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Optimization of Quality of Service (QoS) framework for highway based Vehicular Ad-hoc Networks (VANETs)

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ABSTRACT
The Vehicular Ad-hoc Network is a novel technology. It has the property of higher node mobility. Vehicular Ad-hoc networks offer wireless communications between vehicles themselves (V2V) and between vehicles to the roadside units (V2R). The VANET is an active research area, as it has great prospective to enhance the road and vehicle safety, efficiency of traffic. Vehicular Ad-hoc Network not only just provides the safety applications, but also provides communication to the users. The QoS support in VANET is a challenge when the existing routing paths become no longer are available as a result of changes in the velocity and position of node, and distance between the vehicular nodes or network topology. In this study we designed a framework which provides us the facility to enhance various Quality of Service parameters, such as End to End Delay, throughput and packet loss ratio etc. The proposed model uses layered approach, deep classification as existed QoS components are further broken down and provides Quality of Experience to the users. NCTUns is used as simulation tool to build up simulations. After getting the results of simulation we carried out the performance analysis of various routing protocols. The simulation results indicate that the proposed scheme provides much better performance in terms of various QoS parameters like End to End Delay, throughput and packet loss ratio.
***Keywords* -** QoS, VANET, V2V, V2I, WAVE

I. INTRODUCTION

VANET is subtype of wireless ad-hoc networks that has the property of higher node mobility [1]. The VANET provides a well-known approach for the Intelligent Transport System (ITS). The Vehicular Ad-hoc Networks also provides a variety of services, like safety-related systems, enhanced navigation mechanism, information and entertainment related applications. Vehicular Ad-hoc Network is basically a sub class of wireless ad-hoc networks. The Vehicular Ad-hoc Network (VANET) is a subtype of Mobile Ad-hoc Network (MANET) in which vehicle themselves are the mobile nodes. The communication between the vehicles is possible within the radio range of each other’s as well as with fixed road side units whose basic aim is to increase the road safety, reduce congestion and optimize the traffic flows.

The Vehicular Ad-hoc Network (VANET) has grown a lot now a day to handle the increasing demand of the wireless related products which now may be employed in the vehicles; such products incorporate Personal Digital Assistants (pdas), Remote Keyless Entry devices, mobile phones and laptops. As the mobile wireless networks and devices grow to be gradually more important, so the demand of Vehicle to the Vehicle and the Vehicle to the Roadside units will as well grow constantly.

VANET may be able to be exploited for a large number of safety related and non safety products. It provides Various services like vehicle safety,

improved navigation, automated toll tax payment, location base assistances like locating the nearest restaurant or fuel station and applications like providing access to internet. The drivers can quickly acquire emergent and useful information related to roads at minimal cost. That’s why the vehicular communication has become extremely significant technology.

The vehicles communication is usually used for safety and entertainment purpose. The routing in the networks affects the performance of communication in network. The routing is dependent on the protocols being used for routing in the network. In case of VANET, performance of these routing protocols depends upon various scenarios like urban and the highway. The routing protocols which are position based are usually considered well-matched in case of vehicular setting. In addition, it as well makes available robustness in extremely vibrant ad-hoc networks like for Vehicular Ad-hoc Networks. These networks include On Board Units (OBU) and sensors fitted in car in addition to Road Side Units (RSU). The data that is gathered by the sensors in vehicles is shown to the driver, can also be broadcasted to the other vehicles along with sent to the Road Side Unit.

II. LITERATURE REVIEW

In [2], they presented that due to the limitations of bandwidth and vibrant topology of VANETs, the supporting Quality of Service in VANETs is a difficult task. The main purpose of Mobile agents is to reduce the cost of communication, particularly in case of links with lower bandwidth, by running the function related to processing to data somewhat taking data to the main processor. The basic purpose of the study is to suggest a framework for provision of Quality of Service in VANETs. The suggested framework makes use of local information related to nodes like node's power, buffer and speed to select the routing path. The mobile agents provide the learning abilities to be incorporated to enable bandwidth and delay predictions, and able to make decisions according to the network architecture and load, thus provides flexibility. The mobile agents are also able to provide reusability, maintainability, adaptability, efficiency and scalability. They proposed an intelligent agent base VANET. In relation to that they discussed five various types of agents, which include routing agent, Inside vehicular agent, Mobile agent, Alerting agent and Information sighting agent.

