JURNAL INFOTEL
Informatics - Telecommunication - Electronics
Website: http://ejournal.st3telkom.ac.id/index.php/infotel
ISSN: 2085-3688; e-ISSN: 2460-0997

Energy consumption analysis of DSR reactive routing protocol on mobile ad-hoc network

Tyas Nurfitriana[1,*], Jafaruddin Gusti Amri Ginting[2], Kukuh Nugroho[3]
[1,2,3]Fakultas Teknik Telekomunikasi, Institut Teknologi Telkom Purwokerto
[1,2,3]Jl. D.I. Panjaitan, No. 128, Purwokerto 53147, Indonesia
[*]Corresponding email: 18101211@ittelkom-pwt.ac.id

Received 3 August 2022, Revised 23 December 2022, Accepted 5 January 2023

Abstract — A mobile ad-hoc network is a connection between mobile nodes which uses wireless media. This network does not have an administrative center, so each node in addition to functioning as a sender and receiver of data information, also functions as a router that will look for route information from the source node to the destination node. The topology of the mobile ad-hoc network is always changing because the nodes move dynamically. The changing of mobile ad-hoc network topology resulted in the repetition of route information searches. The process of finding route information requires a routing protocol. The routing protocol-enabled nodes must maintain the energy usage in the route-finding mechanism. Choosing the right routing protocol can be a solution to make energy use by nodes more efficient, especially in ad-hoc networks. This study uses a routing protocol in the reactive category, namely dynamic source routing. This study aims to determine the performance of energy consumption, residual energy, and packet delivery ratio with scenarios of increasing node movement speed and network area. From the result of the research, it is known that DSR can handle changes in the speed of node movement and network area related to energy consumption and residual energy. This is evidenced by the results of research showing that with faster node movements and wider areas, less energy is required. Meanwhile, regarding the success of packet delivery, the dynamic source routing protocol cannot handle changes in node movement and network area speed. This is evidenced by the packet delivery ratio measurement results, which show that with faster node movements and wider areas, many packets are not successfully received by the destination node.

Keywords – DSR, energy consumption, MANET, network simulator 2, reactive routing protocol

I. Introduction

A mobile ad-hoc network (MANET) is a connection between mobile devices using wireless media. Each mobile device is referred to as a node. Each node is connected to other nodes without intermediary devices (routers, switches, access points), so the configuration process is carried out on its nodes. MANET topology is always changing because the nodes move dynamically [1]. This topology change results in repeated route information searches [2]. This network does not have an administrative center. Hence, each node on the network in addition to functioning as a sender and receiver of data information also functions as a router that will look for route information from the sender to the receiver [3]. These functions can be executed if the nodes on the network have sufficient energy. The energy the node uses is a battery, so it is limited. When the energy is used continuously, the energy at the node will decrease [4].

Nodes on the MANET function as routers that carry out the routing process. The router carries out the routing process to determine the route of the received packet and forward it to the destination of the packet [5]. The routing protocols are needed to perform a routing process. MANET routing protocols are required to maintain route information. There are three classifications based on their working mechanism, On-Demand Routing Protocols, Table Driven Protocols, and Hybrid Routing Protocols [6], [7]. The routing protocol activated in the nodes must keep the energy usage in the routing mechanism and data transmission as small as possible. Choosing the right routing protocol can be a solution to make energy use by nodes more efficient.

Several researchers have studied routing protocols on MANET networks and performed a study about DSR routing protocol implementation using random waypoint mobility. In 2017, Qi *et al.* [8] measure the performance of PDR, end-to-end delay, and routing overhead with variations in the number of nodes and speed of nodes. From the test results, the PDR value, end-to-end delay value, and routing overhead value obtained fluctuate against the scenario of variations in the number of nodes and the speed of node movement.

A study conducted by Poonia *et al.* [9] simulates the DSR routing protocol performance. Simulation is carried out using scenario of variations in the network area. The parameter analyzed is the number of dropped packets. The results indicate that the number of dropped packages has increased from 150 × 150 m to 550 × 550 m. However, when the area increased to 650 × 650 and 750 × 750 m, the number of packages dropped decreased. In [10], in addition to using DSR, AODV, and DSDV is also used with scenarios of increasing the number of nodes with dynamic and static conditions. The parameters analyzed are energy consumption, throughput, and packet loss ratio. When the number of nodes is 20, with all nodes being static, the result is that the AODV and DSR routing protocols are 0.3 Joules more efficient than DSDV.

Based on previous research about DSR routing protocol performance on the MANET network, only Suladria *et al.* [10] analyzed energy consumption. The scenario used is the addition of nodes with dynamic and static conditions, so other studies are needed with different scenarios that also affect battery energy consumption on the MANET. This study aims to analyze the performance of DSR using energy consumption, residual energy, and PDR parameters with the scenario of increasing node movement speed and MANET network area using NS 2.35.

