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A closer look through routing protocols in vehicular ad hoc networks (VANETs)

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***Abstract*:** *During last few decades, due to new achievements in network technologies and advancements of wireless technologies researchers attracted towards new network called vehicular ad hoc networks (VANETS). Vehicular ad hoc networks (VANETs) are modern type of mobile ad hoc networks (MANETs), in which on road vehicles communicate with each other or communicate to road side unit for safety and comfort. Most recent research works focus on various areas of VANETs like security, routing and quality of service but no optimal routing algorithm for all VANET application is designed due to dynamic nature of this network. Still there is lots of research to be done for routing algorithms, services and most suitable architecture for these new mobile networks. Proposing a new routing algorithm or changing the existing routing algorithm requires an intense knowledge of pre proposed routing protocols. In this paper we have presented a survey of proposed algorithms of routing in VANETs and their advantages and disadvantages which will be quite beneficial for researchers to understand the routing in VANETs and for proposing a new approach or changing an existing one. In last section of this paper comparison of various routing protocols according to different parameters also presented to understand scope of them according to various applications.*

Keywords: *VANET, MANET, routing protocols.*

I. INTRODUCTION

Wireless communication has got highest attention of researchers during last several decades, as result of this thing a new technology has took birth named vehicular ad hoc networks (VANETs) which is a prominent application of mobile ad hoc networks (MANETs) [1]. In VANET vehicles on road like car, bus, truck, van etc. communicate to each other and roadside units. In VANET environment each vehicle acts a mobile node and for exchanging data it acts a source or a destination or a router. Although VANET is a sub category of MANET but its nature is dynamic due to speed of mobile nodes. So in such a dynamic network routing is very tough task as compared to MANETs and to find an appropriate algorithm for all VANET applications is foremost challenge for researchers. A graphical view of vehicular ad hoc network is shown in the fig. 1.

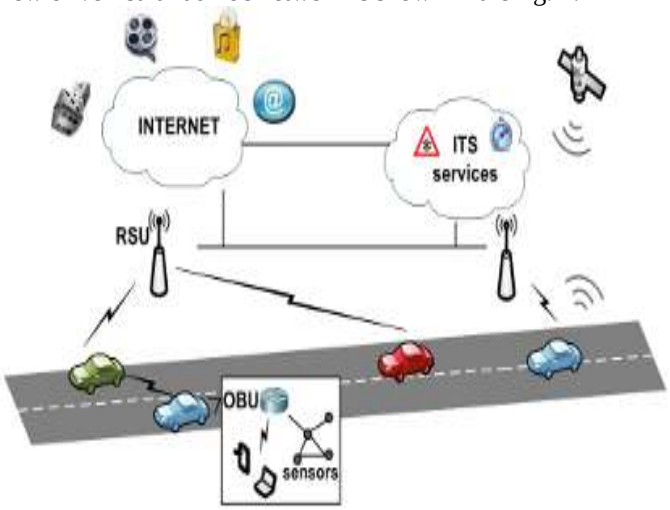

Fig. 1: VANET environment

Routing protocol does three major tasks in vehicular networks: a) it finds the various routes to the destination b) it maintains those routes c) final and most important is selection of an optimal path form given routes. There are two type of communication in VANETs: first is vehicle to vehicle [2] communication shown in fig. 2 and second is vehicle to roadside communication [2] shown in fig. 3.

Fig. 2: Inter vehicle communication

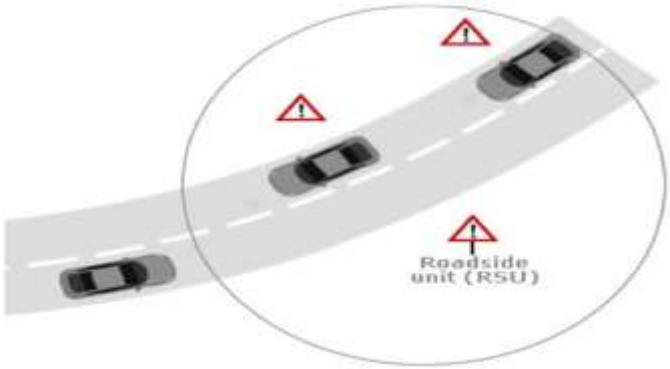

Fig. 3: Vehicle to road side communication

Most of the recent studies on routing algorithms used in VANETs focused on single adhoc routing algorithm, traditional ad hoc topology based routing algorithm and some of them had focused on position based ad hoc routing algorithm. But in reality it is not a case because in ad hoc environment we require various types of routing algorithms to meet different conditions. So in this paper we have discussed a no. of traditional routing protocols available for VANETs to improve the performance.

