ENSC895: SPECIAL TOPICS II: COMMUNICATION NETWORKS

PERFORMANCE ANALYSIS AND COMPARISON OF THREE WIRELESS AD-HOC NETWORK ROUTING PROTOCOLS

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FINAL REPORT

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Abstract

A wireless ad-hoc network is a collection of mobile nodes that makes a multihop autonomous system without relying on an infrastructure. Mobile ad-hoc network routing protocols are divided into three groups of reactive routing, proactive routing, and hybrid routing based on their method of acquiring information from the other nodes. The advantage of On-Demand routing protocols is that it generates less routing overhead in network, but the disadvantage is that the source node may suffer from long delays to obtain a route to destination. The advantage of proactive routing protocols is that a source node can get a routing path immediately if it needs one but the disadvantage is that they generate high routing overhead in network.

In this project, the performances of Ad-Hoc On-Demand Distance Vector (AODV), Dynamic Source Routing (DSR), and Optimized Link State Routing (OLSR) protocols are compared. AODV is a reactive protocol that starts searching for a destination node whenever it needs to send any information to it. It also needs a periodic route advertisement and neighbor detection. DSR is also a reactive routing protocol, but unlike AODV, it is a beacon-less routing protocol and it does not need periodic route advertisement and neighbor detection. OLSR is a proactive routing protocol, and hence, each node periodically broadcasts its routing table allowing each node to build a global view of the network topology. This project will investigate the performance of routing protocols in different scenarios with different traffic loads including end to end delay, throughput, video packet delay variation, and routing traffic overhead. The results of the simulation shows that in the case of file transfer with TCP connection, OLSR acts better in terms of end to end delay and upload response time, but with high routing overhead. In the case of video transfer with UDP connection, AODV acts better in terms of throughput, delay variation, end-to-end delay, and has low routing traffic.

Table of Contents:

List of Figures:

List of Tables:

List of Acronyms:

AODV: Ad Hoc On-Demand Distance Vector routing protocol

DSR: Dynamic Source Routing

OLSR: Optimized Link State Routing

TCP: Transmission Control Protocol

UDP: User Datagram Protocol

E2E: End to End

1. Introduction

A wireless Ad Hoc network is a collection of mobile nodes that form a dynamic autonomous network. Nodes communicate with each other without depending on any infrastructure (e.g. access points or base stations) [1]. Hence, in these networks every node acts both as a host and as a router.

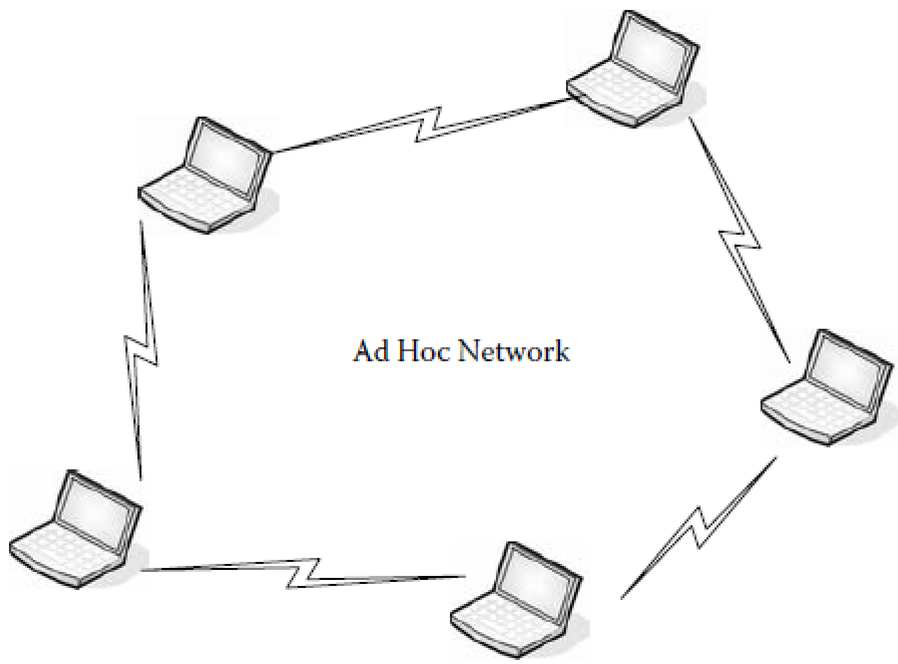


Figure 1: Wireless Ad Hoc network [1]

Ah Hoc Networks have features of easy connection to access networks, dynamic multihop network structures, and direct peer-to-peer communication. Table 1 gives some major differences between Ad Hoc networks and cellular networks.

Table 1: Differences between cellular and Wireless Ad Hoc networks [1]

Cellular	*Ad Hoc Wireless Networks*
Infrastructure networks	Infrastructureless networks
Fixed, prelocated cell sites and base station	No base station, and rapid deployment
Static backbone network topology	Highly dynamic network topologies with multihop
Relatively caring environment and stable connectivity	Hostile environment (noise, losses) and irregular connectivity
Detailed planning before base station can be installed	Ad hoc network automatically forms and adapts to changes
High setup costs	Cost-effective
Large setup time	Less setup time

1.1 Ad Hoc routing

Frequent and unpredictable changes of wireless Ad Hoc networks topology due to their highly dynamic nature make routing difficult and complex between mobile nodes. Routing complexities associated with its importance in communication between the mobile nodes, make this area an active research area in wireless Ad Hoc networks. Routing protocols in wireless ad-hoc networks are divided into three groups of proactive (Table-Driven), reactive (On-Demand), and hybrid routing protocols based on their method of acquiring information from the other nodes in unicast routing classification [1].

In proactive routing protocols, each node periodically distributes routing tables throughout the network. The main disadvantages of such protocols are the large amount of routing overhead generated for maintenance and slow reaction on reestablishing the network and failures. The main advantage of these protocols is that a source node can get a routing path immediately if it needs one [11] [1].

In reactive routing protocols, to reduce overhead, the route between two nodes is discovered only on-demand by flooding the network with route request packet. The main disadvantages of such protocols are the high latency time in finding a route to destination and the probability of clogging network by excessive flooding [11] [1].

In hybrid routing protocols, the merits of both proactive and reactive routing protocols are combined. The initial establishment of the routes is done with some proactively prospected routes and then additionally activated nodes are served on-demand through reactive flooding. The disadvantage of such protocols is dependence of the advantage on amount of nodes activated [11].

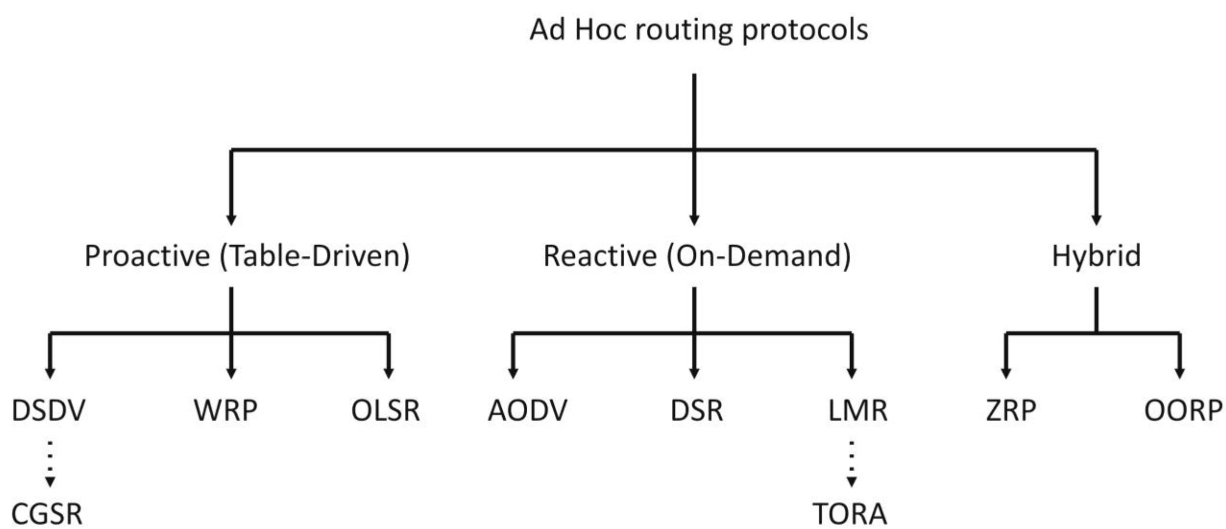


Figure 2: Ad Hoc routing protocols

1.2 Applications of wireless Ad Hoc networks

The wireless Ad Hoc networks are suitable for variety of applications because of their decentralized nature. Nodes in these networks can freely move and they can organize arbitrarily [1]. Minimum configuration and rapid deployment of Ad Hoc networks make them appropriate for emergency situations, such as in disaster recovery or military conflicts. The following are the applications of Ad Hoc wireless networks [1]:

- Community network
- Enterprise network
- Home network
- Emergency response network
- Vehicle network
- Sensor network

1.3 Project description

In this work the performance of Ad-Hoc On-Demand Distance Vector (AODV), Dynamic Source Routing (DSR), and Optimized Link State Routing (OLSR) protocols will be compared and analyzed. Several simulations will conducted for every routing protocol. The main goal of this project will be to determine which one of the protocols act better in different traffic loads and in the presence of motion. Finally the simulation results will provide a guide for choosing a suitable routing protocol in different environments.

2. Ad Hoc On-Demand Distance Vector (AODV) routing protocol

Ad-Hoc On-Demand Distance Vector (AODV) routing protocol is one of the most popular reactive routing protocols. AODV routing algorithm is very suitable for dynamic self-starting network as needed by users who want to use ad hoc networks. AODV ensures loop-free routes even while repairing broken links. Because the protocol does not require global periodic routing advertisements, the overall bandwidth available that is needed for the mobile nodes is considerably less than in those protocols that do necessitate such advertisements [1][6].

AODV defined RREQ, RREP, and RERR message types. These message types are received via UDP, and normal IP header processing applies.

RREQ contains <source_addr, source sequence#, broadcast id, dest_addr, dest sequence#, hop cnt> fields. The pair <source_addr, broadcast_id> uniquely identifies an RREQ because broadcast_id is incremented whenever the source issues a new RREQ [1]. When a source node wishes to send a packet to a specific destination but does not already have a valid route to it, it initiates the *Path Discovery* operation by broadcasting RREQ packet to its neighbors. This request is then forwarded to their neighbors, and so on, until either the destination or an intermediate node with a "fresh enough" route to the destination is located. Destination sequence number is utilized by AODV to ensure loop free routes. Hence, if intermediate nodes have a route to the destination whose corresponding destination sequence number is greater than or equal to that contained in the RREQ packet, they can reply to it. During the process of forwarding the RREQ, intermediate nodes record the address of the neighbor from which the first copy of the broadcast packet is received in their route tables. Thus, they establish a reverse path [5]. Figure 3 shows the propagation of RREQ across the network.

