Article can be accessed online at http: //www.publishingindia.com

Review: Wireless Communication Standards of Vehicular Networks

Jayashree A. Patil* , Nandini S. Sidnal**

Abstract

Intelligent Transportation Systems (ITS) terminology comes into existence in 2002 as accident rates are increased on roads and demand for safety information and infotainment is increased. Vehicular networks plays vital role to control traffic and manage it. VANET is a driving force for ITS, is a subclass of mobile Ad hoc Networks (MANETs), and an emerging technology to enable communications among vehicles to provide intelligent transportation applications. Vehicles are coming with high computing power within itself which is a promising approach for traffic security, infotainment and V2V communication in order to provide stable connections between vehicles. VANET's have special characteristics like high mobility and frequent changes of network topology create some challenging technical issues and also made separate from ad hoc network than from MANET. Automated computation is an important requirement of ITS in present world. Future transport systems must make decisions automatically, analyze input information and act accordingly. So to solve this problem VANET needs new transformation of information dissemination at anytime, anywhere and anything for ITS applications in which communication standards play vital role. In this paper we briefly give the review of VANET and VANET standards.

Keyword: Its, VANET, DSRC, WAVE, ICT, Lte, Lte-A, Wireless Standards

1. Introduction

Demand for in-vehicle services is increasing, to give assistance to driver or people who injured in traffic accidents. So research and investments in computing and wireless communication technologies by the researchers, industries and academia is adequate. Hence VANET is a special case of MANET where in communication between vehicles (V2V) and communication between roadside (V2I) takes place[1]. Nodes in VANET are vehicles having heterogeneous nature as vehicles manufacturers are of different. The most promising challenge with VANET is high mobility than MANETs, no Guarantee of end-to end connectivity, have dynamic topologies not so random, as they need to follow the road line. Since as auto section increased its computing power in vehicle, Vehicular networks have the potential to grow to a very large scale. The major challenge in VANET is to develop scalable, robust, low-latency and high throughput technologies for safety applications that will significantly reduce collisions and save lives and property loss[2]. Vehicular networks are different from Mobile networks in terms of the topology, mobility pattern, energy constraint, and real-life application scenarios [3] Therefore, existing approaches designed for MANETs are not efficient and cannot be directly applied in VANET. Following are the key research challenges in VANET: Frequent Link Disconnections, Highly Dynamic traffic Conditions, Heterogeneity of Applications Information Dissemination.

Applications of VANET

Applications of VANET are classified into two major categories: Safety applications and nonsafety applications. Traffic monitoring and management applications and Infotainment applications are part of nonsafety applications.

To handle these applications FCC (Federation for Communication Consortium) of USA allocated separate

* Assistant Professor, Department of Information Technology, MIT Academy of Engineering, Pune, Maharashtra, India.
** Assistant Professor, Department of Information Technology, MIT Academy of Engineering, Pune, Maharashtra, India.

band of 5.9GHz as DSRC for vehicular communication. Which consist of six control channels and one service channel. So these channels help to handle the different applications mentioned below.

Safety Applications: Timely providing information to drivers about the road conditions and accidents is must. Information is shared between vehicles and road side units. Safety information consists of vehicle's speed, its position, intersection point and distance heading display on the OBU (On Board Unit). And also, In India road conditions are worst so information about the hazardous locations, like slippery sections can be easily located using the exchange of information between the vehicles and the road side units.

Infotainment Applications: Now a days people more time roads they need some infotainment applications messages like location of nearest coffee shop, cinema hall, shopping mall, nearest fuel station and also which station offers the best price in that area, or available parking. Infotainment applications can be either Co-operative local applications or Global Internet Applications. With the development in the field of wireless communications, ITS applications are developed based on car-to-car communication standards such as Wireless Access in Vehicular Environments (WAVE) and Dedicated Short Range Communications (DSRC). WAVE and DSRC standards are defined in IEEE 1609.1-4 and 802.11p respectively. The fact that FCC has allocated dedicated 75 MHz frequency spectrum in the range 5.85 GHz to 5.925 GHz to be used only for Vehicle to Vehicle (V2V) and Vehicle to Infrastructure (V2I) communication. With 60-100 embedded sensors with their corresponding microprocessors.

