Quantitative Performance Mobile Ad-Hoc Network Using Optimized Link State Routing Protocol (OLSR) and Ad-hoc On-demand Distance Vector (AODV)

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ABSTRACT
Information transfer is one of a major issue in information technology development. This is because one of basic purpose of development of information technologies is intended to transfer information between the parties. One of the latest developments in information transfer is the routing called MANET (Mobile Ad-hoc Network) which is used as one standard routing on the wireless world. MANET itself is divided into two methods are proactive routing method, which is represented by the Optimized Link State Routing (OLSR) and reactive routing method, which is represented by the Ad-hoc On-demand Distance Vector (AODV). In this research, will be conduct three different methods qualitative performance about OLSR and AODV to see about their implementation, and performance about those two routing method. This qualitative method that has conduct is the calculation method of the mathematical model, network simulation method, and field testing methods. The network type that have been use to this experiment is type A (using three nodes), type B (using four nodes), type C (using 5 nodes) and for testing a complex network (more than 10 nodes) will be used a network simulation QualNet. Based on the testing results, we can conclude that quantitative performance of AODV routing protocol is better than the OLSR routing protocol in a simple network (no more than 10 nodes), while the OLSR routing on complex networks (more than 10 nodes) better than AODV.

Keywords
MANET, ad-hoc network routing protocols, OLSR, AODV

1. INTRODUCTION
Information transfer is one of a major issue in information technology development. This is because one of basic purpose of development of information technologies is intended to transfer information between the parties. One of the latest developments in information transfer is the routing called MANET (Mobile Ad-hoc Network) which is used as one standard routing on the wireless world. MANET itself is divided into two methods are proactive routing method, which is represented by the Optimized Link State Routing (OLSR) and reactive routing method, which is represented by the Ad-hoc On-demand Distance Vector (AODV) [4].

In this research, will be conduct three different methods qualitative performance about OLSR and AODV to see about their implementation, and performance about those two routing method. Methods that have been used to conduct a qualitative performance are a calculation method using mathematical model, network simulation method, and field testing methods. The network type that have been use to this experiment is type A (using three nodes), type B (using four nodes), type C (using 5 nodes) and for testing a complex network (more than 10 nodes) will be used a network simulation QualNet. For testing data transfer will be done a continuously transfer data in certain numbers of packet and a certain packet size, so that later the performance between the AODV and OLSR based on this testing variables.

2. PROACTIVE AND REACTIVE ROUTING
Proactive routing (figure 1) determine the routes to some nodes in a network that has been developed so that the route will always be ready when needed. Overhead for this routing is large enough because each node must discover all existing routes in the network, thus this method will be create a relative large bandwidth consume to keep this routes keep up-to-date. But in exchange, the package transmit is become fast enough because the route is already exists. Example for this method is like Destination sequenced Distance Vector (DSDV), Optimized Link State Routing (OLSR) and GSR [3].

Meanwhile, reactive routing determines the route only if its necessary so that the overhead of Route Discovery is quite small, this method uses the mechanism of flooding (global search). But in exchange a node that will transmit a packet must wait for the discovery of a route. Examples of reactive routing instance: Dynamic Source Routing (DSR), Ad-hoc On-demand Distance Vector (AODV) and TORA [3].

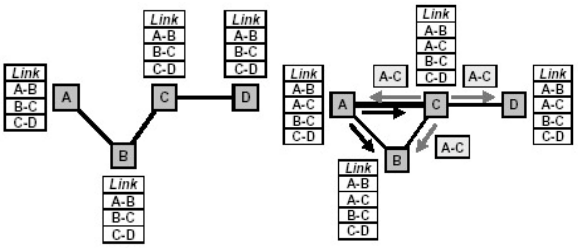

Figure 1. Example of proactive routing algorithm [5]

3. MOBILE AD-HOC NETWORK (MANET)

Mobile Ad-hoc Network (MANET) is one of ad-hoc wireless network type. MANET is a self-configuring network from a multiple mobile routers (and associated hosts) connected by wireless links [2]. Routers are free to move randomly and organize themselves dynamically so that the wireless network topology can change drastically and can not be predicted [9]