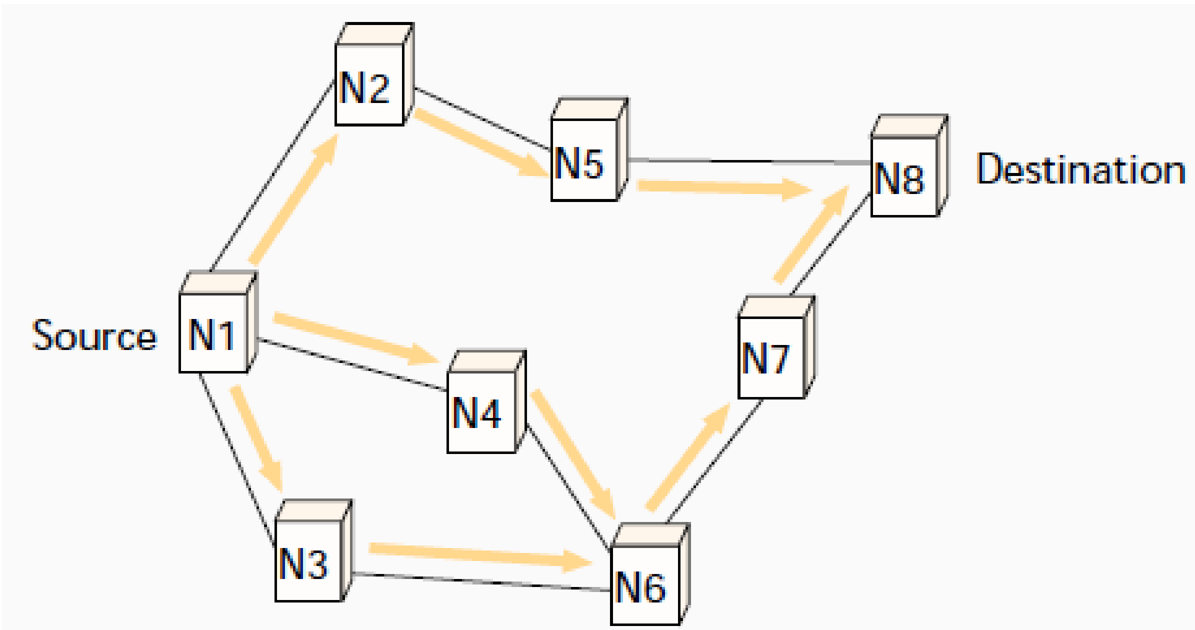


Figure 3: Propagation of RREQ [5]

RREP contains <source_addr, dest_addr, dest_sequence #, hop_cnt, lifetime> fields. After the RREQ reaches the destination or an intermediate node with a fresh enough route, it responds by a route reply (RREP) packet that unicasts to the neighbor which first received the RREQ packet and routes back along the reverse path [5]. Figure 4 shows a path of the RREP to the source.

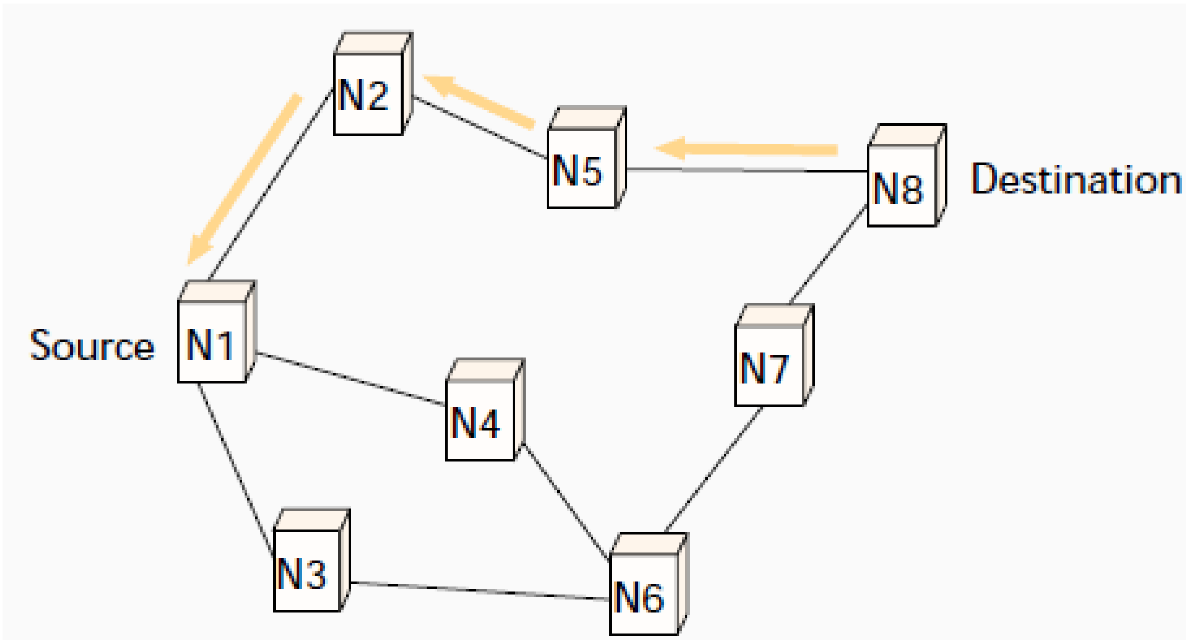


Figure 4: Path of the RREP to the source [5]

When the nodes in the network move from their places and the topology is changed or the links in the active path are broken, the intermediate node that discovers this link breakage propagates an RERR packet that contains unreachable destination IP address and unreachable destination sequence number. Then, the source node re-initializes the path discovery if it still desires the route [7].

3. Dynamic Source Routing (DSR) protocol

Dynamic Source Routing is an on-demand routing protocol that is based on the concept of source routing. This means that each routed packet must carry a complete and ordered list of nodes in its header through which the packet passes. Hence, intermediate nodes do not need to maintain up-to-date routing information in order to route the packets they forward [3]. The protocol consists of two major phases: route discovery and route maintenance. When a source node wishes to send a packet to a destination, it obtains a source route by the route discovery mechanism [3]. At first, a source node consults its route cache to determine whether it already has a route to the destination. If it does not have a route to destination, it initiates route discovery by broadcasting a Route Request packet. It is then answered by a Route Reply packet when the Route Request reaches either the destination itself, or an intermediate node which has an unexpired route to the destination in its route cache [3][5]. Figure 5 illustrates the building of the route record during the route discovery operation.

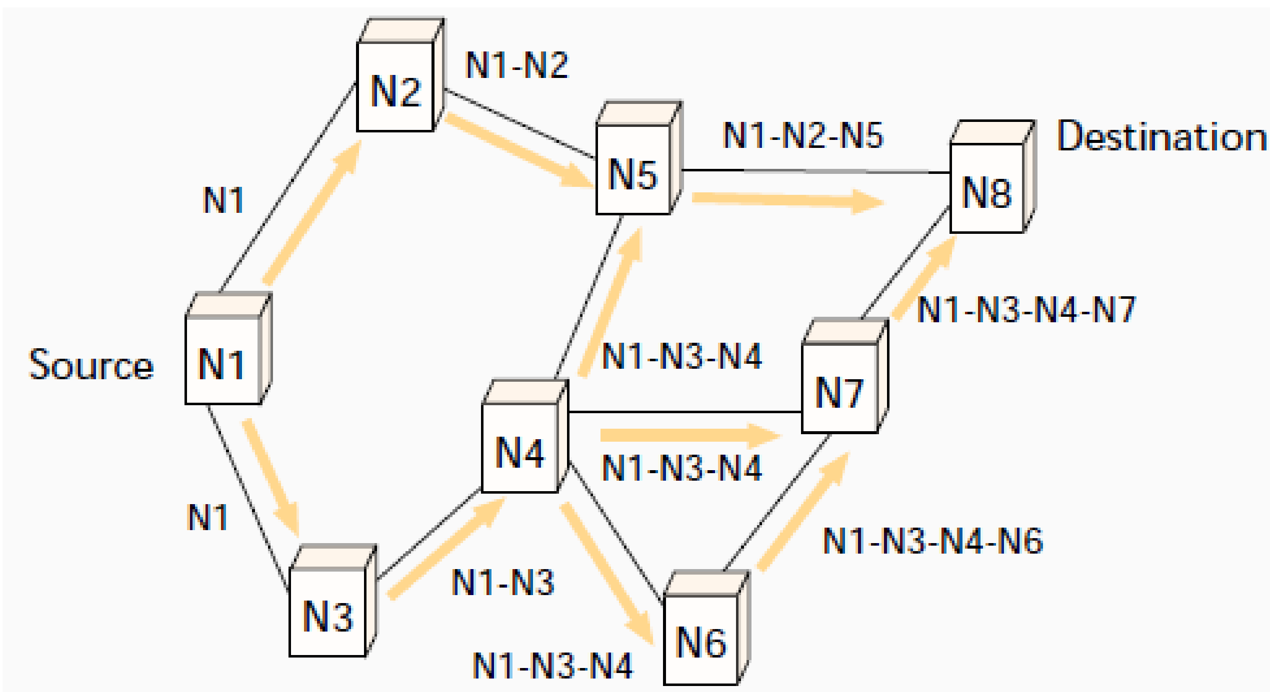


Figure 5: Building of the route record during the route discovery [5]

Route maintenance is a mechanism that uses Route Error packets and acknowledgments. Route Error packets are generated to notify the source node that a source route is broken. When a Route Error packet is received, the node removes the hop in error from its route cache. In addition to route error messages, the correct operation of the route links verify with acknowledgment message [5]. Figure 6 shows the propagation of route reply with the route record in the network.

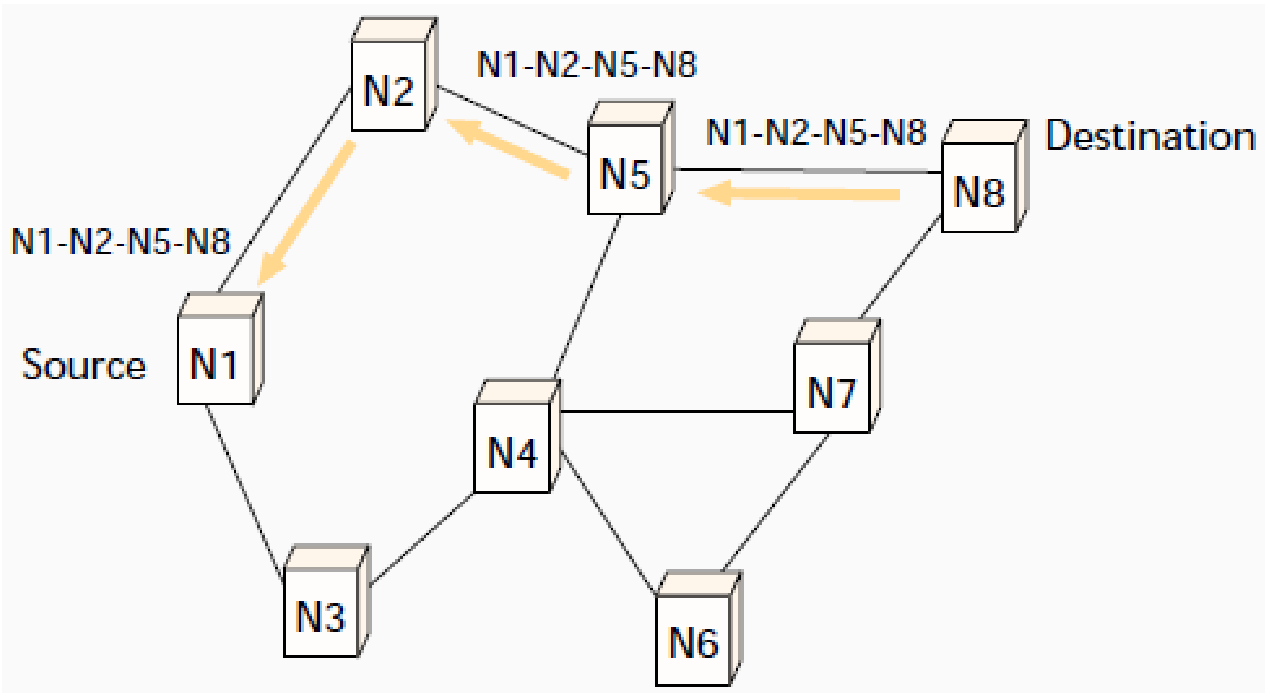


Figure 6: Propagation of route reply with the route record [5]

4. Optimized Link State Routing (OLSR) protocol

Optimized Link State Routing is a proactive routing protocol. It exchanges topology information with other nodes of the network periodically. The periodic nature of the protocol creates a large amount of overhead. OLSR reduces this overhead by using “Multi Point Relays” (MPR). Each node selects a set of its neighbor nodes as MPRs and only those MPRs are responsible for forwarding routing messages and network wide traffic. In OLSR, only nodes which have been selected as MPRs by some neighbor nodes, announce this information periodically. Hence, the network knows it has the ability to reach the nodes that have selected it as an MPR [1].

