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# To Investigate the Performance of MANET Routing Protocols with Varying Node Densities

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**Abstract: -**A Mobile Ad Hoc Network (MANET) is a collection of wireless mobile nodes without any fixed infrastructure in which each node act as a transmitter, router and data sink. In MANET local nodes are connected with each other and communicate to find new routes to the nodes which are out of its transmission range. A network design is said to be efficient if the path routing and protocol selection is done carefully. In MANET, every routing protocol has its own advantages and disadvantages depending upon the performance in the network. The protocol to be selected for designed network should be best in terms of data delivery, data integrity and must be able to overcome some difficulties such as congestion and node connectivity. In this thesis work, performance analysis is carried out on routing protocols of type reactive (Ad Hoc On-demand Distance Vector (AODV)), pro-active (Optimized Link State Routing (OLSR)) and hybrid (Zone Routing Protocol (ZRP)) by varying node density to determine the best among them. The performance of these routing protocols is evaluated analytically and through simulation using an Optimized Network Engineering Tools (OPNET) Modeler. Performance is evaluated and analyzed using OPNET Modeler by considering metrics: throughput, network load, retransmission, data dropped and delay.

Keywords: - MANET, AODV, OLSR, ZRP and OPNET.

## 1.INTRODUCTION

**1.1 MANET: -**Mobile Ad Hoc Network is simply known as MANET. Mobile Ad Hoc networks are infrastructure-less networks since they do not require any central access point involvement for data exchange. In general, communication between far away nodes routes may have multiple hops and sometimes called as multi-hop wireless ad hoc networks. Every node in MANET is able to communicate directly with any other node that resides within its transmission range and for communication within nodes that are out of transmission range, the nodes uses intermediate nodes [14]. A MANET is a type of ad hoc network that can change its locations randomly and is able to communicate anytime and anywhere. Because MANETS are mobile, they

Use wireless connections to connect to various networks. Wireless connection may be a standard Wi-Fi connection, or another medium, such as a cellular phones or satellite transmission [29]. In MANET devices move independently in any direction and change its links to other devices frequently. These devices sometimes act as router because they forward the traffic unrelated to its own use. MANETs are a kind of wireless ad hoc networks that usually has a routable networking environment on top of a Link Layer ad hoc network.

The MANET concept basically came into existence to tackle the disaster situations like terrorist activities, tsunami, earthquake, land-slides and battlefields etc later, the concept has been used in many applications such as gaming, online education and business etc. In some MANET applications group communication is needed to manage the situations. Nodes in MANET do not provide reliable services and QoS (Quality of Service) guarantees as compared to other wireless networks such as Wi-Fi, WiMAX, GSM and CDMA. The main sources of unreliability in MANETs are due to limited storage capacity, limited battery life, processing power, high mobility and varying channel conditions. The QoS parameters to be guaranteed for multimedia group communication are bandwidth, delay, packet loss, jitters and bandwidth- delay product [28].

**1.2 MANET routing protocols: -**The routing protocols of fixed infrastructure are not suitable for MANET as the nodes are mobile. The infrastructure less and the dynamic nature of these networks demands new set of networking strategies to be

 

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implemented in order to provide efficient end-to-end communication. So to provide communication between the nodes routing protocols are developed. The routing protocols are necessary to maintain the network. There are number of routing protocols available .The main objective of ad hoc routing protocols is how to deliver data packets among nodes efficiently without predetermined topology or centralized control. MANET routing protocols can be classified as proactive, reactive and hybrid. Proactive routing protocols, also known as table-driven routing protocols, each node in the network maintains one or more tables that contain up-to-date and consistent routing information to every other node in the network. When the network topology changes, the nodes propagate update messages and the topology change information is distributed across the network. Reactive routing protocols are also known as on-demand routing protocols. A node creates a route in an on-demand fashion i.e. it computes a route only when needed. When a source wants to send packets to a destination, a fresh route is find out from source to destination. In hybrid routing protocols, some of the characteristics of proactive protocols and some of the characteristics of reactive protocols are combined into one to get better solution for mobile ad hoc networks. Proactive approach is used for routing within this zone and reactive approach is used for nodes that are located beyond this zone.

**2. Literature Survey: -** This section discusses the various literatures that are reviewed during the whole research work. Various research papers has been studied during the period, summery of some important of them are as below.

Huda Al Amri et al. [12] have reviewed various network conditions by considering AODV, DSR, LAR, FSR and WRP routing protocols. They have concluded that all considered routing protocols behave well for homogeneous and misbehave in heterogeneous networks. They give results which are unexpected and inefficient in heterogeneous networks. For heterogeneous networks they suffer from high delays and achieve very low packet delivery ratio. Current considered MANET routing protocols have problem with increasing node density. This shows that these routing protocols for MANETs are inadaptable for heterogeneous networking.

A performance investigation of reactive and proactive MANET routing protocols, namely AODV, DSR, TORA and OLSR have been done by Ashish Shrestha and Firat Tekiner [4]. They have concluded that with regards to overall performance, AODV and OLSR performed pretty well. However, AODV routing protocol showed better efficiency to deal with high congestion and it scaled better by successfully delivering packets over heavily trafficked network compared to OLSR and TORA.

