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Reactive & Multipath Routing with Adaptive Urban Area Vehicular Traffic (AUAVT) in VANET Environment

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Abstract: VANET is a special instance of the wireless multi-hop system, which owing to the high vehicle mobility is restricted by rapid changes in the topology. In this work family of AUAVT proposed, road-based information routing protocols that performs well in urban areas as adhoc vehicle networks (VANET). AUAVT protocols take advantage of real time traffic generation and communication to construct internets of vehicle (IoV) network. In the proposed work adaptively reactive and multipath AUAVT routing protocol designed and implemented with comparative analysis done on the basis of QoS parameters which is compared with AODV and OLSR routing protocol using NS-2 simulator. Simulation indicates the proposed AUAVT-$_{Mulp}$, AUAVT-$_{Reac}$ routing protocol gives better performance by 6% and 28% respectively in terms of packet delivery ratio and average throughput with less routing overhead over AODV, OLSR routing protocol.

Keywords: *VANET, IoV, AUAVT, Reactive, Multipath and QoS.*

1. Introduction

Vehicular ad hoc network (VANET) is defined as a subset of mobile ad hoc networks (MANETs) with the distinguishing property where nodes are treated as vehicles running on traffic and road side infrastructure intended to offer a wide range of mobile vehicles which communicated to each other in terms of sharing information including traffic warning distribution and adaptive route planning between the large number of vehicles with various mobility known as Internet of vehicles (IoV). [1]

Prior research indicates that VANET-based routing techniques need to be improved over MANET [2,3,4,5] in terms of end-to-end multi-hop connections. The main obstacles are the packet delivery ratio, end-to-end latency, and throughput. Additionally, the high mobility of VANET causes frequent disconnections during vehicle communications as seen in Figure 1.

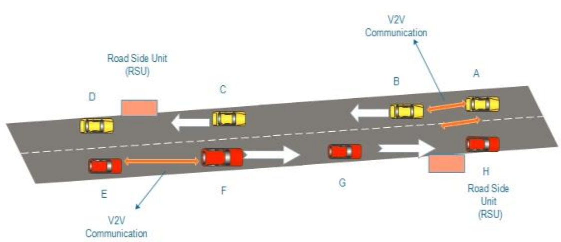

Fig 1. Communication between vehicles

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Geographic routing is better than node-centric routing because any node that shows progress toward the destination can be used to send information [6,7,8]. Geographical forwarding doesn't work well in city-based VANETs, even though there are more stable paths [9,10]. Many road-based routing protocols are implemented by shortest path algorithm, they are also suffered by empty roads, purpose of this work is IoV based routing in urban area scenarios that describes a type of VANET routing based on roads in which road junction sequences that are more likely to have network connectivity are created using real-time traffic statistics. By employing any vehicle on the road to transfer packets between two subsequent intersection locations, it also decreases the path's sensitivity to vehicle movements.

Adaptive Urban area vehicle traffic (AUAVT) routing has two primary favourable circumstances: (1) flexibility to network circumstances by combining real-time vehicle traffic information, and (2) path stability via traffic paths and geographic forwarding. A reactive routing procedure, AUAVT-$_{Reac}$, and a multipath routing protocol, AUAVT-$_{Mulp}$, are presented. AUAVT-$_{Reac}$ identifies paths on-demand and feeds those paths back to the source for inclusion in packet headers. AUAVT-$_{Mulp}$ creates regular frames through multipath of connections that traverse interconnected road segments and preserve the path which establish in a database. Routes to destinations are calculated using this multipath, which is disseminated to all vehicles in the network. Data transmission end-to-end time was lowered in our first NS-2 simulations utilizing an IEEE 802.11Ext VANET when the wireless channel was blocked due to the cost of the periodic "hello" messages needed to maintain the database of neighbors in geographical forwarding. A distributed, receiver-based next-hop selection scheme that takes two ray ground propagation into account is proposed as a way to decrease this outlay. A modest modification of IEEE 802.11's handshaking techniques applied.

