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Reliable protocols in vehicular Adhoc Networks-Study Approach

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Abstract: Vehicular Ad Hoc Network (VANET) is a specification of mobile ad hoc networks. VANET provides wireless communication among vehicles and vehicle to road side equipments. The performance of communication depends on how better the routing takes place in the network. Routing of data depends on the routing protocols being used in network. In this study we investigated about different ad hoc routing protocols for VANET. The main aim of our study was to identify which ad hoc routing method has better performance in highly mobile environment of VANET. To measure the performance of routing protocols in VANET, we considered two different scenarios i.e. city and highway. Routing protocols were selected carefully after carrying out literature review. The selected protocols were then evaluated through simulation in terms of performance metrics i.e. throughput and packet drop. After simulation results, we used MATLAB to plot the graph to compare the results of selected routing protocols with each other. Moreover, we computed the sum of output from each scenario to clearly present the difference in results. From results, we observe that A-STAR shows better performance in form of high throughput and low packet drop as compare to AODV and GPSR in city environment, while GPSR shows better performance as compare to AODV in both highway and city environment of VANET. Based on the results of performance metrics in different environments of VANET, we realized that position based routing method of VANET outperformed the traditional ad hoc topology based routing. However, it is hard to provide any universal routing protocol that can deal with all the various environments of VANET. The selection of a single routing protocol is hard in VANET because the protocol performance depends on vehicle speed, driving environment etc. That may vary from one environment of network to another.
Keywords: *VANET, Routing Protocols, MANET.*

1. INTRODUCTION

The increasing demand of wireless communication and the needs of new wireless devices have tend to research on self organizing, self healing networks without the interference of centralized or pre-established infrastructure/authority. The networks with the absence of any centralized or pre-established infrastructure are called Ad hoc networks. Ad hoc Networks are collection of self-governing mobile nodes [13]. Vehicular Ad hoc Networks (VANET) is the subclass of Mobile Ad Hoc Networks (MANETs). VANET is one of the influencing areas for the improvement of Intelligent Transportation System (ITS) in order to provide safety and comfort to the road users. VANET assists vehicle drivers to communicate and to coordinate among themselves in order to avoid any critical situation through Vehicle to Vehicle communication e.g. road side accidents, traffic jams, speed control, free passage of emergency vehicles and unseen obstacles etc.

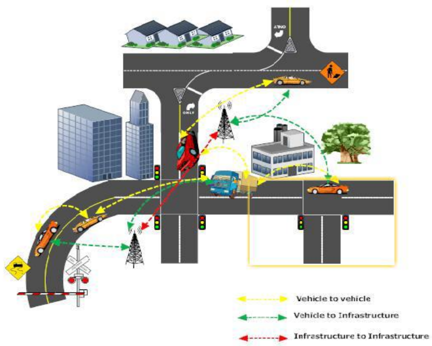

Figure 1: Vehicular Ad Hoc Network overview

Besides safety applications VANET also provide comfort applications to the road users. For example, weather information, mobile e-commerce, internet access and other multimedia applications [2]. The most well known applications include, "Advance Driver Assistance Systems (ADASE2), Crash Avoidance Matrices Partnership (CAMP), CARTALK2000 and Fleet Net" that were developed under collaboration of various governments and major car manufacturers [2]. Figure 1 shows the overall working structure of VANET.

2. Overview

Several routing protocols have been defined by many researchers for VANET. With the passage of time there is a need of having new protocols in order to have successful communication. The history of VANET routing begins with the traditional MANET routing protocols. Several "topology" based routing protocols for MANET had been analyzed for VANET. Jerome Haerri et.al [4] evaluated the performance of AODV and OLSR for VANET in city environment, in their study all the characteristics are handled through the Vehicle Mobility Model. Their study showed that OLSR has better performance than AODV in the VANET, as the performance parameters that they used have less overhead on the network as compared to OLSR. Performance analyses of traditional ad-hoc routing protocols like AODV, DSDV and DSR for the highway scenarios have been presented in [3], and the authors proposed that these routing protocols are not suitable for VANET.

