International Journal of Advancement in Engineering Technology, Management & Applied Science
Volume1, Issue 1 June 2014 ISSN No: 2349-3224

Vehicular Ad Hoc network – Various Challenges and Applications

Vandna Dahiya
PG Research Student (CSE)
PDM College of Engg, for Women
Bahadurgarh (Haryana)

Ajay Dureja
Assistant Professor (CSE)
PDM College of Engg, for Women
Bahadurgarh (Haryana)

ABSTRACT

Vehicular ad hoc networks (VANETs) are classified as an application of mobile ad hoc network (MANET) that has the prospective in improving road safety and in providing travellers comfort. VANETs have evolved as an attractive field for the researchers. The main difference between MANET and VANET is in their architecture, challenges, characteristics and applications. In our paper, we discuss some features of VANET and various applications along with various challenges facing by researchers at present time.

Introduction

Vehicles like cars are used as private means of transportation by many people daily. The increasing number of private transport is also the reason of fatalities that occur due to accidents on the roads; the expense and related dangers have been recognised as a serious problem being confronted by modern society. VANET provides a wireless communication between moving vehicles, using a dedicated short range communication - DSRC. DSRC is IEEE 802.11a revised for low overhead operation to 802.11p. Vehicle can communicate with other vehicles directly forming vehicle to vehicle communication (V2V) or communicate with fixed equipment next to the road, referred to as road side unit (RSU) forming vehicle to infrastructure communication (V2I).

These types of communications allow vehicles to share different kinds of information, for example, safety information for the purpose of accident prevention, post-accident investigation or track jams. Other type of information can be distributed such as traveller related information which is considered as non-safety information. The intention behind distributing and sharing this information is to provide a safety message to warn drivers about likely hazards in order to decrease the number of accidents and save people's lives, or to provide passengers with enjoyable journeys. Various applications and protocols are being developed for VANET to cover various issues like network architecture, communication domains, challenges and applications.

Rest of this paper is organised as follows. Section 2 with describes the network architecture. Section 3 presents the communication domains in VANET. In Section 4, we discuss the wireless access technologies that can be used to establish the communication of the network. Section 5 presents the unique characteristics of VANET. Network challenges and requirements are discussed in Section 6. Section 7 will give a comprehensive explanation for the applications enabled by VANET communications.

2 VANET Architecture

The communication between vehicles, or between a vehicle and an RSU is achieved through a wireless medium called WAVE. This method of communication provides a wide range of information to drivers and travellers and enables safety applications to enhance road safety and provide a comfortable driving. The main system components are the application unit (AU), OBU and RSU. Typically the RSU hosts an application that provides services and the OBU is a peer device that uses the services provided. The application may reside in the RSU or in the OBU; the device that hosts the application is called the provider and the device using the application is described as the user. Each vehicle is equipped with an OBU and a set of sensors to collect and process the information then send it on as a message to other vehicles or RSUs through the wireless medium; it also carries a single or multiple AU that use the applications provided by the provider using OBU connection capabilities. The RSU can also connect to the Internet or to another server which allows AU's from multiple vehicles to connect to the Internet.

1. On board unit (OBU) - An OBU is a wave device usually mounted on-board a vehicle used for exchanging information with RSUs or with other OBUs. It consists of a resource command processor (RCP), and resources include a read/write memory used to store and retrieve information, a user interface, a specialised interface to connect to other OBUs and a network device for short range wireless communication based on IEEE 802.11p radio technology.
2. Application unit - The AU is the device equipped within the vehicle that uses the applications provided by the provider using the communication capabilities of the OBU. The AU can be a dedicated device for safety applications or a normal device such as a personal digital assistant (PDA) to run the Internet, the AU can be connected to the OBU through a wired or wireless connection.

