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Vehicular Ad hoc Network (VANETs): A Review

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ABSTRACT: A Vehicular Ad-Hoc Network or VANET is a sub form of Mobile Ad-Hoc Network or MANET that provides communication between vehicles and between vehicles and road-side base stations with an aim of providing efficient and safe transportation. A vehicle in VANET is considered to be an intelligent mobile node capable of communicating with its neighbours and other vehicles in the network. VANET introduces more challenges aspects as compare to MANET because of high mobility of nodes and fast topology changes in VANET. Various routing protocols have been designed and presented by researchers after considering the major challenges involved in VANETs This paper provides a survey of routing protocols for VANET . It covers application areas, challenges and security issues prevailing in VANETs.

KEYWORDS: VANET; Characteristics; Component; Protocols; Applications; Challenges.

I. INTRODUCTION

Mobile Ad-hoc network (MANET) is emerging globally as a communication mechanism [6]. A MANET is generally defined as a network that has many free or autonomous nodes often composed of mobile devices or other mobile pieces that can arrange themselves in various ways and operate without strict top-down network administration[18]. Mobile Ad-Hoc Networks is integrated with wireless nodes that can communicate anywhere. MANET are categorised into three types: VANET, InVANET and iMANET.

Vehicular Ad Hoc Networks (VANETs) is technology that integrates the capabilities of new generation wireless networks to vehicles. VANET builds a robust Ad-Hoc network between mobile vehicles and roadside units. It is a form of MANET that establishes communication among nearby vehicles and adjacent fixed apparatus, usually described as roadside apparatus. VANET can achieve affective communication between moving node by using different ad-hoc networking tools such as Wife IEEE 802.11 b/g, WiMAX IEEE 802.10, Bluetooth, IRA, [22].

VANET is mainly aimed at providing safety related information and traffic management. Safety and traffic management entails real time information and directly affect lives of people travelling on the road. Simplicity and security of VANET mechanism ensures greater efficiency. Safety is realized as prime attribute of Vehicular Ad Hoc Network (VANET) system. The majority of all nodes in VANET are vehicles that are able to form self organizing networks without prior knowledge of each other. VANET with low security level are more vulnerable to frequent attacks. There are wide range of applications like commercial establishments, consumers, entertainment where VANET are deployed and it is very necessary to add security to these networks so that damage to life and property could not occur [28].

VANET inculcate sufficient potential in vehicles to transmit warnings about environmental hazards, traffic and road conditions and regional information to other vehicles. The major intend of VANETs is to absolute the user's choice on the road and build their drive safe and snug. Vehicles move at such a high speed that it is harder to maintain a seamless handoff and a steady connectivity to the Internet.

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VANETs consist of following entities:
1) Access point: The access points are fixed and commonly connected to the internet. Vehicle to vehicle communication has two types of communication single hop and multi hop.
2) Vehicle: vehicle is nodes of vehicular network. VANET addresses the wireless communication between vehicles (V2V) and between vehicles and infrastructure access point (V2I) [7].

II. CHARACTERSTICS

There are various appealing and attractive features that make a difference from other types of networks.
1) High Mobility:
The nodes present in VANETs move at a very high speed. These moving nodes can be protected saved from attacks and other security threats only if their location is predicable. High mobility leads to various other issues in VANET [20, 25].
2) Rapidly Changing Network Topology:
Vehicles moving at high speed in VANET lead to quick changes in network topology. [20, 27]
3) No Power constraints:
Power constraint always exists in various networks but in VANETs vehicles are able to provide power to on board unit (OBU) via the long life battery [20, 27]. So energy constraint is not always an essential challenge as in MANETs.
4) Unbounded Network Size:
The network size in VANET is geographically unbounded because it can be generated for one city or one country [27, 25].
5) Time Critical:
Timely delivery of information is very essential. Actions can be performed accordingly only when information is available when it is required.[8].
6) Frequent changing information:
Ad-Hoc nature of VANET motivates the nodes to gather information from other vehicles and roadside units. As vehicles move and change their path, information related to traffic and environment also changes very rapidly.
7) Wireless Communication:
Nodes are connected and exchange their information through wireless. [8]
8) Variable network density:
The network density is changed according to traffic density; it is very high in traffic jam and low in suburban traffic. [27, 25]
9) High computability ability:
Due to computational resources and sensors, the computational capacity of the node is increased. [26, 21]

