Survey of Various Routing Protocols in VANET

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Abstract

Vehicular ad hoc networks (VANETs) are the application of mobile ad hoc networks (MANETs). In wireless network VANET is challenging area of environment that pursues the computing for better throughput. VANETs visualize inter vehicle communication or equivalently vehicle to vehicle communication. In VANET nodes are highly mobile and this feature distinguish VANET from MANET. VANET has highly dynamic topology and frequent fragmentation because of mobility of nodes. It also has highly dense network feature along with dynamic scale. The issues of stability, scalability, reliability and security are great concern in VANET. The concept of VANETs is very simple: by including the wireless communication and data sharing capabilities, the vehicles can be turned into a network providing similar services like the ones with which we are used to in our offices or homes. So, VANET is a promising approach for the intelligent transportation system (ITS). The design of routing protocols in VANETs is important and necessary issue for support the smart ITS. MANET routing protocol is not suitable for VANET because MANET routing protocol has difficulties from finding stable routing paths in VANET environments. This paper discusses the advantages / disadvantages and the applications of various routing protocols for vehicular ad hoc networks.

Keywords

VANET, Challenges in Communication Protocols, Different Routing Techniques, Routing Protocols, Topology-based, Position-based, FSR, AODV, DSR, PGB, TORA.

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Introduction

In Mobile ad hoc networks (MANETs) a number of mobile nodes that inter communicate between them using telecommunication. Nodes are organized, configured and controlled in mobile ad-hoc network. VANET has some special characteristics that distinguish it from other mobile ad hoc networks; the most important characteristics are: high mobility, self-organization, distributed communication, road pattern restrictions, and no restrictions of network size, all these characteristics made VANETs environment a challenging for developing efficient routing protocols. In MANET number of ad hoc routing protocols used a few of them used for better throughput. MANET routing protocol has difficulties to maintain stable routing paths in VANET environments that why it is not used with VANET. With the help of protocols characteristics, techniques used, routing information, quality of services, network structures, routing algorithms, author can justify the usage of particular protocol. In various papers VANETs routing protocols classification has been described into: topology-based, position-based, geocast-based, broadcast, and cluster-based routing protocols[1–3]. Other papers classified VANETs routing protocols according to the network structures, into three classes: hierarchical routing, flat routing, and positionbase routing. Moreover, they can be categorized into two classes according to routing strategies: proactive and reactive[5]. Other papers classify into two categories: geographicbased and topology-based, according to the routing information used in packet forwarding[4]. On the basis of topological classification, there are three types of protocols (hierarchical, flat and position aware), concerning with route discovery (reactive, proactive, hybrid and predictive), or based on the MAC layer interaction[6].

Topology Based Routing Protocols

These protocols are responsible to configure route and maintain routing information in a tabular format before the sender data transmission. Further classify into Proactive, Reactive and hybrid protocols.

Proactive protocols

Table driven routing protocol is also known as the proactive protocol. These protocol mechanisms periodically exchange the information of topology for entire network. As per survey consumption of bandwidth is a flaw of proactive protocols. This flaw has not been addressed properly in any other protocols. And this flaw can be overcome by this phenomena that there is no route discovery since route to the destination is maintained in the background and is always available upon lookup. It also provides low latency for real-time application. Proactive routing protocols can be classified as-

Star Tree Adaptive Routing(STAR)

Source-Tree Adaptive Routing (STAR) is link State protocol. Through periodic updates reduces overhead on the network. It is suitable for large scale networks but memory and power consumption is more because it has to maintain large trees for whole network. The Each node maintains a source tree. Each node builds a partial topology graph using aggregates of neighbor information learnt using an underlying neighbor discovery protocol and source trees reported by the neighbors[7].

Cluster head Gateway Switch Routing (CGSR)

CGSR is a clustered multihop mobile wireless network with several heuristic routing schemes. Advantages of CGSR Better bandwidth utilization reduce the size of distance vector table because the routing is performed only over cluster head. Disadvantages of CGSR More time is spend in selection of cluster heads and gateways if the mobile node uses CDMA/TDMA then it can take some time to get permission to send packets Changes in the clusterhead, may result in multiple path breaks.

