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Research Article

Assessment of Video Communication for QoS in Vehicular Ad Hoc Networks

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Abstract

Vehicular ad hoc network (VANET) is one of the largest areas of interest in wireless technology because it provides very wide variety of services in the field of transportation. Intelligent Transportation System (ITS) provides a set of standards for Vehicular Communication networks. The vehicular network provides many useful applications and advantages. The multimedia applications, which are based on vehicular network, are considered to play a very vital role in the future of ITS, but now-a-days they are facing some big challenges on Quality of Services (QoS) issues due to high velocity, network scalability and limited communication range. In this paper, the evaluation of Quality of Videos and services has performed by using proactive, reactive and hybrid routing protocols under different network conditions, in various communication environment using QualNet simulator. Here, the authors have presented the combination of two results of this assessment. The results are considered that which routing protocol is more suitable and determines that which network condition is better in which vehicular network environment provide efficient QoS and video streaming performance. Finally, the authors try to increase the performance of videos and improve the Quality of Services of ITS over vehicular networks in the future.

Keywords:*Vehicular Ad Hoc Network, QoS, Video Communication, Routing protocols.*

1. Introduction

In 2003, Federal Communication Commission (FCC) established the services and license rules for Dedicated Short Range Communication (DSRC) services, which uses the 5.9GHz band (approx.) for the use of public or private safety and applications. The newly developed services and allocated frequency allows vehicles and roadside illuminant to form vehicular ad hoc network (VANET), in which the vehicles are assumes as nodes and they can communicate with each other in wireless network without any central access point.

Intelligent Transportation System (ITS) refers to the effort of adding information and communication technology to vehicles and transport system, in order to reduce the fuel consumption, vehicle wear, transportation time and improve the safety, performance and efficiency. The vehicular networks are a cornerstone of the ITS.VANET is a form of Mobile ad hoc network (MANET). The VANET turns every participating vehicle into a wireless router or node, which communicate with each other to create network with wide range. There are mostly applications of VANET, which needs to send multimedia data for communication, but it is a very challenging task because of some factors such as high dynamic topology, limited transportation range, security problems and high velocity, which are responsible for degrading its quality and services. The main research goals of ITS are Vehicle to Vehicle (V2V) and Vehicle to Infrastructure (V2I) communication with better quality of services.

There are many upcoming opportunities in the growing area of vehicular network. There are various ongoing research projects supported by Governments, institutions and industries like Vehicle Information and Communication System(VISC) by Japan; Car2Car Consortium, CarTalk2000, FleetNet by Europe; PATH, Federal Highway Administration's Vehicle Infrastructure Integration (VII) by US; Mobile Computing Lab / Osaka University; e-Road Project / Rutgers; Self-Organizing Traffic Information System (SOTIS) / Technical University of Hamburg; Rubinet Group / UC-Davisetc, which are focusing on developing intelligent vehicles based on DSRC.

Our purpose is to provide a study of vehicular network in order to find out the most suitable routing protocol for supporting Quality of Services and video communication in different condition and various environments which will further helps to improve the performance of vehicular network in the future researches and projects.

This paper is organized as: the next section deals with the reviews of literature. Section 3 describes the conceptual framework and estimation model used in this work. The simulation and result of the assessment and

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performance of routing protocols are thoroughly discussed in section 4. Section 5 presents our conclusion and future work.

2. Reviews of Literature

Presently, there are some applications which need to send videos for different purpose. So, the authors have used to estimate the quality of video in various condition and environment. Many research works have been done to analyze the quality of video transmission through VANET. *Guo et al*. presented a live video streaming architecture through V2V communication and considered the problem of triggering remote video source in forwarding traffic congestion in the past research of video communication over highway VANETs. The research by *Park et al.* extended the research work of *Guo et al*, by simulating a two ray wireless propagation model and proposed an application layer Forward Error Control-based solution through network coding. *Bucciol et al.* examined the feasibility of H.264/AVC video communication between two vehicles with IEEE 802.11b transceivers in a live setting. *Asefi et al.* proposed an application centric routing framework for real-time video transmission over urban multi-hop VANET. They considered Queuing-based mobility model, spatial traffic distribution and probability of connectivity in design routing protocol by different network condition in VANET scenarios. *Venkataraman et al.* proposed a hybrid IEEE 802.11p-based multi-hop network communication into high-speed vehicular networks which resulting into one of the most promising architecture solution to meet the next generation demand of multimedia transmission in outdoor wireless network and makes use of both infrastructure and ad hoc nodes to deliver quality-oriented real-time multimedia data to high-speed vehicles. *Sergi et al.* presented an analysis of video streaming performance over vehicular network to study the deployability of a video on demand services in a highway environment for vehicular user. *Fei et al.* explain the overview of live video streaming performance over highway under different packet forwarding and buffering management scheme which gives the insight for the design of the future inter-vehicle video streaming. *Kayhan and Kamalrulnizam* studies the review of recent routing protocols for text and video data transmission and focused on quality based comparison of routing protocols for video streaming over VANET. They also discussed some routing challenges for video streaming and text dissemination over VANET. *Shouzhi et al.* studied and evaluated the quality of video communication over VANET with different routing protocols to find out best of them; however, they used only V2V architecture in this study.

After focusing on the above research works, we have presented this paper which helps to provides appraisal of video streaming performance and services under sparse and dense network conditions in highway and city environments with the help of QualNet 6.1 simulation tool in V2V, V2I and Hybrid networks.

3. Conceptual framework and estimation model

In this section, we mainly present the estimation model and simulation tool which helps us to perform the assessment of quality of videos and services by different class of routing protocols under the various environments and conditions. The vehicular networks are used to provide communication among nearby vehicles and between vehicles and infrastructure units. The aims of authors are try to evaluate the quality of video sent over the VANET, with following factors keeping in mind, which affect the communication over VANET:

- The quality of channel can be easily affected by many factors such as vehicle type, road condition etc.
- High velocity of vehicles and less transmission range, which are responsible for less communicating time
- Frequent disconnection of networks due to tall building, crossing streets etc.
- Different communication environment between vehicles affect the network conditions.

Here, authors have used three types of VANET architecture according to the communication perspective: Vehicle to Vehicle (V2V), Vehicle to Infrastructure (V2I) & Hybrid (V2V & V2I) communications as illustrated through VANET Architecture in figure 1(a), 1(b) & 1(c) respectively.

