Analysis of GPS and Zone Based Vehicular Routing on Urban City Roads

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Abstract: *The speedy movement of vehicles in urban city roads results in numerous changes of vehicles' position and speed. This behavior leads to many wrong packet forward decisions for vehicles in Vehicular Ad Hoc Network (VANETs), which has emerged as a novel class of Mobile Ad Hoc Networks (MANETs). Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I) communications have been involving an extensive interest in providing Intelligent Transportation Systems (ITS). This paper presents the routing behaviors of GPS-based and zone-based vehicular routings for V2V communication in Urban City Roads. Vehicular routing protocols are simulated in three different simulators (i.e., SUMO (Simulation of Urban Mobility), MOVE (MObility model generator for VEhicular network) and NS2(Network Simulator 2)) to generate road traffic, urban simulation scenario and examine the performance of protocols, such as throughput, delay and overhead. According to the simulation results, GPSR gives better results than ZRP and is a good choice to optimize for the vehicular ad hoc network.*

Keywords: *GPSR, MOVE, SUMO, VANET, SUMO,ZRP*

1. Introduction

Nowadays ad hoc wireless networking is the most significant development in wireless networking and communications. But from last few years, automobile industries utilized ad hoc network in vehicles, so called VANET. Vehicle communication is emerging as the popular communication to provide the safety and comfortableness for vehicles. In VANET, each vehicle is regarded as not only a node but also a router to exchange data in the network. The two major types of VANET are vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communications. Basically automobile industries use V2V rather than V2I.

The main goal of VANET is to provide safety and comfort for passengers and to help drivers on the roads by anticipating hazardous. Collision warning, Road signal arms and in place traffic view will give the drivers as the essential information to decide the best path along the way events or bad traffic areas using VANET.

In spite of VANET being one of the types of MANETs, many routing protocols in MANETs are not appropriate for VANETs. The communications of the vehicles in VANET generate packet loss, frequent topology changes, and network fragmentation. Thus, a big effort is improved to offer and design improved medium access control access strategies and routing protocols according to the characteristics of VANET. In turn, routing is a challenging task since there is no consideration in charge of finding the routing paths among the nodes and consuming energy. The maximum throughput, the routing overhead and average end-to-end dealy have become the major needs for the routing protocols to provide quickly the alerting information with no data loss for emergency cases. From the above mentioned characteristics, the researchers target the missions to analyze them to use in the specific VANET needs of scenarios and applications.

In VANETs, power consumption and storage capacity are not limited, whereas the coverage area in Wi-Fi is limited. The position of nodes can usually be determined by using GPS. So GPS and zone based routing protocols are very popular in VANET. Among these protocols, Greedy Perimeter Stateless Routing (GPSR) and Zone-based Routing Protocol (ZRP) are popular in VANET. However, they still have some challenging factors for VANET. This paper analyses the performance of these protocols in VANET scenario and discusses which one performs better, as well as gives considerations to improve the protocol in VANET scenarios.

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2. Categories of Routing Protocols in VANET

Generally, there are six categories of routing protocols in VANET as shown in Fig. 1.