II. Research Method

This section discusses MANET, dynamic source routing, energy model, testing scenario design, network design on NS-2, and data retrieval.

A. Mobile Ad-Hoc Network (MANET)

Mobile Ad Hoc Network consists of a collection of nodes that communicate with each other and move dynamically [11]. Because the nodes move dynamically, the network topology can change rapidly and unpredictably. This network is also decentralized, where the network configuration and data transmission processes must be carried out by the nodes themselves.

MANET has several characteristics, including dynamic topology, decentralized network, lower bandwidth capacity compared to wired networks, limitations in terms of energy, and vulnerability to threats [12]. Nodes are connected using wireless networks such as cellular, wi-fi, and Blue-tooth [13]. Wi-fi is a wireless technology commonly used by homeowners, small businesses, and start-up ISPs. Some of standards develop are 802.11a, 802.11b, 802.11g, 802.11n, 802.11ac, and 802.11ax [14]. This network can be implemented in personal area networks, home area networking, post-disaster conditions, and military condition, and it also can use for NFC-based mobile payment services [15].

B. Dynamic Source Routing (DSR)

DSR is a reactive routing protocol that works when there is a request from the source node to send messages to the destination node. The mechanism used by DSR is route discovery and route maintenance [16]. This mechanism finds and maintains the best route from the source to the destination node [17]. Route discovery uses RREQ and RREP, while route maintenance uses RERR. DSR also has cache memory, which stores all routing information of source nodes contained in data packets [7].

The route discovery process begins with sending an RREQ message from the source node to the nearest node. The nearest node that receives the RREQ then looks into its cache to see if there is any information to the destination node; if there is, the node replies with an RREP message containing route information. When the node detects a problem on the route, a RERR message will be sent to the source node. Wthe source node receives the RERR message node, the node on the problematic route will be removed from the route cache. Data transmission will continue using an alternative route still stored in the cache. If there is no alternative route in the route cache, DSR will repeat the route discovery process to find a new route [18].

C. Energy Model

Energy is an important factor in MANET because the energy of nodes is sourced from the battery, so it is limited. Energy i-Nodes consume energy and perform the routing process. Energy usage is divided into four states [19], [20].

1) Transmit

The situation where the node transmits packets with power transmission P_{Tx}.

2) Receive

The state where the node receives a packet with a receiving power P_{Rx}.

3) Idle

The state where no packets are sent through the transmission medium. The node remains silent and continues to listen to the transmission medium with P_{Idle}.

4) Sleep

The state when the radio is turned off, and the node cannot is unable to detect the signal. The node uses P_{Sleep}, which is smaller than the rest of the energy.

Analysis of DSR performance using the NS-2 tools installed on Ubuntu 20.04. The network simulator version used is NS-2.35. These tools will be used to simulate the MANET network with the following parameters as shown in Table 1.

Table 1. Simulation Parameters

Routing Protocol	DSR
Number of Nodes	20
Transmission Range	250 meters
Mobility	Random Waypoint
Traffic-connection	TCP
Connection	10 sources, 10 destinations
Packet Size	1024 bytes
Initial Energy	500 Joule
Simulation Time	300 seconds

D. Testing Scenario Design

The energy consumption research using the DSR routing protocol uses two test scenarios, increasing the node movement speed and the network area. The range of each node is a maximum of 250 meters [21].

a) The Scenario of Increasing Node Speed
This scenario was tested with ten experiments consisting of 20 nodes spread over a 1000 × 1000 meter network. Table 2 is a variation of the speed used.

Table 2. The Scenario of Increasing Node Speed

Experiment	Network area (meter)
1	500 × 500
2	600 × 600
3	700 × 700
4	800 × 800
5	900 × 900
6	1000 × 1000
7	1100 × 1100
8	1200 × 1200
9	1300 × 1300
10	1400 × 1400

b) The Scenario of Increasing Network Area
This scenario was tested with ten experiments. The network consists of 20 nodes. The node movement speed is 28-30 ms^{-1}.

Table 3. The Scenario of Increasing Network Area

Experiment	Network area (meter)
1	500 × 500
2	600 × 600
3	700 × 700
4	800 × 800
5	900 × 900
6	1000 × 1000
7	1100 × 1100
8	1200 × 1200
9	1300 × 1300
10	1400 × 1400

E. Network Design on NS-2

Network design is carried out by determining the scenario to be used, and configuring node mobility, traffic connections, and TCL scripts containing the main program. The node mobility configuration process sets the node's distribution and movement. The node mobility used in this study is a random way point distribution. The nodes in the network spread and move randomly.

The configuration of node mobility in Fig. 1 is carried out in the scenario of increasing the MANET area. The speed of node movements is about 28−−30 ms^{-1}. The mobility configuration of nodes is saved with the name "**mobility1.txt**". Fig. 2 is the result of node mobility configuration in the scenario of the increasing network area.

