A comparative study of Routing Protocols in VANET

Sandhaya Kohli\textsuperscript{1}, Bandanjot Kaur\textsuperscript{2}, Sabina Bindra\textsuperscript{2}

\textsuperscript{1}Dept. of CSE, RIMT-IMT, \textsuperscript{2}Dept. of CSE, RIMT-IET

Abstract

Vehicular Ad Hoc Networks (VANET) is a subclass of Mobile ad hoc networks which provides a distinguish approach for intelligent transport system (ITS). The survey of routing protocols in vanet is important and necessary issue for smart ITS. The chapter discusses the advantages and disadvantages of these routing protocols, it explores the motivation behind the designed and trace the evolution of these routing protocols. Finally it concludes the chapter by comparing the various routing protocols.

Keywords: FSR, AODV, DSR, PGB, TORA, BROADCOMM, Geocast, VANET

1. Introduction

A 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. The main goal of VANET is providing safety and comfort for passengers. 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. Collision warning, Road signal arms and in place traffic view will give the driver essential tool to decide the best path along the way. VANET or Intelligent Vehicular Ad-Hoc Networking provides an intelligent way of using vehicular Networking.

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 leading car manufacturer decided to jointly work with govt. agencies to develop solution aimed at helping drivers on the roads by anticipating hazardous events or bad traffic areas. One of the outcomes has been a novel type of wireless access called wireless access for vehicular environment (WAVE) used for vehicle to vehicle and vehicle to road side communication.

VANET integrates multiple Ad-Hoc networking technologies such as WiFi IEEE 802.11 b/g, WiMAX 802.16, Bluetooth, IRA, ZigBee for easy accurate effective and simple communication between vehicles on dynamic mobility. VANET helps in defining safety measures in vehicles, streaming communication between vehicles, infotainment and telematics

2. Applications

VANET application can be categorized into following categories (a) VANET provide ubiquitous connectivity on the road to mobile users (b) It provides efficient vehicle to vehicle communications that enables the Intelligent Transport System(ITS). ITS includes variety of applications like cooperative traffic monitoring, control of traffic flows, blind crossing and collision prevention. (c) Comfort application are the application to allow the passenger to communicate with other vehicles and with internet hosts, which improves passengers comfort. For example VANET provides internet connectivity to vehicular nodes while on the movement so that passenger can download music, send emails, watch online movies etc.

3. Network Architecture and characteristics

Wireless ad hoc networks do not depend on fixed infrastructure for communication and dissemination of information. The architecture of VANET consists of three categories: Pure cellular/WLAN, Pure Ad hoc and hybrid. VANET may use fixed cellular gateways and WLAN/WiMax access points at traffic intersections to connect to the internet, gather traffic information or for routing purposes. This network architecture is pure cellular or WLAN. VANET can compile both cellular network and WLAN to form the network. Stationery or fixed gateways around the road sides also provides connectivity to vehicles. In such a scenario all vehicles and road sides devices form a pure mobile ad hoc networks. Hybrid architecture consists of both infrastructure networks and ad hoc networks together.

Nodes in VANET can self organized and self manage the information in a distributed fashion without any centralized authority. Since the nodes are mobile so data transmission is less reliable and sub optimal. Some of the distinguishing feature of VANET which make it more challenging class of Manet are:

**High Dynamic Topology:** Since vehicles are moving at high speed, Topology formed by VANET is always changing.

**Frequently disconnected network:** The highly dynamic topology results in frequently disconnected network. This problem is also caused by changing node density.

**Unlimited Battery Power and Storage:** Nodes in VANET are not subject to power and storage limitation as in sensor networks. Nodes have ample amount of energy and computing power. **On Board Sensors:** Nodes
consists of sensors which provide useful information for routing. Many VANET routing protocols consist of GPS unit which provides location information.

4. Overview of Routing Protocols

In VANET, the routing protocols are classified into five categories: Topology based, Position based, Cluster based, Geocast, Broadcast.