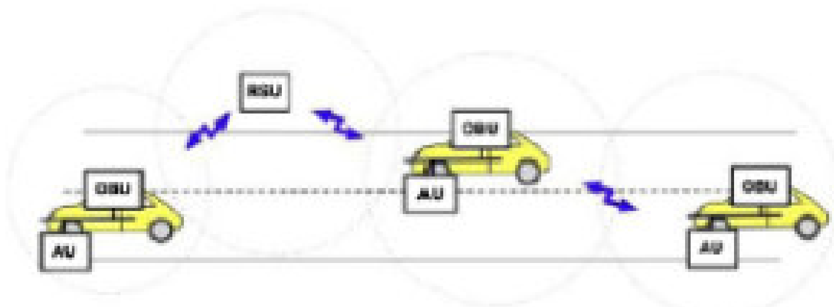

FIG.1

3 Roadside unit (RSU)

The RSU is a wave device usually fixed along the road side or in dedicated locations such as at junctions or near parking spaces. The RSU is equipped with one network device for a dedicated short range communication based on IEEE 802.11p radio technology, and can also be equipped with other network devices so as to be used for the purpose of communication.

International Journal of Advancement in Engineering Technology, Management & Applied Science
Volume1, Issue 1 June 2014 ISSN No: 2349-3224

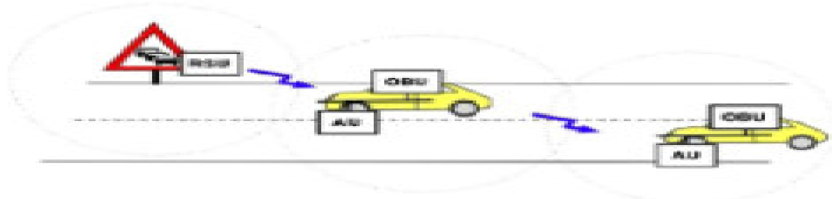

FIG.2

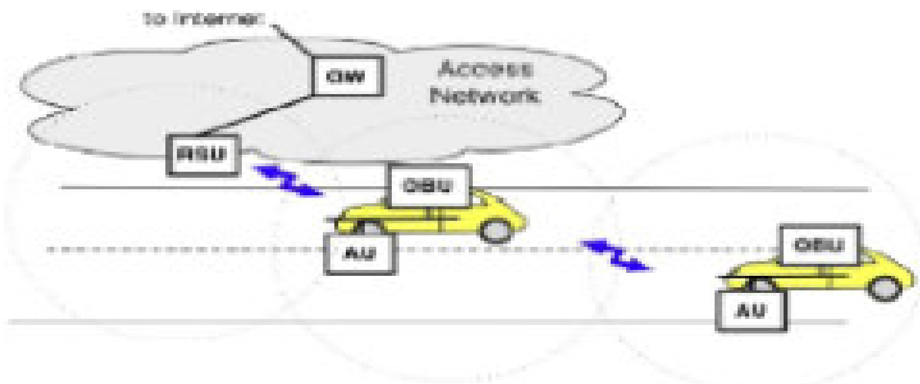

FIG. 3

3. VANET communication domains

The communication between vehicles and the RSU and the infrastructure form three types of domains:

1. In-vehicle domain: This domain consists of an OBU and one or multiple AUs. The connection could be wired or wireless using WUSB or UWB; an OBU and an AU can reside in a single device. The OBU provides a communication link to the AU in order to execute one or more of a set of applications provided by the application provider using the communication capabilities of the OBU.
2. Ad hoc domain: The ad hoc domain on VANET is composed of vehicles equipped with OBUs and a station along the road side, the RSU owing the ability to improve

International Journal of Advancement in Engineering Technology, Management & Applied Science
Volume1, Issue 1 June 2014 ISSN No: 2349-3224

road traffic safety, driving efficiency and to extend on board device horizons.