Their simulation results showed that these conventional routing protocols of MANET increase the routing load on network, and decrease the packet delivery ratio and end to end delay. Kakkasageri et .al [1] compared AODV and DSR with Swarm intelligence routing algorithm and have shown that AODV and DSR has less performance than swarm intelligence routing algorithm in VANET. O. Abedi et.al enhanced traditional MANET routing protocol AODV to improve route stability and less overhead of network and makes it suitable for VANET, they named it as PAODV and DAODV [5, 6]. Their study showed that more appropriate routes can be found with and without mobility prediction. In their study, they selected fewer routes to overcome routing overhead on network and this effect overcomes the link breakage as compared to AODV. Besides conventional ad hoc routing protocols, several position based routing protocols have been proposed. The comparison between topology based and position based routing had been carried out in [7, 8] and study showed that position based routing is more suitable than topology based routing in highly mobile environment like VANET. As delivery ratio of position based routing protocol is higher than topology based routing protocol. Genping Liu et.al [9] proposed a new position based routing protocol Anchor based Street and Traffic Aware Routing (A-STAR). A-STAR was evaluated in city environment and it used road maps to calculate the number of nodes by which packet successfully reach to its destination. It showed that delivery ratio is more successful and it also decreased end to end delay.

Moreover, some position based routing protocols had been proposed that need geographic information for the selection of nodes. Karp and Kung [10] proposed a position based routing protocol i.e. greedy perimeter stateless routing (GPSR) that uses geographic information of the nodes which are close to destination in order to forward data packets and make communication successful. But this routing algorithm has some problems when it was evaluated for large city environments because it uses direct communication and with the existence of obstacles (building) in the city environments may interrupt the communication. To overcome these problems several other protocols have been defined in [11, 12]. The proposed protocols in [11] used topology information with the position based routing to deliver data from source to destination. Our research in VANET not only focused on single routing issue. We focused on traditional MANET routing protocols applicability to most recently proposed position based VANET routing protocols. We then compared their performance in order to be able to suggest which routing protocol has better performance in highway and city scenarios in VANET.

3 Problem Statement

Previous studies on VANET routing focused more on single ad hoc routing method (e.g. most researchers focused on traditional ad hoc topology based routing, while some other focused on position based ad hoc routing method in VANET). The selection of routing method heavily depends on the nature of the network. Thus single ad hoc routing method is not sufficient enough in meeting all the different types of ad hoc networks. In this study we focus on different ad hoc routing methods and figure out which recent advancement had been made to provide "in time" and scalable routing in order to avoid any critical situation on roads.

Furthermore, most researchers focused on single environment of VANET i.e. either on highway or in city to evaluate the performance of different routing protocols. Therefore in our study we focus on both environments i.e. city and highway for the performance evaluation of different routing protocols. Moreover, the performance of different routing protocols had not been well measured since each researcher used different simulator and performance metrics for performance evaluation. Due to aforementioned problems there is continuous need to study various ad hoc routing methods in order to select appropriate method for different environments of VANET.

4. Aims and objectives

Aim of our study is to identify which ad hoc routing method has better performance in VANET. The main purpose this study different routing methods of ad networks which is applicable in VANET and to find protocols that more suitable in various scenarios (City & Highway). We will use these parameters i.e. throughput and packet drop for comparison with already implemented protocol in VANET. On the basis of comparison we will be able to suggest which routing protocol is suitable for which scenario of VANET. To achieve this aim we have set the following objectives:

- Finding problems with various proposed routing techniques for VANET.
- Comparing performance results of the suggested protocols with the traditional MANET routing protocols.

5. Paper Organization

Chapter 2 highlights the issues of recently proposed position based routing protocols in VANET and it also provides with the details of available approaches which can be use to overcome these issues. In chapter 3, we present empirical work of our study and in addition it also discusses about the simulation and modeling in accordance with our study. In Chapter 4, we compare and evaluate selected traditional ad hoc routing protocols with position based routing protocols of VANET through simulation. Finally, provide the conclusion of our study.