2. Proposed Modeling

In order to generate road-based routes in urban area, the AUAVT routing protocols make use of real-time information about vehicular traffic flow. AUAVT routes can be built on-demand or in advance, depending on the situation. In this work two AUAVT protocols proposed, AUAVT-$_{Reac}$ and AUAVT-$_{Mulp}$, each demonstrating a different technique of path generation with IEEE 802.11Ext and Dedicated Short Range Communication (DSRC) is wireless interfaces used by vehicles to exchange packets. All of these things are assumed in the AUAVT protocols: a GPS receiver, digital maps and a navigation system that outlines GPS locations on roadways, and so on [11,12].

- AUAVT-$_{Reac}$: Adaptive Urban Area Vehicle Traffic Reactive Routing Algorithm

AUAVT-$_{Reac}$ is a reactive source routing system for VANETs that uses “connected” sections to generate road-based pathways known as on-demand routes. A linked road segment is one that connects two intersecting roads and has enough vehicle traffic to maintain communication [13,14,15,16]. These routes, which are represented various junctions, are recorded in the data packet headers and used by intermediary vehicles to forward packets through junctions geographically for communication between vehicles.

Route Identification: Figure 2 illustrates the route identification process when an information inventor vehicle wants to deliver information to a receiver vehicle. Information inventor vehicle sends route identification (R_I) packet with the information inventor's address and location, the receiver's address, and a sequence number in the header. In this work vehicles have their own addresses. The area around the information inventor is multicast with R_I in order to find a path to the receiver. Because AUAVT-$_{Reac}$ doesn't expect a service that can be used to find out where the receiver is, multicasting is needed. The multicasting domain is restricted by a TTL value provided in the header for scalability considerations.

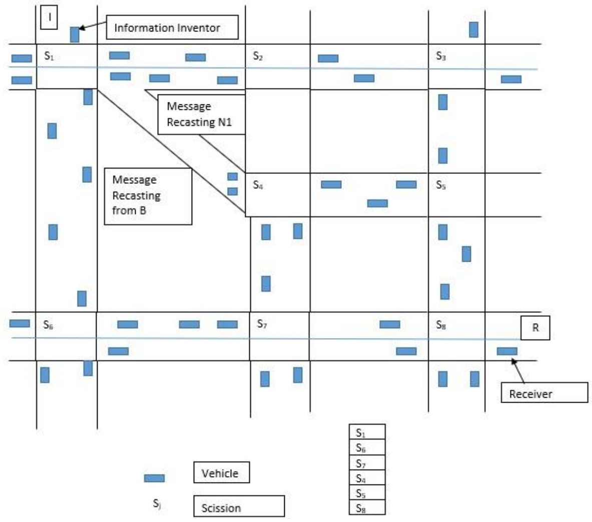

Fig 2. Communication between information inventor vehicle and receiver

AUAVT-$_{Reac}$ employs an enhanced multicast technique similar to mitigate the impacts of the broadcast storm issue [17]. Receiving the identical information inventor address and sequence number from another vehicle, which is then deleted by itself. Rather than being broadcast again right once, when a vehicle receives a new R_I, the data packet is held for a period of time equal to the distance between that vehicle and the information inventor vehicle. Once the waiting period has passed, a vehicle will only rebroadcast the information of R_I, the information for road segment discarded if it is not rebroadcast by vehicles.

In AUAVT-$_{Reac}$, the route is developed in stages, one after the other. A list of routes is first contained in the R_I packet. Vehicles that get the R_I packet for the first time verify that they are on a separate road segment/scission than the packet's sender. As a result, the receiving vehicle adds road junctions to the route list that the R_D packet "traversed" from the transmitter point. Figure 2 shows the process of creating routes. To find a route to receiver (R), Information Inventor vehicle (I) sends an R_I packet to the destination. Information Inventor vehicle (I), than broadcast its own location in the packet. In the enhanced flooding method, mediator vehicle receives the packet on segment/scission S1 - S6, but only one vehicle will rebroadcast it. S1 is added as a prefix to route before rebroadcasting. Other vehicle on the other hand, will not alter its route when it gets the R_I packet because it is positioned on the same road section as previous. At next vehicle, a new scission (S6) is added. TTL expires or the packet reaches its receiver.

Vehicles on multiple lane of road may receive the R_I packet. This can only happen if the packet's implicitly visited junction sequence can be determined prior to packet modification. It's possible that certain vehicles won't be able to update their R_I packets in the IoV network. For this reason, IP packet headers and how many bytes are needed to identify each road junction limit how many road pathways may be included in a single R_I packet. In R_I, the maximum number of junctions can be increased by using hierarchical junction's technique.

