Performance Of Routing Protocols For Mobile Ad Hoc Networks

San San Naing, Zaw Min Naing, Hla Myo Tun

Abstract: Mobile ad hoc network has become popular in wireless network communication technology. Recently many researchers are studying based on new communication techniques, especially wireless ad hoc networks. This paper presents the performance of routing protocol for mobile ad hoc network (MANET). Routing is one of the challenging issues in mobile ad hoc network. Therefore, the performances of ad hoc routing protocols are tested with different mobile node numbers at different mobility speeds. We have made an attempt to compare different mobility models and provide an overview of their current research status in this paper. The main focus is on Random Waypoint Mobility Model and Realistic Mobility Model. Firstly, we present a survey of the characteristics, drawbacks and research challenges of mobility modeling. Secondly, the simulation results of routing protocols. They are also experimented by implementing a realistic mobility model. The proposed network area is specified to 800 × 800 square meter. The commonly used network simulator (NS2) has been utilized as a core simulator for this research.

Index Terms: Wireless Network, MANETs, AODV, DSR, Network Simulator, Performance Metrics

1 INTRODUCTION

WIRELESS communication techniques have become popular among network researchers in recent years. Wireless networks allow the components within the network to roam without the constraints of wired connections. People can deploy a wireless network easily and quickly. Hosts and routers in a wireless network can transport all around the network. The advancement in wireless communication and economical, portable computing devices have made mobile computing possible [2]. There are two architectures in wireless networks: infrastructure and infrastructure less. The first one is dependent on fixed equipment such as base stations or access points (AP) to connect mobile terminals (MTs) to the wired infrastructure, as illustrated in Figure.1. When a source MT wants to establish a conversation with another MT, it does not need to know routes between each other for the source MT will establish routes with the base station first.

Fig.1. Infrastructure Network Model

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[1]However, ad hoc, the second approach does not contain any fixed infrastructure. All nodes in a mobile ad hoc network can be dynamically connected to each other and are free to move. All nodes in the network are hosts and routers as well [1]. Ad hoc networks usually have lower available resources compared with infrastructure networks and the highly dynamic nature of ad hoc networks means that many special factors have to be considered when designing a routing protocol specialized for them, such as network topology, routing path and routing overhead; also it must find a path quickly and efficiently. The transmission range of each node is limited in wireless ad hoc networks and thus not all nodes can directly communicate with each other. A node is often required to forward packets to another node to accomplish a communication across the network. An ad hoc routing protocol must dynamically establish and maintain routes between source and destination nodes for there is no static network topology and fixed routes. The sample diagram of mobile ad hoc network is depicted in figure 2.

Fig. 2 Infrastructureless (Ad Hoc) Netwrok Model

Our goal has been focused on the performance of ad hoc routing protocols. Two ad hoc routing protocols have been tested with three performance metrics by using different mobility model. Firstly, the research is addressed on the random waypoint mobility model. Secondly, it is also contributed to a realistic mobility model. These two explorations have been performed within the same network area and in the same simulation time. The main goal of this paper is focused on the presentation of a number of mobility models for the network researchers in order to select the harmonious mobility model for the network simulations. The rest of this paper configuration is as follow: routing in mobile ad hoc networks will presented in the next section. The subtitle three will elucidate the different mobility model and network simulator. The simulation environment will be described in section four. The test and outcome of our research will be illustrated in section five. Finally, the section six will discuss the performance of ad hoc routing protocols and conclude overall investigation of this research.