III. COMPONENT OF VANET

VANET is an autonomous self organizing wireless network. VANETs contains following entities:
1) Vehicles:
Vehicles are the nodes of vehicular network. VANET address the wireless communication between vehicles (V2V) and between vehicles and infrastructure access point (V2I) [7].
2) Infrastructure:
Infrastructure related to outside environment include road side base station. Base stations are the roadside unit and they are located at dedicated location like junctions or near parking spaces. Their main functions are to increase the communication area of the ad hoc network by re-allocating the information to others and to run safety application like low bridge warning, accident warning etc.
3) Communication channels:
Radio waves are a type of electromagnetic radiation with wavelengths in the electromagnetic spectrum longer than infrared light. Radio waves have frequencies from 190 GHz to 3Khz. Radio propagation model plays a strong role in the performance of a protocol to determine the number of nodes within one collision domain [19].

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IV. COMMUNICATION IN VANET

Various types of communication technique are used in VANET. Some of them are given below:

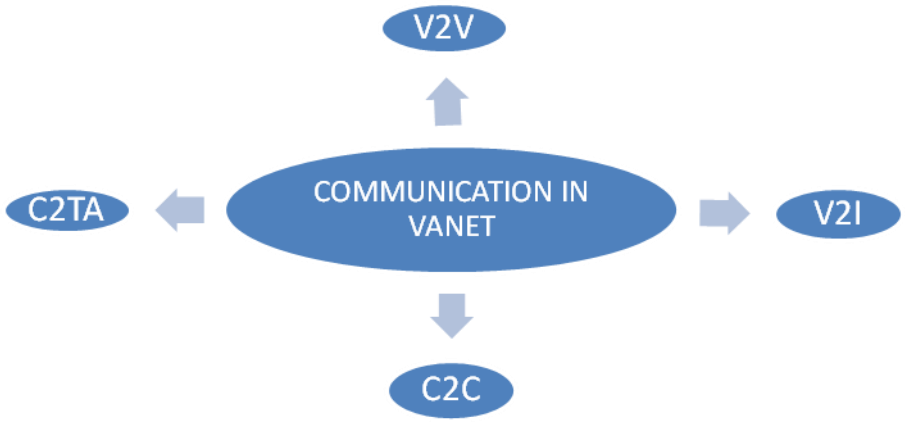

Fig.1 Communication in VANET

1. VEHICLE TO VEHICLE COMMUNICATION:
It refers to inter vehicle communication. Vehicles or a group of vehicles connect with one another and communicate like point to point architecture. It proves to be very helpful for cooperative driving.

2. VEHICLE TO INFRASTRUCTURE COMMUNICATION:
Number of base stations positioned in close proximity with a fixed infrastructure to the highways is necessary to provide the facility of uploading/downloading of data from/to the vehicles. Each infrastructure access point covers a cluster.

3. CLUSTER TO CLUSTER COMMUNICATION:
In VANETs network is split into clusters that are self managed group of vehicles. Base Station Manager Agent (BSMA) enables communications between the clusters. BSMA of one cluster communicates with that of other cluster.

V. RELATED WORK

Josefa Z. Hernandez [29] is a decision support framework proposed for VANET. Comparison between combined TRYS and TRYS autonomous agents has been presented in this paper. This framework was agent-based architectures for intelligent traffic management systems. Marc Torrent Moreno [30] presented mechanism that was aimed at investigating broadcasted messages to a neighbour by another neighbour node in VANETs. Sascha et. al .[31] presented Modern decision support systems (DSS) for transportation management that store huge amounts of decision-relevant data, as well as intend at assisting decision-makers to explore the meaning of that particular data, and to obtain decisions based on understanding this architecture. Nabeel Akhtar [32] has presented realistic analysis of the VANET topology characteristics over time and space for highway . In this analysis, Author integrate real-world road topology and real-time data extracted from the Freeway Performance Measurement System (PeMS) database into a microscopic mobility model to generate realistic traffic flows along the highway. Umar Farooq Minhas [33] introduced multi-faced trust model that is an intelligent agent based scheme for vehicular Ad-hoc network. In this scheme drivers exchange information with other drivers regarding road and traffic conditions. Christian Adler et. al [34] presented the concept of self-organized and context-adaptive information diffusion in VANETs. Christian Lochert et. al [35] presents information dissemination in vehicular ad-hoc networks (VANETs) in city scenarios. Zhou Wang et. al [36] examined the cooperative packet forwarding schemes in VANETs. VANET insists cooperative communication with peer nodes below its operation environment of high mobility, quickly changing topology and low associatively redundancy. Mingliu Zhang et. al [37] reviewed the routing protocols for VANETS. Imran Khan et. al [38] evaluated the performance of AODV and OLSR routing protocols under realistic radio channel characteristics using NS-2 with