Route Response: As soon as the information inventor vehicle sends its Route identification (R_I) packet to its receiver, it sends a Route Response (R_R) packet. A copy of the R_I header's route is placed in the header field of responder. From inventor to receiver vehicle, this path lane is depicted in Figure 2. Responder position is also included to the R_R header. According to the header, R_R packets are routed along road segments specified by the junctions in whom geographic forwarding is utilized to take use of every accessible vehicle on the way to the responder. There is a possibility that the receiver will obtain duplicate R_I packets. New responses are only returned if the recently obtained packet has a better route than the previous one. The number of vehicles on a route, the number of lanes it has, and the speed at which traffic moves are all indicators of a route's quality. Information inventor begins transmitting data after receiving the R_R packet. It is transmitted as per the network requirement along the route provided in the header of each data packet.

Route preservation: Established routes are updated to reflect changes in information inventor and receiver locations over time and disconnected communication paths [18]. Due to the fact that both information inventor and receiver are moving vehicles, it is not expected that the identification phase would remain the same as defined earlier. In order to maintain route consistency, we employ a dynamic route updating method at the information inventor vehicle. In Figure 2, if vehicle Information Inventor vehicle (I) travels to segment S1-S6, scission S1 should be deleted. A route update control packet tells the receiver of this new path, which is made at the source. Mediator vehicle may also be moved to the road section S5-S8 in the same way. It should be deleted from the route's list of junctions whenever this occurs. A route update packet is sent to the source by the destination as a result. A legitimate route can be utilized for future data transfers when this update is received at the source.

This packet may be sent before changing road segments in certain conditions. When a vehicle node makes a turn that adds a junction to its path, obstacles may cause a momentary loss of communication. This might prevent the update packet from being successfully transmitted. Instead of waiting until the turn to the next segment is complete to broadcast the route update packet, vehicle nodes equipped with AUAVT-$_{Reac}$ can do so before the turn. It's a route error when there isn't a forwarding node that can get you to the next junction. When a node notices that a route is wrong, it sends the packet back to the source. We've found that many times, routes that don't work are only for a short time. When the source gets a route error notice, it doesn't send out a new R_D packet right away in order to keep things from getting too crowded. In response, it suspends the route in question for a certain period of time [19,20].After the hold timeout expires, packets are queued for that destination.

- AUAVT-$_{Mulp}$: Adaptive Urban Area Vehicle Traffic Multipath Routing Algorithm

AUAVT-$_{Mulp}$ is a proactive multipath routing protocol for VANETs intended for efficient local route reformation that have one active and various alternative routes as a backup for receiver vehicle in its routing database for urban area network. In the AUAVT-$_{Mulp}$ on demand multipath technique [21,22] implemented for alternate multipath route when there is no route to receiver. This proposed work achieves higher consistency in terms of successfully delivered packet.

Route Identification: Route identification uses on demand multipath technique in which if route required to initiate communication in the network then inventory vehicle broadcasts an R_{REQ} message to its neighbor's vehicles and so on until the receiver vehicle obtained the R_{REQ}. The information inventory vehicle starts an R_{REQ} message by specifying a TTL and a hop count. In the process of route identification if more than one routes identified in the receiving vehicle cache than the generated response reflected in the form of single/multiple routes in network.

Route Response: In route response process, all vehicles in the network check their address in R_{REQ} message and response only those who identified its own address which declared as a receiver vehicle and responds against an R_{REP} message to the information inventory vehicle. Receiving vehicle is believed to be inaccessible when the TTL values in the R_{REQ} reach a predefined significant value, and messages queued for this receiving vehicle are destroyed, each vehicle in IoV has a successively rising sequence number through which protocol ensures if vehicle only uses sequence numbers to update routes with newer ones than protocol treated all paths to the network's receiving vehicle as loop-free [21]. Vehicles along the path can update their routing table entries according to the most recent receiver sequence number. At the time of route identification, this latest receiver sequence number included for R_{REQ} and R_{REP} messages.

