Topology Based Routing Protocols in Vehicular Ad hoc Network

Ranjit Sadakale, R.A.Patil, N V K Ramesh

Abstract*: Number of routing protocols has been proposed for Vehicular Ad hoc Networks (VANETs) based on various architectures, challenges and applications. Primary aim of these protocols is to maximise throughput and to minimize packet loss. Most of the researchers facing challenges while developing efficient routing protocol. So VANET require novel type of routing protocols. Unlike wired network, router nodes are not used as dedicated and protocols have to be performed by user, which is undependable. For supporting Intelligent Traffic System efficient design of routing protocol is important in VANETs. As it must for communication, the VANET routing protocol should create an efficient route between network nodes.

Keywords: ITS, Mobile Ad hoc Network, Routing Protocols, Vehicular Ad hoc Network

I. INTRODUCTION

Vehicular Ad hoc Networks (VANETs) are a growing research in the field of wireless network. VANET is a subclass of mobile ad hoc network (MANET), which does not depends on fixed communications, in which the nodes are highly movable. For safety and regulation of vehicle flow drivers has to provide about condition of road, traffic and related information. VANET typically addresses this problem to achieve timely and accurate information. New generation wireless networks integrate with new technology like VANET for vehicles. This aims to offer (i) continuous connectivity for mobile user while they are on road, and (ii) capable wireless connection between vehicles without access to any communications, which helps to the intelligent transportation system (ITS) [1]. VANET provides improved road safety, minimum traffic flow, which reduce congestion for ITS architecture [1].

Similar to mobile ad hoc network (MANET), features of VANET are typically similar like self-organization, self-management, and low bandwidth and shared radio transmission conditions [1]. It is possible in future that, VANET will play an important role in the accident early warning, traffic safety, and traffic management and can offer safe and comfortable driving environment to end users. Also it can be a typical application of the Internet of things [2]. VANET is a kind of large scale MANET that revolves moving cars into wireless nodes. Unlike MANET, VANET have high mobility of nodes, high speed vehicles (nodes) which is required for real time applications [3]. In this paper we compare many routing protocols which are based on topology used to form network. Simply main purpose of routing is to route data from a one sender to one or more destinations.

The main aim of this paper is a complete study of routing protocols in VANET communication useful for future research. In addition, this study categorizes routing protocols according to the architecture of VANETs and present new classification of VANET routing protocols. Also we discuss topology based routing strategies, strengths and limitations of routing protocols of each class. As routing protocols in VANET are divided into proactive, reactive and hybrid routing [4]. For proactive, every reachable node evaluate and provide routing information constantly. But in reactive protocol path will be search only it is required for routing. While hybrid protocols combine proactive and reactive routing to form hierarchical network structure. VANET nodes are dynamic in nature, so for finding and maintaining routes it is not easy. Different routing strategies defined based on VANET architecture. In this paper performance evaluation of different topology based routing like proactive, reactive and hybrid protocols are studied. Destination Sequenced Routing (DSR), Optimized Link State Routing (OLSR) and Source Tree Adaptive Routing (STAR) are the examples of Proactive routing. Ad Hoc On-Demand Distance Vector Routing (AODV), Temporally-Ordered Routing Algorithm (TORA) and Dynamic Source Routing (DSR**)** have been studied for reactive routing protocols. Zone Routing Protocol (ZRP) and Hybrid Ad Hoc Routing Protocol (HARP) are the examples of Hybrid Routing Protocols.

The paper is organized as follows. Section II discusses overview of VANET technology. System model and challenges are described in section III. The routing topologies and protocols used are described in section IV. Issues analyzed in routing protocols in section V. Finally, section VI concludes this paper.

II. OVERVIEW OF VANET TECHNOLOGY

A. VANET architecture

As there is no such permanent VANET architecture and topology that it should follow. Each moving vehicle (node) communicate with other vehicle (node) as well as nearby road side unit (RSU).As compare to MANET, VANET having vehicle as moving nodes which follows fixed path such as urban roads and highways.VANET connected to the exceptionally active surroundings of highways transportation. Fig.1 shows active surroundings of road with pure wireless local area network which is nothing but pure ad hoc, and hybrid architecture of VANETs. While designing of network architecture being research area it is important to think of VANETs [17].