Issues and Challenges of VANET

In VANET it is required to design efficient and effective radio resource management strategies, as it is different than MNAET. Management strategies like Quality of Service control, interference control, in advance bandwidth reservation, gain in throughput, and packet scheduling and fairness assurance in VANET, To achieve various applications in a vehicular environment, new and effective strategies are required to be couturier specifically meant for VANET. Following are the key research challenges in VANET: -

Frequent Link Disconnections: Vehicles are highly mobile and generally travel at very high speeds, especially on highways and thus changes the topology of a network so analysis of connectivity and management of mobility-aware resource are important.

Heterogeneity of Applications: Safety and infotainment are two major applications of VANET technologies. Generally, road safety applications need low latency and high reliability. On the other hand, infotainment applications require better throughput, low packet loss, higher resource utilization. So channel access protocols and network resource allocation strategies should be adaptive to ensure efficient, orderly, and fair communications among all the vehicles on road. In VANETs, safety-related messages assigned high priority and infotainment messages should be of low priority.

Information Dissemination: Dissemination of traffic information may be safety or infotainment in VANET is a critical problem because of heterogeneity in traffic nature Internet data is typically unicasted, but traffic information has a nature which requires broadcasting. Traffic information is destined for public interest, and not for an individual. Therefore, disseminating the traffic information using broadcasting scheme is more suitable as compared to a routing approach that employs unicasting. Large numbers of solutions are provided by the scientists but still no method overrides the efficient solution. Vehicular ad hoc networks system architecture can be categorized into three domains. Jakub Jakubiak et,al [20], discussed research challenges of VANET in 2008, some of them summarized as below,Wireless Access technology: now 4G and 5G technologies overcome this problem. In Spectrum issues presently cognitive technologies helps in this regard. Broadcasting and message dissemination still is a problem now also. Routing issues Power management, Security and Privacy and modeling and simulation still have problems to be solved.

Literature Survey

In this paper we are discussing different emerging wireless and communication technology standards required for vehicle to vehicle communication. Some of the technologies are implemented in some part of the world and some are under development. In Intelligent Transportation system automated computation is required. Future transport systems must make decisions automatically, analyzing input information and acting accordingly, triggering coordinated actions to improve system performance. Different standards has been designed and developed to have automatic computation. In following sections we will see the survey on different wireless standards technologies. Vehicles utilize a variety of wireless technologies to communicate with other devices. Dedicated Short Range Communication (DSRC) technology is designed to support various applications. In DSRC terms like V2V(Vehicle to Vehicle) and V2I(Vehicle to Infrastructure) are used where V2V communication paradigm is called as zero Infrastructures because communication is completely adhoc in nature several industry and governments consortiums are striving to identify different kinds of VANET safety applications that will provide the greatest safety benefits. These organizations include Crash Avoidance Metrics Partnership (CAMP) [4] which is the joint collaboration of vehicle companies like BMW, Daimler Chysler, Ford, GM, Honda, Nissan, Toyota and Volkswagen [5]. Dedicated Short Range Communication (DSRC) spectrum allocated by the U. S. Federal Communication Commission is developed in 1999 for ITS applications specially. DSRC lies in the 5. 9 GHz range and has 75 MHz for V2V and V2R communication. DSRC is split into seven 10 MHz channels. Channel 178, the fourth channel is used for safety communications only and is called the control channel [6]. There are four service channels and the first and the seventh channel are for special purposes DSRC PHY/MAC layer is to offer robust transmission between vehicles on shared media. Two methods to for sharing a medium. The first is to use controlled-access protocols, where in the medium is decided in advance such as in TDMA. The second way is to use random access protocols like CSMA for MAC requirements in DSRC is Distributed coordination function (DCF) is used widely as a basis for V2V communications[7]. Another important requirement for VANETs is for vehicles to exchange important messages immediately and efficiently. The probability of collision and the corruption of emergency messages must be low. The problem is that current wireless local area networks (WLANs) mostly handle data without time constraints. They have no real QoS or real-time traffic support. The transmission rate depends upon the transmission range, maximum speed, and the deceleration capability of the cars and the channel conditions. Ott and Kutscher [29] provide WLAN-based Internet access for vehicles based on the drive-thru architecture. They identify three phases when a vehicle is passing through a connectivity cloud. Namboodiri, *et al.* [30] suggest using multi-homed vehicles to act as gateways together with predictive protocols. The mobile gateways would share their bandwidth and computing power to provide other vehicles with connectivity to the Internet and other resources. The European Telecommunications Standards Institute (ETSI) also allocated a radio spectrum of 30 MHz at 5.9 GHz for ITSs. Every standard aimed to improve quality-

