A Review on Fractal Geometry Enhanced Vehicular Communication under 5G Environment

K. Raghavendra*, Dr .Deepti Kakkar

Department of ECE, Dr.B.R Ambedkar National Institute of Technology

*Corresponding author

doi: https://doi.org/10.21467/proceedings.114.38

Abstract

A lot of technological advancements in the field of vehicular communication has seen in the past decade, which has brought an increasing in a great extent day by day and it's becoming as a leading research area which provides the scope in terms of safe driving, accident controllability, enhanced security and portability. As we are moving towards the fifth generation, which is showing its dominance on vehicular communication in the next coming years. In this regards the antennas which are used for communication is also an important factor and this paper brings a complete vision over vehicular communication, relevant antennas specified for the latest 5G communication and the paper is concluded with discussion on Internet of vehicles. The impact of Fractal geometry based antennas in the fields of vehicular communication as well as 5G for connected autonomous vehicles are also discussed through this paper.

Keywords: Portability, 5G, Autonomous vehicles, Fractal antenna, Vehicular Communication.

1 Introduction

The basic elemental keys or objectives according to the model specified by Norman Bel Geddes to build automated road such that the safety can be improved, which gives better comfort, at a very high data transfer and efficiency [1]. By considering these four objectives the entire automation system was developed in the earlier days. As the generations, changing advancements in the fields of communications are happening which provides scope to go with some enhanced features in the automated vehicular communications like road safety, traffic management, accident avoidance, comfort less in driving, reduce fuel consumption, smart traffic light by providing priority to ambulance [2].

In order to move on with the above mentioned smart features through automated vehicles we need more bandwidth and also improved advancements for multi-band applications [3].Based on these requirements automated vehicle should have a communication control unit (CCU) and the system should accommodate with GSM band 2 (i.e.800/1900).Transceiver models with RF antennas are present in CCU which provides interface for every communication to permit the data exchange or transfer of information with different wireless access technologies:IEEE802.11a,Bluetooth,WIMAX(World Wide Interoperability for Microwave Access),LTE 2600,radio band ISM2.4G,UMTS (Universal Mobile Telecommunication System), DSRC (Dedicated Short Range Communication) [4].We are in a need of multi-hop communication or direct communication since the data transformation can be done between automated vehicle to vehicle, vehicle to node (device), vehicle to network and vehicle to everything [5]. At present we are operating with spectrum which is below 6GHz range for this multi-hop communication we are forwarding towards mm wave communication whose frequency spectrum is from 30 to 300 GHz, which is a bit higher when we talk about on-going spectrum range[6]. As mm wave frequency spectrum is used so its impact over vehicular spectrum as well as benefits of moving with wider spectrum are also discussed in this paper.

Proceedings DOI: 10.21467/proceedings.114; Series: AIJR Proceedings; ISSN: 2582-3922; ISBN: 978-81-947843-8-8

As we are mentioning about the enhanced features through this vehicular communication the requirement of powerful antennas are very much essential [7]. This paper is intended to provide a broad understanding of vehicular communication and Antennas used for wireless applications.

2 Vehicle to Everything (V2X) Communication Overview

General the Vehicular Communication Network comprises vehicles and other communication entities [8]. To achieve the enhanced features through this automated vehicular system the data should get exchanged between vehicles and different communication entities, this mechanism of data sharing between the vehicles and different entities is named as Vehicle to Everything (V2X) Communication [9]. V2X integrates different modes of communication such as

(i) V2V which is a Vehicular Ad-hoc Network where the two automated vehicles interact directly if they are located at nearby distances which works on the principle of Dedicated Short Range Communication (DSRC), if not a multi-hop communication is followed for data transmission. Identification of free slot available at parking lots, area can be considered as an example for this type of communication before the arrival of vehicle [10].

(ii)Vehicle2Network (V2N) /Infrastructure Communication comes when the data sharing is between Vehicle and road side communication or vice-versa i.e. the data is transferred towards networks like cloud, fog and grid. This communication needs facilities like special devices or infrastructure where the road side nodes were connected using wireless mediums like Wi-Fi data later data forwards towards cloud [11].

iii) Vehicle to Device (V2D) communication is a method where communication takes place between vehicle and a device which are person/pedestrian/Passenger/cyclist. Due to this it can also be named as Vehicle to Pedestrian (V2P) communication [12].

