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# Simulation of Ad Hoc On-Demand Distance Vector Routing Protocol in Mobile Ad Hoc Networks

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**ABSTRAK**

Untuk mensimulasikan dengan menggunakan simulator yang dibuat dengan bahasa pemrograman serta menguji sistem jaringan mobile ad hoc network pada proses mengirimkan packet dari node sumber ke node tujuan agar dapat di evaluasi kestabilan terhadap protokol routing yang digunakan. Penelitian ini menggunakan protokol Ad Hoc On-Demand Distance Vector (AODV) yang diharapkan mampu mengurangi waktu pemrosesan (overhead) yang sering terjadi pada jaringan mobile ad hoc network, karena tabel routing tidak dipertukarkan (interchanged) antar node selama proses mode ad hoc sedang berlangsung pada jaringan mobile ad hoc network sehingga akan mempercepat proses pengiriman packet. Pengujian dilakukan dengan menentukan jumlah node yang berbeda dan terus bertambah mulai dari 5, 15, 25, 35 dan 50 node, dengan bandwidth 2 Mbps, packet 1 Mbps dan luas area 10x10 m2, kemudian menjalankan proses simulasi dengan simulator dengan protocol Ad Hoc On-Demand Distance Vector (AODV). Hasil pengujian menunjukkan nilai performance metric pada throughput dan delay memiliki performa baik dan stabil pada area jaringan mobile ad hoc network.

***ABSTRACT***

*To simulate using a simulator made with a programming language and test the mobile ad hoc network system in the process of sending packets from the source node to the destination node in order to evaluate the stability of the routing protocol used. This research uses the Ad Hoc On-Demand Distance Vector (AODV) protocol which is expected to reduce the processing time (overhead) that often occurs in mobile ad hoc networks, because the routing table is not exchanged between nodes during the ad hoc mode process is taking place in the mobile ad hoc network so that it will speed up the packet delivery process. Tests were carried out by determining the number of different nodes and increasing starting from 5, 15, 25, 35 and 50 nodes, with a bandwidth of 2 Mbps, 1 Mbps packets and an area of 10x10 m2, then running the simulation process with a simulator with the Ad Hoc On-Demand Distance Vector (AODV) protocol. The test results show that the performance metric values on throughput and delay have good and stable performance in the mobile ad hoc network area.*

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## 1. INTRODUCTION

Mobile Ad Hoc Network is a wireless network model that can be configured dynamically without using a fixed network infrastructure[1]. This network model can be formed by several nodes that can move dynamically without an administrative center and special infrastructure, such as routers or other devices, so that nodes can move freely[2]. In a mobile ad hoc network each node is not only a host but also a router that can forward data packets to other devices. An ad-hoc network can also be a collection of mobile nodes that communicate with each other using wireless media without a fixed infrastructure[3]. Each device connected to the mobile ad hoc network must cooperatively provide network services that are usually provided by various devices such as routers or switches, so that communication between nodes will utilize other nodes as relays if the direct communication range is outside the communication destination node. Users in a mobile ad hoc network can communicate suddenly from anywhere, even though the transmission range is limited [4].

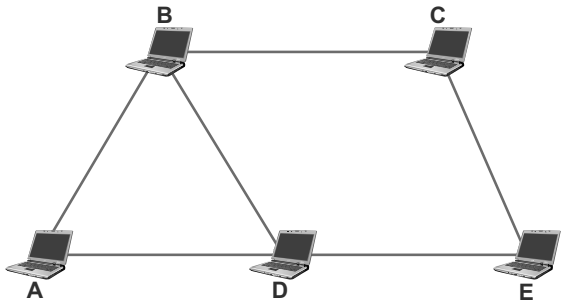


Figure 1. *Mobile Ad Hoc Network Illustration*

An illustration of the mobile ad hoc network topology is described in Figure 1, which depicts the peer-multi-hop model, which represents the ad hoc network model[5]. A node A will communicate directly (single-hop) with node B, this can happen if there is sufficient connectivity channel between the two to connect. Otherwise, multi-hop communication requires one or more nodes to switch and must act as relays between each node. If there is no direct (radio) communication channel (depicted as a line) between node A and node C or between node A and node E then node B and node D must act as routers to switch communication between node A and node C, and then between node A and node E. If there are different features or nodes of the ad hoc network then all nodes must be able to act as routers on demand along with acting as sources and destinations for packets. To prevent packets from traversing long and weak paths, it is necessary to choose good communication paths and short paths.