A.A.A. Radwan et al. [1] have done a systematic evaluation of performance of some routing protocols for Ad Hoc networks. They have compared three routing protocols Ad hoc On-Demand Distance Vector Routing (AODV), Dynamic Source Routing (DSR) and Location-Aided Routing (LAR) with 100 and 200 node densities. The comparison of routing protocols is evaluated using different performance metrics and concluded that each protocol behave differently with respect to node densities. With node density 100 LAR shows good performance for routing overhead, delay, throughput, data packets sent etc, AODV protocol showed better performance for ACK packets received, collisions, signals arrived with power above RX sensitivity etc, DSR protocol showed good performance for packets retransmitted, signals arrived with power above RX threshold, signals transmitted and with node density 200 LAR protocol shows good performance for average end-to-end delay, normalized routing overhead, collisions, throughput, data packets received, data packets sent, etc, AODV protocol shows better performance for packets retransmitted, throughput etc, DSR protocol shows good performance for signals transmitted and signals arrived with power above RX threshold.

N. Adam et al. [26] have done the formal evaluation of performances of three types of MANET routing protocols, when the number of nodes or the node density varies. The protocols included are Ad Hoc On-demand Distance Vector (AODV), Temporally Ordered Routing Algorithm (TORA) and Dynamic Source Routing (DSR) protocol. The analysis had been done through simulation using an Optimized Network Engineering Tools (OPNET) Modeler. The performance metrics considered are the routing load, packet delivery ratio, packet dropped, end-to-end delay, and throughput. The results have shown that in all the scenarios, AODV displays the smallest delay and loss ratio and the adaptive ability is also of relative strength.

Savita gandgi et al. [32] have evaluated the performance of three routing protocols DSR, OLSR and ZRP by using performance metrics such as throughput, packet delivery fraction, delay and load. They have concluded that the performance of DSR is the best in comparison to OLSR and ZRP for almost all of the performance metrics. DSR performance is the best considering its ability to maintain connection by periodic exchange of information.

The performance evaluation and simulation of MANET routing protocols, namely AODV, DSR, TORA and DSDV is done by Li Layuan et al [20]. They have concluded that TORA has a lowest routing load and a good scalability, it functions as the underlying protocol for the routing algorithms and provides multicast capability for smaller network, DSR routing load is

 

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moderate, in the moderate topology, it has a less loss ratio, a large throughput and a long delay, which is suitable to the medium scale network environment without higher delay demand, DSDV must maintain the entire situation information, when topology changes frequently and network size increases, the increment of routing load is very quickly, and it is not fit for large-scale and high-speed moving wireless environment and AODV which fits in all scenario shows the smallest delay and loss ratio and the greatest throughput. Its scalability, connectivity and the adaptive ability is also of relative strength.

**3. Simulation Results and Discussion: -**In this section simulation results are presented and discussed briefly. Performance is evaluated using performance metrics which are as follows.

- **Throughput: -** Throughput is the average rate of successful message delivery over a communication channel to the destination [30].
- **Retransmission: -** While delivering the data packets over network some of the packets may be lost in-between source to destination. So retransmission is the rate by which how many times the data packets are transmitted to the destination.
- **Network load**: **-** The total number of packets transmitted during the simulation over network.
- **Delay: -** It is the total time to deliver the entire message from source to destination. This includes all the possible delays caused by route discovery, retransmission delays, queuing at the interface queue, propagation time, processing time and transfer times [13].
- **Data dropped: -** Sometimes routers might be failing to deliver the packets if they arrive when the buffers of routers are already full. In this situation some, none or all the data or packets might be dropped, depending upon the state of the network, and it is impossible to determine in advance that what could happen**.**

Following are the simulation results and their discussion of the MANET routing protocols with node densities of 20, 40, 60 and 80.

## 3.1 Comparison of AODV, OLSR and ZRP with node density 20.

**3.1.1 Throughput of AODV, OLSR, ZRP in case node density 20: -** In this scenario AODV and OLSR have nearly equal throughput and behaves well as compare to ZRP till 5s of simulation time but from 5s to 60s of simulation time ZRP has performed well, finally OLSR shows better throughput from 60s till 300s of simulation time. OLSR has shown good performance than other two protocols because of its proactive nature, all the routes from a node to another node are known in advance so OLSR has not faced any problem to deliver data packets from source to destination in this small network that is why OLSR has maximum throughput than AODV and ZRP.

**3.1.2 Delay of AODV, OLSR and ZRP in case node density 20: -** Figure 6.2 shows delay caused by AODV, OLSR and ZRP in MANET. ZRP protocol has maximum and OLSR has minimum delay as compare to the considered protocols. OLSR has minimum delay because it is a proactive protocol; every node has a route list to other nodes in its cache and does not need to discover the route to destination at the time communication take place. It just selects best route from node cache and saves a lot of time which results in minimum delay.

**3.13 Network load of AODV, OLSR and ZRP in case node density 20: -** Network load by AODV, OLSR and ZRP in this scenario is illustrated in figure 6.3. AODV has minimum load and ZRP has maximum load on network as compare to the considered protocols. ZRP has maximum network load because within each zone it is active all the time. ZRP sends and receive messages for route maintenance which results in load on network, and in outer zones ZRP uses proactive strategy and uses hello messages to find route to destination which again results in load on the network.