2 Routing in Mobile Ad Hoc Networks

In MANETs, each node acts both as host and as router, thus, it must be capable of forwarding packets to other nodes. Topologies of these networks change frequently. To solve this problem, special routing protocols for MANETs are needed because traditional routing protocols for wired networks cannot work efficiently in MANETs. Hence, a specific dynamic routing protocol for MANETs which discovers and maintains the routes, and deletes the obsolete routes continuously is necessary. Because of the fact that it may be necessary to hop several hops (multi-hop) before a packet reaches the destination, a routing protocol is needed. The routing protocol has two main functions, selection of routes for various source-destination pairs and the delivery of messages to their correct destination. The second function is conceptually straightforward using a variety of protocols and data structures (routing tables). This report is focused on selecting and finding routes. The routing protocols for MANETs try to maintain the communication between a pair of nodes (source-destination) in spite of the position and velocity changes of the nodes. To achieve that, when those nodes are not directly connected, the communication is carried out by forwarding the packets, by using the intermediate nodes. Currently there is research on the behavior of a lot of those routing protocols and the IETF (Internet Engineering Task Force) is working on the standardization of some of them. MANETs are necessary to have different routing protocols from the wired networks. There are three types of routing protocols for MANETs: Table-driven (Proactive), Demand-driven (Reactive) and Hybrids. The classifications of routing protocols in mobile ad hoc network can be seen in figure. 3. In the proactive protocols, each node has a routing table, updated periodically, even when the nodes don't need to forward any message. In the reactive protocols, the routes are calculated only when required. When a source wants to send information to some destination, it calls on route discover mechanisms to find the best route to this destination. The hybrids protocols try to use a combination of both to improve them.

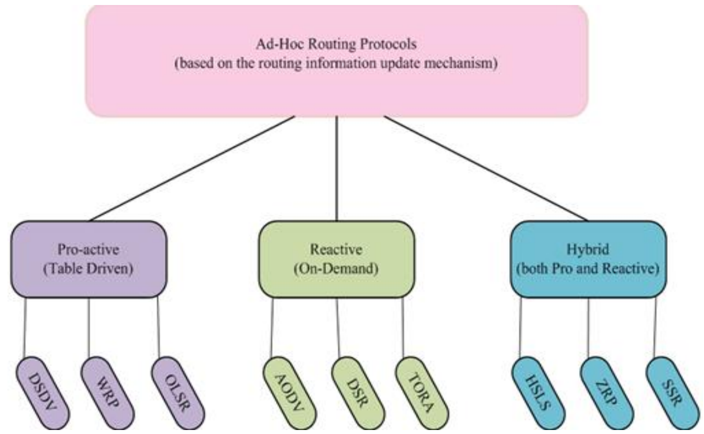

Fig. 3. The Classification of Ad Hoc Routing Protocols

2.1 AODV Routing Protocol

Ad hoc On-demand Distance Vector (AODV) is a reactive routing protocol. Reactive routing protocols are also called on-demand routing protocols and it performs two major phases: Route Discovery (route set-up) phase and Route maintenance phase. Route Discovery (route set-up) phase: in this phase, as demand arises, a route is set up between the source and the destination. Then, the following process takes place: the network is initially flooded with requests for the route; then the request is flooded until the TTL becomes 0; after that, the request packet is discarded. The next stage involves caching a route that is set up. The route will be cached for a specified period of time. This is a variable, and its value changes based on the protocol being used. Route maintenance: This phase is responsible for maintaining the routes. If the route is not available, then an error message will be sent, and all the nodes will be notified [5,6].

2.2 DSR Routing Protocol

Dynamic Source Routing (DSR) protocol is also a reactive ad hoc routing protocol. In dynamic source routing (DSR) [3], source node floods a route request to all nodes. Source routing protocol is composed of two main mechanisms to allow the discovery and maintenance of source to destination routes in the ad hoc networks. To commence the route discovery mechanism, wireless node floods a route request to all nodes which are in the wireless transmission range. The originator (source) and objective (destination) of the route discovery is identified by each route request packet. The source node also provides a unique request identification number in its route request packet. For responding to the route request, the target node usually scans its own route cache for a route before sending the route reply toward the initiator node. However, if no suitable route is found, target will execute its own route breakthrough mechanism in order to reach toward the originator. A routing entry in DSR contains all the middle nodes of the route rather than just the next hop information [5] [6]. A source puts the entire routing path in the data packet and the packet is sent through the middle nodes specified in the path. If the source does not have a routing path to the destination, then it performs a route discovery by flooding the network with a route request (RREQ) packet. Any node that has a pathway to the destination in question can reply to the RREQ packet by sending a route reply (RREP) packet. The reply is sent using the route recorded in the RREQ packet. The advantages of this routing are to provide multiple routes and keep away from loop formation where as disadvantages are large end-to-end delay, scalability problems caused by flooding and source to destination routing mechanisms [7].