Remaining paper presents characteristics in section II, applications of VANET in section III, section IV contains all the existing ad hoc routing protocols their advantages and disadvantages. Various future challenges for routing protocols are presented in section V. Conclusion of paper is given in section VI and in final section comparison of these all protocols is made.

II. CHARACTERISTICS OF VANET

VANET has some unique characteristics those make difficult to design and develop new applications and differentiate it from MANETs. Some of these challenging ones are given below:

a) Dynamically changing topology

In VANETs most challenging task is that its topology changing so frequently because vehicles are running on very high speeds. Suppose two vehicles are moving on speed of 15m/sec. in opposite direction radio range between them is 180m so the link between will last only for 6 sec. (180/30). So in this way topology of such networks is highly dynamic.

b) Connection loss

Because topology of VANETs is changing very fast so when two vehicles sending data to each other will go out of radio range between them there will be a connection loss. As a result of which they can't continue their transmission.

c) Mobility modeling

In mobile environment it is very difficult to model nodes which are moving on various speeds and different type of patterns are forming among them. Mobility modeling is also depends a lot on drivers nature and their driving habits.

d) Battery capacity and life

In modern vehicles there are long life and high storage capacity batteries are available so in this characteristic VANET is better than MANET where nodes have battery problems with them.

e) Communication environment

Communication for dense network and sparse network is different for vehicles because sparse networks like highway does not has any communication obstacle but in dense networks there are lots of obstacles like buildings and other things. So communication method should be different for these different conditions of VANETs.

III. VANET APPLICATIONS

A. Public safety applications

On road side main focus should be on safety of occupant of vehicle. Most of danger to human life always is from accidents. So to prevent this VANET applications provide collision warnings, road condition warnings, merge assistance and deceleration warnings. From all of above collision alert is most important and should be sent to vehicles on time.

B. Comfort applications

The travelling time should be very pleasant and not boring one. So VANET provides back seat games, TV, inter vehicle chatting, sharing of photos, videos to internet. In this way journey of passengers is quite enjoyable.

C. Informative applications

On road side traveler can get information which he/she wants by using maps, GPS and short messages limited by time and space. It also makes the journey of passenger very easy by providing updated information.

D. Traffic management applications

These applications try to improve the travelling time, fuel consumption of vehicles by monitoring and resolving traffic conditions properly. It also monitors emergency conditions and provides best suitable path for vehicles like ambulances. Traffic management applications also provide balance on roads of cities and congested areas.

E. Payment applications

In old scenarios it was often seen that there were long waiting lines on toll collection barriers and parking fee collection points. But in VANET scenario is totally automatic when a vehicle crosses a toll road toll tax automatically deducted from the account registered by owner with central taxation authority and a message regarding this transaction is also delivered on registered mobile number of customer.

IV. ROUTING PROTOCOLS FOR VANET

Many routing protocols have been proposed till now for ad hoc networks [3], [4], [5] but these protocols are not suitable for VANET because of the dynamic characteristics of this network. So these protocols could not be directly applied for communication in VANET environments. Various routing protocols used in VANETs are topology based routing protocols, position based routing protocols, geo-cast based routing protocol, broadcast based routing protocols and cluster based routing protocols. These protocols are categorized according to their area of application. Fig. 4 shows various routing protocols of VANETs.

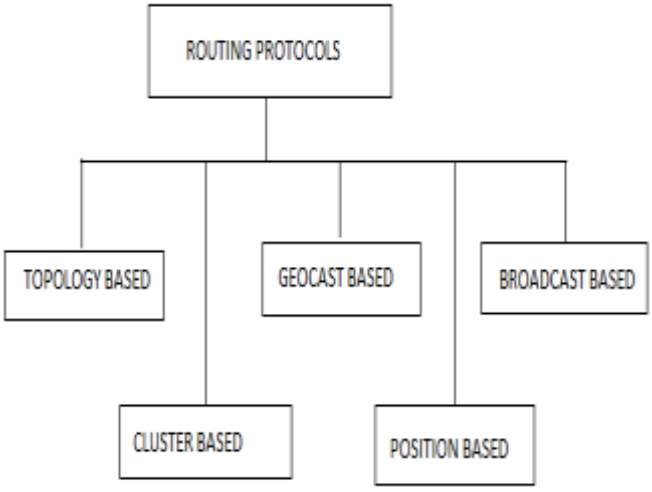

Fig. 5: VANET routing protocols

A. TOPOLOGY BASED ROUTING

These protocols save the information of link in a table before sending data from source to destination. Many algorithms have been proposed till now based on this routing approach. This technique is further divided into three categories: proactive routing, reactive routing and hybrid routing as shown in fig. 6.