**3.1.4 Retransmission of AODV, OLSR and ZRP in case node density 20: -** Retransmission of data packets is shown in the figure 6.4, OLSR and AODV has maximum need to retransmit data packets as compare to ZRP. Here ZRP shows good results and has minimum need to retransmit data packets because ZRP perform good for smaller network with small zones radius.

 

**3.1.5 Data dropped of AODV, OLSR, ZRP in case node density 20: -** figure 6.5 displays the average data dropped by three routing protocols. Here ZRP did not perform well at starting but after 60s of simulation time ZRP shows good results by decreasing average data drop ratio. OLSR has performed well till 150s of simulation time but after that the average data drop ratio increases with time. AODV has shown minimum and consistent data drop ratio.

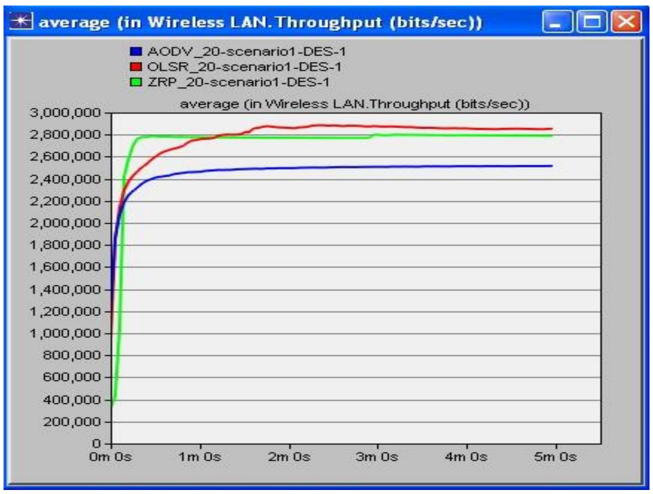


Figure 6.1 Throughput of AODV, OLSR and ZRP with respect to time with node density 20

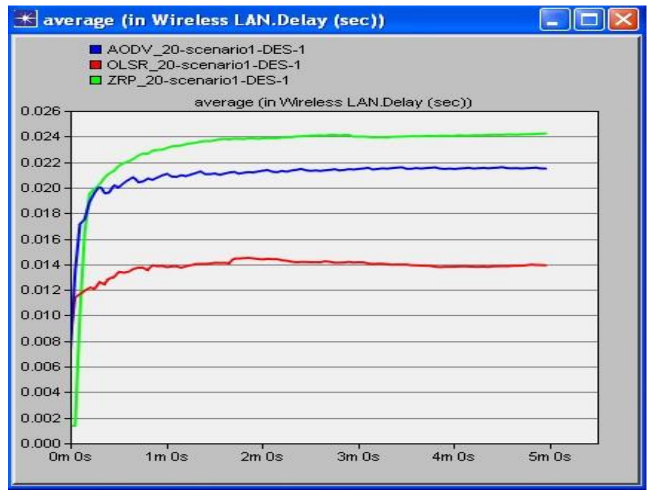


Figure 6.2 Delay of AODV, OLSR and ZRP with respect to time with node density 20

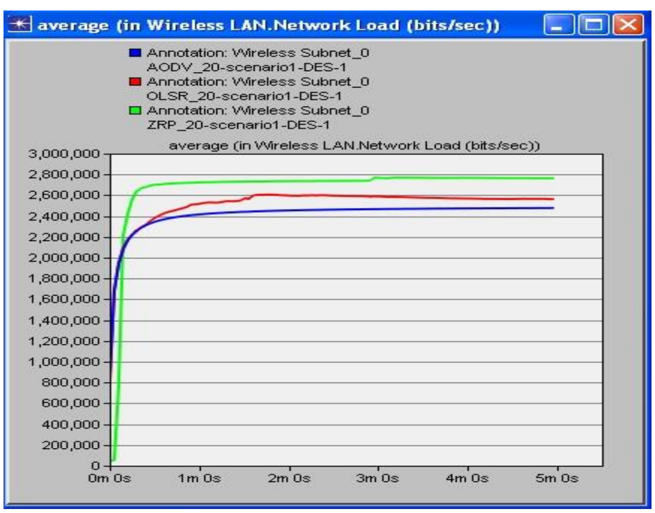


Figure 6.3 Network loads of AODV, OLSR and ZRP with respect to time with node density 20

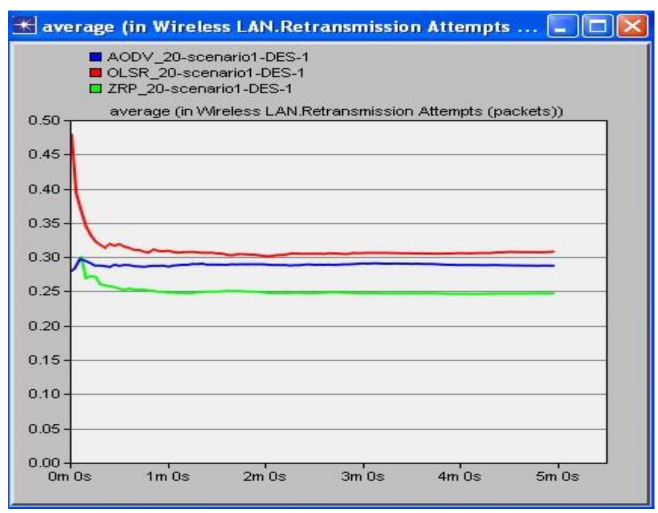


Figure 6.4 Retransmission of AODV, OLSR and ZRP with respect to time with node density 20