3 Mobility Models and Network Simulator (NS2)

In all the existing routing protocols, mobility of a node has always been one of the important characteristics in determining the overall performance of the ad hoc network. Thus, it is essential to know about various mobility models and their effect on the routing protocols. A Mobility model (MM) is used to describe the movement of a mobile node, its location and speed vary over time while a performance of routing protocol is simulating. It is one of the key parameters that researchers have to consider the selection of appropriate mobility model before analyzing and simulating the performance of the routing protocols.The classification of different mobility models is illustrated in figure 4.

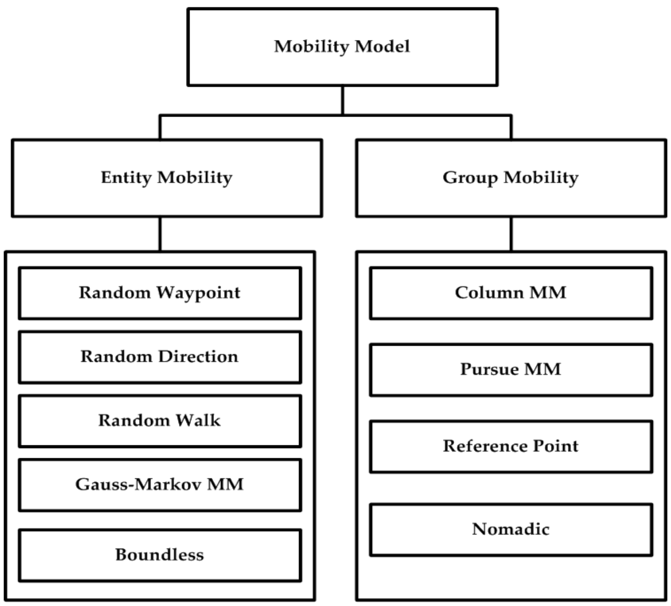

Fig. 4. The Classifications of Mobility Models

Two types of mobility models are Entity Mobility Models and second one is Group Mobility Models. Each mobility model has many characteristics. One of them is to ensure that none of the mobile nodes can travel outside the network simulation area [8]. Since there are a large number of MMs, we have chosen some important models for our observation. One frequently used model in simulation of MANET routing protocols is Random Waypoint Model which is utilized for this study. Manhattan Mobility Model is also used for this research to implement the realistic mobility model.

A. Random Waypoint Mobility Model

The Random Waypoint Mobility Model used by Johnson [13] and Lee [15] includes pause times between changes in direction and/or speed. In all the random based mobility models, the mobile nodes are set free to move randomly in any direction within the simulation area. We can say that a node is free to select its destination, speed and direction independent of the neighbor nodes. RWPMM is the only model that is widely implemented & analyzed in simulation of routing protocols because of its simplicity and availability. It was first proposed by Johnson and Maltz [14]. At the start of the simulation each mobile node waits for a specified time called pause time, tp and randomly selects one location. A MN chooses a new random destination after staying at its previous position for a time period of tp till its expiry. A node travels across the area at a random speed distributed uniformly from v0 to vmax where v0 and vmax represent the minimum and maximum node velocities. This process of choosing random destination at random velocity is repeated again and again until the simulation is finished. If *v*max is small and tp is long then the network is stable and in reverse case it is dynamic. When tp = 0, it represents a continuous mobility. This concept was proposed by Perkins & Royer [9], Nesargi & Prakash [12]. They modified the existing RWPMM to let a MN travel at a uniform speed throughout the simulation by setting pause time to zero. In this case the RWPMM behaves similar to Random Walk Mobility Model.

Advantages are as follow:

- The most common use mobility model, because of its simplicity.
- A building block for developing a variety of mobility models.

Disadvantages are as follow:

- Lack of regular movement modeling.
- Exhibits speed decay.
- Generates density waves.
- Memory-less movement behaviors (a common problem for all random waypoint variations) [10, 11].

