Ariel University
The Faculty of Natural Sciences
The Department of **Computer Science**

Performance Analysis Protocols Comparison In MANET

Or Shemesh, Benyamin Darmoni, Oranit Cohen, Sapir Gofshtein, Karin Aharon

Under the supervision of
Dr. Amit Dvir and Aviram Zilberman

October 2020

Ariel University
The Faculty of Natural Sciences
The Department of **Computer Science**

Performance Analysis Protocols Comparison In MANET

Or Shemesh, Benyamin Darmoni, Oranit Cohen, Sapir Gofshtein, Karin Aharon

A final project submitted in partial fulfillment of the requirements
for the degree Bachelor of Science (B.Sc.)

Under the supervision of
Dr. Amit Dvir and Aviram Zilberman

Signature of student: ______________ Date: ______________
Signature of supervisor: ______________ Date: ______________
Signature of chairperson of the
committee for graduate studies: ______________ Date: ______________

October 2020

Abstract

In this project we compared 3 different routing protocols: DSR, OLSR and AODV. We created 6 different topologies and performed packets between several pairs of vertices in each topology with varying number of nodes. We compared the results obtained per topology and per protocol and drew conclusions which protocol has the best performance. We also presented the various simulations using by ns-3 simulator and the Netanim tool.

Contents

List of Figures

1 Manet

MANET stands for Mobile adhoc Network also called as wireless adhoc network or adhoc wireless network that usually has a routing networking environment on top of a Link Layer ad hoc network. They consist to set of a mobile nodes connecter wirelessly in a self configured self healing network without having a foxed infrastructure. MANET node are free to move randomly as the net work topology changes frequently. Each node behaves as a router as they forward traffic to other.

Types of MANET

1) Vehicular Ad hoc Network (VANET) Enable effective communication with another vehicle of roadside equipment.

2) Smart Phone Ad hoc Network (SPANC) Creating peer to peer network without relying on cellular networks, wireless access points.

3) Internet based Mobile Ad hoc Network (iMANET) Internet protocols such as TCP/UDP and IP . To link mobile nodes and establish routes distributed and automatically.

4) Military or Tactical MANET This used by the military units. Use for example UAV (Unarmed Aerial Vehicle) Fast re routing during mobility radio range etc.

5) Flying Ad hoc Network (FANET) UAV (Unarmed Aerial Vehicle) Fast re routing during flying (drone)

Advantages of MANET

1) Router free Connection to internet without any wireless router is the main advantage of using a mobile ad hoc network. Because of this running

an ad hoc network can be more affordable than traditional network.

2) Fault Tolerance MANET supports connection failures because routing and transmission protocols are designed to manage these situations.

3) Mobile Ad hoc Network is a collection of autonomous and mobile elements such as laptops smartphone etc.

4) The mobile nodes can dynamically self-organize in arbitrary temporary network topology.

2 Routing protocols

The Routing Protocols in MANET

The routing protocols are available in MANET which defines the routes and transport the packets in the nodes, that in from node x to node y (for example). Various routing protocols have been proposed in MANET. The are three main types of routing protocols in MANET, Proactive Reactive and Hybrid routing protocols

1) Proactive routing protocol: Also known as Table driven routing protocols. Each mobile node maintains a separate routing table which contains the information of the routes to all possible destinations. Since the topology in the mobile ad-hoc network is dynamic, these routing tables updated periodically as and when the network topology changes. (OLSR)

2) Reactive routing protocol Also known as on demand routing protocol. In this type of routing, the route os discovered when it is required or needed. The process of route discovery occurs by flooding the route request packets throughout the mobile network. It consist of two major phases named: route discovery - (Most optimal path) and route maintenance (AODV, DSR)

3) Hybrid routing protocol: The combination of the advantages of both reactive and proactive routing protocols These protocols are adaptive in nature and adapts according to the zone and position of the source and destination mobile nodes. (most common ZRP – Zone routing protocols : the whole network divided to different zone and the position of the source and destination is observed. If the source and destination in the same zone we will used proactive otherwise we will use reactive.

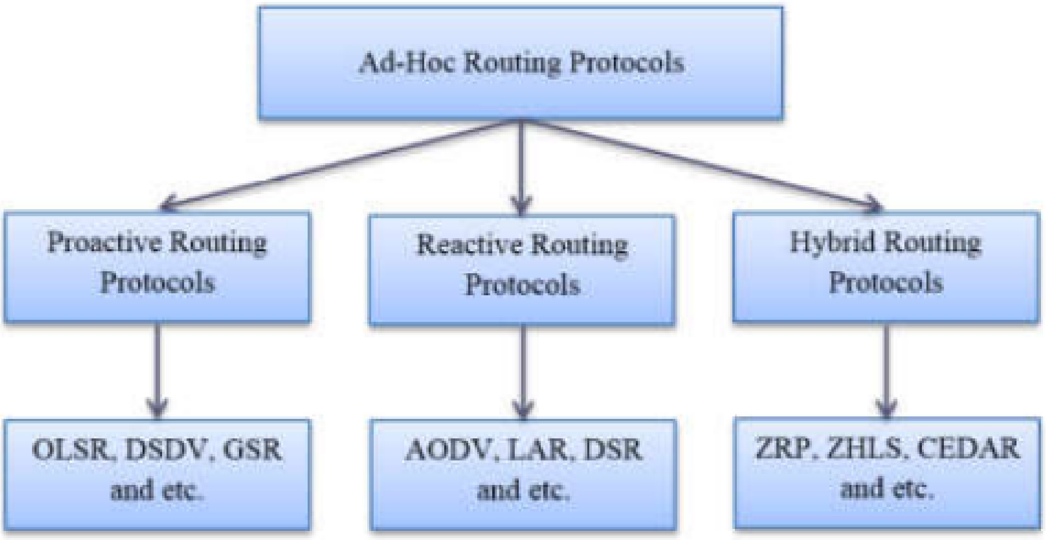

Figure 2.1: routing protocols

3 Security in Manet

An Overview of Security in MANET.

MANET often suffer from several security attacks because of its features like open medium, changing its topology dynamically, cooperative algorithms, , lack of central monitoring and management and no clear defense mechanism. These factors have changed the battle field situation for the MANET against the security threats.

Major vulnerabilities which have been so far researched are mostly these types which include selfishness, dynamic nature, and severe resource restriction and also open network medium. MANET work without a centralized administration where node communicates with each other on the base of mutual trust. This characteristic makes MANET more vulnerable to be exploited by an attacker from inside the network. Wireless links also makes the MANET more susceptible to attacks which make it easier for the attacker to go inside the network and get access to the ongoing communication . Mobile nodes present within the range of wireless link can overhear and even participate in the network.

Flaws in MANETS MANETs are very flexible for the nodes i.e. nodes can freely join andleave the network. There is no main body that keeps watching on the nodes entering and leaving the network. All these weaknesses of MANETs make it vulnerable to attacks.

CLASSIFICATION OF ATTACKS- External and Internal Attack , Active and Passive Attack , Warmhole Attack , Rushing Attack: An Active Attack, Gray Hole Attack , Jellyfish Attack , Modification Attack and more.

Each of these attacks has many defense methods, one of the defenses we tried to simulate is by Secret sharing.

Secret sharing - A secure secret sharing scheme distributes shares so that anyone with fewer than t shares has no more information about the secret than someone with 0 shares.

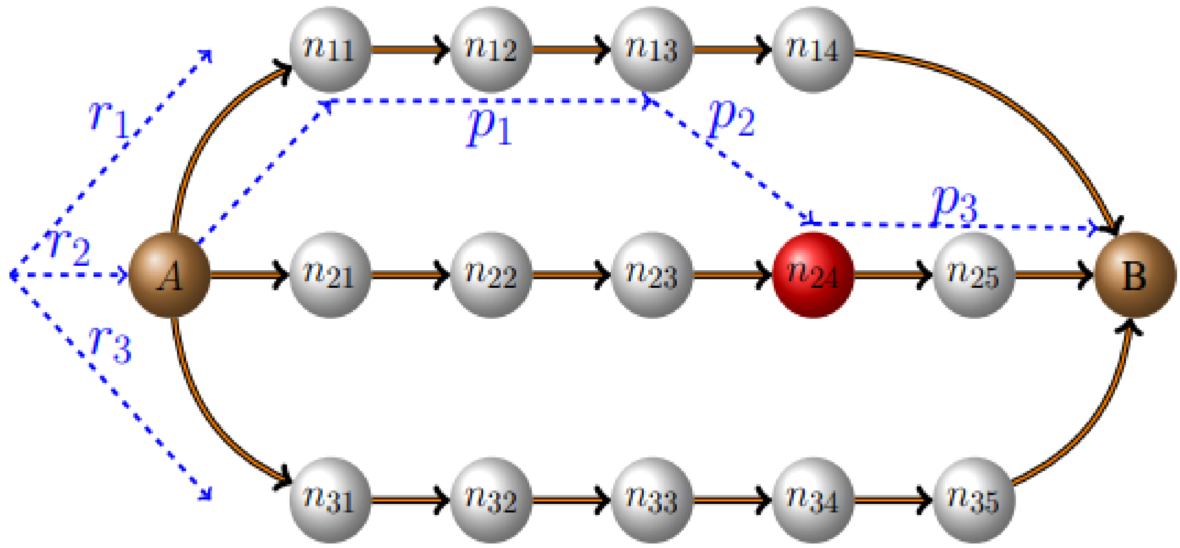

Figure 3.1: security in MANET

4 DSR protocol

A Dynamic Source Routing.
A reactive routing protocol used in MANET. The routes for a packet are discovered only when a node wants to send a packet. To send a message, the source node begins a routing process with 3 phases: route request, route response and packet transmission.

How it works?

This protocol is based on routing sources whereby all routing information is stored at the mobile nodes and is constantly updated. There are two main steps: discovering and maintaining the routes. The routing response will be generated only if the message has reached the intended destination node. In fact, this protocol creates routes by flooding route request message on the network. The destination node, in receiving the route request message, responds by sending the route reply packet back to the source node, which holds the route that the received route request packet passes.

To determine the route of the source node and in to create a routing, the addresses of all the nodes between the source node and the destination node must be accumulated in the packets routed during route discovery. This can cause high overhead for long routes or large addresses, such as IPv6.

When there is a source node that has no route to the destination node, it initiates a route request message. This route request is flooded across the network. Each node, upon receipt of the route request packet, re-transmits the packet to its neighbors if it has not forwarded it already.

Each route request has a sequence number created by the source node and the traversed route. Upon receipt of the route request packet, each node checks the sequence number in the packet before passing it on. The sequence number in the packet is used to prevent loop formation and to prevent multiple transmissions of the same route request by an intermediate node which receives it in multiple routes.

Advantages and Disadvantages

This protocol uses a responsive approach which means it does not flood the network with table update messages. Only when it is necessary to find a route the routing process start and therefore there is no need to find routes to all the other nodes in the network. Intermediate nodes also use the information in the cache which reduces overhead. The disadvantage of this protocol is that the route maintenance mechanism does not repair a locally broken link.

5 AODV protocol

A reactive routing protocol used in MANET.
It is designed to be self-starting in an environment of mobile nodes, withstanding a variety of network behaviors such as node mobility, link failures and packet losses.
At each node, AODV maintains a routing table. The routing table entry for a destination contains three essential fields: a next hop node, a sequence number, and a hop count.

How it works?

The source node requests a route to the destination by sending a route request message to all its neighbors. When a node receives a route request message but does not have a route to the desired destination, it forwards the route request message. Also, it remembers a reverse-route to the requesting node which can be used to forward subsequent responses to this route request. This process repeats until the route request reaches a node that has a valid route to the destination. This node responds with a route reply message. This route reply message is uni-cast along the reverse-routes of the intermediate nodes until it reaches the original requesting node. Thus, at the end of this request-response cycle a bidirectional route is established between the requesting node and the destination.