## 3.2 Comparison of AODV, OLSR and ZRP with node density 40.

**3.2.1 Throughput of AODV, OLSR, ZRP in case node density 40: -** Throughput of all the considered protocols is shown in figure 6.6 here throughput is maximum in case of ZRP and is minimum in case of AODV whereas OLSR gives

 

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moderate results. ZRP performs well, it maintains all the routes prior to a request because of its proactive nature within zones and create fresh route if request contain destination node outside the zone.

**3.2.2 Delay of AODV, OLSR, ZRP in case node density 40: -** Delay in the network is illustrated in the figure 6.7 here AODV shows least delay the reason for this is that it finds routes faster, the routes are shorter and more optimal.

**3.2.3 Network load of AODV, OLSR and ZRP in case node density 40: -** In figure 6.8 AODV displays least load on the network. ZRP has maximum load on the network than OLSR and AODV because the network size is large and as we increase the size of network the routing overhead for ZRP also increases and exchanges many control messages which results in load in the network, and ZRP also has highest throughput which again deliver more data packets hence results in load on network.

**3.2.4 Retransmission of AODV, OLSR and ZRP in case node density 40: -** In this scenario OLSR has maximum need to retransmission of data packets because node route entry table sometimes has old routes and data packets are directed over these old route which has broken link due to mobility of some nodes and need data packets to be retransmitted**.** AODV shows moderate results. ZRP has minimum retransmission need because ZRP perform well for small network by creating fresh route.

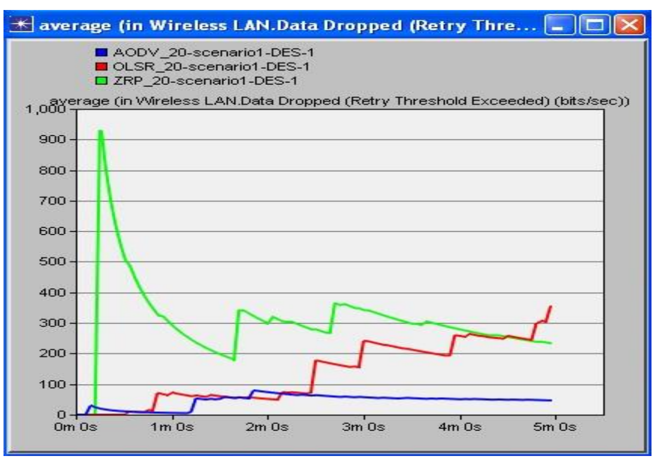


Figure 6.5 Data dropped of AODV, OLSR and ZRP with respect to time with node density 20

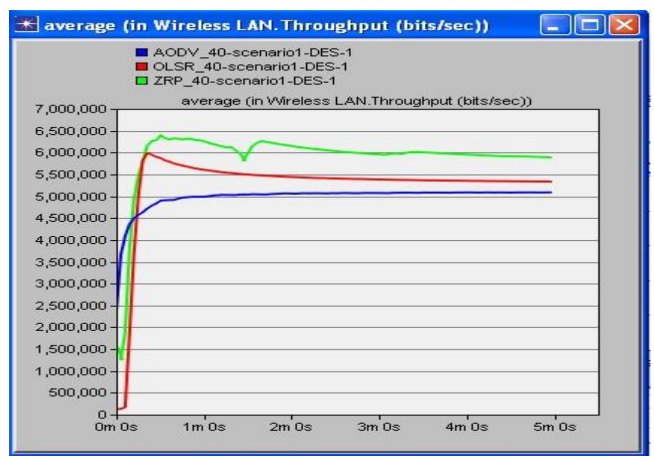


Figure 6.6 Throughput of AODV, OLSR and ZRP with respect to time with node density 40

 

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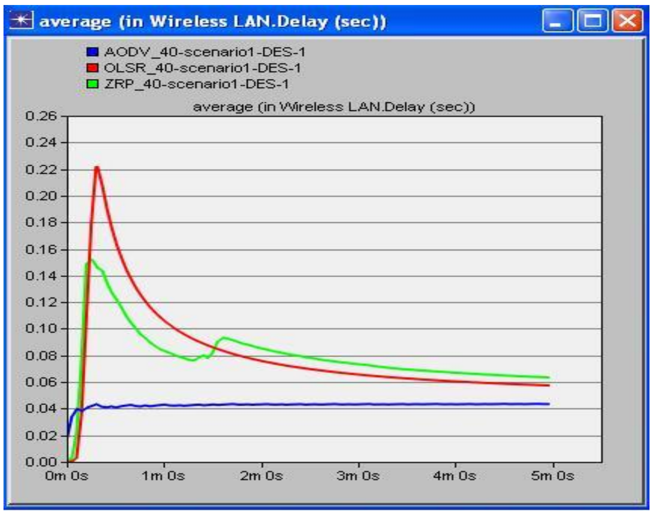