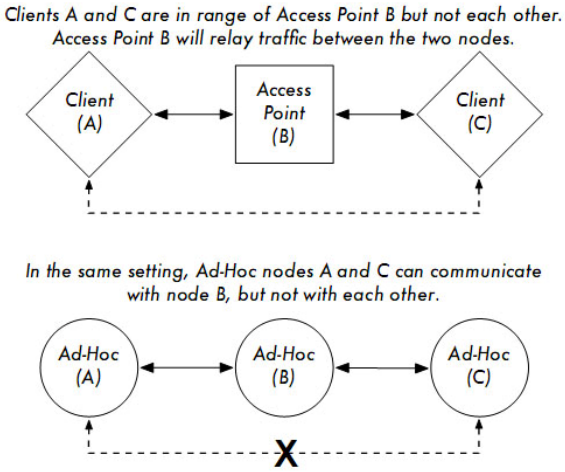

Figure 2. Ad-hoc mode and managed mode [9]

One of the lacks from an ad-hoc mode is the inability of the node to forward data packets to the third node (figure 2). If the network using an access point, even node A and node C not in each other range area, but they can still communicated each other through the access point that still within their reach area. In the ad-hoc mode, node A and C can't communicate each other because their location is out off their range area (figure 2). But with a routing protocol, the second node in the middle is inserted in the ad-hoc mode (figure 3), packet can carry data from the first node (A) to the third node (C). In this case, the second node to act as a relay to widen the reach of wireless networks (figure 4). One of the implementation of mesh routing technique is a MANET.

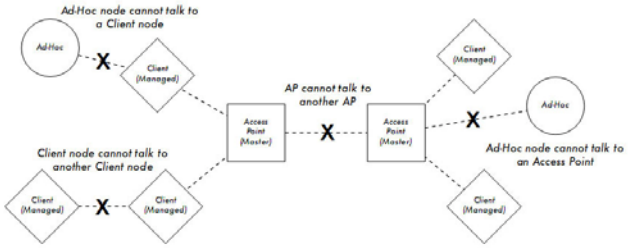

Figure 3. Master mode (access point) and client/managed mode [9]

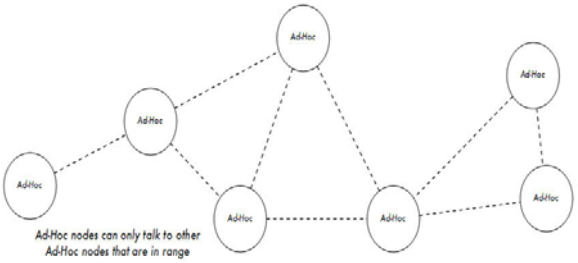

Figure 4. Ad-hoc mode [9]

4. OPTIMIZED LINK STATE ROUTING (OLSR)

Optimized Link State Routing (OLSR) is a proactive routing in mobile ad-hoc network. This protocol has the stability of link state algorithm and has the advantage with a route that's quickly available when it's needed. OLSR is an optimization of the classical link state protocol designed for wireless network usage.

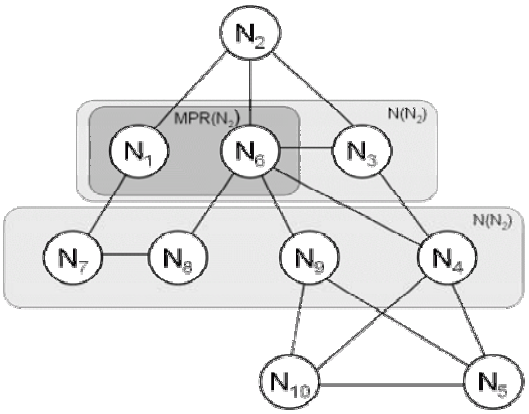

Figure 5. Examples of routing protocol OLSR [8]

Each node on the network, for example in figure 5 is node N2, will select multiple nodes in the network of his neighbors. These nodes will send packets to node N2. Neighboring nodes, namely the N1 and N6 called Multipoint relays of node N2. Node N2 chose him for the Assembly to cover all the nodes that are two hops away, for example node N7, N8, N9, and N4.

Beside that, OLSR does not require sequential message delivery. Each control message has a sequence number that otomatically increase for each message. This causes the receiver of the message can identify the latest message [6].

5. AD-HOC ON-DEMAND DISTANCE VECTOR (AODV)

On-demand Distance Vector (AODV) routing protocol is designed for ad-hoc network [1]. Which AODV can perform unicast and multicast routing. AODV is a reactive routing protocol that use on-demand-based algorithm, which means that this protocol will make the route in the network only if it's required by the source node to send a message. AODV route runs only as long as needed by the source. Additionally, AODV makes tree connecting member and the member-node multicast group.