OLSR does not require reliable control message delivery because each node sends control messages periodically and can hence sustain reasonable loss of control messages. Each control message uses a sequence number which is incremented for each message. Therefore, it does not require sequenced delivery of messages [1]. OLSR uses Topology Control messages to provide sufficient link state information to every node of the network to allow route calculation [1]. In ad hoc networks mobility causes topology changes and this causes link breakage. In OLSR, after detecting a broken link, the source node is not immediately notified; but rather it is notified that the route is broken only when the intermediate node broadcasts its next packet.

5. Simulation design

In this project, OPNET modeler 14.0A is used to simulate a wireless ad hoc network. Figure 7 shows the wireless ad hoc network architecture of OPNET. This figure illustrates how an ad hoc routing protocol communicates with the IP layer of network.

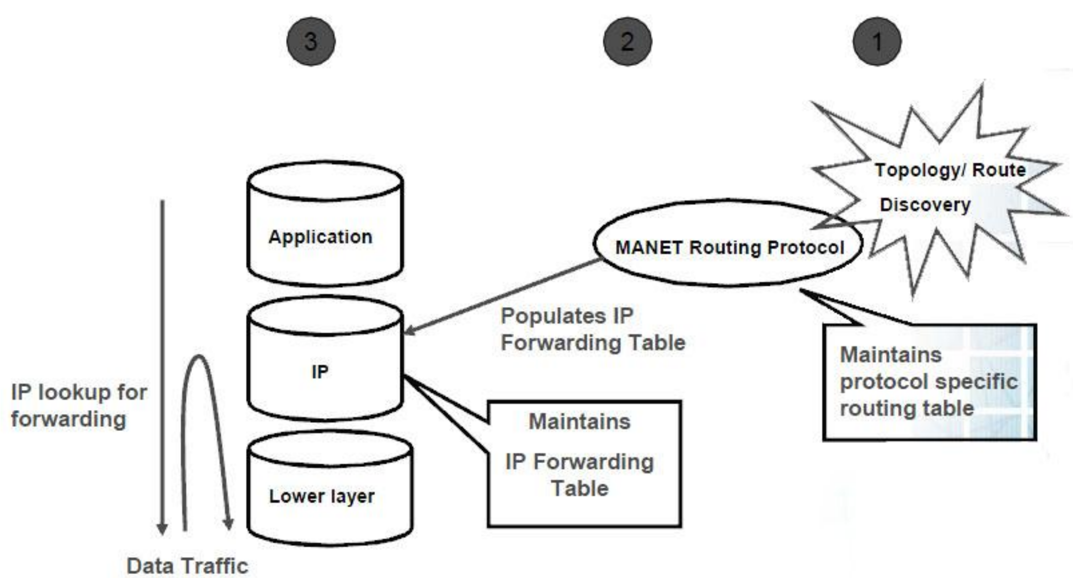


Figure 7: Wireless ad hoc network architecture [9]

Models of AODV, DSR and OLSR are available in OPNET version 14.0A. Figure 8 illustrates node model architecture of a MANET node. This node could be a WLAN workstation operating in ad hoc mode. The function of ip_dispatch of the ip_encap process creates a manet_mgr that manages all ad hoc routing protocols in OPNET except OLSR. The manet_mgr itself creates another specific process for the required ad hoc routing protocol as defined in the parameters [6]. As said before, OLSR does not require reliable control message delivery, hence it sits over UDP. Figure 9 shows model architecture of OLSR protocol.

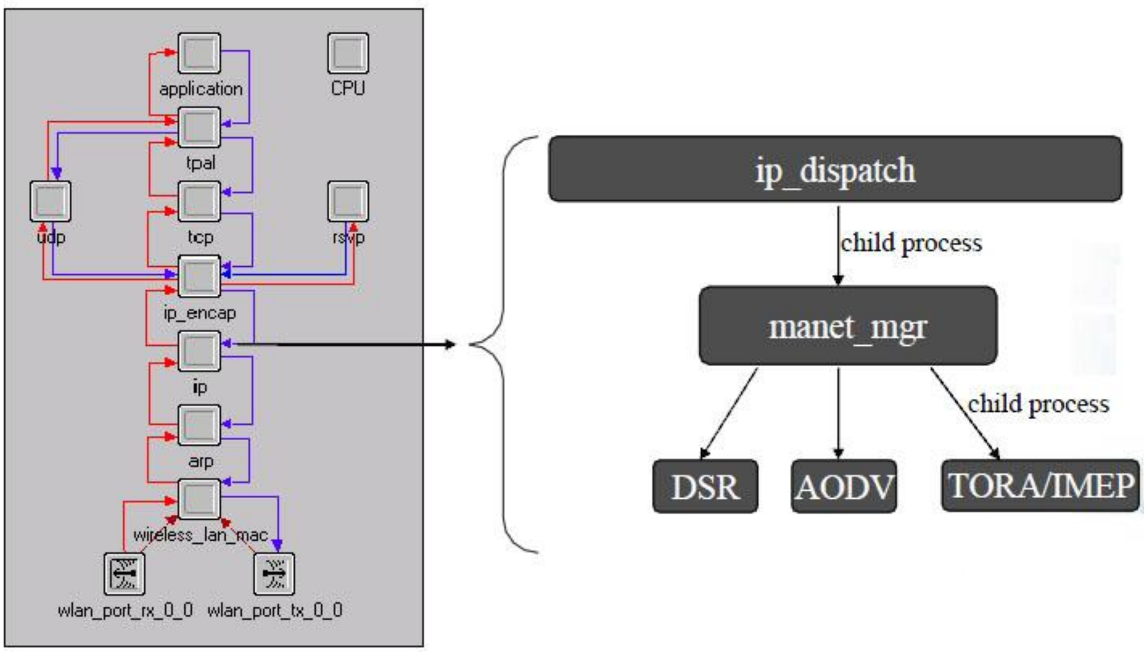


Figure 8: MANET model architecture (AODV, DSR, and TORA) [9]

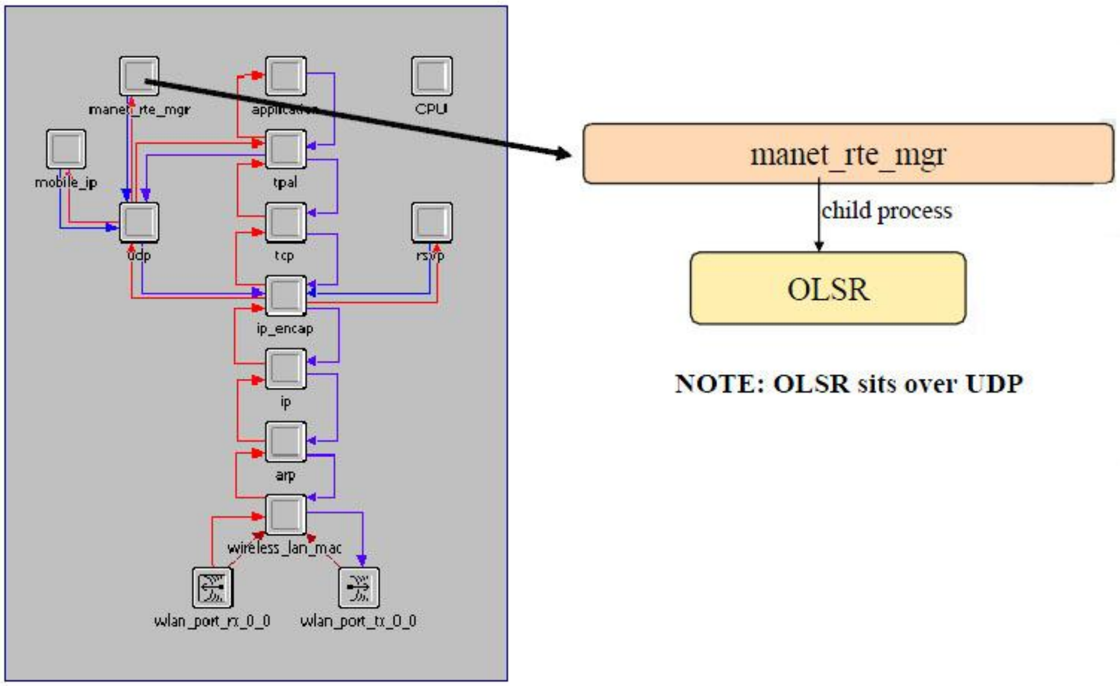
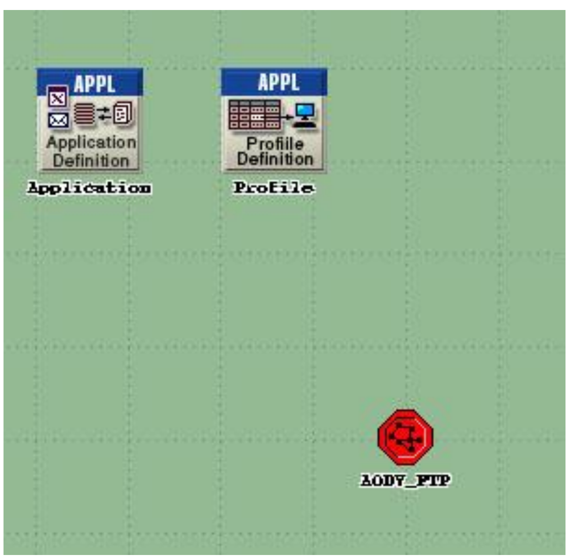


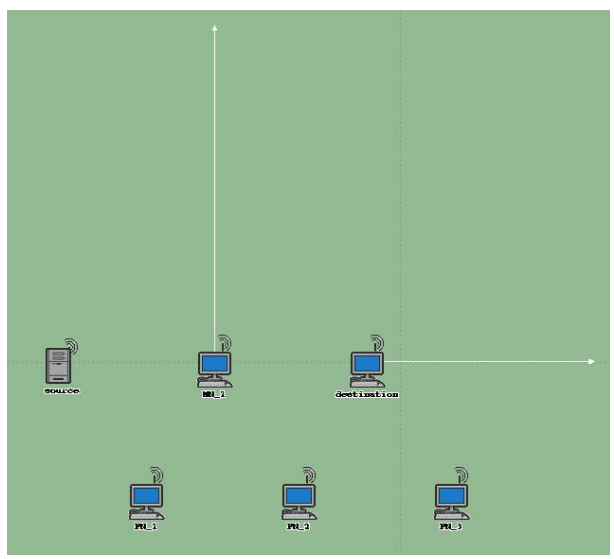
Figure 9: MANET model architecture (OLSR) [9]

In order to compare routing protocols, 12 simulation scenarios are created for Ad Hoc network. Three scenarios are created for each AODV and DSR routing protocols and six scenarios are created for OLSR routing protocol with different characteristics.

Figure 10 shows one common scenario that is created to compare wireless ad hoc network's routing protocols. There is a subnet (Figure 10.a) that contains six WLAN nodes that are operating in ad hoc mode (Figure 10.b). Each node is 450 meters apart from its neighbor nodes. Four nodes are fixed nodes and two nodes are mobile nodes. The first mobile node starts moving after 3 minutes, and it takes 2 minutes to move 1km. The other mobile node that is the destination node starts moving after 8 minutes and it takes 80 seconds to move 650m. At the beginning of the simulation, the source node will find the destination node with one hop distance through the mobile node. After moving the mobile node, the route between the source and the destination will break, causing the source to start another route discovery operation to find a new route to the destination. The new route will be found through two fixed nodes, and the distance between source node and destination node will change to two hops. Again after a couple of minutes that the destination node starts moving, previously found two hop distance route between source and destination will break, hence source will start another route discovery operation to find a new route to destination. The new route will be found through three fixed nodes and the distance between source node and destination node will change to three hops. Transmit power for every node is 5 mW with packet reception power threshold of -90dbm that limits the coverage area to approximately 650 meters. Hence each node can only see its neighbor nodes in its coverage area.



a. Subnet of the network



b. Six nodes operating in ad hoc mode

Figure 10: configured six node campus network for all protocols

In the first three scenarios, AODV routing protocol is used. Figure 11 shows the attributes that are used for this routing protocol. Hello interval is selected to be a uniform distribution of (1, 1.1) seconds. Net Diameter is selected to be 6 because of six nodes in the scenario. Local repair is enabled, and finally, for packet queue size, the attribute is set to infinity.