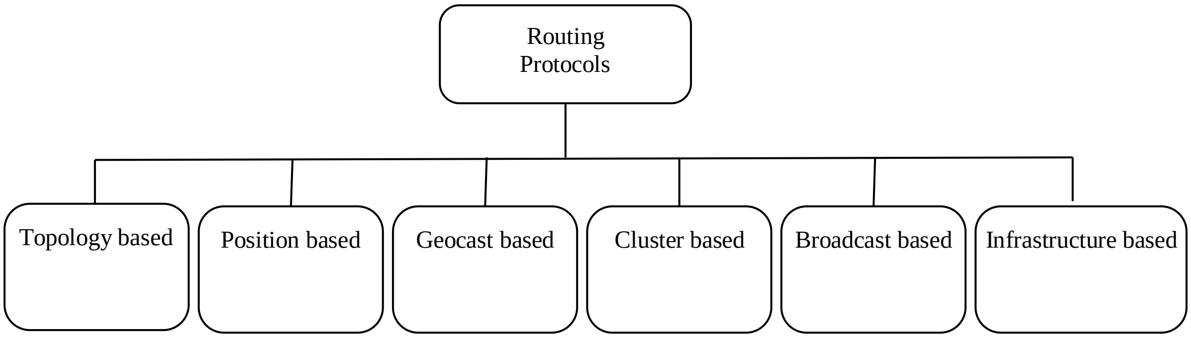


Fig. 1: Categories of Routing Protocols in VANET

- *Topology based Protocols:* These protocols discover the routes and maintain them in a table before the sender begins transmitting data. They are further divided into reactive, proactive and hybrid protocols [1].
  - *Reactive protocols.* These protocols are called as on-demand routing protocols as they periodically update the routing table, only when there is some data to send. But these protocols suffer from the initial route discovery process, which makes them unsuitable for safety applications in VANET.
  - *Proactive protocols.* The proactive protocols are also known as table driven routing protocols. These protocols work by periodically exchanging the knowledge of topology among all nodes of the network.
  - *Hybrid protocols.* The hybrid protocols are introduced to reduce the control overhead of proactive routing protocols and decrease the initial route discovery delay in reactive routing protocols.
    - *Zone based Protocols.* These protocols allow a larger area to divide the small particular zones. Efficient zone gives the better performance and so dividing zone is a major function in these protocols to provide the maximum throughput.
- *Position based protocols:* These protocols use geographic positioning information to select the next forwarding hops so no global route between source and destination needs to be created and maintained. They are also called geographic-based protocols. In this class, each vehicle has the mean to know its geographical position (as GNSS - Global Navigation Satellite System) [2, 3].
  - *GPS based Protocols:* These protocols depend mainly on the position information of the destination which is known either through GPS system or through periodic beacon messages. The messages can be routed directly without knowing the topology of the network or prior route discovery according to their own position and destination position from GPS.
- *Geocast based protocols:* These protocols are used to send a message to all vehicles in a pre-defined geographical region. Geocast routing protocols follow the principle of routing data packets from a single source vehicle to all vehicles belonging to the destination area called zone of relevance ZOR [2].
- *Cluster based protocols:* In cluster based routing protocols vehicles near to each other form a cluster. Each cluster has one cluster-head, which is responsible for intra and inter-cluster management functions. In VANET due to high mobility dynamic cluster formation is a towering process [3].
- *Broadcast based protocols:* This class of routing protocols uses the simple flooding on the network in order to reach all vehicles. Different relay selection techniques are used to reduce the message overhead [4].
- *Infrastructure based protocols:* The following protocols are infrastructure based because the relay on fixed infrastructure for their routing. This class of routing protocols uses infrastructure nodes as relays, such as the use of Roadside Units (RSU) in junctions and along the roads to route packets to reachable vehicles in the transmission range [3].

3. Related Works

In [5], performance analysis are carried out on the simulation results of two location based routing protocols, ZRP and GPSR. All the simulations are performed over mobile ad hoc network. From the investigation, GPSR outperformed ZRP in terms of end-to-end delay, packet delivery fraction and routing overhead. The two protocols have similar high throughput in varying node density and traffic load. High node speeds in GPSR can break the links in the network. So the throughput of GPSR decreases when the speed of node increases. ZRP has high end-to-end delay and routing overhead whereas GPSR has low end-to-end delay and routing overhead. This is the main reason of performance degradation of the routing protocols in high end-to-end delay and routing overhead. From previous simulation, it has been observed that GPSR performs better than ZRP. This paper considered simulations for GPSR and ZRP only in MANET environments. There is no consideration of VANET environments.

In [6], performance comparisons of AODV and GPSR in VANET are presented. Packet loss is less in case of AODV, initially but it increases when the node density increases. On the other hand, the packet loss of GPSR is very high and it even outperforms the AODV in high node density. In case of delay of first data packet GPSR outperforms the AODV in both city and highway scenarios. The region for poor performance of AODV is the route discovery process precedes every data transmission to unknown destination. So it concluded that AODV is well suited in VANET where packet ratio is very important and vehicular density is low but not in application where quick response time is required and GPSR performed well in geographically sparse network having high vehicular density.