6. VANET ROUTING PROTOCOLS

6.1 Position Based Routing

The dynamic and highly mobile nature of VANET, where nodes behave very rapid and changes its location frequently demands such routing method that can deal with the environment of such network. These demands tend the researchers to use positions of nodes in order to provide successful communication from source to destination. Such method in which geographical positions of nodes are used to perform data routing from source to destination is called position based routing. Position based routing assumes that each node have knowledge about its physical/ geographic position by GPS or by some other position determining services. In it each node also has the knowledge of source, destination and other neighboring nodes. As compared to topology based routing, position based routing uses the additional information of each participating node to applicable in VANET, that additional information is gathered through GPS. Position based routing provides hop-by-hop communication to vehicular networks. A position based routing protocol consists of many major components such as "*beaconing*", "*location service and servers*" and *"recovery and forwarding strategies"* [15, 14].

6.2 Greedy Perimeter Stateless Routing-GPSR

Greedy Perimeter Stateless Routing (GPSR) [10] is one of the best examples of position based routing. GPSR uses closest neighbor's information of destination in order to forward packet. This method is also known as greedy forwarding. In GPSR each node has knowledge of its current physical position and also the neighboring nodes. The knowledge about node positions provides better routing and also provides knowledge about the destination. On the other hand neighboring nodes also assists to make forwarding decisions more correctly without the interference of topology information. All information about nodes position gathered through GPS devices. GPSR protocol normally devised in to two groups:

- Greedy forwarding: This is used to send data to the closest nodes to destination [10].
- Perimeter forwarding: This is used to such regions where there is no closer node to destination [10].

When two or more edges cross each other in a single graph is called planar graph. "*Relative Neighborhood Graph (RNG)"* and "*Gabriel Graph (GG)"* [10] are two types of planar graphs used to remove the crossing edges. Relative neighborhood graph (RNG) is defined as, when two edges intersect with radio range of each other and share the same area. For example, x and y are the two edges that share the area of two vertices x and y. The edge x, y are removed by using RNG because another edge from x towards v is already available.

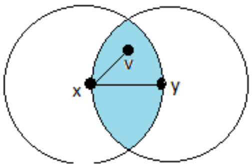

Figure 2: Example of RNG [10]

Gabriel Graph (GG) is used to remove only those crossing edges which are in between the shared area of two nodes having the same diameter as the other nodes have. Figure 3 depicts GG:

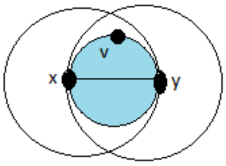

Figure 3: Example of GG [10]

Figure 3 shows that the midpoint diameter is less than the diameter of node x or node y. Thus the edge from the x, y cannot be removed. So there is less network disconnection in the GG as compared to RNG.

6.2.1 Features of GPSR

GPSR combines the greedy forwarding with the perimeter forwarding to provide better routing decision on both full and planarized network graph by maintaining neighbor's information in the location table. For the forwarding decisions in perimeter mode GPSR packet header include the following distinct characteristics [10].

1. GPSR packet header has the flag identity that is used to identify whether packet is in greedy forwarding or in perimeter forwarding.
2. It contains destination node physical address.
3. GPSR packet header also contains location of packet in the perimeter mode and the location of the new face to take a decision whether to hold the packet in the perimeter mode or to return it to the greedy mode.
4. GPSR also have the record of sender and receivers address of the packet when the edge's crosses in the new face.

GPSR also have several distinct characteristics that are if the packet is in perimeter mode then its location address is compared to forwarded node address and if distance to location and destination node is less then packet it switched to greedy mode to forward packet towards destination. GPSR discard those packets that are repeatedly forwarded as destination for such packets are not in range. The packets in perimeter mode never send twice through the same link if destination is in range. Overall GPSR is an efficient example of the position based routing that uses the geographic location of nodes and reduced usage of routing state on each node. Furthermore, it provides maximum robustness in highly dynamic wireless ad hoc networks.