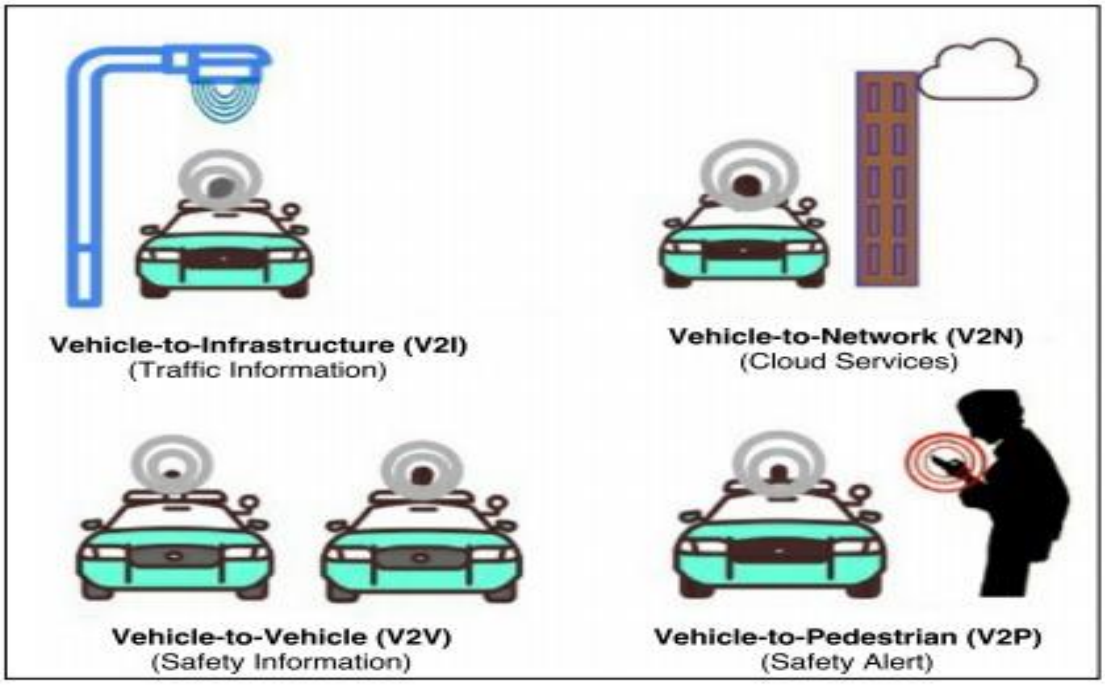

Fig.1. Overview of V2X model

The way how V2X integrates different modes of communication and how vehicle communicate with surroundings are mentioned in fig 1 which helps us to obtain the enhanced features like safe driving, accident controllability, enhanced security ,portability, traffic flow and accident alerts[13].

3 Vehicular Network Framing (VNF)

For establishing different integrities of V2X Communication, a highly potential network framing is needed and it is comprised of following specified domains named as In- Vehicle domain, ad-hoc domain, Infra-structure domain as well as Service domain [14].

In Vehicle Domain relates to the information regarding the status or condition of vehicle such as thermal conditions inside the vehicle, fuel consumption, reactivity towards voice based controls. To get the data regarding vehicle domain, manual interface with microcontroller based Controller networks are needed. This can also be achieved by using different wireless technologies such as Bluetooth, Wi-Fi, Wimax and GPS [15].