Route Maintenance: During route maintenance, if a vehicle hasn't got a reply from outgoing vehicle types in a certain amount of time, it is deemed to be inactive in the network. Instead of sending an error message to the information inventory vehicle, the foregoer vehicle try to find alternate route for establishing communication, it is accomplished by sending out a R_{REQ} with TTL equal to the receiver's vehicle last known distance plus an increment value. This TTL number is based on the assumption that the receiver vehicle will not be far from disconnected path. Before broadcasting its R_{REQ} message, this precursor vehicle increases the sequence number of the receiver by one.

Algorithm 2.1.1: Route Discovery for route identification at vehicle Xv // (Xv: intermediate vehicle)

1. {
2. Information inventory vehicle first generate R_I frame includes own address, receiver address, unique sequence number from Xv.
3. **If** (Xv == Rv) && provision route is ≤ route length // (Rv receiver vehicle)
4. {
5. Set routes equal to provisional route.
6. Transmit R_R frame by receiver Vehicle which includes route, own address, and information inventory vehicle address
7. return
8. end if
9. }
10. **If** R_I is not seen previously
11. {
12. **If** L(Xv) ≠ L (Yv)) & (L(Xv ∉ R_P) // (L(Xv) and L(Yv): Lane where vehicle Xv and Yv respectively is located and R_p provisional routes)
13. {
14. Includes the lane where vehicle Xv is located to Provisional path
15. end if
16. }
17. This frame is not immediately broadcast when the vehicle gets a new R_I; instead, it is held by the vehicle for a length of time that is inversely proportionate to the distance between them and the Information inventory vehicle. Broadcast storm issue
18. **Else**
19. {
20. Stop the timer and broadcast the frame
21. }
22. end if
23. }
24. end if
25. }

Algorithm 3.1.2: Receiver vehicle

1. For received R_R frame from vehicle Yv ;
2. **If** (x_v == i_v)
3. {
4. Save decent route obtained by Information inventory Vehicle in receiver database.
5. Forward Information frame via decent route obtained by R_R frame.
6. }
7. **Else**
8. {
9. Transmit R_R frame with same header as R_I frame received by Information Inventory vehicle
10. }
11. end if
12. }
13.

Algorithm 2.2.1: AUAVT-$_{Mulp}$ **-** Information Inventory vehicle's Algorithm:

1. **If** (no R_{REQ} frame is forwarded ahead)

2. {

3. **For** (every neighbour vehicle's of Information Inventory vehicle)

4. Determine $outlay_{x,y}$ for neighbour vehicle y;

5. Include the unique incident Identity to the R_{REQ} frame;

6. // Id of the information inventory node is same as unique incident Identity

7. Transmit R_{REQ} frame to the vehicle with least $outlay_{x,\ y}$;

8. }

9. **If** (a R_{REP} *frame is* obtained from the I^{st} or II^{nd} path)

10. {

11. Forward Information frame over the identified route(s) /using load balancing

12. Identity = unique incident Identity;

13. **For** (every neighbour vehicle's of Information Inventory vehicle)

14. **If** (Vehicle $_Y$ does not belong to the route with the unique vehicle Identity number equal to Identity.)

15. Determine $outlay_{x,y}$ for neighbour vehicle y;

16. **If** (discovered a decent neighbour vehicle)

17. {

18. Include the unique incident Identity to the R_{REQ} frame;

19. Transmit R_{REQ} frame to the vehicle with least $outlay_{x,\ y}$;

20. }

21. **Else**

22. **If** (The R_{REP} frame is obtained from the II^{nd})

23. Transmit a F_{REQ} frame to the Receiver vehicle via the II^{nd} route;

24. }

25. **If** ((a R_{REP} frame is obtained from the mth route)&&($n \geq 3$))

26. Forward Information frame over the mth identified route(s) employing the algorithm for load balancing;

27. **If** ((a positive feedback is obtained from the mth identified route) &&($n \geq 2$)) The mth identified route provides positive feedback.

28. {

29. Identity = unique incident Identity;

30. **For** (every neighbour vehicle's of Information Inventory vehicle)

31. **If** (Vehicle $_Y$ does not belong to the route with the unique vehicle Identity number equal to Identity)

32. Determine $outlay_{x,y}$ for neighbour vehicle y;

33. **If** (discovered a decent neighbour vehicle)

34. {

35. Include the unique incident Identity to the R_{REQ} frame;

36. Transmit R_{REQ} frame to the vehicle with least $outlay_{x,\, y}$;

37. }

38. **Else**

39. Transmit a F_{REQ} frame to the Receiver vehicle via the final identified route;

40. // the last built route is the $(m+1)^{th}$ route.

