A Survey of VANET Routing Protocols

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***Abstract*—Vehicular Ad-hoc network (VANET) is an on-demand wireless network that provides for communication between moving vehicles (V2V) and between vehicle and infrastructure (V2I). VANET implements intelligent transportation system (ITS) and aims to optimize traffic flow, improve road safety and reduce congestion. The communication depends on routing. The sporadic connectivity and sudden changes in network topology are the characteristics of VANET that make routing a challenging task. This paper gives a brief overview of routing protocols in VANET, their issues which are under research.**

Keywords: VANET, Routing, WAVE, ITS

I. INTRODUCTION

VANET is a subclass of mobile ad-hoc networks (MANETs). It is a self organizing network without any physical infrastructure. VANET allows the fast moving vehicles to exchange real-time information that can assist the drivers to avoid any situation like-accidents, traffic jams, etc .With the rapid increase in the vehicular traffic on roads, the corresponding increase in accidents created a security issue that drew the attention of researchers towards VANET. Dedicated short range communication (DSRC) facilitates the wireless communication in VANET. DSRC is IEEE 802.11p standard and is a MAC protocol operating at 5.9 GHz [13]. IEEE has standardised the whole communication stack that is referred to as wireless access in vehicular environments (WAVE). VANET provides a wide variety of applications for both safety and non-safety purposes. The major application of VANET is ITS [14]. In addition several value added services such as enhanced navigation; automated toll payment, internet access, and location based services are also provided. In VANET, each vehicle is equipped with devices that allow it to send, receive and exchange information with other vehicles or road side units.[8] Facilitating communication among the vehicles and developing an efficient routing protocol in VANET is a challenging task due to the following reasons: signal fading due to the presence of obstacles (buildings etc.), bandwidth constraints, high mobility of the vehicles and the speed depends on the traffic signs and signals. High mobility results in frequent fragmentation in the network [11]. The routing protocols devised for use in VANET can be categorised under topology based and position based routing.

The rest of the paper is organised as follows. In section II, a brief introduction to the different VANET protocols is given. Section III provides the related work in routing. Section IV provides a survey on recent routing protocols and various issues. Section V concludes the paper.

II. ROUTING PROTOCOLS

VANET's involve vehicles that act as both mobile nodes and routers for the purpose of data dissemination and enable ITS. Routing is a major research challenge in VANET because of high mobility and abrupt changes in topology. Research is being done for designing an efficient routing protocol. Due to the similarities between Mobile Ad-Hoc networks (MANET) and VANET, the traditional ad-hoc routing protocols for MANET are also applied to VANET. These include the topology based routing protocols [14]. Further other routing protocols devised for VANET fall under the following categories-Position based, cluster based, broadcast and geocast routing. We briefly describe topology based and position based routing protocols.

A. Topology Based Routing

These protocols discover the route based on the link information and maintain it in a table. They are further branched into three categories namely, proactive, reactive and hybrid protocols [10].

B. Proactive Protocols

Table driven routing protocol is another name for proactive protocols. Any change in the topology of the network is recorded by the nodes in their respective tables and the tables are periodically exchanged with the neighbours. Although these protocols consume much bandwidth for periodic updates of topology but delay involved for initial route discovery is almost negligible. Routing protocols that fall under this category are:

1. Destination sequence distance vector routing (DSDV).
2. Optimized link state routing (OLSR).
3. Source-tree adaptive routing (STAR).
4. Fisheye state routing (FSR).
5. Reactive protocols.