Fig. 2 shows the configuration results of node 0 displacements in experiment 1 in the scenario of the increasing network area. The initial position of node 0 is at coordinates x 198.15, y 287.20, and z 0.00. Node 0 moves to the coordinates 317.99 and 420.30 with a speed of 28.40 m/s at the 0th second. Node 0 then moves to points 450.40 and 41.88 with a speed of 29.15 at 6 seconds.

The traffic connection configuration is used to manage connections between nodes in the network, and the transport,layer protocol is used. Fig. 3 is a traffic-connection configuration in the scenario of increasing the node movement speed and the network area. The configuration result will make connections between 10 source nodes and 10 destination nodes. These nodes communicate using the TCP transport layer protocol. The transport layer protocol configuration is saved under the name "**tcp.txt**"

Fig. 4 shows the results of the connection configuration between node 1 and node 2. Node 1 will transmit data with node 2 as the destination at 2.56 seconds. The data sent by node 1 is 1024 bytes in size. The data is sent using the FTP service.

The MANET network simulation is built with the main program,as shown in the description in Fig. 5. The beginning of the program is the definition of simulation parameters as seen in Table 1. Then, the program continues with the model energy configuration and calls the mobility and traffic-connection configuration files.

Each node in the network is configured with an initial energy of 500 Joules. *Tx* power is the power used by nodes to transmit data. *Rx* power is the power used by nodes to receive data. Idle power is the power used when the node is idle. In this condition, each node can receive or send data. The power used in the sleep state is sleep power. In sleep mode, before the sleep power is awakened, nodes cannot receive or send data [20].

Fig. 7 shows the main program's calling of "**mobility-1**" and "**tcp**" files. Both files must be in the same directory as the main program. The main program of experiment 1 scenario of increasing network area is stored under the name **DSR1.tcl**.

F. Data Retrieval

The data retrieval process uses a trace file generated from the simulation process. The trace file is obtained after running the main program TCL file. The trace file contains all the information during the simulation

```
user@user-Lenovo-B40-30:~/ns-allinone-2.35/ns-2.35/indep-utils/cmu-scen-gen/setdest$ ./setdest
-v 2 -n 20 -s 1 -m 28 -M 30 -t 300 -P 1 -p 0 -x 500 -y 500 > mobility1
user@user-Lenovo-B40-30:~/ns-allinone-2.35/ns-2.35/indep-utils/cmu-scen-gen/setdest$ ./setdest
-v 2 -n 20 -s 1 -m 28 -M 30 -t 300 -P 1 -p 0 -x 600 -y 600 > mobility2
user@user-Lenovo-B40-30:~/ns-allinone-2.35/ns-2.35/indep-utils/cmu-scen-gen/setdest$ ./setdest
-v 2 -n 20 -s 1 -m 28 -M 30 -t 300 -P 1 -p 0 -x 700 -y 700 > mobility3
user@user-Lenovo-B40-30:~/ns-allinone-2.35/ns-2.35/indep-utils/cmu-scen-gen/setdest$ ./setdest
-v 2 -n 20 -s 1 -m 28 -M 30 -t 300 -P 1 -p 0 -x 800 -y 800 > mobility4
user@user-Lenovo-B40-30:~/ns-allinone-2.35/ns-2.35/indep-utils/cmu-scen-gen/setdest$ ./setdest
-v 2 -n 20 -s 1 -m 28 -M 30 -t 300 -P 1 -p 0 -x 900 -y 900 > mobility5
user@user-Lenovo-B40-30:~/ns-allinone-2.35/ns-2.35/indep-utils/cmu-scen-gen/setdest$ ./setdest
-v 2 -n 20 -s 1 -m 28 -M 30 -t 300 -P 1 -p 0 -x 1000 -y 1000 > mobility6
user@user-Lenovo-B40-30:~/ns-allinone-2.35/ns-2.35/indep-utils/cmu-scen-gen/setdest$ ./setdest
-v 2 -n 20 -s 1 -m 28 -M 30 -t 300 -P 1 -p 0 -x 1100 -y 1100 > mobility7
user@user-Lenovo-B40-30:~/ns-allinone-2.35/ns-2.35/indep-utils/cmu-scen-gen/setdest$ ./setdest
-v 2 -n 20 -s 1 -m 28 -M 30 -t 300 -P 1 -p 0 -x 1200 -y 1200 > mobility8
user@user-Lenovo-B40-30:~/ns-allinone-2.35/ns-2.35/indep-utils/cmu-scen-gen/setdest$ ./setdest
-v 2 -n 20 -s 1 -m 28 -M 30 -t 300 -P 1 -p 0 -x 1300 -y 1300 > mobility9
user@user-Lenovo-B40-30:~/ns-allinone-2.35/ns-2.35/indep-utils/cmu-scen-gen/setdest$ ./setdest
-v 2 -n 20 -s 1 -m 28 -M 30 -t 300 -P 1 -p 0 -x 1400 -y 1400 > mobility10
```

