An Analysis of Vehicular Ad-Hoc Network: Perspectives, Challenges and Applications

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Abstract-**An active area of research today includes Vehicular Ad-Hoc Networkwhich is a special class of Wireless Ad-Hoc Network that provides communication between vehicle to vehicle (V2V) and vehicle to roadside base stations (V2I).Being ad-hoc in nature and due to the tremendous potential possessed by such network,providing an optimum performance becomes a challenging task.This paper involves the evaluation of main characteristics of VANET, its componentsand application areas. The paper also throws light on VANET architecture, classification of routing protocols and various challenges prevailing in VANETs.**

Keywords-**VANET, protocol, mobility, routing, road-side unit, topology**

I. INTRODUCTION

In the last few decades, due to the deployment of wireless technologies accompanied with the expanding number of wireless products on motorized vehicles,automation industries have opened a wide range of possibilities for both vehicle drivers and their passengers.But along with this advancement, road accidents, parking issues and traffic jams have become major issues to deal with.These challenges have led to the evolution of the use of Vehicular Ad-Hoc Network.

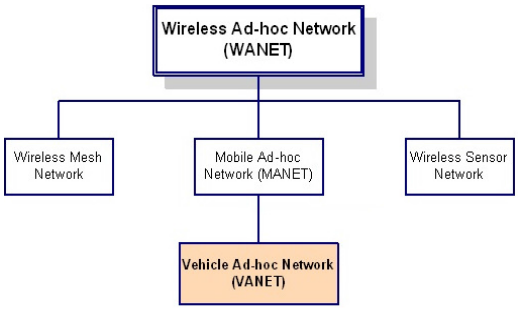

Fig 1. Classification of Wireless Networks

VANETs are a subset of MANETs that enable vehicles to behave as mobile nodes and communicate with other vehicles moving at a high speed (V2V) or with the road side units that are stationary along the road (V2I). Each node acts as both a data terminal and a router communicating with other nodes within their radio range.

VANET uses Dedicated Short Range Communication (DSRC) to facilitate low overhead communication information like accident alerts, road conditions, traffic flow etc.The traditional IEEE 802.11 WLAN standard used in VANET lags in providingtimely vehicular data exchange and fast communication. Therefore to address all these challenges a universally acceptable standard Wireless Access in Vehicular Environment (WAVE) is formed by combining DSRC with IEEE 802.11 to become a new standard IEEE 802.11p.

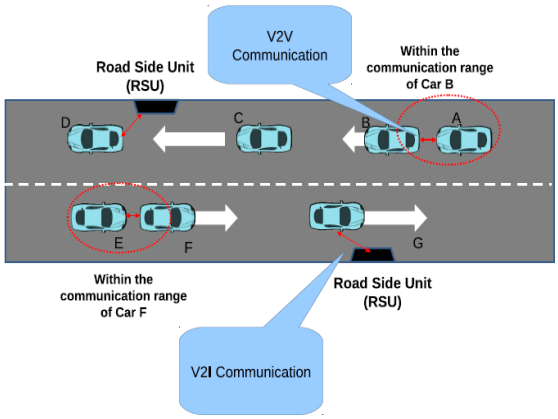

Fig. 2 Types of communication in VANET scenario

II. VANET CHARACTERISTICS

A. *High speed-*

As the nodes in VANET are vehicles, they move at a high speed. The propagation of safety threats and traffic information among such high mobility becomes a challenging task.

B. *Predictable Mobility*-

The mobile nodes move in set pattern as the road layout is fixed and the nodes move on them by following road signs and traffic signals.

C. *Rapid change in topology*-

Vehicles in VANET move at a very high speed leading to rapid change in network topology. The nodes stay in each other's communication range for a short duration of time which results in frequent establishment and termination of link.

D. *Variable network density*-

The network density in VANET may vary depending upon the location. It is high in case of traffic jams and low in suburban areas.

E. *Immense computational ability*-

The vehicular nodes in VANET are equipped with high speed processors, huge memory size, modernized GPS technology and powerful sensors. All these resources aid in achieving high computational power making the communication reliable and accurate among the nodes.

F. *Indefinite network size*-

There is no fixed size of VANETs. It may vary and can be employed ranging from a city to even a particular country.

