-critical latency. IEEE 802.11p based DSRC standard requires less than 100 ms whereas 5G provides less than 1 ms. FCC allocated operating frequency as 5.9GHz in range of 5.850 – 5.925 GHz whereas 5G work at 60 GHz frequency band. Data rate of IEEE 802.11p ranges from 3Mbps to 27 Mbps whereas 5G supports up to 1Gbps to 10 Gpbs. Coverage of DSRC within 1 km whereas 5G covers long range distance also. Connected vehicle are limited in DSRC whereas 5G also 100 times higher than DSRC. Wifi based IEEE 802.11p uses electromagnetic waves whereas 5G supports millimeter wave communication also. IEEE 802.11p standards are released in 2010 by IEEE whereas 5G released 16 and beyond need to be standardized. Last but not least existence and establishment of 5G technology requires some more time in the market whereas DSRC field tests are under processing.

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