Fig. 1. Node mobility configuration.

```
$node_(0) set X_ 198.158465376348
$node_(0) set Y_ 287.209157887731
$node_(0) set Z_ 0.000000000000
$ns_ at 0.000000000000 "$node_(0) setdest 317.989543579012 420.301468093578 28.407850433335"
$ns_ at 6.304225803019 "$node_(0) setdest 450.400233078573 41.878148962430 29.148885067312"
```

Fig. 2. Results of Node Mobility Configuration

```
user@user-Lenovo-B40-30:~/ns-allinone-2.35/ns-2.35/indep-utils/cmu-scen-gen$ ns cbrgen.tcl
 -type tcp -nn 20 -seed 1 -mc 10 -rate 1 > tcp
```

Fig. 3. Traffic connection configuration.

```
# 1 connecting to 2 at time 2.5568388786897245
#
set tcp_(0) [$ns_ create-connection  TCP $node_(1) TCPSink $node_(2) 0]
$tcp_(0) set window_ 32
$tcp_(0) set packetSize_ 1024
set ftp_(0) [$tcp_(0) attach-source FTP]
$ns_ at 2.5568388786897245 "$ftp_(0) start"
```

Fig. 4. Results of traffic connection configuration.

```
set val(chan)           Channel/WirelessChannel
set val(prop)           Propagation/TwoRayGround
set val(ant)            Antenna/OmniAntenna
set val(ll)             LL
set val(ifq)            Queue/DropTail/PriQueue
set val(ifqlen)         50
set val(netif)          Phy/WirelessPhy
set val(mac)            Mac/802_11
set val(rp)             DSR
set val(x)              500
set val(y)              500
set val(finish)         300
set val(nn)             20
```

Fig. 5. Network parameter configuration in main program of node mobility configuration.

```
 -energyModel "EnergyModel" \
 -initialEnergy 500.0 \
 -txPower 0.9 \
 -rxPower 0.7\
 -idlePower 0.6 \
 -sleepPower 0.1 \
```

Fig. 6. Model energy configuration.

process. The trace file has a **.tr** extension, and this file will be filtered using AWK programming. Filtration aims to retrieve data on energy consumption parameters, residual energy, and PDR.

```
source mobility1
source tcp
```

Fig. 7. File calling commands "**mobility-1**" and "**tcp**"

$$
\begin{aligned}
E_{(N/M)} &= 1_{(n>0)}(1_{(M=N)}E_{(T_ack)} \\
&= +1_{(M\neq N)}E_{(R_ack)}) + 1_{(m>0)} \\
&= (1_{(M=N)}E(T_pck) + 1_{(M\neq N)}E_{(R_pck)})
\end{aligned} \tag{1}
$$

where $E_(N/M)$ Isis node N energy consumed due to node M, $E_(T_ack)$ is the energy to transmit a single ACK packet, $E_(T_pck)$ is the energy used to transmit one data, $E_(R_ack)$ is the energy to receive one ACK packet, and $E_(R_pck)$ is the energy to receive one data.

a) Energy Consumption (EC)
The energy use nodes use use communicate with each other is the definition of energy consumption. During the simulation process, the nodes on the MANET network communicate with each other to send, forward, receive data and perform the routing process [22].
b) Residual Energy (RE)
The residual energy [3] is the energy that the node has used then the simulation has ended.

$$RE = InitialEnergy - EC \tag{2}$$

where *Residual energy*is the amount of energy that is not used by a node, *Initial energy* is the total energy before the simulation, and *energy* *consumed* is the energy used by the node during the simulation process.

c) Packet Delivery Ratio (PDR)
PDR compares the number of packets that are successfully received by the destination node and the number of packets that are successfully sent by the source node at a certain time [23].

$$PDR = \frac{Receive}{Send} \times 100\% \quad (3)$$

where $Receive$ is the number of packets that are successfully received by the destination node, and $Send$ is the number of packet that is successfully sent by the source node.

III. Result

In the DSR routing protocol performance research, network simulations were carried out using the Network Simulator 2.35 tools. The network consists of 20 nodes. The source node will send a packet of 1024 bytes using the TCP transport layer protocol. The nodes are configured using the DSR routing protocol with a random way point distribution pattern.

In this distribution mobility model, the nodes in the network are randomly distributed. First, each node will select a target location with a random speed then the node will continue to move to another location target with another random speed [24], [25]. The simulation is carried out in two scenarios, the first scenario is the addition of variations in the speed of node movement and the second scenario is the addition of the network area. The scenarios aim to determine the effect of increasing the speed of node movement and network area using PDR, energy consumption, and residual energy parameters.