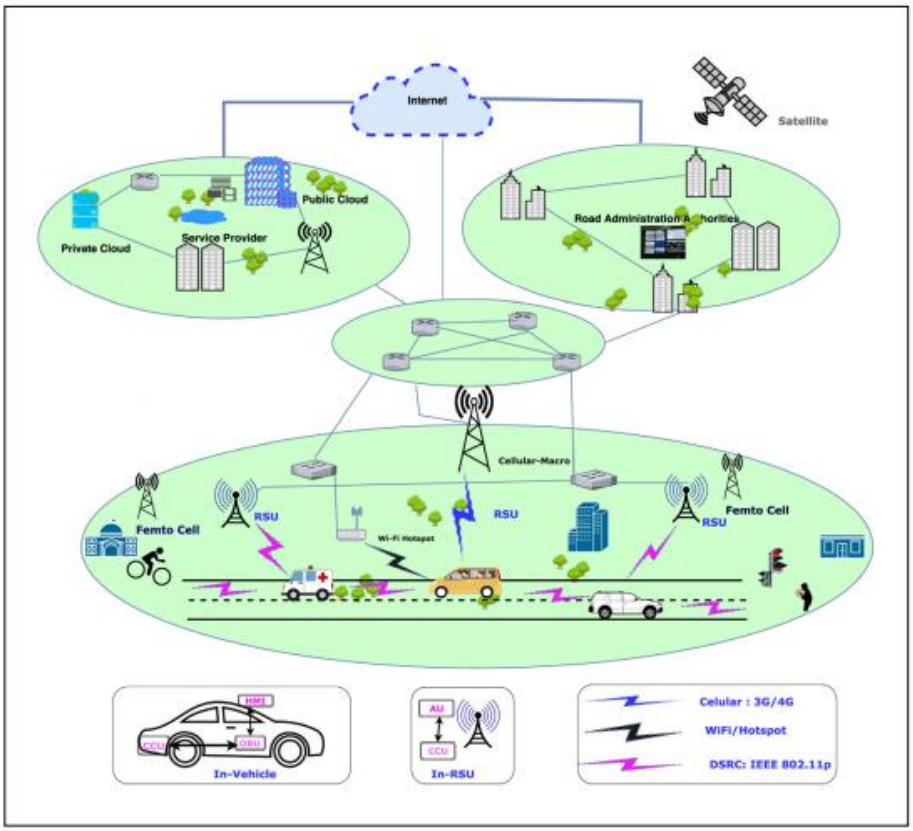

Fig.2. Vehicular Network Frame (VNF)[1]

Ad-hoc domain, where stream-less wireless network connection is done for inter-vehicle communications i.e. V2V communication and based on range, sometimes multi-hopping is essential. The RSUs sometimes help in the extension of range or else we can prefer a controller named as Communication Controller Unit (CCU) for the extension of range.

Infra-structure domain relates a group of wired as well as wireless communication in which RSUs get connected through wired network infra-structure components to establish wireless transfer using hotspots and also switches' and router's. Access control for authorities can be made possible with wired connections.

Proceedings DOI: 10.21467/proceedings.114
ISBN: 978-81-947843-8-8

Series: AIJR Proceedings
ISSN: 2582-3922

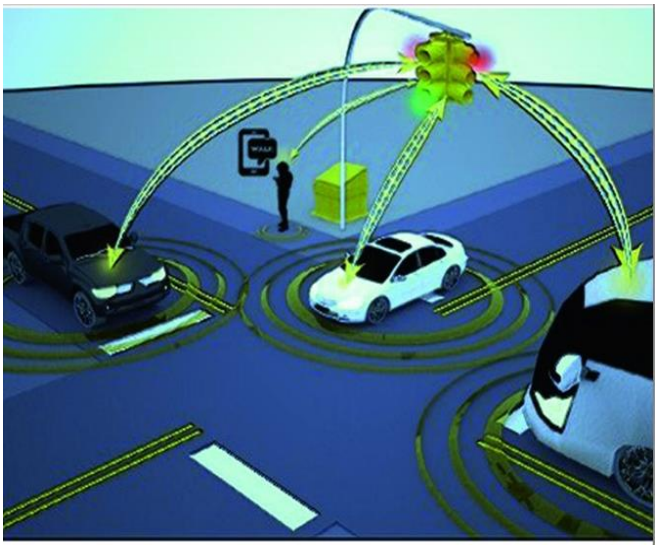

Fig.3. Model of Infrastructure Domain [6]

Service domain gives services to the automated vehicles using Infra-structure domain through V2I connectivity. Traffic related Services and Generic Services are the two classifications in this domain. Generic services relates to manufacture services, internet based services, subscription based services.

4 Vehicular Communications Applications (VCA)

Vehicular Network technology founds countless applications which are used to provide safe,secure,relief and portable environment.Here sequential programming module and event driven programming module are utilized to accessthe above mentioned applications..Based on the above mentioned features the vehicular communication applications are categorized into two ways named as safety and non- safety applications[6].