Advantages and Disadvantages

AODV responds very quickly to the topological changes affecting active routes, thanks to its ability to adapt to highly dynamic networks. In addition, it supports both single-packet and multi-broadcast packets, even for constantly moving nodes. AODV has a lower installation delay for connections and identifying the last route to the destination. When a link break occurs, many control packets are created. These control packets increase the congestion in the active route. It has a high demand for processing and needs a large portion of the bandwidth. It takes a long time to build a routing table. As the network size increases, various performance metrics begin to decline.

6 OLSR protocol

A proactive routing protocol used in MANET.
The OLSR protocol is an enhancement of the LSR protocol.

LSR

In this protocol each node functions as a network router. The basic principle is to build a map in the form of a graph which describes the connections in the network. Each node independently computes the next best step to reach the destination. Each collection of the best routes creates a routing table. Initially each node sends to all its neighbors in flooding the network status for it, to whom it is connected, once the node has received a message it has already seen, it does not forward it again. Thus, all nodes send messages until all nodes receive the network image of all nodes, and from this information they build a complete snapshot of the network. To find a route to another node, the source node uses the Dijkstra algorithm to find the shortest route to it until a routing table is completed. The problem with this method, is that there are too many duplicate messages sent on the network and this is what the OLSR protocol comes to improve.

How OLSR works?

Each node chooses from its neighbor's nodes that will do the flooding for it, these nodes are called MPR nodes - multi point relay. Only these nodes can relocate packets. First select the nodes that are one hops away and cover isolated nodes, then select from the unselected nodes one that covers the maximum of nodes in 2 hops until all neighbors in 2 hops are covered. There are 2 types of packets in this protocol: Hello packets- Each node sends these messages to its neighbors in broadcast. The messages contain the information about the neighbors in one hop and their connection status. In addition, they contain the addresses of the neighbors with whom the same node has a 2 hops connection, and a list of the addresses of the nodes that can hear the same node. Topology Control Packets- Each MPR node holds a table of the nodes that selected it, and in TC messages it transmits this information. And so, each node that receives this message builds a topology table based on the information it received in the message.

Advantages and Disadvantages

OLSR has less average end to end delay therefor its used for applications which need minimum delay. It does not require the link is reliable for the control messages, since the messages are sent periodically and the delivery does not have to be sequential. OLSR Maintain the routing table for all the possible routes. When the number of mobile hosts increases, then the overhead from the control message also increases. OLSR need considerable time to re-discover a broken link. It requires more processing power than other protocols when discovering an alternate route.

7 NS-3

The ns-3 simulator is a discrete-event network simulator targeted primarily for research and educational use. The ns-3 project, started in 2006, is an open-source project developing ns-3.

ns-3 has been developed to provide an open, extensible network simulation platform, for networking research and education. In brief, ns-3 provides models of how packet data networks work and perform, and provides a simulation engine for users to conduct simulation experiments. Some of the reasons to use ns-3 include to perform studies that are more difficult or not possible to perform with real systems, to study system behavior in a highly controlled, reproducible environment, and to learn about how networks work. Users will note that the available model set in ns-3 focuses on modeling how Internet protocols and networks work, but ns-3 is not limited to Internet systems; several users are using ns-3 to model non-Internet-based systems.

Many simulation tools exist for network simulation studies. Below are a few distinguishing features of ns-3 in contrast to other tools.

ns-3 is designed as a set of libraries that can be combined together and also with other external software libraries. While some simulation platforms provide users with a single, integrated graphical user interface environment in which all tasks are carried out, ns-3 is more modular in this regard. Several external animators and data analysis and visualization tools can be used with ns-3. However, users should expect to work at the command line and with C++ and/or Python software development tools. ns-3 is primarily used on Linux or macOS systems, although support exists for BSD systems and also for Windows frameworks that can build Linux code, such as Windows Subsystem for Linux, or Cygwin. Windows users may also use a Linux virtual machine. ns-3 is not an officially supported software product of any company.

In our project we developed the ns-3 system in the programming language c ++ and python , And we used the “Netanim” tool to simulate the networking system we wanted to simulate.

8 Previous work

8.1 A. A Comparative Performance Analysis Of Routing Protocols in MANET using NS3 Simulator, Published online in MECS, on March 2015, by Rakesh Kumar Jha and Pooja Kharga

Rakesh Kumar Jha and Pooja Kharga wrote this article about routing comparison of protocols in MANET in 2015. They compare 3 Protocols - AODV, DSDV, and OLSR. Initially, Jha and Kharga intended to analyze the DSR protocol as well, but it was not yet developed properly in NS3 at the time, so they performed the simulation on the other protocols. After explaining about these protocols in MANET and about NS3, they examine the performance of each protocol, such as throughput, packet delivery ratio and End to end delay. They used different number of nodes and reached the conclusion that OLSR was better in packet delivery ratio then AODV. Regarding End to end delay, They showed that with different number of nodes, OLSR has not changes it's behavior much, and has the lowest delay, while DSDV had the highest delay that increased as the number of nodes increased. In addition, their simulation resulted in higher throughput for AODV protocol, and low packet dropped number for OLSR. With these results, they concluded that AODV's performance was superior with varying nodes for throughput, and OLSR gives better results in packet delivery ratio, packet dropped and end to end delay.

8.2 B. Performance Comparison of AODV, DSDV, OLSR and DSR Routing Protocols in Mobile Ad Hoc Networks by S. A. Ade1 P.A. Tijare2

First, the researchers compare the properties of the protocols and then their Performance.
Properties: in figure 8.1

Large Performance results:

Packet Delivery Fraction (PDF): As we know, PDF is the ratio between the numbers of packets originated by the application layer sources and the number of packets received at the destination. In this article it was found that in terms of packet delivery ratio, DSR performs well when the number of nodes is less as the load will be less. However, its performance declines with increased number of nodes due to more traffic in the network. The performance of DSDV is better with a greater number of nodes than in comparison with the other two protocols. The performance of AODV is consistently uniform.

Average End to End Delay Result: As we know, the delay is affected by high rate of CBR packets as well. The buffers become full much quicker, so the packets must stay in the buffers a much longer period before they are sent. This can be seen at the DSR routing protocol when it was reach around 2400 packets at the 0 mobility. For average end-to-end delay, the performance of DSR and AODV are almost uniform. However, the performance of DSDV is degrading due to increase in the number of nodes the load of exchange of routing tables becomes high and the frequency of exchange also increases due to the mobility of nodes. Number of Packets Dropped: The number of data packets that are not successfully sent to the destination. In terms of dropped packets, DSDV's performance is the worst. The performance degrades with the increase in the number of nodes. AODV and DSR performs consistently well with increase in the number of nodes.

CONCLUSION: This paper does the realistic comparison of three routing protocols DSDV, AODV and DSR. As expected, reactive routing protocol AODV performance is the best considering its ability to maintain connec-

Table 1

Protocol Property	DSDV	DSR	AODV	OLSR
Multicast Routes	No	Yes	No	Yes
Distributed	Yes	Yes	Yes	Yes
Unidirectional Link Support	No	Yes	No	Yes
Multicast	No	No	Yes	Yes
Periodic Broadcast	Yes	No	Yes	Yes
QoS Support	No	No	No	Yes
Routes Maintained in	Route Table	Route Cache	Route table	Route table
Reactive	No	Yes	Yes	No

Figure 8.1: Artical B

tion by periodic exchange of information, which is required for TCP, based traffic. AODV performs predictably. Delivered virtually all packets at low node mobility and failing to converge as node mobility increases. Meanwhile DSR was very good at all mobility rates and movement speeds and DSDV performs almost as well as DSR, but still requires the transmission of many routing overhead packets. At higher rates of node mobility, it is more expensive than DSR. Compared the On-Demand (DSR and AODV) and Table-Driven (DSDV) routing protocols by varying the number of nodes and measured the metrics like end-end delay, dropped packets, As far as packet delay and dropped packets ratio are concerned, DSR/AODV performs better than DSDV with large number of nodes. Hence for real time traffic AODV is preferred over DSR and DSDV. For a smaller number of nodes and less mobility, DSDV's performance is superior.

8.3 C. Performance Evaluation of AODV, DSR, OLSR, and GRP MANET Routing Protocols Using OPNET, by Adel Aneiba and Mohammed Melad

In this article, four protocols were analyzed: AODV, OLSR, DSR, GRP to evaluate and validate their implementation. The first two protocols were selected from a proactive category (OLSR, GRP) and the other two were selected from the responsive category (DSR, AODV).

In this article, experiments and simulations were performed and the 4 protocols were examined in different scenarios using the OPNET simulation tool. OPNET provides serval MANET routing protocol models which are integrated with IP and wireless LAN models.
An evaluation process was performed which is based on the rate of FTP (high load) traffic and by increasing the number of nodes in different scenarios to evaluate the performance of each protocol. The performance was analyzed using 2 performance metrics delay and throughput. Delay (seconds): This is the ratio of the time difference between each packet sent and received to the total time difference over the total number of packets received. Throughput - is defined as the total ratio of data coming to the receiver from the sender. The time it takes for the recipient to receive the last message. Output is expressed in bytes or bits per second.

Two main scenarios were made, one for 20 nodes, and the other for 80 nodes. Both scenarios were used to evaluate the performance of the 4 protocols with a different number of users with heavy FTP traffic. The simulation time was set to be 3600 seconds for each scenario. In this simulation random waypoint mobility was used as a model for a simulation exercise. Using random mobility, shows more behavior, good mobility and it was easy to use. 100 m / s was used as a constant speed of movement of mobile nodes until these nodes reached their destination. 200 seconds were used as "pause time" and then a new destination was searched and selected randomly. Scenario A investigated how these four MANET routing protocols behave under heavy FTP traffic with respect to delay and throughput for 20 nodes, and scenario B explored the same but for 80 nodes.
Experimental results
OLSR had the smaller delay while AODV was very similar to OLSR, whereas

GRP had a moderate delay compared to DSR which had the highest delay than the rest of the routing protocols. Conclusion: OLSR has the lowest latency and performs better than any other protocol. AODV has a smaller delay than DSR while GRP and OLSR have the lowest delay and there are small differences between them. It was found that OLSR is the best protocol during the delay after that GRP and OLSR. According to the 20-node scenario and tthroughput, the OLSR had the highest output, while DSR had the lowest output. This result clearly shows that OLSR surpasses the other protocols. According to the 80 nodes scenario again OLSR has the highest throughput, followed by AODV then GRP and the protocol with the lowest throughput is DSR for this scenario.
conclusion
OLSR is the best protocol for all scenarios during delay and throughput simulations for 20 and 80 nodes. The 4 experiments yielded similar results. OLSR protocol is better at reducing the delay compared to the other protocols and this is s due to the working mechanisms of the OLSR over the other protocols, which lead to a speeding-up of the content delivery process. This can be attributed to the fact that OLSR uses MPR to reduce network overhead. OLSR can be considered as the best protocol in terms of bandwidth utilization.

9 Experiments

In this project, we test the performance of DSR, AODV and OLSR in different topologies and different number of nodes.
The topologies were lines, grid, square, circle, circle with line, random, and random with mobile nodes.
All the topologies were for non-mobile nodes, except the topology of the random with mobile nodes. In each experiment, we tested 50, 70, or 100 nodes.
The time for each simulation is 30 seconds, and there were 10 coupled of sending and receiving nodes, with each sending node sending 70 packets. To avoid randomization, each experiment was tested 3 times, and the results are the average of the three experiments and the 10 nodes.

Output Data Analysis We examine the following output: 1. Packet Receive Ratio = the number of packets received/packets sent. 2. End to End delay = Delay Sum / Received packets. 3. Throughput = (Received Bytes*8)/(simulation time * 1024*1024) 4. Number of packets lost.