The major concern of the study is to conserve the required Quality of Service of applications in the mobile setting without launching significant overhead. The main idea of mobile agent based systems is to share out the management functionality all over the network, whose aim is to handle rapid changes and the scalability issues of the complex VANETs.

In [3], they focus the Adaptive Modulation scheme to get better throughput of data and the channel spectrum efficiency in VANETs. The results shown that the adaptive modulation technique provides good performance and enhances the throughput as compared to various other modulations techniques, when it was used especially in case of dynamic network topology such as VANETs.

It is much difficult to make use of the benefits properly without assured Quality of Service or adequate throughput which will support such type of networks. These networks basically support critical operation packets like accident messages, emergency warnings, which have need of some Quality of Service. As we know that by nature VANETs are dynamic networks, therefore protocols are required which enable them to converge rapidly to avoid any sort of loss of data. The results shown that throughput of the network can be enhanced by the use of adaptive modulation thus effectively making use of channel spectrum.

In [4], they presented the study that in case of Vehicular Ad hoc Networks cars are used as mobile nodes. VANET allow cars about a range of 100- 300 m each other to associate and as a result make a wide scale network. As the cars move far from the range of signals and it drops out from network, the new cars which go in, encounters the communication range. The study used an opportunistic routing scheme to provide the trustworthiness in VANETs.

The policy based routing allows dispensation of various requests of routing to verify the entire available routes towards destination. If the source node obtains numerous responses, afterward it makes use of route that has highest expected route life span. The vehicles end out their data via the route which has utmost lifetime. Every vehicle in the network enables reliable communication if link failure is reduced. The proposed design is evaluated by plotting graphs. The parameters like throughput, packet loss ratio, packet deliverance ratio and end to end delay are used to assess the functioning.

In [5] they proposed a routing protocol which provides an improvement in Quality of Service with the help of packets dissemination between the links with extended time to expire calculated with the use of relative velocity vector. Through the selection and maintenance of one path for routing and one as backup route, it will reduce the topology vibrant, and hence avoids the flooding of control messages on the entire network when it discovers new routes, therefore as a result it improves bandwidth throughput. In spite of this, it may as well direct to disturb the communication if backup route happen to obsolete for the reason that of the rapidly varying topology in case of VANETs.

In [6] they proposed new Quality of Service framework which is built upon a Proxy-base vehicle-internet protocol which has routing algorithm based on prediction and IEEE802.11p .EDCA to send data to the internet devoid of using gateway. The vehicle that is selected, is proxy based and it communicates with road side units whose purpose is to access internet. The results shown with the help of simulation, that the proposed framework is able to shorten the end-end delay and reduce the quantity of dropped packets. Also by making use of improved prediction base routing and the IEEE 802.11p EDCA gives better Quality of Service in internet connectivity.

In [7] they proposed a scheme, which is a means to Quality of Service provisioning in VANETs. The major focus of the study is to set the priority of messages according to their importance. As we normally use broadcasting mechanism for communication in VANET that have no acknowledgement and safety, and the reliability of the network is also very low. To overcome this problem they planned to send messages repeatedly. The repetitions depend upon the message priority. They used to send messages with higher priority more repetitively than that of low priority messages, and its aim was to elevate the possibility of successful transfer of messages with high priority. This mechanism used IEEE 802.11e for the purpose of service differentiation which is priority based like emergency messages, that grant relative dependability discrimination. The presented technique gives lower delay and higher throughput in case of messages with priority.

In [8] they proposed Multi-protocol Label switching mechanism, which is considered as efficient technique for forwarding data packets throughout the network by the use of label contents which are attached with IP packets. Multi-protocol Label switching is also called as layer 2.5 technique for the reason that it works at both layers, network layer and the data link layer. The various Quality of Service metrics such as packet loss ratio and end-end delay are more effective by using multi protocol label switching in VANET scenarios. They used NS2 simulator and SUMO to carry out simulations in the study. They used the data set of Manhattan mobility model. The results of the simulation show that after the use of MPLS technique, the Quality of Service parameters become more effective and have better results.