These protocols are known as on-demand routing protocols since they modify the routing table periodically only in case there is some data to send. Flooding process is utilized by these protocols for the purpose of route discovery which causes routing overhead. Some of the protocols under this category are:

1. Ad-hoc on demand distance vector routing (AODV).
2. Dynamic source routing (DSR).

3. Temporally-ordered routing algorithm (TORA).
4. Hybrid protocol.

The overhead in proactive routing and the initial route discovery delay in reactive protocols led to the discovery of hybrid protocols. In this protocol, reliability for route discovery and maintenance is provided by dividing the network into zones [15]. The protocol under this category is:

1. Zone routing protocol(ZRP)

C. Position Based Protocols

These protocols assume that each node has knowledge about its physical/geographic position by GPS. The physical location is used to select the next forwarding hop and hence no global route between the source and the destination needs to be maintained. [9]Some of the protocols that fall under this category are:

1. Greedy Perimeter Stateless Routing (GPSR).
2. Geographical Source Routing (GSR).
3. Anchor-based street and traffic aware Routing (A-STAR).

III. LITERATURE SURVEY

Considering the growing need of VANET for security purposes, various researchers have proposed different routing protocols for efficient data delivery with minimum time delay and performed comparisons to find the best among the already existing protocols.

1. K. Prasanth, Dr. K. Duraiswamy [1] in 2009 come up with a greedy position based routing approach. In this approach, the source node identifies its neighbour nodes in its transmission range and that are moving in the direction of the destination node. Finally, the specific edge node within the limited transmission range is chosen as the next hop. Results have shown that this proposed edge node based greedy routing out performs the GPSR and PDGR in terms of packet delivery ratio.
2. Jerome Haerri [2] in 2009 used Vehicle Mobility Model to study the characteristics for the purpose of evaluating the working of AODV and OLSR for VANET in city environment. The results showed that OLSR had better performance over AODV in city scenario.
3. Shaikhul Islam Chowdhury,Won-lee, Youn-Sang Choi [3] in 2011 used different mobility models to evaluate the performance of reactive routing protocol like DSR, AOMDV, AODV by considering different performance metrics, the simulation showed that AOMDV performs better than AODV and DSR in terms of end to end delay.
4. Dharmendra Sutariya, Dr Shrikant Pradhan [4] in 2012, proposed a new version of AODV called improved AODV (IAODV) that ensured timely and accurate delivery of information to the vehicle drivers. Simulation results showed that TAODV outperforms AODV in city scenarios in terms of end-end delay, packet loss ratio, and packet delivery ratio.
5. Jamal Toutour, Jose Garcia Neito [5] in 2012 proposed on intelligent OLSR routing protocol optimization for VANET. They presented a solution to the optimization problem in order to tune the OLSR used in MANET to fit the characteristics of VANET. The quality to service of OLSR significantly improved by changing the configuration parameters.
6. Mohammad Al-Rabayah, Robert Malaney [6] in 2012 proposed a new scalable hybrid routing protocol in order to overcome the excessive overhead resulting from link failures due to high mobility of vehicles. HLAR succeeds in reducing the routing overhead compared to the standard reactive and geographic routing protocol.
7. Qinlin, Changle li, Xin Wang [7] in 2013 realized the routing issues that arise when the known VANET protocols like proactive, reactive, position based are applied in 3D scenarios of VANET. These protocols are mainly analyzed and designed based on ideal plane scenarios so when applied to 3D scenarios, server problems occur. A 3D scenario oriented routing protocol is devised for the 3D scenarios like tunnel, ramp.TDR is tested to be better than GPSR in terms of average hops, end-end delay and delivery ratio.
8. Baber Aslam, Faisal Amjad [12] in 2013 came up with a Privacy-enhancing Multilayer Trajectory based Routing Protocol (PMTR) for VANET. Setting up VANET when the number of VANET-enabled vehicles and road side units are limited, is a complex task. The routing protocols available will have poor performance since the connection among the vehicles (V2V) will be frequently disrupted. Initial deployment of VANET is of concern in the near future. PMTR routes messages using the past traffic history and trajectory information provided by vehicles. This protocol uses carry and forward paradigm and previous traffic statistics to preserve privacy. It is found that PMTR has less overhead and provides better privacy as compared to the other geographical protocols.