III. COMPONENTS OF VANET

A. *Vehicles*-

Vehicles that are embedded with wireless technologies act as nodes that move on roads in a fixed pattern.

B. *Infrastructure*-

It includesbase stations situated at dedicated locations like junctions or parking lots. They propagate traffic and vehicle related information to one another for efficient communication. They are categorized as:

- Road Side Unit (RSU)-It is the fixed infrastructure that registers the vehicle that wants to participate in VANET to form a group.
- On Board Unit (OBU)-It is equipped within vehicle and is used for exchanging information with RSUs or with other OBUs.
- Application Unit (AU)-It is installed within the vehicle using the applications provided by the providerusing the communication capabilities of OBU.

C. *Communication Medium*-

Radio waves with frequency ranging from 190 GHz to 3 KHz are as a communication medium.

IV. VANET ARCHITECTURE

VANET system architecture is divided into five layers from network point of view: physical layer, MAC layer, network layer, transport layer, application layer.

A. *Physical layer*:

All the work related to antenna setup, modulation, spectrum allocation etc. are handled by this layer.

B. *MAC layer:*

To avoid the collisions that occur during transmission, this layer implements the MAC protocol. It helps in making the communication reliable and efficient.

C. *Network layer:*

Geographical addressing and routing is achieved with the help of this layer. Functions like traffic congestion resolution, vehicular movement and data dissemination etc. are dealt here.

D. *Transport layer*:

The data is transported between vehicles with the help of this layer. It also satisfies certain services like delay control, reliability and so on.

E. *Application layer*:

This layer relates to different types of safety, entertainment and comfort applications for vehicle drivers and their passengers.

V. ROUTING PROTOCOLS IN VANET

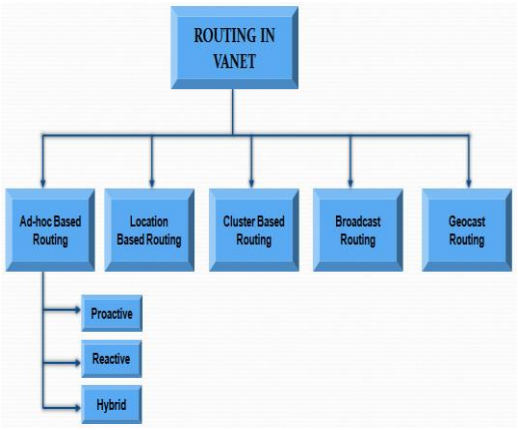

Fig. 3 Classification of VANET routing protocols

A. *Ad-hoc or topology driven routing-*

These are the typical wireless routing protocols that use the link information existing in the network to perform multi hop packet forwarding to destination. These are categorized as:

- *Proactive protocol:* These are also referred to as table-driven routing protocols as they use routing table to store the information of all the other nodes irrespective of its need.The main advantage is that there is no time wasted in route discovery since route is already maintained in the background. Protocols like Fisheye State Routing (FSR),DSDV and OLSR.
- *Reactive routing protocol:* These are also termed as on demand routing protocols as they discover a route only when it is required thereby reducingthe overhead and congestion on network.It includes protocol like Dynamic Source Routing (DSR), Ad hoc Distance Vector (AODV) routing protocol, Temporally Ordered Routing Algorithm (TORA).
- *Hybrid Routing:* To make routing more scalable and efficient characteristics of both active and reactive routing protocols are combined to form hybrid protocols. Reliability is achieved by dividing the nodes into different zones like Adaptive Distance Vector (ADV) routing protocol.

B. *Location based routing-*

To disseminate the information, the geographic location of vehicles is obtained by sources like GPS or maps. It uses multicast routing to deliver a packet from source to all other nodes within a specified geographic region. Protocols such as Geographic Source Routing (GSR), Location Assisted Routing (LAR) are used here.

C. *Cluster based routing:*

This routing paradigm is used to reduce the network traffic and overheads in VANET. A network architecture is created by forming small groups of vehicles called cluster-head and the size of cluster depends on routing algorithm which is based on number of vehicles in a cluster or the geographic location of vehicle.

