Routing Protocols in VANET- A Survey

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Abstract--- Intelligent Transportation Systems (ITS) is an integrated approach being developed to exchange relevant information to increase the safety and efficiency of the road transportation systems. Vehicular Ad hoc Network (VANET), a variant of mobile ad hoc networks (MANET), is a core component of ITS. Performance of this smart ITS mainly owes to the design of efficient routing protocols in VANETs. Distinct features of VANETs like unsteady connectivity, high mobility and partitioning of the network have made routing of the information in VANETs difficult and challenging, hence dictating the development of efficient routing protocols. The computation of the best route measures the performance of communication whereas routing protocols takes care of communication & routing of the data. Provision of smart communication, necessitates the analysis of routing protocols in VANET. Accordingly in this paper we have reviewed various types of existing routing protocols in VANET, listing their advantages and disadvantages. Lastly possible inclinations of forthcoming research linked to VANET routing are discussed.

Keywords: VANET, Characteristics, Routing protocols, Perspectives.

I. INTRODUCTION

The increasing percentage of people depending upon vehicular transportation has steered issues related to safety and traffic jams. VANET is a variant of MANET in which nodes are replaced by vehicles. VANET is the primary component in ITS that is envisioned towards providing road safety and comfort zone to their users [2]. Apart from safety VANET also provides several value added services like audio/video sharing and other multimedia applications etc.

VANET makes the communication between the vehicle drivers, to evade any acute situation e.g. accidents on roads, roadblocks, speed control, unrestricted way for ambulances and concealed obstacles etc. Vehicles communicate among themselves directly making vehicle to vehicle communication (V2V), else communicate with fixed equipment next to the road (RSU) constituting vehicle to infrastructure communication (V2I) [10]. Through these communication variants vehicles exchange varieties of information. Thus Information propagation is very important in a VANET environment. Routing plays a vibrant role in information propagation. Routing in VANET is categorized based on topology, position, clustering, geocast and broadcasting.

The design of dynamic routing protocol itself is the principal challenge in VANET. Exceptional features of VANET like ever altering topologies, varying speed & density of vehicles, etc. makes routing in VANET very puzzling. The designed routing protocols should deal with the unanticipated and pulsating behavior of VANET to yield optimal performance. Above all, computing and sustaining ideal paths is very complicated task associated with routing in VANET. These arresting features and unfamiliar characteristics have indeed made VANET thrilling.

In this paper we have reviewed various types of existing routing protocols in VANET. The benefits and drawbacks of various routing protocols are also discussed. Rest of the paper is structured as: Unit 1.1 presents the distinct characteristics of VANET. In unit 2 various routing protocols in VANET are reviewed. Probable track of future trends related to VANET routing is offered in unit 3. Conclusion is provided in unit 4.

I.1 Characteristics of VANETs:

- *High Mobility*: Owing to the high speed of vehicles in VANETs, taking decisions related to routing and security issues based on guessing node's position is very tricky [6].
- *Rapidly changing Network topology*: In VANET vehicles travel continuously and that too with high speed. Thus the position of vehicle changes repeatedly leading to recurrent topology changes.
- *Unbounded network size*: The range of the VANET is limitless. Thus network extent in VANET is physically uncontrolled [3].
- *Frequent exchange of information*: Owed to the ad hoc nature of VANET frequent information exchange between vehicles and also with RSUs is desired.

II. CATEGORIES OF ROUTING PROTOCOLS

Broadly routing protocols in VANETs are characterized into 5 brands viz. *Topology based, Position based, Broadcast based, Geo cast based and Cluster based routing protocols*[1] [5] as shown in Fig. 1.