As in case of VANETs due to higher mobility of vehicular nodes, MPLS does not respond very well, so they implemented the Multi-protocol Label switching in base stations because they are connected to wired network. The vehicles in the network send data via base station meant for processing through wired network. The communication between the vehicular nodes and wired Multi protocol label switching domain is possible via base stations. The vehicular nodes are going to communicate among each other and the base stations transmit data packets to other base station via wired network. MPLS technique seems to be more reliable and faster as compared to the previous techniques. The study revealed the improvement in various Quality of Service parameters like packet loss, throughput and delay in case of highway scenario.

In [9] they discussed that VANET is a novel technology, so for the safety and the entertainment purpose, the communication among the vehicles is much important. The effectiveness of the communication is reliant upon the phenomena of routing in a network. The process of routing depends upon the protocols which are deployed in the network. In case of vehicular networks, usually position based protocols are considered to be the best.

In this study they proposed a routing protocol in which provided an alternative to greedy approach, named as necessity first algorithm. The presented protocol is considered much appropriate in case of vehicular networks as they have higher mobility. To estimate the effectiveness of various OLSR patterns, they considered the three major Quality of Service parameters, which include end-end delay, network routing load and packet delivery ratio. The already existing protocols are sufficient for vehicular ad-hoc networks, but we always look for the much improved performance. In this study they improved the existing OLSR protocol using MPR. As a result the improved OLSR provides much better performance. The scheme used by them called necessity first algorithm seems to be much helpful in reducing the network traffic load.

III. PROPOSED WORK

The proposed framework is based on adaptive Quality of Service. It depends upon the critical situation to enhance the road safety using VANET's, Quality of Service. Maximum resources must be provided in the critical situation. The Quality of Service term usually has focus on throughput, jitter, latency etc. Therefore the Quality of Service model should be adaptive in nature. When we are in normal situation then the Quality of Service parameters should behave like its conventional definition but when the critical situation approaches then the life safety mechanism should be adapted and critical messages whether textual, voice or video should be given more importance depending upon the situation.

The proposed framework is adaptive in nature with respect to the situation and the user demands. In case of normal circumstances the major focus is on power conservation, process execution according to the normal data packets sequence like first interactive video, audio data and then text data respectively, considering the load and other related parameters.

In case of emergency or critical situation the proposed framework, the major focus and top priority is given to life safety and then text interactive communication, audio according to the user demands and bandwidth. The QoS new dimension set new priorities for ever class of messages. The user's demands relative emergency life safety is important.

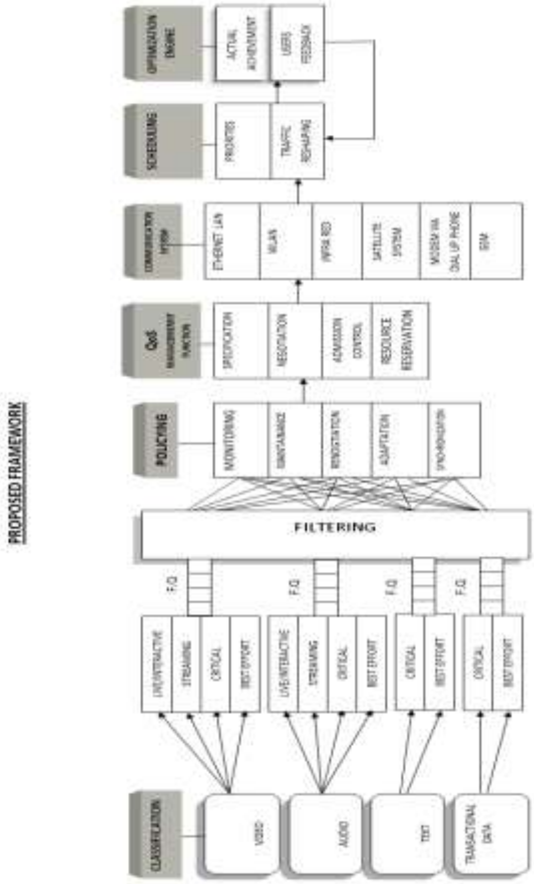

Fig. 3.1 Proposed Framework

Here are some assumptions of our proposed framework. We have classified the data into four main categories which are video, audio, text and transactional data. All these types of data in VANET are supported by our framework. The video data may be live/interactive, streaming, critical and best effort. The audio data also may be live/interactive, streaming, critical and best effort. The text data may be critical and best effort. The transactional data also may be critical and best effort.