Attribute	Value
AODV Parameters	(...)
Route Discovery Parameters	(...)
Route Request Retries	5
Route Request Rate Limit (p...	10
Gratuitous Route Reply Flag	Disabled
Destination Only Flag	Disabled
Acknowledgement Required	Disabled
Active Route Timeout (seconds)	3
Hello Interval (seconds)	uniform (1, 1.1)
Allowed Hello Loss	2
Net Diameter	6
Node Traversal Time (seconds)	0.04
Route Error Rate Limit (pkts/sec)	10
Timeout Buffer	2
TTL Parameters	(...)
TTL Start	1
TTL Increment	2
TTL Threshold	7
Local Add TTL	2
Packet Queue Size (packets)	Infinity
Local Repair	Enabled
Addressing Mode	IPv4

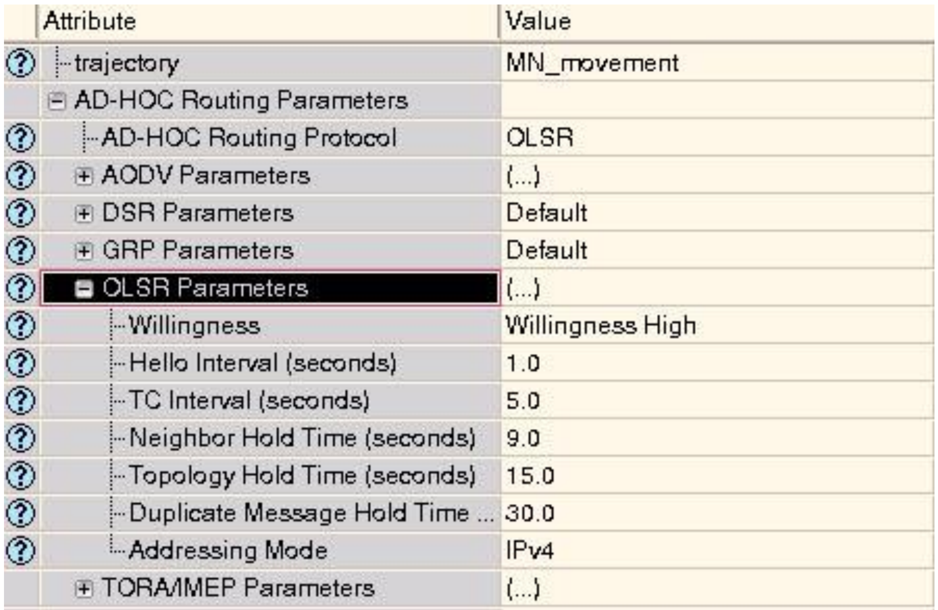
Figure 11: Configuration of AODV

In the second three scenarios, DSR routing protocol is used. Figure 12 shows the attributes that are used for this routing protocol. Route Expiry Timer is set to 30 seconds, which means that every route that is not used for 30 seconds will be expired.

Attribute	Value
DSR Parameters	(...)
Route Cache Parameters	(...)
Max Cached Routes	Infinity
Route Expiry Timer (seconds)	30
Route Cache Export	Do Not Export
Send Buffer Parameters	(...)
Max Buffer Size (packets)	Infinity
Expiry Timer (seconds)	30
Route Discovery Parameters	(...)
Request Table Size (nodes)	6
Maximum Request Table Id...	16
Maximum Request Retrans...	16
Maximum Request Period (s...	10
Initial Request Period (seco...	0.5
Non Propagating Request Ti...	0.03
Gratuitous Route Reply Tim...	1
Route Maintenance Parameters	(...)
Maximum Buffer Size (packe...	50
Maintenance Holdoff Time (...	0.25
Maximum Maintenance Retr...	2
Maintenance Acknowledge...	0.5
DSR Routes Export	Do Not Export
Route Replies using Cached ...	Enabled
Packet Salvaging	Enabled
Non Propagating Request	Disabled
Broadcast Jitter (seconds)	uniform (0, 0.05)

Figure 12: Configuration of DSR

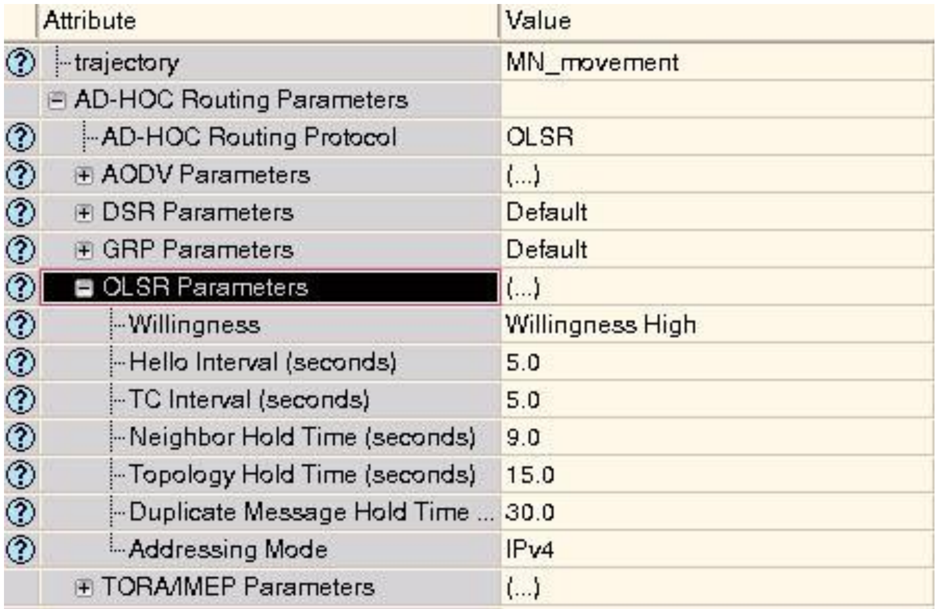
In the third three scenarios, OLSR routing protocol with periodical Hello message every 1 second is used. Figure 13 shows the attributes that are used for this routing protocol. Willingness is set to high for every node, which means every node is highly willing to be forwarding traffic on behalf of other nodes. Hello Interval is set to 1 second, which means that the Hello message will broadcast every one second.



Attribute	Value
trajectory	MN_movement
AD-HOC Routing Parameters	
AD-HOC Routing Protocol	OLSR
AODV Parameters	(...)
DSR Parameters	Default
GRP Parameters	Default
OLSR Parameters	(...)
Willingness	Willingness High
Hello Interval (seconds)	1.0
TC Interval (seconds)	5.0
Neighbor Hold Time (seconds)	9.0
Topology Hold Time (seconds)	15.0
Duplicate Message Hold Time ...	30.0
Addressing Mode	IPv4
TORA/IMEP Parameters	(...)

Figure 13: Configuration of OLSR for periodical Hello message every 1

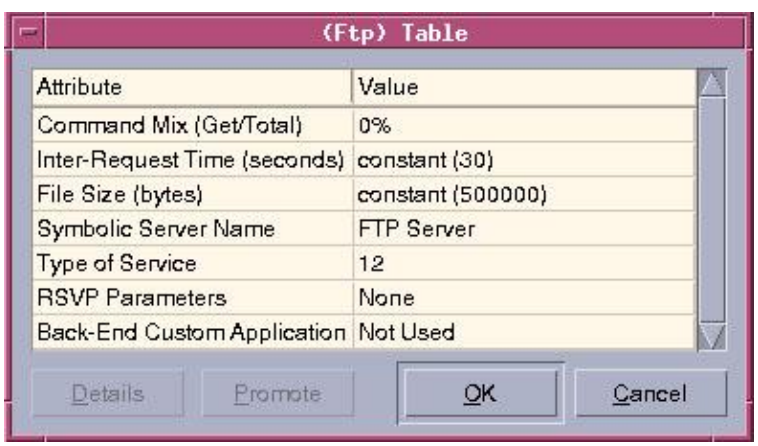
In the fourth three scenarios, OLSR routing protocol with periodical Hello message every 5 seconds is used. Figure 14 shows the attributes that are used for this routing protocol. Willingness is set to high for every node, and that again means that every node is highly willing to be forwarding traffic on behalf of other nodes. Hello Interval is set to 5 seconds, which means again that the Hello message will broadcast every five seconds.



Attribute	Value
trajectory	MN_movement
AD-HOC Routing Parameters	
AD-HOC Routing Protocol	OLSR
AODV Parameters	(...)
DSR Parameters	Default
GRP Parameters	Default
OLSR Parameters	(...)
Willingness	Willingness High
Hello Interval (seconds)	5.0
TC Interval (seconds)	5.0
Neighbor Hold Time (seconds)	9.0
Topology Hold Time (seconds)	15.0
Duplicate Message Hold Time ...	30.0
Addressing Mode	IPv4
TORA/IMEP Parameters	(...)

Figure 14: Configuration of OLSR for periodical Hello message every 5

Three applications are defined for this project: heavy file transfer, MPEG4 video transfer, and MPEG2 video transfer. Figure 15 shows the attributes that are used for FTP application. Inter-request time is selected as a constant for every 30 seconds. File size is also a constant value of 500000 bytes.



(Ftp) Table

Attribute	Value
Command Mix (Get/Total)	0%
Inter-Request Time (seconds)	constant (30)
File Size (bytes)	constant (500000)
Symbolic Server Name	FTP Server
Type of Service	12
RSVP Parameters	None
Back-End Custom Application	Not Used

Figure 15: Configuration of FTP application

MPEG4 and MPEG2 video configurations are the same that are defined in [10]. MPEG4 video is trace of the Matrix III film with a resolution of 352x288 pixels at 25 fps. MPEG2 video is trace of the Terminator 2 film with a resolution of 1280x720 pixels at 30 fps [10].

6. Simulation results and comparisons

The average traffic received of network in FTP scenario is shown in Figure 16. The horizontal axis shows the time in minutes and the vertical axis shows the average traffic received in bytes/sec. The figure shows that all protocols have sent all the FTP traffic, but at different times and with different delays that are shown in Figure 17. The horizontal axis shows the time in minutes and the vertical axis shows the average TCP delay in seconds.