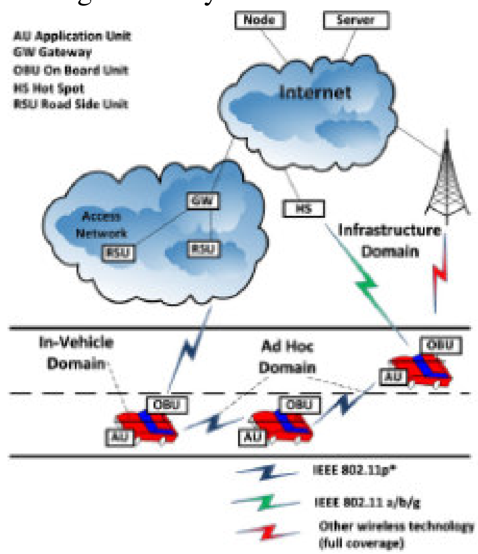

FIG .4

single hop vehicle to vehicle communication (V2V); when there is no direct connection between them a dedicated routing protocol is used to forward data from one vehicle to another until it reaches the destination point, forming multi-hop vehicle to vehicle communication.

3 Infrastructural domain: The RSU can connect to the infrastructural networks or to the Internet, allowing the OBU to access the infrastructure network; in this case it is possible that the AUs are registered with the OBU to connect to any internet based host. OBU can also communicate with other hosts for non-safety applications, using the communication of cellular radio networks (GSM, GPRS, UMTS, HSDPA, WiMax and 4G.

4 Wireless access technology in VANET

Various wireless technologies which can be used today to provide the radio interface for the vehicles in order to provide communication among the vehicles can be described as follows-

Cellular systems (2/2.5/2.75/3G): Global system for mobile (GSM) communication considered to be one of the cellular system standards that provides a data rate of a maximum of 9.6 Kbps and is characterised as a second generation. General packet radio service (GPRS) also known as 2.5 G is an evolved version of GSM.

WiMAX: Mobile WiMAX or IEEE 802.16e is an modification to the original worldwide interoperability for microwave access (WiMAX), or IEEE 802.16-2004. IEEE 802.16e provides a high data rate and covers a wide transmission range with

International Journal of Advancement in Engineering Technology, Management & Applied Science
Volume1, Issue 1 June 2014 ISSN No: 2349-3224

reliable communications and high quality of service, features such as multimedia, video and voice over internet protocol (VoIP) applications are possible.

DSRC/WAVE: DSRC is a 75 MHz licensed spectrum at a 5.9 GHz band allocated by the US Federal Communications Commission in 1999, to be used solely for vehicle to vehicleand vehicle to infrastructure communication in the United States.

5 VANET characteristics

VANET has unique characteristics when compared with other types of MANETs, that include:

1 Predictable mobility: VANET differs from other types of mobile ad hoc networks in which nodes move in a random way, because vehicles are constrained by road topology and layout and by the requirement to obey road signs and traffic lights and to respond to other moving leading to predictability in term of their mobility.

2. Providing safe driving, improving passenger comfort and enhancing traffic efficiency: VANET provides direct communications among moving vehicles, thus allowing a set of applications, demanding direct communication between nodes to be applied over the network. Such applications can provide drivers travelling in the same direction with warning messages about accidents, or about the need for sudden hard breaking; leading the driver to build a broader picture of the road ahead. Moreover, additional kinds of applications could be applied via this type of network in order to improve passenger comfort and traffic efficiency by disseminating information about weather, traffic flow and point of interest information.

3. No power constraints: Power in VANET is not a critical challenge as in MANETs, because vehicles have the ability to provide continuous power to the OBU via the long life battery

4. Variable network density: The network density in VANET varies

5. Rapid changes in network topology: High speeds typify moving vehicles, especially at the highway leading to rapid changes in network topology. Moreover, driver behaviour is affected by the necessity to react to the data received from the network, which causes changes in the network topology

6. Large scale network: The network scale could be large in dense urban areas such as the city centre, highways and at the entrance of the big cities.