IV. ISSUES

TABLE 1 PROS AND CONS OF VARIOUS ROUTING PROTOCOLS

Protocol	Pros	Cons
Proactive Protocols	1) Initial route discovery is not required. 2) Low delay in real time applications	1) Bandwidth is wasted in storing unused paths 2) Significant overhead in periodically sharing tables.
DSDV	1) Loop free path to the destination is achieved	1) Full dump packets decrease the bandwidth utilisation as only updates are sent not the complete information. 2) Incremental packets increase the overhead as send frequently.
OLSR	1) Well suited for high density networks	1) Requires a routing table for all possible routes, leading to overhead and constrains scalability.
Star	1) Reduces overhead as no frequent updates are required.	1) Requires large memory for maintaining large trees for the network.
Reactive Protocols	1) Beaconless so it saves the bandwidth. 2) Less overhead by maintaining only the currently active routes.	1) Delay in route discovery and maintenance. 2) Not suitable for large scale networks.
AODV	1) The path to the destination is updated using the destination sequence number. 2) Low memory requirements and route redundancy. 3) Reduces flooding and network overhead. 4) AODV responds to the link failure in the network. 5) Applicable to large scale ad hoc network.	1) Connection setup and establishment of route is time consuming. 2) Extra bandwidth is needed for periodically sending beacon messages.
DSR	1) No periodic update required in DSR. 2) A node can save more than one route to a destination .The cache roué can be used in case a route breaks.	1) In large networks, byte overhead results from the huge amount of route information stored. 2) Performance worsens with increasing mobility. 3) Broken links cannot be repaired locally.
Hybrid Protocols-ZRP	1) Reduces network overhead caused by proactive protocols and handles delay caused by reactive protocols	1) Not suitable for VANET where there is dynamic change in topology.
Geographical Protocols	1) Route maintenance is not required. 2) Stores information of source, destination & neighbouring nodes.	1) Availability of position determining services is a must. 2) Due to the absence of satellite signal, GPS device is unable to function.
GPSR	1) Greedy and perimeter forwarding provide better routing decisions. 2) Forwarding packet decisions are made dynamically. 3) Robust in highly dynamic network.	1) High mobility can make a node unable to maintain information of its next hop neighbour. 2) Beacons may be lost due to bad signal.
GSR	1) GSR has a better packet delivery ratio as compared to AODV & DSR. 2) GSR is scalable than AODV & DSR.	1) The situation such as sparse network where there are not enough nodes for forwarding packets is ignored by this protocol.
A-STAR	1) A new local recovery strategy that is more practical/applicable in city environment is used by A-STAR.	1) A-STAR has a lower Packet delivery ratio as compared to GSR & GPSR.

V. CONCLUSION

The main goal of this survey was to study the routing protocols proposed for VANET. The article provides a review of several traditional routing protocols devised for use in VANET, including reactive and proactive protocols. The issues in these protocols are summarized in Table 1. The proactive and reactive protocols have inherent supposition of network connectivity. Disconnection and discovery of new nodes is ignored hence these protocols are not well suited for VANET. Several improved versions of the traditional routing protocols like AODV, OLSR, hybrid protocols are proposed for improving their performance, details of which are in [4, 5, and 6]. Research is being carried out for designing protocols and algorithms that can perfectly fit in the characteristics of VANET. The main limitation of many protocols is long time delay and the number of retransmissions. It has been found that position-based routing, geocasting are most promising for data dissemination in VANET as given in [13]. The survey shows that a routing protocol works well only in a particular scenario like city, urban environment etc. There is no universal protocol which is suitable for all VANET's application scenario. A specific routing protocol is needed to satisfy the requirements of a particular VANET application, which is a difficult task.

In future, work needs to be done to generalize algorithms to fit in different scenarios. Instead of designing new protocols, a protocol should be able to adapt to the abrupt changes in network and diverse mobility patterns. Work can also be done for making routing more secure as privacy is a major issue in VANET's.

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