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In VANET architecture every vehicle (node) having separate transmitter and receiver.

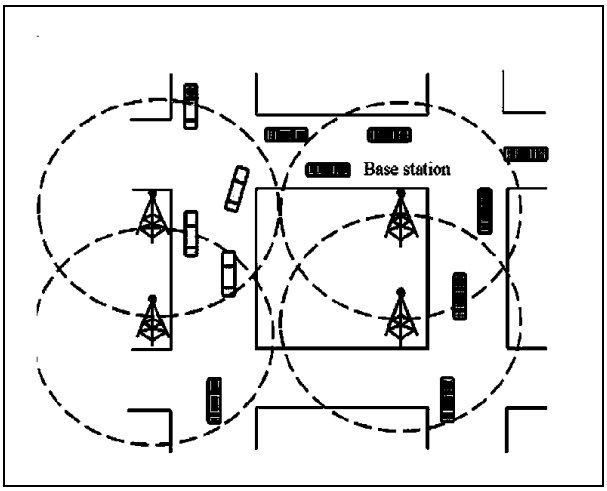

Fig 1. VANET network Architecture

VANET includes V2V communication and V2I communications and is important component of ITS. In a typical VANET architecture, vehicles (nodes) communicate through vehicle to vehicle (V2V) communication and through vehicle to infrastructure (V2I) communication through road side units (RSU). Communication components with typical VANET as shown in figure 1 [5, 6]. VANET is used to reduce blocking, safety for driver and improvement in traffic flow. V2V communication uses multi-hop/ multi cast technique. Also it uses two types of broadcasting: naive broadcasting and intelligent broadcasting. V2I communication requires high bandwidth link with vehicle and roadside equipment. Here RSU broadcast messages to all.

III. BASIC PRINCIPLES and CHALLENGES

VANET network architecture is simple which can takeover expensive Wireless Local Area Network (WLAN) technique to connect computers with each other. In VANET vehicles communicate directly as one-hop or multi-hop communication [6]. RSU deployed to increase coverage or to increase strength of communication. VANET communication having challenges like routing, security frameworks, Quality of service and broadcasting [7].

IV. ROUTING PROTOCOLS

For date transfer in network routing protocols are used as standard for communication. Every routing protocol individually takes routing decisions in network. VANETs having five different routing protocol types: Topology based routing protocol, Position based routing protocol, cluster based routing protocol and Geo cast routing protocol [9]. These protocols are characterized on the basis of area and application. Within network each routing protocol use associative information for sending data packets from source to destination [7, 8].

Table 1. Routing Protocols

Topology Based Routing	Proactive Routing	DSR
		OLSR
		STAR
	Reactive Routing	AODV
		TORA
		DSR
	Hybrid Routing	ZRP
		HARP

Topology based routing protocols classified into proactive (table-driven), reactive (on-demand) routing and hybrid routing. In Proactive protocol, each node evaluates its route and maintains its routing information regularly. In reactive protocol, path for routing will be search only when required. And hybrid routing protocols combine proactive and reactive routing for hierarchical VANET network [9]. Additional node information is required during decision process for topology based routing protocols.

4.1Proactive Routing Protocol

Every node in the network maintains up-to-date information about routing continuously. One or more routing table is maintained by each node which represents the entire topology of the network and updated regularly [10]. Proactive routing protocols are based on shortest path algorithms, which keep information of all neighbouring nodes in table form. Later on, these tables are shared with neighbouring node. Every node updates its routing table if any change occurs in network topology. In Proactive routing protocols no route discovery is required and low latency for real time applications. Disadvantages for Proactive routing protocol is, it occupy part of bandwidth for unused path.

4.1.2 Destination Sequenced Routing (DSR)

DSR is improved version of Bellman-Ford routing algorithm which uses table driven routing technique. Similar to the Routing Information Protocol (RIP), each node holds a routing table with all the possible paths to reach destination within network. In table it consists number of hops to reach destination [11]. For finding hope distance following steps are required [12].