7. High computational ability: Because the nodes in VANET are vehicles, they can be equipped with a sufficient number of sensors and computational resources; such as processors, a large memory capacity, advanced antenna technology and global position system (GPS). These resources increase the computational capacity of the nodes.

International Journal of Advancement in Engineering Technology, Management & Applied Science
Volume1, Issue 1 June 2014 ISSN No: 2349-3224

6 Requirements and Issues in VANET

Many issues arise when efforts are gathered towards running vehicular ad hoc networks in an attempt to provide an improvement to driver behaviour, with the aim of reducing the number of fatalities caused by automobile accidents.

1. Signal fading: Objects placed as obstacles between two communicating vehicles are one of the challenges that can affect the efficiency of VANET; these obstacles can be other vehicles or buildings distributed along roads especially in the cities.
2. Limitations of Bandwidth: Another key issue in the VANET is the absence of a central coordinator that controls the communications between nodes, and which has the responsibility of managing the bandwidth and contention operation. Therefore it is necessary to utilise the availability of bandwidth efficiently. There is a high probability that channel congestion can occur, owing to the limited range of bandwidth frequency.
3. Connectivity : Owing to the high mobility and rapid changes of topology, which lead to a frequent fragmentation in networks, the time duration required to elongate the life of the link communication should be as long as possible. This task can be accomplished by increasing the transmission power; however, that may lead to throughput degradation.
4. Diameter Effective: Owing to the small effective network diameter of a VANET, that lead to a weak connectivity in thecommunication between nodes. Therefore, maintaining the complete global topology of the network is impracticable fora node. The restricted effective diameter results in problems when applying existing routing algorithms to a VANET
5. Security and privacy: Keeping a reasonable balance between the security and privacy is one of the main challenges in VANET; the receipt of trustworthy information from its source is important for the receiver. However, this trusted informationcan violate the privacy needs of the sender.
6. Routing protocol: Because of the high mobilityof nodes and rapid changes of topology, designing an efficient routing protocol that can deliver a packet in a minimum period of time with few dropped packets is considered to be a critical challenge in VANET. Furthermore, many researchers have concentrated on designing a routing protocol suitable for dense environments that have a high density of vehicles with close distances between them.

7 VANET APPLICATIONS

V2V and V2I communications allow the development of a large number of applications and can provide a wide range of information to drivers and travellers:

1. Entertainment applications: They also referred to as non-safety applications, and aim to improve drivers and passengers comfort and enhance traffic efficiency. Example-

International Journal of Advancement in Engineering Technology, Management & Applied Science
Volume1, Issue 1 June 2014 ISSN No: 2349-3224

weather and traffic information and detail the location of the nearest restaurant, petrol station or hotel and their prices.

2. Safety applications: These applications use the wireless communication between vehicles or between vehicles and infrastructure, in order to improve road safety and avoid accidents; the intention being to save people's lives and provide a clean environment. They can be further classified as follows-

   Intersection collision avoidance - systems will lead to the avoidance of many road accidents as follows-

   Warning about violating traffic signal - application is designed to send a warning messages to vehicles to warn the drivers about a dangerous situation (accident) that would occur happen if the vehicle does not stop;

   Warning about violating stop sign - designed to send a warning messages to a vehicles to warn the driver about the current distance between the vehicle and the stop sign and the speed required to prevent the necessity of hard breaking

   Left turn assistant - application is to help the driver to make a left turn at an intersection in a safe;

   Intersection collision warning - collects the information about the road intersection via sensors and in-vehicles sensors and analyses this information, if there is a probability of an accident occurring the system will generate and send a warning messages to all the vehicles approaching the intersection. The data gathered by the sensors includes vehicle velocity, position, acceleration and road surface information;

   Warning about blind merge detection - a collision at the merge point where the visibility is poor. The system will alert vehicles trying to merge if there is an unsafe situation, at the same time it will warn the remaining vehicles on the road. The system collects and processes the data at the intersection and if there is an unsafe situation detected it will generate a warning messages to vehicles;

   Pedestrian crossing information - warn drivers if there is a pedestrian crossing the road, by collecting information about the walkers via sensors installed in the walk side.