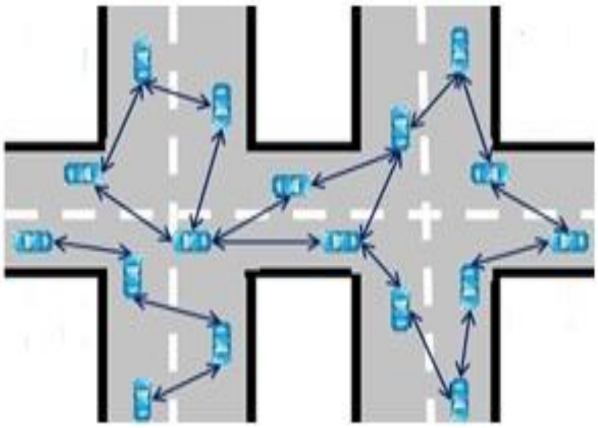


Figure 1(a)

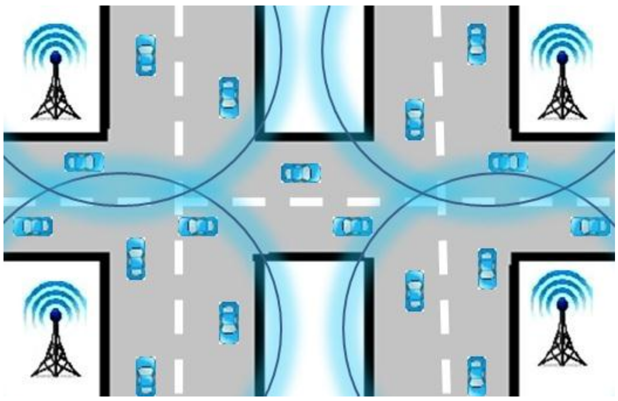


Figure 1(b)

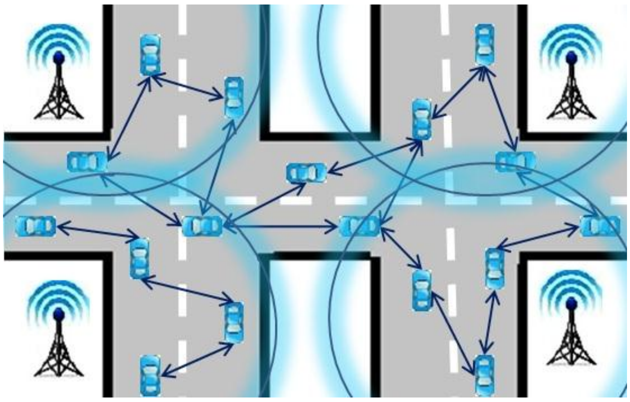


Figure 1(c)

Figure 1: VANET Architecture,
Fig.1 (a): V2V Architecture
Fig. 1(b): V2I Architecture
Fig. 1(c): Hybrid (V2V & V2I) Architecture

Depending on suitability of communication, VANET routing protocols falls in three main categories: Proactive routing protocols, Reactive routing protocols and Hybrid routing protocols. We have taken three routing protocols to analyze the above with each category respectively, which correspondingly contains Optimized Link State Routing (OLSR), Ad hoc On-demand Distance Vector (AODV) and Zone Routing Protocol (ZRP).

QualNet Virtual Internetworking (QVI) Tool

For the estimation of multimedia transmission performance over VANET, we proposed a conceptual framework named as QualNet virtual Internetworking (QVI). This approach works with QualNet simulation tool, which is composed of following tools: Architecture, Analyzer, Packet Tracer, File Editor and Command Line Interface, which helps to create realistic vehicular environment, that provides user friendly support, with various routing protocols and analyzing capabilities. The QVI framework provides an absolute environment for designing protocols, creating & animating networking models as well as analysing their performance. It is also helpful for examining the behaviour of the system in virtual computational world. By this proposed approach; we can simply estimate the performance and quality of video transmitted over VANET. This framework also helps to designs various scheme such as QoS, network topologies and protocols in a realistic vehicular environment. The QVI framework is illustrated in fig.2.

Working Steps with QualNetVirtual Internetworking (QVI)

First Phase: The first stage determines the scenario creation steps. It includes the following steps of working:

Step 1: *Configuring General Parameters* –The first step includes the setting of general parameters such as name of experiment, simulation time, seeds and terrain property specification.

Step 2: *Node Placement with Mobility and Subnet* – This step describes the initial position and properties of nodes. The mobility of nodes specifies the position of nodes that changes during the simulation with respect in time. It is configure through mobility way point which provides way point information of nodes in accordance with time.

Step 3: *Network Topology Definition & Channel Configuration* – In this step, network topology specifications are discussed, which can be determines through wired & wireless links between nodes and the subnets. The subnet describes a network composed of two or more nodes. Each node in the scenario must appear at least in one link or subnet. The channel configuration describes the number of channels and its property setting which includes channel frequencies, pathloss model, shadowing model and fading model.

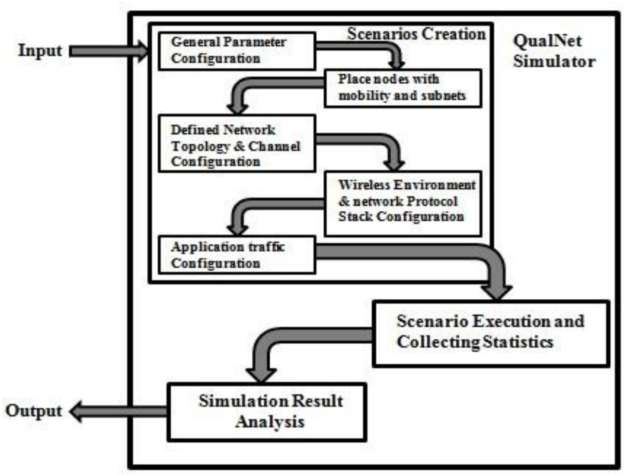


Figure 2: QualNet Framework for Evaluation of Video Transmission

Step 4: *Configuration of Wireless Environment & Network Protocol Stack* – This step includes the configuration of wireless environment and property of wireless subnet in networks. The wireless subnet includes protocol stacks configuration. It basically follows these configurations: The physical layer configuration includes the channel masking, radio, antenna & energy models with bandwidth & transmission power setting. The MAC layer configuration mainly includes MAC protocol setting in accordance with properties. The network layer configure the network and related protocols, parameters to enable forwarding of packets & assign IP addresses and subnet mask to interfaces. The router properties setting of wireless subnet involve the specification of routing protocols properties.