Figure 6.7 Delay of AODV, OLSR and ZRP with respect to time with node density 40

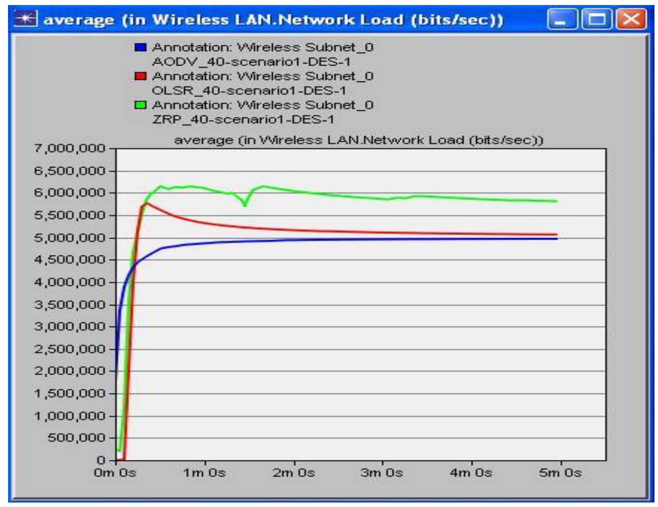


Figure 6.8 Network loads of AODV, OLSR and ZRP with respect to time with node density 40

**3.2.5 Data dropped of AODV, OLSR and ZRP in case node density 40: -** The average data drop ratio is higher for ZRP and OLSR. AODV has minimum data drop ratio because AODV create the route to destination when some source node request to transfer data, AODV finds the optimal, fresh route and avoids the busy nodes within route so that data can be successfully delivered.

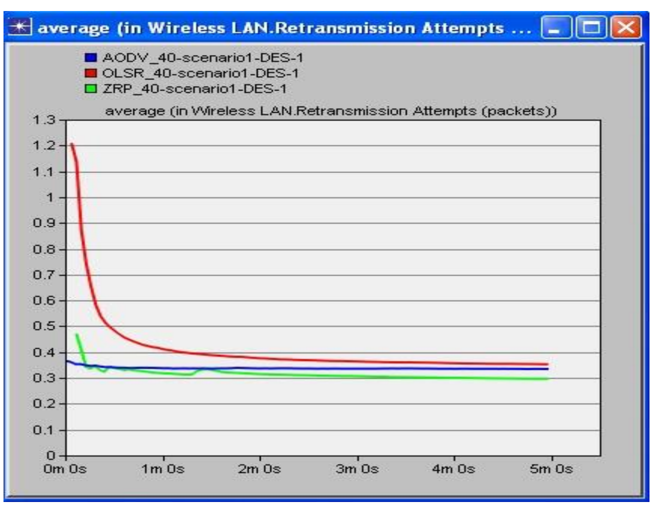


Figure 6.9 Retransmission of AODV, OLSR and ZRP with respect to time with node density 40

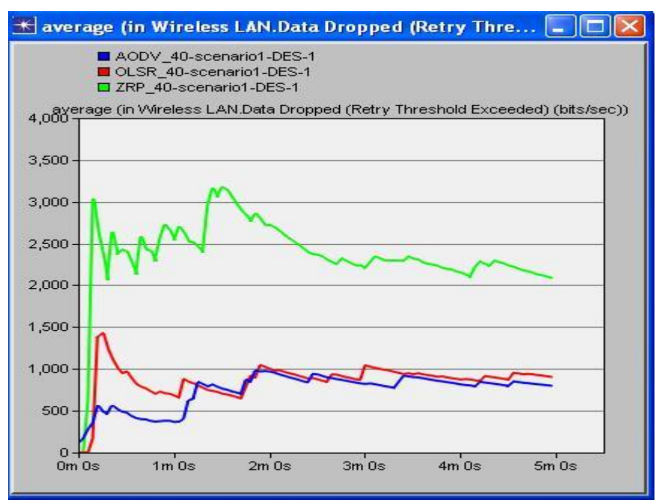


Figure 6.10 Data dropped of AODV, OLSR and ZRP with respect to time with node density 40

## 3.3 Comparison of AODV, OLSR and ZRP with node density 60.

**3.3.1 Throughput of AODV, OLSR and ZRP in case node density 60: -** In this situation OLSR has maximum throughput as compare to AODV and ZRP. Here network size is large and by increasing number of nodes routing overhead also increases but OLSR performance is better than other protocols because OLSR deliver data packets successfully at higher rate by choosing best route from number of available routes.

**3.3.2 Delay of AODV, OLSR and ZRP in case node density 60: -** Figure 6.12 displays the delay caused in the network by AODV, OLSR and ZRP. ZRP has maximum delay due to its routing overheads. ZRP suites to the medium size network with small zone radius, for larger network its extra overheads like outer zones connectivity for route creation, control messages within zones makes delay in the network. AODV and OLSR have shown good performance with minimum delay.

**3.3.3 Network load of AODV, OLSR and ZRP in case node density 60: -** Network load of all the protocols is shown in figure 6.13. OLSR has shown maximum load and AODV has shown moderate results with consistent load whereas ZRP has minimum load on the network. OLSR has maximum network load because it delivers more data packets, the nodes have high mobility which in turn results in periodic broadcast of "hello message" and Topology Control (TC) messages in order to discover neighborhood nodes. In addition, OLSR is a link state protocol which uses a table driven approach. Therefore, OLSR generates more communication overhead and takes more maintenance time which adds to the overall load in the network.