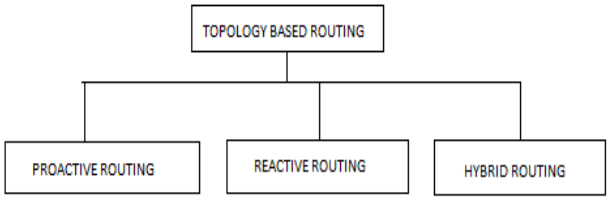

Fig. 6: Topology based routing

Proactive routing protocols: proactive routing protocols are based on table driven technique because these protocols store information of each connected node in tables maintained by each node. Whenever any change made on any node then it conveys all the other nodes of network about this change so they can update the tables stored with them. This technique is mainly used by Fisheye state routing (FSR), Cluster head routing (CGSR), Wireless routing protocol (WRP), Optimal link state routing (OLSR) and Destination Sequence Distance-vector routing (DSDV),Topology Dissemination Based on Reverse Path Forwarding (TBRPF), Global State Routing (GSR), Source Tree Adaptive Routing (STAR). A complete survey of these protocols is given in papers [6-12].

Advantages:

- In these protocols route discovery is not required because all links are already stored in background.
- These protocols have best end to end delivery on high load costs.

Disadvantages:

- Major flaw of these protocols is that these could not be used in real time applications due to their low latency.

Reactive routing protocols: These routing protocols are designed to overcome the flaws of proactive routing protocols. These protocols are also called as on-demand routing protocols because they find and create route only when to send data from source to destination and only between required nodes. Reactive routing can be categorized as hop by hop routing or source routing. In source routing data packet contains all the information regarding the route of packet and intermediate nodes between sender and receiver. Intermediate nodes can take the routing information from data packet and store it in the header of data packet. In source routing intermediate nodes need not to update all information to send the data packet to final node. This technique is used in Ad Hoc On Demand Distance Vector (AODV), Preferred Group Broadcasting (PGB), Dynamic Source Routing (DSR), Temporally Ordered Routing Algorithm (TORA), Junction-based Adaptive Reactive Routing (JARR), Associability Based Routing (ABR) and Signal Stability Based Adaptive Routing (SSA), discussed in papers [13-19].

Advantage:

- Need not to maintain all paths of network.
- Link is established when required.

Disadvantages:

- Route finding latency is very high because route is found spontaneously rather than in advance.
- Excessive flooding of packets can disrupt the network.

Hybrid routing: This routing strategy is combination of both features of both reactive routing and proactive routing. It removes the control overhead of proactive routing as well as initial route finding flaw of reactive routing protocol. In this method vehicles have option to communicate to roadside units when they are not in direct communication due to limitations of radio range so these roadside units are act as routers for mobile nodes. This is area based technique in which vehicles are divided into zones for efficient route discovery and maintenance of route.The routing protocols that come under this class are Zone Routing Protocol (ZRP) and Hybrid Ad hoc Routing Protocol (HARP) [20], [21].

Advantages:
- In has removed the flaws of reactive routing and proactive routing.

Disadvantages:
- It is not successful in low vehicle density conditions.

B. POSITION BASED ROUTING PROTOCOLS

Position based routing protocols use vehicle's location data rather than link information to find the optimal route for data communication. Whole information of source, destination and intermediate nodes is contained by all the vehicles in this technique. These protocols are better than topology based protocols because of low overheads. A position based routing protocol has many components like beaconing, location service, recovery and forwarding techniques [20]. Network performance of these protocols is better than that of topology based protocols because in these links are created between nodes only when communication required. Position based routing is further divided into two categories: greedy V2V protocols, Delay tolerant protocols [22]. Network in which Greedy forwarding protocols are used, an intermediate vehicle forwards data packet to farthest neighbor in the direction of next node or destination. Each node must required three parameters: position of itself, position of neighbor and position of destination. Location of vehicle itself can be obtained by Global positioning system (GPS). Location of neighbor can be received through messages and location of destination is generally received through location services. If location server is unavailable then quorum-based location services may be built into vehicles or fully distributed location services can be used.