A. Energy Consumption

Energy consumption is used to communicate between nodes during the simulation process [3]. During the simulation, the nodes in the network use energy to communicate with , other nodes such as sending, receiving, forwarding data packets, and executing routing processes. Energy consumption is carried out in two scenarios, increasing the speed of node movement and increasing the area of the MANET.

a) The Scenario of Increasing Node Speed
Increasing speed is done by increasing the speed interval by duration two ms^{-1}. The details of the speed increase are $1-3$ ms^{-1}, $4-6$ ms^{-1}, $7-9$ ms^{-1}, $10-12$ ms^{-1}, $13-15$ ms^{-1}, $16-18$ ms^{-1}, $19-21$ ms^{-1}, $22-24$ ms^{-1}, $25-27$ ms^{-1}, and $28-30$ ms^{-1}. The nodes spread and move randomly using a random way point distribution. This scenario is simulated on a network with an area of 1000 $\times$ 1000 meters.
Based on the simulation results in the scenario of increasing the speed of node movement as

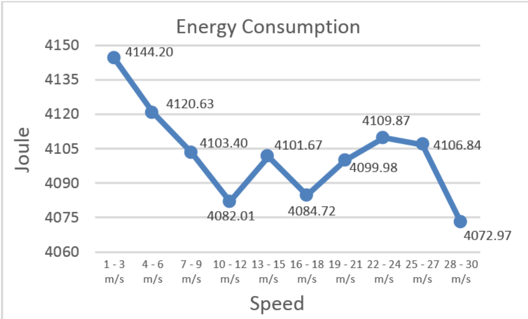

Fig. 8. Energy consumption of node speed scenario.

shown in Fig. 8, the lowest energy consumption is 4072.97 Joule occurs when the node movement speed is in the range of $28-30$ ms^{-1}, and the highest energy consumption of 4144.20 Joule occurs when the node movement speed is in the range of $1-3$ ms^{-1}.

b) The Scenario of Increasing Network Area
In the second scenario, increasing the MANET network area, the variations of network area used are a (500 $\times$ 500 meters), b (600 $\times$ 600 meters), c (700 $\times$ 700 meters), d (800 $\times$ 800 meters), e (900 meters $\times$ 900 meters), f (1000 $\times$ 1000 meters), g (1100 $\times$ 1100 meters), h (1200 $\times$ 1200 meters), i (1300 $\times$ 1300 meters), and j (1400 $\times$ 1400 meters). The network consists of 20 nodes that move using a random waypoint distribution with a movement speed of $28-30$ ms^{-1}.

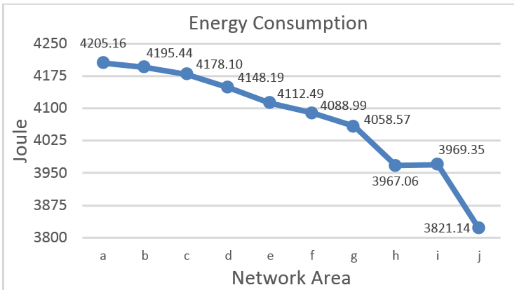

Fig. 9. Energy consumption of network area scenario.

Based on the simulation results using the scenario of increasing the MANET network area, as shown in Fig. 9, node energy consumption decreases as the MANET network area increases. The total energy consumed by the node is 4205.16 Joules in the simulation using an area of 500 $\times$ 500 meters, the experiment with the highest energy consumption. Energy consumption continues to decrease until the network area is 1200 $\times$ 1200 meters. Then in the experiment using an area of 1300 $\times$ 1300 meters, energy consumption increased from the previous experiment by a difference of 2.29 Joules. Finally in the experiment with an area of 1400 $\times$ 1400, energy consumption decreased to 3821.14 Joules, which is the experiment with the least energy consumption.

B. Residual Energy

The residual energy is not used by the node until the simulation process ends [3]. Therefore, the residual energy consumption parameter is obtained from the accumulation of the residual energy consumption at 20 nodes.

a) The Scenario of Increasing Node Speed
In this scenario, experiments were carried out with speed ranges of duration two ms^{-1} during 1−3 ms^{-1} until 28−30 ms^{-1}. The experiment was carried out on a 1000 × 1000 meter network. The residual energy tends to increase as the speed of node movement increases as shown in Fig. 10. From ten experiments with different node movement speeds, the results show that the most residual energy, which is 5927.04 Joules occurs when the nodes on the network move in the speed range of 28−30 ms^{-1}, and the least residual energy is 5855.80 Joules when the node is moving at a speed range of 1−3 ms^{-1}.

b) The Scenario of Increasing Network Area
In the scenario of increasing the area of the MANET, experiments were carried out with different network areas. The variations of network area used are a (500 × 500 meters), b (600 × 600 meters), c (700 × 700 meters), d (800 × 800 meters), e (900 meters × 900 meters), f (1000 × 1000 meters), g (1100 × 1100 meters), h (1200 × 1200 meters), i (1300 × 1300 meters), and j (1400 × 1400 meters). Each network area consists of 20 nodes that spread and move at the speed of 28−30 ms^{-1}.