Step 5: *Configuring Application Traffic* – Last step follows application traffic configuration which includes setting of application used for transferring data in the scenario & implements traffic generators. We have to transmit multimedia data so we used CBR application in this research because CBR generates traffic at a constant rate by transmitting packets of a fixed size at a fixed rate and includes services such as video-conferencing and telephony (voice services). It includes the information of source and destination with number of packets to send size of each packet, its start & end time with interval.

Second Phase: This phase specifies the scenario execution and statistics collections. The scenario execution turns the QualNet simulator from design tovisualization mode. The live simulation starts with clicking the run simulation button. After the running of scenario, the simulation results appear at Analyzer, from where we can collect the statistics of various metrics according to the layer properties. Simulation results also include scenario animation as well as runtime & final statistics.

Third Phase: The last phase of this framework specifies the simulation result analysis of different scenarios with various routing protocols. The Analyzer tool of QualNet is helpful for this work. With this tool we can compare the result of different scenarios in a particular time, with values. The compare displays various metrics output with values, which are collected during simulation.

Estimation Model

The authors are considering some valuable metrics to perform the evaluation of quality of video send over VANET, which is used in the proposed approach. These metrics parameters are – Transmission delay, signal power, utilization, pathloss, signal received with error, average jitter, peak queue length, average delay, throughput, end-2-end delay and packet loss rate. Here, it is worth to mention, that some calculation is necessary to find out the result of few metrics such as transmission delay, end-to-end delay and packet loss rate.

***Transmission delay*:** Transmission delay is proportional to the packet's length in bits. It is calculated by the formula given below:

$D_T = N/R$

D_T = Transmission delay

N = number of bits

R = rate of transmission

***End-to-End delay*:** In end-to-end delay, a packet may take longer time to reach to the destination due to queuing and various routing ways shown as under:

$D_{end\text{-}end} = N\,[\,D_{trans} + D_{prop} + D_{proc} + D_{queu}]$

$D_{end\text{-}end}$ – end-to-end delay

D_{trans}– transmission delay

D_{prop} – propagation delay

D_{proc}– processing delay

D_{queu} – queuing delay

N – Number of links (no. of routers + 1)

***Packet loss rate*:** It is the failure of transmitted packet to arrive at the receiver. It can be calculated as follows-

Packet loss rate = (total packet sent – packet received) / maximum simulation time.

4. Simulation and Result

In accordance with the environment of operating vehicles, Vehicular network can be set up in various situations like city environment, highway environment, disaster situation, extreme weather condition and so on. We build up the two distinct scenarios here on the basis of environment: city and highway scenarios, to transmit a real video file from source to destination. We also create two different traffic conditions over each environment: sparse & dense and apply them over VANET Architectures as given in section 2.

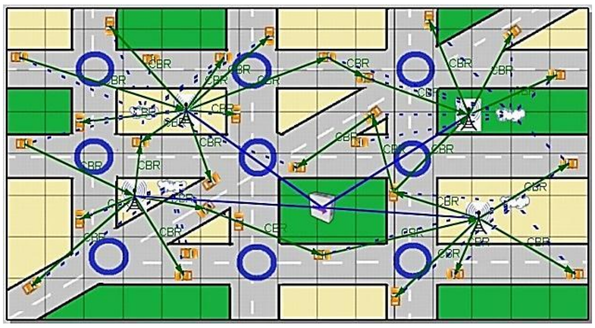


Figure 4(a)

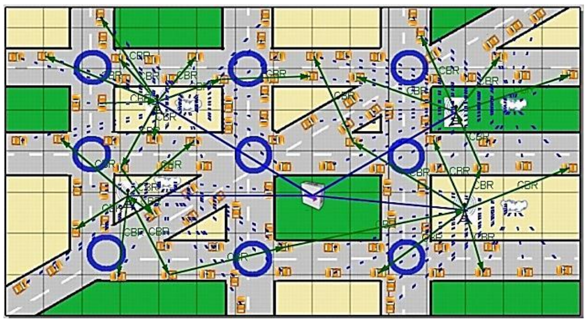


Figure 4(b)

Figure 4: City Scenario
Fig. 4(a): City Sparse Network Scenario
Fig. 4(b): City Dense Network Scenario

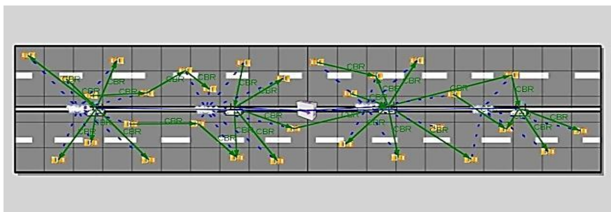


Figure 5(a)

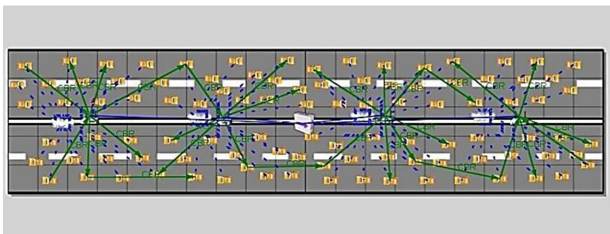


Figure 5(b)

Figure 5: Highway Scenario
Figure 5(a): Highway Sparse Network Scenario
Figure 5(b): Highway Dense Network Scenario

In consonance with scenarios, we perform following activities to present our work:

Activity 1: The city sparse network scenario as illustrated in figure 4(a) is created in 1500 X 750m^2 areas with some streets and roads connected to each other with bi-directional lane which sometime creates traffic problem as real city environment. It contains 30 nodes as vehicles, which are distributed over the scenario. The city dense network scenario shown in figure 4(b) is also created in same area as city sparse network, but it contains 100 nodes as vehicles distributed over the area.

Activity 2: In highway sparse network scenario, as illustrated in figure 5(a), 2000 X 500 m^2 area has taken to create two lane road as in live highway environment, the roads are wide and long. So here, vehicles are more dynamic. It contains 30 nodes as vehicles distributed over highway while in highway dense network scenario as shown in figure 5(b), contains 100 nodes as vehicle distributed in the same area, so here the vehicles are less dynamic than sparse network.