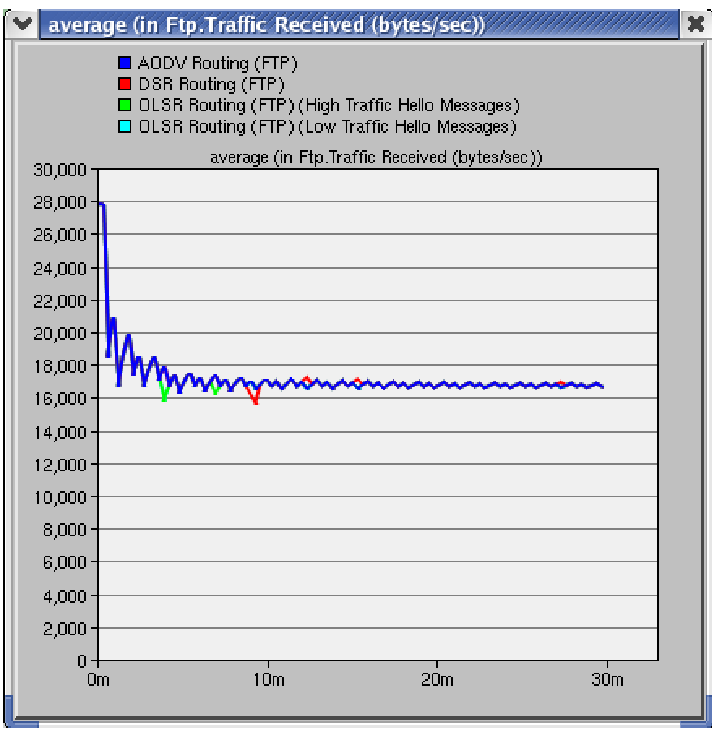


Figure 16: Average FTP traffic received (bytes/sec)

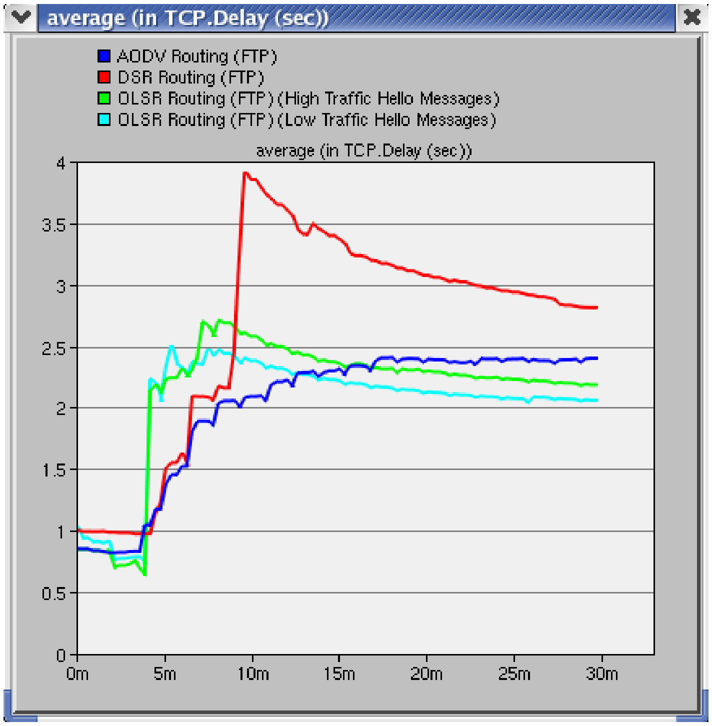


Figure 17: Average TCP delay (sec)

As it can be seen in Figure 17, in first 4 minutes, since the distance between the source and the destination is one hop, the delay is low. After movement of the mobile node, we see a dramatic rise in TCP delay of both OLSR scenarios. At the 9th minute of the simulation, due to the movement of the destination node, the distance between the source and destination changes to 3 nodes. Hence, another dramatic rise occurs in the simulation for the DSR routing protocol.

Upload response time in an FTP scenario is shown in Figure 18. The horizontal axis shows the time in minutes and the vertical axis shows the upload response time in seconds. As it can be seen, the trends of lines are the same with average TCP delay (Figure 17).

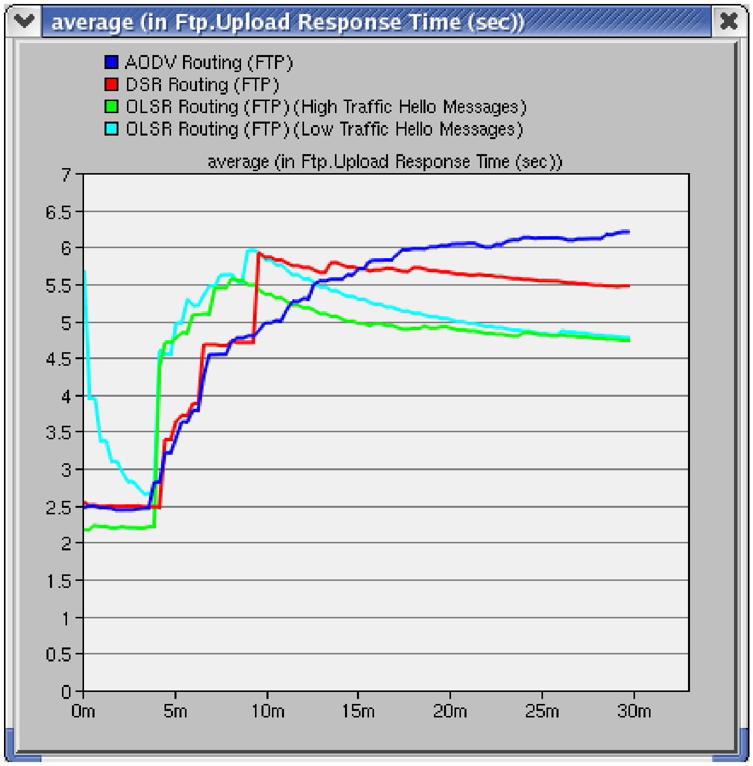


Figure 18: Upload response time (sec)

Proactive routing protocols generate more routing traffic overhead than reactive protocols. Figure 19 shows the sent routing traffic in FTP scenarios and in source node for all routing protocols. The horizontal axis shows the time in minutes and the vertical axis shows packets sent in pkts/sec. In this figure, we can clearly see the difference of reactive and proactive routing protocols. In both OLSR scenarios, routing traffic is very dense in time and causes a large overhead in the network. However, we can see that the routing traffic size in OLSR with less frequent Hello messages is 5 times less than the routing traffic size with more frequent Hello messages. This will cause less buffer overflow in the case of having low buffer size. In both on-demand routing protocols, we can see that their routing traffic is more separate apart than proactive routing protocols, and in the case of routing traffic size, we can see that AODV sends less routing traffic than DSR.

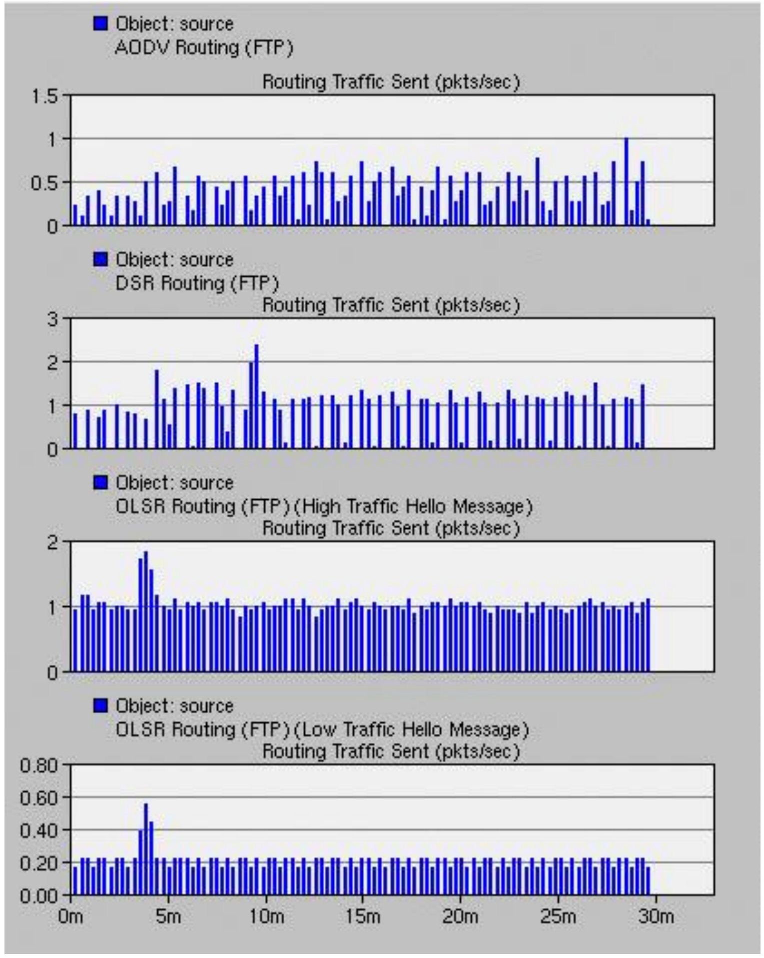


Figure 19: Routing traffic sent in FTP scenario (pkts/sec)

Figure 20 shows routing traffic received in FTP scenarios and in the destination node for all routing protocols. The horizontal axis shows the time in minutes and the vertical axis shows packets received in pkts/sec. This figure shows the routing overhead for finding and maintaining a route to the destination node. It is clear that the amount of packets received in the destination node per second is more than the packets that are sent before by the source node. This is because all nodes in the network are responsible for broadcasting all of the packets, and so the destination node receives more than one copy of each route request through different routes.

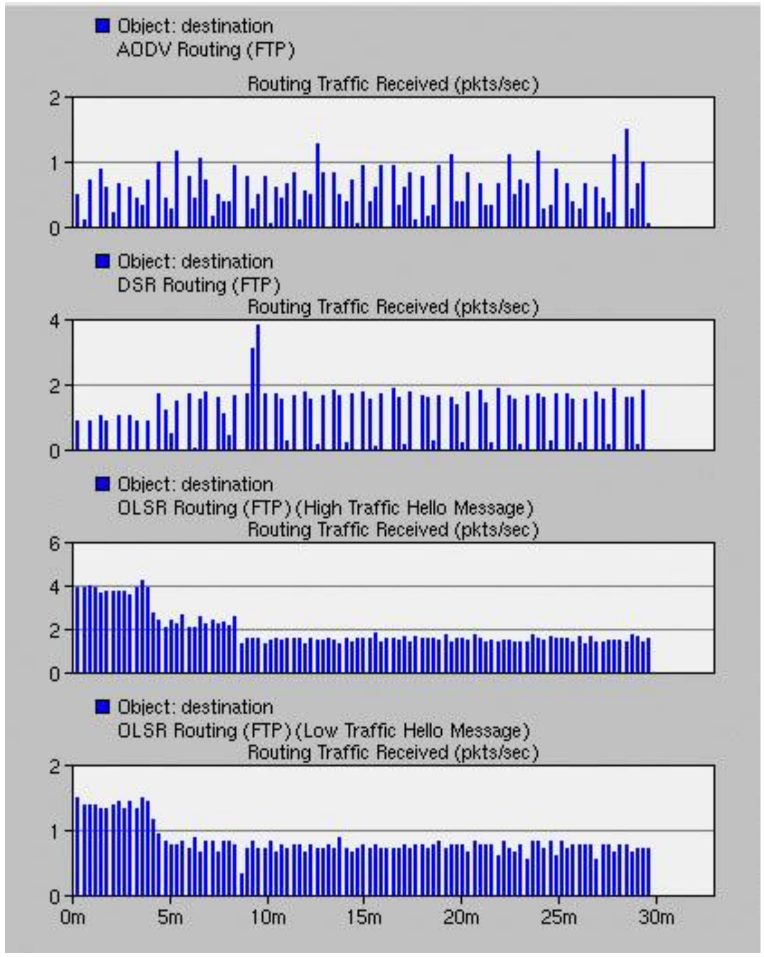
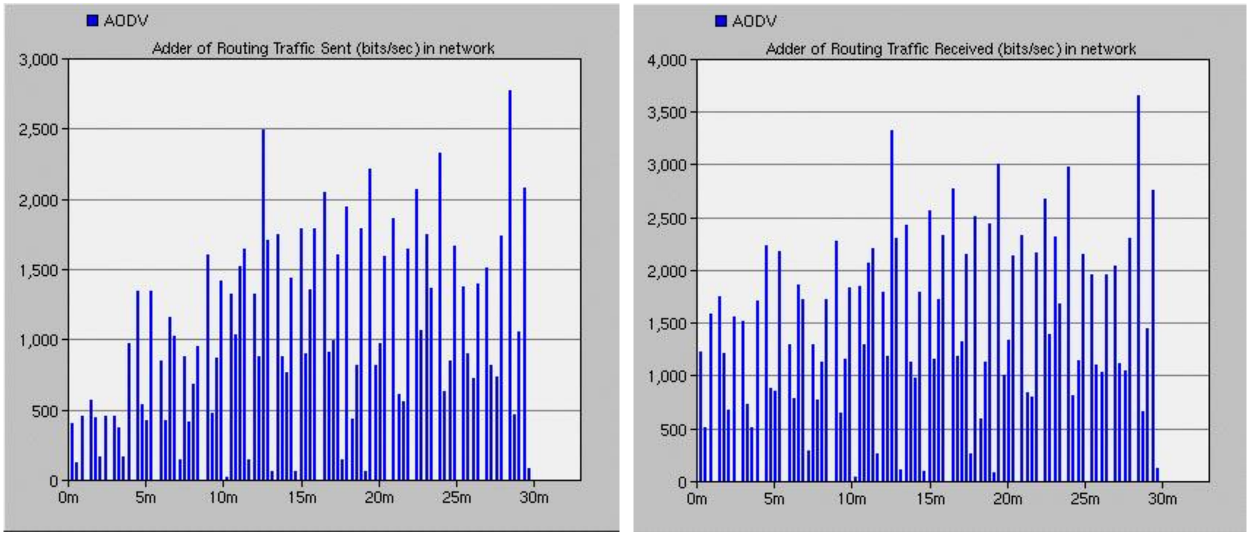