In AODV, to find a route to destination, the source will broadcasts route request packets to the neighbor. The neighbor node will then broadcast the packet to their neighbor until it reaches the node that has information about the node destination or until it reaches the destination node. Route request packet will be used a sequential numbers to ensure that these nodes will repply only with the latest information alone [5] [6]

When a node sends a route request to neighboring nodes, the package also store information from which the package first arrived in its routing table. This information is used to create a route back from the route request packet. AODV uses only symmetric links because the route request packets follow the route back from the route request packet. Whereby when the route reply packet transmitted back to the source (figure 2), the nodes along the route include further routes into its routing table.

The advantage from AODV is that this protocol does not create additional traffic on the communications links that already exist. This makes routing simple and does not require a lot of memory allocation for routing calculations. However, AODV needs more time to create connections, and initial communication needed to create sometimes more difficult than some other methods [7]

6. NETWORK DESIGN

To perform quantitative performance test in data transfer between MANET proactive routing protocol (OLSR) and reactive routing method (AODV), there's three types of networks (type A, B, and C) that designed for represent several type of ad-hoc wireless networks. Ranging from relatively simple to quite complicated network. Three types of this networks are as follows (figure 6, 7, and 8). Where the Laptop source will be placed on T building and laptop destination will be place on W building.

6.1 Network Structure Type A

Network Structure Type A (figure 6) builds by three wireless ad-hoc devices using three laptops. Network Structure Type A designed with the simplest structure among this three types of experimental network, so the performance of this type is expected become the best-performing network.

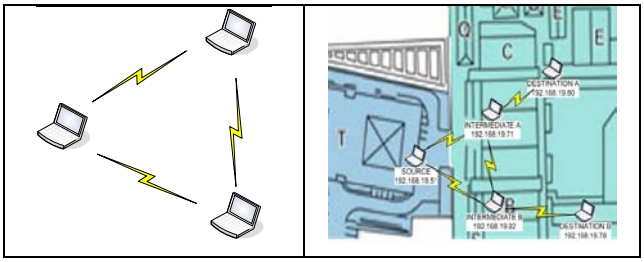

Figure 6. Network structure type A

6.2 Network Structure Type B

Network Structure Type B builds by four wireless ad-hoc devices using four laptops (Figure 8).

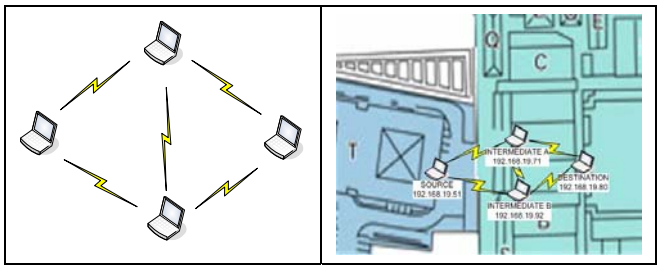

Figure 7. Network structure type B

6.3 Network Structure Type C

Network structure type C build by five wireless ad-hoc devices using five laptops. This network type is designed with the most complicated structure among another network structure types for this experiment, so this performance supposed become the worst.

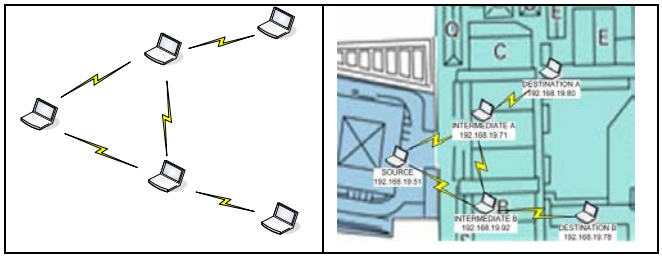

Figure 8. Network Structure Type C

7. Implementation and System Testing

Implementation and system testing for both OLSR and AODV is performed by delivery a several data packets, up to 30 packages with each package size is 512 bytes. Testing also also conducted with a large delivery of data packets from 512 bytes to 16 kilobytes. The process of comparison of results of OLSR and AODV will be based on packet delivery ratio, end to end delay, packet control ratio, path length ratio, and throughput generated by network structure design type A, B, and C.