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Nakagami fading model.Haidar N. AL-Hashimi et. al [39] presented an inter-domain PMIPv6 handover scheme for vehicular environment. The proposed PMIPv6 handover system is based on MIIS information function.Francesco Lupi et. al [40] evaluate the performance of broadcast routing protocol in a VANET presented and also presented the employment of RSUs inside the vehicular network. Abderrahim Benslimane [41] introduced a novel architecture that combines 3G/UMTS networks with VANET networks. Muhammad Nadeem Majeed [42] review the necessary processes twisted in a VANET handoff process. P. Suresh [43] proposed an analytical model for warning messages through collision avoidance (CA) system.

VI. ROUTING PROTOCOLS FOR VANET

Various protocols have been proposed by researchers so far that are based on some category. Given below is the category wise analysis of protocols already proposed for VANET.

TABLE 1
Analysis of existing routing protocols for VANETs

Protocols	Definition	Example	Pros	Cons
Ad-hoc routing[3]	Used for frequent link breaking as expected	AODV[13],DSR	Improve packet driving ratio communication	Time consuming
DTN[3]	Uses carry & forward strategy to overcome frequent disconnection	VADD,GeOpps[7]	Overcome frequent disconnection	Frequent updating by intermediate nodes are not performed with mobility of destination nodes
BEACON	Transmit short hello messages periodically	PBR-DV,GRANT, GPSR	Predicting presence & position of nodes	Deletion of entry after every traffic failure.
OVERLAY[2]	Connects network by virtual or logical links	GPCR[15],GSR[12],CAR[16]	Good Performance for multi hop data delivery	Due to change of topology & traffic density it causes large delay
Reactive protocol[2]	Also called demand routing because enforces route discovery when needs to communicate with other node	DSR[14],TORA[21]	Saves bandwidth[2]	High Latency[2]
Proactive[5]	Based on shortest path algorithms and forms tabular structure	FSR, OLSR[5]	No route discovery overhead[3]	Unused paths occupy a significant part of the available bandwidth[2]
Geocast based[1]	Location based multicast routing protocol where each node deliver message to other node that is isolated in a specific geographic region	TIGER,DRG	Scalability	Requires position determining services
Cluster based [1]	Many groups of nodes are made, every cluster is represented by a cluster head	COIN,LORA-CBF	Increase tolerance limit, & dynamic movement schemes	Doesn't consider velocity and direction metrics[2]
Broadcast based[2]	Specially used to communicate safety related message	UMB,HV-TRADE	Overcome simple flooding problem.	Higher collision overhead

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VII. APPLICATIONS OF VANET

There are many commercial applications that are benefied with the deployment of VANET's. The applications where VANET can play major role as decribed below.

TABLE 2
Application of VANETs

CATEGORY	SUB CATEGORY	OBJECTIVE	DESCRIPTION
1)Safety Application	**Traffic signal warnings to avoid collision[25]**	1)Violating traffic signal[20,24]	Send alert messages to vehicles to warn drivers about dangerous situation.
		2)Intersection collision warning	Collect information about road intersection.
		3)Violating stop sign & stop sign movement assistant[20,25]	Send messages to vehicle about current distance between vehicles & in form about stop signs and turn about hazardous situation
		4)Left turn assistant	Inform drivers to make a left turn at an intersection in a safe way.
		5)Warning about blind merge detection	Prevents collision at the merge point where visibility is poor.
		6)Pedestrian crossing information	Generating alert about pedestrian crossing
	Public safety[20]	1)Emergency vehicle warning	Provide clear road for emergency vehicle.
		2)SOS services	Works in life threatening situation.
		3)Post crash warning	Prevent potential accident before happening.
	Sign Extension[20]	1)In vehicle signage	Relies on the RSU being fixed in a specific area.
		2)Curve speed warning	Relies on the RSU being fixed before the curve to disseminate messages to approaching vehicles & alerting them about the location of the curve.
		3)Low parking structure and bridge warning	To alert the driver regarding the height of park.
		4)Low bridge warning	To alert the driver about the height of bridge.
		5)Wrong way driver warning	To alert the vehicle regarding their wrong direction.
		6)Work zone warning	To alert the vehicle regarding work zone area.
2)Traffic monitoring	**Vehicle diagnostic & maintenance [20,21]**	1)Safety recall notice	Send message to rewind about recall.
		2)Just-in-time repair notification	To alert about fault resolution.
	Information from other vehicles[20]	1)Cooperative forward collision warning	Send message about collision situation.
		2)Vehicle-based road condition warning	Send warning message to other vehicles about road condition.
		3)Emergency electronic brake lights	Warn other vehicles for sudden hard breaking.