Providing the information about the curvature of road ahead, about accidental zone ahead, about weather conditions, about pedestrian crossings ahead,about road maintainence ahead comes under the safety applications i.e. safety applications are related in a direct form to the vehicles on road.All the service related works like repairs, next fuel station information, maintainence, navigation, hotels nearby and many comes under non-safety applications.Now we just move towards the impact of 5G on Vehicular communication applications.

5 Impact of 5G on VCA

Based on the growing needs of human beings the era of wireless communications had drastically changed from first generation to present fourth generation i.e. 4G in
providing services like high quality and reliable communication.The development in wireless communication is set for providing high data rate, data capacity standards, multiple analysis and frequency reuse methods upto 4G[1].

In 5G the concept of milli-meter wave communication came into picture whose operating spectrum is from 30 to 300GHz . As compared with present spectrum i.e. of 6GHz for vehicular communication the mm wave operating frequency spectrum is very high. By utilzing various coding techniques and improved modulation schemes as well as antenna beam forming analysis, using MIMO techniques and by applying fractal geometry leads to provide us high data rate, reduce interferance and reusablity of spectrum.In automative radar systems mm wave technique is used at a very high frequency of operation i.e. around 70GHz. The main requirement from 5G is of multi tasking capability and service

provision for various networks. As the author specified that for 5G communication the bit rate is around 20Gbps with a frequency band of 700MHz and 500Km/hr mobility supportbut the maintainence of beam alignment with low latency is a major task according to the author[4].

As IoT came into picture which has created a lot of impact towards technology even IoV also create an effect with millimeter wave communication and frequency band of operation.The data from the nodes (in this case automated vehicles) are forwarded towards cloud for sharing as well as accessing the information.As vehicles are huge so the data transfer rate will also be huge so this data whichever sent must be preserved in a dedicated cloud which completely relates to vehicle communication.The neraest transceiver named as EDGE collects the data from vehicles and later it is moved to fog and then to cloud. EDGE is the best option to reduce latency,as the vehicles dump the data therefore faster access is possible with enhanced protection and convinience.In between cloud and EDGE,fog acts as a middle level to provide faster data transfer and to minimize latency.

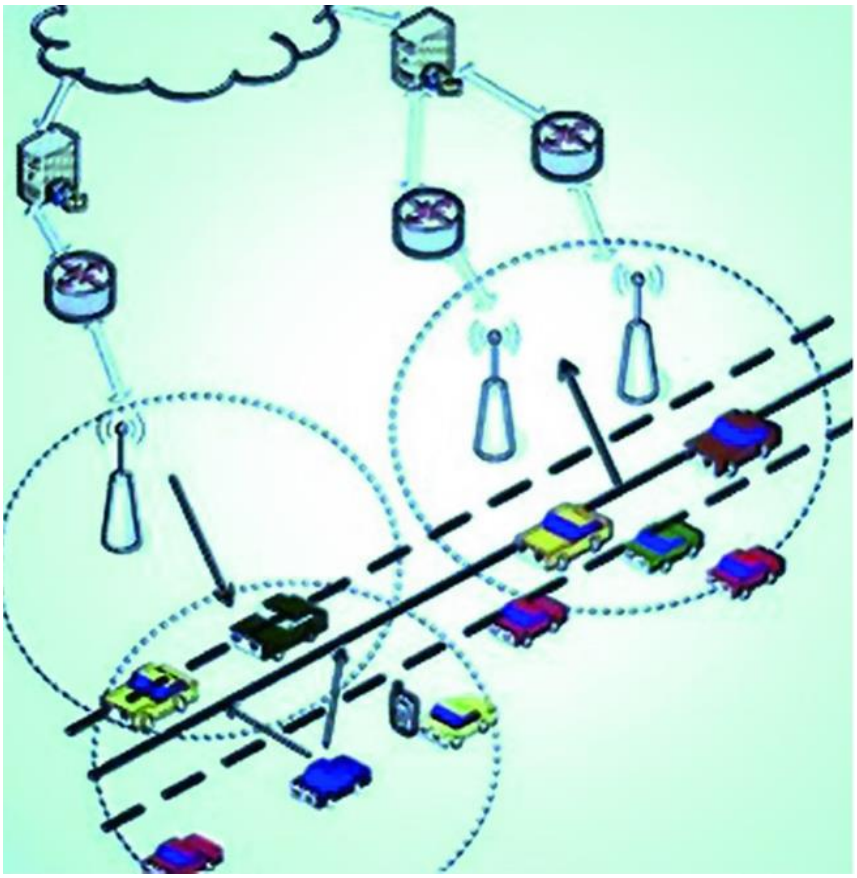

Fig. 4. Model of Internet of Vehicles[3]