There are no literatures yet that consider the GPS-based and zone based protocols for VANET. Therefore this paper considers two location-based protocols using three simulators for V2V communication in VANET.

4. Comparison of GPS and Zone Based Routing Protocols

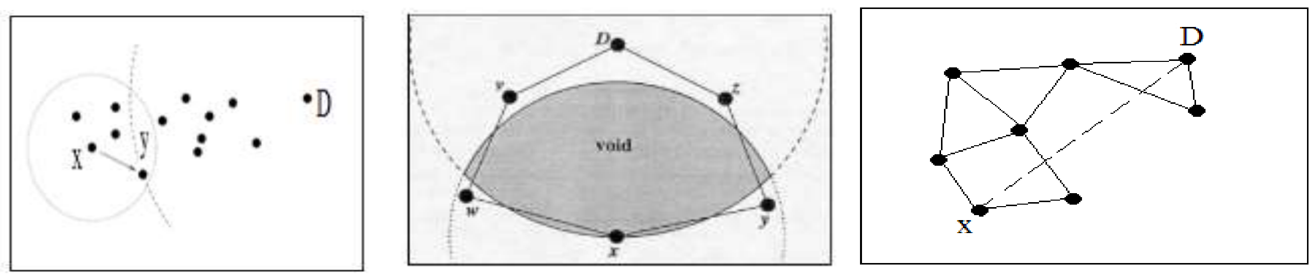
GPSR is the popular GPS based routing protocols and ZRP is also the distinct protocol in zone based protocols. General comparison of GPSR and ZRP are shown in Table 1.

TABLE I: General Comparison of GPS and Zone based Routing Protocols

VANET Routing Protocols	**GPS based Routing**	**Zone based Routing**
1.Methods Used	1.Beaconing 2.Vehicles position information 3.Global positioning service	Link's information stored in the routing table as a basis on forwarding a packet
2. Strengths	1.No need to create and maintain global routes 2.More stable in high mobility environment 3.More fitting for network distributed nodes 4.More scalable	1. The shortest route from source to destination 2.Less resource consumption 3.Save bandwidth
3. Limitations	1.Obstacles in highway scenario 2.Deadlock problem in location server 3.Position services may fail in tunnel or obstacles (missing satellite signal)	1.Routes discover and maintaining delays 2.Fail to discover a complete path (frequent network changes) 3.Unnecessary flooding
4. Comments	More suitable for VANETs; but need more researches for small networks and control congestion	These protocols generally are proposed for MANETs

4.1. Greedy Perimeter Stateless Routing

In GPSR, each node periodically broadcasts a beacon message to all its neighbors containing its id and position [3]. If any node does not receive any beacon message from a neighbor for a specific period of time, GPSR router assumes that the neighbor has failed or out of range, and deletes the neighbor from its table.



(a) (b) (c)

Fig. 2: (a) Greedy Forwarding (b) Node X's Void (Empty Intersection Of X's And D's Neighbors) with Respect to Destination D (C)Planarized Graph

It takes greedy forwarding decisions using information about immediate neighbors in the network. In Fig. 2(a), the point x is source node, the point D is destination node and the point y is chosen as forwarding node because it is not only in forwarding region but also the nearest node from D. For any node, if greedy forwarding as shown in Fig. 2(b) is impossible, then it uses perimeter of the region strategy to find the next forwarding hop. In a city scenario, greedy forwarding is often restricted because direct communications between nodes may not exist due to obstacles such as buildings and trees. Converting network topology into planarized graph in Fig. 2(c) when greedy forwarding is not possible will solve the problem that the greedy fails.

4.2. Zone Based Routing Protocol

ZRP is the first protocol developed as a hybrid routing protocol, it allows a network node to divide the network into zones according to many factors; like: power of transmission, signal strength, speed and many other factors.