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		4)Lane change warning 5)Blind spot warning 6)Highway merge assistant 7)Visibility enhancer 8)Cooperative collision warning 9)Cooperative adaptive cruise control 10)Road condition warning 11)Pre-crash sensing and Highway/collision warning 12)V2V road feature notification 13)Cooperative vehicle-highway automation system	Designed to avoid crashes. Send message about blind spot. To prevent accident. Alert about bad weather condition. Warn the driver about accident. Adjust the speed of vehicles. Alert about poor road condition. Predict the situation in which an accident is about to happen. Collect information about the road infrastructure. Controls the velocity and position of vehicles.
3)Entertainment		**Comfort/Entertainment Applications[20,9,25]**	Aim to improve drivers & passengers comfort levels.

VII. SECURITY REQUIREMENTS FOR VANET

Authentication

In VANET greedy drivers or the other adversaries can be condensed to a greater extent by authentication mechanism that ensures that the messages are sent by the actual nodes. Authentication, however, increases privacy concerns, as a basic authentication scheme of connecting the identity of the sender with the message. It, therefore, is absolutely essential to validate that a sender has a certain property which gives certification as per the application. For example, in location based services this property could be that a vehicle is in a particular location from where it claims to be [23].

Message Integrity

Integrity of message ensures that the message is not changes in transit that the messages the driver receives are not false [22].

Message Non-Repudiation

In this security based system a sender can be identified easily. But only specific authority is approved for sender identification. Vehicle could be identified from the authenticated messages it sends [23].

Access control

Vehicles must function according to rules and they should only perform those tasks that they are authorized to do. Access control is ensured if nodes act according to specified authorization and generate messages accordingly [22].

Message confidentiality

Confidentiality is required to maintain privacy in a system. Law enforcement authority can only enforce this privacy between communicating nodes [22].

Privacy

This system is used to ensure that the information is not leaked to the unauthorized people. Third parties should not be able to track vehicle movements as it is a violation of personal privacy. Location privacy is also important so that no one should be able to learn the past or future locations of vehicles [23].

Real time guarantees

It is essential in VANET, as many safety related applications depend on strict time guarantees. This feature is necessarily required in time sensitive road safety applications to avoid collisions [22].

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VIII. CHALLENGES IN VANET

There are many issues in VANET. Some of them are given below:

1) Technical Issue: Due to high portability, the network topology and channel condition changes rapidly. It is difficult to manage network and control congestion collision in network. In VANET the electromagnetic waves of communication are used and these are affected by environment. Environmental impact need to be considered in VANET. Other technical issues are related to design and architecture of Mac layer [9].

2) Security Issue: VANET is time critical where safety related message should be delivered with 100ms transmission delay. Even authenticate node can perform malicious activities than can disturb the network. The major challenge is to distribute privacy keys among vehicles [9].

3) Security Requirement issue: Authentication ensures that the message is created by the authorized user. DoS attacks can bring down the network. Non repudiation means a node can't deny that she/he doesn't transmit message. It may be crucial to determine correct sequence. A regular verification of data is required to eliminate the false messaging [10].

4) Attackers on VANET:

Insider and outsider: Insiders are the authenticated members of network whereas Outsiders are the intruders and hence limited capacity to attack.

Malicious and Rational: Malicious attackers have not any personal benefit after attack; they just harm the functionality of the network. Rational attacks can be predicable as they have the personal profit [10].

Active and Passive: Active attackers generate signals or packet whereas passive attackers only sense the network.

5) Attacks in VANET: Hijackers hijacks the session easily after connection establishment. Generally, a driver is itself owner of the vehicles so getting owner's identity can put the privacy at risk. Eavesdropping is a most common attack on confidentiality. Routing attacks are the attacks which destroy the vulnerability of network layer routing protocols [11].

IX. CONCLUSION AND FUTURE WORK

VANET are very effective means of communication between moving vehicles. In this paper various protocols have been presented and analysed. Various research issues and security requirements have been described. It has been found that various schemes and techniques have been proposed to overcome these challenges but still various loopholes are remaining in this field and solutions are yet to be discovered. From this survey it has been realized that standard protocols must exist that enables effective communication for various applications all together in a multidimensional way and overcome issues related to those applications. VANET would provide better platform and effective communication between vehicles with further advancement and evolution of new approaches.

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