B. Manhattan Mobility Model

Manhattan model was introduced to emulate the movement pattern of mobile nodes on streets defined by maps [16, 17]. It can be useful in modeling movement in an urban area where a pervasive computing service between portable devices is provided. The map is composed of a number of horizontal and vertical streets. Each street has two lanes for each direction (north and south direction for vertical streets, east and west for horizontal streets). The mobile node is allowed to move along the grid of horizontal and vertical streets on the map. At an intersection of a horizontal and a vertical street, the mobile node can turn left, right or go straight. This choice is probabilistic: the probability of moving on the same street is 0.5, the probability of turning left is 0.25 and the probability of turning right is 0.25.

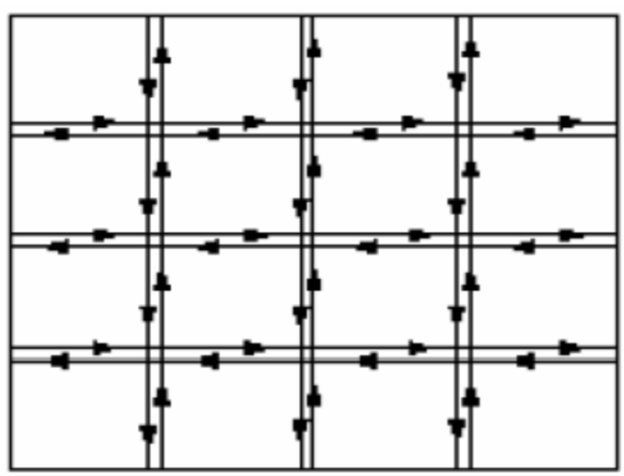

Fig. 5. Manhattan Mobility Model

However, it differs from the Freeway model in giving a node some freedom to change its direction. Figure 5 shows the movement trace of mobile nodes in Manhattan MM. The Manhattan mobility model is also expected to have high spatial dependence and high temporal dependence.

C. Network Simulator (NS2)

The entire simulations were carried out using ns 2.35 network simulator which is a discrete event driven simulator developed at UC Berkeley [18] as a part of the VINT project. The goal of NS2 is to support research and education in networking. It is suitable for designing new protocols, comparing different protocols and traffic evaluations. NS2 is developed as a collaborative environment. It is distributed as open source software. A large number of institutes and researchers use, maintain and develop NS2. NS2 Versions are available for Linux, Solaris, Windows and Mac OS X. NS2 [8,23,24] is built using object oriented language C++ and OTcl (object oriented variant of Tool Command Language). NS2 interprets the simulation scripts written in OTcl. The user writes his simulation as an OTcl script. Some parts of NS2 are written in C++ for efficiency reasons. The data path (written in C++) is separated from the control path (written in OTcl). Data path object are compiled and then made available to the OTcl interpreter through an OTcl linkage. Results obtained by ns2 (trace files) have to be processed further by other tools like Network Animator (NAM), perl, awk script etc. The overall simulation procedure of NS2 can be seen in figure 6.