We compared the results in two ways -

The first one - for each output, we compare the performance between the three protocols for each topology and for each number of nodes - 50, 70 or 100. The second way - for each output and protocol, we compare between different topologies for the same protocol for 50 nodes only.
In that way, we can analyze the influence of the topology on the performance, and how each protocol deals with each topology.

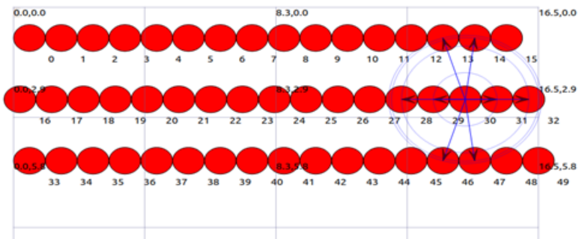

Figure 9.1: Lines topology

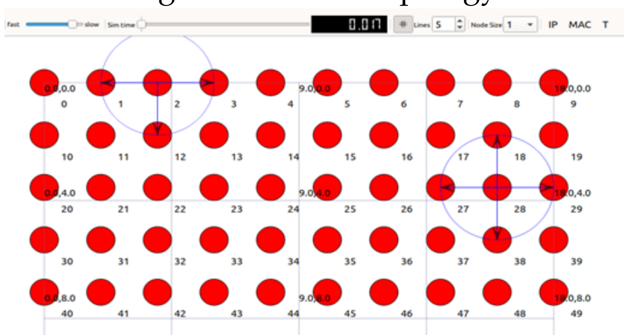

Figure 9.2: Grid topology

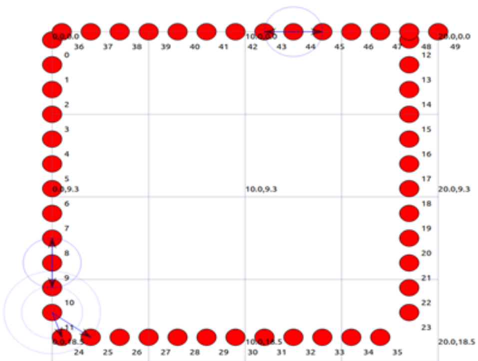

Figure 9.3: Square topology

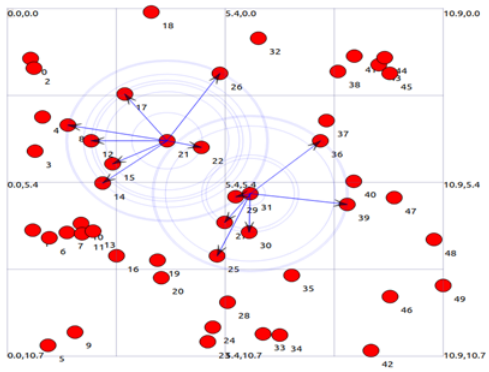

Figure 9.4: Random, and random mobile topology

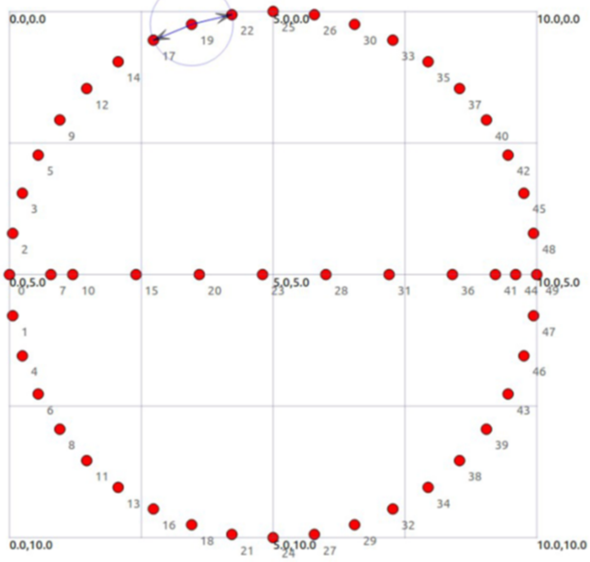

Figure 9.5: Circle with line topology

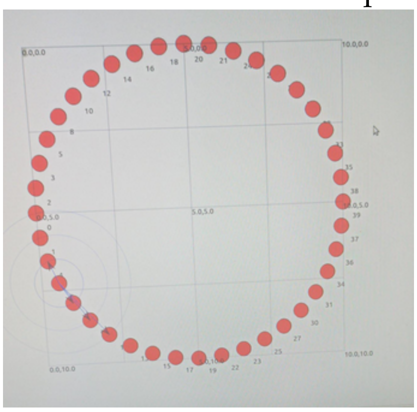

Figure 9.6: Circle topology

10 Insights

Topology Comparison

Square topology:

As we can conclude from figure 10.1 The throughput of the OLSR protocol in Square topology is the lowest . we can see that in AODV and DSR protocol acting we the same with all number of the nodes. number does not affect it.

figure 10.2 shows us the time per packets in seconds, the OLSR protocol takes the longest time on average to send a package, AODV and DSR protocols show fast performance for sending a packet on average.

figure 10.3 shows us the packet loss for the 3 protocols OLSR protocol loses the highest number of messages especially in 70 vertices, In contrast, it can be seen that the AODV protocol packet loss I much lower but also like OLSR the largest lost is in 70 vertices. The DSR protocol in terms of message loss is stable, and it loses the least number of messages.

In square topology with the previous graphs, we can see that the highest number of messages coming is in the DSR protocol then in AODV and finally in the OLSR protocol. That have direct reason for figure 4.4, That show us that the DSR protocol received the highest thank AODV and then OLSR.

Figure 10.5 we can see the delay of the DSR and AODV protocols is low compare to the result we see in OLSR , DSR again is the lowest than AODV and then OLSR, that his result is significantly higher relative to the other protocols.

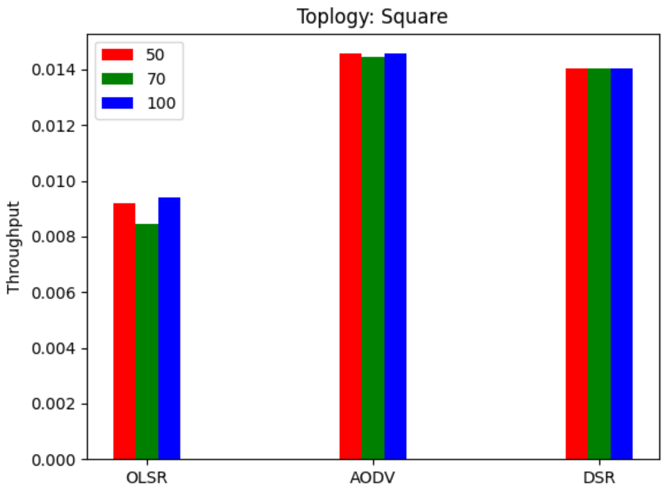

Figure 10.1: Square topology throughput

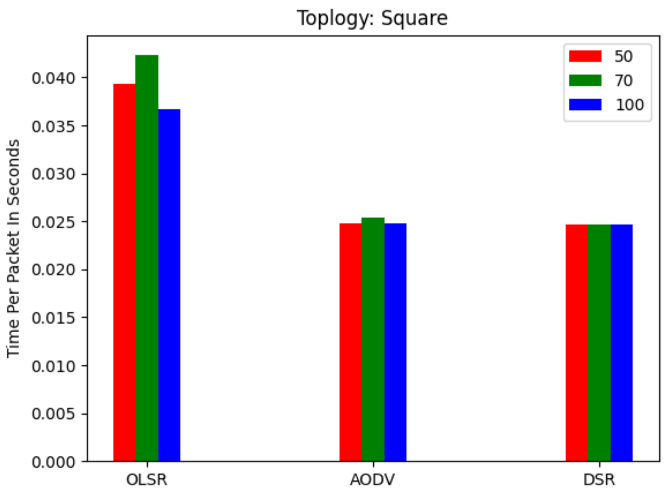

Figure 10.2: Square topology Time per packet in second

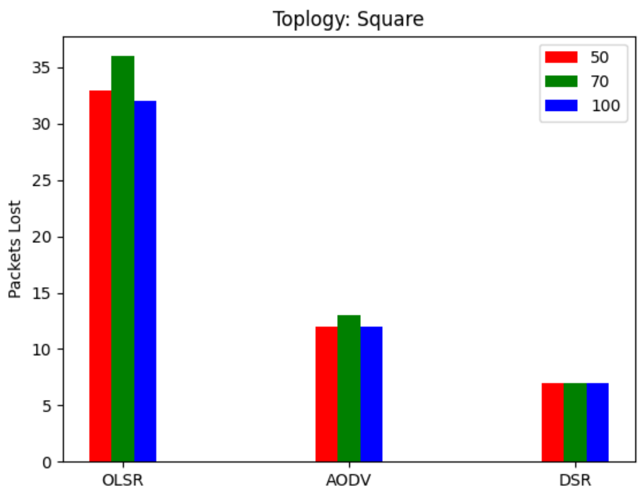

Figure 10.3: Square topology packets lost

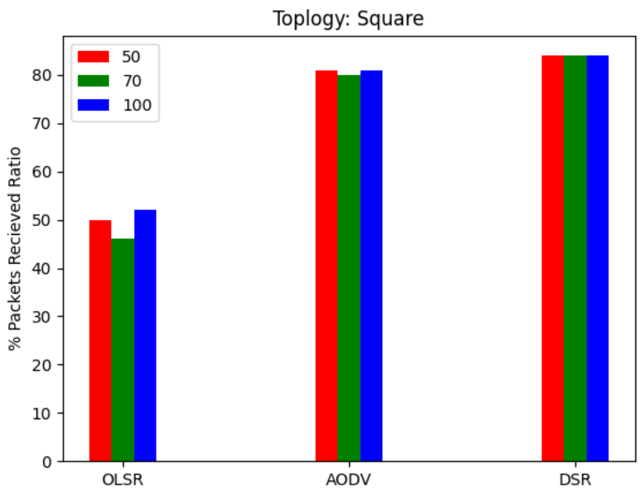

Figure 10.4: Square topology ratio

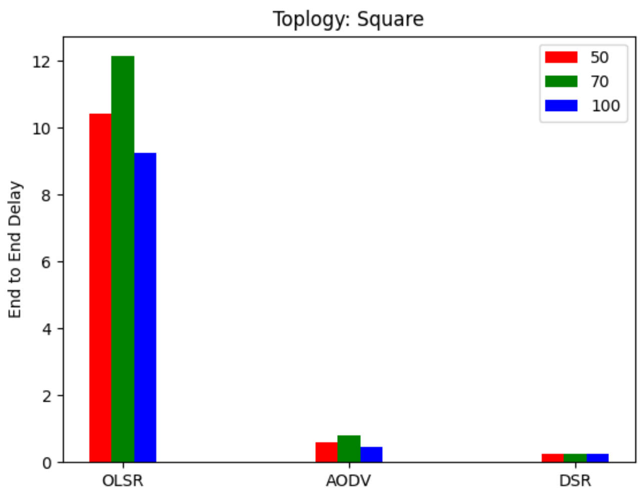

Figure 10.5: Square topology end to end delay

Random topology: As we can conclude from figure 10.6, The throughput of the OLSR protocol in Random topology is the lowest especially in 50 vertices. We can see that in AODV that when number of vertices increase the throughput getting larger DSR protocol acting the same with all number of the vertices.

In figure 10.7 we can see the delay of the DSR and AODV protocols is low compare to the result we see in OLSR , DSR again is the lowest than AODV and then OLSR, that his result is significantly higher relative to the other protocols.

Figure 10.8 shows us the packet los for the 3 protocols OLSR protocol loses the highest number of messages especially in 70 vertices, In contrast, it can be seen that the AODV protocol packet loss I much lower , the largest lost is in 50 vertices, but yes lower than OLSR . The DSR protocol in terms of message loss is stable, and it loses the least number of messages.

figure 10.9 shows us the time per packets in seconds, the AODV protocol takes the longest time on average to send a package with 50 vertice, OLSR takes the longest in general. DSR protocols show fast performance for sending a packet on average.