6.3 Geographic Source Routing- GSR

6.3.1 Introduction

Due to deficiencies of GPSR in presence of radio obstacles, network demanded new routing strategies that can compete with challenges occurred due to radio obstacles. Therefore, Geographic Source Routing (GSR) is proposed [11]. It deals with high mobility of nodes on one hand, on the other hand it uses roads layout to discover routes. GSR finds the destination node using "*Reactive Location Service (RLS)".* GSR combines both geographic routing and road topology knowledge to ensure promising routing in the presence of radio obstacles [11].

6.3.2 Working of GSR

GSR routing was proposed to deal with challenges faced by GPSR in city environment. There are two main issues in the city environment, one is dealing with high mobility issue in the city and other is topology structure of a city [11]. In GSR position based routing is used that support the city map also. Vehicles have navigation system installed so getting map of city is normal. GSR use reactive location service to find the physical location for node.

RLS is used for position discovery in reactive position-based routing. In RLS a source node broadcast "*position request*" with some identification for the required node. When the node with that identification receives the position request, it responds with "*position reply*" containing its current physical position [11].

The sender node reaches the destination by using the road topology map and the above information. In other words in GSR the source node finds the shortest path to destination on the graph using simple graph algorithms [16] and mark the packet with destination´s location. In this the packet travels through junctions to reach the destination.

6.3.3.1 Local recovery

GSR use "*switch back to greedy*" method for local recovery. After a packet reach to its local maximum, it switch back to greedy forwarding [18].

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

6.4.1 Introduction

Anchor-based Street and Traffic Aware Routing (A-STAR) is position based routing protocol. The development of A-STAR was inconsideration with city environment. In city area, almost all roads and streets are covered by big buildings and there are close ends in the streets and so frequent stop signal, turns and speed breakers make routing more challenging. Problems faced by the position based routing protocols in city environment defined before in GSR. The capability of A-STAR protocol to overcome these problems will be defined here. A-STAR is anchor based routing protocol. In anchor based routing before transmitting the packet, source node address add in the header of packet and information of all intermediate node junction that packet must travel to reach the destination [16]. To use city maps and road information of town to make routing decisions called "*Spatial Aware Routing*". Spatial awareness is used to get topology information and different nodes position in the network. Mostly anchor based routing and spatial aware routing used together [16].

6.4.2 Working of A-STAR

Same like GSR, A-STAR was proposed for city environment. Both GSR and A-STAR compute the number of junctions to reach the destination but A-STAR also use traffic information and street awareness in path finding [17]. In street awareness, A-STAR gets the anchor information according to the street map. A-STAR has two new features that make it differ from GSR in working. A-STAR uses statically and dynamically rated maps to find the number of junctions. In statistically rated maps, A-STAR uses schedule of buses to ensure the high connectivity e.g. some streets are served by regular city buses their connectivity can be high due to presence of city buses. In dynamically rated maps, A-STAR collect the latest information of traffic to find the anchors/junctions to compute the path e.g. some roads are wider than other so there are more traffic. It means that connectivity is high on wider roads with high traffic (more vehicles). Using this traffic information A-Star assign the weight to the street [17] e.g. more vehicles less weight and less vehicles more weight. This dynamic process helps this protocol to calculate anchors more accurately [16].

6.5 Summary

In this chapter we discussed various routing approaches used in VANET and what are the different routing issues in different position based routing protocols. VANET suffers from several internal and external factors of its dynamic nature. Internal factors include dynamic and highly movement of mobile nodes, frequent changes in network topology etc. External factors include impact of outside environment on network such as roads layout in city and interference of obstacles such as building, railway crossing etc. To overcome these internal and external issues several routing approaches have been proposed.

Position based routing uses the physical position/location of nodes (vehicles) to make routing decisions in VANET. Position based routing assumes that each node in network is aware of its physical location with help of GPS. Thus position based routing contain many different protocols in order to provide successful communication in a highly dynamic network.