Destination Sequenced Distance Vector Routing (DSDV)

DSDV is one among the oldest form of ad hoc type routing protocol. It works on distance vector routing and follows shortest path algorithm for implementation of a single route to the destination present in a routing table. To maintain reliability in different routes, each node should broadcast its routing table on periodic basis to its neighbors. DSDV protocol gives assurance about the loop free routs, excludes additional traffic caused from frequent updates and plays significant role to reduce control message overhead. Even it maintains only the optimal path to every node instead of keeping multi paths. In this way, DSDV is helpful in reducing the total size of routing table. Benefits of DSDV are: It has the ability to create ad-hoc networks even by using small number of nodes, Resolve different problems related to Routing Loop, Reduces the count towards infinity problem, DSDV maintains only the best possible path instead of dealing with multiple paths to every destination. Drawbacks present in DSDV are: DSDV requires update of its routing tables on regular basis, which results in consumption of the battery power and consumption of a small amount of bandwidth even when the communication network remains idle and at the time when changes in network topology takes place, DSADV requires for a new sequence number and finally, DSDV usually fail to give appropriate results in case of highly dynamic networks.

1) Fisheye state routing (FSR)

In FSR, the node updates its routing table periodically according to the latest information it receives from neighboring nodes. Updating of entries in the routing table entries that focuses a specific destination should be broadcasted via different frequencies for neighbors. This means, lower frequency ranges should be used for broadcasting of table entries, which remain at the distance, while higher ranges for nearer entries. This scheme fails to guarantee about decrease in broadcast overhead in case of large distances routing process. However, FSR could give accurate results when data packets come relatively close to the destination. Main issue with FSR is that, growth in network sizes results in increase in the routing tables, moreover, if changes in topology are increased, the route towards any remote destination becomes inappropriate. Other than this, in case the destination goes out of scope present in source node, it may not be able to identify the route[8].

2) Optimized link state routing protocol (OLSR)

OLSR protocol primarily implements the link state strategy; it maintains a routing table comprises of information about every possible route towards network nodes. Once variation takes place in network topology, each node has to send the updated information to specific nodes, which retransmit the obtained information to its other selective nodes. On the other side, unselected nodes may only read as well as process the packet.

Reactive Protocols

Reactive routing protocols or on-demand protocols reduce the overhead of the network by maintaining routes only when required when source node begins a route discovery procedure, if it requires any non existing route towards a destination, it performs this process by flooding the entire network with the help of a route request message. Once the message goes to the destination node (or to the node that contains a specific route towards destination), this node will send a message of route reply back to the source node with the help of unicast communication. Reactive routing protocols are applicable to various large size mobile ad hoc networks, which come with high mobility and frequent changes in topology. Large numbers of reactive routing protocols have undergone developments, among which following sections would illustrate about characteristics present in some reactive protocols.

1) Ad-hoc on-demand distance vector (AODV)

AODV routing protocol is available for mobile ad hoc network. AODV offers low level of network overhead by simply reducing flooding of messages within the network as compared to when compared to proactive routing protocols. Other than reducing the memory size requirement; by reducing the routing tables which stores only entries for latest active routes, also keeps next hop for any other route instead of the entire route. It also provides dynamic updates to adapt the required route conditions and eliminates looping in between routes; via usage of destination sequence numbers. So AODV is flexible towards highly dynamic type of network topology and large-scale network. However, it creates delays for longtime in discovery of a route, also route failure may involve identification of a new route which produces additional delays leading to decrease in the rate related to transmission of data and boost the network overhead.

2) Dynamic source routing (DSR)

This protocol includes two operations i.e. “Route Discovery” and “Route Maintenance”. These operations make the routing protocol self-configuring and selforganizing. Another important feature of this protocol is network type Disadvantages of DSR -

Mechanism of route maintenance fails to repair any broken link locally. In addition, the protocol causes higher delay in connection setup as compared to that found in any table-driven protocols. This routing overhead is directly proportional to length of the path.

3) Dynamic MANET On demand (DYMO)

DYMO is also a reactive routing protocol that performs its functions in multi hop type wireless networks. DYMO incorporates a simple design and allows for easy implementation. DYMO protocol performs basic functions, which are route discovery and route Maintenance, which were studied extensively with comparison of the two different on-demand routing protocols.

4) Temporally Ordered Routing Algorithm (TORA)

TORA is a distributed type of routing protocol that uses multi hop routes; it plays significant role to reduce the communication overhead associated with adapting of frequent changes in the network. TORA categorizes under the family of link reversal type of routing, where directed cyclic graph is created to direct the flow of data packets and makes sure about its reachability to all the available nodes. A node would create directed graph as per broadcasting of query packets. On receiving a particular query packet, if a node shows downward link towards destination it would broadcast a reply packet; otherwise it drops the same packet. When a node receives a reply packet it will update the height only in case the height of any replied packet is minimum than other available reply packets. Benefit of TORA Algorithm is

that it provides a route to each of nodes present in the network, but maintenance of all such routes is a complicated task in VANET.