Then we have forwarding ques. Then the data is being filtered out to verify its reliability. Then there is policing, which is carried out by the service provider. It includes different factors like monitoring, maintenance, renegotiation, adaptation and synchronization. Here monitoring means to measure the really offered quality of service, maintenance means to sustain a certain level of quality of service by modifying various parameters, renegotiation is a process in which a contract is renegotiated and this is needed when during the maintenance specified metrics are unable to attain according to the contract, adaptation means that the modifications made in the quality of service of system are adapted by applications, and synchronization means combination of two or more streams by means of temporal quality of service, such as to synchronize the video and audio streams.

Then we have the quality of service management function, which includes specification, negotiation, admission control and resource reservation. The term specification means the nature of quality of service constraints or potentials, negotiation means to reach at decided specification among various parties, admission control means to compare the needed quality of service and the ability to meet up the constraints, resource reservation means to allocate various resources toward the streams and the connections.

Then we have various common communication systems which includes local area network, Wireless network, modem through dial up telephone, satellite system, infra-red system and GSM etc. In scheduling, we have priorities and traffic reshaping; a scheduler is what carries out the scheduling activity. Schedulers are often implemented so they keep all compute resources busy (as in load balancing), allow multiple users to share system resources effectively, or to achieve a target quality of service. Priorities include different message priorities and traffic reshaping is used to optimize or guarantee performance, improve latency and/or increase the usable bandwidth for some kinds of packets by delaying other kinds. The practice involves delaying the flow of packets that have been designated as less important or less desired than those of prioritized traffic streams. Then we have the optimization engine, which includes the actual achievement of the quality of service and the user feedbacks.

Table 3.1 Message Classification

Messages	**Prioritization**
Critical Messages	Priority 1
Live messages	Priority 2
Streaming messages	Priority 3
Best Effort messages	Priority 4

3.1 Algorithm

Initiative Vehicle = Iv
Number of Services = Ns
video ⟶ critical = P_{00}
video ⟶ live = P_{01}
video ⟶ streaming = P_{02}
video ⟶ best effort = P_{03}
audio ⟶ critical = P_{10}
audio ⟶ live = P_{11}
audio ⟶ streaming = P_{12}
audio ⟶ best effort = P_{13}
text ⟶ critical = P_{20}
text ⟶ best effort = P_{21}
t.data ⟶ critical = P_{30}
t.data ⟶ best effort = P_{31}

Table 3.2 Message Priorities

	P_1	P_2	P_3	P_4
Video	Critical	Live	Streaming	Best Effort
Audio	Critical	Live	Streaming	Best Effort
Text	Critical	Best Effort		
Transactional Data	Critical	Best Effort		

```
loop:
for  1 Ns to n Ns
{
if(video  ──▶  live )
 {      video ──▶ live        ──▶     P00
        video ──▶ critical    ──▶     P01
        }
if(video  ──▶  streaming )
 {      video ──▶ streaming   ──▶     P00
        video ──▶ live        ──▶     P02
        }
if(video  ──▶  critical )
 {      video ──▶ critical    ──▶     P00
        video ──▶ streaming   ──▶     P01
        }
if(video  ──▶  best effort )
 {      video ──▶ best effort ──▶     P00
        video ──▶ critical    ──▶     P03
        }
if(audio  ──▶  live )
 {      audio ──▶ live        ──▶     P10
        audio ──▶ critical    ──▶     P11
        }
if(audio  ──▶  streaming )
 {      audio ──▶ streaming   ──▶     P10
        audio ──▶ live        ──▶     P12
        }
if(audio  ──▶  critical )
 {      audio ──▶ critical    ──▶     P10
        audio ──▶ streaming   ──▶     P11
        }

if(audio  ──▶  best effort )
 {      audio ──▶ best effort ──▶     P10
        audio ──▶ critical    ──▶     P13
        }
if(text   ──▶  critical )
 {      text  ──▶ critical    ──▶     P20
        text  ──▶ best effort ──▶     P21
        }
if(text   ──▶  best effort )
 {      text  ──▶ best effort ──▶     P20
        text  ──▶ critical    ──▶     P21
        }
if(t.data ──▶  critical )
 {      t.data ──▶ critical    ──▶    P30
        t.data ──▶ best effort ──▶    P31
        }
if(t.data ──▶  best effort )
 {      t.data ──▶ best effort ──▶    P30
        t.data ──▶ critical    ──▶    P31
        } }
```