41. }

42. **If** (a negative feedback is obtained from the mth identified route)

43. {

44. The mth identified route is prohibited;

45. Forward Information frame over the m−1 accessible routes;

46. }

47. **If** (a R_{REQ} frame is obtained from the mth route)

48. //on the basis of previous identified route

49. Transmit a F_{REQ} frame to the Receiver vehicle via the $(m-1)^{th}$ route;

50. **If** (an *error frame* is obtained) // when there's a break in the route

51. {

52. Prohibit the communication route from which this frame was obtained;

53. Spread Information frames along the available routes;

54. Begin the process of creating a new route;

}

Algorithm 2.2.2: Intervening (Intermediate) Vehicles' Algorithm:

1. **If** (A R_{REQ} frame is discovered)

2. {

3. Identity = unique incident Identity can be seen on the R_{REQ} frame;

4. **If (**This vehicle belongs to the route with the unique vehicle Identity number equal to Identity.*)*

5. Previous identified obtained R_{REQ} frame;

6. **Else**

7. {

8. **For** (every neighbour vehicle's of Information Inventory vehicle)

9. **If** (Vehicle $_Y$ does not belong to the route with the unique Identity vehicle number equal to Identity)

10. Determine outlay $_{x,y}$ for neighbour vehicle y;

11. **If** (discovered a decent neighbour vehicle)

12. {

13. The current event Identity's route variable is 1;

14. Transmit R_{REQ} frame to the vehicle with least outlay $_{x,y}$;

15. }

16. **Else**

17. Previous obtained R_{REQ} frame;

18. }

19. }

20. **If** (a R_{REP} frame is obtained)

21. {

22. Transmit the R_{REP} frame is obtained in the downwards route towards the Information inventory vehicle;

23.For instance, the current incident Identity has a route variable of 2.

24. Requesting the most recent route information;

25. }

26. **If** (a R_{REP} frame is overheard from vehicle *Y*)

27. {

28. Extract the backward packet reception rate to vehicle *Y* from the neighbouring database.

29. Append the retrieved value. To the obstruction state variable;

30. }

31. **If** (a break in connection happens during the information forwarding)

32. // when a route break happens;

33. Transmit an *error frame* in the reverse/backward route towards the Information inventory vehicle;

34. **If** (a previous R_{REQ} frame obtained)

35. {

36. Identity = unique incident Identity provided in the R_{REQ} frame

37. **For** (Every neighbouring vehicles apart from the vehicle from which R_{REQ} frame has been

Obtained)

38. **If** (Vehicle *Y* does not belong to the route with the unique vehicle Identity number equal to Identity)

39. Determine outlay $_{x,y}$ for neighbour vehicle y ;

40. **If** (discovered a decent neighbour vehicle)

41. Transmit R_{REQ} frame to the vehicle with least outlay$_{x,y}$;

42. **Else**

43. {

44. Previous obtained R_{REQ} frame;

45. *The current incident Identity's route variable is 0;*

46. }

47. }

Algorithm 2.2.3: Receiver Vehicle's Algorithm

1. **If** (a R_{REQ} frame is obtained from either the Ist or IInd route)

2. {

3. Transmit R_{REP} frame over Ist or IInd route towards the information inventory vehicle;

4. }

5. **If** ((a a R_{REQ} frame is obtained from the mth route)&&($n \geq 3$))

6. {

7. **If** (AFT of $m-2$ routes) <=(AFT of m−1 routes)) // (AFT: Average frames throughput)

8. **{**

9. Transmit a positive feedback for the information inventory vehicle over the $(m-1)^{th}$ routes ;

10. Transmit a R_{REP} *frame* over the mth route towards the information inventory vehicle;

11. }

12. **Else**

13. Transmit a negative feedback for the information inventory vehicle over the $(m-1)^{th}$ routes;

14. }

15. **If** (The mth route is used to obtain a F_{REQ} frame)

16. {

17. **If** ((AFT of m−1 paths) <= (AFT of *m* paths))

18. Transmit a positive feedback over the m^{th} routes for the information inventory vehicle;

19. **Else**

20. Transmit a negative feedback over the m^{th} routes for the information inventory vehicle;

21. }

1. Quality of Service Metrics

The enhancement and evaluation considered on the basis of quality of service (QoS) Parameters [5,23,24,] which are as below:

Packet Delivery Ratio (PDR): The number of data packets successfully delivered on destinations divided by the number of data packets given by the source is the definition of this metric (excluding duplicate packets which increases routing overhead).The average performance ratio demonstrates that the routing protocol can effectively transport data end-to-end[19].

