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A Comprehensive Review on Recent Issues and Applications in VANETS

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Abstract—*Vehicular Ad Hoc Networks (VANETs) are classified as a special application of mobile ad hoc networks (MANETs) which promise the new possibilities to improve traffic efficiency, road safety and driving convenience. By providing the safety and non-safety applications and sharing the useful information through vehicle to vehicle (V2V) or vehicle to roadside (V2R) communications to avoid accidents and provide reliable information to travelers, such hot issues seeks much attention of researchers in this field. VANET and MANET shares several common characteristics but VANET differs by their applications, architecture, challenges, mobility patterns and power constraints, so MANET routing protocols are not applicable with VANET. This paper provides relevant aspects of the field to distinguish and understand the main features of VANET like challenges, routing, applications and glimpse of routing protocols in a comparative manner.*

Keywords: *Vehicular Ad Hoc Networks (VANETs), RSU, OBU, V2V, V2R, challenges and applications of VANET.*

1. INTRODUCTION

At the present time where private vehicles and other transport vehicles like car, scooter, motorcycles, truck, buses etc. are in common use by the millions of people. The major problem is the number of fatalities increasing due to the road accidents which is caused by the increased use of private transport [1], according to the World Health Organization (WHO), lots of people die every year around the world because of vehicle collisions on the road, about 50 millions of people injured in vehicular accidents[8] , thus researchers of computer networking field proposed a concept of wireless networks called Vehicular Ad Hoc Wireless Networks (VANETs) which are classified as a special type of Mobile Ad Hoc Networks (MANETs) [1,4]. In VANETs every vehicle act as mobile node or router to transfer the data to other moving nodes in a mobile network unlike MANETs [4,9], where vehicles move on predetermined roads and their speed depends upon the speed signs additionally these vehicles have to follow the traffic signs and signals. A wireless communication is provided by VANET [18] between the moving vehicles to improve the road traffic safety and also provides well-structured roads in future by communicating the useful information to drivers in a timely manner. VANETs need a pack of security protocols and privacy assurance like any of the recent communication networks, which will be fulfilled to assure the acceptance by users and can be used in a successful manner [5]. In VANETs vehicles share different kinds of information to avoid the hazardous situations and events, information like road conditions, weather conditions, traffic jams, pedestrian crossing information, post-accident investigation are classified as safety applications and non-safety applications[1] includes travelers comfort which include the information like nearest hotel, restaurant, petrol station and optimal path from source to destination through a navigation system which are installed in the vehicles [10,16,20]. Various Routing protocols are considered by the researchers in past few years but Position based routing protocols gives effective results in efficient data delivery between the nodes, maximize the throughput and decreases the overall delay in forwarding than topology based routing protocols [6,8,21]. This paper provides the detailed information which elaborates the main aspects of the field related to VANET.

Rest of the paper organized as follows: Section 2 represents the wireless access technologies used for communication in VANET. Section 3 presents the challenges and hot issues in VANET. Section 4 describes routing in VANETs, Section 5 provides the explanation of various applications of VANET communications before we conclude the paper in Section 6.

2. TECHNOLOGY FOR VANETS

VANET uses a dedicated short range communication (DSRC) which is an IEEE 802.11p standard modified from IEEE 802.11a standard protocol used for short range wireless communication, the IEEE then referring Wireless Access in Vehicular Environment (WAVE) and standardizes the whole communication stack by the 1609 family of standards. DSRC

is a 75MHz licensed spectrum which works on 5.9GHz Radio Signal Frequency and Supports data rate more than 27mbps, the Communication range is approximate of 300 to 1000 meters and supports an environment in which vehicles moving at speed of up to 200kmph [1, 19]. IEEE 802.21 Media Independent Handover Standard reduces delays in diverse networks and provide better services and continuous connections to moving nodes by new and growing technologies like LTE-Advanced, WiMAX rel 2 and IEEE 802.11ac standard which provides high data rates, reduce noise ratio, decreases energy consumption in moving vehicles in highly mobile networks [7].

3. CHALLENGES IN VANETS

The major challenges in VANETS are Signal fading, Bandwidth limitations, Connectivity problem, Security and privacy and Routing protocols. Due to high mobility the network topology changes dynamically which makes communication difficult by causing network portioning frequently [1, 4, 10, 17, 18, 28].

3.1. Driver's Behavior

Many researchers work on the factor "Driver's Behavior" in an urge to improve this factor regarding the received messages or information. So that to decrease the number of fatalities in road accidents.

3.2. Signal Fading and Attenuation

Signal fading is a major challenge in VANET; Objects act as obstacles between the vehicles communication, they prevent the signal to reach its final destination, these objects may be other vehicles or large buildings in the cities which weakens the intensity of the transmitted signal, and the radio waves from towers and microwaves from electronic items like refrigerator, microwave ovens may attenuate the signal.

Table 1: Comparison of routing protocols on the basis of recent issues and challenges.