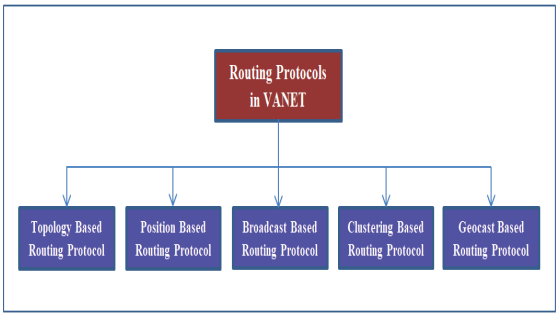

Fig. 1. Nomenclature of routing protocols in VANET.

A. *Topology Based Routing Protocols*

This protocol relies on the topology of underlying network [9] [10]. This protocol maintains routing tables for storing the link information and based on this stored data it forwards packet from source vehicles to destination vehicles. It makes use of global information for making routing decisions. Many existing algorithms of this category try to bring balance between being conscious of the probable routes and minimizing the control overhead. The overhead here mentions bandwidth and time involved in routing the packet. Based on the stored link information or the information acquired when needed, these routing protocols choices the routing path to destination. Before forwarding the data to destination either maintaining a route table or searching the path is mandatory. During routing process topology based routing protocol requires additional node topology. Owing to high mobility in VANET scenario leading to recurrent partitioning of the network and route breakage, the re-computation of topology is necessitated. The protocol performs slower than any other routing protocols in VANET.

A.1. *Proactive Routing Protocols*

Proactive routing denotes routing the information [9]. Every node maintains a routing table representing the topology, with each record in the table representing next relay node towards destination. Thus the necessity of route discovery is eliminated as the destination route is always stored in the table. Routing tables are updated regularly and exchanged between nodes. Two ways to update the routing table are periodic update and triggered update. The size of the table grows with more number of nodes leading to increase in load. Irrespective of the communication requests a table comprising of next forwarding hop is maintained because of which unused paths will have to be maintained further reducing the available bandwidth. Examples of this protocol are *Destination Sequenced Distance Vector Routing (DSDV), Fisheye State Routing (FSR)*, etc.

Advantages

- No necessity of route discovery.
- For real time applications latency is low.

Disadvantages

- Wastage of bandwidth with the storage of idle paths.
- Increase in overhead as tables are regularly exchanged.
- High routing overhead.
- Storage requirement is high.

A.2. *Reactive Routing Protocols*

This protocol [10] [15], also termed as *On Demand* routing protocol establishes the path only after the node wishes to engage in communication. This substantially reduces the burden on the network. In route discovery phase, the protocol discovers the route by flooding the packets into network. When the query packet reaches the destination node, route information reply is reverted to source by employing unicast communication. These protocols are further classified as hop-by-hop routing or source routing. In the former only next relay node and destination information is provided. Whereas in the latter complete information of route is comprised in the data packets. Comparatively hop-by-hop routing is better both in terms of throughput and delay. Examples of this protocol are *Ad-hoc On-Demand Distance Vector (AODV), Dynamic Source Routing (DSR)*, etc.

Advantages

- Less resource is consumed due to the nonexistence of large routing table.
- Routing overhead is less.
- It saves bandwidth as it is beaconless.

Disadvantages

- High latency time due to search of routes.
- Delay in route discovery and maintenance.
- Disruption of the nodes communication due to excess flooding.

B. *Position Based Routing Protocols*

This protocol, also identified as Geographic routing is the most promising one among all algorithms in VANET as it supports geographical position information of each vehicles to offer routing [8] [12]. The protocol is dependent on GPS, a location service. Through GPS every node knows the position of itself, neighbors and the destination. Through the information obtained from GPS the protocol is capable of calculating best optimal path for destination location. It neither maintains the routing table nor is engaged in of state information with the neighbors. No need to establish the global path between source and destination as the path is designed w.r.t. its position. Greedy forwarding is employed in which the source node forwards the

packet to its immediate neighbor node which is nearer to the destination. The downside of this approach is it may fail if there is no such node available. This condition is termed as local optimal and should be dealt with a recovery method. In urban scenarios with obstacles Greedy forwarding does not do well. However this algorithm ensures stable routes in the highways. Based on sustenance w.r.t. delay the variants of this protocol are Delay tolerant, Non Delay tolerant and Hybrid protocols. Examples of this protocol are *Connectivity-Aware Routing (CAR), Vehicle Assisted Data Delivery (VADD)*, etc.