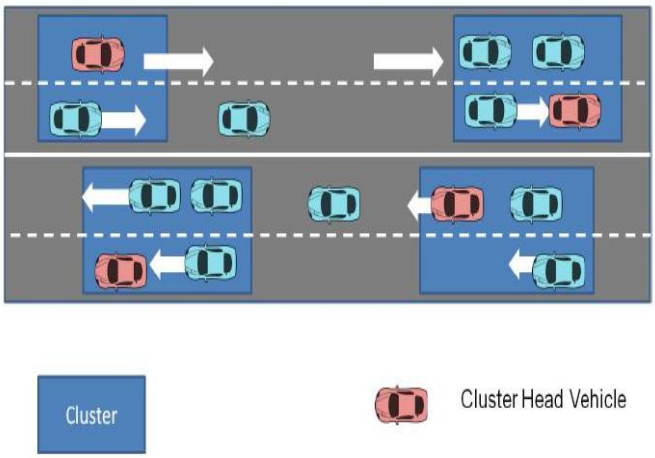

Fig. 4 A cluster based routing scenario

D. *Broadcast routing*:

When the vehicle to which message is to be sent is outside the range, broadcast routing is used.Packets are flooded over network to reach the destination but requires extensive resources of bandwidth. It includes protocols like BROADCOMM and Nth- Powered P-persistent Broadcast (NPPB) protocol.

E. *Geocast routing:*

When the information is to be disseminated in a specific area of relevance, geocast routing protocol is used. The main idea of this protocol is to shrink down the search for next hop to a Specific Zone of Relevance (ZOR). Geocast routing protocols is Robust Vehicular Routing (ROVER).

VI. Literature Review

In [1] Lihong Zhang et al. discussed bout the state of-the-art of VANET and put light on issues like signal modelling, propagation mechanism, network security and routing protocols of VANET. This paper considered all parameters like QoS, minimum latency etc.

The paper concluded that some of the algorithm perform well in urban environment and that a proper modeling technique is required for implementing consistent communication in VANET.

In [2] Irfan Khan et al. made a survey on potential applications, medium access control schemes and routing protocols for VANET. He elaborated the main MAC for VANET i.e. IEEE 802.11p.

The conclusion drawn from this paper is that however reactive and position based schemes work well, but proactive protocols can also work well in VANET scenarios. The paper also inferred that there is lack of proper evaluation for VANET routing protocol.

In [3] U D Prasan and DR. S Murugappan started with the basic architecture of VANET, then focused on various research issues and ended up exploring the challenges of VANET. The VANET applications are categorized here as comfort oriented, convenience oriented and safety oriented applications. They highlighted the main difference Wireless Sensor Network and VANET.

In [4] Saleh Yousefi et al. provided a comprehensive study of challenges in VANETs which is a promising technology for Intelligent Transportation System (ITS).

Due to the limited bandwidth of the channel, there is a need for congestion control. By making use of traffic flow theory special mobility models should be developed so that simulation results could be trustworthy.

In [5] Komal Sharma highlighted the different routing protocols for evaluating the overall performance in highly mobile VANET environment.

The paper concluded that a single routing protocol is difficult to be selected for whole diverse VANET environment and that the issues related to packet delay and path connectivity should be improved.

VII. Conclusion and Future Work

With the advancement of VANET, the field of Intelligent Transportation System (ITS) is developing rapidly. This article emphasized on the main potential of VANET suggesting that it will not only provide road safety and lifesaving applications but also prove to be a good tool for traffic management.

The paper put light on VANET system architecture, its major characteristics, components and the classification of VANET routing protocols. It sums up the related research done earlier in this field under the heading literature review.

As the field of VANET is very wide and continuously increasing, there are specific fields which need special focus. The main challenges that can be considered in future could be:

A. *Quality of Service (QoS) –*

Main focus should be laid on improving the quality of various services provided by VANET like controlling transmission delay, reducing the number of retransmissions and reliable transmission of safety alerts.

B. *Effective routing strategy*-

As VANETs are highly dynamic, algorithms that have minimum delay, maximum system capacity and less complexity must be evolved for timely and delivery of packets from source to destination.

C. *Network Security*- Since the communication in VANET is active at all the time,there may be some confidential information that must be protected explicitly. Designing such algorithms that will provide proper authentication and trustworthy security will always be an interesting and open research area in VANET.

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