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Routing in Vehicular Ad Hoc Network (VANET)

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Abstract*—This paper talks about an emerging and exciting application of ad-hoc network where vehicles are serving as nodes. This area has certain promised aspects and activities to be offered, which are broadly related with the safety, convenience, entertainment, and various other topics of interest. It is an ad hoc network of vehicles, known as 'Vehicular Ad Hoc Network (VANET).' Vehicular Ad-Hoc network is a form of Mobile ad-hoc Networks, to provide communication among nearby vehicles and between vehicles and nearby fixed equipment i.e. roadside equipment. Various routing protocols in VANET have been studied in this paper.

Keywords*— Vehicular Ad Hoc Network (VANET), Routing Protocol, Mobile Ad Hoc Network, AODV, DSR, DSDV, AOMDV.

I. INTRODUCTION

With the advent of recent developments in the field of Wireless Communication and Technology, the world has become a "Global Village". Wireless Networking has entirely drifted the communication paradigm which we observe today as they require easy deployment and setup phases. The devices have minimal energy requirements and are easily available in their specified ranges to form connections and networks, in order to communicate with each other without any need of wires or ducts. Furthermore, these wireless networks are classified depending on their deployment modes of fixed and flexible mobile scenarios, and therefore termed as wireless infrastructure and wireless ad-hoc networks respectively.

II. VEHICULAR AD HOC NETWORKS

Vehicular Ad-Hoc network is a form of Mobile ad-hoc Networks, to provide communication among nearby vehicles and between vehicles and nearby fixed equipment i.e. roadside equipment. VANET or Intelligent Vehicular Ad-Hoc Networking provides an intelligent way of using vehicular Networking. VANET is a technology that uses moving vehicles as nodes in a network to create a mobile network. Each vehicle equipped with VANET device will be a node in the Ad-hoc network and can receive & relay other messages through the wireless network. With the sharp increase of vehicles on roads in the recent years, driving becomes more challenging and dangerous. Roads are saturated, safety distance and reasonable speeds are hardly respected. The primary VANET's goal is to increase road safety. To achieve this, the vehicles act as sensors and exchange warnings or – more generally – telematics information (like current speed, location or ESP activity) that enables the drivers to react early to abnormal and potentially dangerous situations like accidents, traffic jams or glaze. The information provided by other vehicles and stationary infrastructure might also be used for driver assistant systems like adaptive cruise control (ACC) or breaking assistants. Besides that, the VANET should increase comfort by means of value-added services like location based services or Internet on the road. VANET integrates multiple Ad-Hoc networking for easy accurate effective and simple communication between vehicles on dynamic mobility.

For the wide spread and ubiquitous use of VANETs, a number of technical challenges exist. Many research projects were initiated to address these challenges. FleetNet (Sep 2000 – Dec 2003) [1] was one of the earliest European projects in this field. This project developed a platform for inter-vehicular communication and implemented demonstrator applications. Some other prominent projects in this area were Network on Wheels (NoW)[2] and CarTALK2000 [3]. The organization overseeing VANET research activities in Europe is Car-to-Car Communication Consortium (C2C-CC) [4]. It includes many automobile industry members like Daimler, BMW, Audi, Fiat, Renault and some German universities. A survey of potential applications, medium access control schemes and routing protocols for VANETs is presented in [5].

III. ROUTING PROTOCOLS IN VANETS

Routing is the process of forwarding data from source to destination via multi-hop steps. Specifically, routing protocols are responsible for determining how to relay the packet to its destination, how to adjust the path in case of failure, and how to log connectivity data. A good routing protocol is one that is able to deliver a packet in a short amount of time, and consuming minimal bandwidth. Different from routing protocols implemented in MANETs, routing protocols in VANET environment must cope with the following challenges:

- **Highly dynamic topology:** VANETs are formed and sustained in an ad hoc manner with vehicles joining and leaving the network all the time, sometimes only being in the range for a few seconds.

- **Network partitions:** In rural areas traffic may become so sparse that networks separate creating partitions.
- **Time sensitive transmissions:** Safety warnings must be relayed as quickly as possible and must be given high priority over regular data.

A. Topology Based Routing Protocols

These routing protocols use links information that exists in the network to perform packet forwarding. They are further divided into Proactive and Reactive protocols.

Proactive routing protocols

The proactive routing means that the routing information, like next forwarding hop is maintained in the background irrespective of communication requests. The advantage of proactive routing protocol is that there is no route discovery since the destination route is stored in the background, but the disadvantage of this protocol is that it provides low latency for real time application. The various types of proactive routing protocols are protocols are: FSR, DSDV, OLSR, CGSR, WRP, TBRPF.

Reactive/Ad hoc based routing

Reactive routing opens the route only when it is necessary for a node to communicate with each other. Reactive routing consists of route discovery phase in which the query packets are flooded into the network for the path search and this phase completes when route is found. The various types of reactive routing protocols are AODV, PGB, DSR, TORA, and JARR.