The topology used in both the environment is usually two dimensional. We take V2V, V2I and Hybrid networks architecture and apply them over these scenarios one by one respectively. For V2V network, only wireless network is configured but for V2I network, access points are also put up in some distance of road and Hybrid networks include the both above network properties and channel configuration is needed here for base stations situated on road side. Then we get four different results from each architecture (for example: V2V City Dense Scenario, V2V City Sparse Scenario, V2V Highway Dense Scenario, Highway Sparse Scenario; same as for V2I & Hybrid networks). The simulation parameters, which we have used in this paper are listed as follows:

Table 1: parameters used in Simulation

Parameter	Description
Simulation Tool	QualNet 6.1
Simulation Time	240 sec
Bandwidth	20MHz
Transmission Power	20dBm
Antenna	Omni Direction
Physical Layer Protocol	802.11n
MAC Protocol	802.11e
Routing Protocols	AODV, OLSR, ZRP
Traffic Generator	CBR

We use QualNet simulator, as described in section 3, to estimate the performance and quality of video & services by using three different routing protocols: AODV, OLSR & ZRP.

The video file hellofd.flv contains 300 frames; frame rate is 25fps; bit rate of 269.5333kbps; resolution is 384X288; AVC codec used; frame aspect ratio is 4:3 or 1.33333; size of video is 576592 bytes; type of file is macromedia flash video, has to transmit over the network. Our work is based on these three routing protocols, because we transmit video data in all the scenarios one by one over these routing protocols to find out which routing protocol performs best in various environment & conditions under different architectures of VANET.

After running the scenarios, we record the network information and collect the values for making a comparison analysis. The result of this paper is divided according to sparse & dense condition of the network. So, we discuss both results one by one:

(a) *Results of Sparse Traffic Scenarios:* There are 30 cars are distributed on the roads in sparse network condition. The comparison graph of transmission delay has shown in fig 6.

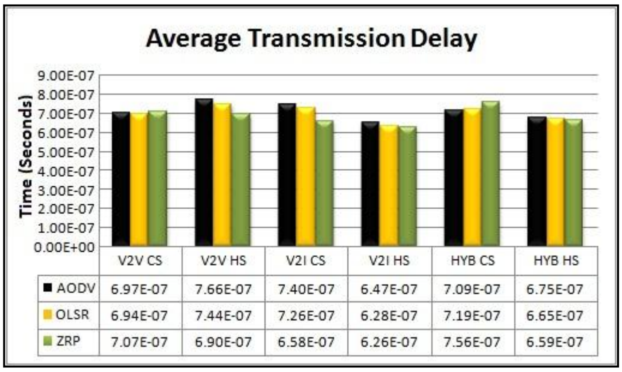


Figure 6: Graph for Average Transmission Delay

The low transmission delay is always desirable in any communication network. The above graph shows that ZRP protocol shows the less transmission delay in V2V highway sparse (V2V HS), V2I city sparse (V2I CS) & highway sparse (V2I HS) & in Hybrid highway sparse (HYB HS), but in V2V city sparse (V2V CS) OLSR shows less transmission delay and AODV protocol shows less transmission delay in Hybrid city sparse (HYB CS) network. But overall, the ZRP has lowest value (6.26e-07s) for V2I HS.

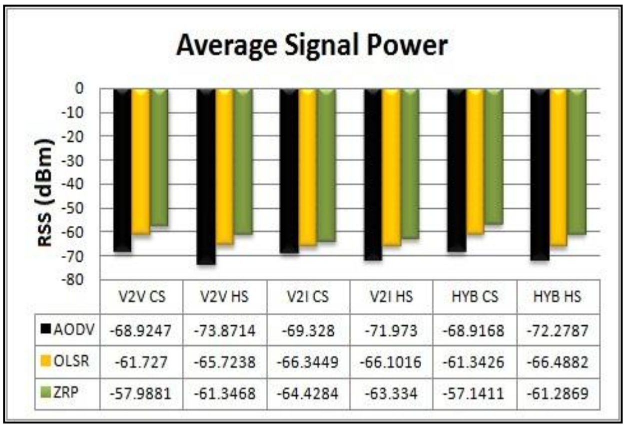
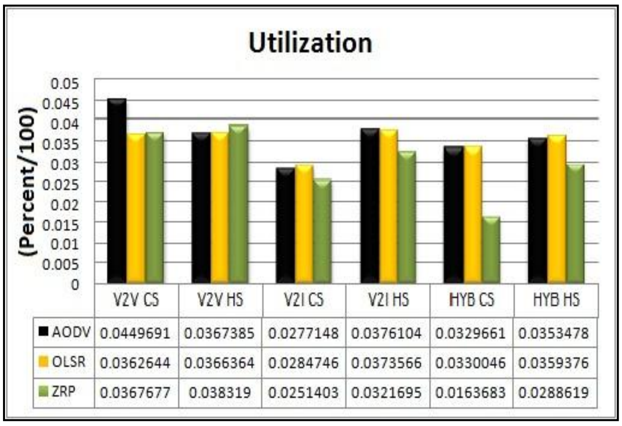


Figure 7: Graph for Average Signal Power

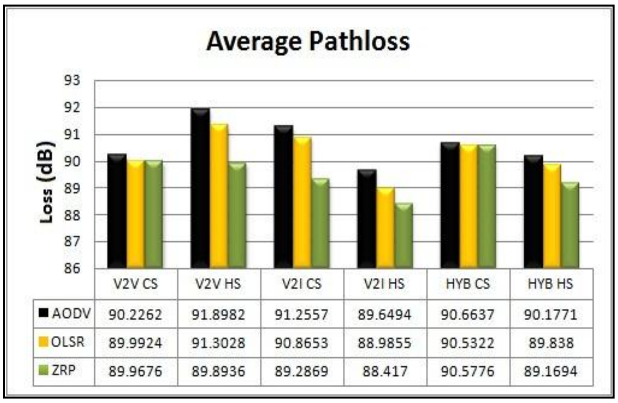
The graph of fig. 7 presents the average signal power of the network. It is measured dBm unit of RSS (Received Signal Strength). The high negative value shows the high signal power of network. The graph shows that ZRP protocol has low negative value & AODV has high negative value in the entire network environment & the AODV of V2V HS has highest negative value so, it has the highest signal power.