As a constantly changing and mobile network, the ad hoc mode may cause the reachability to change at any time in the communication link, thus requiring routing updates. The reachability between nodes in an ad hoc network will be subject to continuous change for

various reasons. For example, a node goes too far out of range of the ad hoc network, or there is a failure in the operation of the hardware or software used in the ad hoc network in a flexible manner that will cause nodes to join or leave. Network topology updates will become more frequent and more complex, reducing the network resources available to exchange information among nodes. Under these conditions, ad hoc networks will use routing algorithms that are suitable for ad hoc networks to improve performance by minimizing the amount of overhead and increasing network reliability in the process of sending packets from source nodes to destination nodes.

Ad Hoc On-Demand Distance Vector (AODV) protocol is one of the routing protocols that is often used for mobile ad hoc networks. The Ad Hoc On-Demand Distance Vector (AODV) protocol uses a reactive approach[6]. The Ad Hoc On-Demand Distance Vector (AODV) protocol will establish communication paths only when they are needed[7]. The AODV protocol must adapt to rapidly changing network conditions, which results in Quality of Service that is sometimes unstable because it is susceptible to delay when used in networks with high levels of mobility[8]. This research aims to simulate the performance of the Ad Hoc On-Demand Distance Vector (AODV) protocol in various network conditions, when the number of nodes continues to increase in the communication process.

The simulation process will model network scenarios with various configurations and measure performance parameters, such as throughput and delay. In addition, the simulation allows the exploration of potential optimizations of the Ad Hoc On-Demand Distance Vector (AODV) protocol so as to improve routing efficiency under certain conditions[9]. This is expected to provide new value in the form of maximum parameter recommendations for the use of the Ad Hoc On-Demand Distance Vector (AODV) protocol in certain scenarios, so that it can contribute to the development of more adaptive routing protocols in mobile ad hoc networks..

## 2. METHOD

The constantly changing and mobile nature of mobile ad hoc networks makes this system model very difficult to evaluate and design with formal analysis. One of the commonly used scenarios in mobile ad hoc network models is to test using devices that are suitable for implementation in real life environments, such as in military networks, transportation networks or special conditions during disasters. Under these conditions, testing using appropriate devices is very difficult to do because the price of the device is quite expensive and the research time is limited. To simplify and study the behavior of nodes and routing protocols in the packet delivery process, a simulation model is used. Simulation is carried out with the aim of creating an artificial environment created using a computer program to be able to see the important characteristics of the phenomenon or condition being studied. Simulation is an economical way to be able to conduct analysis and testing so that results are obtained in accordance with the research objectives. The main purpose of the simulation is to determine the path (route) that will be traveled by the node in the process of sending packets from the source node to the destination node in the ongoing mobile ad hoc network using the Ad Hoc On-Demand Distance Vector (AODV) protocol [10].

The mobile ad hoc network configuration is a graph representation with N as nodes and M as links. All links shown are the amount of connectivity path which is the bandwidth (bits/sec) and transmission time (sec). It is intended that each node can store and forward packets in the queue in the mobile ad hoc network system where outgoing and incoming packets are then stored. The temporary

storage (buffer) on the node will be shared among all queues when the node enters to connect or exit the mobile ad hoc network that is running. The packet transfer process can be a data packet or a routing packet. A packet will be read from the routing table information process regarding which link to use to follow and send to the destination node. When the link is available, the packet delivery process will be prepared. When a packet is picked up to be moved from one node to a neighboring node will depend on the packet size, bandwidth and data transmission characteristics used. When the packet reaches its destination, it will be stored in the memory buffer. If there is insufficient storage space (buffer) then the packet will be discarded or ignored. To build a mobile ad hoc network configuration and routing process from the source node to the destination node, the Ad Hoc On-Demand Distance Vector (AODV) protocol is used to ensure the packet delivery process can be successful.