In Random topology with the previous graphs, we can see that the highest number of messages coming is in the DSR protocol then in AODV and finally in the OLSR protocol. That have direct reason for figure 10.10 That show us that the DSR protocol received higher than AODV and then OLSR.

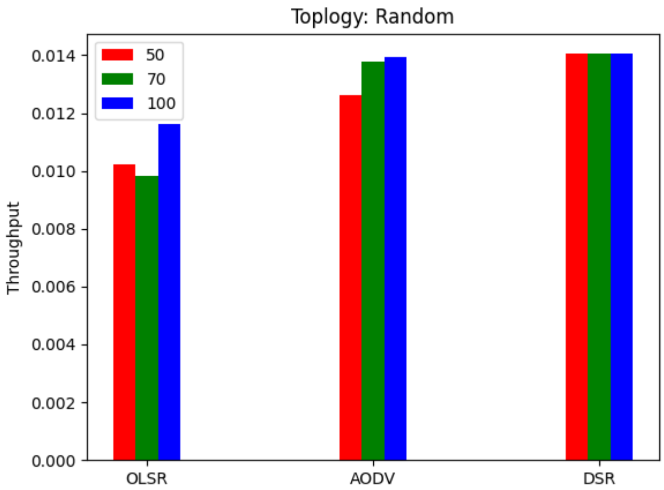

Figure 10.6: Random topology throughput

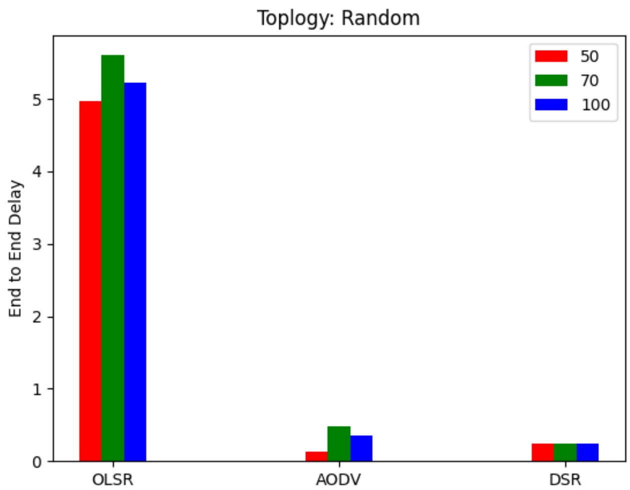

Figure 10.7: Random topology end to end delay

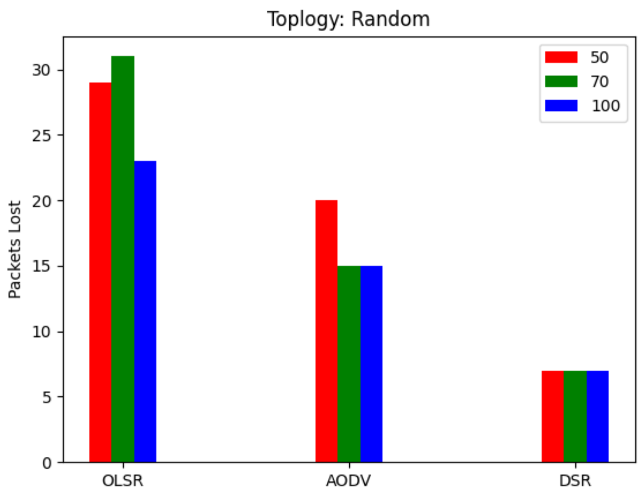

Figure 10.8: Random topology packets lost

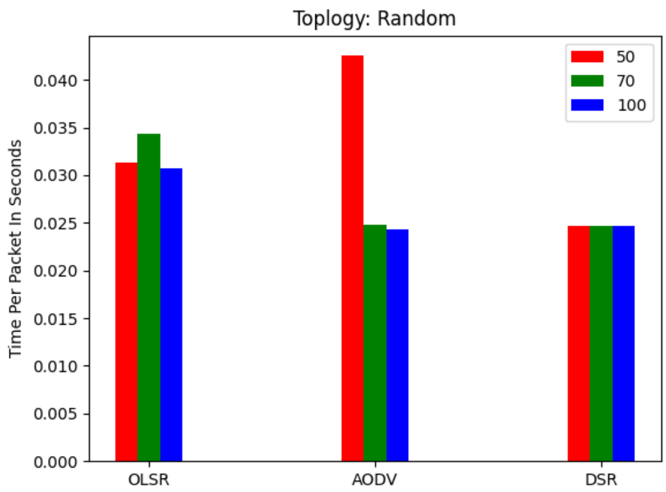

Figure 10.9: Random topology time per packet in second

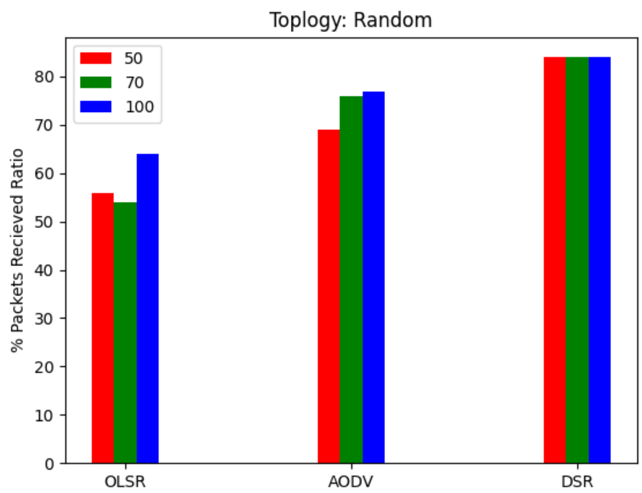

Figure 10.10: Random topology ratio

Grid topology: As we can conclude from figure 10.11, The throughput of the OLSR protocol in Grid topology is the lowest. We can see that in AODV and DSR protocol acting we the same with all number of the nodes.

Figure 10.12 we can see the delay of the DSR and AODV protocols is low compare to the result we see in OLSR. DSR again is the lowest than AODV and then OLSR, that his result is significantly higher relative to the other protocols.

Figure 10.13 shows us the packet lost for the 3 protocols OLSR protocol loses the highest number of messages especially in 100 vertices, In contrast, it can be seen that the AODV protocol packet loss I much lower The DSR protocol in terms of message loss is stable, and it loses the least number of messages.

Figure 10.14 shows us the time per packets in seconds, the OLSR protocol takes the longest time on average to send a package, we can see that in OLSR that when number of vertices increase the time per packets in seconds getting larger AODV and DSR protocols show fast performance for sending a packet on average.

In Grid topology with the previous graphs, we can see that the highest number of messages coming is in the DSR protocol then in AODV and finally in the OLSR protocol. this fact have direct reason for figure 10.15 That show us that the DSR protocol received higher than AODV and then OLSR.

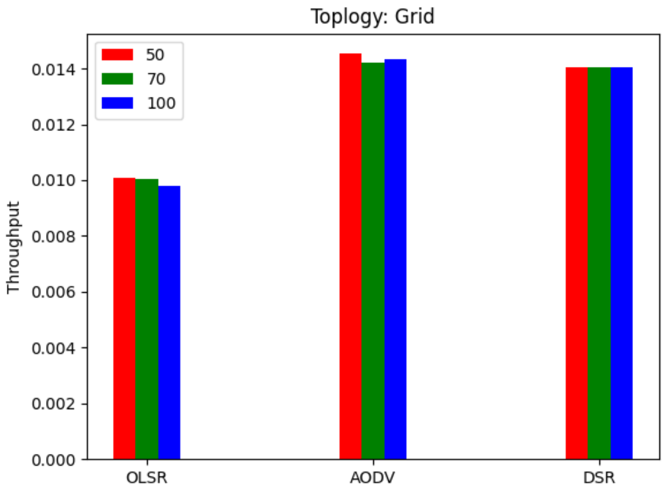

Figure 10.11: Grid topology throughput

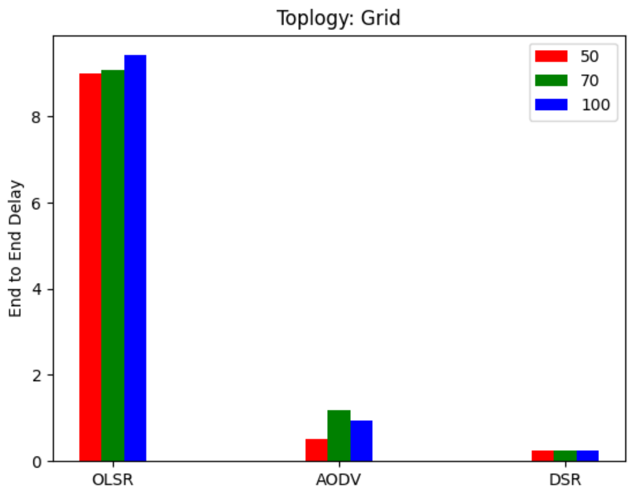

Figure 10.12: Grid topology end to end delay

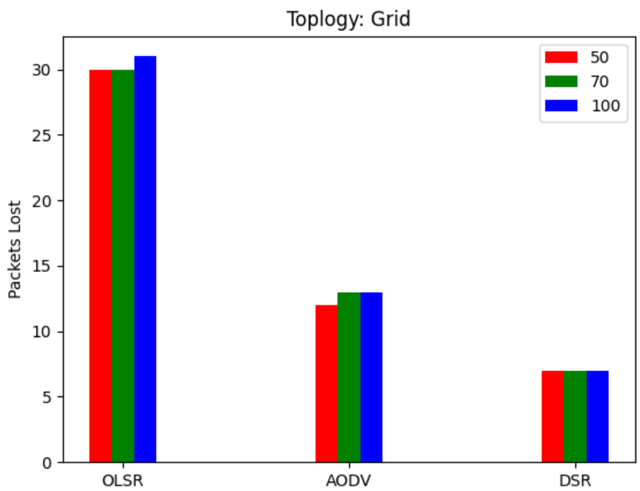

Figure 10.13: Grid topology packets lost

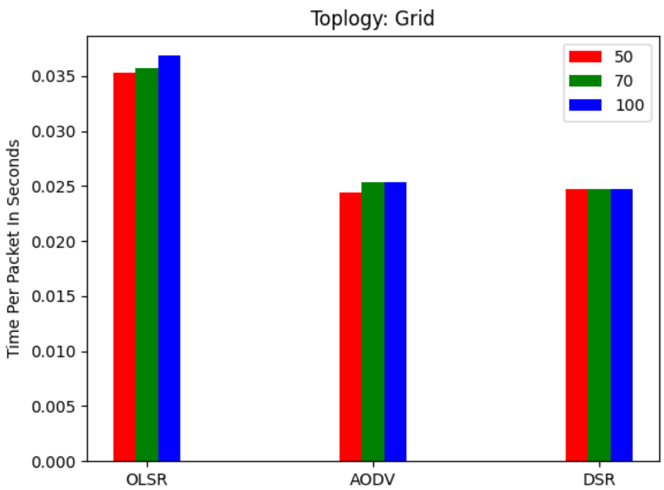

Figure 10.14: Grid topology time per packet in second

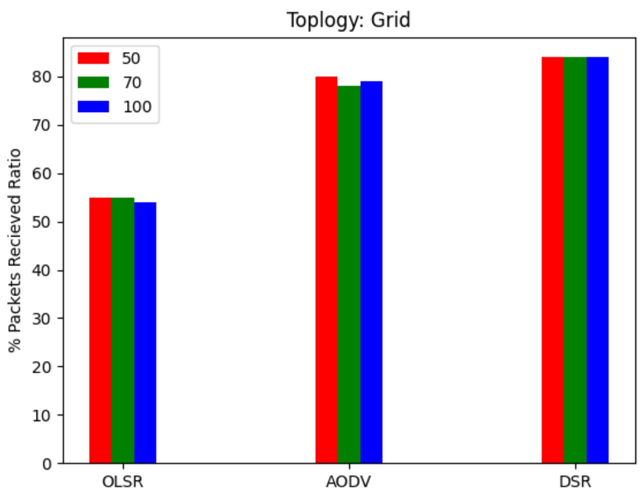

Figure 10.15: Grid topology ratio

Mobile topology: As we can conclude from figure 10.16, The throughput of the OLSR and AODV protocols in Mobile topology is the lowest. We can see that AODV throughput is a little bit larger than OLSR DSR protocol acting the same with all number of the vertices and have the best result.