The area inside the zone is the routing range area for the node and vice versa for outside zone. ZRP uses the reactive routing schemes for outside the zone and the proactive routing schemes for inside the zone; with a view to keep the latest route information within the inside zone. In the local inside the zone, the source node uses a proactive cached routing table to initiate a route to a destination, which can be helped in transmitting packets directly without delay. ZRP uses independent protocols inside and outside the zone; it may use any existing proactive and reactive routing protocols. For outside zone, the ZRP reactively discover a route; that the source node transmits a route request packet to the border nodes of its routing zone; and the packet includes a unique sequence number, the source address and the destination address. When a border node receives a route request packet, it looks for the destination within its inside zone. If the destination is found, it sends a route reply on reverse path to the source node.

Otherwise, the border node adds its address to the route request packet and forwards it to its own border nodes. After the source received a reply, it stores the path included in the route reply packet to use it for data transmission to the destination [1]. The weakness of ZRP protocol is that it performs like a pure proactive protocol particularly for large size zones; however for small zones it performs similar to a reactive protocol.

5. Simulation Parameters

In order to evaluate the performance of GPSR and ZRP protocol, firstly the map file as shown in Fig. 3(a) is generated using MOVE and SUMO. Fig. 3(b) shows the movement of vehicles in SUMO simulation. General parameters for simulation are described in Table 2. The simulations are done within 1100 m × 1100 m simulation area for about 100 seconds. The comparisons are made by the following outputs resulted from the simulation using GPSR and ZRP protocols such as throughput, packet delivery ratio, average end to end delay and routing overheads. The definitions of these outputs are

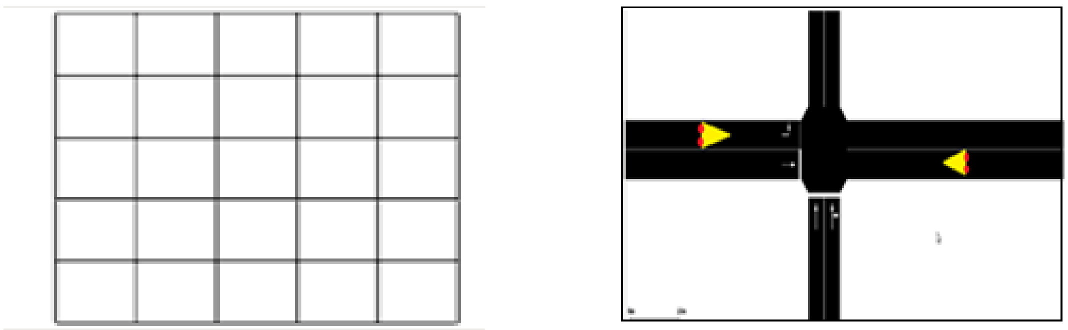
- Throughput: It is the number of useful bits per unit of time forwarded by the network from a certain vehicle to another certain vehicle.

$$Throughput=(total\_packets\_received)/(simulation\_time) \quad (1)$$

- Average end-to-end Delay: It is defined as the average time taken by the packet to reach the destination node from the source node.

$$Delay=(total\_packets\_sent)/(simulation\_time) \quad (2)$$

- Routing Overhead: Routing overhead means how many extra messages are used to achieve the acceptance rate of improvement.



(a) (b)

Fig. 3: (a) Sample Map for Simulation (b) Movements of Vehicles in SUMO Simulation

TABLE II: General Parameters for Simulation

Parameters	Value
Simulation area	1100m×1100m
Simulation time	100 s
Maximum number of packets	1000 packets
Packet size	512 bytes
No. of lanes	2
Number of vehicles' flow	2
Connections	10 cbr
No. of vehicles	30, 40, 60
No. of Traffic	4, 12, 30
Speed of Vehicles	10m/s, 30m/s, 50 m/s