Average Frame Throughput (AFT): For a certain period of time, the term "throughput" refers to the number of packets that were successfully transmitted via the network by a particular vehicle. It is necessary to measure the total number of packets that have been successfully delivered to the designated vehicles in order to estimate the throughput of a link between two vehicles. Increasing throughput levels is a good sign of improved efficiency. Bits per second (kbit/s or kbps) are the unit of measurement. The following equation can be used to express throughput quantitatively [25].

Routing overhead: In computing this value, divide the number of extra routing packets received at destinations by the number of unique data packets received at destinations. The amount of additional traffic generated by the routing protocol for packets that have been correctly delivered is referred to as the overhead.

Simulation Scenario: In order to analyze and simulate the routing protocol, we considered the nearest urban area of wankhede stadium in Mumbai, Maharashtra with 18.950288 latitude and 72.823913 longitudes of the selected geographical area using OpenStreetMap (OSM). The reason to consider this area because most of this area has significant traffic and no alternative is available for vehicles moment to avoid heavy traffic [26]. If vehicle-to-vehicle communication is considered in the selected area it is possible to avoid traffic congestion and may be traffic will be reduced only.

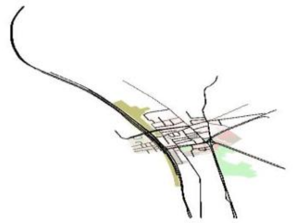

Fig 3. Geographical area using OpenStreetMap

Traffic Generation: The genuine framework with vehicle traffic is established for the aforementioned region using SUMO. This network is analyzed for proactive and reactive routing protocols [4,14,18,27,28,29,30,31]The NS2 simulator is utilized to verify the functioning of Destination-Sequenced Ad hoc On demand Distance-Vector Routing protocol (AODV), Optimized Link State Routing Algorithm (OLSR), Urban area vehicle traffic-Reactive routing protocol (AUAVT-$_{Reac}$) Urban area vehicle traffic-Multipath routing protocol(AUAVT-$_{Mulp}$). We considered number of vehicles with 1500 sec simulation time and MAC protocol is IEEE802.11 Ext.

Fig 4. Simulation region by SUMO

Simulation Setup: Simulation setup defines which are as follows:-

Table 1 Simulation Parameters

S.No.	Parameter	Values
1	Vehicles	40
2	Simulation Environment	2018*2224 m
3	TCP Routing Agent	4
4	Range of Transmission	1000m
5	Simulation time (sec)	1500
6	Packet Size	Random
7	Vehicle movement speed	Random
8	Standard protocol	IEEE 802.11 Ext

3. Results and Discussions

3.1 Packet Delivery Ratio

Figure 5 shows the comparison of packet delivery ratio for AODV and OLSR routing protocol with proposed AUAVT-$_{Reac,}$ AUAVT-$_{Mulp}$ routing protocol, it is clear that the proposed protocol AUAVT-$_{Reac}$ gives better performance as compared to AODV and OLSR routing protocol. With the same perspective AUAVT-$_{Mulp}$ routing protocol provides enhanced performance over AUAVT-$_{Reac}$.

AUAVT-$_{Mulp}$ yields enhancement by more than 8% and 2% in performance with respect to AODV and OLSR routing protocol respectively. Whereas AUAVT-$_{Reac}$ shows improvement by 5% over AODV in terms of successfully delivered frames.