DSR Algorithm Steps:

i. The nodes choose the route with the higher sequence number and discard the old sequence number if new address has a higher sequence number,
ii. If the incoming sequence number is identical to the one belonging to the existing route, a route with the cost is chosen.
iii. New routing information is incremented for all the metrics chosen.
iv. This process continues until all the nodes are updated. If there are duplicate updated
v. packets, the node considers keeping the one with the least-cost metric and discards the rest.

For broken link new sequence number is assigned as cost of metric which is always greater than or equal to sequence number of that node [12].

4.1.2 Optimized Link State Routing (OLSR)

In OLSR three levels of optimization is achieved. OLSR is the proactive routing protocol designed for VANET. Similar to the multipoint relays (MPRs) during the flooding process each node broadcast messages. This can reduce message overhead as compared with conventional flooding mechanism. After receiving copy of message each node retransmits message. In OLSR, each elected node treated as MPR which generates link state information [13]. In this MPR reduces size of related control packets which consists optimization of a pure link state routing protocol. In response to link failures this protocol does

not generate any message other than control message. OLSR does not reliable transmission of control messages because each node sends control messages periodically. Sequence number of the control message is incremented for every message.

OLSR doesn't require any changes to the format of IP packets. Therefore to interact with routing table it can use any existing IP stack.

4.1.3. Source Tree Adaptive Routing (STAR)

During initialization each node in STAR protocol required to send an update message to its neighbouring nodes. Also it sends update messages about new destinations and cost of path [14]. Each node informs about its selected path to reach to destination and update its source-tree information of used wireless links. A router broadcasts to its neighbours to provide information of the parameters used in source routing tree. Each link of the router reaches to known destination in the network and selected node in the network have to be supposed to provide path to every destination [15]. For unreachable path, node initiates nonexistence message for which node to whom it wants to send packets [16].

4.2. Reactive Routing

Reactive routing protocols cannot maintain routing tables when topology changes. It starts to search route only when particular destination starts a session. To establish and update the routing tables in reactive protocol path can be chosen by node. While communicating with other node it opens a route if it is necessary [17]. To reduce load on the network reactive routing protocols maintain only those routes which are currently in use.

4.2.1 Ad Hoc On-Demand Distance Vector Routing (AODV)

For identifying neighbouring nodes AODV use HELLO message because AODV is source initiated routing protocol. For neighbours source node broadcasts a route request and neighbours forward to its destination [16]. After receiving request destination node send unicast message to the source node. Broadcast id is increment for every new request and node maintains it. The packet id is discarded if the received broadcast id is less than or equal to previous received message [17]. Based on DSDV and DSR algorithms, this protocol maintains its routing tables and start route discovery process. Performance of AODV is best, which is based on three parameters: Packet delivery ratio, Routing Overhead and path optimality [17].

4.2.2 Temporally-Ordered Routing Algorithm (TORA)

TORA is reactive and on demand routing protocol. By using directed cyclic graph these protocols directs the flow of packets to reach all the nodes, similar to the link reversal routing [14]. TORA is highly scalable, multipath and non-hierarchical protocol. By broadcasting query packets nodes will construct the directed graph. Instead of shortest path algorithm it uses Directed Acyclic graph (DAC) for communication [17]. The advantage TORA algorithm is, it gives a route to all the nodes in the network. It minimize the communication overhead when topology change. TORA performance is better than DSR in network. Basic functions performed by TORA protocol are as below:

i) Route Creation
ii) Route maintenance
iii) Route erasure

4. 2.3. Dynamic Source Routing (DSR)

DSR forms routs on demand and depend on source routing instead of table similar to AODV. Simply in DSR route will be search only if it is needed [17]. Acknowledged routes are maintained by each node in DSR cache. All source routes contain information about all intermediate nodes in the path. Using flooding route request message DSR finds new path in the network similar to AODV. Once route request message reached to the destination, it reply with message to destination [16]. Information of these entire route reply message is stored in destination node.

For self-configuration and self-organization two types of operations will be performed by this protocol. Broken links does not repaired by DSR route maintenance process.