	V2V CS	V2V HS	V2I CS	V2I HS	HYB CS	HYB HS
AODV	0.0449691	0.0367385	0.0277148	0.0376104	0.0329661	0.0353478
OLSR	0.0362644	0.0366364	0.0284746	0.0373566	0.0330046	0.0359376
ZRP	0.0367677	0.038319	0.0251403	0.0321695	0.0163683	0.0288619

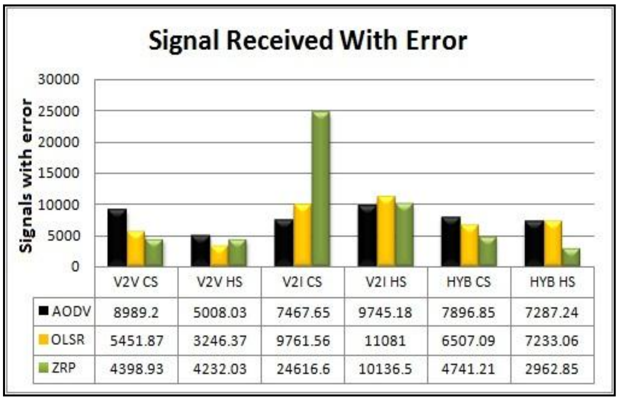
Figure 8: Graph for Utilization

The fig. 8 shows the utilization graph of all sparse networks. It shows that AODV protocol shows highest utilization in V2V CS & V2I HS, but in V2V HS, the result is just opposite i.e. in V2V HS, the AODV shows lowest & ZRP shows highest utilization, while in V2I CS, HYB CS & HYB HS, the OLSR gives highest utilization. But overall, AODV performs best for V2V CS as it has highest value of utilization.



	V2V CS	V2V HS	V2I CS	V2I HS	HYB CS	HYB HS
AODV	90.2262	91.8982	91.2557	89.6494	90.6637	90.1771
OLSR	89.9924	91.3028	90.8653	88.9855	90.5322	89.838
ZRP	89.9676	89.8936	89.2869	88.417	90.5776	89.1694

Figure 9: Graph for Average Pathloss

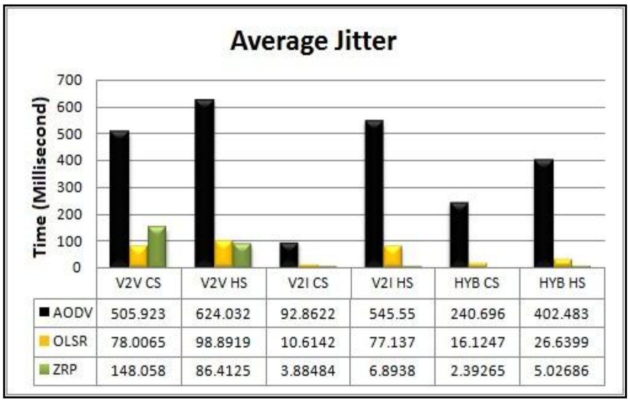


	V2V CS	V2V HS	V2I CS	V2I HS	HYB CS	HYB HS
AODV	8989.2	5008.03	7467.65	9745.18	7896.85	7287.24
OLSR	5451.87	3246.37	9761.56	11081	6507.09	7233.06
ZRP	4398.93	4232.03	24616.6	10136.5	4741.21	2962.85

Figure 10: Graph for Signal Received with Error

The less pathloss value is always good for any communication network. The graph of average pathloss shown in fig. 9 presents that ZRP protocol has less pathloss in all the scenarios, except HYB CS. In HYB CS, the OLSR shows lowest pathloss, as compared to other protocols.

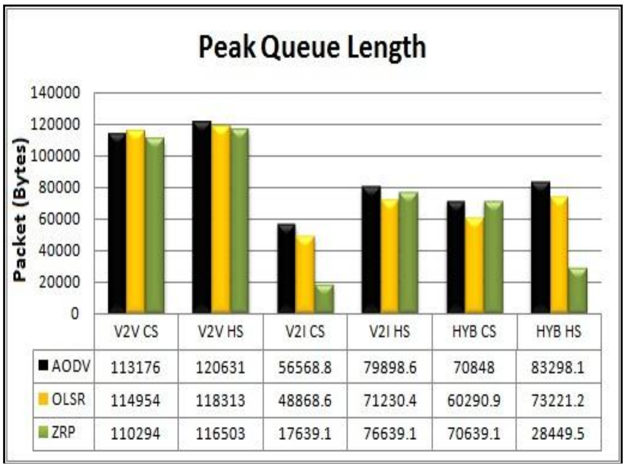
The fig.10 represent the graph for signal received with error, which shows that in V2V CS, HYB CS & HYB HS, the ZRP has less signal received with error, but in V2V HS, the OLSR has less signal received with in error, while in V2I CS & V2I HS, the AODV shows the lowest value of signal received with error.



	V2V CS	V2V HS	V2I CS	V2I HS	HYB CS	HYB HS
AODV	505.923	624.032	92.8622	545.55	240.696	402.483
OLSR	78.0065	98.8919	10.6142	77.137	16.1247	26.6399
ZRP	148.058	86.4125	3.88484	6.8938	2.39265	5.02686

Figure 11: Graph for Average Jitter

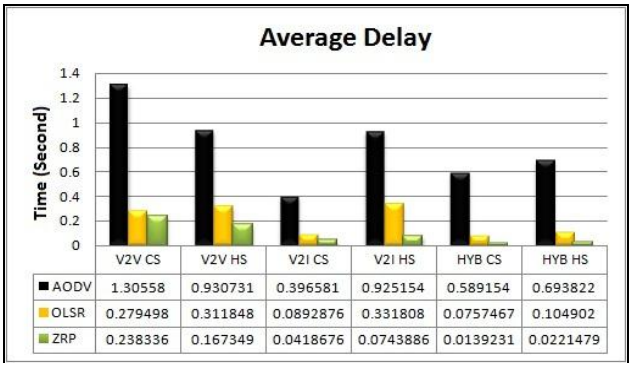
Jitter value must be less in any communication network for good performance. Fig.11 presents the graph for average jitter, which shows that AODV performs worst for all networks environment because of its highest value, while ZRP performs best for all except V2V CS. In V2V CS, OLSR performs best.