Of-service (QoS) and spectrum utilization, multiple channels are expected to be employed in vehicular communications [12]. Through global positioning system (GPS) Location information and updation of vehicles is generally available. End-to-end paths can then be recognized via location-aware V2V and/or V2I transmission for information delivery. The author proposed that in near future, this emerging vehicular networking paradigm is expected to provide variety of automotive applications, ranging from collision warning/ avoidance to road traffic monitoring to seamless inter-vehicle video streaming. DSRC forms the basis for IEEE 802.11p known as WAVE (Wireless Access for Vehicular Environment). Some of the challenges related to MAC layer in VANET are fast network topology changes, priority of applications being transmitted, reduction in medium access delay and transmission reliability.

The International Organization for Standardization (ISO) is developing a family of international standards and architecture on communications access for land mobiles (CALM). It is expected that the future CALM system will make use of a wide range of technologies[10] including satellite, cellular (GSM, 3G and 4G/WiMAX), Wi-Fi wireless local area network (WLAN) and its wireless access in vehicular environments (WAVE) evolutions (IEEE802. 11P and IEEE P1609), Bluetooth wireless personal area network (WPAN), mm-Wave, infrared and radio frequency identification (RFID). In addition, many sensing technologies such as radar, imaging and video processing will be integrated into the CALM architecture. However, the DSRC solutions are not fully field proven. There are significant DSRC-related social and technical challenges that have to be dealt with before large-scale deployment. So WAVE has been designed to overcome the above said problems. DSRC forms the basis for IEEE 802. 11p also known as WAVE (Wireless Access for Vehicular Environments).Wireless Access Vehicular Environment (WAVE) system has two components. On-board unit (OBU) and roadside unit (RSU). They are equivalent to the mobile station (MS) and base station (BS) in the cellular systems respectively. There are two classes of communications enabled by the OBUs and RSUs: vehicle to vehicle (V2V) and vehicle to infrastructure (V2I). WAVE networks have a set of technical challenges not encountered in other wireless networks. One challenge is to use WAVE technology in collision avoidance between fast moving vehicles. For example, it can be used to warn the drivers at the crossing between roads and railways if there is dangers of collision and also inform an abnormal situation is when two cars are traveling on a narrow two-way street towards each other at fast speed [10]. 802.11p is proposed as draft amendment for 802.11 to exchanges traffic information. MAC layer is based on prioritized and contention based enhanced distributed channel Access (EDCA) scheme of 802.11e. Marica Amadeo [11] proposed W-HCF (Wave based Hybrid Coordination Function) which is designed to provide time bounded delays and differentiated treatment to non-safety applications. W-HCF relies on controlled channel access procedure, considers multi-channel WAVE operation and makes use of basic service set initiation procedure. Wireless strategies discussed above provide safety applications to drivers and passengers. But does not support Internet access. Yunpeng Zang [12] proposed method known as drive-thru Internet, in which original IEEE 802.11 WLAN is used MAC enhancement to WAVE protocol. In this method two architectures are studied, one is to make use of the direct communication between WAVE On-Board Units (OBUs) and Road Side Unit (RSU), while the other integrates the MYCAREVENT VCGs [13] and WAVE OBUs. Dedicated Short Range Communication (DSRC) can provide efficient real-time information exchange among vehicles without the communication infrastructure. While mobile cellular networks are capable of providing wide coverage for vehicular users, but it cannot provide guarantee for stringent real-time safety by, Therefore, Kan Zheng et,al proposed Heterogeneous Vehicular NETwork (HetVNET), which integrates cellular networks with DSRC, which is a potential solution for meeting the communication requirements of the ITS. HetVNET is consists of three main components, namely a Radio Access Network (RAN), a Core Network (CN), and a Service Center (SC). Service providers can often supply a variety of services to vehicular users through the SC. The CN is a key component of the Het- VNET because it provides many important functions, such as aggregation, authentication, switching and so on. RAN can be either V2V or V2I. With the rapid development of information and communication technologies (ICT) and People's expectations to have in their cars the same Internet connectivity as they have at home and at work, equipping automobiles with wireless communication capabilities is expected to be the next frontier for automotive revolution [25].