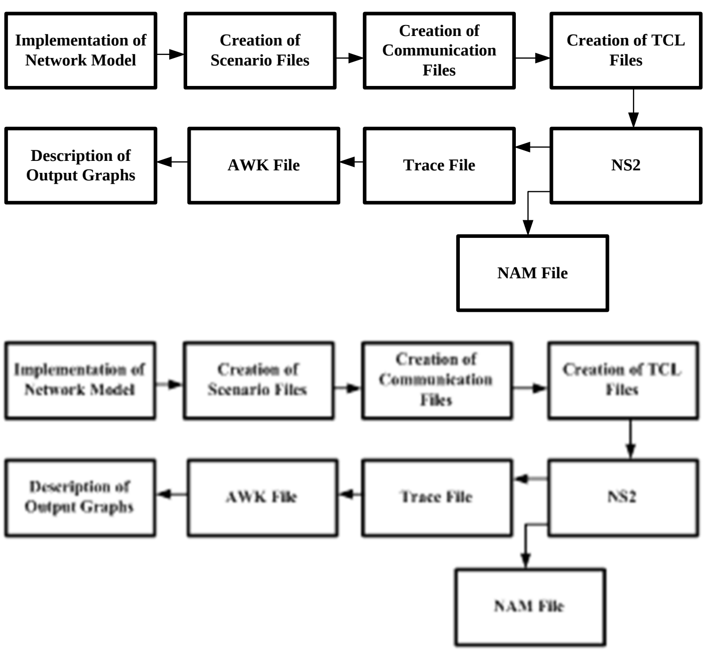

Fig. 6. The Overall Simulation Procedure of NS2

4 Simulation Environment

This paper presents a number of mobility models for the network researchers in order to select the harmonious mobility model for the network simulations. In addition, the main goal of this paper is to explore the performance of two ad hoc routing protocols using the different mobility models. Firstly, we explored the performance of AODV and DSR routing protocols using Random Waypoint Mobility Model. And then, a realistic mobility model has been implemented using Manhattan Mobility Model for the vital area of Mandalay Technological University (MTU). The proposed network area is depicted in figure 7.

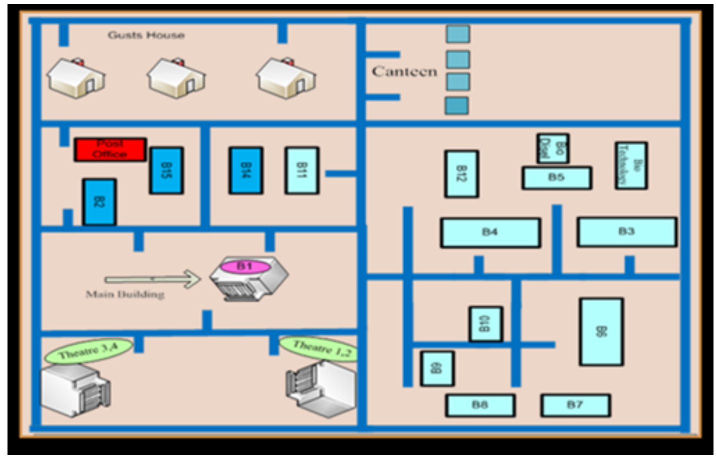

Fig. 7. The Block of Proposed Network Area

4 Performance Metrics

The performance of routing protocols is addressed with three performance metrics: packet delivery fraction (PDF), average end-to-end delay and average throughput. Packet delivery fraction (PDF) is the fraction of number of packet received at the destination to the number of packet sent from the source multiply by 100.

Pr = total packets received

Ps = total packets sent

$$\text{Packet Delivery Ratio (PDF)} = \frac{Pr}{Ps} \times 100 \qquad (1)$$

Average end-to-end delay includes all possible delays caused by buffering during route discovery latency, queuing at the interface queue, retransmission delays at the MAC, and propagation and transfer times of data packets. Average end-to-end delay is also caused by queuing for transmission at the node and buffering data for detouring. Once the time difference between every CBR packet sent and received was recorded, dividing the total time difference over the total number of CBR packets received gave the average end-to-end delay for the received packets. This metric describes the packet delivery time: the lower the end-to-end delay the better the application performance.

$$\text{Average End-To-End Delay} = \frac{\sum_1^n (\text{CBRsentTime} - \text{CBRrecTime})}{\sum_1^n \text{CBRrecv}} \qquad (2)$$

Throughput is a very important parameter in evaluating the modifications performance. It is calculated as the number of bits received per second. Throughput is affected by the number of packets dropped or left wait for a route which is calculated as the summation of the number of packets dropped or left wait for a route for all the nodes. There is two representations of throughput; one is the amount of data transferred over the period of time expressed in kilobits per second (Kbps). The other is the packet delivery percentage obtained from a ratio of the number of data packets sent and the number of data packets received.