Though position based routing considered to be efficient routing method for VANET but it still have some issues regarding its routing protocols. Greedy perimeter Stateless Routing (GPSR) [10] is one of the best examples of position based routing. GPSR uses two routing methods that are greedy forwarding and perimeter forwarding. Greedy forwarding uses knowledge of the closest nodes to destination in order to send the packets to destination. One of the important advantages of greedy forwarding is that it contains knowledge of source, destination and the greedy region closer to destination. To cope this drawback perimeter forwarding is used. Perimeter forwarding used right hand rule that uses the counterclockwise traversing mechanism to reach at a specific destination. Perimeter forwarding considers to be well known recovery strategy of GPSR where interference of obstacles are less such as highway but this forwarding method suffers with several problems such as network disconnection, multiple hops, routing loops and selection of invalid route in city environment. So, there is a need of such routing protocol that can use position information of the nodes with topological information of roads layout to provide successful routing in city environment.

Geographic Source Routing (GSR) [11] is another example of position based routing that uses position information of existing nodes and combines it with the topological information of roads. The need for GSR arises with the problems in GPSR. GSR gathers physical position by means of Reactive location services (RLS). The gathered information through RLS combined with geographic maps of streets layoutin order to find the destination. The originator calculates total number of junctions to reach at destination and using the shortest path algorithm to reach at specific destination.

Anchor based street and traffic aware routing (A-STAR) [9], is another protocol which is used to overcome the challenges that occurs due to GPSR and GSR in city environments. A-STAR is most recent example of position based routing to make routing scalable in the city environments. A-STAR works similar as GSR, A-STAR originator include the information of all the intermediate junctions in the header of packet in order to locate destination. A-STAR also combines position information of the node with the topological information of streets maps in order to provide successful communication, but it computes topological information with the actual traffic awareness.

In this chapter we found the working of different position based routing protocols for VANET and what are the issues in these routing protocols. In addition to this, recent advancement to overcome these routing issues has also kept inconsideration. Further we will investigate how these position based routing methods suitable for VANET through empirical work.

7. RESULTS AND ANALYSIS

In this chapter we discuss simulation results and analyze them. Many situations can be considered and many possibilities can be simulated in order to perform VANET simulation. In our study we want to check the performance of different routing protocols in different network environments of VANET. For this purpose we built two different network scenarios and named them as highway and city.

We selected AODV and GPSR routing protocols to evaluate their performance in the highway scenario of VANET in terms of different performance metrics i.e. throughput and packet drop. For city scenario we selected A-STAR, GPSR and AODV routing protocols and analyze how these routing protocols provide reliable communication in the presence of different obstacles. The reason to selecting A-STAR for city environments is that it uses nodes position information and street information in order to make routing decisions. From literature findings, we realized that A-STAR efficiently discovers routes in the presence of radio obstacles. To validate the literature findings, we selected A-STAR for city scenario in order to check its performance against other position based routing protocol and topology based routing protocol of MANET.

7.1 Highway Scenario

In this scenario each simulation was performed for 400 s. 20 nodes (vehicles) were selected as the participants of network and each node movement was highly mobile. Each node equipped with 802.11b wireless module for communication with other nodes. Nodes move with speed of 20 m/s i.e. 72 km/h and 30 m/s i.e. 108 km/h. In this simulation AODV and GPSR routing protocols were selected for simulation and their performance will be checked in terms of throughput and packet drop. Results of each performance metric are shown in figure 6-9 below. Each input parameter for the simulation of this scenario is as follows:

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Table 1: Input Parameters for Highway scenario

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

7.1.1 Throughput

Throughput is described as the total number of received packets at destination out of total transmitted packets [1]. Throughput is calculated in bytes/sec. The simulation result for throughput of AODV and GPSR shows total received packets at destination in KB/sec, mathematically throughput is shown as:

Throughput (bytes/sec) = (Total number of received packets at destination* packet size)/Total simulation time.

If network throughput is high it means most of the sent packets to destination has been received, thus this factor reduce delay as packet receive success rate is high.