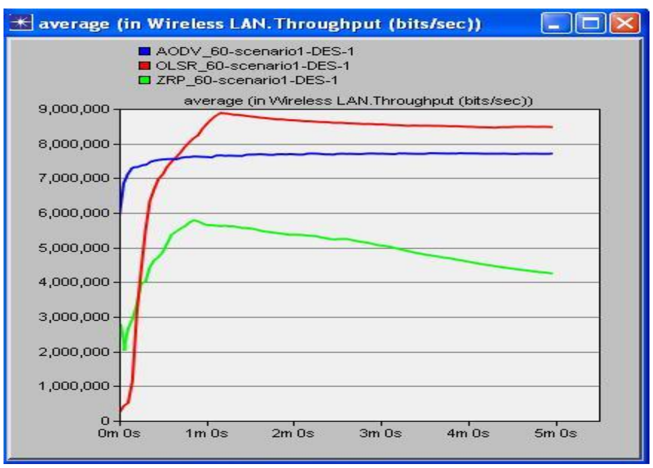


Figure 6.11 Throughput of AODV, OLSR and ZRP with respect to time with node density 60

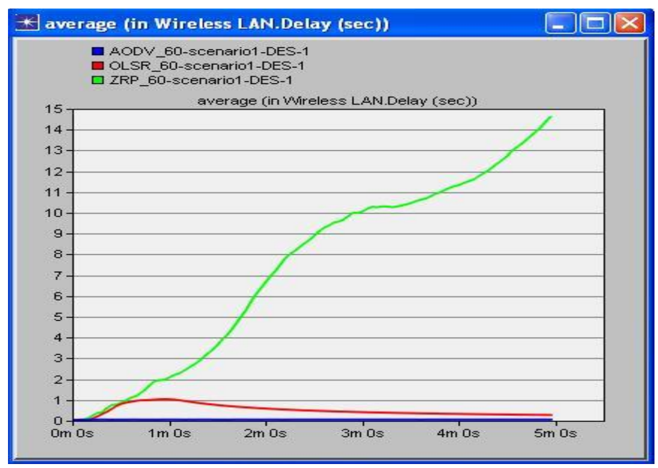


Figure 6.12 Delay of AODV, OLSR and ZRP with respect to time with node density 60

**3.3.4 Retransmission of AODV, OLSR, ZRP in case node density 60: -** Retransmission of packets by considered routing protocols is shown in figure 6.14 here AODV and OLSR shows good results than ZRP. AODV has shown best results because it is highly adaptive to topology changes than other two routing protocols and need less retransmission of packets.

**3.3.5 Data dropped of AODV, OLSR, ZRP in case node density 60: -** Data drop ratio is shown in the figure 6.15 here AODV and OLSR have good performance as compare to ZRP. ZRP has shown worst results. AODV has minimum data drop ratio than other two protocols because it uses routes intermediate nodes which have less load on them.

## 3.4 Comparison of AODV, OLSR and ZRP with node density 80: -

**3.4.1 Throughput of AODV, OLSR and ZRP in case node density 80: -**Throughput of considered routing protocols is shown in fig.6.16. It can be noticed that the throughput in the case of AODV protocol is high as compared to others. OLSR and ZRP have shown least throughput and it decreases with respect to time. ZRP has shown least throughput as compared to AODV and OLSR.

 

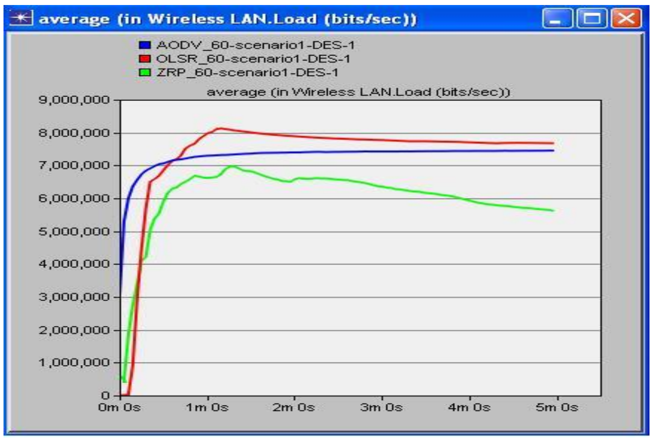


Figure 6.13 Network loads of AODV, OLSR and ZRP with respect to time with node density 60

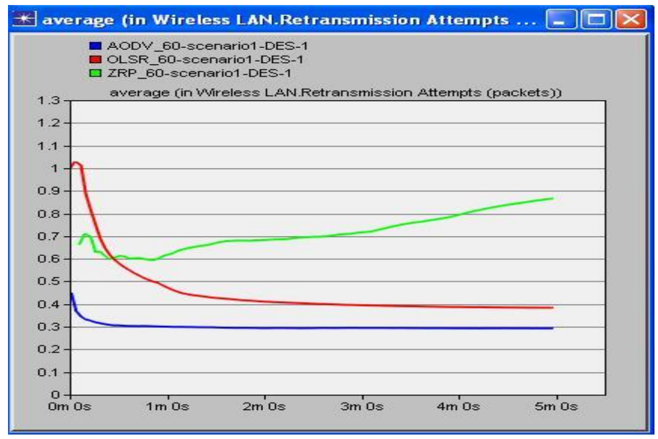


Figure 6.14 Retransmission of AODV, OLSR and ZRP with respect to time with node density 60