   Public safety: Public safety applications aim to aid drivers when an accident has occurred and to support emergency teams by minimising their travel time and provide their services, most of the emergency vehicles response time are wasted in their way to the destination.

   SOS services: The SOS system works in conditions where a life threatening situation occurs; by sending SOS messages in the case of accidents. The SOS signal can be trigged either automatically by the system or a driver. Both types of communication (V2V and V2I) can be used to serve the system, depending on the situation for instance, the signal could be sent to the nearest infrastructure point directly,

International Journal of Advancement in Engineering Technology, Management & Applied Science

Volume1, Issue 1 June 2014 ISSN No: 2349-3224

alternatively it depends upon the vehicles in range repeating the signal and delivering it to the nearest infrastructure.

Post crash warning: This application aims to prevent potential accidents before they happen; a vehicle which is disabled because of foggy weather or due to an accident sends a warning messages to other vehicles coming travel-ling in the same direction, or the opposite direction by using both types of communications (V2I and V2V) to inform them about its location, heading, direction and status information.

Sign extension: The main goal of this application is to alert inattentive drivers to signs that are placed on the side of the road while driving in order to prevent accidents. Most of the sign extension applications use a minimum frequency of 1 Hz relying on I2V communication and the use of periodic safety messages with a communication range of 100–500 m, these applications can be classified as follows:

In-vehicle signage: for example in a school zone, hospital zone or animal passing area to send alert messages to vehicles approaching the zone.

Curve speed warning: This application relies on the RSU being fixed before the curve to disseminate messages to approaching vehicles alerting them about the location of the curve, the speed required to negotiate the curve safely and the road conditions.

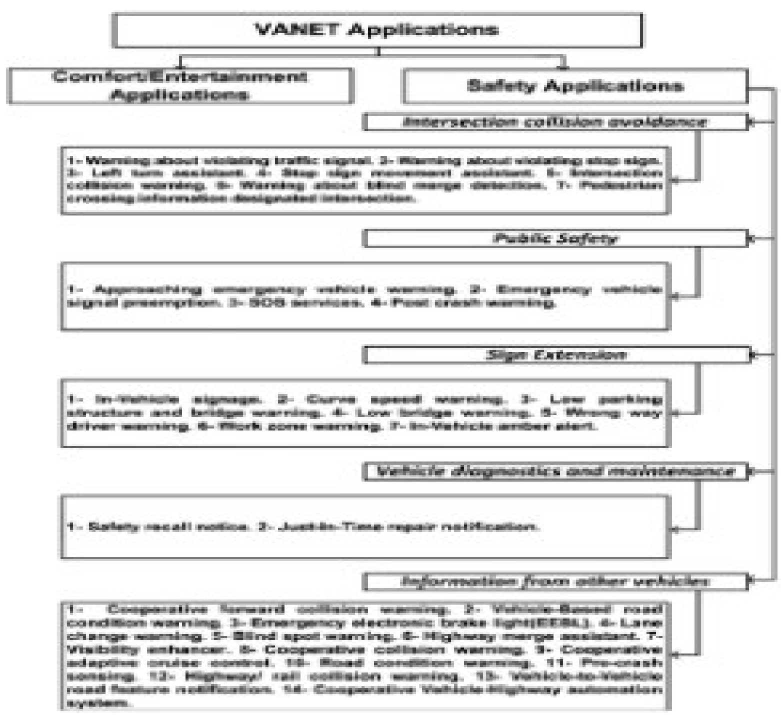

FIG: 5

Low parking structure and bridge warning: This application is designed to alert the driver regarding the minimum height of the park they are trying to enter, by sending a warning messages to the vehicle via an RSU installed close to the parking facility, then the OBU can determine whether it is safe to enter the structure.