The mobility of nodes connected to a mobile ad hoc network cannot be predicted with certainty due to topology changes that can occur continuously and quickly[11]. To create an appropriate simulation, a mobility model is used in the ongoing routing process in the mobile ad hoc network. Node movement is used to describe the movement of nodes so that each node can have a role or task in the mobile ad hoc network simulation.

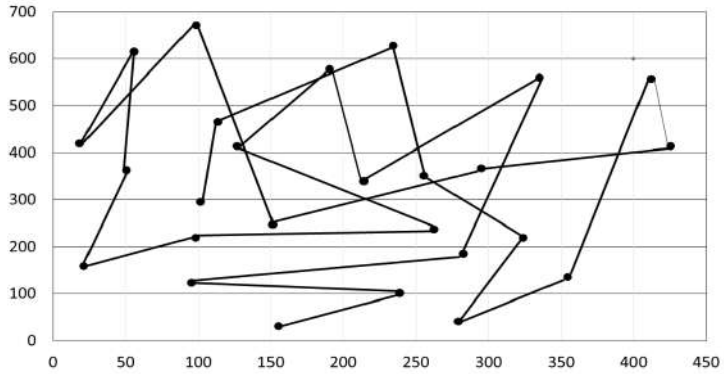


Figure 2. Random Waypoint Mobility (RWM) Movement Model[12]

This model will move randomly and tend to zigzag in the mobile ad hoc network area and is one of the most popular node movement models[13]. When a network node experiences a time lag between direction and speed changes, a source node will stay at one location for a certain period of time (i.e., pause time). After the pause time ends, the node randomly selects a destination node (next hop) in the simulation area with various speeds [minspeed, maxspeed]. After reaching the destination (next hop), the node will stop for a while (pause time) before starting the process again to reach the actual destination. The simulation scenario is shown in the mobile ad hoc network flow chart using the Ad Hoc On-Demand Distance Vector (AODV) protocol[14].

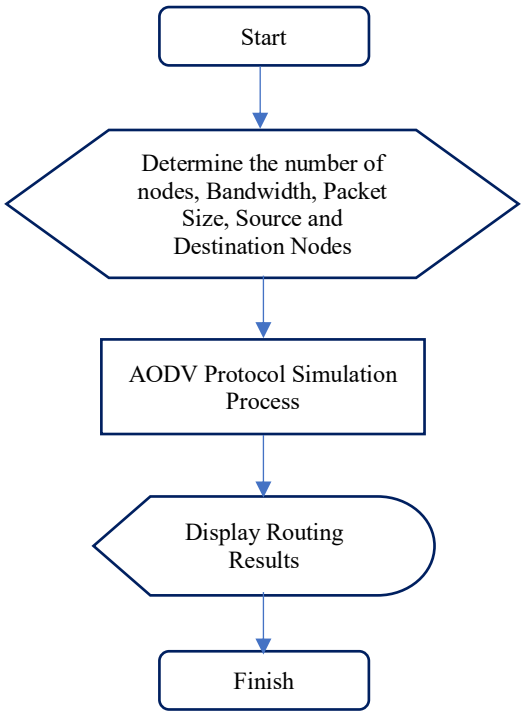


Figure 3. Stages of Mobile Ad Hoc Network Simulation

At the beginning of the simulation, we will initiate the number of nodes, bandwidth, packet size, node mobility and the number of nodes that will be connected to the mobile ad hoc network as well as determining the source and destination of packet delivery[15]. The result of the initiation process will be improved performance with Ad Hoc On-Demand Distance Vector (AODV) protocol towards troughput and small delay. The results of the scenario-based simulation process that has been carried out will be displayed in the form of statistical data in tabular format. When the simulation process is run, there are a number of nodes that are initially placed randomly and continuously moving in a simulated 100 × 100 $m^2$ square area based on the Random Waypoint Mobile (RWM) model. Each node travels between hops or to a random destination in the mobile ad hoc network simulation area, then pauses for a second session. After the pause period, the node goes to another place or randomly selected neighboring nodes. This process will continue to be repeated during the simulation, causing continuous changes (node mobility) in the mobile ad hoc network topology. The simulation model uses a simulator built with a programming language based on the approach and parameters required. The simulation model parameters used in the experiment are described in Table 1.