Figure 10.17 shows un the packet lost for the 3 protocols OLSR protocol and AODV loses the highest number of messages especially OLSR, In AODV the highest lost will be in 100 vertices The DSR protocol in terms of message loss is stable, and it loses the least number of messages.

Figure 10.18 shows us the time per packets in seconds, the OLSR protocol takes the longest time on average to send a package with 50 vertice, AODV protocol in 2nd plcae DSR protocols show fast performance for sending a packet.

In Mobile topology with the previous graphs, we can see that the highest number of messages coming is in the DSR protocol then in AODV and finally in the OLSR protocol. That have direct reason for figure 10.19 That show us that the DSR protocol received higher than AODV and then OLSR.

In Mobile topology with the previous graphs, we can see that the highest number of messages coming is in the DSR protocol then in AODV and finally in the OLSR protocol. That have direct reason for figure 10.19 That show us that the DSR protocol received higher than AODV and then OLSR.

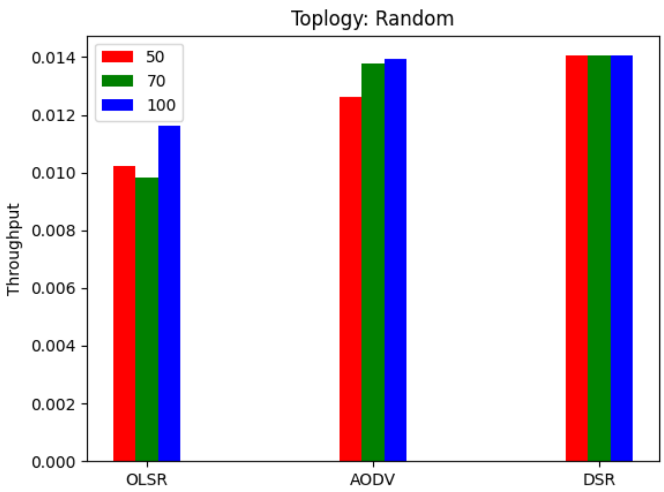

Figure 10.16: Mobile topology throughput

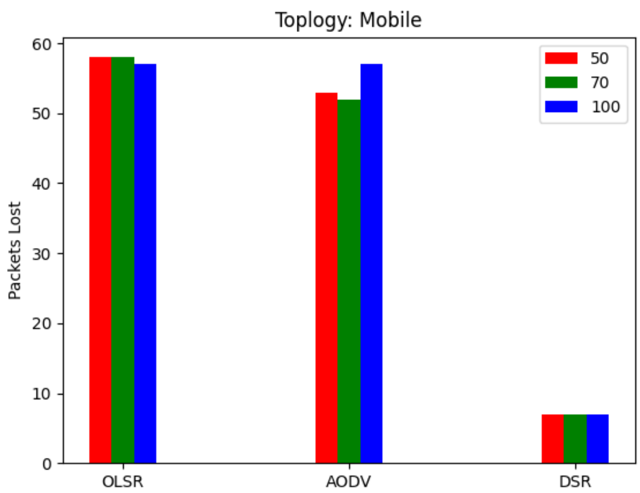

Figure 10.17: Mobile topology packets lost

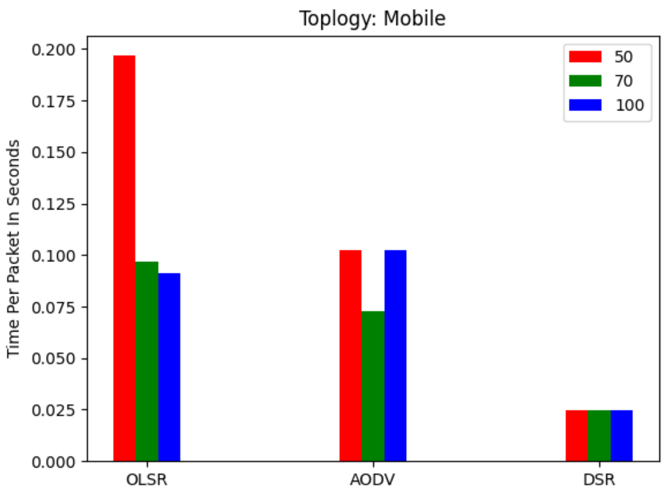

Figure 10.18: Mobile topology time per packet in second

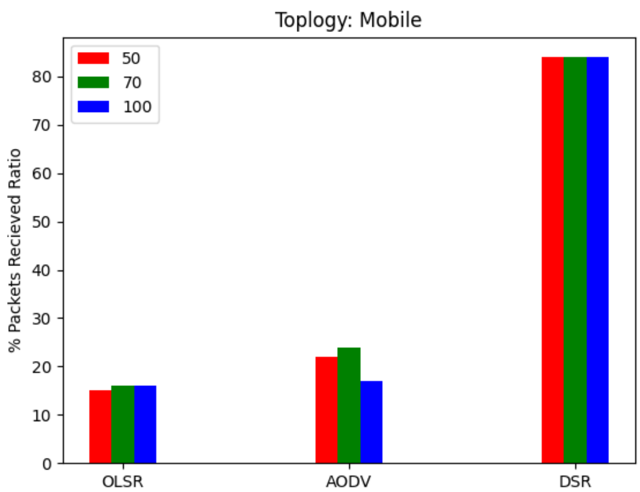

Figure 10.19: Mobile topology ratio

Line topology:

As we can conclude from figure 10.20, The throughput of the OLSR protocol in line topology is the lowest, and the number of nodes does not affect it so much. In the other hand, we can see that in AODV protocol when we deal with more nodes the throughput increase. In DSR protocol the throughput is stable, and the nodes number does not affect it.

As we can see in figure 10.21, the OLSR protocol takes the longest time on average to send a package, the other protocols however show fast performance for sending a packet on average.

It can be seen from figure 10.22 that the OLSR protocol loses the highest number of messages, and the number of nodes does not affect the loss of messages. In contrast, it can be seen that the AODV protocol when the number of vertices is small then the amount of message loss is relatively large, and when there are more vertices then the amount of messages being lost is small. The DSR protocol in terms of message loss is stable, and it loses the least number of messages.

In line with the previous graphs, it can be seen in figure 10.23 that the highest number of messages coming is in the DSR protocol then in AODV and finally in the OLSR protocol.

It can be seen in figure 10.24 that the delay of the DSR and AODV protocols is low and similar, whereas the delay of the OLSR protocol is significantly higher relative to the other protocols.

It can be seen in figure 10.24 that the delay of the DSR and AODV protocols is low and similar, whereas the delay of the OLSR protocol is significantly higher relative to the other protocols.

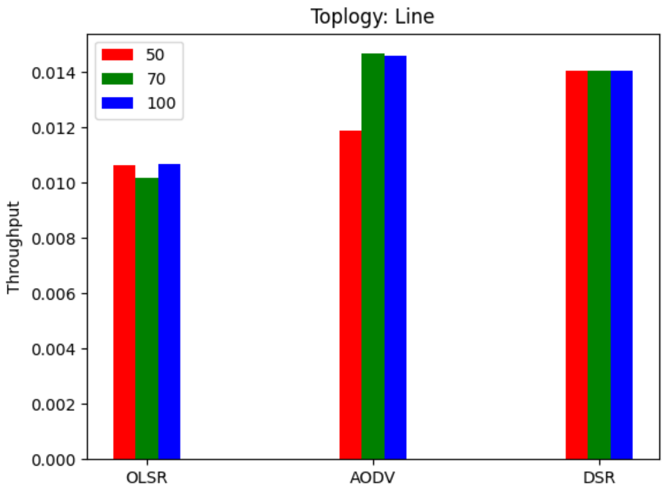

Figure 10.20: Line topology throughput

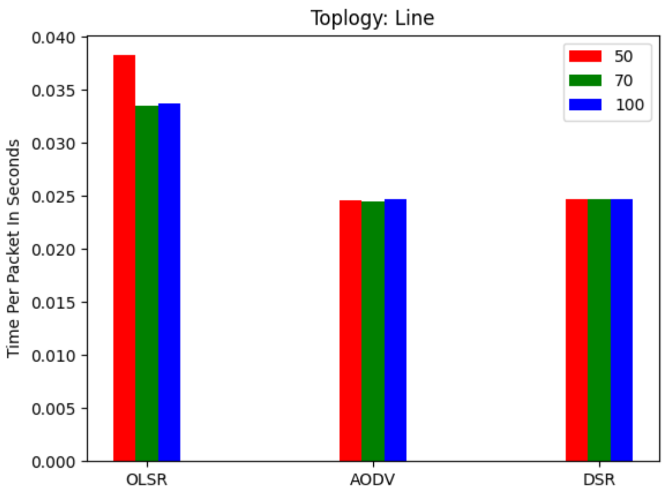

Figure 10.21: Line topology time per packet in second

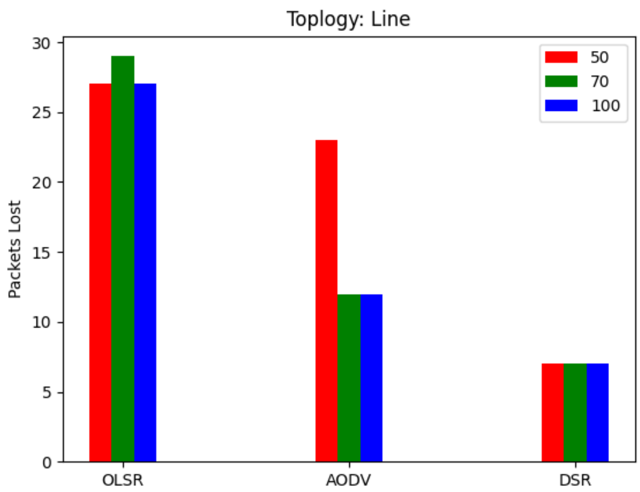

Figure 10.22: Line topology packets lost

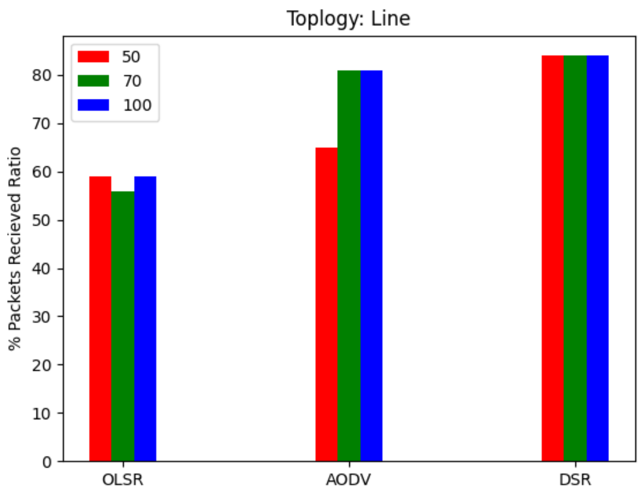

Figure 10.23: Line topology ratio

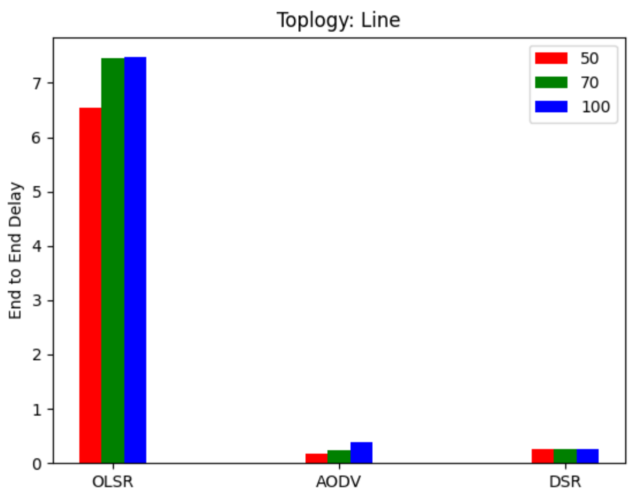

Figure 10.24: Line topology end to end delay

Circle topology:

As we can conclude from figure 10.25, The throughput of the OLSR protocol in circle topology is the lowest but not so bad, and the number of nodes affect it. We can see that when the nodes number increase the throughput increase too. In addition, we can see that in AODV protocol when we deal with more nodes the throughput does not change too much. In DSR protocol the throughput is high and stable, and the nodes number does not affect it.