	V2V CS	V2V HS	V2I CS	V2I HS	HYB CS	HYB HS
AODV	113176	120631	56568.8	79898.6	70848	83298.1
OLSR	114954	118313	48868.6	71230.4	60290.9	73221.2
ZRP	110294	116503	17639.1	76639.1	70639.1	28449.5

Figure 12: Graph for Peak Queue Length

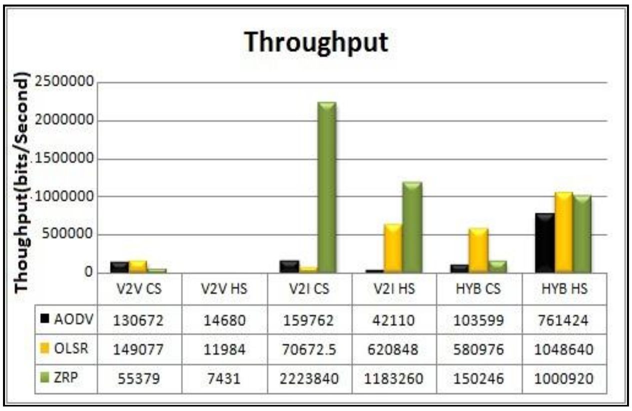
Small peak queue length is always desirable for all communication networks. The graph of fig. 12 represents the value of peak queue length of all sparse networks, which shows that AODV perform worst in all scenarios, because of its highest value except V2V CS. In V2V CS, the OLSR has highest peak queue length. In V2V CS, V2V HS, V2I CS & HYB HS, the ZRP has smallest peak queue length, but in V2I HS & HYB CS, OLSR has smallest peak queue length



	V2V CS	V2V HS	V2I CS	V2I HS	HYB CS	HYB HS
AODV	1.30558	0.930731	0.396581	0.925154	0.589154	0.693822
OLSR	0.279498	0.311848	0.0892876	0.331808	0.0757467	0.104902
ZRP	0.238336	0.167349	0.0418676	0.0743886	0.0139231	0.0221479

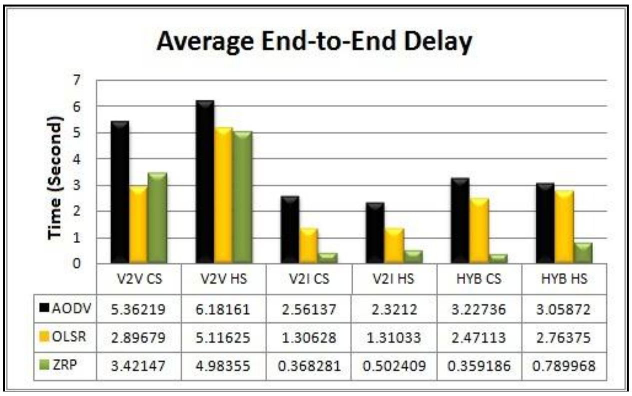
Figure 13: Graph for Average Delay

The fig.13 shows the graph for average delay of packets in all sparse networks. It analyze that AODV perform worst & ZRP perform best result for average delay over the entire networks environment in sparse condition.



	V2V CS	V2V HS	V2I CS	V2I HS	HYB CS	HYB HS
AODV	130672	14680	159762	42110	103599	761424
OLSR	149077	11984	70672.5	620848	580976	1048640
ZRP	55379	7431	2223840	1183260	150246	1000920

Figure 14: Graph for Throughput

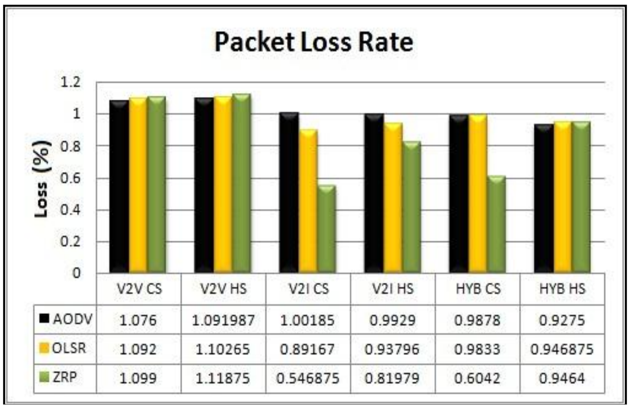


	V2V CS	V2V HS	V2I CS	V2I HS	HYB CS	HYB HS
AODV	5.36219	6.18161	2.56137	2.3212	3.22736	3.05872
OLSR	2.89679	5.11625	1.30628	1.31033	2.47113	2.76375
ZRP	3.42147	4.98355	0.368281	0.502409	0.359186	0.789968

Figure 15: Graph for Average End-to-End Delay

High value of throughput is always favourable in networks. Fig.14 represents the throughput graph, which analyze that OLSR gives highest throughput in V2V CS, HYB CS & HYB HS network scenarios, while ZRP perform highest throughput in V2I CS & V2I HS and AODV presents highest throughput in V2V HS as compared to other protocols.

The fig.15 shows that AODV has the highest value in all the sparse networks. It shows that AODV performs worst while ZRP has lowest value, so it gives best performance except V2V CS, because in V2V CS, the OLSR shows the lowest value.

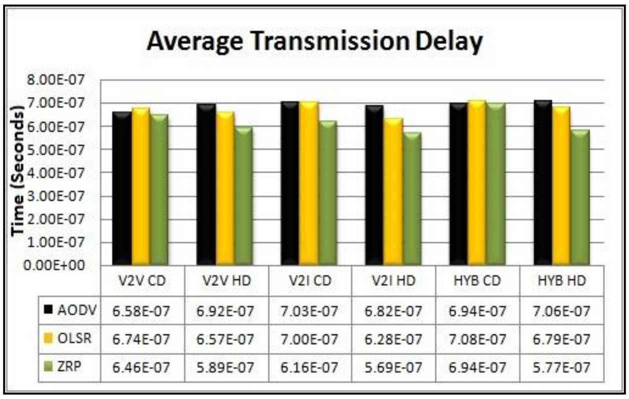


	V2V CS	V2V HS	V2I CS	V2I HS	HYB CS	HYB HS
AODV	1.076	1.091987	1.00185	0.9929	0.9878	0.9275
OLSR	1.092	1.10265	0.89167	0.93796	0.9833	0.946875
ZRP	1.099	1.11875	0.546875	0.81979	0.6042	0.9464

Figure 16: Graph for Packet Loss Rate

The fig.16 of packet loss rate graph shows the packet loss rate of all sparse network scenarios. The ZRP performs best for V2I CS, V2I HS & HYB CS because it shows less packet loss rate while, AODV perform best for V2V CS, V2V HS & HYB HS scenarios because of showing less packet loss rate.

(b) *Result of Dense Traffic Scenarios*: For creating dense network, we have used 100 vehicles & distributed them over the roads. The fig.13 presented below, shows the graph of average transmission delay.



	V2V CD	V2V HD	V2I CD	V2I HD	HYB CD	HYB HD
AODV	6.58E-07	6.92E-07	7.03E-07	6.82E-07	6.94E-07	7.06E-07
OLSR	6.74E-07	6.57E-07	7.00E-07	6.28E-07	7.08E-07	6.79E-07
ZRP	6.46E-07	5.89E-07	6.16E-07	5.69E-07	6.94E-07	5.77E-07

Figure 17: Graph for Average Transmission Delay

From the fig.17 it is clear that ZRP performs best because it shows the lowest transmission delay in all the dense network scenarios. Here, one thing to be notices that in Hybrid city dense (HYB CD), AODV & ZRP, both have same values.

