Journal of Theoretical and Applied Information Technology
31st August 2014. Vol. 66 No.3

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

A COMPARATIVE AND ANALYSIS STUDY OF VANET ROUTING PROTOCOLS

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ABSTRACT

Vehicular Ad Hoc Network (VANET) is a kind of mobile ad hoc networks. VANET is used to endow wireless communication between vehicles and vehicle to road side equipments. The communication between vehicles is used for safety, placate and for entertainment as well. The performance of communication depends on the performance of routing in the network. Routing of data is dependent on the routing protocols used in network.

In this study we investigated about various ad hoc routing methods so as to select suitable method for different kinds of network in VANET. The main aim of our study was identification of the ad hoc routing method that has better performance in highly mobile environment of VANET. Comparing on the basis of throughput and packet drop, it seems that position based routing method of VANET as better performance as compared to the traditional ad hoc topology based routing. However, it is not easy to provide any universal routing protocol that can deal with all the cases of VANET. The selection of a single routing protocol is not easy in VANET because the performance of the protocol depends on speed of the vehicle, driving environment etc. These factors may vary from one environment of network to another.

Keywords: *VANET, Routing protocol, Wireless,Performance.*

1. INTRODUCTION

VANET refers to Vehicular Ad Hoc Network. At present time, this is considered to be one of the rising technologies that will help in achieving intellectual inter-vehicle communications, flawless internet connectivity that will bring improvement in the road safety, necessary alerts and accessing various comforts and entertainment. This kind of technology combines WLAN, cellular and Ad Hoc networks for achieving the constant connectivity. VANET is independent and self-managing wireless communication network, wherein all the nodes present in the network (VANET) act like the servers and/or clients in order to exchange and share information. The complete architecture of VANET can be categorized into three categories that are: “pure cellular/WLAN, pure ad hoc, and hybrid” [1-3].

The latest improvements done in the field of mobile ad hoc network (i.e. MANET) technology and the increasing safety needs and also the consumer’s interest in Internet access have resulted in making the VANET to be one of the most important research topics. Communication between different vehicles and the communication from vehicle to roadside have become important parts of vehicle infrastructure integration. Most of research done for the VANET has also focused on urban, rural as well as suburban roadway situations, where the number of vehicles s high, the spacing between vehicles is very small, ground is not the important factor, and fixed infrastructure of communication is available[4, 5].

Vehicular Ad Hoc Network and some of the important applications of such kind of network can be illustrated with the help of following diagram:

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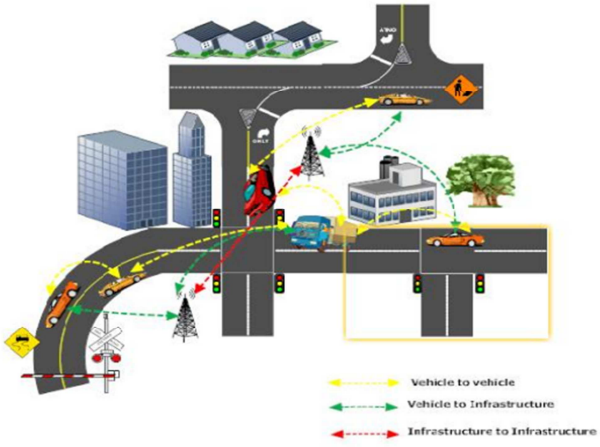

Figure 1 Vehicular Ad hoc network and its applications [6]

The major applications of VANET include Vehicle collision warning, Driver support, Security distance caution, supportive driving, supportive travel control, distribution or broadcasting of road information, access of Internet, Location in the Map, Automatic parking, and vehicles without any driver [7].

There are a number of routing protocols that have been proposed so as to have effective and unswerving routing in VANET [8]. The classification can be done as follows:

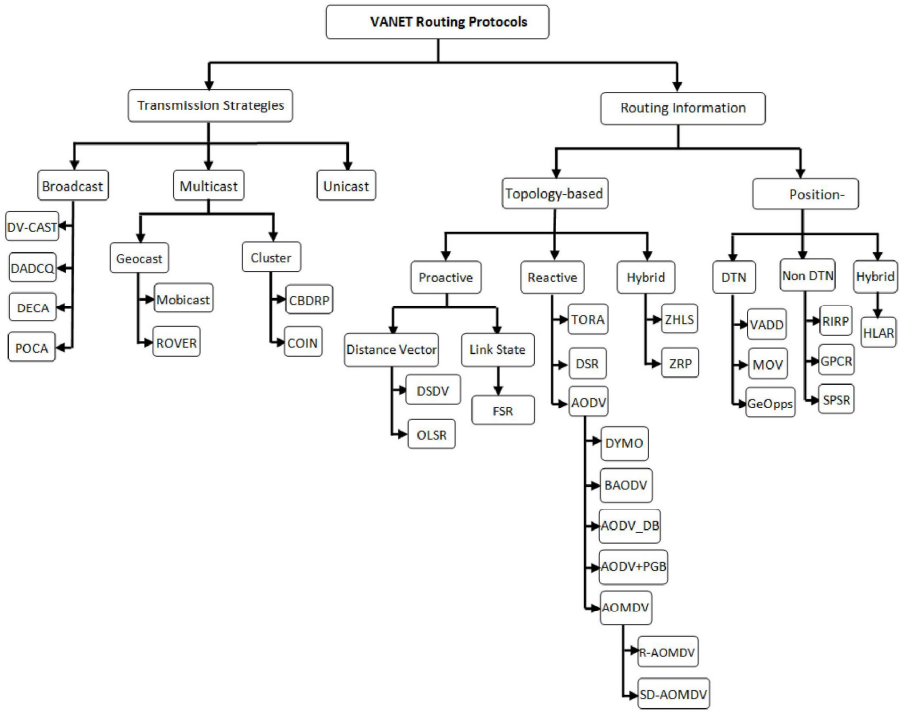

Figure 2 Routing Protocols [1]

Multi hop routing protocols such as MDDV and VADD [3,4] deliver packets by using vehicles present on the road in the form of nodes. "Static-Node Assisted Adaptive routing protocol in Vehicular Networks" (SADV) makes the use of static nodes for routing traffic[9]. There are some geographical based routing protocols as well (GFG and GOAFR)[10] that are developed for

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

providing scalable communication in VANET. "Road-Based using Vehicular Traffic information" (RBVT) works according to the real time information for routing traffic. RBVT has been further extended to proactive protocol RBVT-P and reactive protocol RBVT-R for routing the traffic in VANET [9].

2. PROBLEM STATEMENT

Previous studies and research done on VANET routing mainly focuses on single ad hoc routing protocols (such most the main focus is given to traditional ad hoc topology based routing, while there are some researches done that focus on position based ad hoc routing protocols in VANET). Routing protocol to be used is mainly selected on the basis of the kind of the network present. So, single ad hoc routing method is not adequate enough so as to meet all kinds of the present ad hoc networks. Each researcher has used a different simulator and performance parameter o evaluate the performance of these protocols. As a result, this performance is not measured in a proper manner as different researcher used different parameter. Due to aforesaid issues, there is high need of studying various ad hoc routing methods so as to select suitable method for different kinds of network in VANET.
Some of the important challenges and problems in existing VANET routing are as follows:

- There should be a kind of routing available that can be approached if there is any case of low network density. The result of extreme density variability should be included into the protocol designing.
- One of the major challenges in protocol designing in case of VANET is how the reliability of different kinds of routing protocols" can be improved for simultaneously reducing the delivery delay time and the number of packet retransmissions.
- Behaviour of the driver should also be considered to design the delay-bounded routing protocols since carry-and-forward method is the main approach used for delivering the packets.
- While designing the routing protocol in a big city, the interference caused due to the tall buildings present on the roads should also be considered.
- Scalability is considered to be another important factor for designing the routing protocol. The VANETs can be large and metropolitan networks. There should be the possibility that more than one routing request are processed simultaneously. The conflict in different routing requests between vehicles should be taken into consideration.

Other than the above mentioned points, the security is also one of the major issues in VANET. We need to further investigate and analyze the cooperation between inter-vehicular networks and sensor networks that are placed within the vehicles or beside the road. With the increase in the number of vehicles on road, the trust between these vehicles should also be sustained in order to have the smooth communication.

3. ANALYSIS OF EXISTING ROUTING PROTOCOLS

In this section, we will mainly focus on position based routing protocols for VANET that will help us to conclude which protocol will be most suitable to use.

Position Based Routing

Position based routing is such kind of a method where the data routing between source and destination is done on the basis of the geographical positions of nodes. In Position based routing it is assumed that each node has information about its physical or geographic position using GPS or by other means of determining the position. Each of the nodes has the information about the source, destination and other neighbouring nodes [5].