IV. COMPARISON OF ROUTING PROTOCOLS

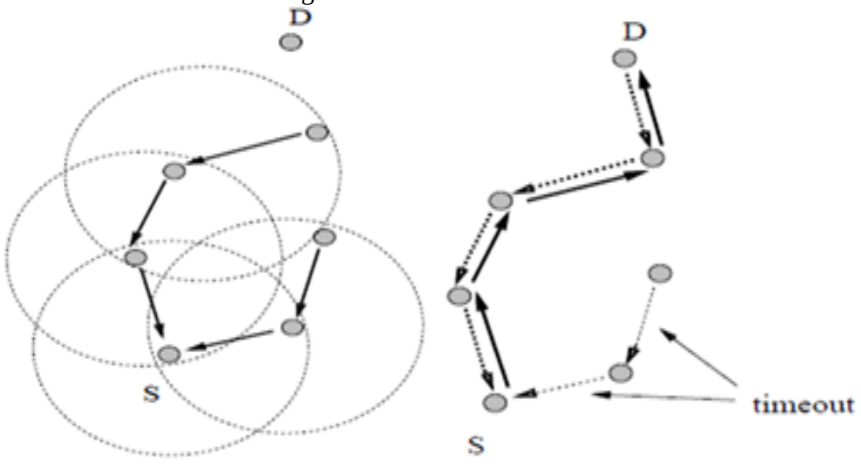
Based on the associated literature review, there are various routing protocols which are proposed with their suitability in VANET perspective. After careful consideration, following are some chosen ones for the exploration of this study.

A. Ad Hoc on Demand Distance Vector Routing (AODV):

Ad hoc On-Demand Distance Vector (AODV) [6] routing is a routing protocol for mobile ad hoc networks and other wireless ad-hoc networks. It is an on-demand and distance-vector routing protocol meaning that a route is established by AODV from a destination only on demand.

It works with the help of 4 messages:

1. ROUTE REQUEST message
2. ROUTE REPLY message
3. HELLO message
4. UNCOLITATED ROUTE REPLY message



(a) (b)

Figure 4.1: AODV Route Discovery (a) Reverse Path Formation (b) Forward Path Formation

Source node broadcasts ROUTE REQUEST message to all nodes in the network. If receiving node have any information about destination then it sends ROUTE REPLY message to source node otherwise it forwards the packet after adding its id to packet. In this for route maintenance every node sends HELLO message after particular instants of time, if a node does not receive HELLO message from long time then it might be disconnected from network. Then it sends UNCOLITATED ROUTE REPLY message to its neighbour nodes, after receiving UNCOLITATED ROUTE REPLY message new route is created.

Advantages

- Routes are established on demand and destination sequence numbers are used to find the latest route to the destination.
- The connection setup delay is less.

Disadvantages

- Intermediate nodes can lead to inconsistent routes if the source sequence number is very old and the intermediate nodes have a higher but not the latest destination sequence number, thereby having stale entries.
- Multiple Route Reply packets in response to a single Route Request packet can lead to heavy control overhead

B. Dynamic Source Routing (DSR):

Dynamic source routing protocol (DSR) [7] is an on-demand, source routing protocol, whereby all the routing information is maintained (continually updated) at mobile nodes. DSR allows the network to be completely self - organizing and self-configuring, without the need for any existing network infrastructure or administration. The protocol is composed of the two main mechanisms:

1) Route Discovery.
2) Route Maintenance.

Route Discovery is done by sending two messages:

- ROUTE REQUEST Message
- REPLY Message

Node which wants to send packets floods the network by ROUTE REQUEST message. Route Reply would only be generated if the message has reached the projected destination node. To return the Route Reply, the destination node must have a route to the source node. If the route is in the route cache of target node, the route would be used. Otherwise, the node will reverse the route based on the route record in the Route Reply message header. In the event of fatal transmission, the Route Maintenance Phase is initiated whereby the Route Error packets are generated at a node. The incorrect hop will be detached from the node's route cache; all routes containing the hop are reduced at that point. Again, the Route Discovery Phase is initiated to determine the most viable route.