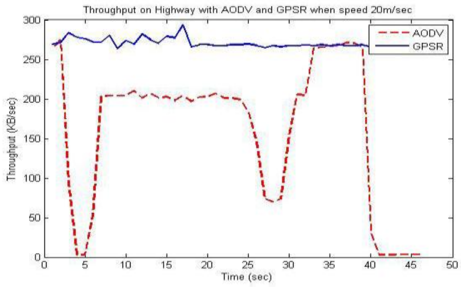

Figure 6: Throughput with 20 m/s node speed

Figure 6 depicts the network throughput of AODV and GPSR routing protocols with the node speed of 20m/s i.e. 72km/h on highway. In this case we can see that AODV throughput rate starts with the approximately 270 Kbytes/ sec and within matter of seconds the throughput rate fall to the lowest level i.e. approximately 5 KB/ sec. As compared to AODV, GPSR shows higher throughput rate in entire simulation time. GPSR throughput rate in the highly mobile environment of VANET is constant. GPSR in this case uses the closer destination nodes position information to successfully deliver packet that's why GPSR out performs AODV in terms of throughput in the highly mobile network as the maximum number of sent packets are received by destination. So overall in this scenario GPSR performs well as compared to AODV.

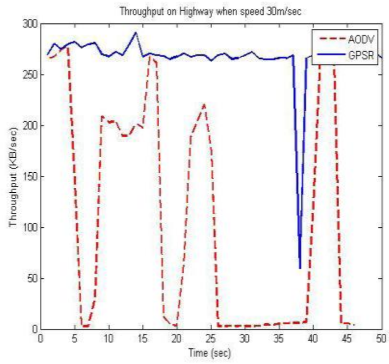

Figure 7: Throughput with 30 m/s node speed

Figure 7 depicts performance of AODV and GPSR routing protocols with nodes speed 30 m/s i.e. 108 km/h. AODV throughput rate dramatically decrease from 275 KB/ sec to the almost 0 KB/sec.

7.1.2 Packets Drop

Packet drop shows the total number of data packets that are not sent to destination successfully. Packet drop affects the network performance by consuming time and more bandwidth to resend a packet. The protocol performance considered to be efficient if packet drop rate is lower.

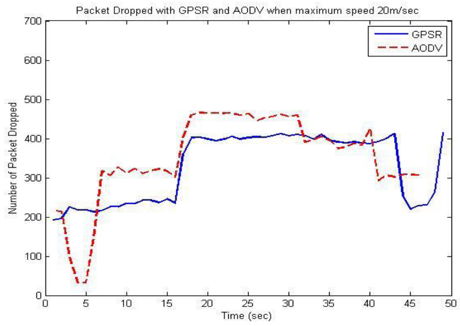

Figure 8: Packet Drop at 20 m/s node speed

Figure 8 shows behavior of AODV and GPSR in terms of packet drop at maximum node speed of 20 m/s. For AODV routing protocol the packet drop rate for first 5 seconds reduced from approx 225 to 30 packets. On the other hand the packet drop ratio of GPSR from figure 8 starts from 200 packets drop and this ratio gradually increases with the time but Figure 8 shows that at 15 seconds there is a sudden increment in the packet drop ratio and it reached at 400 packets drop but this ratio remained constant for the rest of time and decrease at 40 seconds to again the level where it was before. The sudden changes in the packet drop ratio in GPSR may be due to the longer beaconing interval.