The proposed algorithm is focusing on QoS by dealing cognitively with three QoS metrics, which are throughput, End-to-End Delay and packet loss. As the classification of multimedia services have been carried out it deal with various services parameters such as video, audio, text and transactional data etc. After classifying the services, the level 2 classification of these services have done and on the basis of these classifications the algorithm initialize the priorities of each service with respect to QoS and current situation of network or service requirement. Initially as shown in figures, the priorities to the different services were assigned. As it may be noticed that the critical video has the highest priority and the best effort transactional data have the lowest priority. This is because that the video require high bandwidth, throughput, low end-to-end delay and packet loss, and further the audio require low QoS level then video. Text and transactional data require much less QoS metrics then video and audio.

Therefore the proposed algorithm initially assigns the high priorities to those services which require high QoS level and low priority to those services which have low QoS requirements. But in network sometime nobody is using video and audio, on any specific service, the algorithm will switch the priority cognitively between services based on requirement of the service, if nobody is using the video, it will reduce the priority of the video and give high priority to the service which is used by more number of users. This cognitive switching between priorities ensures the high throughput, low end to end delay and packet loss for the required service.

In this study NCTU*ns* 6.0 (National Chiao Tung University Network Simulator) network simulation tool used for testing and evaluation of results. It provides [10] various exclusive features that conventional network simulators are unable to offer.

IV. Highway based scenario

In highway based scenario we used 25 vehicular nodes on an area of 2000X1000 meter. We have arbitrarily selected the distance among the vehicular nodes. The overall simulation time for vehicular movement is about 400 sec in highway based scenario. The speed of the vehicles in the network is about 25 m/s to 30 m/s.

Fig 4.1 Highway scenario

4.1.1 End to End Delay vs. No.of Nodes

Fig 4.2 illustrates the network Average End-End Delay of AODV, AODV-R, OLSR and AQ-MAC protocols along with number of nodes in highway based scenario. Here we may realize that the Average End-End Delay of AODV-R protocol start at about 1.02 m.sec and with the increase in number of nodes, the average End-End Delay increases gradually close to its higher value , i-e about 5.05. Even though the AODV-R is considered as a good reactive routing protocol but here in case of VANET higher node mobility its performance declines by means of higher average End-End delay. The basic reason of higher average End-End Delay is the higher node mobility in case of VANETs.

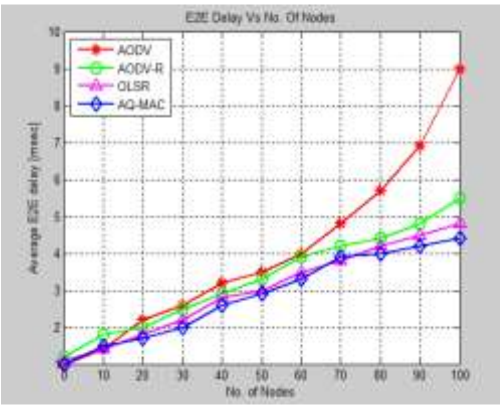

Fig 4.2 E2E Delay vs. Number of Nodes

On the other hand we may realize that the Average End-End Delay of AODV protocol start at about 1.0 m-sec and with the increase in number of nodes, the average End-End Delay increases gradually close to its higher value , i-e about 9.0. Even though the AODV is considered as one of the best reactive routing protocol but here in case of VANET higher node mobility its performance declines by means of higher average End-End delay. The basic reason of higher average End-End Delay is that the working of AODV protocols is depends on basis of demand, so whenever a source node forwards a request to send data to the nearby destination node that is moving with higher speed, thus, the source do not receive any response from the nearby nodes. AODV sends the request recurrently to transmit data packets to the destination. As a result there is higher average End-End Delay.