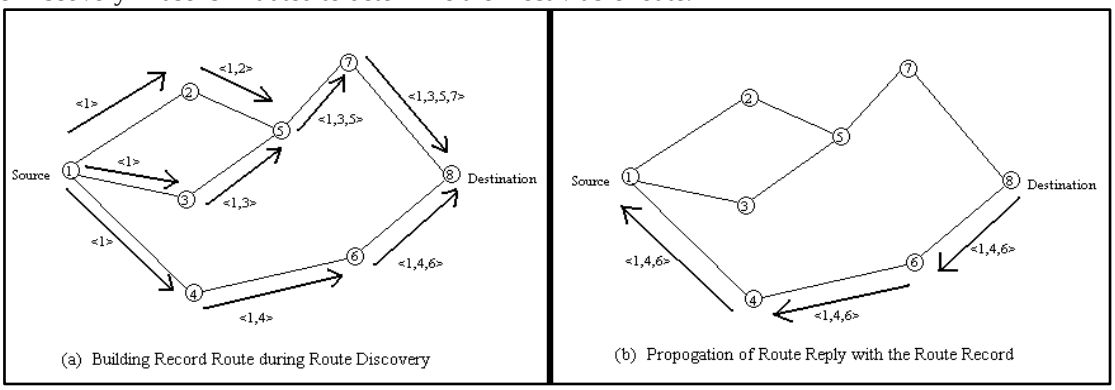


Figure 4.2: DSR Route Discovery and Route Reply

Advantages

- DSR uses a reactive approach which eliminates the need to periodically flood the network with table update messages which are required in a table-driven approach.
- The intermediate nodes also utilize the route cache information efficiently to reduce the control ov`erhead.

Disadvantages

- The route maintenance mechanism does not locally repair a broken down link.
- The connection setup delay is higher than in table-driven protocols.

C. Destination-Sequenced Distance-Vector Routing (DSDV):

Destination-Sequenced Distance-Vector Routing DSDV [8] is a table-driven routing scheme for ad-hoc mobile networks based on the Bellman- Ford algorithm. The main contribution of the algorithm was to solve the routing loop problem. Each entry in the routing table contains a sequence number, the sequence numbers are generally even if a link is present; else, an odd number is used. The number is generated by the destination, and the emitter needs to send out the next update with this number. Routing information is distributed between nodes by sending full dumps infrequently and smaller incremental updates more frequently.

Advantages

- No Route Discovery is required.
- Low Latency for real time applications.

Disadvantages

- DSDV requires a regular update of its routing tables, which uses up battery power
- and a small amount of bandwidth even when the network is idle.
- DSDV is not suitable for highly dynamic networks.

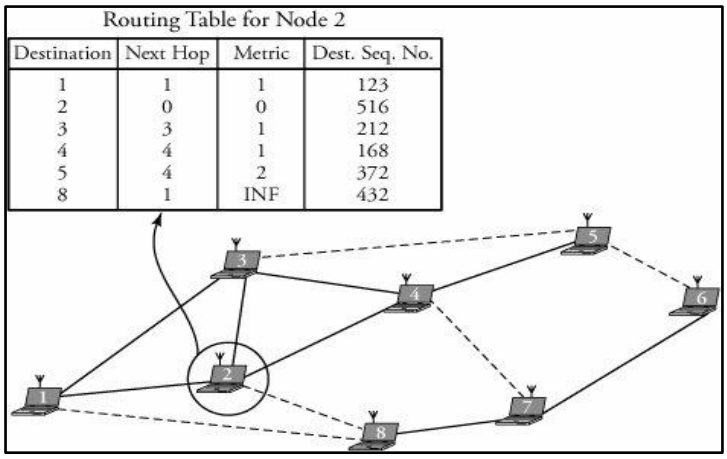


Figure 4.3 DSDV Routing Table and Management

D. Ad-Hoc On-Demand Multipath Distance Vector Routing (AOMDV):

On demand multipath protocols discover multiple paths between the source and the destination in a single route discovery [9]. So, a new route discovery is needed only when all these paths fail. AOMDV is based on a prominent and well-studied on-demand single path protocol known as ad hoc on-demand distance vector (AODV). AOMDV extends the AODV protocol to discover multiple paths between the source and the destination in every route discovery. Multiple paths so computed are guaranteed to be loop-free and disjoint.

This protocol has four components:

- Routing table structure
- Route discovery
- Route maintenance
- Data packet forwarding

AOMDV has three novel aspects compared to other on-demand multi path protocols:

- It does not have high inter-nodal coordination overheads like some other protocols.
- It ensures disjointness of alternate routes via distributed computation without the use of source routing.
- AOMDV computes alternate paths with minimal additional overhead over AODV; it does this by exploiting already available alternate path routing information as much as possible.
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V. CONCLUSION AND FUTURE WORK

Four Protocols namely Ad Hoc on Demand Distance Vector Routing (AODV), Dynamic Source Routing (DSR), Destination-Sequenced Distance-Vector Routing (DSDV) and Ad-Hoc On-Demand Multipath Distance Vector Routing (AOMDV) have been discussed in this paper and there advantages and disadvantages have been enlisted. Many improved protocols based on DSDV have been developed. These improvements of DSDV include Global State Routing (GSR) described in [10], Fisheye State Routing (FSR) described in [11] and Ad Hoc On- Demand Distance Vector Routing (AODV) [6].

Till date, most of the comparisons done between protocols have been limited to their individual characteristics and specification, and as such very less research and analysis is done in a Real Map Scenario. These algorithms can be simulated in Real Map Scenario, to actually find their productivity and efficiency under various circumstances and find how they will behave in real world.

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