Advantages

- No necessity of route discovery & management.
- Suitable for high mobility environment.
- Scalability.
- Less overhead.

Disadvantages

- Requirement of position finding services.
- Occurrence of deadlock in location server.
- As satellite signal is absent in tunnel, GPS device doesn't work in tunnel.

C. *Broadcasting Routing Protocol*

This variant of routing is often employed in VANET for apprising emergency circumstances amongst vehicles [2] [4]. This technique is used when message is to be propagated to far distant vehicle away from the transmission range. A packet is sent to every node in the network by employing flooding. The delivery of packet is thus guaranteed. However there is wastage of bandwidth. The performance of broadcast is better in environment with small number of nodes. There are three regimes for broadcasting in VANETs:

1. Dense traffic regime: In this regime traffic density is high. Serious problem faced in this regime is obstructing of the common medium due to the extreme broadcast of identical safety message by numerous nodes. This regime suffers from broadcast storm problem wherein contention and collisions in transmission among neighboring nodes occurs due to the instinctively broadcast of the packets on a shared medium.
2. Sparse traffic regime: This is a regime with less number of vehicles on the road. In this scenario the target node is beyond transmission range of the source and the traffic is very less to accomplish multi-hop relay to destination is not possible. This may also occur when there are not many vehicles on the road.
3. Regular traffic regime: In normal traffic regime vehicles may have many neighbors while some may have very few neighbors, i.e. topology is not same for every vehicle. Hence in this environment to conserve the environment broadcast suppression algorithm is followed by some vehicles while others retain carry forward strategy.

The various broadcasting methods are simple broadcasting, Flooding and multi destination routing. In simple Broadcasting the packet is sent to each destination leading to the wastage of bandwidth. In flooding every vehicle upon receiving the message for the first time, re-broadcasts it. More bandwidth is consumed as point to point routing algorithm is employed. Multi destination works with the scheme in which every packet contains a list of destinations. Router will decide the outlines required corresponding to the list. Only on those lines, the copies of the packets are forwarded thus reducing the consumption of bandwidth. Examples of this kind of protocols are *BROADCOMM, Urban Multi-hop Broadcast (UMB)*, etc.

Advantages

- Performance is better in scenario with small number of nodes.
- Nodes will receive the message in very short time.
- Reduced overhead.

Disadvantages

- Consumption of network bandwidth.
- Duplication of messages is very high yielding to network congestion.
- Applicability is restricted to only simple freeway networks.

D. *Clustering Based routing protocol*

Routing protocols of this variety are reliant on the location and scope of clusters [13] [14]. Several separate clusters in the network are formed by the protocol in a dispersed style. Mobility of the vehicles determines the architecture of the cluster. Thus cluster construction is based on mobility metrics to maintain stability of cluster, thus reducing its dependence on topology. Generally there are two different ways to group the vehicles. The first is the group of vehicles within the scope of dynamic sources and the second in the scope of static sources installed at traffic signals, etc. These groups termed as dynamic and static clusters respectively decrease the rates of re-affiliation and re-clustering. The routing protocol thus is the blend of both static and dynamic clusters. For every cluster a cluster head is designated to facilitate communication within and outside the cluster through the existing unidirectional links. With the technique of

clustering, the protocol proficiently reduces the traffic due to flooding in the course of route discovery. Cluster based Routing in VANET is very well suited in environments involving better routing and scalability requirements. Examples of this variant are *Clustering for Open IVC Networks (COIN), Hierarchical Cluster Based Routing (HCB)*, etc.

Advantages

- Scalability is consistent for larger networks.
- Routing overhead is minimized as routes are not discovered.
- Packet delivery ratio is good.

Disadvantages

- Some of the vital parameters viz. velocity and direction is not taken into account by the protocol.
- Delays are introduced in highly dynamic networks.