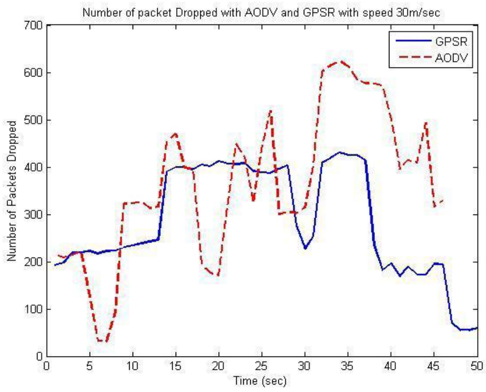

Figure 9: Packet Drop at 30 m/s node speed

Figure 9 shows the behavior of AODV and GPSR in terms of drop packets in the presence of high nodes speed that is 30m/s. At start AODV performs better that the number of dropped packets decreases to the lowest level but after one second there is gradual increment in the number of dropped packets. In the presence of node"s speed of 30 m/s there is no significant change in the drop packets rate of GPSR at the initial time interval. From figure 9 it can be seen that the reduction in GPSR drop packets at 40 seconds and it gradually decreased.

7.2 City/ Urban Scenarios

The main aim to design this network is to check how different routing protocols suffered from the radio obstacles and which routing protocol has better scalability in city roads.

Each input parameter for city scenario is shown in the following table:

Table 2: Input Parameters for City Scenario

Parameter	**Setting**
Environment Size	2000 meters
Total number of nodes	30
Number of Radio Obstacles	10
Node Type	Highly Mobile nodes (Vehicles)
Node Speed	8 m/s
Packet Type	UDP
Packet Size	1400 Bytes
Simulation Time	400 seconds
Number of Receiver	One

7.2.1 Throughput

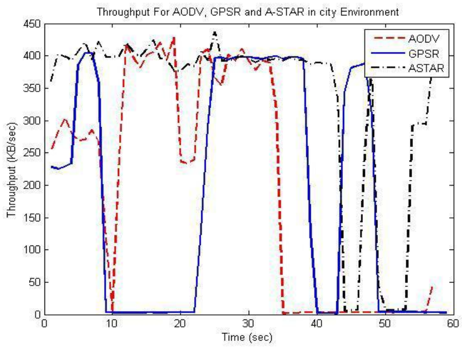

Figure 10: Throughput in city scenario

On the other hand GPSR shows the average throughput results in the city scenario. There were also some dramatically changes in the performance of GPSR shown in Figure 10. Although GPSR is a position based routing protocol but its performance was average and at some level throughput rate reduced to zero. A-STAR outperformed AODV and GPSR in terms of throughput in the presences of radio obstacles in the large city environments. As shown in Figure 13 A-STAR has better performance. Only the short changes occurred in the performance of A-STAR for the initial 45 seconds. Then sudden decrease in the performance of A-STAR for a couple of seconds may due to the route selection at that time was not optimal. On the whole it can be concluded that A-STAR has better performance in terms of throughput as compared to GPSR and AODV where there is number of obstacles interrupt the communication. Furthermore, GPSR outperformed AODV in terms of throughput.

7.2.2 Packet Drop

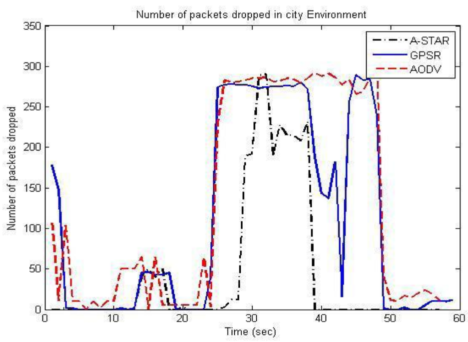

Figure 11: Packet Drop in city scenario

The above figure shows the average number of dropped packets by AODV, GPSR and A-STAR routing protocols in the presence of obstacles. Figure 11 shows instability in the performance of all three routing protocols in terms of packets drop. AODV packet drop rate was high than GPSR and A-STAR. While AODV showed unexpected results in the large city environments by dropping less number of packets for the first 20 seconds. As distance between the nodes with in the city environments are less and also the vehicles moved with low speed that is why AODV successful to deliver some packets to the destination as it received RREP from the closed nodes immediately.

A-STAR has less number of drop packets at the start but there was sudden change in its performance and number of drop packets increased. Sudden increment in drop packet rate may be due to the packet traverse to such anchor path that is temporarily marked as “out of service” by A-STAR. But suddenly the number of drop packets rate reduced and reach at the same level as it was before due to the local recovery strategy of A-STAR, as it rerouted the packets towards destination instead of drop them. Furthermore, GPSR and AODV showed slight difference in terms of drop packets in the presence of obstacles.