6 Existing Methods

More Initiations on mixed antenna designs for upcoming generation are proposing by many researchers. In the regards of saving the space is concerned then conformal antennas plays a vital role because these conformal antennas are easily processed on the surface of the carrier. The conformal antenna may be a split type as well as Microstrip and strip-line. A way to maintain proper angle in between planar array and major lobe depends on the shape of the conformal antenna, due to this reason a cylindrical shape is concerned in many cases[8]. Conformal antennas are operated in a frequency range of 30 to 35GHz is suited for vehicular communication as mentioned in the fig 5.

Proceedings DOI: 10.21467/proceedings.114
ISBN: 978-81-947843-8-8

Series: AIJR Proceedings
ISSN: 2582-3922

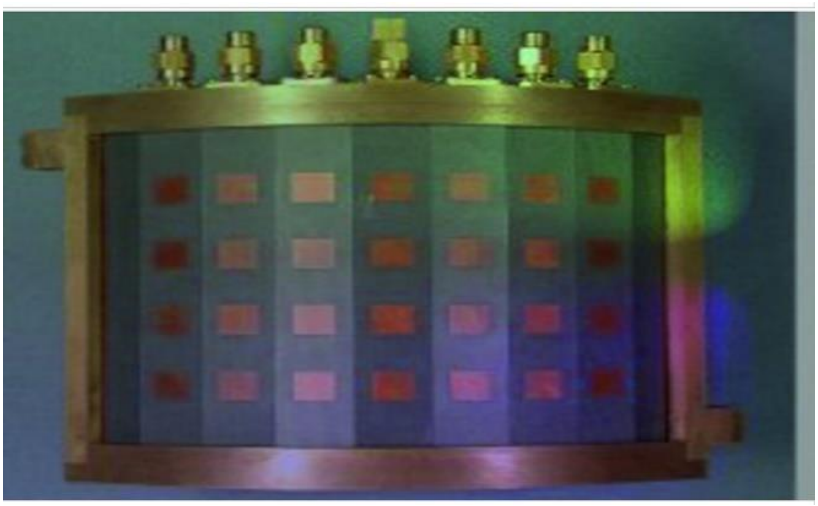

Fig. 5. Conformal Antenna[6]

By using conformal antenna the gain is more than 12dB and at the same time bandwidth achieved is more than 10%. As a point of drawback is concerened here is when the frequency of operation of antenna is very high then the radiation pattern becomes uncontrollable but in vehicular communication the pattern must be more directional and accurate [12].For this accuarte pattern achievement author proposed a model where polarization switching mechanism should be done in a precised way and orthogonally circular polarized modes using a dipole of type magneto-electric.

The below figure shows a MIMO practical antenna used to capture the information from the nearest moving vehicles.

Fig. 6. A view of MIMO antenna[6]

As a move towards studying the papers on antenna designs, we found a captivating aerial whose operation matches to 5G spectrum, whose structure contains two resonators named as split ring and a closed ring. This specified aerial fabricated by a substrate named as Rogers of 0.2554mm thickness and has a low profile

of 6×8 mm²and its maximum gain is 4.64 dBi with improved efficiency up to 80%. As we go on increasing the radiators the size of antenna will also increase to overcome this staircase model antennas are preferred to reduce the overall size whose name is proposed as Zero-order resonance antenna [12].An antenna design for multiband operations and as well as increased bandwidth parameters are concerned the best antenna that comes into researchers mind is fractal antenna. Let us proceed with fractal antenna importance in vehicular communication and its applications.

7 Fractal Antennas

Fractal geometry based antenna design implementation is found as a very interesting approach among the researchers, where this geometry focuses on two areas: one relates to design methodology and analysis of fractal antenna elements and the second one is on application of fractal concepts for antenna arrays. Fractal approach is majorly observed in UWB technology based applications like image sensing, Vehicular radar applications and measurements. Emerging designs based on fractal geometry are finding a lot of scope in upcoming 5G communications.