E. *Geocast-based routing protocols*

Geocast is a variant of multicast communications in which specific region will act as destination and the nodes belonging to that region are participants of the geocast group [7] [11].Contrasting to multicast, in which a packet is sent to random nodes, geocast sends a packet to every node within a pre-defined geographical area. Guaranteed delivery subjected to low cost is the main objective of geocast protocol.

Based on destination region this protocol is divided into two types. The first kind is comprised of protocols working with the assumption that the destination area is close to the source, whereas the second type encompasses protocols developed for routing to far distant destination region. The latter category of routing protocols is further separated into two subcategories viz. flooding and unicast. With the first sub-category, message is broadcast to destination area by every vehicle in the forwarding region. However in second type, a path in the forwarding region is found to onward message to the destination area. Hence comparatively congestion and overhead is lower in unicast. Nevertheless, in the destination region, flooding is used for information propagation. A major problem with this protocol is to make sure that a packet reaches far distant.

There are three different techniques of geocast routing:

a) *Simple Flooding*: In this technique the geocast packet is flood through the whole network regardless of the geocast destination region. It is up to the receivers to verify whether they are within the destination area.

b) *Routing with Directed Flooding*: In this technique a forwarding zone associated with the destination is defined. The packet is thrown away outside the forwarding zone. The relay node forwards a packet only if it is connected to the forwarding zone.

c) *Routing with no flooding*: This protocol employs a unicast routing protocol between the sender and the destination region. Flooding is employed within the destination region, and other routing protocol is employed exterior to the destination region.

Examples of this protocol are *Robust Vehicular Routing (ROVER), Inter-Vehicle Geo cast (IVG)*, etc.

Advantages

- Reduced network overhead.
- Reliable packet delivery in highly dynamic topology.
- Route maintenance is not required.

Disadvantages

- Packet transmission delays due to network disconnection.
- Only suited to large networks.

III. FORTHCOMING VIEWPOINTS OF ROUTING PROTOCOLS IN VANET

In next age band society, VANETs will probably be assessed by safety and comfort applications. In recent times many innovative vehicle applications are developed in numerous areas which range from context aware to stylish games. Therefore continuous exploration and research is mundane in the scope of VANETs. Hence the design stage of futuristic routing protocols in VANETs must also think through the following areas.

1) Delay and information retransmission are the vital constraints associated with routing. Hence protocols reliability is a major apprehension.
2) Driver's behavior is prone to change because of the delay bounded routing protocols and content of multicast / geocast / broadcast messages. This may lead to changes in network topology. Thus, the design phase of protocol should take into account the linkage between the message content and network topology.
3) City environment is prone to comprise tall buildings, trees and many other obstacles. Henceforth the design of robust routing protocols against all types of interferences is more applicable.

4) Scope of the VANET is unlimited. Hence scalability is critical parameter in the plan of protocol. Protocols should permit concurrent operations of unicast routing requests, while considering the issue of conflicts arising from multiple routing requests.

5) Protocols should handle multicast and geocast from many sources. The reliability of such protocols is the call of the day and future. For comfort applications the development of capable and low bandwidth consuming multicast, broadcast and geocast protocols is the need of the hour.

6) Even during off peak hours i.e. when density is low the protocols should be capable to broadcast message. Owing to the unbounded size of VANET, scalability of multicast / broadcast protocols should be taken into account.

IV. CONCLUSION

VANET is a self-configuring network, variant of MANET and primary component of ITS. VANET can trim down traffic accidents, provide safety and increase the performance. Distinct characteristics of VANET viz. ever altering network, unstable connectivity, high mobility and network partitioning, and limitless network size have made the development of efficient routing protocols complicated. Provision of smart communication, necessitates the analysis of routing protocols in VANET. Hence in present article review of various types of existing routing protocols in VANET is done. The benefits and drawbacks of the surveyed protocols are described. We have also discussed some possible roadway of imminent research linked to VANET routing.

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