Thus Connected vehicles on the go to be proactive, cooperative, well-informed, well connected and coordinated, and will pave the way for supporting various applications for road safety, smart and green transportation and location-dependent services. Connecting vehicles to the Internet can be envisioned not only to meet the mobile data demand [16], but also enrich safety-related applications, such as online diagnosis [17] and intelligent antitheft and tracking [18], in which the servers can be on the Internet cloud. The European Commission proposed to implement a mandatory "eCall" system in cars from 2015, by which cars can automatically establish a telephone link for emergency services in case of a collision [19]. Characteristics and Challenges Different from generic wireless sensor networks, intra-vehicle wireless sensor networks show unique characteristics that provide the space for optimization. Different applications may require different signal transmission directions for example Braking Warning signals should be sent to vehicles behind the transmitting vehicle, but Lane Change Warning signals are interested by both prior and rear vehicles. On other hand in many cases, messages should be shared by several vehicles such that the complete transmission is conducted via multiple hops [26]. Thus, network connectivity may play a more important role in vehicular communications, compared with system throughput. DSRC/WAVE technologies does not support above said applications. Long Term Evolution solves this problem. LTE consists of Evolved UMTS Terrestrial Radio Access (E-UTRA) air interface, which is a technology transmission: FDD and TDD [28]. As cellular technologies are evolving Long Term Evolution has higher impact from fast transmission. So authors in [22] simulated LTE versus IEE 802.11p using NS3.17 the result shows that LTE outperforms than IEEE 802.11p in terms of delay, reliability, and scalability, whereas IEEE 802.11p offers acceptable performance for sparse network topologies, authors simulated on both infrastructure and infrastructure less networks. The authors also observed that as load increases, denser networks with higher transmission frequencies results in higher end-to-end delay. Another issue is of scalability, where the performance degrades significantly as the number of vehicles increases. On the other hand, although the improved capacity, reliability and Long-Term Evolution-Advanced (LTE-A); LTE-A is the *fourth*-generation (4G) wireless communication system and dominates the 4Th Generation wireless networks and to support a wide variety of applications that require higher data rates with more reliable transmission. [3]. LTE-A was defined by the International Telecommunication Union as an International Mobile Telecommunications-Advanced (IMT Advanced) 4G technology in November 2010 and has adopted relaying for cost-effective throughput enhancement and coverage extension [4], [5]. Using this technology Mohamed F. Feteiha, et.al [22] proposed (RVC-Net) which is a relaying vehicular cloud networking where in vehicles acts as relay to reduce power consumption at the end-user mobile terminal RVC-Net will become integral part of wireless communication.

Conclusion

With fast development of information and communication technologies (ICT), and People's expectations, present cars should have Internet connectivity as they have at home and at work, equipping automobiles with wireless communication capabilities is expected to be the next frontier for automotive revolution. Thus connected vehicles on the go to be proactive, cooperative, well informed, well connected and coordinated, thus in this paper we addressed different communication technologies from 2002 to 2015. DSRC supports only safety applications in dedicated bands. In order to achieve the social technological requirement and scalability WAVE has been proposed. To have high data rate and Internet connectivity while on go LTE and LTE-A has been proposed. So Vehicular networks are moving from traditional way of data transmission to cloud. This is one of challenging task.