We may also realize that the Average End-End Delay of OLSR protocol start at about 1.0 m-sec and with the increase in number of nodes in the network, the average End-End Delay increases gradually close to its higher value ,i-e about 4.8. Thus here in case of VANET higher node mobility its performance declines by means of higher average End-End delay. The basic reason of higher average End-End Delay is the higher node mobility in case of VANETs.

We may also realize that the Average End-End Delay of AQ-MAC protocol start at about 1.0 sec and with the increase in number of nodes in the network, the average End-End Delay increases gradually close to its higher value ,i-e about 4.4. As compared to the AODV, AODV-R and OLSR the proposed protocol AQ-MAC provides better performance in terms of lower value of average End-End Delay

4.1.2 Throughput vs. Number of Nodes

Fig 4.3 illustrates the network throughput of AODV, DSDV, OLSR and AQ-MAC protocols along with number of nodes in highway based scenario. Here we may realize that the throughput of DSDV protocol start at about 835 Kb/sec and with the increase in number of nodes, the throughput decreases gradually close to its lower value, i-e about 605 Kb/sec. Even though the DSDV is considered as an effective routing protocol but here in case of VANET higher node mobility its performance declines by means of lower throughput. The basic reason of lower throughput is the higher node mobility in case of VANETs.

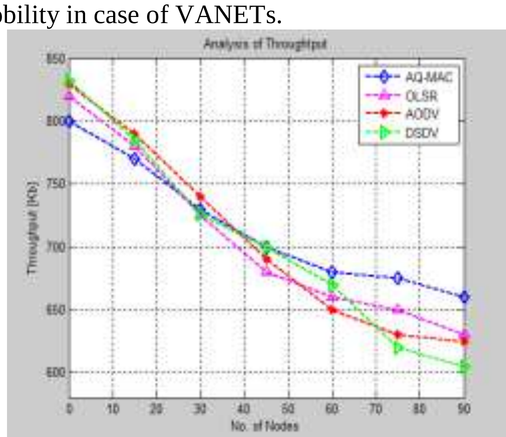

Fig 4.3 Throughput vs. Number of Nodes

On the other hand we may realize that the throughput of AODV protocol start at about 830 Kb/sec and with the increase in number of nodes, the throughput decreases gradually close to its lower value, i-e about 630 Kb/sec. Even though the AODV is considered as one of the best reactive routing protocol but here in case of VANET higher node mobility its performance declines by means of lower throughput. The basic reason of lower throughput is that the working of AODV protocols is depends on basis of demand, so whenever a source node forwards a request to send data to the nearby destination node that is moving with higher speed, thus, the source do not receive any response from the nearby nodes and it contemplates that destination node is not in range. AODV sends the request recurrently to transmit data packets to the destination. As a result there is lower throughput.

We may also realize that the throughput of OLSR protocol start at about 820 Kb/sec and with the increase in number of nodes in the network, the throughput decreases gradually close to its lower value, i-e about 630 Kb/sec. Thus here in case of VANET higher node mobility its performance declines by means of lower throughput. The basic reason of lower throughput is the higher node mobility in case of VANETs.

We may also realize that the throughput of AQ-MAC protocol start at about 800 Kb/sec and with the increase in number of nodes in the network, the throughput decreases gradually close to its lower value, i-e about 660 Kb/sec. As compared to the AODV, DSDV and OLSR the proposed protocol AQ-MAC provides better performance in terms of higher value of throughput.