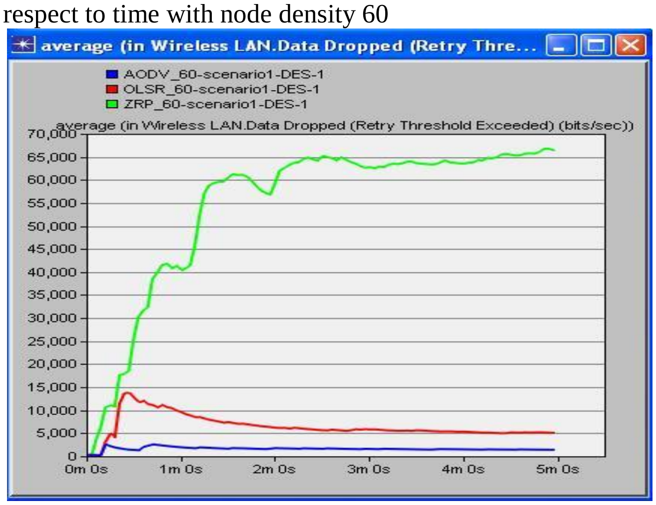


Figure 6.15 Data dropped of AODV, OLSR and ZRP with respect to time with node density 60

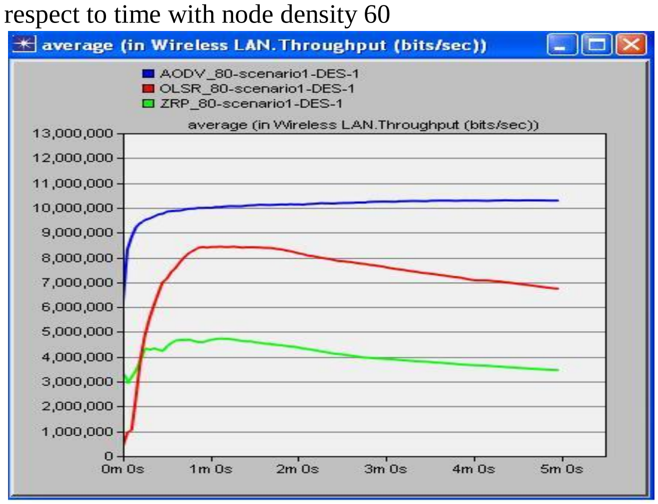


Figure 6.16 Throughput of AODV, OLSR and ZRP with respect to time with node density 80

**3.4.2 Delay of AODV, OLSR and ZRP in case node density 80: -** Fig.6.17 demonstrates the average end to end delay of the AODV, OLSR and ZRP. It is clear that ZRP has maximum delay as compare to AODV and OLSR. AODV protocol has shown minimum delay than ZRP and OLSR because once the route is created after that AODV didn't suffer from large delay.

**3.4.3 Network load of AODV, OLSR and ZRP in case node density 80: -**In Fig.6.18, network load of considered routing protocols are shown here AODV has maximum load on the network as compare to OLSR and ZRP because throughput of AODV is more which shows load on the network is due to delivery of data packets. ZRP has the minimum load on the network than the other two routing protocols.

**3.4.4 Retransmission of AODV, OLSR and ZRP in case node density 80: -**Fig.6.19 demonstrate the retransmission need of considered protocols, the rate of retransmission of data packets is high in case of ZRP as compare to

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other two routing protocol and is lower for the AODV routing protocol as compared with the OLSR and ZRP. Retransmission of data packets is low for AODV because it uses fresh routes.

**3.4.5 Data dropped of AODV, OLSR and ZRP in case node density 80: -** The data dropped is displayed in the Fig.6.20. AODV perform well with minimum data dropped in the network because AODV selects route with intermediate nodes having large buffer size and low load. The other two routing protocols OLSR and ZRP have higher data drop rate compared to AODV.

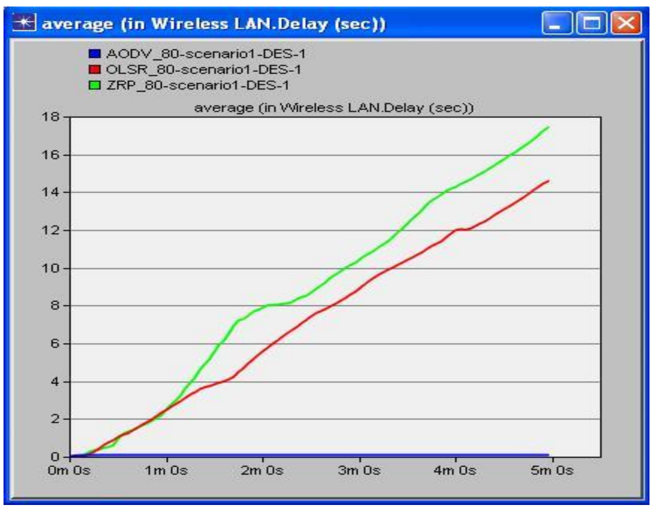


Figure 6.17 Delay of AODV, OLSR and ZRP with respect to time with node density 80