Position based routing does not need any kind of route maintenance. The route is determined only when there is a need to forward any packet. One of the other advantages of position based routing is that it has information related to source, destination as well as the neighbouring nodes. Because of these advantages, position based routing is a suitable option in VANET [10].

Greedy Perimeter Stateless Routing-GPSR

"Greedy Perimeter Stateless Routing (GPSR)" [11] is one of the best examples of position

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

based routing. GPSR uses the information of the closest neighbour of destination so as to forward the required packet efficiently. This kind of routing is called as "greedy forwarding". In GPSR each node has information of its existing physical position as well as the neighbours. The knowledge about position of node helps in giving a better routing and also gives some knowledge related to the destination. Other than this, all the neighbouring nodes help in making the forwarding decisions in an appropriate manner without interfering with the information related to topology.

The advantage of "greedy forwarding" is that it keeps the currently existing position of the forwarding node. This helps in decreasing the distance to destination node and packets can also be transmitted in a short duration of time. Other than this, there are a few disadvantages as well. Some of the topologies in this protocol result in limiting the packet from moving to a particular range or distance from the destination. This method also does not work if there is no closer neighbour present to destination.

Greedy forwarding is not suitable for such vehicular networks where the nodes are highly movable and the node will be unable in maintaining its next neighbour's information as the other node can become out of the range because of the high mobility of the node. This may result in loss of data packets.

Geographic Source Routing GSR

As GPSR is not suitable if there are any radio obstacles because at that time, network may demand some new routing strategies that can fight with various challenges. Therefore, "Geographic Source Routing (GSR)" is introduced [12]. It is able to deal with high mobility of nodes and also uses roads layout for discovering routes. GSR uses "*Reactive Location Service (RLS)" to know the location of the destination.* GSR is the combination of both "geographic routing" and "road topology knowledge" and ensures potential routing in the presence of any kind of obstacles. In GSR, the source node makes use of the simple graph algorithms for finding the shortest path to destination on the graph and the packet is marked with the location of destination.

Anchor-based Street and Traffic Aware Routing- A-STAR

A-STAR protocol uses a new kind of recovery method. When any packet faces problem for passing from a junction then that junction is marked as "*out of service*" so that all other packets are restricted to cross that junction until that junction is marked to "*Operational*" state [13]. When any junction is not in order, each node in the network is informed about that junction and the respective routing information and city maps are updated by marking that junction as "out of order". So, no node will use that junction as anchor to be passed to reach destination.
A-STAR takes the help of the street map for obtaining the information of anchor. A-STAR has two main features that make it different from GSR in implementation. A-STAR uses "statically and dynamically rated maps" for finding out the number of junctions. It means that connectivity is high on wider roads with a more number of vehicles. A-STAR also makes the use of traffic information and street awareness in order to find out the path.

4. SIMULATION MODELING & SETUP

"Simulation is the technique of solving problems by the observation of the performance, over the time, of a dynamic model of the system" [14]. The process of Simulation can be represented as follows:

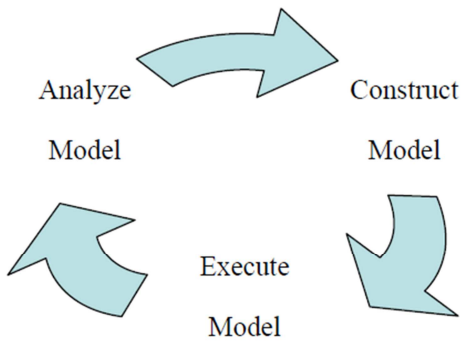

Figure 3 Simulation Model

Development of Simulation is an iterative process in which the "construction, execution and analysis of a model repeatedly perform in order to achieve desired level of understandings" [15].

Journal of Theoretical and Applied Information Technology
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ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

Simulation tool/ Simulator and Performance Metrics

The simulation tool used is "NCTUns (National Chiao Tung University Network Simulator ") [14] to validate all the findings.
There are a number of performance metrics and factors that can be used to evaluate the performance of the routing protocols in VANET. The performance of these protocols is measured on the basis of following parameters:

- Average delivery ratio
- Average Delay
- Average length of the path
- Total Overhead

We have mainly selected throughput and packet drop performance parameters to evaluate the routing protocols.