Challenges/Parameters	Topology based routing protocols	Position based routing protocols
Network scalability	Not scalable	Scalable
Network topology	Fixed	Dynamic
Bandwidth utilization	Low	High
Technology	DSRC/WAVE	DSRC/WAVE
Mobility	Random	Predictable
Performance	Low	High
Power constraint	High	Low
Resource utilization	Low	High
Message overhead	High	Low
Suitable for and stable in	Small networks	High-mobile environments

3.3. Bandwidth Constraints

Better use of bandwidth impacts in lowering the delay time in transmitting the useful information. If vehicles have to wait for transmitting a message, when there is no congestion free channels available to transmit the data due to the limited bandwidth frequency, then it will increases the latency. All we need is a central coordinator which manage the bandwidth and controls the channel congestion.

3.4. Routing Protocol

To develop an efficient routing protocols is a contingent task in VANET. Developing that improves in delivering more no. of packets, network scalability, communication among moving vehicles, decreasing the attenuation and interference caused by obstacles like buildings in cities.

3.5. Power Constraints

Unlike MANETs power constraint is not a major issue in VANETs, because devices like OBU's get continuous power supply from vehicles long life powerful batteries. This field attracts researchers in developing energy efficient techniques in VANETs as life span of batteries decreases by utilization of power by various sensors in vehicles.

3.6. Dynamic Topology

Network topology depends upon the life span of the radio communication link between vehicles. High speed vehicles, their directions and most important driver's behavior leads to the topology changes rapidly in the network. If we increase the radio communication range the life time of the link survive more in general. Thus link connectivity in the vehicles plays a major role in changing the network topology, where several unused paths are disconnected.

3.7. Mobility

Nodes are moving in a random fashion in mobile ad hoc networks but in VANET mobility is predictable; they have to follow the various constraints like road layout, road signs, traffic lights, road topologies and communicate with other vehicles to give and get the useful information.

3.8. Scalability

The network should be scalable in more dense areas like highway and city scenarios, not stable in small and rural areas, the size of network is large in highly dense urban areas. where vehicles are moving in large numbers.

On the basis of recent issues and challenges a comparison in (table 1) is being made between topology based and position based routing protocols in VANETs, which describes position based routing protocols is more effective and performs better than topology based routing protocols.

4. ROUTING IN VANETS

Table 2: Comparison of topology based and position based routing strategy.

Parameters	Topology based routing strategy	Position based routing strategy
Simulation Scenario	Highway, Rural	City, Urban
Mobility model	Yes	Yes
Propagation model	Yes	Yes
Simulation tool	Yes	Yes
Network scalability	Poor	Good
Control packet overhead	High	Low
Delay time	High	Low
Mobility factor	Low	High
Packet Delivery	Best effort	Best effort/ Guaranteed
Traffic cognizance	No	No

The main goal of routing protocols [17] is to provide the optimal path between network nodes via minimum overhead. Traditional topology based routing protocols, like AODV [2], DSR [13], DSDV [2] increases the path repair overhead due to frequent topology changes and maintains routing information of used and available paths which may acquire significant part of the bandwidth in the network [2, 10,19]. Position based routing protocols, such as GPSR [6,16], GPCR [2,6], BBR [11,12], MFR [10,14], BMFR [10], AMAR [15], MAGF[15], should be aware of the nodes location in packet forwarding through the Geographic Position system (GPS) [15,20], These protocols are considered to be more stable and suitable for VANETs with high mobility environment [3].

Routing protocol	**Approach used**	**Strengths**	**Limitations**	**Remarks**
Topology based routing protocol	Table formation scheme is used to store link's information and to forward data packet.	No use of beacon messages. Low resource utilization reserve bandwidth Path optimization is used for shortest route to destination Support unicast messages in route reply and broadcast in route request also support multicast messages.	More overhead, while rebuilding the routes. Unneeded flooding of messages, while route discovery. Due to rapidly changing network topologies, fails to detect the entire path. Route maintenance delays	Using fixed network topology, may lead to overhead in route maintenance in highly mobile environments. Adaptable for MANETs, not much suitable for VANETs. Suitable for small networks.
Position based routing protocol	GPS system	Suitable for high mobile environments. Minimum overhead as no. of exchange messages are low. Network should be scalable. No Route discovery and maintenance is required. Using position of the vehicles to forward the data packets, through GPS system	Data is not transmitted due to congestion in network. Sometimes location server suffers from Deadlock problem. Obstacles like buildings weakens the signal strength. GPS system sometimes fails in tunnels and by large buildings in cities.	Generally suitable for VANETs. Not much stable in small networks and rural areas. Congestion control should be avoided by better utilization of bandwidth. Performs better then topology-based routing protocols.