Table 1. Simulation Scenario Parameters

| Simulation Parameters | Unit Value |
|---|---|
| ***Area*** | 100 x100 $m^2$ |
| **Number of Testing Nodes** | 5, 15, 25, 35, to 50 *node* |
| **Bandwidth** | 2 Mbps |
| **Network Model** | *Mobile* |
| **Mobility Model** | *Random Waypoint Mobility* (RWM) |
| **Packet Size** | 1 Mbps |
| **Transmission Distance** | 1-100 m |
| **Routing Protocol** | AODV |

After the number of nodes and test parameters are determined, the next step is to determine the source node and destination node to send packets that have been determined previously. The results of the simulation process that has been carried out will be displayed in table format.

## 3. RESULT AND DISCUSSION

Testing is carried out in stages from 5 to 50 nodes in the simulator grid area. The simulation process is carried out to see the performance of the Ad Hoc On-Demand Distance Vector (AODV) protocol by placing nodes on a simulation grid area measuring 100x100 $m^2$. The nodes are placed randomly with a random waypoint mobility model.

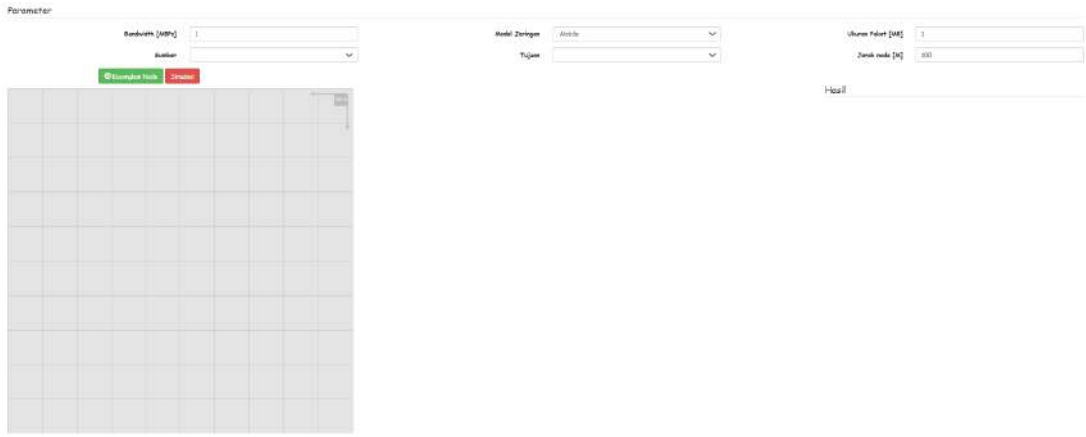

Figure 4. System View For Mobile Ad Hoc Network Simulation

### 3.1. Simulation With 5 Node

The first simulation testing process was conducted using 5 nodes. Nodes were simulated with the same types of parameters, as described in Table 1.

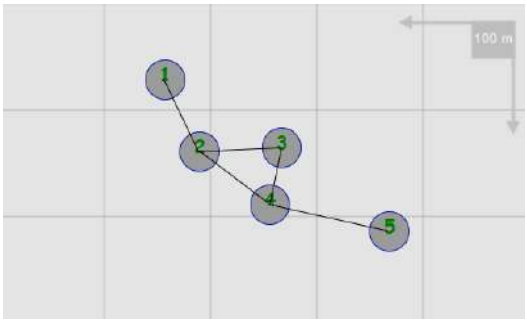


Figure 5. Simulation Process with 5 Nodes

The test results (results) using 5 nodes using the mobile network model are described in Table 2.