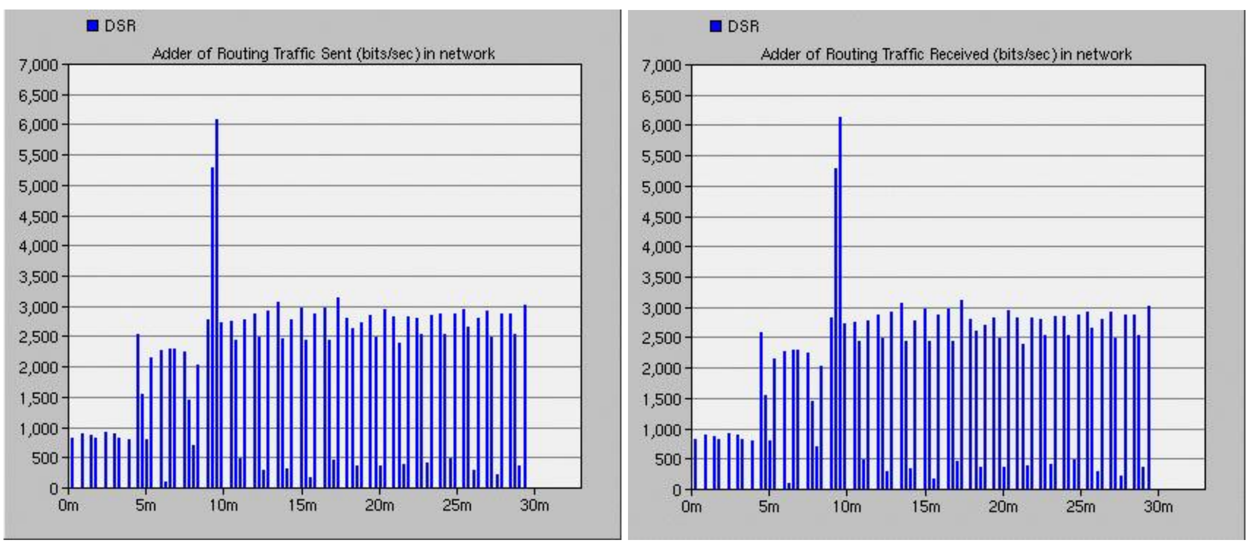
Figure 20: Routing traffic received in FTP scenario (pkts/sec)

Figure 21 shows the adder of routing traffic sent (21.a) and received (21.b) in the network for AODV routing protocol, and Figure 22 shows the adder of routing traffic sent (22.a) and received (22.b) in the network for DSR routing protocol. The horizontal axis shows the time in minutes and the vertical axis shows packets sent or received in bits/sec.



a. Adder of routing traffic sent (bits/sec) b. Adder of routing traffic received (bits/sec)

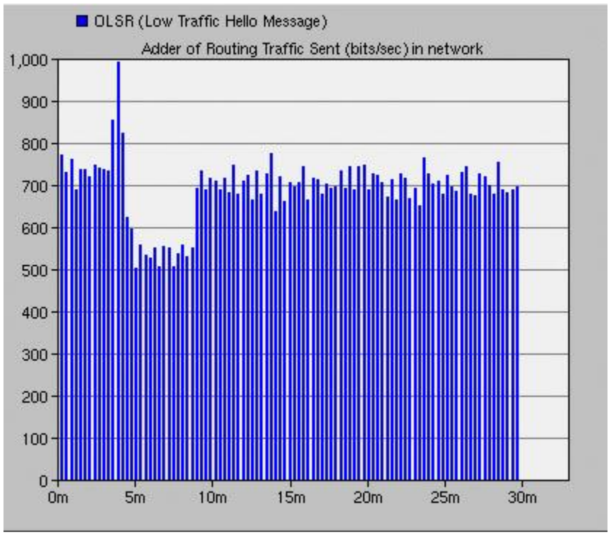
Figure 21: Adder of Routing Traffic sent and received in AODV



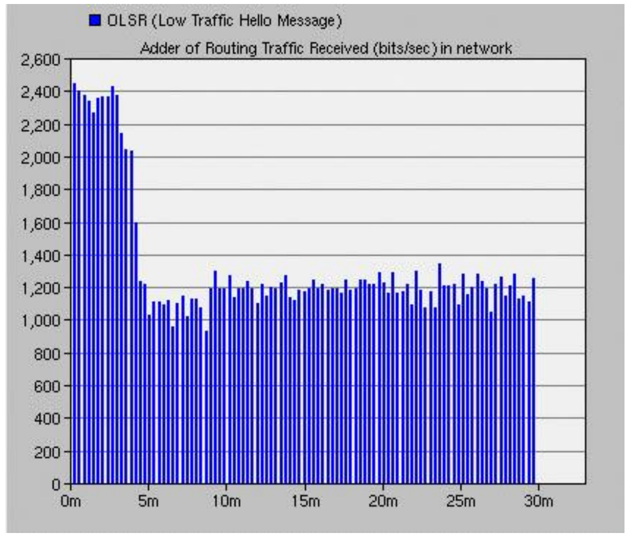
a. Adder of routing traffic sent (bits/sec) b. Adder of routing traffic received (bits/sec)

Figure 22: Adder of Routing Traffic sent and received in DSR

To compare on-demand routing protocols, we can see that the overall routing traffic size in DSR in more than AODV. One possible reason for this could be the source routing concept of DSR, which means that each routed packet carries a complete and ordered list of nodes in its header through which the packet passes. This causes larger packet sizes in DSR routing protocol, but keeps the same routing traffic sent and received in the network.

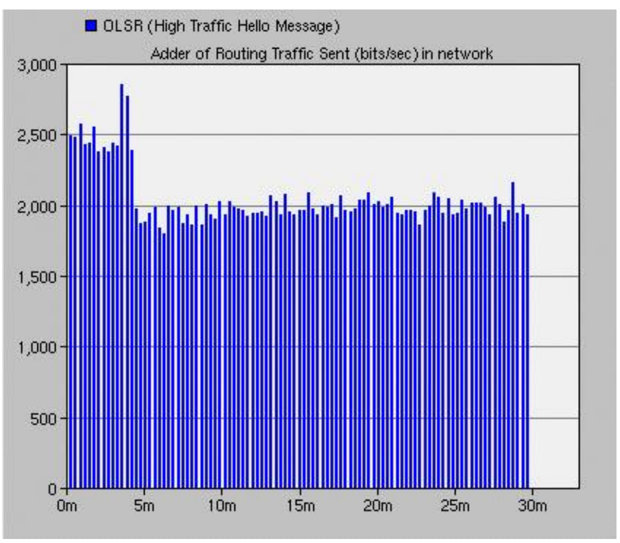


a. Adder of routing traffic sent (bits/sec)

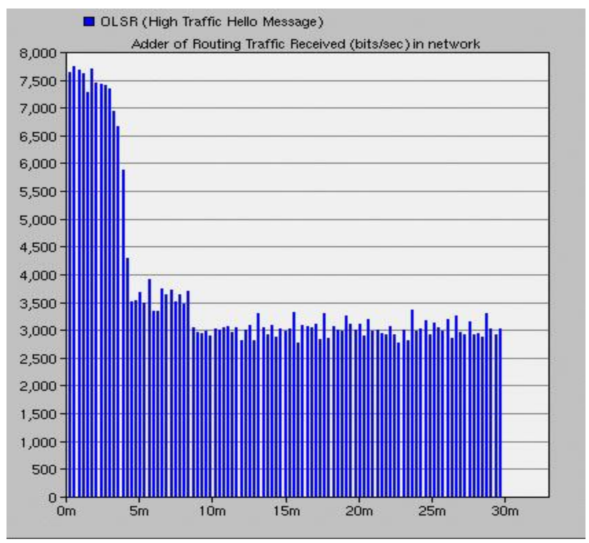


b. Adder of routing traffic received (bits/sec)

Figure 23: Adder of Routing Traffic sent and received in OLSR with periodical Hello message every 5 seconds



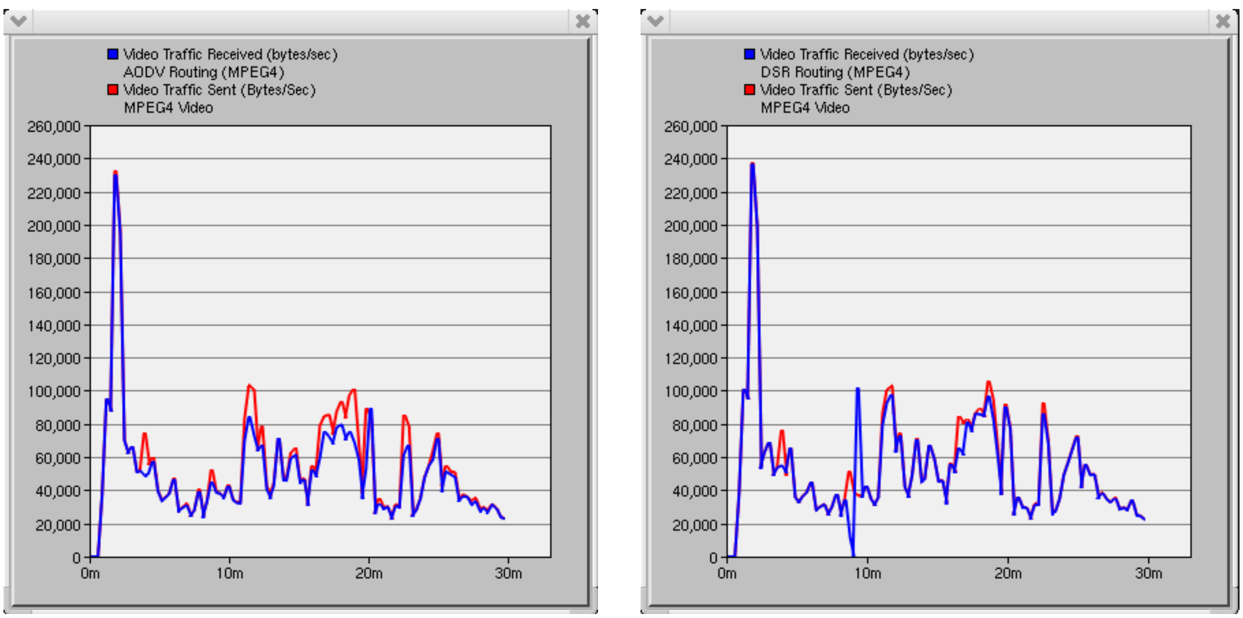
a. Adder of routing traffic sent (bits/sec)



b. Adder of routing traffic received (bits/sec)