6. Simulation Results

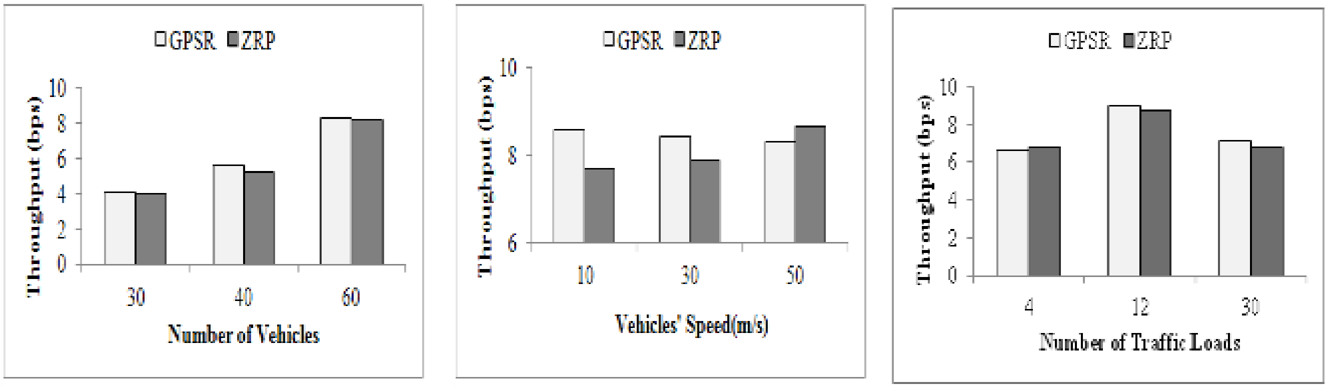
In comparison, each output is tested varying with number of vehicles, the speeds of vehicles and the number of traffics.

6.1. Throughput Test

In this division, throughput is compared with different numbers of vehicles as shown in Fig. 4(a). The throughput values of GPSR and ZRP increases while increasing the number of vehicles. GPSR produces the results slightly better than ZRP. It is observed that the performance of two protocols is not significantly different from each other when the number of vehicles increases.

Although the vehicles are tested with different speeds, the results of GPSR and ZRP only have little changes as shown in Fig. 4(b). On average, GPSR has a 4.2% only better than ZRP.

When the number of traffics in the same map is increased in Fig. 4(c), ZRP seems a little better for a small amount of traffic. However, as the number of traffic increases, GPSR performs better than ZRP.



(a) (b) (c)

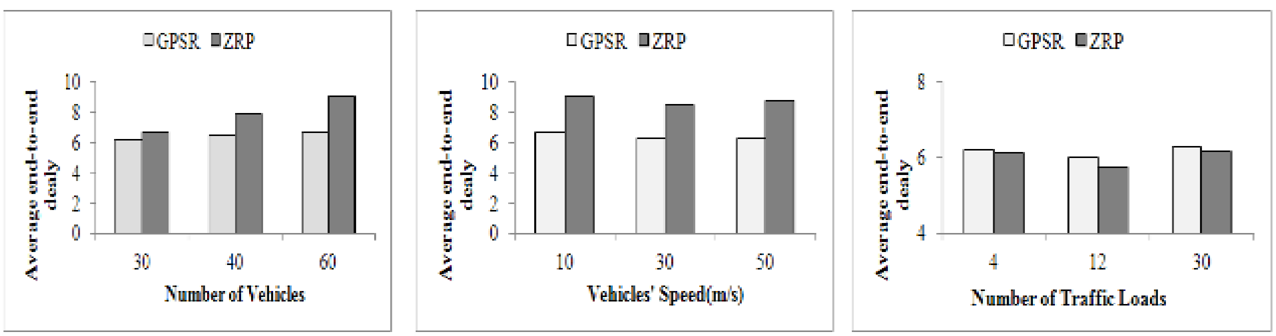
Fig. 4: (a) Throughput vs. Vehicle Test (b) Throughput vs. Speed Test (c) Throughput vs. Traffic Test

6.2. Average End-to-end Delay Test

In this division, average end to end delay is compared with different numbers of vehicles as shown in Fig. 5(a). It is found that GPSR outperforms ZRP in terms of average delay. As the number of vehicles increases the delay of ZRP also increases. This is because ZRP is hybrid protocol, allows dividing zones and thus establishing routes between intra and inter zones make the delay higher.