5 Simulation Parameters

The performance of two proposed routing protocols has been simulated in network simulator NS2 within the network area 800 × 800 m^2. It has also been explored with the various mobile node numbers at the different mobility speeds. The detail expression of simulation parameters is illustrated in Table

TABLE 1. SIMULATION PARAMETERS

Parameter	Value
Network Simulator	NS 2.35
Transmission Range	250 m
Number of Mobile Nodes	10, 20, 30, 40, 50
Mobility Speeds (m/s)	2, 5, 10, 20, 30
Simulation Time	500 s
Pause Time	1.0 s
Traffic Type	Constant Bit Rate
Packet Rate	4 packets/s
Packet Size	512 bytes
Network Area	800 x 800 m^2

5 ERESULTS OF THE PERFORMANCE OF AODV AND DSR ROUTING PROTOCOLSQUATIONS

This research has been simulated on the network of 800 × 800 meter square with different speed and different network sizes. The simulation time for this research has been specified to 500 seconds with 1 second pause time. By using different mobility models such as Random Waypoint and a realistic mobility model using Manhattan Mobility Model, this research has been investigated. The diagram of network animator visualization for a network with 50 nodes by using Random Waypoint Model is shown in Figure. 8.

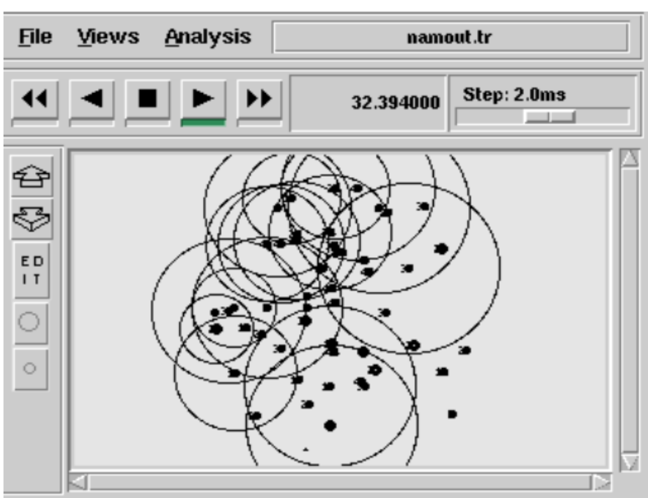

Fig. 8. The Visualization of Network Animation for 50 nodes using Random Waypoint Mobility Model

The diagram of network animator visualization for the network with 50 nodes by sing the realistic mobility model is illustrated in Figure 9.

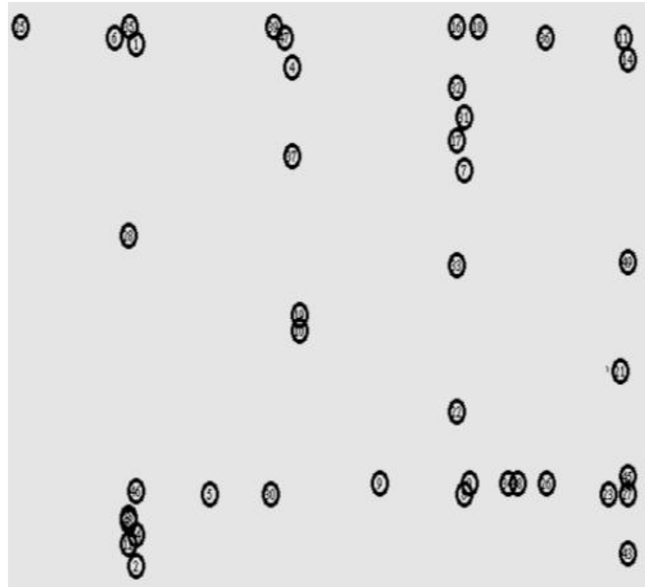

Fig. 9. The Visualization of Network Animation for 50 nodes using Realistic Mobility Model

The simulation results of performance comparisons of three metrics for AODV and DSR routing protocol for mobile ad hoc network by using Random Waypoint Mobility Model are shown with the appropriate figure. The simulation results of DSR routing protocol using Random Waypoint Mobility Model is shown in Figure 10, 11 and 12.