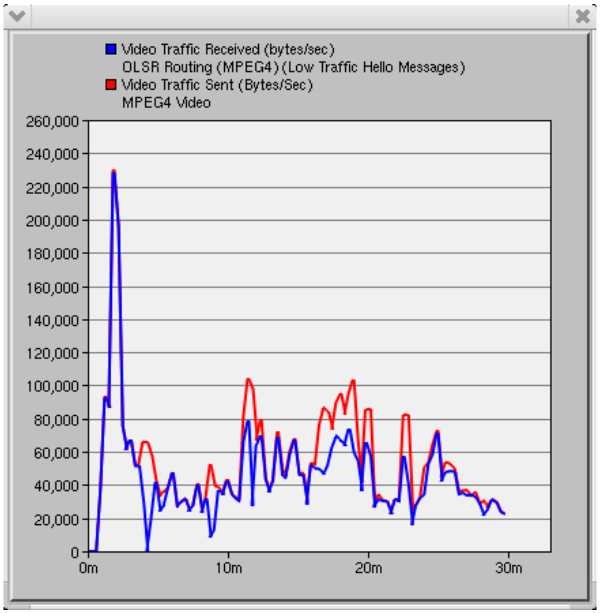
Figure 24: Adder of Routing Traffic sent and received in OLSR with periodical Hello message every 1 second

Figure 23 shows the adder of routing traffic sent (23.a) and received (23.b) in the network for OLSR routing protocol with less frequent Hello messages and Figure 24 shows the adder of routing traffic sent (24.a) and received (24.b) in the network for OLSR routing protocol with more frequent Hello messages. The horizontal axis shows the time in minutes and the vertical axis shows packets sent or received in bits/sec. It can be seen that routing traffic overhead in OLSR with more frequent Hello messages is more than OLSR with less frequent Hello messages. This causes a considerable difference in the buffer size of the nodes in the network; however, the throughput and delay is approximately the same in both OLSR scenarios.

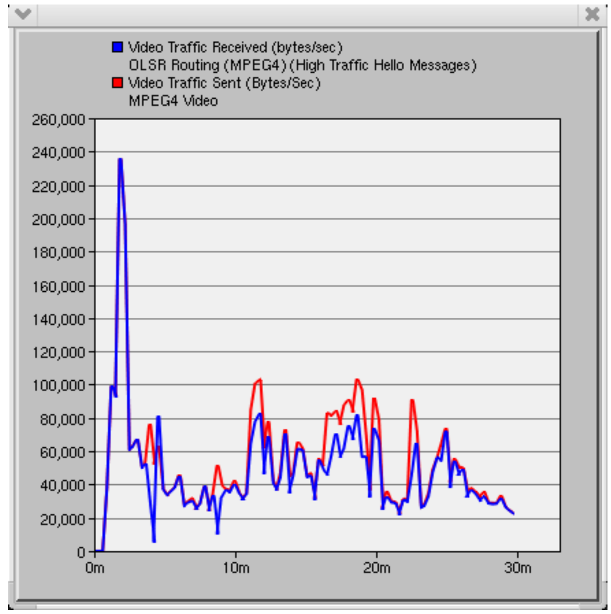


a. MPEG4 video traffic in AODV b. MPEG4 video traffic in DSR

Figure 25: MPEG4 video traffic sent and received in on-demand routing protocols



a. MPEG4 video traffic in OLSR (Hello message every 1s)



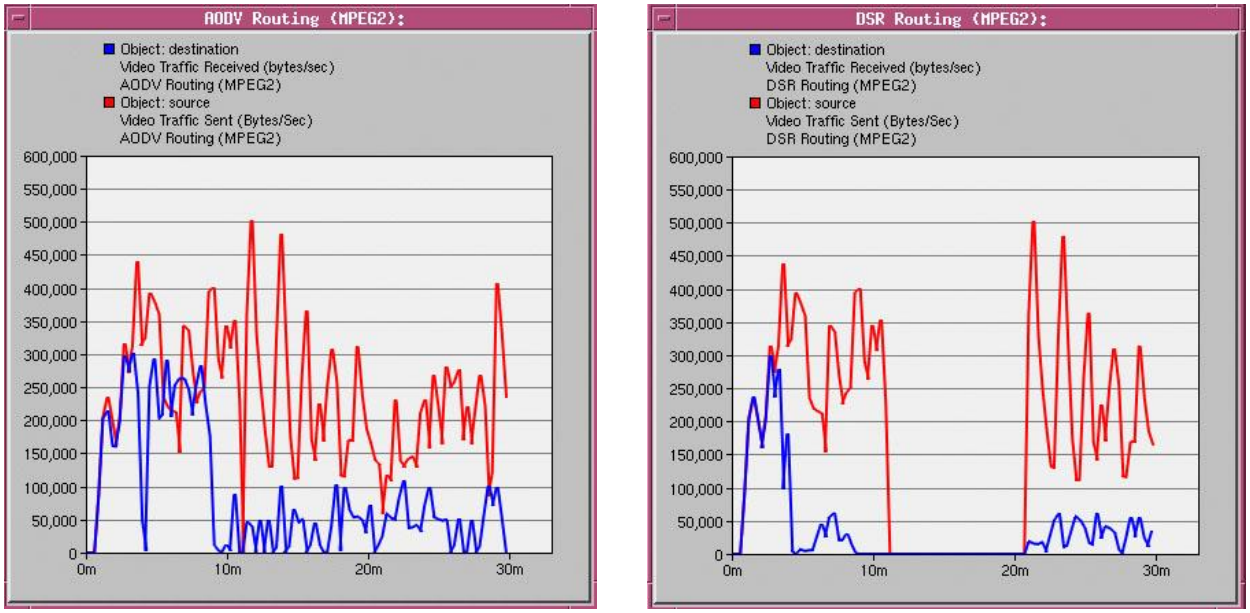
b. MPEG4 video traffic in OLSR (Hello message every 5s)

Figure 26: MPEG4 video traffic sent and received in proactive routing protocols

Figure 25 shows the throughput of MPEG4 video in AODV (25.a) and DSR (25.b) routing protocols and Figure 26 shows the throughput of MPEG4 video for both OLSR routing protocols. The horizontal axis shows the time in minutes and the vertical axis shows video traffic in bytes/sec. It can be seen that throughput in both on-demand routing protocols are better than OLSR routing protocol.

Similar to Figures 25 and 26, Figure 27 shows the throughput of MPEG2 video in AODV (27.a) and DSR (27.b) routing protocols and Figure 28 shows the throughput of MPEG2 video for both OLSR routing protocols. The horizontal axis shows the time in minutes and the vertical axis shows video traffic in bytes/sec. It can be seen that throughput in all routing protocols is not adequate and protocols do not act well in transferring MPEG2 video. However, Figure 27.a shows that AODV sends more video traffic compared to other routing protocols, and in Figure

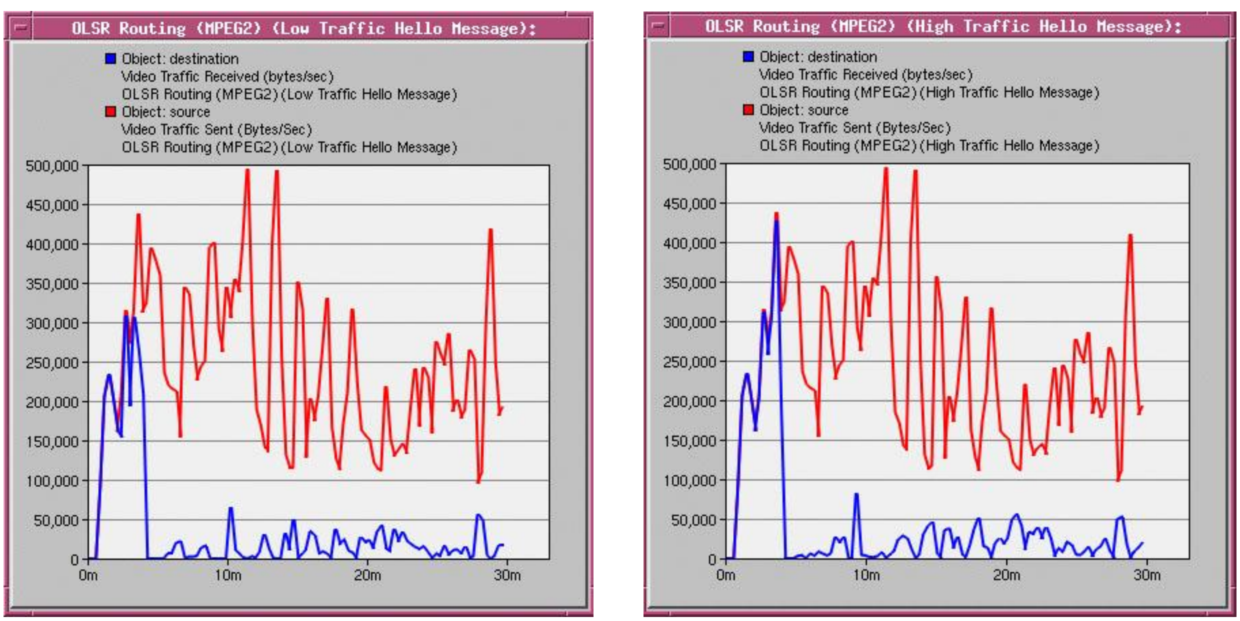
27.b we can see that DSR could not find a route to the destination node for almost 10 minutes after movement of the destination node.



a. MPEG2 video traffic in AODV

b. MPEG2 video traffic in DSR

Figure 27: MPEG2 video traffic sent and received in on-demand routing protocols



a. MPEG2 video traffic in OLSR (Hello message every 1s)

b. MPEG2 video traffic in OLSR (Hello message every 5s)

Figure 28: MPEG2 video traffic sent and received in proactive routing protocols

In case of delay variation in MPEG4 movie transfer, Figure 29 shows that in AODV and OLSR with less periodic hello messages, packet delay variations are almost zero while packet delay variations in DSR reach to 17 after movement of the destination node. In figure 29 the horizontal axis shows the time in minutes and the vertical axis shows video packet delay variation.

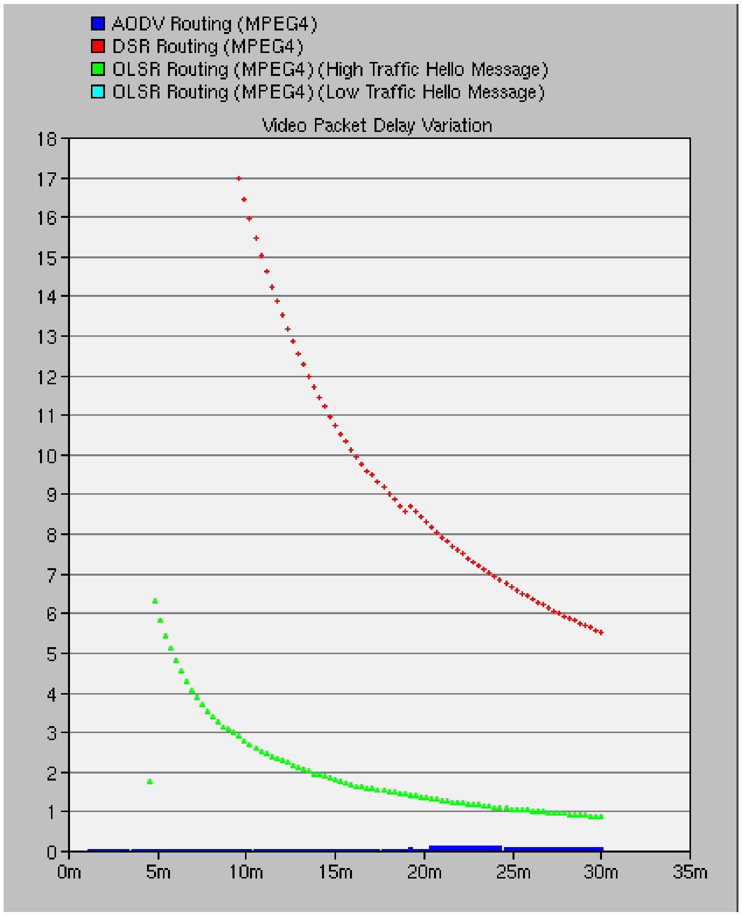


Figure 29: MPEG4 video packet delay variation

Figure 30 shows video packet delay variation for MPEG2 scenario. The horizontal axis shows the time in minutes and the vertical axis shows video packet delay variation. Despite the fact that

AODV has almost zero packet delay variation in the MPEG4 scenario, it has a large number of packet delay variation in MPEG2 scenario.