7.1 Testing on Network Structure Type A

7.1.1 Network Test based on Amount of Packet Transmision on Network Structure Type A

On this experiment, each of network structure will be tested by a number of packets (1, 5, 10, 15, 20, 25 and 30 packets) that transmitted from source node to destination node with a packet size 512 bytes for each Packet. The simulation results from network type A using AODV routing can be seen in table 1. Meanwhile, test results against OLSR routing based can be seen in table 2

Table 1. Network structure type A testing using AODV routing based on amount of packets

Amount of Packets	Packet Delivery Ratio (%)		Delay End-to-End (milisecond)		Packet Control Ratio (O/H)	Path Length Ratio	Throughput (bit/s)
	Dest. A	Dest. B	Dest. A	Dest. B			
1	100	100	1.7	2.4	4:1	1:1	0
5	100	100	6.1	10.3	4:5	1:1	5200
10	100	100	4.7	8.6	4:10	1:1	4600
15	100	100	4.3	8.1	4:15	1:1	4400
20	100	100	4.1	7.8	4:20	1:1	4300
25	100	100	3.9	7.6	4:25	1:1	4250
30	96	96	3.8	7.5	4:30	1:1	4100

Table 2. Network structure type A testing using OLSR routing based on amount of packets

Amount of Packet	Packet Delivery Ratio (%)		Delay End-to-End (milisecond)		Packet Control Ratio (O/H)	Path Length Ratio	Throughput (bits/s)
	Dest. A	Dest. B	Dest. A	Dest. B			
1	50	50	3.3	6.6	15:1	5:3	0
5	60	60	3.4	6.7	15:5	5:3	6200
10	80	80	3.4	6.8	15:10	5:3	4700
15	86	86	3.4	6.9	15:15	5:3	4400
20	90	90	3.3	6.9	15:20	5:3	4300
25	92	92	3.3	6.9	15:25	5:3	4300
30	93	93	3.3	6.9	15:30	5:3	4200

From table 1 and 2 we can see that both the routing AODV and OLSR routing has their own superiority on different variables. However, there is a tendency that AODV routing have a better performance than OLSR routing on network structure type A.

In figure 9, shows the results of packet delivery ratio from network type A based on amount of packets, which shows that AODV routing is better than OLSR routing. In the figure 10, shows that the results delay end-to-end network type A from routing AODV is better than OLSR. Except on the first testing, it shows that the delay end-to-end on AODV is smaller than OLSR.

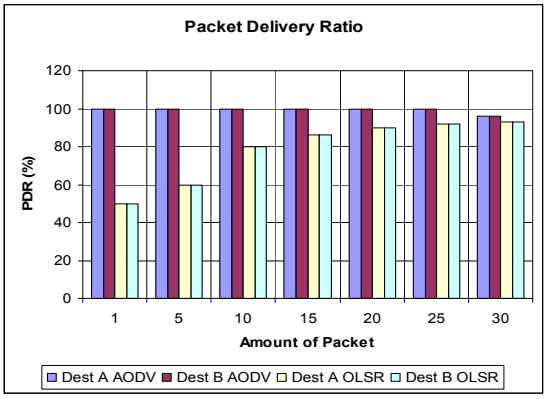

Figure 9. Packet delivery ratio testing from network type A based on amount of packets

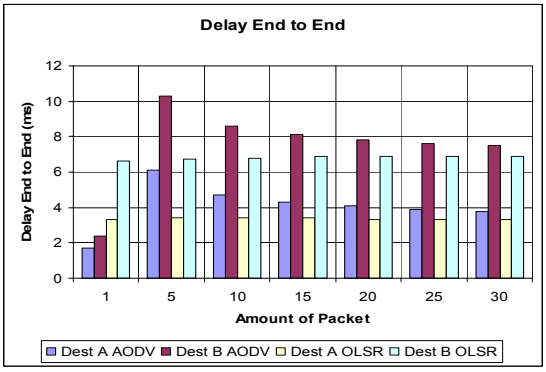

Figure 10. Delay end-to-end from network type A based on amount of packets

7.1.2 Network Test based on Size of Packet Transmision on Network Structure Type A

The parameters have been used in this testing based on the size of packets that transmitted from the source node to destination node. The size of the packets is range from 512 to 16.384 bytes, for each test the source will send five packets to destination. The testing using AODV routing on Network Structure type A can be seen in Table 3, while for OLSR in Table 4.