References

1. Wang-Hei Ho, I. (2011). Stochastic model and connectivity. *IEEE/ACM Transactions on Networking*, February, 19(1), 195 - 208.
2. Alazawi, Z. (2014). Transportation evacuation strategies based on VANET disaster management system. *Procedia Economics and Finance*, 18, 352-360.
3. Sharef, B. T. (2013). Vehicular communication ad hoc routing protocols: A survey. *Journal of Network and Computer Applications*, 40(1), 363-396.
4. Viriyasitavat, W., Boban, M., Tsai, H. M., & Vasilakos, A. V. (2015). Vehicular Communications. *IEEE Vehicular Technology Magazine*, June, pp. 1556-6072. Springer, New York.
5. Hussain, R., Rezaeifar, Z., & Oh, H. (2015). A paradigm shift from vehicular Ad Hoc networks to VANET-based clouds. *Wireless Personal Communications*, 83(2), 1131-1158.
6. Yanamandram, S. (2009). Analysis of DSRC based MAC protocols for VANETs. *IEEE International Conference on Ultra Modern Telecommunications and Workshops*, pp.1-6.
7. Toor, Y. (2008). Vehicle Ad Hoc networks: Applications and related technical issues. *IEEE Communications, Surveys & Tutorials*, 10(3), 74-88.
8. Meyer, H. (2011). VANET mobility modeling challenged by feedback loops. *The 10th IFIP Annual Mediterranean Ad Hoc Networking Workshop*.
9. Veeraraghavan, M. (2011). A Survey of Research Literature on Vehicular Networking. *IEEE ICC,* Kyoto, Japan.
10. Li, Y. J. (2011). An Overview of the DSRC/WAVE technology. Lecture Notes of the Institutes for Computer Sciences, 74, (pp. 544-558).
11. Amadeo, M. (2010). Enhancing IEEE 802.11p/ WAVE to provide infotainment applications in VANETS. Ad Hoc Networks 10 (2012), 253-269.
12. Zang, Y. (2008). Opportunistic wireless internet access in vehicular environments using enhanced WAVE devices. *International Journal of Hybrid Information Technology*, 10(10), 83-100.
13. Egger, E. (2015). Architecture, challenges, and solutions. *IEEE Communication Surveys & Tutorials*, 17(4), Fourth Quarter.
14. Lu, N. (2014). Connected vehicles: Solutions and challenges. *IEEE Internet of Things Journal,* August, 1(4).
15. Lin, J., Chen, S., Shih, Y., & Chen, S. (2009). A study on remote on-line diagnostic system for vehicles by integrating the technology of OBD, GPS, and 3G. *World Academy of Science, Engineering and Technology*, 56, 56.
16. Balasubramanian, A., Mahajan, R., Venkataramani, A., Levine, B. N., & Zahorjan, J. (2008). Interactive

WiFi connectivity for moving vehicles. *ACM SIGCOMM Computer Communication Review*, 38(4), 427-438.

17. Ramadan, M., Al-Khedher, M., & Al-Kheder, S. (2012). Intelligent anti-theft and tracking system for automobiles. *International Journal of Machine Learning Computing*, February, 2(1), 88-92.
18. e-Call. Online. Retrieved from http://ec.europa.eu/digital-agenda/en/ecalltime- saved-lives- Saved
19. Ho, I. W. H. (2011). Stochastic model and connectivity. *IEEE/ACM Transactions on Networking*, February, 19(1), 195-208.
20. Jakubiak, J., & Koucheryavy, Y. (2008). State of the art and research challenges for VANETs. 5^{th} *IEEE Conference on Consumer Communications and Networking*.
21. Mir, Z. H., & Filali, F. (2014). Performance comparison between IEEE 802.11p and LTE-based vehicular networks. *79^{th} IEEE Conference on Vehicular Technology*.
22. Feteihaet, M. F. (2015). Enabling cooperative relaying VANET clouds over LTE-A networks. *IEEE Transactions on Vehicular Technology*, April, 64(4), 1468-1479.
23. Al-Sultan, S. (2014). A comprehensive survey on vehicular Ad-Hoc network. *Journal of Network and Computer Applications*, January, 37, 380-392.
24. Bhattacharyya, D. (2010). *Architecture of Vehicular Ad Hoc Network*. IGI Global.
25. Lu, N. (2014). Connected vehicles: Solutions and challenges. *IEEE Internet of Things Journal*, August, 1(4).
26. Liang, (2015). Vehicular Ad Hoc networks: Architectures, research issues, methodologies, challenges, and trends. *International Journal of Distributed Sensor Networks*.
27. Kenney, J. B. (2011). Dedicated Short-Range Communications (DSRC) standards in the United States. *Proceedings of the IEEE*, July, 99(7), 1162-1182.
28. Matolak, D. W., Wu, Q., Sanchez-Sanchez, J. J., & Morales-Jiménez, D. (2014). *Performance of LTE in Vehicle-to-Vehicle Channels*.
29. Kutscher, D., & Ott, J. (2004). The ‘Drive-Thru’ architecture: WLAN based internet access on the road. *IEEE 59^{th} Vehicular Technology Conference*, Spring, 5, pp. 2615-2622.
30. Namboodiri, V., Agarwal, M., & Gao, L. (2004). A study on the feasibility of mobile gateways for vehicular Ad-Hoc networks. *Proceedings of the 1^{st} ACM International Workshop on Vehicular Ad Hoc Networks*, (pp. 66-75).