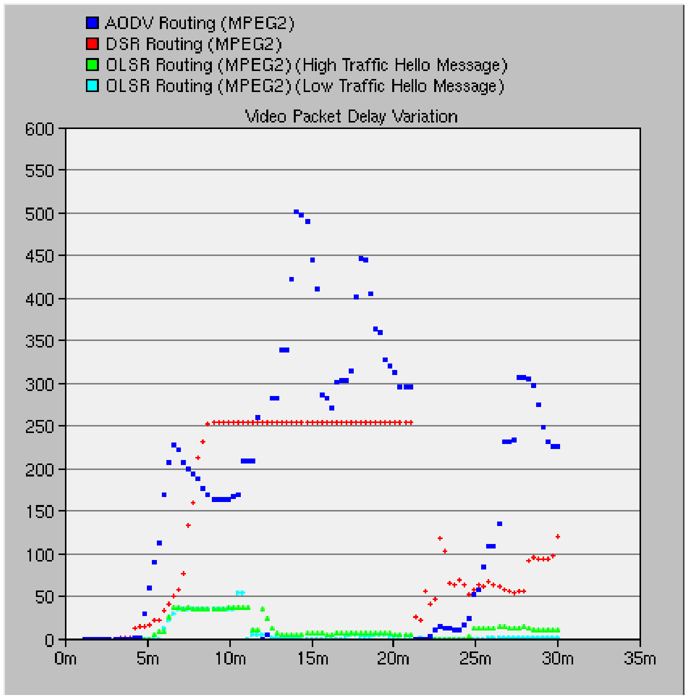


Figure 30: MPEG2 video packet delay variation

MPEG4 video end-to-end delay is shown in Figure 31. Figures 29 and 31 depict that OLSR with more frequent hello messages and DSR could not act well in the case of network topology changes in the MPEG4 scenario. Hence, packet e2e delay and delay variation dramatically increase after moving nodes in the 4^{th} and 9^{th} minutes. In Figure 31 the horizontal axis shows the time in minutes and the vertical axis shows end to end delay in seconds.

The same result is shown in Figure 32 for MPEG2 scenario. Although AODV has adequate results in the case of e2e delay in the MPEG4 scenario, it too, just like the other routing protocols, does not act well in the MPEG2 scenario.

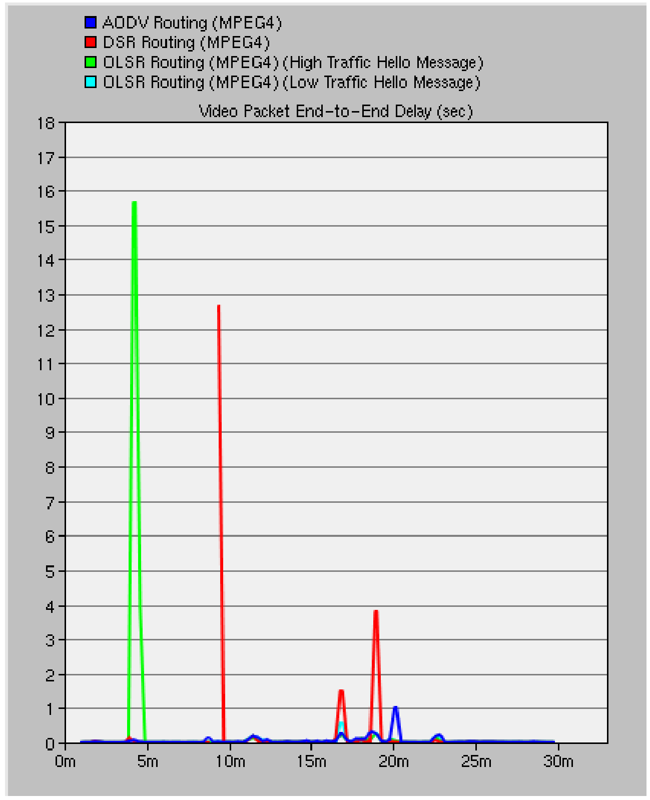


Figure 31: MPEG4 video packet end to end delay (sec)

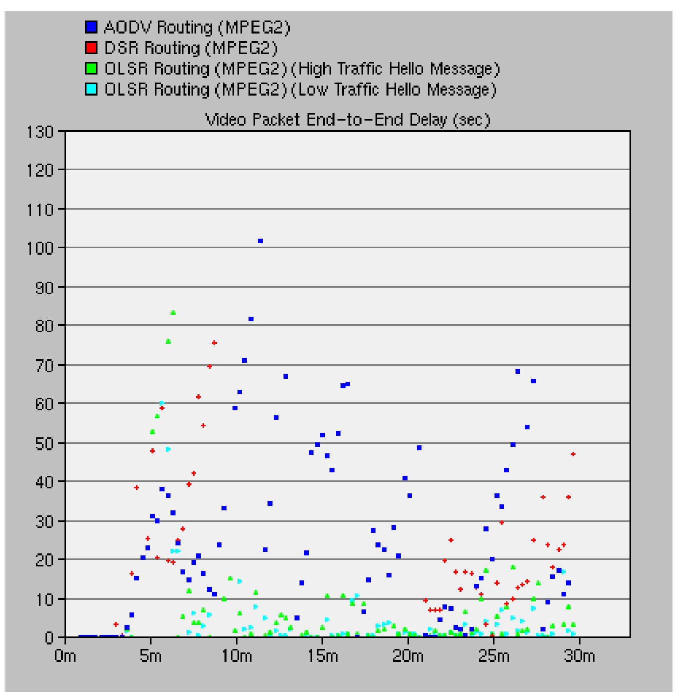


Figure 32: MPEG2 video packet end to end delay (sec)

Finally, route discovery time is shown in figure 33 and 34. This statistic is only for on-demand routing protocols because they must search for a route before they start sending data to the destination, while proactive routing protocols find all routes to all nodes beforehand.

Route Discovery time for the MPEG4 scenario is shown in Figure 33. The horizontal axis shows the time in minutes and the vertical axis shows time in seconds. Also, Figure 34 shows route Discovery time for MPEG2 scenario. It can be seen that route discovery time increases as data rate increases. In the MPEG4 scenario, AODV could find routes faster, but it searched for routes more than DSR did.

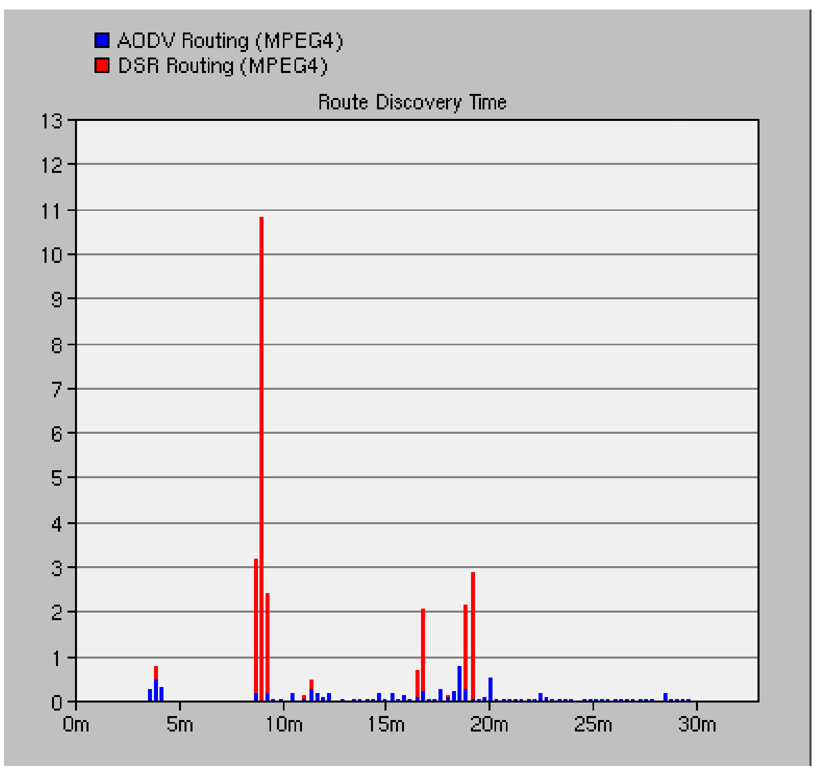


Figure 33: Route discovery time in MPEG4 scenario (sec)

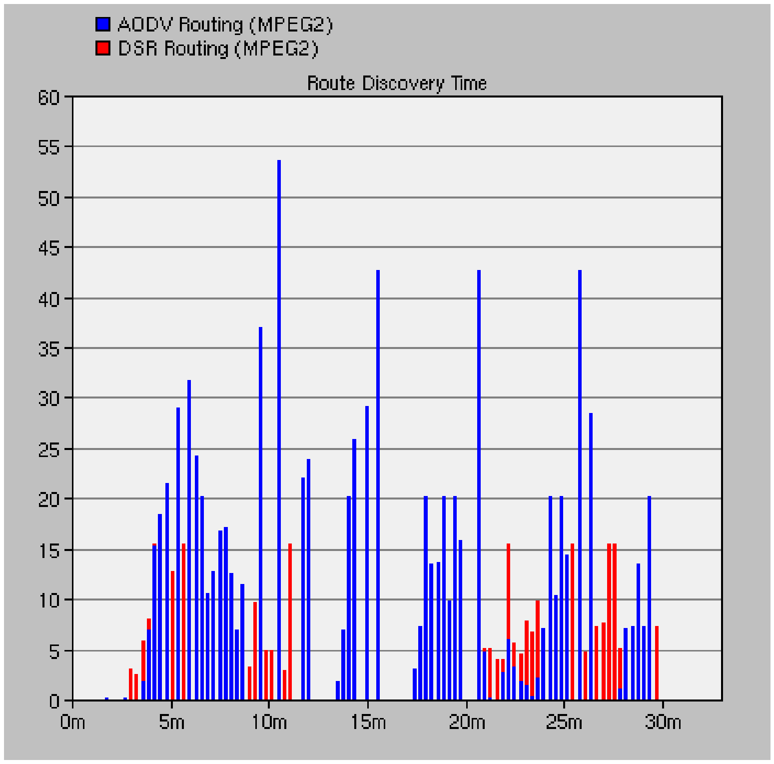


Figure 34: Route discovery time in MPEG2 scenario (sec)

7. Conclusions

This study has compared the performance of wireless ad hoc routing protocols in different scenarios and with different traffic loads. Increasing data rate causes decreasing performance of ad hoc routing protocols.

In this project, each scenario's simulation time was 30 minutes. Hence, in total, the simulation time was 6 hours for 12 scenarios. The actual time for simulating the project was approximately 7 hours.

In the file transfer scenario, almost all of the protocols had similar results. The major difference was routing traffic overhead and delay. OLSR with less frequent hello messages performed better in FTP if we consider delay an important factor, but if we consider routing traffic overhead instead, AODV was better routing protocol.

In the MPEG4 scenario, AODV outperformed other protocols in the case of packet delay and delay variation together with good throughput and low routing overhead.

In the MPEG2 scenario, all of the protocols performed poorly, and we can conclude that ad hoc networks are not suitable for transferring high-rate data (e.g. high quality videos).

8. References

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