It can be seen in figure 10.26 that the delay of the DSR and AODV protocols is low and similar, whereas the delay of the OLSR protocol is significantly higher relative to the other protocols. In addition, we can see that as the number of vertices increases the delay of receiving the messages decreases.

It can be seen from figure 10.27 that the OLSR protocol loses the highest number of messages, and the number of nodes affect the loss of messages, and as the number of nodes increases the packets lost decreases. In addition, in AODV protocol that the packets lost do not changes too much but as the nodes number increase the packets lost increase too. The DSR protocol in terms of message loss is stable, and it loses the least number of messages.

As we can see in figure 10.28, the OLSR protocol as the number of nodes increase the time sending decrease. In the other hande in AODV as the node number increase the time sending increase too. The DSR protocols however show a stable and fast performance for sending a packet on average.

In line with the previous graphs, it can be seen in figure 10.29 that the highest number of messages coming is in the DSR protocol then in AODV and finally in the OLSR protocol.

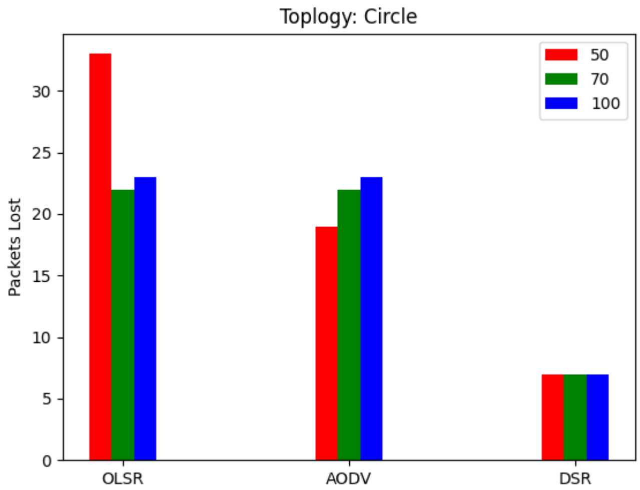

Figure 10.25: Circle topology throughput

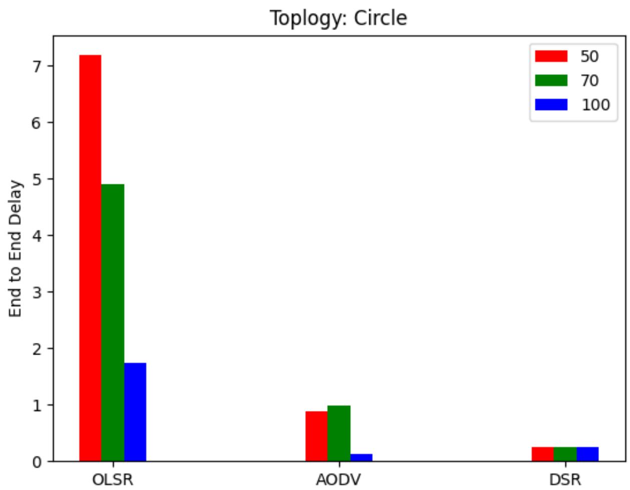

Figure 10.26: Circle topology end to end delay

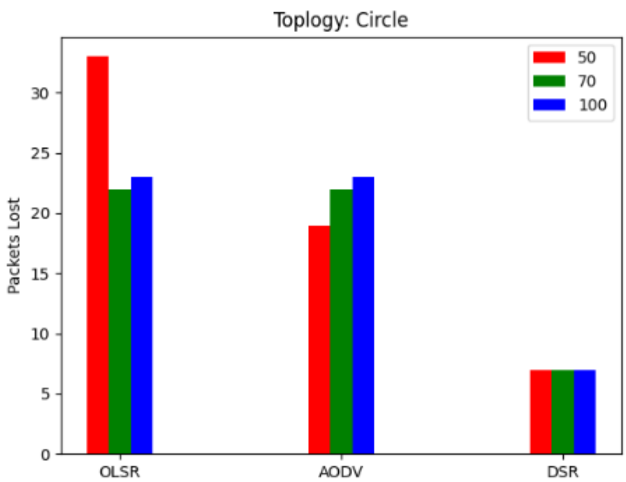

Figure 10.27: Circle topology packets lost

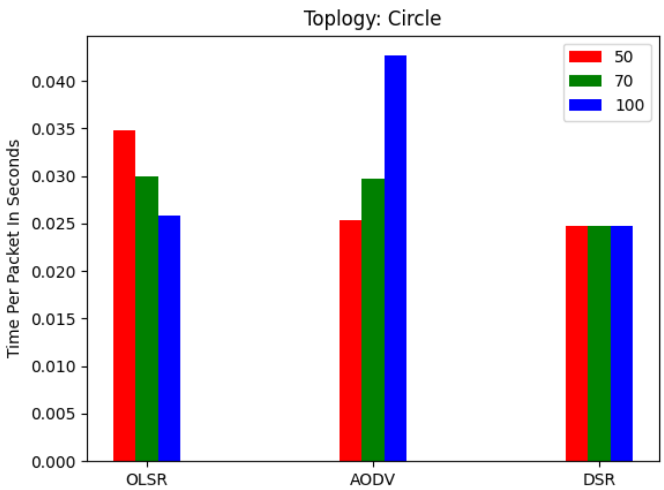

Figure 10.28: Circle topology time per packet in second

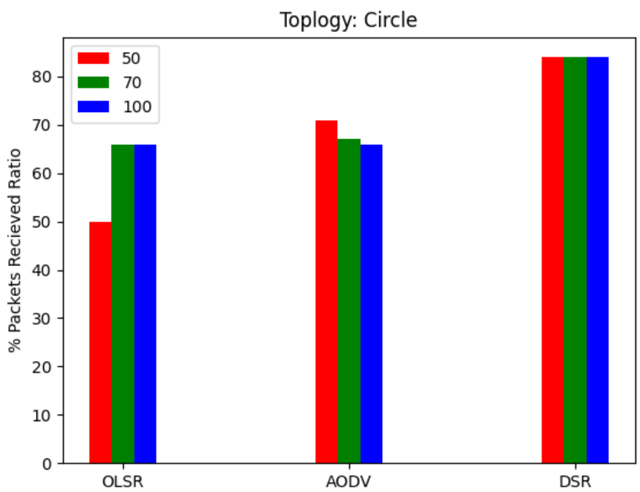

Figure 10.29: Circle topology ratio

Circle with line topology:

In line with the previous graphs, it can be seen in figure 10.30 that the highest number of messages coming is in the DSR protocol then in AODV and finally in the OLSR protocol.

In figure 10.31 we can see that DSR and AODV throughput are high, and OLSR throughput is lower.

it can be seen in figure 10.32 that the delay of the DSR and AODV protocols is low and similar, whereas the delay of the OLSR protocol is significantly higher relative to the other protocols. In addition, we can see that as the number of vertices increases the delay of receiving the messages decreases.

In figure 10.33 we can see that protocol OLSR loss the highest number of packets, and then AODV protocol. DSR protocol loss the least number of packets.

As we can see in figure 10.34, the send time packet of DSR and AODV are similar and low opposite to the send time packet in OLSR.