For the frequency range of 3.2 to 10.5GHz a new fractal design was proposed and this proposed system also relates study on distribution of current, group delays and radiation pattern whose results are found satisfactory but further enhancement is also possible. Further enhancement is done using two methods where the first approach specifies using fractal layers and the second method is two layered fractal . These antennas are highly significant in vehicular to everything communications/applications in present platform. Researchers can move on for the progress for various modes of applications in 5G with the help of fractal antenna designs.

8 Conclusion

A complete review on vehicular communications and vehicular communication applications are provided through this paper. A review on antennas used for 5G communications and what sort of problems encounter in antenna design for 5G and the remedies for those problems in different authors point of view are also discussed. Novelty of various antennas with fractal geometry was discussed along with their impact on the society and technology in the upcoming applications.

References

[1] Malik P.K., Parthasarthy, H., Tripathi, M.P.: Alternative mathematical design of vector potential and radiated fields for parabolic reflector surface. In: Unnikrishnan, S., Surve, S., Bhoir, D. (eds.) Advances in Computing, Communication, and Control. ICAC3 2013.Communications in Computer and Information Science, vol. 361. Springer, Berlin, Heidelberg (2013)

[2] N. Wolff, S. Chevtchenko, A. Wentzel, O. Bengtsson and W. Heinrich, "Switch-Type Modulators and PAs for Efficient Transmitters in the 5G Wireless Infrastructure," 2018 IEEE MTT-S International Microwave Workshop Series on 5G Hardware and System Technologies (IMWS-5G), Dublin, 2018, pp. 1-3.doi: 10.1109/IMWS-5G.2018.8484690

[3] Rahim, A., Malik, P.K., SankarPonnapalli, V.A.: Fractal antenna design for overtaking on highways in 5g vehicular communication ad-hoc networks environment. Int. J. Eng. Adv. Technol. (IJEAT). ISSN: 2249–8958, 9(1S6), 157–160 (2019)

[4] Malik, P.K., Tripathi M.P.: OFDM: A Mathematical Review. J. Today's Ideas–Tomorrow's Technol. 5(2), 97–111 (2017)

[5] Arif, A., Zubair, M., Ali, M., Khan, M.U., Mehmood, M.Q.: A compact, low- profile fractal antenna for wearable on-body WBAN applications. IEEE Antennas Wirel.Propag.Lett. 18(5), 981–985(2019)

[6] Rahim A., Malik P.K., SankarPonnapalli V.A. (2020) State of the Art: A Review on Vehicular Communications, Impact of 5G, Fractal Antennas for Future Communication. In: Singh P., Pawłowski W., Tanwar S., Kumar N., Rodrigues J., Obaidat M. (eds) Proceedings of First International Conference on Computing, Communications, and Cyber-Security (IC4S 2019). Lecture Notes in Networks and Systems, vol 121. Springer, Singapore. https://doi.org/10.1007/978-981-15- 3369-3_1

[7] Singh, P.K., Nandi, S.K., Nandi, S.: A tutorial survey on vehicular communication state of the art, and future research directions. Veh.Commun.18, 100164 (2019). ISSN 2214-2096

[8] Madhav, B.T.P., Anilkumar, T., Kotamraju, S.K.: Transparent and conformal wheel-shaped fractal antenna for vehicular communication applications. AEU—Int. J. Electron.Commun. 91, 1–10 (2018)

[9] Malik, P., &Parthasarthy, H. ."Synthesis of randomness in the radiated fields of antenna array". International Journal of Microwave and Wireless Technologies,3(6), 701-705,2011

[10] Malik, P.K., Singh, M.: Multiple bandwidth design of micro strip antenna for future wireless communication. Int. J. Recent Technol.Eng. 8(2) (2019). ISSN: 2277-3878

[11] Kumar, A., Gupta, M.: A review on activities of fifth generation mobile communication system. Alexandria Eng. J. 57(2), 1125–1135 (2018)

[12] Rahim, A., Raghavendra, K., International Journal of Engineering and Advanced Technology, 2019, 8(6 Special Issue 3), pp. 1813–1816

[13] Abdul Rahim, Dr.Praveen Kumar Malik, Analysis and Design of Planner Wide Band Antenna for Wireless Communication Applications: Fractal Antennas, Design Methodologies and Tools for 5G Network Development and Application, IGI Global,page196-208.