4.3. Hybrid Routing Protocol (HRP)

Features of Reactive and Proactive Routing protocols are combined in Hybrid Routing Protocols. To reduce control overhead of proactive routing protocol and to decrease delay in route discovery of reactive routing protocols HRP is used [20]. It minimizes overhead and improves the packet delivery rate to destination [17]. Hybrid routing protocols are also called as zone based protocols because for route maintenance and discovery of new route nodes are divided into separate zones.

4.3.1. Zone Routing Protocol (ZRP)

In ZRP the network is divided into overlapping zones [16]. In this protocol using hope distance and topological distribution of nodes zones are created. To reduce control overhead and to minimize latency ZRP is used, which is advance compared with reactive routing protocol. For hierarchical network ZRP protocol wants to be hybrid. For such hierarchical network, each individual cluster node or different cluster requires different protocols for communication. In this protocol one-to-one connection of nodes and different routing zones may cause overlapping between zones which are maintained by individual node. Using this protocol delay decreases and used for high overhead to discover the route [17].

4.3.2. Hybrid Ad Hoc Routing Protocol (HARP)

In HARP routing is performed on two levels: intra-zone and inter-zone, which are depending on position of destination. Unlike ZRP, it divides entire network into non-overlapping zones. To improve delay HARP maintains stable route from source to destination. On the basis of stability it choose best route to limit flooding in the network [18]. For intrazone and inter-zone routing it uses proactive and reactive routing protocols.

V. RESULTS AND DISCUSSION

In this we formulate some open research problems for VANET Routing protocols. Major challenges in design of VANET are the development of a routing protocol that can help to broadcast the information from

one vehicle to another. Routing in VANET is different than MANET routing because in MANET, topologies used are highly dynamic and ever changing topologies. As mentioned by Sahib ur Rehman, M.Arif Khan ,Tenveer A. Zia and Lihong Zhe ng [19] at earliest some protocols of MANET are tested on MANET, but the problems remains the same. Design of new routing protocols for VANET must be efficient, reliable and secure.

Table 1: Comparison between VANET and MANET

Sr No.	Parameters	VANET	MANET
1	Mobility	High	Low
2	Network Topology Change	Frequent and very fast	Slow
3	Bandwidth	1000 kps	100 kps
4	Range	Up to 500m	Up to 100m
5	Node Lifetime	It it depends on Vehicle life time	It is depend on Power source
6	Density in Node	Frequent variable and Dense	Sparse
7	Reliability	High	Medium

Objective of new topology based routing protocol communication between vehicles (nodes) with best possible route. Traditionally due to high speed of vehicles VANETs are difficult to manage because topology changes with respect to speed of vehicle [20]. The main challenges in VANET are as follows:

1. Signal fading
2. Bandwidth limitations
3. Connectivity
4. Security and Privacy
5. Routing Protocol

Table 2: Comparison of Various protocols

Protocols → / Parameters ↓	Proactive Protocols	Reactive Protocols	Hybrid Protocols
Forwarding Method	Wireless multi hop forwarding	Wireless multi hop forwarding	Wireless multi hop forwarding
Realistic Traffic Flow	Yes	Yes	No
Digital Map Requirement	No	No	Yes
Virtual infrastructure Requirements	No	No	Yes
Recover strategy	Multihop forwarding	Carry and forward	Carry and forward
Scenario	Urban	Urban	Highway

Design of efficient routing protocol is required to deliver a packet in minimum period of time with minimum drop of packet, because VANET having high mobility of nodes (vehicles) and rapid changes in topology [21]. Design of new routing protocol will be suitable for busy network that have close distance between vehicles with high density.Design of an efficient routing protocol has an impact on many factors as reliability, packets delivery and interference caused by environment [22,23]. As per the surrounding condition each vehicle need to broadcasts its position, timing information in its communication range for topology based routing. VANET faces many challenges in terms of application, routing, power management.

VI. CONCLUSION

Topology based routing protocols for VANET network is presented in this paper. Initially, we discussed different topology based routing protocols and their routing issues. Packet delivery ratio, average path length, throughput and routing overhead these performance parameters we pointed for routing. For topology based routing protocol, there is no predetermined solution or standard routing solution for evaluation purpose, which can develop in future research opportunities.

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