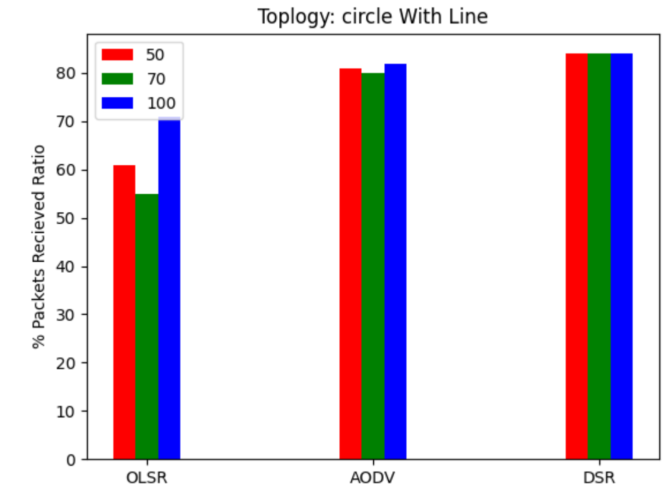

Figure 10.30: Circle with line topology ratio

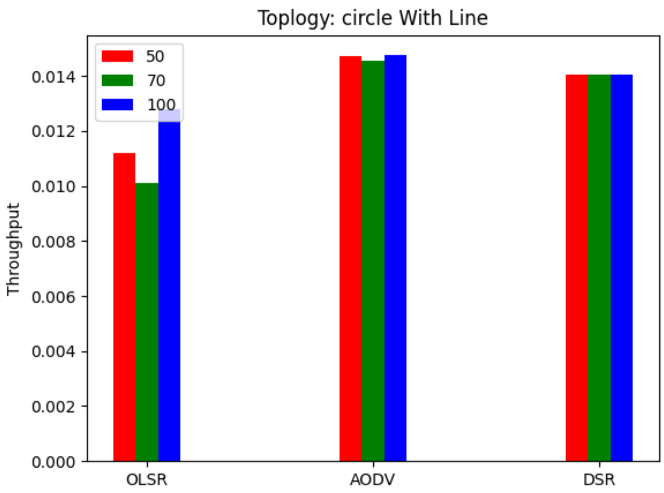

Figure 10.31: Circle with line topology throughput

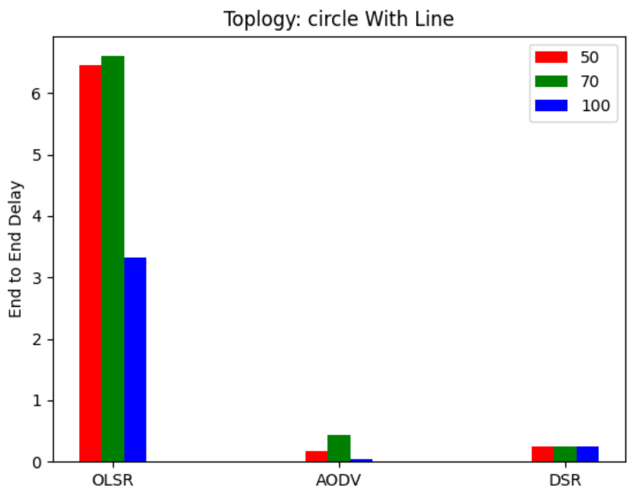

Figure 10.32: Circle with line topology end to end delay

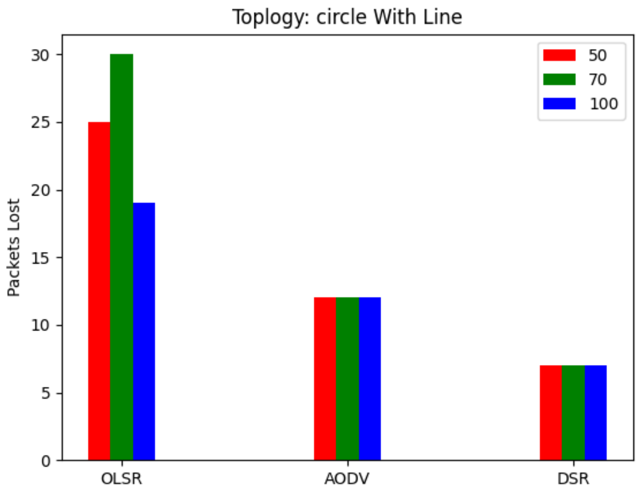

Figure 10.33: Circle with line topology packets lost

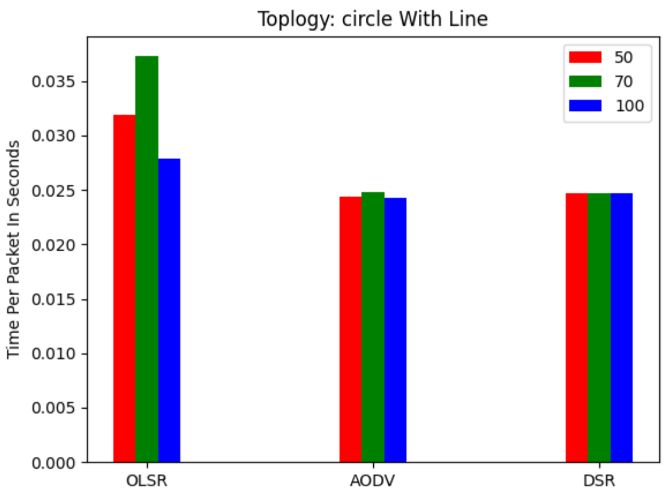

Figure 10.34: Circle with line topology time per packet in second

Protocol Comparison

Packets Received Ratio:

As we can see in figure 10.35, 10.36 and 10.37, for all three protocols, the percentage of packets received in mobile topology is the lowest no matter what protocol we use, this is because of the constant movement of the nodes, combining reception range not changing, that leads to nodes not hearing each other and not being able to pass packets of each other.
Circle, and Circle with line topologies seemed to be the best in ratio, and DSR in General has better results.

End to end delay:

We can conclude from the graphs 10.38, 10.39, 10.40 together that the end-to-end delay in the AODV and DSR protocols is very similar. Mobile topology has the highest delay while Random has the lowest. In general, the delay in all topologies is low compared to the OLSR protocol where the delays are very high but also here the delay in random topology is the lowest.

Throughput:
We can conclude from the graphs 10.41,10.42 and 10.43 together that in mobile topology the throughput was the lowest in the three protocols and circle with line was best at all three graphs. In general, the throughput in OLSR protocol is the lowest, and DSR seem to have the best results.

Time per packet in seconds:
In graphs 10.44, 10.25, 10.46 in mobile topology, the time to send a packet was the highest in the three protocols. The time to send a packet in OLSR protocol is the highest compared to the other protocols. In random and mobile topologies, DSR is better than AODV in these terms.