As shown in Fig.5(b), varying the speed of vehicles does not considerably impact on both protocols. The average delay of GPSR is approximately 27% lower than ZRP.

Fig. 5(c) shows average end-to-end delay by varying the number of traffic while keeping the number of vehicles sets to 40. Varying traffic loads does not significantly affect on both protocols.



(a) (b) (c)

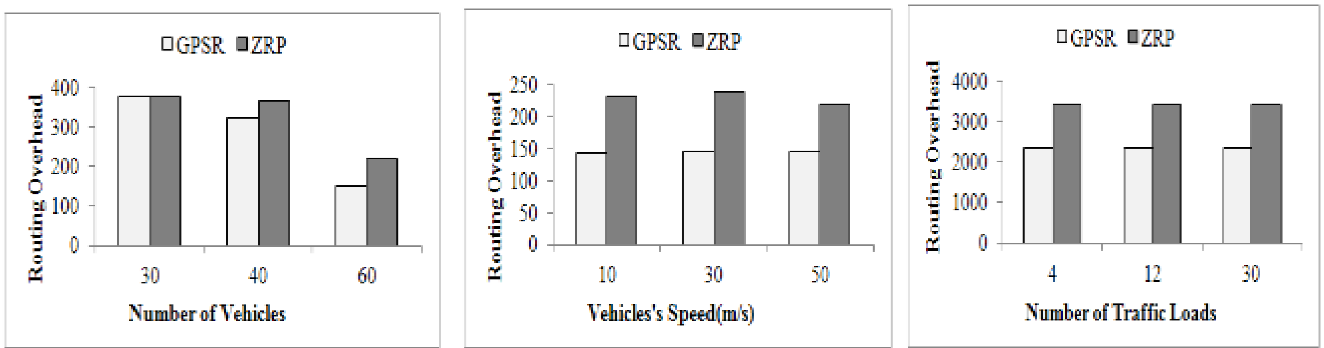
Fig. 5: (a) Average End-to-end Delay vs. Vehicle test (b) Average End-to-end Delay vs. Speed test (c) Average End-to-end Delay vs. Traffic test

6.3. Routing Overhead Test

In this division, routing overhead for GPSR and ZRP are compared with different numbers of vehicles as shown in Fig. 6(a). The more the number of vehicles increases, the lower the routing overhead decreases in both. But both protocols use the high routing overhead when the simulation uses the less number of vehicles. This is because the lacks of connections are encountered and so the higher routing overhead is needed to find the new routing paths. Otherwise large numbers of vehicles are continuously connected and so they save the routing overhead.

The non-effectiveness on routing overhead of varying the speed of vehicles for GPSR and ZRP protocols is presented in Fig. 6(b). It can be clearly seen that the routing overhead of GPSR is lower than ZRP. In practical, there could be different speeds between vehicles. However, in simulation, when all vehicles are set to the same speed, increasing the speed does not obviously rely on the performance of each protocol. On average, GPSR performs 37% better than ZRP.

In Fig. 6(c), none of GPSR and ZRP changes in routing overhead due to increase the number of traffic. Moreover, GPSR has low routing overhead than ZRP. As usual GPSR outperforms than ZRP. As a whole, both protocols do not significantly depend on the traffic load variation.



(a) (b) (c)

Fig. 6: (a) Routing Overheads vs. Vehicle Test (b) Routing Overheads Vs. Speed Test
(c) Routing Overheads vs. Traffic Test

7. Conclusion

In this paper, two protocols (GPSR and ZRP) are simulated for vehicular ad hoc networks. The purpose of this research is to know which protocol gives better results to be optimized for VANETs. Therefore, the performance results of both protocols are examined by varying the number of vehicles, the number of traffic loads, the number of vehicles' speeds in urban city. Simulation results show that the throughput performance of both protocols is not significantly different from each other. GPSR outperforms than ZRP in terms of average end-to-end delay and overhead while varying the number of vehicles and speeds. However, variations of traffic loads do not significantly impact on both protocols. As a whole, it can say that GPSR is a good choice to be optimized for vehicular ad hoc network.

8. References

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