From table 3 and 4 we can see that both the routing AODV and OLSR routing has their own superiority on different variables. However, there is a tendency that AODV routing have a better performance than OLSR routing on network structure type A.

Table 3. Network structure type A testing using AODV routing based on the size of packets

Packet Size (bytes)	Packet Delivery Ratio (%)		Delay End-to-End (milisecond)		Packet Control Ratio (O/H)	Path Length Ratio	Throughput (bits/s)
	Dest. A	Dest. B	Dest. A	Dest. B			
512	100	100	6.1	10.3	4:5	1:1	5200
1024	100	100	8.1	14.1	4:5	1:1	10300
1536	100	100	10.2	18.2	4:5	1:1	15500
2048	100	100	14.2	25.2	4:5	1:1	20600
3072	100	100	18.2	33.8	4:5	1:1	31000
4096	100	100	24	44.8	4:5	1:1	41000
6144	100	100	34	64	4:5	1:1	62000
8192	100	100	43	84	4:5	1:1	82500
12288	100	100	64	124	4:5	1:1	124000
16384	100	100	82	162	4:5	1:1	165000

Table 4. Network structure type A testing using OLSR routing based on the size of packets

Packet Size (bytes)	Packet Delivery Ratio (%)		Delay End-to-End (milisecond)		Packet Control Ratio (O/H)	Path Length Ratio	Throughput (bits/s)
	Dest. A	Dest. B	Dest. A	Dest. B			
512	60	60	3.4	6.7	15:5	5:3	6200
1024	60	60	7	10.9	15:5	5:3	12200
1536	60	60	7.5	14.9	15:5	5:3	18500
2048	60	60	11	21.9	15:5	5:3	24600
3072	60	60	15	30.1	15:5	5:3	37000
4096	60	60	20.2	42	15:5	5:3	49000
6144	60	60	30.2	60.4	15:5	5:3	74000
8192	60	60	39	80	15:5	5:3	98000
12288	60	60	60	120	15:5	5:3	148000
16384	60	60	78	158	15:5	5:3	198000

On packet delivery ratio and delay end to end testing AODV has a greater result than OLSR. But, on control packet and path length ratio AODV has a smaller result than OLSR, the same result is also happened on testing using amount of packets. On throughput both of AODV and OLSR have a quite same result.

7.2 Testing on Network Structure Type B

7.2.1 Network Test based on Amount of Packet Transmision on Network Structure Type B

Testing network structure type B based on the amount of packets is shown in table 5 (for AODV) and table 6 (for OLSR). Where is seen that the packet delivery ratio in AODV is greater than in OLSR, as well as the delay of end-to-end and control packet. While the ratio for the path length was found that AODV is smaller than OLSR. Meanwhile, the network throughput for type B shows that in almost all the testing, both AODV and OLSR have a similar result except in fifth test shows that the throughput of OLSR which is greater than AODV.

Table 5. Network structure type B testing using AODV routing based on amount of packet

Amount of Packet	Packet Delivery Ratio (%)	Delay End-to-End (milisecond)	Packet Control Ratio (O/H)	Path Length Ratio	Throughput (bits/s)
1	100	13.0	4:1	1:1	0
5	100	31.8	4:5	1:1	5300
10	100	19.5	4:10	1:1	4600
15	100	15.4	4:15	1:1	4400
20	100	13.4	4:20	1:1	4300
25	100	12.2	4:25	1:1	4250
30	96	11.5	4:30	1:1	4200

Table 6. Network structure type B testing using OLSR routing based on amount of packet

Amount of Packet	Packet Delivery Ratio (%)	Delay End-to-End (milisecond)	Packet Control Ratio (O/H)	Path Length Ratio	Throughput (bits/s)
1	50	7.1	29:1	14:4	0
5	60	7.1	29:5	14:4	6200
10	80	7.1	29:10	14:4	4700
15	86	7.1	29:15	14:4	4400
20	90	7.1	29:20	14:4	4300
25	92	7.1	29:25	14:4	4300
30	93	7.1	29:30	14:4	4300

7.2.2 Network Test based on Size of Packet Transmision on Network Structure Type B

Testing network structure type B based on the size of packets is shown in table 7 (for AODV) and table 8 (for OLSR). Which, the result on packet delivery ratio, delay end-to-end, and control packet ratio showed that AODV packet has a greater result than OLSR. While for path length ratio and throughput AODV result is smaller than OLSR.