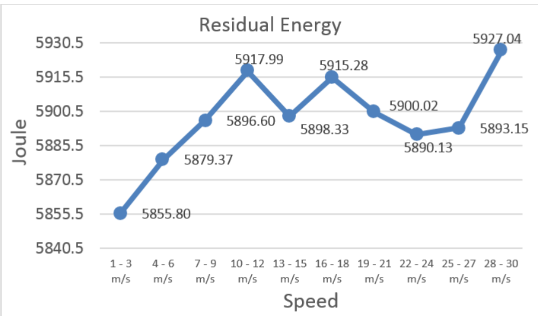

Fig. 10. Residual energy of node speed scenario.

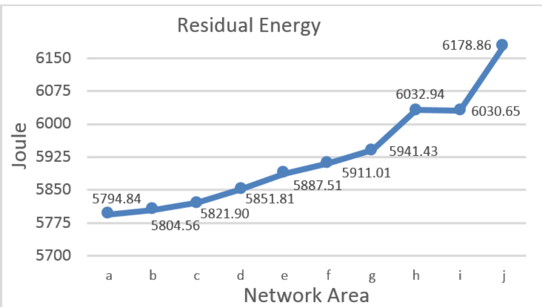

Fig. 11. Residual energy of network area scenario.

Fig. 11 shows the residual energy nodes consumed of increasing the MANET network area. The value tends to increase as the MANET network area increases. For example, when experimenting with an area of 500 × 500 meters, the residual energy is 5794.84 Joules; this is an experiment with the least residual energy consumption. While the residual energy consumption mostly occurs in the experiment with a network area of 1400 × 1400 meters, the residual energy is 6178.86 Joules.

C. Packet Delivery Ratio (PDR)

The PDR compares the number of packets that are successfully received by the destination node and the number of packets that are successfully sent by the source node at a certain time [23]. The source node and destination node in each research consist of 10 nodes. The packet sent source node to the destination was sized at 1024 bytes.

a) The Scenario of Increasing Node Speed
Experiments were carried out at different speeds in the scenario of increasing the speed of node movement. This scenario is simulated with 20 nodes spread over a network area of 1000 × 1000 meters.

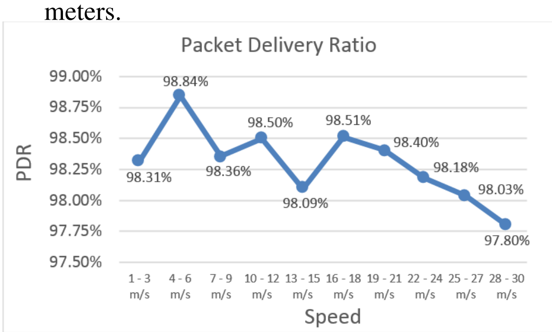

Fig. 12. PDR of node speed scenario.

Fig. 12 shows the research result using the variation of node speed movement scenario, the price peace. The The of PDR tends to decrease as the speed of node movement increases. From the data obtained, the highest PDR percentage is 98.84%. The percentage result occurs when the nodes in the network move at a speed of 4−6 Lowest percentage of PDR is 97.80%. The percentage result occurs when the nodes in the network move at a speed of 28−30 ms^{-1}.

b) The Scenario of Increasing Network Area
This scenario is simulated with 20 nodes spread out using a random waypoint distribution pattern with a node movement speed of 28−30 ms^{-1}. During the simulation process, nodes on the network perform the process of receiving and sending packets. This packet number will be used to get the PDR parameter value. The PDR parameter values for each experiment were then compared to determine the effect of the MANET network area on PDR.

Based on the graph in Fig. 13, the PDR value tends to decrease as the MANET network area increases. For

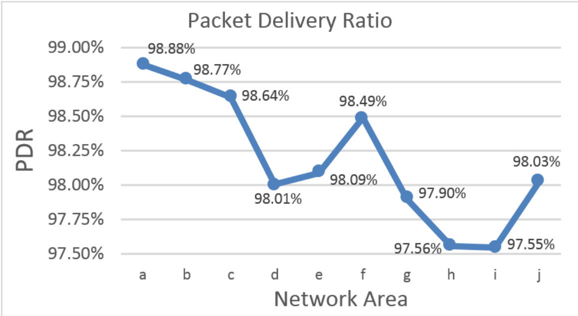

Fig. 13. PDR of network area scenario.

example, the highest percentage of PDR of 98.88% occurred when the experiment used an area of 500 × 500 meters. On the other hand, the lowest percentage of PDR was 97.55% when the network was simulated using an area of 1300 × 1300 meters.