Table 2. Simulation Results with 5 Nodes

| Simulation Parameters | Unit Value |
|---|---|
| **Source Node** | Node 1 |
| **Destination Node** | Node 5 |
| **Bandwidth** | 2 MB |
| **Network Model** | *Mobile* |
| **Protocol** | AODV |
| **Nodes Traveled Through** | Node 1→ Node 2→ Node 4→Node 3→Node 5 |
| **Packet Size** | 1 MB |
| **Throughput** | 0,92 MBps |
| **Delay** | 2,37 s |

### 3.2. Simulation With 15 Node

Further testing by adding a number of 10 new nodes, so that in the grid area the number of nodes increases to 15 nodes.

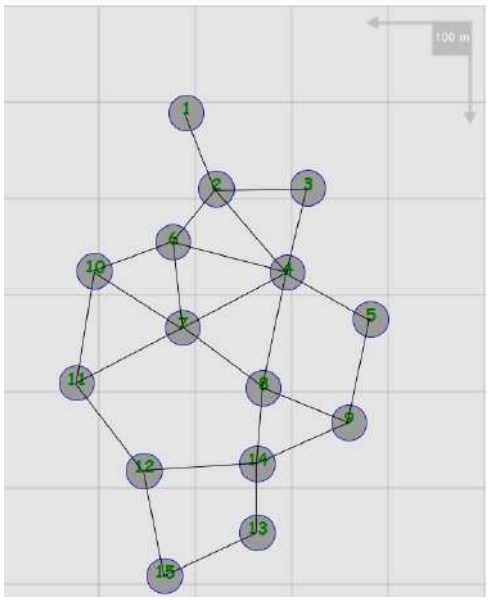


Figure 6. Simulation Process with 15 Nodes

After the simulation process is run and the destination node is changed to the last node placed into the grid area, namely at node 15.

Table 3. Test Results With 15 Nodes

| Simulation Parameters | Unit Value |
|---|---|
| **Source Node** | Node 1 |
| **Destination Node** | Node 15 |
| **Bandwidth** | 2 MB |
| **Network Model** | *Mobile* |
| **Protocol** | AODV |
| **Nodes Traveled Through** | Node 1→ Node 2→ Node 4→Node 8→Node 14→Node 13→Node 15 |
| **Packet Size** | 1 MB |
| **Throughput** | 0,87 MBps |
| **Delay** | 3,62s |

### 3.3. Simulation With 25 Node

The next test added 10 more nodes to the grid area, making it 25 nodes, as described in Figure 7.

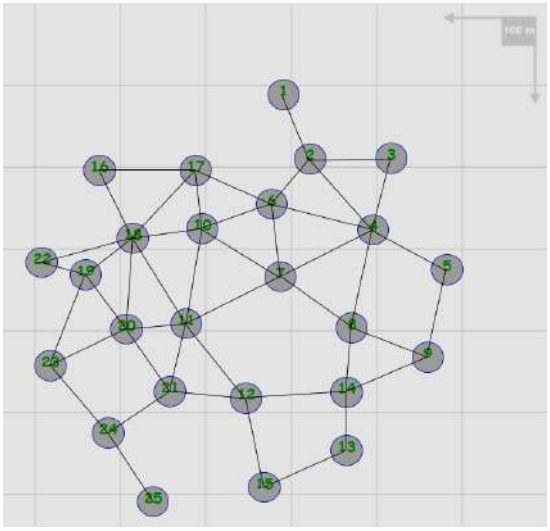

Figure 7. Testing with 25 Nodes

After the simulation process is run again with the same parameters, only the destination node is changed to node 25.

Table 4. Test Results with 25 Nodes

| Simulation Paraeters | Unit Value |
|---|---|
| **Source Node** | Node 1 |
| **Destination Node** | Node 25 |
| **Bandwidth** | 2 MB |
| **Network Model** | *Mobile* |
| **Protocol** | AODV |
| **Nodes Traveled Through** | Node 1→ Node 2→ Node 6→Node 10→Node 11→Node 21→Node 24→Node 25 |
| **Packet Size** | 1 MB |
| **Throughput** | 0,79 MBps |
| **Delay** | 4,06s |

### 3.4. Simulation With 35 Node

The next testing process the number of nodes is added again as many as 10 new nodes, so that the number of nodes in the grid area is 35 nodes.