Table 7. Network structure type B testing using AODV routing based on size of packets

Packet Size (bytes)	Packet Delivery Ratio (%)	Delay End-to-End (milisecond)	Packet Control Ratio (O/H)	Path Length Ratio	Throughput (bits/s)
512	100	31.8	2:5	1:1	5300
1024	100	35.8	2:5	1:1	10600
1536	100	40	2:5	1:1	15800
2048	100	47	2:5	1:1	21200
3072	100	55	2:5	1:1	31800
4096	100	66.5	2:5	1:1	42000
6144	100	86	2:5	1:1	63000
8192	100	105	2:5	1:1	84000
12288	100	145	2:5	1:1	127000
16384	100	184	2:5	1:1	169000

Table 8. Network structure type B testing using OLSR routing based on size of packets

Packet Size (bytes)	Packet Delivery Ratio (%)	Delay End-to-End (milisecond)	Packet Control Ratio (O/H)	Path Length Ratio	Throughput (bits/s)
512	60	7.1	29:5	14:4	6200
1024	60	11.2	29:5	14:4	12300
1536	60	15.2	29:5	14:4	18500
2048	60	22.8	29:5	14:4	24600
3072	60	31	29:5	14:4	37000
4096	60	42	29:5	14:4	49000
6144	60	62	29:5	14:4	74000
8192	60	81	29:5	14:4	98000
12288	60	122	29:5	14:4	148000
16384	60	159	29:5	14:4	198000

7.3 Testing on Network Structure Type C

7.3.1 Network Test based on Amount of Packet Transmision on Network Structure Type C

Testing network structure type C based on the amount of packets is shown in table 9 (for AODV) and table 10 (for OLSR). Where is seen that the packet delivery ratio in AODV is greater than in OLSR. While for delay end-to-end testing almost all the testing packages (except for 25 and 30 packets testing), delay end-to-end on AODV is greater than OLSR. Meanwhile, on the packet control ratio and path length ratio, AODV test result is less than OLSR. Meanwhile, for throughput testing showed that the throughput at AODV and OLSR relatively the same result, except

for the fifth test, which the throughput of OLSR packet is smaller than the AODV.

Table 9. The simulation results of AODV Routing Type C network based amount of packet

Amount of Packet	Packet Delivery Ratio (%)		Delay End-to-End (milisecond)		Packet Control Ratio (O/H)	Path Length Ratio	Throughput (bits/s)
	Dest. A	Dest. B	Dest. A	Dest. B			
1	100	100	114	124	4:1	1:1	0
5	100	100	34	31	4:5	1:1	5250
10	100	100	23.8	20.8	4:10	1:1	4600
15	100	100	20.8	17	4:15	1:1	4400
20	100	100	19	15	4:20	1:1	4300
25	100	100	18.1	13.6	4:25	1:1	4300
30	96	96	17.6	12.9	4:30	1:1	4200

Table 10. The simulation results of OLSR Routing Type C network based amount of packet

Amount of Packet	Packet Delivery Ratio (%)		Delay End-to-End (milisecond)		Packet Control Ratio (O/H)	Path Length Ratio	Throughput (bits/s)
	Dest. A	Dest. B	Dest. A	Dest. B			
1	50	0	7.4	0	34:1	19:5	0
5	60	20	7.2	14.5	34:5	19:5	3100
10	80	60	10.2	12.5	34:10	19:5	4600
15	86	73	10.6	12.6	34:15	19:5	4450
20	90	80	10.6	12.8	34:20	19:5	4300
25	92	84	10.4	13.1	34:25	19:5	4250
30	93	86	10.3	13.2	34:30	19:5	4200

7.3.2 Network Test Based on Size of Packet Transmision on Network Structure Type C

Testing network structure type C based on size of packets is shown in table 11 (for AODV) and table 12 (for OLSR). Where is seen that the packet delivery ratio, delay end-to-end, and throughput in AODV is greater than in OLSR. While for packet control ratio dan path length ratio AODV is smaller than OLSR.