Hybrid Routing Protocols

Hybrid protocol is a combination of both reactive and proactive protocols; it minimizes the control overhead of proactive routing protocol and reduces the delay associated with the route discovery method presents within on-demand type of routing protocols. Hybrid protocol usually divides the entire network to different zones and thereby, provides higher reliability to perform route discovery as well as maintenance procedures. In general, these protocols have higher scalability as compared to pure proactive as well as pure reactive protocols; Reason for this is that such protocols reduce the numbers of rebroadcast messages achieved from working together of network nodes and the involvement of the most appropriate nodes for setting up a route.

1) Zone routing protocol (ZRP)

ZRP is the first type of protocol developed in the form of a hybrid routing protocol, it helps any a network node to divide the entire network into zones based on different factors; like: transmission of power, speed, signal strength and many more. ZRP utilizes reactive routing schemes for outer parts of the zone and the proactive routing schemes for inner zone; with the aim to store the latest routing information within the zone.

2) Zone-based hierarchical link state (ZHLS)

ZHLS protocol divides the complete network into non overlapping zones; where every network node possesses its own ID and a zone ID, measurement of which is done by the help of GPS.

Position-Based Routing Protocol

Position or geographic routing protocol performs its functions according to positional information present in any routing process; in which the source sends a data packet to the destination using its geographic position rather than using the network address. In this protocol, each node should be able to decide its own location and the location of neighbors with the help of Geographic Position System (GPS) assistance. The node identifies its neighbor node as any node that located within the radio range of the same node. When the source has to send a data packet, it stores the destination's position inside the packet header to forward the packet towards destination without any requirement of route maintenance, route discovery or even awareness about the used network topology. Geographic routing protocols are available under three major classes: Delay Tolerant Network (DTN) Protocols, Non Delay Tolerant Network (Non DTN) Protocols and hybrid.

A. Delay tolerant network (NON DTN) protocols

DTN is a type of wireless network designed primarily to perform functions within networks in efficient way. It has few major characteristics; like large scale, frequent disconnection communication, limited bandwidth, power constraints, long unavoidable delays and high bit fault rates. In this network, each node helps every other node for forwarding of packets (store and forward scheme). These nodes contain a limited range of transmission; so packets transmission will result in large delays.

B. Non delay tolerant network (NON DTN) protocols

The non-DTN protocols are various geographic routing protocols, but they do not consider any disconnectivity issue. Instead, it assumes about the presence of specific number of nodes to set up

communication successfully; hence, the protocol suits only for high density network. In these protocols, the node is responsible for forwarding of packets to closest neighbors towards the destination, however, this approach may not prove to be success in case there exists no closest neighbor towards the destination instead of the current node itself.

Broadcast Routing Protocols

Broadcasting in VANET is a complicated area of study and research work. Broadcasting method used in VANET is somewhat different from broadcasting method followed in MANET. The difference takes place because of many reasons, like mobility patterns, network topology, traffic patterns and demographics at different times. As vehicles move at high speeds in VANET, dynamic changes in topology takes place frequently, leading to changes in available routing information. Broadcasting in VANETs may result in dissemination of assistant traffic condition messages towards all vehicles present in a particular geographical area. Flooding acts as the simplest possible way to implement a particular type of broadcast service; where each vehicle rebroadcasts messages to all of the neighbors excluding the one it received. Flooding makes sure that the message will reach to each available node i.e. vehicle eventually in the network. Various Broadcast routing protocols are BROADCOMM, UMB, PGB, VTRADE, and DV-CAST.

A. BROADCOMM Routing Protocol

BROADCOMM[9] performs functions based on a specific hierarchical structure for different highway networks. In BRAODCOMM the highway is divided into different virtual cells, which move as similar to vehicles. The nodes present in the highway remain organized into two-level hierarchy: where the first Level includes each node in a cell, cell reflector is responsible for representing the second level, which are few nodes located very close to geographical centre of the cell. Cell reflector performs its functions for specific time interval in the form of cluster head and deals with the emergency messages, which arrive from same cell members and neighbors.

B. Urban Multihop Broadcast protocol (UMB)

UMB is designed to overcome the problem related to collision of data packets, interference and hidden node problems at the time of message distribution in case of multi hop broadcast. In UMB, the sender node attempts to choose the farthest node present in the broadcast direction to forward and acknowledge the packet without the availability of topology information before in hand. UMB protocol performs its functions successfully at higher packet loads and vehicle traffic densities.