The fig.18 of average signal power graph measured in RSS (Received signal strength) presents that AODV has the highest negative value, while ZRP has the lowest negative value for average signal power in all the dense network scenarios.

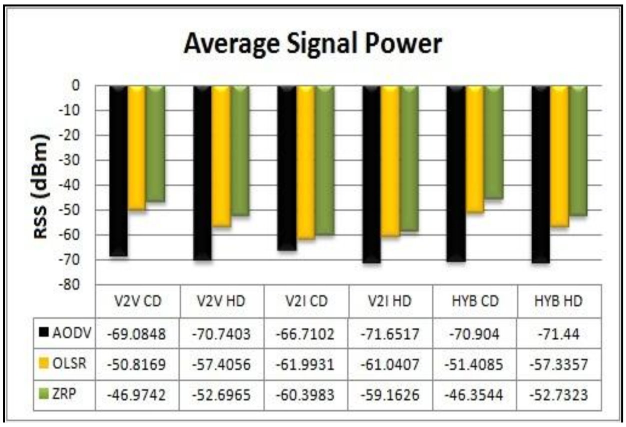


Figure 18: Graph for Average signal Power

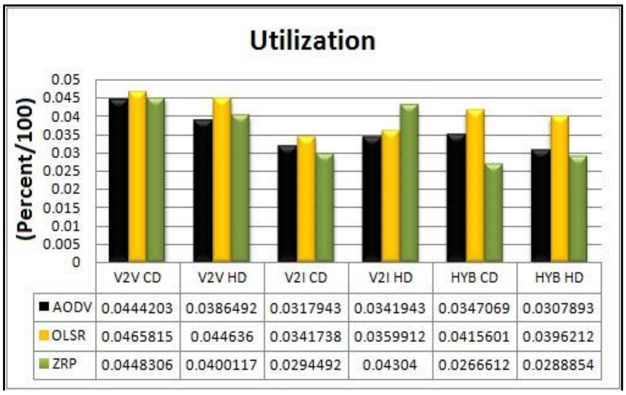


Figure 19: Graph for Utilization

Fig.19 shows the graph for utilization, which presents that OLSR performs highest utilization in V2V city dense (V2V CD), V2V highway dense (V2V HD), V2I city dense (V2I CD), Hybrid city dense (HYB CD) & Hybrid highway dense (HYB HD), while ZRP performs highest utilization in V2I highway dense (V2I HD).

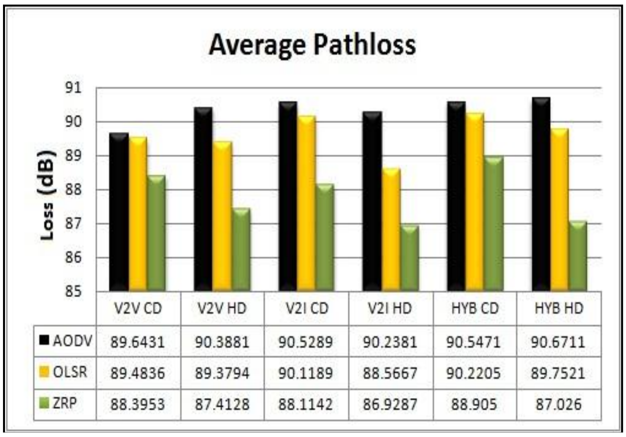


Figure 20: Graph for Average Pathloss

The graph of fig.20 shows the average pathloss of network scenarios. It perform that AODV has the highest pathloss while ZRP has the lowest pathloss in all the dense network environments. So, here ZRP performs best.

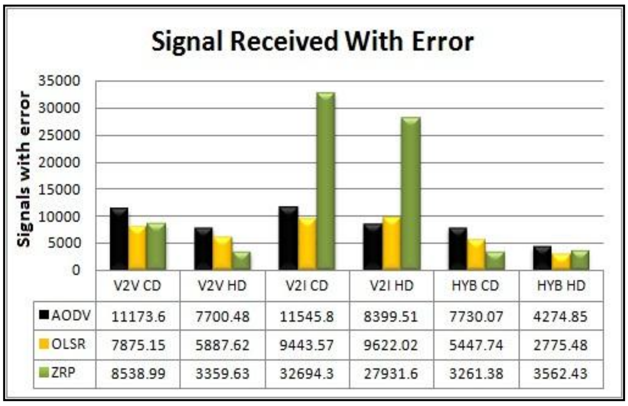


Figure 21: Graph for Signal Received with Error

Fig.21 shows the graph for signal received with error, which performs that in V2V CD, V2I CD & HYB HD, OLSR shows smallest value of signals received with error, while in V2V HD & HYB CD ZRP has the smallest value of signals received with errors and AODV shows the smallest value of signal received with error in V2I HD network scenario.

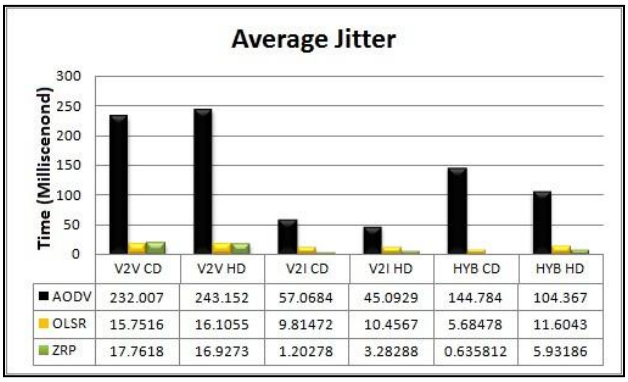


Figure 22: Graph for Average Jitter

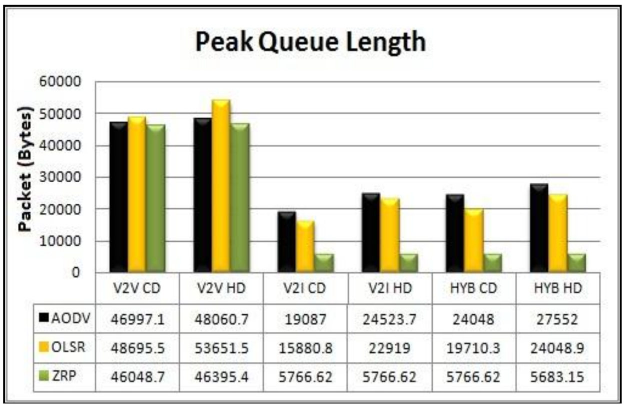


Figure 23: Graph for Peak Queue Length.