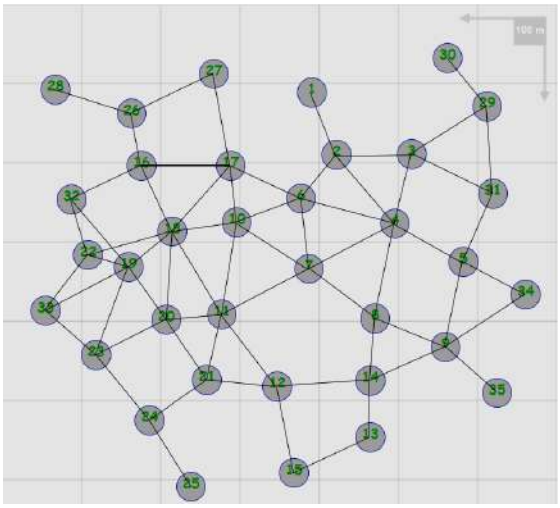

Figure 8. Testing with 35 Nodes

After the simulation process is run with the same parameters, only the destination node is changed to the last node that enters or is placed into the grid area to become 35 nodes.

Table 5. Test Results With 35 Nodes

| Simulation Parameters | Unit Value |
|---|---|
| **Source Node** | Node 1 |
| **Destination Node** | Node 35 |
| **Bandwidth** | 2 MB |
| **Network Model** | *Mobile* |
| **Protocol** | AODV |
| **Nodes Traveled Through** | Node 1→ Node 2→ Node 4→Node 5→Node 9→Node 35 |
| **Packet Size** | 1 MB |
| **Throughput** | 1 MBps |
| **Delay** | 2,95s |

### 3.5. Simulation With 50 Node

The last testing process with the addition of a significant number of new nodes as many as 15 new nodes. so that the number of nodes in the grid area becomes 50 nodes.

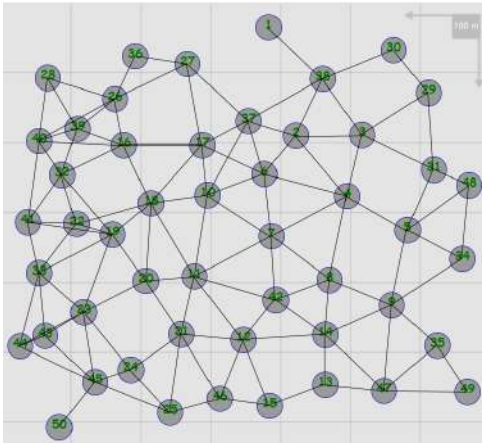

Figure 9. Testing with 50 Nodes

The results of testing with 50 nodes on the communication process and sending packets from the source node to the destination node are described in Table 6.

Table 6. Test Results with 50 Nodes

| Simulation Parameters | Unit Value |
|---|---|
| **Source Node** | Node 1 |
| **Destination Node** | Node 50 |
| **Bandwidth** | 2 MB |
| **Network Model** | *Mobile* |
| **Protocol** | AODV |
| **Nodes Traveled Through** | Node 1→ Node 38→ Node 37→Node 10→Node 11→Node 21→Node 24→Node 45→Node 50 |
| **Packet Size** | 1 MB |
| **Throughput** | 0,64 MBps |
| **Delay** | 5,23s |

## 4. CONCLUSSION

Based on the results of the discussion using the simulator that has been done, when the communication process takes place and the gradual increase in the number of nodes on the mobile ad hoc network using the Ad Hoc On-Demand Distance Vector (AODV) routing protocol can stably send packets from the source node to the destination node. The Ad Hoc On-Demand Distance Vector (AODV) routing protocol is quite good to use on dense communication lines (traffic) or on minimal communication facilities, because of its stability in minimizing overhead, although the delay value is still quite large.

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