4.1 Topology based routing protocols

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

4.1.1 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 packets are constantly broadcast and flooded among nodes to maintain the path, then a table is constructed within a node which indicates next hop node towards a destination. The advantage of proactive routing protocols is that there is no route discovery is required 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, it also leads to the maintenance of unused data paths, which causes the reduction in the available bandwidth. The various types of proactive routing protocols are:

4.1.2 Fisheye state routing (FSR)

FSR is similar to LSR, in FSR node maintains a topology table (TT) based upon the latest information received from neighboring and periodically exchange it with local neighbors. For large networks to reduce the size of message the FSR uses the different exchange period for different entries in routing tables. Routing table entries for a given destination are updated preferably with the neighbors having low frequency, as the distance to destination increases. The problem with the FSR routing is that with the increase in network size the routing table also increases. As the mobility increases route to remote destination become less accurate. If the target node lies out of scope of source node then route discovery fails.

4.1.2.1 Temporally Ordered Routing Algorithm (TORA)

TORA belongs to the family of link reversal routing in which directed a cyclic graph is built which directs the flow of packets and ensures its reachability to all nodes. A node would construct the directed graph by broadcasting query packets. On receiving a query packet, if node has a downward link to destination it will broadcast a reply packet; otherwise it simply drops the packet. A node on receiving a reply packet will update its height only if the height of replied packet is minimum of other reply packets. TORA Algorithm has the advantage that it gives a route to all the nodes in the network, but the maintenance of all these routes is difficult in VANET.

4.2 Position based routing protocol

Position based routing consists of class of routing algorithm. They share the property of using geographic positioning information in order to select the next forwarding hops. The packet is send without any map knowledge to the one hop neighbor which is closest to destination. Position based routing is beneficial since no global route from source node to destination node need to be created and maintained. Position based routing is broadly divided in two types: Position based greedy V2V protocols, Delay Tolerant Protocols.

4.2.1 Position Based Greedy V2V Protocols

In greedy strategy and intermediate node in the route forward message to the farthest neighbor in the direction of the next destination. Greedy approach requires that intermediate node should possessed position of itself, position of its neighbor and destination position. The goal of these protocols is to transmit data packets to destination as soon as possible that is why these are also known as min delay routing protocols. Various types of position based greedy V2V protocols are GSR, GPSR, SAR, GPCR, CAR, ASTAR, STBR, CBF, DIR and ROMSGP

4.2.1.1 Geographic Source Routing (GSR)

Earlier GSR was used in MANET. Then it was improved to use in VANET scenario by incorporating in to it greedy forwarding of messages toward the destination. If at any hop there are no nodes in the direction of destination then GPSR utilizes a recovery strategy known as perimeter mode. The perimeter mode has two components one is distributed planarization algorithm that makes local conversion of connectivity graph into planar graph by removing redundant edges. Second component is online routing algorithm that operates on planer graphs.

So in VANET perimeter mode of GPSR is used. In GPSR if any obstruction or void occurs then algorithm enter perimeter mode and planner graph routing algorithm start operations, it involves sending the message to
intermediate neighbor instead of sending to farthest node, but this method introduces long delays due to greater no.
of hop counts. Due to rapid movement of vehicles, routing loops are introduced which causes dissemination of
messages to long path. GPSR uses static street map and location information about each node, since GPSR
does not consider vehicle density of streets so it is not an efficient method for VANET.

4.3 Broadcast Routing

Broadcast routing is frequently used in VANET for sharing, traffic, weather and emergency, road conditions
among vehicles and delivering advertisements and announcements. Broadcasting is used when message
needs to be disseminated to the vehicle beyond the transmission range i.e multi hops are used. Broadcast
sends a packet to all nodes in the network, typically using flooding. This ensures the delivery of the packet but
bandwidth is wasted and nodes receive duplicates. In VANET, it performs better for a small number of nodes.
The various Broadcast routing protocols are BROADCOMM, UMB, V-TRADE, and DV-CAST.

4.3.1 BROADCOMM Routing Protocol

BROADCOMM is based on hierarchal structure for highway network. In BROADCOMM the highway is
divided into virtual cells which move like vehicles. The nodes in the highway are organized into two level of
hierarchy; the first Level includes all the nodes in a cell, the second level is represented by cell reflectors, which
are few nodes located closed to geographical centre of cell. Cell reflected behaves for certain interval of time as
cluster head and handles the emergency messages coming from same members of the cell or nearby neighbor. This
protocol performs similar to flooding base routing protocols for message broadcasting and routing overhead.

4.3.2 Urban Multihop Broadcast protocol
(UMB)

UMB is designed to overcome the interference, packet
collision and hidden node problems during message
distribution in multi hop broadcast. In UMB the sender
node tries to select the furthest node in the broadcast
direction for forwarding and acknowledging the packet
without any prior topology information. UMB protocol
performs with much success at higher packet loads and
vehicle traffic densities.