1. Throughput

Throughput is the average number of the data packets that were successfully delivered on a communication network or any network node. It is calculated in "bytes/sec or data packets per second". The formula for Throughput can be given as follows:

$$\text{Throughput (bytes/sec)} = \frac{\text{Total number of received packets at destination* packet size}}{\text{Total simulation time}}$$

2. Packet Drop

Packet drop is the factor used to show the total number of data packets that were unable to reach the destination successfully. This can happen because of the congestion, defective hardware or overflow in the queue etc. Packet drop results in affecting the network performance as it consumes a long time and more bandwidth for resending a packet. As low as the packet drop rate is, protocol performance will be higher.

Simulation Setup and Results

The simulation for these protocols were carried out and different experiments performed on the basis of the network density, wherein, 350 nodes represent dense network, 250 nodes means medium traffic and 150 nodes means less traffic.

The performance is checked in two kinds of networks, namely, highway and city.
In the highway scenario, AODV [16]and GPSR are selected and evaluated in the presence of low and high speed of nodes on highways. The highway scenario's simulation can be represented as follows:

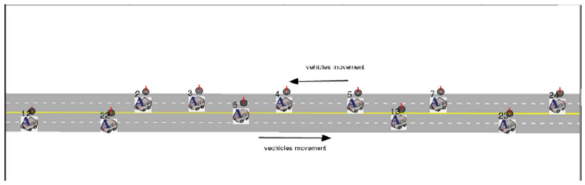

Figure 4 Highway Scenario

In this simulation "AODV and GPSR routing protocols" are selected for the purpose of simulation and the performance will be checked on the basis of throughput and packet drop. Each input parameter for the simulation of this scenario is as follows:

Parameter	Setting
Environment Size	1500 x 800 meters
Total number of nodes	20
Node Type	Highly Mobile nodes (Vehicles)
Node Speed	20 m/s , 30 m/s
Packet Type	UDP
Packet Size	1400 Bytes
Simulation Time	400 seconds
Number of Receiver	One

The results for highway scenario with node speed of 20 m/sec in VANET in terms of throughput and drop packets are mentioned below:

Table 1 Highway Scenario

Routing Protocol	Throughput (KB/ sec)	Packet Drop
AODV	7370	16090
GPSR	12449	15073

The throughput obtained for various conditions can be explained with the help of following graph:

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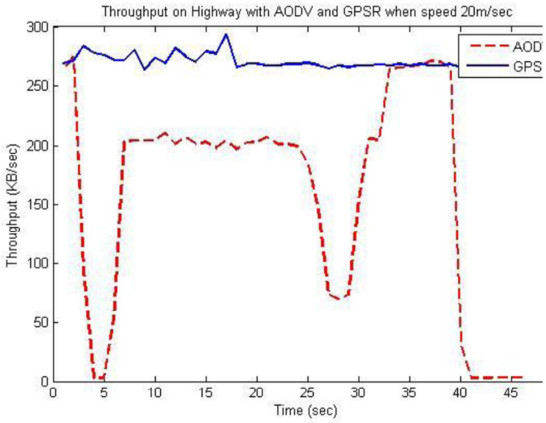

Figure 5 Throughput Obtained In Highway Scenario

In the same way, the packet drop rate in case of highway scenario can be represented as follows:

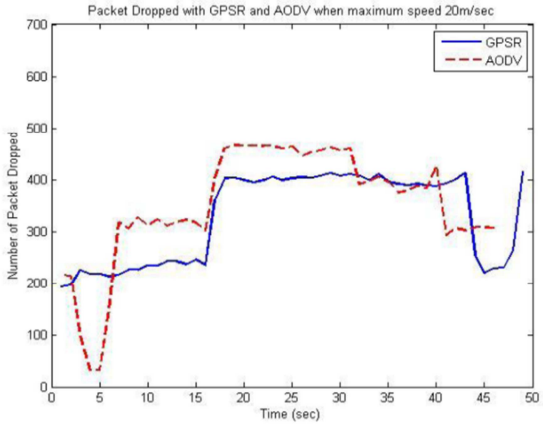

Figure 6 Packet Drop Rate In Highway Scenario

In the city scenario, AODV, GPSR and A-STAR routing protocols are selected for checking their performance in the large city in the presence of obstacles. In city scenario, the speed of nodes is taken very small. The city scenario can be represented as follows:

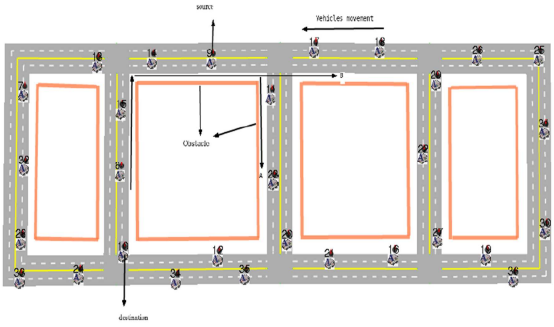

Figure 7 City Scenario

The throughput obtained for various conditions in city based scenario can be explained with the help of following graph:

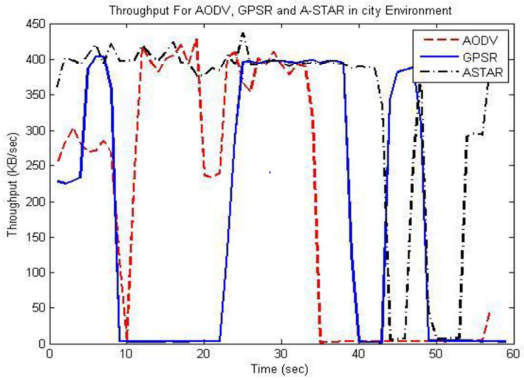

Figure 8 Throughput In City Based Scenario

In the same way, the packet drop rate in case of city based scenario can be represented as follows:

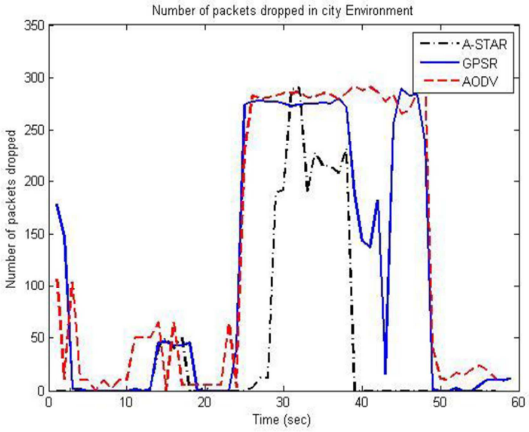

Figure 9 Packet Drop Rate In City Based Scenario

The results for city based scenario with node speed of 20 m/sec in VANET in terms of throughput and drop packets are mentioned in the following table:

Table 3 Results Obtained In City Based Scenario

Routing Protocol	Throughput (KB/sec)	Packet Drop
AODV	9921	7573
GPSR	13859	6495
A-STAR	19008	2457

After analyzing the highway scenario, it can be noticed that the throughput and the packet drop ration is better for GPSR. However, if we see the city scenario, the performance of A-STAR is better as it has the highest throughput among all three of them.

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

5. CONCLUSION AND FUTURE PERSPECTIVE

The main goal of this research is to study various ad hoc routing methods so as to select suitable method for different kinds of network in VANET.

We also found that the position based routing protocols show better results as compared to traditional ad hoc routing protocols in VANET. We mainly analyzed two position based routing protocols, which are GPSR and A-STAR in two different situations of VANET. GPSR outperforms AODV completely in both highway and city environments of VANET. GPSR is affected because of the presence of various obstacles (such as buildings) in case of large city. On the other hand A-STAR outperforms both GPSR and AODV in city environments of VANET. A-STAR makes the use of anchored based street information for finding the routes in large city environment, so it cannot be an alternative in case of highway scenarios. So we found that A-STAR is useful in such cases of VANET where number of nodes is higher and radio obstacles are also involved, while GPSR is useful for direct communication between nodes. Furthermore, all of the position based routing protocols cannot be used in all kinds of environments of VANET.

From the complete study, it can be suggested that position based routing protocols seem to be more promising as compared to traditional ad hoc routing protocols for VANET. Although position based routing is found to be scalable for VANET however it is not easy to suggest any single routing protocol that can handle different cases of VANET. The selection of a single routing protocol is a tough task in VANET because the performance of the protocol mainly depends on speed of the vehicle, driving environment etc that mostly varies from one environment of network to another.

Talking about the future aspect, there are a number of improvements that need to be done. Some of them are as follows:

- Security in routing is one of the major challenges. Due to the unsecure and ad hoc nature of VANET, it is prone to different security attacks that may result in devastating consequences. So, various security attacks should be checked with respect to different attacks in case of VANET.
- New algorithms should be found for providing reliable QoS for safety and comfort applications in VANET.
- Different position based routing protocols can also be evaluated in real environment of VANET for checking the efficiencies of these protocols in real situation.

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