4.1.3 Packet loss vs. Node speed

Fig 4.4 illustrates the network packet loss percentage of AODV, DSDV, GPSR and AQ-MAC protocols along with speed of nodes in highway based scenario. Here it may be realized that the packet loss percentage of DSDV protocol start at about 72 and with the increase in speed of nodes, the packet loss percentage decreases up to the speed of 70 km/h and then it gradually increase close to its higher value, i-e about 98. Even though the DSDV is considered as an effective routing protocol but here in case of VANET higher node mobility its performance declines by means of higher packet loss percentage. The basic reason of higher packet loss percentage is the higher node mobility in case of VANETs.

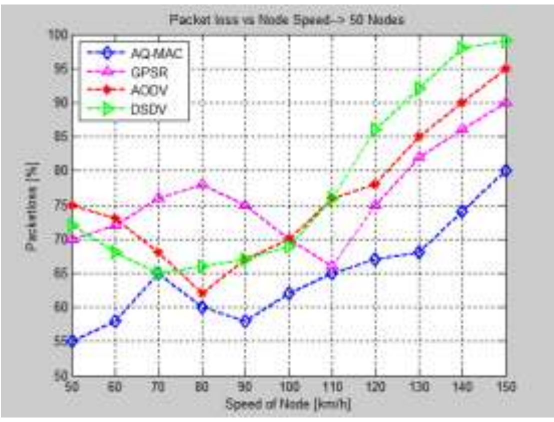

Fig 4.4 Packet loss vs. Node speed

On the other hand it may be realized that the packet loss percentage of AODV protocol start at about 75 and with the increase in speed of nodes, the packet loss percentage decreases up to the speed of 80 km/h and then increases gradually close to its higher value, i-e about 95. Even though the AODV is considered as one of the best reactive routing protocol but here in case of VANET higher node mobility its performance declines by means of higher packet loss percentage. The basic reason of higher packet loss percentage is that the working of AODV protocols is depends on basis of demand, so whenever a source node forwards a request to send data to the nearby destination node that is moving with higher speed, thus, the source do not receive any response from the nearby nodes and it contemplates that destination node is not in range. As a result there is higher packet loss percentage.

It may be realized that the packet loss percentage of GPSR protocol start at about 70 and with the increase in speed of nodes in the network, the packet loss percentage increases up to the speed of 80 km/h, then it decreases up to the speed of 110 km/hand then gradually increases close to its higher value, i-e about 90. Thus here in case of VANET higher node mobility its performance declines by means of higher packet loss percentage. The basic reason of higher packet loss percentage is the higher node mobility and dynamic nature of VANETs.

It may be realized that the packet loss percentage of AQ-MAC protocol start at about 55 and with the increase in speed of nodes in the network, the packet loss percentage increases up to the speed of 70 km/h, then it decreases up to the speed of 90 km/h and then gradually increases close to its higher value, i-e about 80. As compared to the AODV, DSDV and GPSR the proposed protocol AQ-MAC provides better performance in terms of lower packet loss percentage.

V. CONCLUSION

This study, recommends a survey of routing protocols and the techniques that are used to improve the quality of service in VANETs. We proposed an improved scheme to provide QoS to vehicular Ad-hoc Networks on the basis of messages Classification that a vehicle can send or receive to / from BSS & Adaptive MAC. Our improvements are as follows. (1) A vehicle can send or receive to / from BSS messages are classified by priorities on the basis of their importance & urgency. And (2) most important factor of our AQ_MAC is that it is priority based and works by assigning various priorities according to message type. In some cases the MAC should react immediately to drastic changes in specific environment, & queries/ messages for life critical situations should not delayed & should be handled immediately so adaptive nature of AQ_ MAC make it possible to handle both normal & critical situations. AQ_MAC shows its best performance in Life Critical situation where performance of many MAC protocols do not maintain the QoS Parameters. AQ_MAC behavior in drastic situation too not only maintains the QoS parameters but after every problem it get back to its normal mode & also re-conserve the energy utilized in dealing with that drastic situation.

The simulation results of AQ_MAC protocol that are also present in the performance analysis indicates that this protocol performs very well in maintaining QoS parameters like End to End Delay , throughput , packet loss ratio and enhancing the adaptability. The proposed framework uses layered approach, deep classification as existed QoS atoms are further broken down and provides Quality of Experience to the users. The graphical results also show that AQ_MAC protocol perform very well in all the parameters defined as goal & gives very reliable results.

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