[14]W. Cao, L. Ma, S. Li, C. Zhou, and Y. Liu, "Conformal multi-beamdirectional array antenna," in 2016 11th International Symposium onAntennas, Propagation and EM Theory (ISAPE), 2016, pp. 315-317.

[15] Abdul Rahim , Dr.Praveen Kumar Malik and Dr.V.A.SankarPonnapalli, Design and Analysis of Multi Band Fractal Antenna for 5G Vehicular Communication, Test Engineering and Management,volume 83,pg26487 – 26497, March-April 2020.

[16] S. Tsugawa, Inter-vehicle communications and their applications to intelligent vehicles: an overview, in: Intelligent Vehicle Symposium, 2002, in: IEEE, vol. 2, IEEE, 2002, pp. 564–569.

[17] Y. Toor, P. Muhlethaler, A. Laouiti, Vehicle ad hoc networks: Applications and related technical issues, IEEE Commun. Surv. Tutor. 10 (3) (2008).

[18] C. Sommer, F. Dressler, Progressing toward realistic mobility models in VANET simulations, IEEE Commun. Mag. 46 (11) (2008).

[19] J. Harri, F. Filali, C. Bonnet, Mobility models for vehicular ad hoc networks: a survey and taxonomy, IEEE Commun. Surv. Tutor. 11 (4) (2009).

[20] H. Hasrouny, A.E. Samhat, C. Bassil, A. Laouiti, VANet security challenges and solutions: A survey, Veh. Commun. 7 (2017) 7–20.

[21] X. Lin, R. Lu, C. Zhang, H. Zhu, P.-H. Ho, X. Shen, Security in vehicular ad hoc networks, IEEE Commun. Mag. 46 (4) (2008).

[22] R.G. Engoulou, M. Bellaïche, S. Pierre, A. Quintero, VANET security surveys, Comput. Commun. 44 (2014) 1–13.

[23] M.N. Mejri, J. Ben-Othman, M. Hamdi, Survey on VANET security challenges and possible cryptographic solutions, Veh. Commun. 1 (2) (2014) 53–66.

[24] H. Hartenstein, L. Laberteaux, A tutorial survey on vehicular ad hoc networks, IEEE Commun. Mag. 46 (6) (2008).

[25] P. Papadimitratos, A. De La Fortelle, K. Evenssen, R. Brignolo, S. Cosenza, Vehicular communication systems: Enabling technologies, applications, and future outlook on intelligent transportation, IEEE Commun. Mag. 47 (11) (2009).

[26] G. Karagiannis, O. Altintas, E. Ekici, G. Heijenk, B. Jarupan, K. Lin, T. Weil, Vehicular networking: A survey and tutorial on requirements, architectures, challenges, standards and solutions, IEEE Commun. Surv. Tutor. 13 (4) (2011) 584–616.

[27] S. Zeadally, R. Hunt, Y.-S. Chen, A. Irwin, A. Hassan, Vehicular ad hoc networks (VANETS): status, results, and challenges, Telecommun. Syst. 50 (4) (2012) 217–241.

[28] S. Al-Sultan, M.M. Al-Doori, A.H. Al-Bayatti, H. Zedan, A comprehensive survey on vehicular ad hoc network, J. Netw. Comput. Appl. 37 (2014) 380–392.

[29] S.K. Bhoi, P.M. Khilar, Vehicular communication: a survey, IET Netw. 3 (3) (2013) 204–217.

[30] Car 2 Car – Communication Consortium: Manifesto, available at https://www. car-2-car.org/index.php?id=31.

[31] Intelligent Transport Systems (ITS); Communications Architecture, European Telecommunications Standards Institute ETSI Technical Specification TS 102 665, 2009 (2009).

[32] W.J. Mitchell, C.E. Borroni-Bird, L.D. Burns, Reinventing the Automobile: Personal Urban Mobility for the 21st Century, MIT Press, 2010.

[33] N. Gupta, A. Prakash, R. Tripathi, Medium access control protocols for safety applications in Vehicular Ad-Hoc Network: A classification and comprehensive survey, Veh. Commun. 2 (4) (2015) 223–237.