IV. Discussion

The energy consumed by nodes decreases as the speed of node movement increases and the network area increases. The faster node movement, the more difficult the handshaking process will be so that the node does not consume a lot of energy for packet transmission. The larger network area, the more difficult for nodes to reach other nodes. Inaccessibility to other nodes hence does not consume a lot of energy for packet transmission.

The residual energy consumption parameter has a value that is inversely proportional to energy consumption because the more energy consumed, the less energy remains. In the PDR parameter, DSR cannot handle changes in the speed of node movement. This is because the failure of the handshaking process causes many packets unsuccessfully received by the destination node. DSR also cannot handle changes in network areas related to PDR. This is because the larger network area, the more difficult for nodes to reach other nodes. The inaccessibility causes many packets that are sent not to reach the destination node.

V. Conclusion

Based on the results and discussion, several points can be concluded as follows. DSR routing protocols can handle changes in the speed of node movement related to energy consumption. This is evidenced by the results of research showing that faster node movement requires less energy. With a small energy requirement, the residual energy owned by the node is getting bigger. However, the DSR routing protocol has not been able to handle changes in the speed of node movement related to the success of packet delivery. This is evidenced by the results of research showing that with faster node movements, many packets are not successfully received. This is indicated by the low PDR value.

The DSR routing protocol can handle changes in the MANET network area related to energy consumption. This is evidenced by the results of research showing that a larger area requires less energy. With a small energy requirement, the residual energy owned by the node is getting bigger. However, in the PDR parameter, the DSR routing protocol cannot handle changes in the network area. This is evidenced by the results of research showing that with a larger area, many packets are not successfully received. This is indicated by the low PDR value.

References

[1] S. D. Anggraini, "Analisis perbandingan performasi protokol routing AODV Dan DSR pada mobile ad-hoc network (MANET)," *Semin. Nas. IPTEK Terap.*, August, pp. 112–118, 2017, [Online]. Available: http://conference.poltektegal.ac.id/index.php/senit2017

[2] E. S. Manapa, E. A. M. Sampetoding, and G. Lewakabessy, "Potensi penggunaan mobile ad-hoc network (Manet) sebagai alat komunikasi data pada transportasi di Indonesia," *J. Dyn. Saint*, vol. 4, no. 2, pp. 8650-–868, 2020, doi: 10.47178/dynamicsaint.v4i2.889.

[3] N. F. Assidiq, "Analisis pengaruh kinerja routing protocol ad-hoc on-demand vector (AODV) dan destination sequenced distance vector (DSDV) terhadap konsumsi energi node pada jaringan manet," 2018.

[4] B. S. Kusuma, D. Risqiwati, and D. R. Akbi, "Analisis perbandingan performansi protokol ad-hoc on-demand distance vector dan zone routing protocol pada mobile ad hoc network," *Kinet. Game Technol. Inf. Syst. Comput. Network, Comput. Electron. Control*, vol. 2, no. 3, pp. 1650-–174, 2017, doi: 10.22219/kinetik.v2i3.91.

[5] K. Nugroho, A. D. Abrariansyah, and S. Ikhwan, "Perbandingan kinerja library paramiko dan netmiko dalam proses otomasi jaringan," *Infotekjar J. Nas. Inform. DAN Teknol. Jar.*, vol. 1, 2020.

[6] D. W. Sudiharto, N. R. Pradana, and S. Prabowo, "The comparative analysis of energy consumption between olsr and zrp routing protocols," *J. Commun.*, vol. 14, no. 3, pp. 202-–209, 2019, doi: 10.12720/jcm.14.3.202-209.

[7] A. Alamsyah, E. Setijadi, I. K. E. Purnama, and M. H. Purnomo, "Analisis kinerja protokol routing reaktif dan proaktif pada manet menggunakan NS2," *J. Nas. Tek. Elektro dan Teknol. Inf.*, vol. 7, no. 2, pp. 138-–143, 2018, doi: 10.22146/jnteti.v7i2.414.

[8] H. A. S. Qi, R. Anggoro, and M. Husni, "Implementasi routing protocol DSR pada skenario mobility random way point dengan menggunakan propagasi Nakagami," *J. Tek. ITS*, vol. 6, no. 2, 2017, doi: 10.12962/j23373539.v6i2.23600.

[9] R. Poonia, A. K. Sanghi, and D. Singh, "DSR routing protocol in wireless ad-hoc networks: drop analysis," *Int. J. Comput. Appl.*, vol. 14, no. 7, pp. 18-–21, 2011.