Low bridge warning: This application is designed to alert the driver to the height of the bridge they are trying to pass under, by sending warning messages to the vehicle.

Wrong way driver warning: To alert a vehicle if it is travelling in the wrong direction. By using V2V communication a vehicle travelling the wrong way can alert the other vehicles around it via warning messages to prevent accidents occurring.

Work zone warning: This system relies on the RSU installed closed to the work zone in order to warn approachingvehicles about the work zone area, sending warning messages using I2V communication.

Vehicle diagnostics and maintenance: This applicationaims tosend notification messages to vehicles in order to remind drivers about safety defects and that it is time for the vehicle to receive maintenance. These applications rely on I2V communication and use event-driven safety messages with a communication range.

Conclusion

We conclude various aspects of architecture, challenges and applications of VANET in this paper and provide the key concepts to undertake all these concepts. Various applications of VANETs are being discussed and can help in concluding the on going researches.

REFERENCES

[1] Y. Fernandess, D. Malkhi. “K-clustering in wireless ad hoc networks”. *Proceedings of the second ACM international workshop on Principles of Mobile Computing*.2002. pp. 31-37.

[2] L. Dehni, F. Krief, and Y. Bennani, "Power Control and Clustering in Wireless Sensor Networks," in 4th Annual Mediterranean Ad Hoc Networking Workshop (IFIP), France, 2005, pp. 31-40.

[3] B. An, S. Papavassiliou. “A mobility-based clustering approach to support mobility management and multicast Routing in mobile ad-hoc wireless networks”. *International Journal of Network Management.* Vol. 11. 2001. pp. 387-395.

[4] Mohammad et al.,”A review of clustering algorithms as applied in MANETs”, International Journal of Advanced Research in Computer Science and Software Engg 2 (11), November- 2012, pp. 364-369.

[5] C.-c. Chiang, H.-K. Wu, W. Liu, and M. Gerla, "Routing in Clustered Multi hop, Mobile Wireless Networks with Fading Channel," presented at the Proceeding IEEE Singapore International Conference of Networks, SICON'97, Singapore, Apr. 1997.

[6] M. Gerla and J. Tsai, "Multicluster, mobile, multimedia radio network," ACM-Baltzer Journal of Wireless Networks, vol. 1, pp. 255-265, 1995.

International Journal of Advancement in Engineering Technology, Management & Applied Science
Volume1, Issue 1 June 2014 ISSN No: 2349-3224

[7] L. Klein rock and F. Kamoun, "Hierarchical routing for large networks: Performance Evaluation and Optimization," Computer Networks, vol. 1, pp. 155-174, 1977.

[8] G. Chen, F. Nocetti, J. Gonzalez, and I. Stojmenovic, "Connectivity Based k-hop clustering in Wireless Networks," In Proceedings of the 35th Hawaii International Conference on System Sciences, 2002, pp. 188-190.

[9] A. D. Amis, R. Prakash, T. H. P. Vuong, and D. T. Huynh, "Max-min d-cluster formation in wireless ad hoc Networks," Presented at proceedings of IEEE, 19th of annual joint Conference on Computer Communications (INFOCOM'00), Tel Aviv, Mar. 2000.

[10]1 Y. -X. Wang, F. S. Bao. "An Entropy-based Weighted Clustering Algorithm and Its Optimization for Ad Hoc Networks". 2006. [Online]. Available: http://forrest.bao.googlepages.com/WCA_ETS.pdf. Consultado Diciembrede 2006.

[11] D. Turgut, S.K. Das, R. Elmasri, B. Turgut. "Optimizing clustering algorithm in mobile ad hoc networks using *Global Telecommunications Conference, IEEE.* Vol. 1. 2002. pp. 62-66.

[12] D. Turgut, B. Turgut, R. Elmasri, T. V. Le. "Optimizing clustering algorithm in mobile ad hoc networks using Simulated annealing". *Wireless Communications and Networking, IEEE.* Vol. 3. 2003. pp.1492-1497.