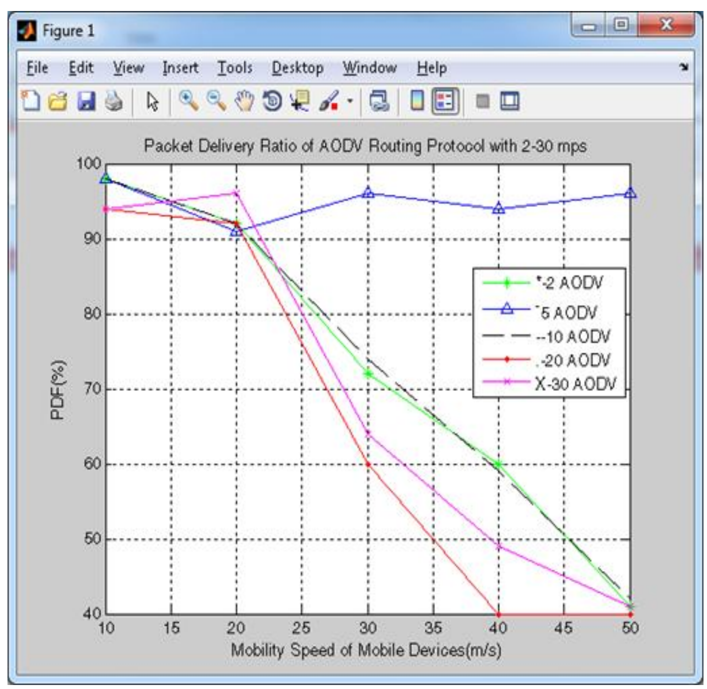

Fig. 10. The diagram of Packet Delivery Fraction of AODV for different nodes at various mobility speeds

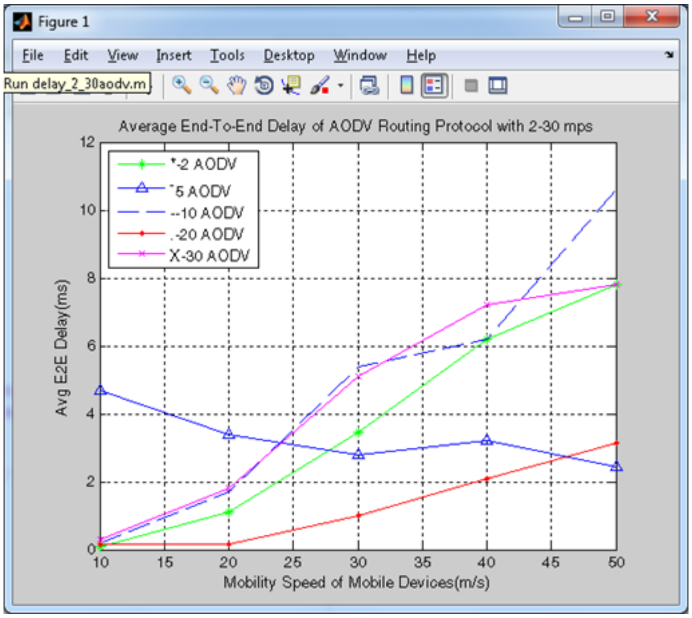

Fig. 11. The diagram of Average End-To-End Delay of AODV for different nodes at various mobility speeds

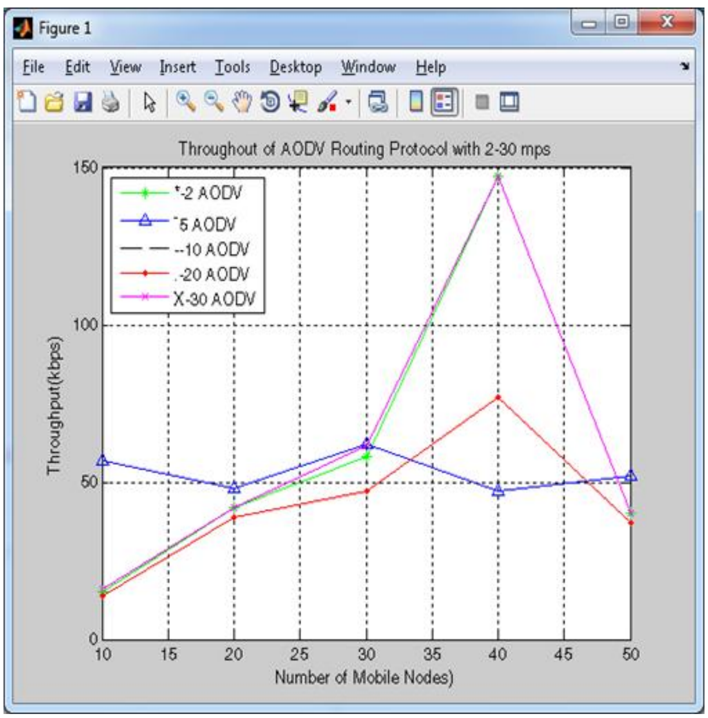

Fig.12. The diagram of Average Throughput of AODV for different nodes at various mobility speeds