Performance of routing protocols in different mobility models should be evaluated by the simulation tools, which evaluate their performance in different conditions [22]. *A comparison* is made between position based and topology based routing protocols in VANET, highlighting their main strengths, limitations and approaches used in (Table 3), and their routing strategies by taking different parameters in (Table 2), emphasizing position based routing strategy is better than topology based routing strategy by minimizing delay time, increasing packet delivery ratio and throughput.Table 3. Comparison of VANET routing protocols.

5. APPLICATIONS OF VANETS

Various safety and non-safety applications for VANETs are elaborated in (Fig. 1) which have great importance in vehicular environments and distinguished briefly [23-28].

5.1. Non-safety Applications

Comfort and Entertainment applications are related to this category of applications, enhancing travelers comfort is the main goal. These applications provide services like traffic information, shortest path to destination through GPS system, weather conditions, nearest hotel, restaurant for fatigue, nearest service center, gas/petrol station for the necessary requirements of the vehicle. Providing internet access while connecting with the infrastructural network allowing them to play games online, and further surfing on the internet.

5.2. Safety Applications

Safety applications provides warning and safety messages to the drivers or passengers of the moving vehicles which are in the communication range of the RSU and other vehicles, in order to avoid road accidents and improving the road safety. VANET provides a wide range of safety applications, some of them are discussed briefly.

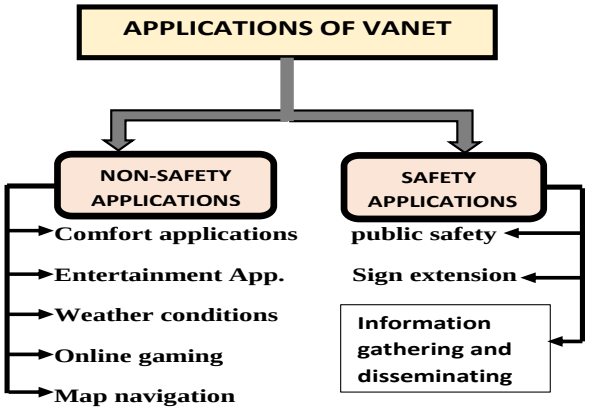

Fig. 1: Applications of VANETS

5.2.1. Public Safety: This application aims to provide medical ailment to the passengers suffered from accidents in shortest time span, it indicate emergency teams to reach the accident spot as soon as possible by minimizing their travel time. This application uses I2V, V2V communication for disseminating the event-driven messages under the dedicated communication range of 300-1000m.

- Using *SOS* services is a good method to transfer the information regarding accident to the nearest infrastructure, either directly by the driver or the system or by using V2V communication.
- When emergency vehicle is on the way to approach the destination, this application provides a clear road using V2V communication. These messages contain the speed, direction and lane information along with path of the emergency vehicle.

5.2.2. Sign Extension: This application provides alert messages to the drivers about the road signs, so as to avoid the road accidents. Sign extension application using 1 HZ frequency and I2V communication to disseminate the periodic messages in 100-500 meters of communication range.

- Curve speed warning messages using the RSU's to deliver the information regarding the curves and the required speed of the vehicle on the curve.
- Wrong side driving messages, low bridge warning messages, pedestrian crossing and work zone alert messages to alert the vehicle driver about their direction and the height of the bridge.

5.2.3. Information Gathering and Disseminating: this application work on the frequency of 2-50 HZ, using V2V, I2V communication for disseminating the periodic and event driven messages.

5.2.3.1. Road Condition Warning: Main goal of this application is to provide the status of the road to the drivers to avoid accidents.

- Vehicles collecting information from other moving vehicles using V2V communication about the road conditions with the help of sensors, then In-vehicle domain processing the data and AU provides the warning message to the drivers of the vehicle about the road status.
- RSU's gathering the useful information and disseminate to other vehicles regarding the unsafe conditions and poor conditions of the road. So that to avoid the accidents by providing the warning messages and suggestions to adjust the speed and required road safety conditions.

5.2.3.2. Collision Avoidance: This application provides the way to avoid the accidents due to collision, following are some cases and conditions:

- Warning messages regarding the intersections on the roads, this application provides the neighbor vehicles position, speed and distance from the vehicle and suggests the speed adjustments to negotiate with the intersection or curve on the road to avoid the collision.
- RSU get information from vehicles or infrastructure and disseminate the pre-accident warning messages to other vehicles using multi-hop technique with V2V communication, which includes the speed, direction and position of the vehicles, so as to avoid road accidents.

6. CONCLUSION

Overview of recent issues and applications are discussed and emphasizing the importance of safety and non-safety applications in VANETs, current challenges and issues are elaborated to enhance improvements in technology and overcome these pitfalls from VANET, a comparison emphasize the performance of both topology based and position based routing protocols undertaking different challenges as parameters and their working parameters depicts position based routing performs better depends on the vehicular density, mobility of nodes and other factors like road conditions and driving environment. Security in VANET and sender's privacy safety applications should be enhanced in future as they are the hot issues in recent times.

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