The fig.22 presents the graph for average jitter which shows that AODV perform the worst in all the dense scenarios, while ZRP performs the best except V2V CD & V2V HD because in these two scenarios, the OLSR has the lowest value of jitter, so here OLSR performs best.

The fig. 23 shows that ZRP has the lowest peak queue length in all the dense network scenarios. So, it is clear that ZRP perform best here.

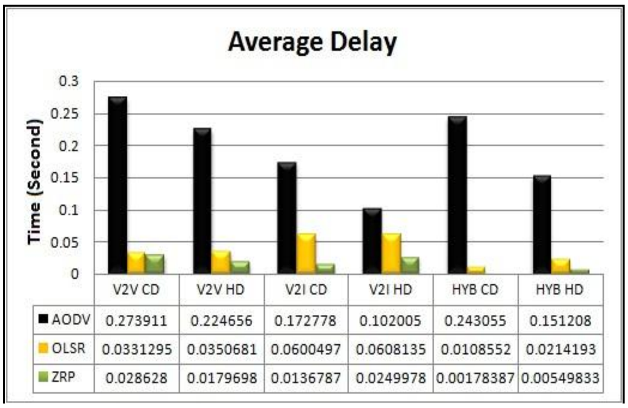


Figure 24: Graph for Average Delay

Fig.24 presents the graph of average delay which shows that AODV performs worst because of highest values of delay, while ZRP performs best because of lowest values of delay in all scenarios of dense network.

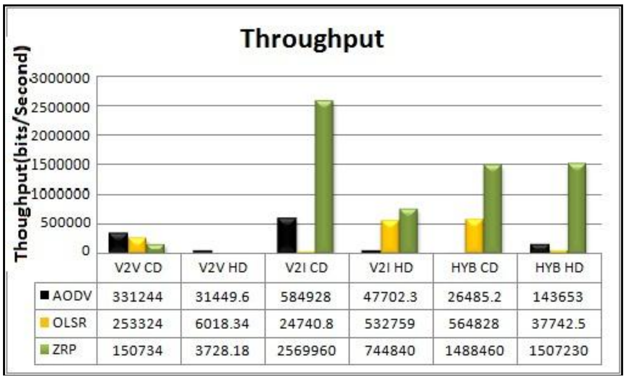


Figure 25: Graph for Throughput

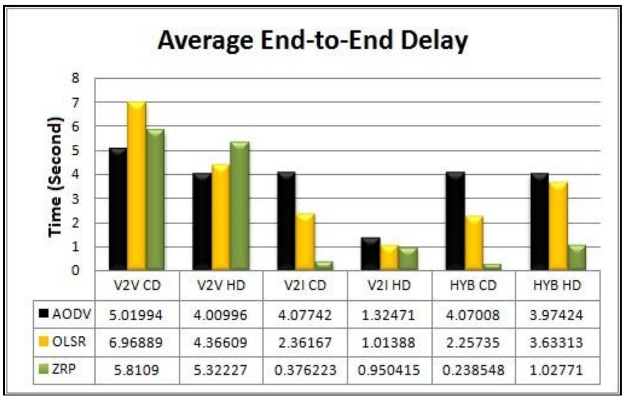


Figure 26: Graph for Average End-to-End Delay

Fig.25 shows that ZRP performs highest throughput in the entire dense networks except V2V CD & V2V HD. In these both scenarios AODV shows highest throughput value.

The fig 26 shows that ZRP show the best result of average end-to-end delay for V2I CD, V2I HD, HYB CD & HYB HD, but for V2V CD & V2V HD, AODV performs the best result because of its less value as compared to other protocols.

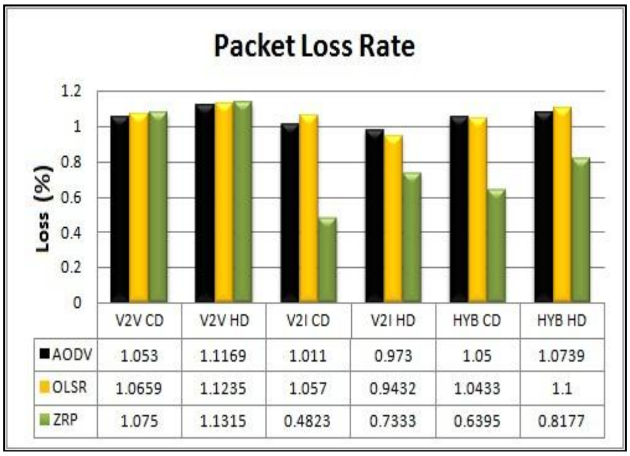


Figure 27: Graph for Packet Loss Rate

Fig.27 shows that, ZRP has the lowest packet loss rate as compared to other protocols except V2V CD & V2V HD. In V2V CD & HD, AODV protocol shows the lowest packet loss rate.

Conclusion

In accordance with routing protocol, the hybrid routing protocol (ZRP) presents the best performance in terms of mostly metrics of both, Sparse and dense network because it takes advantages of proactive and reactive protocols. It is based on the zones concept which creates zone of nodes and gives good signal strength to all the nodes of its zone. AODV has uncontrollable flooding problem, it takes more time to build routing table and it consumes more share of bandwidth. OLSR has the problem of wider delay distribution, it needs more time to rediscovering a broken link and it requires more processing power to discover an alternate route.

On the basis of network condition, the dense network performs better than sparse network for almost metrics because dense network creates more traffic problem. So, the vehicle's speeds become slow and data can transmit easily. But in sparse network, there is less traffic congestion, so vehicle's speeds are fast & it create difficulty to transmit whole data because of the limit of transmission range.

According to the architectures of VANET, V2I network performs best in mostly metrics such as average transmission range, pathloss, throughput & packet loss rate of both network conditions, average signal power, average jitter of dense network and peak queue length of sparse network due to receiving good signal strength from infrastructure.

In consonance with environment, City environment is more suitable for mostly metrics because in city environment the velocity of vehicles is slower as compared to highway network, so data can transmit easily in time.

Finally, we find out that hybrid routing protocol is more efficient for multimedia data transmission compared to proactive & reactive routing protocols. Since VANETs have high velocity & various atmospheres affect to QoS of transmitted multimedia data, as such, on the basis of VANET architecture and environment, protocols must be more powerful to deal with problem related to its QoS.

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