Advantages:
- Maintain vehicle location information for better and fast routing.
- It is very beneficial to reduce road accidents.

Disadvantages:
- These routing protocols highly dependent on GPS.
- Location servers are not always in range.

C. GEOCAST ROUTING PROTOCOLS

In these protocols location based multicast technique is used. In this message is send to all vehicles in a pre-defined geographical zone. In this source node sends message to Zone of Relevance (ZOR). Technique uses directed flooding strategy within a ZOR so that it can reduce packet overheads. Different Geo-cast protocols are IVG, DG-CASTOR and DRG. Although these protocols have done very well but distributing packets in a geo-cast region with high probability is a difficult task. The variousprotocols based on this Geo-cast routing strategy are IVG, DG-CASTOR and DRG.

Advantages:
- These protocols have reduced the network congestion.
- These protocols have high packet delivery rate.

Disadvantages:
- Delivering packets to all nodes in a ZOR is very tough task.

D. CLUSTER BASED ROUTING PROTOCOLS

Cluster based routing uses position and clusters to communication among vehicles. In this square shape clusters are formed and one cluster head is selected. In this intra vehicle communication is done via direct links means vehicles within one cluster can communicate with each other directly but inter vehicle communication is done via cluster header. The most important task in such kind of formation is to select cluster headers for clusters. This cluster header sends/receives messages to/from other cluster headers. Cluster based routing protocol are COIN [23], LORA-CBF [24], CBDRP [25].

Advantages:
- These protocols are very scalable for medium to large size networks.

Disadvantages:
- In dynamic networks like VANETs cluster management is very difficult task.

E. BROADCAST BASED ROUTING PROTOCOLS

These protocols are very useful in conditions like emergency, accidents, road blockage etc. where we have to send the message to at most nodes those are beyond a given range. In these protocols message is

forwarded to all vehicles for broadcast or announcement purpose. Flooding is used for message broadcast and receivers further broadcast to all neighbors. Main limitation of these protocols is that they waste lots of bandwidth by sending duplicate packets to nodes. In this way nodes may receive message more than once. Protocols based on this method are BROADCOMM, UMB, V-TRADE, and DV-CAST [26].

Advantages:

- Message received by all nodes in very short time.

Disadvantages:

- Wastage of network bandwidth.
- Duplication of messages is very high results in network congestion.

V. CHALLENGES FOR EXISTING ROUTING PROTOCOLS

Vehicular ad hoc networks (VANETs) are modern type of mobile ad hoc networks (MANETs) for wireless communication among vehicles on road or vehicles and roadside units. These networks are dynamic in nature so routing protocols play a vital role in performance in such networks. Many studies and researches have proposed protocols for these networks but there is not a single protocol, which can perform efficiently in every condition. The existing algorithms are successful only in low traffic situations. Proactive routing protocol fails when topology changes rapidly and on information exchange stage. Reactive routing protocol fails to find whole network path due to network partition. Position based routing protocols require physical location information of nodes on road. Topology based routing protocols are not suitable for VANETs due to their high mobility nature. So in this way many challenges are present in front of researchers to make a best suitable routing protocol for VANETs.

Table 1: Comparison of various VANET routing protocols

Protocols	Reactive protocols	Proactive protocols	Geo cast based	Cluster based	Position based	Broadcast based
Prior Forwarding Method	Wireless multi hop forwarding	Wireless multi hop forwarding	Wireless multi hop forwarding	Wireless multi hop forwarding	Heuristic method	Wireless multi hop forwarding
Realistic Traffic Flow	yes	yes	yes	no	yes	yes
Virtual Infrastructure Requirement	no	no	no	yes	no	no
Digital Map Requirement	no	no	no	yes	no	no
Recovery Strategy	Carry & forward	Multi hop forwarding	flooding	Carry & forward	Carry & forward	Carry & forward
Scenario	urban	urban	highway	urban	urban	highway

VI. CONCLUSION

Due to advancements in engineering technologies, vehicles become a part of our global network. Wireless technologies played a vital role in these networks and made these networks highly contactable. So due to this combination VANETs came into existence which are very dynamic in nature and making routing algorithm for such highly dynamic networks is still a big challenge. In this paper we have present various pros and cons of existing routing protocols and their future challenges. We have also presented comparison of these protocols using various network and communication parameters in table 1. Still there is need to develop a best suitable routing protocol which will fulfill all needs of dynamically changing network like VANET.

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