4.3.3 Vector Based Tracing Detection
(V-TRADE)

It is a GPS based message broadcasting protocols. The
basic idea is similar to unicast routing protocols Zone
Routing Protocol (ZRP). V-TRADE classifies the
neighbors into different forwarding groups depending
upon position and movement information. For each
group only a small subset of vehicles is selected to
rebroadcast the message. V-TRADE improves the
bandwidth utilization but some routing overheads are
associated with selecting the next forwarding node in
every hop.

4.3.4 Geocast Routing

Geocast routing is basically a location based multicast
routing. Its objective is to deliver the packet from source
node to all other nodes within a specified geographical
region (Zone of Relevance ZOR). In Geocast routing
vehicles outside the ZOR are not alerted to avoid
unnecessary hasty reaction. Geocast is considered as a
multicast service within a specific geographic region. It
normally defines a forwarding zone where it directs the
flooding of packets in order to reduce message overhead
and network congestion caused by simply flooding
packets everywhere. In the destination zone, unicast
routing can be used to forward the packet. One pitfall of
Geocast is network partitioning and also unfavorable
neighbors which may hinder the proper forwarding of
messages. The various Geocast routing protocols are IVG,
DG-CASTOR and DRG

5. Conclusion & Future Perspectives

In this section we have reviewed existing routing
protocols. Table 1 gives a Comparison of these protocols.
Prior forwarding method describes the first routing
decision of the protocol when there are packets to be
forwarded. In case of Delay Bounded protocols the prior
forwarding method is used, whereas in all other routing
protocols wireless multi hop method of forwarding is
used. Digital map provides street level map and traffic
statistics such as traffic density and vehicle speed on road
at different times. Digital map is mandatory in case of
Some of Cluster Based Routing Protocols. Virtual
Infrastructure is created through clustering of nodes in
order to provide scalability. Each cluster can have a
cluster head, which is responsible for secure
communication between inter-cluster and intra cluster
coordination in the network. Recovery strategy is used to
recover from unfavorable situations. Recovery strategy is
the criteria, which is used to judge the performance of
protocol.
Table 1: Comparison of Various Protocols

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Prior Forwarding Method</td>
<td>Wire less multi hop Forwarding</td>
<td>Wire less multi hop Forwarding</td>
<td>Heuristic method</td>
<td>Carry &amp; Forward</td>
<td>Wireless Multi hop Forwarding</td>
<td>Wire less multi hop Forwarding</td>
<td>Wire less multi hop Forwarding</td>
</tr>
<tr>
<td>Digital Map Requirement</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Virtual Infrastructure Requirement</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Realistic Traffic Flow</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Recovery Strategy</td>
<td>Multi Hop Forwarding</td>
<td>Carry &amp; Forward</td>
<td>Carry &amp; Forward</td>
<td>Multi hop Forwarding</td>
<td>Carry &amp; Forward</td>
<td>Carry &amp; Forward</td>
<td>Flooding</td>
</tr>
<tr>
<td>Scenario</td>
<td>Urban</td>
<td>Urban</td>
<td>Urban</td>
<td>Sparse</td>
<td>Urban</td>
<td>Highway</td>
<td>Highway</td>
</tr>
</tbody>
</table>

The future perspectives for VANET routing protocols should include following:

1. A major challenge in protocol design in VANET is to improve reliability of Protocols and to reduce delivery delay time and the number of packet retransmission.

2. Driver behavior should be considered for designing of delay bounded routing protocols since carry and forward is the mainly approach to deliver packets.

3. Geo cast routing for comfort applications should also considered. Comfort messages are usually tolerant of delay, Network bandwidth is generally reserved for emergency messages. It is worth to develop an efficient geo cast routing protocol for comfort applications with delay tolerant capabilities with low bandwidth utilization.

References

2. Sascha Schnaufer, Holger Fuisler, Matthias Transier, Wolfgang Effelsberg, “Unicast Ad-hoc Routing in Vehicular City Scenarios” in “Network on wheels” project under contract no. 01AK064F and Matthias Transier.
7. Maxim Raya, EPFL Jean-Pierre Hubaux, EPFL “Security Aspects of Inter-Vehicle Communications” 5th Swiss Transport Research Conference Monte Verita/Ascona, March 9-11, 2005