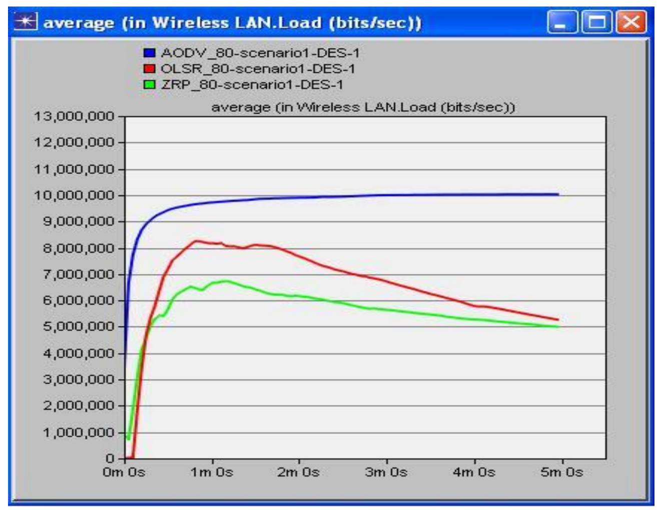


Figure 6.18 Network loads of AODV, OLSR and ZRP with respect to time with node density 80

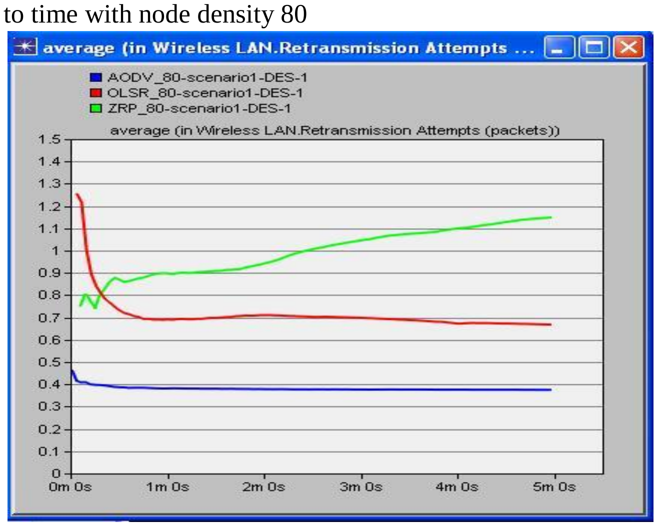


Figure 6.19 Retransmission of AODV, OLSR and ZRP with respect to time with node density 80

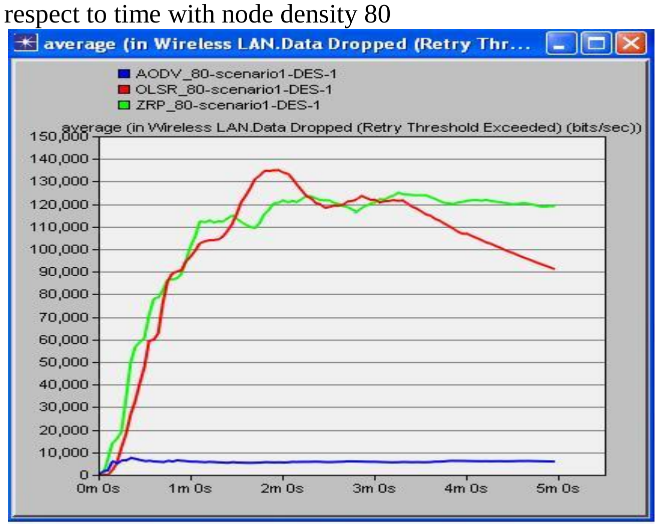


Figure 6.20 Data dropped of AODV, OLSR and ZRP with respect to time with node density 80

**4. Conclusion and Future Scope: -** In the first scenario (20 nodes), AODV protocol showed good performance for data dropped. However, OLSR showed better performance for throughput, delay and network load. Finally, ZRP showed good performance for retransmission of data packets.

In the second scenario (40 nodes), AODV protocol showed good performance for delay, and data dropped. However, OLSR showed moderate results for all the performance metrics. Finally, ZRP showed good performance for throughput, network load and retransmission of data packets.

In the third scenario (60 nodes), AODV protocol showed good performance for delay, retransmission, data dropped and throughput. However, OLSR showed good performance for throughput and network load. Finally, ZRP showed worst performance for all performance metrics.

In the fourth scenario (80 nodes), AODV protocol showed good performance for all of the performance metrics. However, OLSR showed moderate results for all performance metrics. Finally, ZRP showed worst results for all performance metrics.

From the above results of four scenarios it can be easily concluded that OLSR, ZRP and AODV have performed well for small (20 nodes), medium (40 nodes) and large (60-80 nodes) networks respectively.

While in this research work we have evaluated the performance of routing protocols in MANET with maximum 80 nodes, further research can be done to investigate the performance of routing protocols by considering larger network size and other performance metrics.

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