[34] Safespot: Integrated Research Project, available at http://www.safespot-eu. org/.

[35] F.G. N.T., The CAMP Vehicle Safety Communications Consortium consisting of BMW, DaimlerChrysler, VW, Vehicle Safety Communications Project Task 3 Final Report Identify Intelligent Vehicle Safety Applications Enabled by DSRC, Tech. rep., NHTSA, USDOT, 2005.

[36] G. Cordahi, R. Kamalanathsharma, J. Kolleda, D. Miller, S. Novosad, T. Poling, S. Sundararajan, Connected Vehicle Pilot Deployment Program Phase 1, Application Deployment Plan–Tampa (THEA), Tech. rep., 2016. [37] C. Suthaputchakun, Z. Sun, M. Dianati, Applications of vehicular communications for reducing fuel consumption and CO2 emission: the state of the art and research challenges, IEEE Commun. Mag. 50 (12) (2012) 108–115, https:// doi.org/10.1109/MCOM.2012.6384459.

[38] K. Katsaros, R. Kernchen, M. Dianati, D. Rieck, C. Zinoviou, Application of vehicular communications for improving the efficiency of traffic in urban areas, Wirel. Commun. Mob. Comput. 11 (12) (2011) 1657–1667. [39] M. Amoozadeh, H. Deng, C.-N. Chuah, H.M. Zhang, D. Ghosal, Platoon management with cooperative adaptive cruise control enabled by VANET, Veh. Commun. 2 (2) (2015) 110–123.

[40] K. Abboud, H.A. Omar, W. Zhuang, Interworking of DSRC and cellular network technologies for V2X communications: A survey, IEEE Trans. Veh. Technol. 65 (12) (2016) 9457–9470.

[41] N. Lu, N. Cheng, N. Zhang, X. Shen, J.W. Mark, Connected vehicles: Solutions and challenges, IEEE Int. Things J. 1 (4) (2014) 289–299.

[42] Steven Underwood, Institute for Advanced Vehicle Systems University of Michigan Dearborn, Michigan 48128, Automated, Connected, and Electric Vehicle Systems, Expert Forecast and Roadmap for Sustainable Transportation, Tech. rep.

[43] NIST-CDV Workshop on ITS, I.T.S. Car-toCar Communications Standards, 2010.

[44] Y.J. Li, An overview of the DSRC/WAVE technology, in: International Conference on Heterogeneous Networking for Quality, Reliability, Security and Robustness, Springer, 2010, pp. 544–558.

[45] A. Festag, Cooperative intelligent transport systems standards in Europe, IEEE Commun. Mag. 52 (12) (2014) 166–172.

[46] DSRC APPLICATION SUB-LAYER ARIB STD-T88, ARIB STANDARD Ver.1.0 ARIB STD-T88, Version 1.0 MAY 25, 2004, available at http://www.arib.or.jp/english/ html/overview/doc/5-STD-T88v1_0-E2.pdf.

[47] D. Jiang, L. Delgrossi, IEEE 802.11p: Towards an international standard for wireless access in vehicular environments, in: Vehicular Technology Conference, 2008, VTC Spring 2008. IEEE, IEEE, 2008, pp. 2036–2040. [48] IEEE-802.11-2010, IEEE Standard for Information Technology– Telecommunications and information exchange between systems–Local and metropolitan area networks–Specific requirements–Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications Amendment 6: Wireless Access in Vehicular Environments, IEEE Std 802 (11).

[49] IEEE-802.11-2012, IEEE Std 802.11-2012 IEEE Standard for Information Technology–Telecommunications and information exchange between systems–Local and metropolitan area networks–Specific requirements–Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications Amendment 6: Wireless Access in Vehicular Environments, IEEE Std 802 (11).

[50] A. Standard, E2213-03 (2010), Standard specification for telecommunications and information exchange between roadside and vehicle systems—5 GHz band Dedicated Short Range Communications (DSRC) Medium Access Control (MAC) and physical layer (PHY) specifications, ASTM International, West Conshohocken, PA, 2003.

[51] R.F. Atallah, M.J. Khabbaz, C.M. Assi, Vehicular networking: A survey on spectrum access technologies and persisting challenges, Veh. Commun. 2 (3) (2015) 125–149.