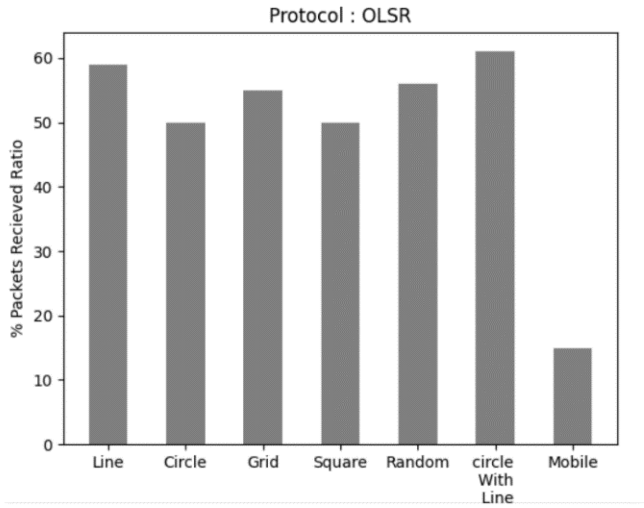

Figure 10.35: OLSR protocol ratio

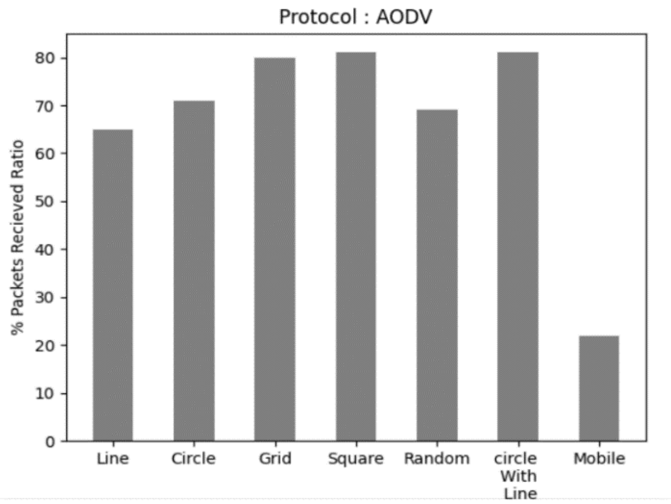

Figure 10.36: AODV protocol ratio

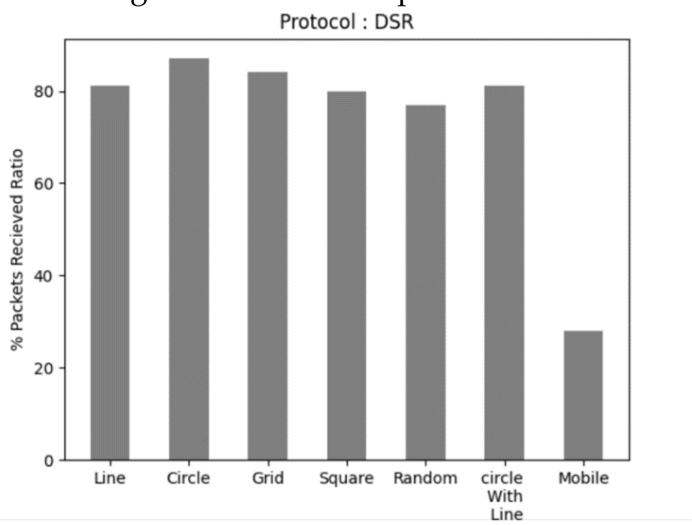

Figure 10.37: DSR protocol ratio

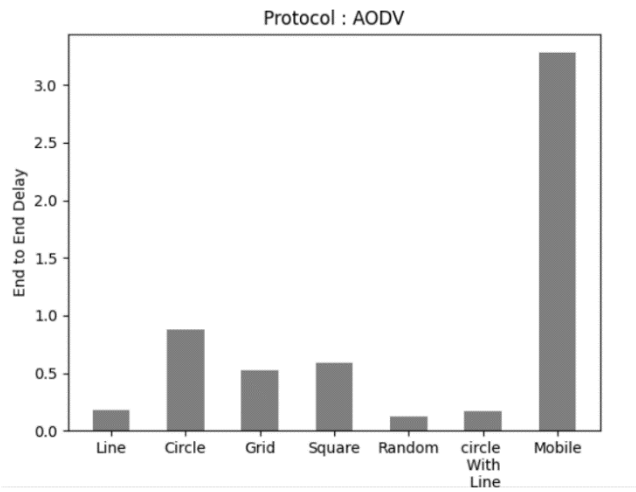

Figure 10.38: AODV protocol end to end delay

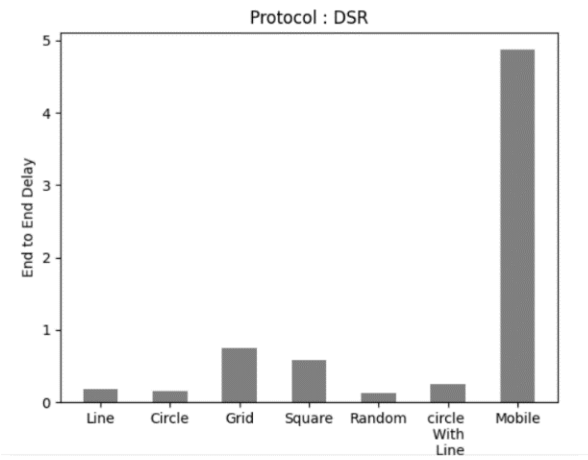

Figure 10.39: DSR protocol end to end delay

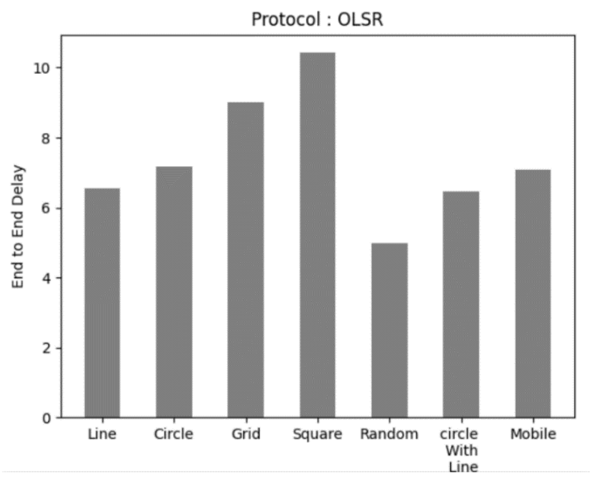

Figure 10.40: OLSR protocol end to end delay

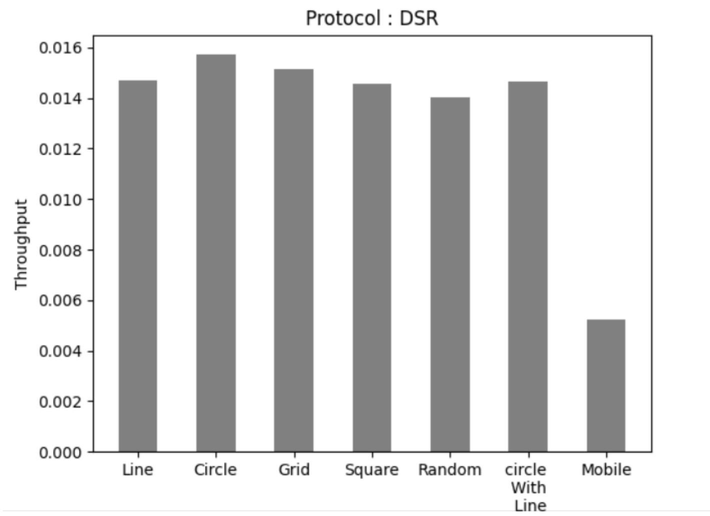

Figure 10.41: DSR protocol throughput

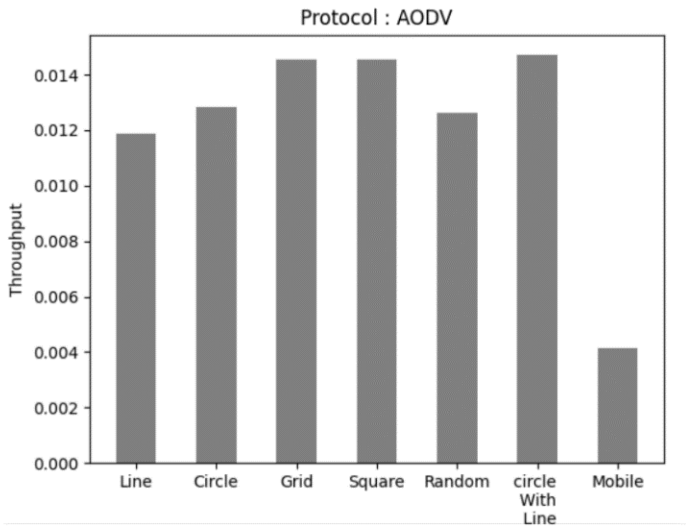

Figure 10.42: AODV protocol throughput

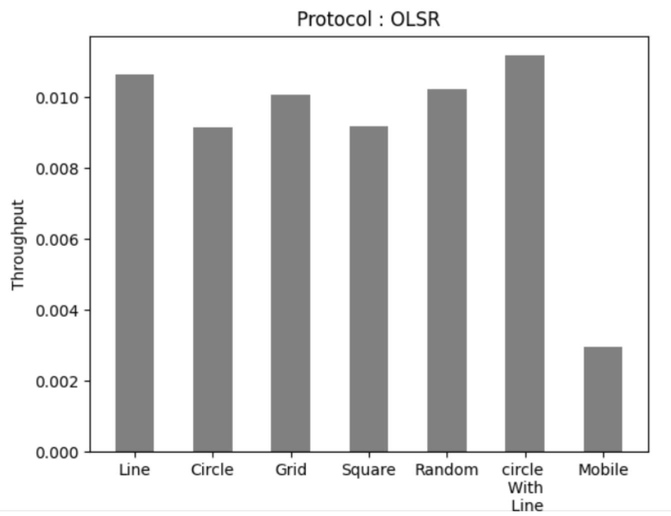

Figure 10.43: OLSR protocol throughput

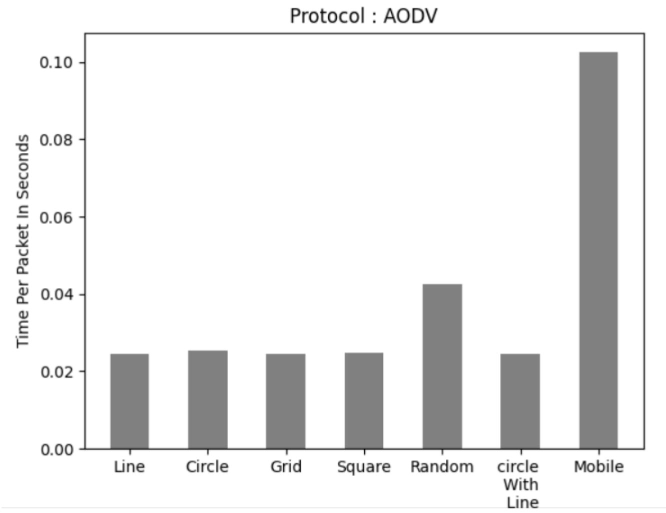

Figure 10.44: AODV protocol time per packet in seconds

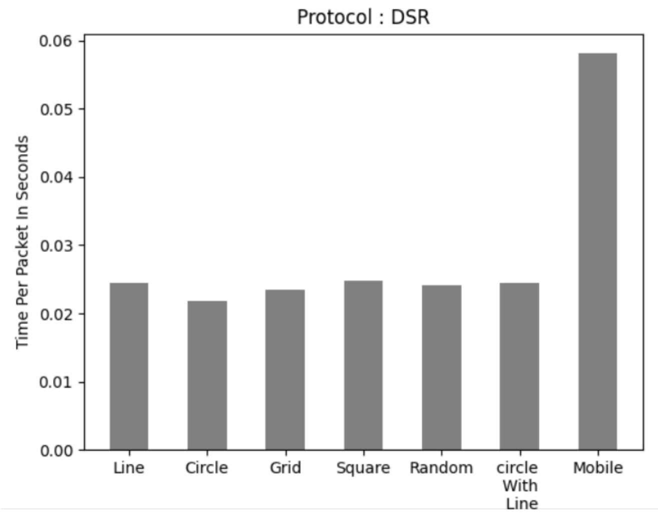

Figure 10.45: DSR protocol time per packet in seconds

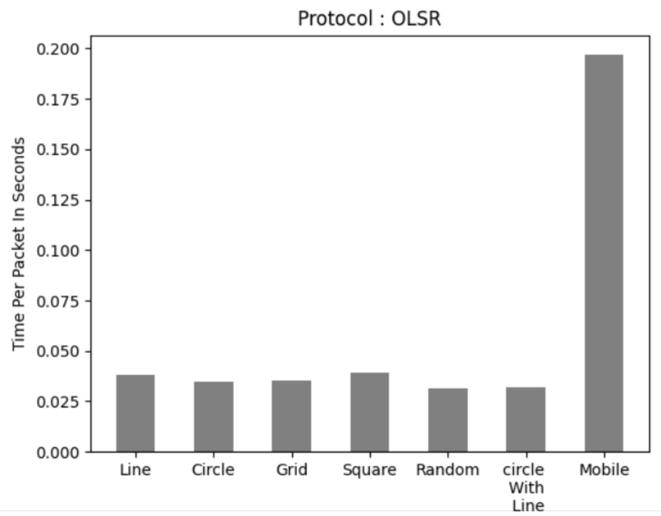

Figure 10.46: OLSR protocol time per packet in seconds

Protocol	Topology	Average Packets Received	Average Packets Lost	Average Ratio	Average Time Per Packet	Throughput	End to End Delay
DSR	lines	47	11	81	0.0243823	0.0147017	0.185853
DSR	circle	61	7	87	0.0218308	0.015719	0.157613
DSR	grid	59	10	84	0.0234862	0.0151377	0.74402
DSR	square	57	12	80	0.0247062	0.0145564	0.579216
DSR	random	55	14	77	0.0241282	0.0140478	0.126005
DSR	CircleWithLine	57	12	81	0.024383	0.0146775	0.248718
DSR	randomWalk	20	49	28	0.0580927	0.00523158	4.87235
AODV	lines	46	23	65	0.0245585	0.0118801	0.182506
AODV	circle	50	19	71	0.0253858	0.0128489	0.880662
AODV	grid	57	12	80	0.0244252	0.0145322	0.525329
AODV	square	57	12	81	0.0247795	0.0145564	0.584938
AODV	random	49	20	69	0.0425448	0.0126188	0.123301
AODV	CircleWithLine	57	12	81	0.0243791	0.0147017	0.166143
AODV	randomWalk	16	53	22	0.102461	0.00415378	3.28056
OLSR	lines	41	27	59	0.0382468	0.0106448	6.5391
OLSR	circle	35	33	50	0.0348317	0.00916738	7.18384
OLSR	grid	39	30	55	0.0353295	0.0100878	8.99245
OLSR	square	35	33	50	0.0393552	0.0091916	10.4222
OLSR	random	40	29	56	0.0313795	0.010221	4.97227
OLSR	CircleWithLine	43	25	61	0.0319528	0.0111777	6.45406
OLSR	randomWalk	11	58	15	0.196725	0.00296699	7.09262

Figure 10.47: 50 nodes

Protocol	Topology	Average Packets Received	Average Packets Lost	Average Ratio	Average Time Per Packet	Throughput	End to End Delay
DSR	lines	57	11	81	0.024312	0.014738	0.132073
DSR	circle	61	7	87	0.022098	0.015731	0.039191
DSR	grid	59	10	84	0.023645	0.015186	0.724112
DSR	square	55	13	79	0.025342	0.014229	1.22068
DSR	random	60	8	86	0.02325	0.015465	0.411239
DSR	CircleWithLine	58	11	82	0.024184	0.014896	0.103502
DSR	randomWalk	19	49	28	0.081953	0.00511	3.5638
AODV	lines	57	12	81	0.024486	0.014678	0.227579
AODV	circle	47	22	67	0.029704	0.01211	0.988634
AODV	grid	55	13	78	0.025379	0.014193	1.18505
AODV	square	56	13	80	0.025444	0.014447	0.79679
AODV	random	53	15	76	0.024752	0.013769	0.473689
AODV	CircleWithLine	57	12	80	0.024827	0.014569	0.442294
AODV	randomWalk	17	52	24	0.072861	0.004517	5.43862
OLSR	lines	39	29	56	0.033504	0.010185	7.45271
OLSR	circle	46	22	66	0.03001	0.011977	4.89312
OLSR	grid	39	30	55	0.035712	0.010051	9.0869
OLSR	square	32	36	46	0.042311	0.008453	12.1468
OLSR	random	38	31	54	0.034401	0.009821	5.60398
OLSR	CircleWithLine	39	30	55	0.037281	0.010088	6.59948
OLSR	randomWalk	11	58	16	0.096968	0.002979	7.27207

Figure 10.48: 70 nodes

Protocol	Topology	Average Packets Received	Average Packets Lost	Average Ratio	Average Time Per Packet	Throughput	End to End Delay
DSR	lines	47	11	81	0.024363	0.01475	0.131412
DSR	circle	58	11	82	0.024246	0.014896	0.890946
DSR	grid	57	11	81	0.024477	0.01475	0.109829
DSR	square	56	13	80	0.025038	0.014435	0.732019
DSR	random	59	10	84	0.024242	0.015174	0.691434
DSR	CircleWithLine	58	11	82	0.024267	0.014762	0.017562
DSR	randomWalk	14	55	19	0.10864	0.003633	3.17935
AODV	lines	57	12	81	0.02466	0.014593	0.391237
AODV	circle	46	23	66	0.042657	0.011904	0.126091
AODV	grid	56	13	79	0.025355	0.014326	0.931695
AODV	square	57	12	81	0.024734	0.014569	0.462411
AODV	random	54	15	77	0.024342	0.013927	0.346687
AODV	CircleWithLine	58	12	82	0.024282	0.01475	0.036778
AODV	randomWalk	12	57	17	0.102182	0.003161	6.88121
OLSR	lines	41	27	59	0.033721	0.010681	7.47282
OLSR	circle	46	23	66	0.025874	0.011929	1.74835
OLSR	grid	38	31	54	0.036835	0.009809	9.42177
OLSR	square	36	32	52	0.03673	0.00941	9.24249
OLSR	random	45	23	64	0.030758	0.011638	5.2232
OLSR	CircleWithLine	50	19	71	0.027909	0.0128	3.32402
OLSR	randomWalk	11	57	16	0.091017	0.003088	5.43109

Figure 10.49: 100 nodes

11 Conclusion

All the graphs make a sure conclusion from these experiments - the DSR protocol showed the best performances, in almost all topologies, at almost all manners and OLSR showed the worst.

We have reached the conclusion that OLSR is probably the worst because it is a proactive protocol - which creates high overhead in the network and interfere the packets from being send. It creates overhead even though it is not always necessary in order to update the routing tables. Because of AODV and DSR are reactive protocols - they create overhead only when a packet needs to be sent and that is the reason they are better from OLSR.

With that being said, we assume that the reason DSR is slightly better than AODV is that we used mostly in non-mobile nodes. as we can see in the graphs, when using mobile nodes, AODV was better then DSR or similar in most ways. In addition, AODV has more overhead in contrast to DSR, because AODV uses periodic routing messages, in contrast to DSR.

12 Bibliography

REFERENCES

[1] Aviram Zilberman , Ariel Stulman Senior Member, IEEE, , and Amit Dvir Member, IEEE.
Where is Eve: Identifying a Malicious Node in a UAV Network .

[2] Adel Aneiba and Mohammed Melad , February 2016 , Performance Evaluation of AODV, DSR, OLSR, and GRP MANET Routing Protocols Using OPNET.

[3] S. A. Ade1 and P.A.Tijare2 , July-December 2010 , Performance Comparison of AODV, DSDV, OLSR and DSR Routing Protocols in Mobile Ad Hoc Networks.

[4] Rakesh Poonia , Amit Kumar Sanghi , Dr. Dharm Singh , February 2011 , DSR Routing Protocol in Wireless Ad-hoc Networks: Drop Analysis

[5] Rakesh Kumar Jha, Pooja Kharga, March 2015, A Comparative Performance Analysis of Routing Protocols in MANET using NS3 Simulator.

[6] https://www.nsnam.org/