7.3 Summary of the results

We selected throughput and packet drop performance metrics for the evaluation of routing protocols. To check the performance of routing protocols in VANET we designed two different networks and named them as highway and city.For the highway scenario we have selected AODV and GPSR and evaluate them in the presence of low and high node‟s speed on highways. While in city scenario we selected AODV, GPSR and A-STAR routing protocols to check their performance in the large city environment in the presence of radio obstacles. The results of various routing protocols for both highway and city scenarios in VANET in terms of throughput and drop packets has shown in the tabulated form below.

Table 3: Highway scenario results with node's speed 20 m/s

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

Table 4: Highway scenario Results with node's speed 30 m/s

Routing Protocol	Throughput (KB/ sec)	Packet Drop
AODV	5043	16712
GPSR	12209	13877

The above results shows that GPSR out performs AODV in both scenarios of highway in terms of throughput. There was no significant effect in the throughput rate of GPSR with the increment in nodes speed. While drop packet rate of GPSR became lower with the increment in nodes speed. However, a little increment in drop packets of AODV with node’s high speed From results we also realized that AODV performance suffers with nodes speed which reduced its throughput rate. Furthermore, increment in speed reduces the drop packet rate of GPSR.

Table 5: City scenario Results

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

As compared to highway scenarios the node's speed was very low in city scenario. That's why all three protocols perform well in this scenario. Table 5 results shows that A-STAR completely outperformed AODV and GPSR in terms of throughput and drop packets. While GPSR also had better throughput rate than AODV. We realized that throughput rate of A-STAR was higher than AODV and GPSR. However, slight difference in the performance of AODV and GPSR in terms of drop packet. From above results we realized that A-STAR provides scalable results in city environments of VANET. We also realized that there was slight difference in performance of GPSR and AODV in terms of drop packets. However, GPSR provides higher throughput than AODV in the presence of radio obstacle.

Conclusion

The main goal of this thesis is to identify different issues in ad hoc routing protocols and to evaluate these routing protocols against each other in VANET. In this study we focused from traditional ad hoc routing protocols to recently proposed position based routing protocols. We have examined how different routing protocol suffers from the highly mobile nature of VANET.

In this study, by literature surveying we found reactive routing protocols of traditional ad hoc networks are applicable for VANET. From the results of our study we realized that the traditional ad hoc reactive routing protocols have unstable performance in VANET. We examined reactive ad hoc routing protocol AODV against position based routing protocols i.e. GPSR and A-STAR and found that the performance of AODV suffers from the high speed of nodes, radio obstacles and sudden change in position of nodes in VANET. So high speed of nodes and involvement of radio obstacles are major challenges for traditional ad hoc routing protocols that makes them unsuitable for VANET.

We found that position based routing protocols shows better results than traditional ad hoc routing protocols in VANET. We evaluated two position based routing protocols that are GPSR and A-STAR in two different scenarios of VANET. GPSR outperforms AODV completely in both highway and city environments of VANET. While GPSR affected with the involvement of obstacles in the large city environments. On the other hand A-STAR outperforms both GPSR and AODV in city environments of VANET. As A-STAR uses the anchored based street information to find the routes in large city environments, therefore it is not an alternative for highway scenarios. So we realized that A-STAR is scalable for such environments of VANET where numbers of nodes are higher and radio obstacles involved, while GPSR is reliable for direct communication among nodes. Furthermore, all position based routing protocols cannot deal with all various environments of VANET.

From the conducted study, we suggest that position based routing protocols are more promising than traditional ad hoc routing protocols for VANET. Although position based routing is scalable for VANET but it is hard to suggest any single routing protocol that can deal with different scenarios of VANET. The selection of a single routing protocol is hard in VANET because the protocol performance depends on vehicle speed, driving environment etc that may vary from one environment of network to another.

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