[10] G. B. Suladria, A. N. R., Hafidudin, and Satrya, "Analisis performansi konsumsi energi protocol routing AODV, DSR, Dan DSDV pada mobile ad-hoc network," *J. Food Syst. Res.*, vol. 14, no. 2, pp. 70-–75, 2007, doi: 10.5874/jfsr.14.2_70.

[11] M. A. Bahari, P. H. Trisnawan, and R. A. Siregar, "Analisis kinerja protokol ad-hoc on-demand distance vector (AODV) Dan ad-hoc on-demand multipath distance vector (AOMDV) terhadap serangan aktif pada jaringan MANET," *J. Pengemb. Teknol. Inf. dan Ilmu Komput.*, vol. 3, no. 4, pp. 3235–3244, 2018.

[12] T. J. Chong, Chim, W. Raymond, L. S. Soon, and Hui, "Mobile Ad Hoc Networking," 2014.

[13] A. Nasipuri, Mobile Ad Hoc Networks. 2004. doi: 10.1016/B978-075067695-3/50005-7.

[14] S. K. Sarkar, T. G. Basavaraju, and C. Puttamadappa, "Ad-hoc mobile wireless networks, Principles, Protocols, and Applications, Second Edition" 2016. doi: 10.1201/b13094.

[15] W. C. Wu and H. T. Liaw, "A study on high secure and efficient MANET routing scheme," *J. Sensors*, vol. 2015, no. 1, pp. 19–22, 2015, doi: 10.1155/2015/365863.

[16] A. O. A. Salem, G. Samara, and T. Alhmiedat, "Performance analysis of dynamic source routing protocol," *J. Emerg. Trends Comput. Inf. Sci.*, vol. 5, no. 2, pp. 97–100, 2014.

[17] M. Barati, K. Atefi, F. Khosravi, and Y. A. Daftari, "Performance evaluation of energy consumption for AODV and DSR routing protocols in MANET," in *2012 Int. Conf. Comput. Inf. Sci. ICCIS 2012 - A Conf. World Eng. Sci. Technol. Congr. ESTCON 2012 - Conf. Proc.*, vol. 2, pp. 636-–642, 2012, doi: 10.1109/ICCISci.2012.6297107.

[18] H. E. Wahanani, "Kinerja protokol DSR pada jaringan MANET dengan metode node disjoint and alternative multipath," in *Seminar Nasional Teknik Informatika*, September, 2013, pp. 33-–41,.

[19] W. A. Rachman, P. H. Trisnawan, and M. A. Fauzi, "Analisis konsumsi energi protokol routing fisheye state routing (FSR) pada mobile ad-hoc network (MANET)," *Teknol. Inf.*, vol. 3, no. 5, pp. 4455-–4466, 2019, [Online]. Available: http://j-ptiik.ub.ac.id/index.php/j-ptiik/article/view/5242

[20] H. R. Sitorus, P. H. Trisnawan, and A. Basuki, "Pengaruh model mobilitas terhadap konsumsi energi protokol routing optimized link state routing (OLSR) pada mobile ad hoc network (MANET)," *Inf. dan Ilmu Komput*. e-ISSN, vol. 5, no. 1, pp. 183-–190, 2021, [Online]. Available: http://j-ptiik.ub.ac.id/index.php/j-ptiik/article/download/8415/3889

[21] A. Ahmad, R. C. Joshi, and R. Gowri, "A smart booster approach in wireless ad hoc network," *Int. J. Eng. Technol.*, vol. 8, no. 1, pp. 300-–304, 2016.

[22] T. Goto, "Evaluation of the energy consumption of recycling process," *Post-Consumer Waste Recycl. Optim. Prod.*, pp. 170-–183, 2012, doi: 10.5772/45998.

[23] D. W. Pradanaputra, P. H. Trisnawan, and R. A. Siregar, "Pengaruh eenergi terhadap pengiriman data pada protokol fisheye state routing (FSR) dalam mobile ad hoc network (MANET)," *Pengemb. Teknol. Inf. dan Ilmu Komput.*, vol. 4, no. 8, pp. 2538—2545, 2020.

[24] P. Nayak and P. Sinha, "Analysis of random way point and random walk mobility model for reactive routing protocols for MANET using netsim simulator," in *Proc. - AIMS 2015, 3rd Int. Conf. Artif. Intell. Model. Simul.*, pp. 427–432, 2016, doi: 10.1109/AIMS.2015.87.

[25] S. Laqtib, K. El Yassini, M. Houmer, M. D. El Ouadghiri, and M. L. Hasnaoui, "Impact of mobility models on Optimized Link State Routing Protocol in MANET," in *Proc. - 2016 Int. Conf. Wirel. Networks Mob. Commun. WINCOM 2016 Green Commun. Netw.*, no. Dmi, pp. 104-–109, 2016, doi: 10.1109/WINCOM.2016.7777199.