C. Preferred group broadcast (PGB)

PGB is although an unreliable broadcasting protocol, it provides a solution for prevention of the problem of broadcast storm from broadcasting of route request. Each node in PGB will be able to sense the level of signal strength from nearby broadcast. The signal strength is useful for calculation of waiting timeout. Nodes present in the edge of circulated broadcast will set short possible waiting timeout. Only node with shortest timeout is able to rebroadcast the entire message. But there exists a problem in case of low density area.

Multicast-Based Routing Protocols

Multicast refers to sending of packets from a single source to members of a specific group by multi hop communication. Multicast routing in VANETs is available in two categories: geocast and cluster-based routing.

Geocast-based routing protocol

In VANETs, the geocast routing protocol is a type of multicast service that allows a single vehicle to transmit a data packet to other vehicles belonging to a specified geographical area labeled as zone of relevance (ZOR). Nodes refer to elements belonging to a single ZOR group, if they are available within the same and a specified geographical area. The node membership undergoes changes when the node goes out from the scope of defined geographical area, and in this case, it drops the packet. A zone of forwarding (ZOF) implies the geographic area, where vehicles of the area have to deliver packets towards other ZOR vehicles. ZOF aims to achieve a reliable delivery of packets in highly dynamic topology. It allows for a periodic retransmission, to handle changes take place inside the network. The one disadvantage of geocast is delay in packet transmission that mainly takes place by disconnecting of networks.

Robust vehicular routing (ROVER)

ROVER is a geographical multicast protocol; that allows each vehicle to deliver a data packet to each vehicle present inside a particular ZOR; with the help of on-demand routing to identify packets within a ZOR. This protocol assumes that vehicles have particular identification numbers, digital map, and global locations information. The source node starts discover a route by flooding its ZOR by route request packet, this packet included source ID, its location, its recent ZOR, and a sequence number of the route. When a vehicle received the route request packet, it accepts the packet; if it was nearly close to the source and located inside the ZOF and ZOR. If the vehicle was outside the ZOR, it doesn't send a reply. After a vehicle accepts the route request packet, it sends back a reply packet contains its ID to one-hop neighbors, besides recorded the route request packet information in its routing table. And then retransmit the route request packet.

Cluster-Based Routing Protocol

This protocol divides the network to clusters, where nodes have the same characteristics, like same direction or same velocity, or so on. Each cluster has a cluster head, its task is to manage communication processes inside, and to outside its cluster. Nodes inside the cluster communicate by direct paths, but their communication with other nodes outside the cluster is achieved by their cluster header, and this creates a virtual infrastructure for networks. This scheme can provide a good scalability for large networks; however it may increase network overhead and delays in highly dynamic network.

Clustering for open IVC network (COIN)

COIN selects clusters according to three parameters: mobility of nodes, nodes positions and behavior of nodes. The protocol provides each cluster specific time which is a time to live; in order to decrease control overhead. Inter vehicles communication system (IVC) deals with the unstable distances of inter vehicles. To enable a head of cluster node and the cluster member node stay continue communicate, their

mobility should be low and related to the mobility of each, in this case they can reside in radio contact for a longer time.

Cluster-based directional routing protocol (CBDRP)

In CBRP the network is divided into several clusters. Each cluster has a cluster head which is responsible for the routing procedure. These cluster heads communicate with each other via gateway nodes which are nodes that have more than one cluster head. When a source node requests a route, it floods the network by request packet. The CBRP clustered structure reduces traffic overhead, because request packet only passes among cluster heads. However, in density networks, the packet overhead will increase and the transmission delay will increase; because information of each node in the route should be added to the routed packet which increases the size of the packet. One more limitation of the CBRP, it maintains unidirectional links, while most of link layer protocols support only bidirectional links.

Conclusion

This paper has presented an overview of various routing protocols in VANET. While a number of schemes for handling routing and information dissemination in vehicle networks exist, few may be able to handle the requirements of safety applications. This is mainly due to the overhead in discovering and/or maintaining routes and node positions in highly mobile networks of uncoordinated vehicles. Position of the vehicle is one of the most important data for vehicles. Position based routing protocols need the information about the physical location of the participating vehicles to be made available. After analyzing the survey of protocols, it is found that the position based routing has better performance because there is no creation and maintenance of global route from source node to destination node. In the position based routing protocol, all the packets are received with small average delay, better throughput, and effective utilization and also helps to prevent the accidents on the road effectively. Overall, routing vehicle safety communications remains a challenging topic requiring innovative approaches.

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