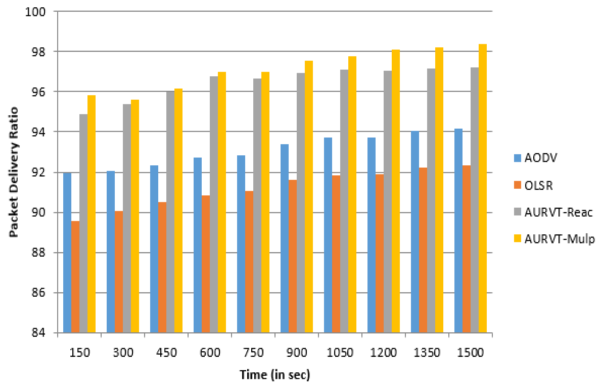

Fig 5. Packet Delivery Ratio

3.2 Average Frame Throughput

Figure 6 represents the average throughput comparison among AODV, OLSR, AUAVT-$_{Reac}$ and AUAVT-$_{Mulp}$ routing protocol. Here also AUAVT-$_{Mulp}$ provides enhanced throughput over AODV and OLSR by 36% and 29% respectively. Further AUAVT-$_{Reac}$ routing protocol gives better throughput compared to AODV and OLSR by 27% and 21% respectively.

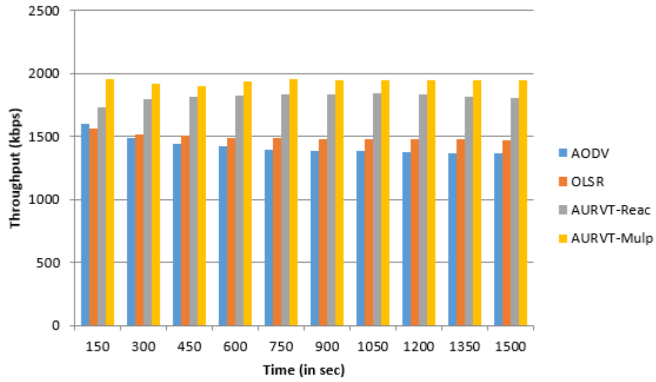

Fig 6. Throughput

3.3 Routing Overheads

Figure 7 shows graphical representation of routing overheads which indicates that the AUAVT-$_{Reac}$ and AUAVT-$_{Mulp}$ generate fewer amounts of routing overheads for network communication in VANET. This is compared with AODV and OLSR routing protocol.

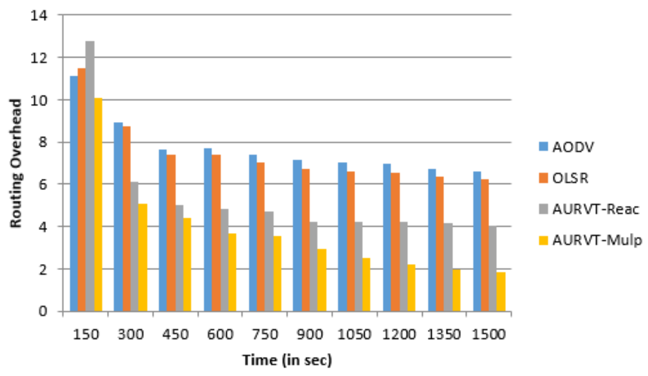

Fig 7. Routing Overhead

4. Conclusion

VANET can be described as vehicle to vehicle communication but due to the high mobility speed of the vehicle VANET is suffered from frequently disconnection between the vehicles during communication which needs a routing protocol to provide uninterrupted communication in the network. In this work AUAVT-$_{Reac}$ and AUAVT-$_{Mulp}$ routing protocol for urban area with heavy traffic are proposed that provides adaptive routing efficiency during the communication for real time traffic at which QoS parameters are observed with enhanced performance in VANET. The proposed routing protocols, AUAVT-$_{Reac}$ and AUAVT-$_{Mulp}$, reflected enhancement over AODV and OLSR routing protocol in terms of QoS parameters as represented by simulation. For real-world driving conditions with buildings and other road characteristics like dead end lanes, the AUAVT protocols perform well since data is sent along the lane lines. Further in future we can include security feature for different types of attacks for the proposed VANET.

Author contributions

Akanksha Vyas: Conceptualization, Methodology, Software, Field study, Data curation, Writing-Original draft preparation, Software, Validation, Field study. **Dr. Sachin Puntambekar:** Visualization, Investigation, Writing-Reviewing and Editing.

Conflicts of interest

The authors declare no conflicts of interest.

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