Table 11. The simulation results of AODV routing type C network based on size of packet

Packet Size (bytes)	Packet Delivery Ratio (%)		Delay End-to-End (milisecond)		Packet Control Ratio (O/H)	Path Length Ratio	Throughput (bits/s)
	Dest. A	Dest. B	Dest. A	Dest. B			
512	100	100	34	31	4:5	1:1	5250
768	100	100	39	33.6	4:5	1:1	7900
1024	100	100	42	36	4:5	1:1	10500
1280	100	100	45	38	4:5	1:1	13100
1536	100	100	48	42	4:5	1:1	15800
1792	100	100	52.5	44	4:5	1:1	18500
2048	100	100	62	57	4:5	1:1	21000
2304	100	100	65	59	4:5	1:1	23700
2560	100	100	68	62	4:5	1:1	26200
2816	100	100	72.6	67	4:5	1:1	29000

Table 12. The simulation results of OLSR routing type C network based on size of packet

Packet Size (bytes)	Packet Delivery Ratio (%)		Delay End-to-End (milisecond)		Packet Control Ratio (O/H)	Path Length Ratio	Throughput (bits/s)
	Dest. A	Dest. B	Dest. A	Dest. B			
512	60	20	7.2	14.5	34:5	19:5	3100
768	60	20	9.3	18.6	34:5	19:5	4625
1024	60	20	11.2	22.8	34:5	19:5	6150
1280	60	20	13.4	26.8	34:5	19:5	7700
1536	60	20	15.5	31	34:5	19:5	9250
1792	60	20	17.7	35	34:5	19:5	10800
2048	60	20	25.5	45.1	34:5	19:5	12200
2304	60	20	27.5	49	34:5	19:5	13900
2560	60	20	29.5	53.5	34:5	19:5	15300
2816	60	20	32	57.5	34:5	19:5	16900

7.4 Testing Results on Complex Networks

To test a complex network that consists of more than 10 nodes will be tested using simulation software Qualnet, as been seen on figure 11. The result on testing packet delivery ratio for a complex network (more than 10 nodes) in the static condition can be seen on table 13 and 14. The result shows that OLSR routing has better quantitative performance compared with AODV.

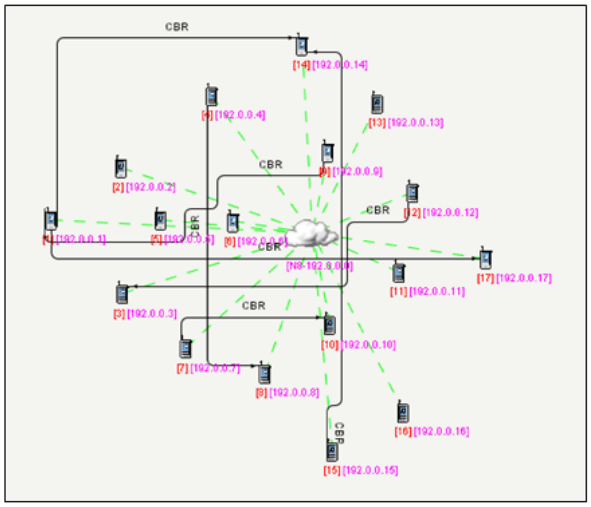

Figure 11. Complex network design using qualnet simulation software

Table 13. AODV Packet Delivery Ratio Testing on Complex Network

Packet Size (bytes)	Packet Delivery Ratio (%)						
	node 1-17	node 1-14	node 15-14	node 7-10	node 4-8	node 12-3	node 9-1
512	40	40	60	60	40	40	20
768	40	40	40	60	40	40	20
1024	40	40	40	60	40	40	20
1280	40	40	40	60	40	40	20
1536	40	40	40	60	40	40	20

Table 14. OLSR packet delivery ratio testing on complex network

Packet Size (bytes)	Packet Delivery Ratio (%)						
	node 1-17	node 1-14	node 15-14	node 7-10	node 4-8	node 12-3	node 9-1
512	100	80	100	100	80	100	100
768	100	80	80	100	100	80	100
1024	80	60	100	100	100	100	100
1280	100	60	100	100	100	100	100
1536	60	100	60	100	100	80	80

8. CONCLUSION

The conclusion that can be obtained based on the design and testing is that there's a tendency that the quantitative performance from AODV routing protocol is better than OLSR in a network that less complex (less than 10 nodes) either on the network type A, B and C. But for a complex network (more than 10 nodes) there's a tendency that quantitative performance from OLSR routing protocol is better than AODV.

9. REFERENCES

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