The simulation results of DSR routing protocol using Random Waypoint Mobility Model is shown in Figure 13, 14 and 15.

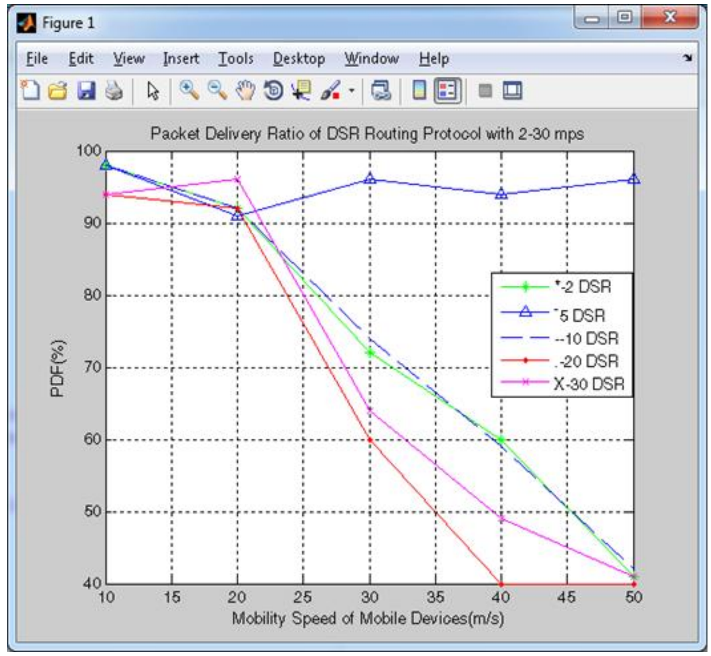

Fig. 13. The diagram of Packet Delivery Fraction of DSR for different nodes at various mobility speeds

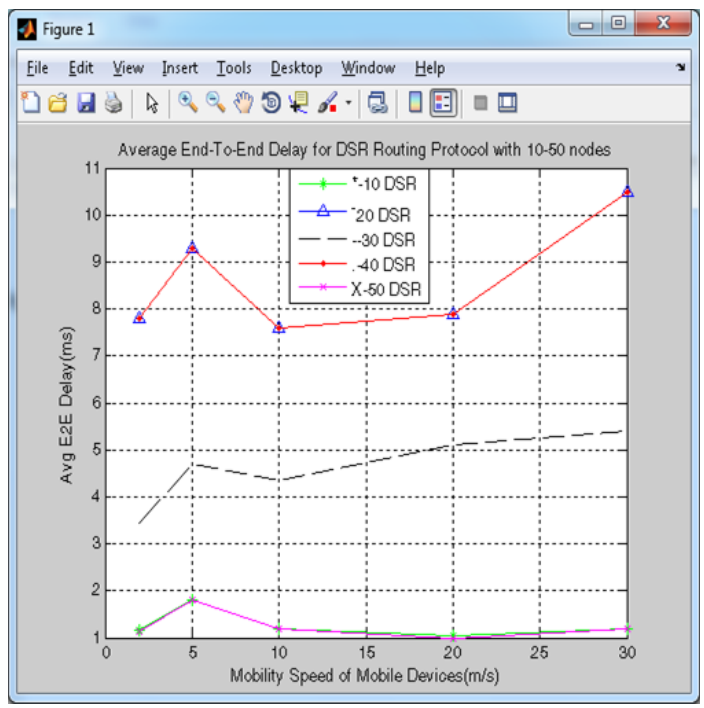

Fig. 14. The diagram of Average End-To-End Delay of DSR for different nodes at various mobility speeds

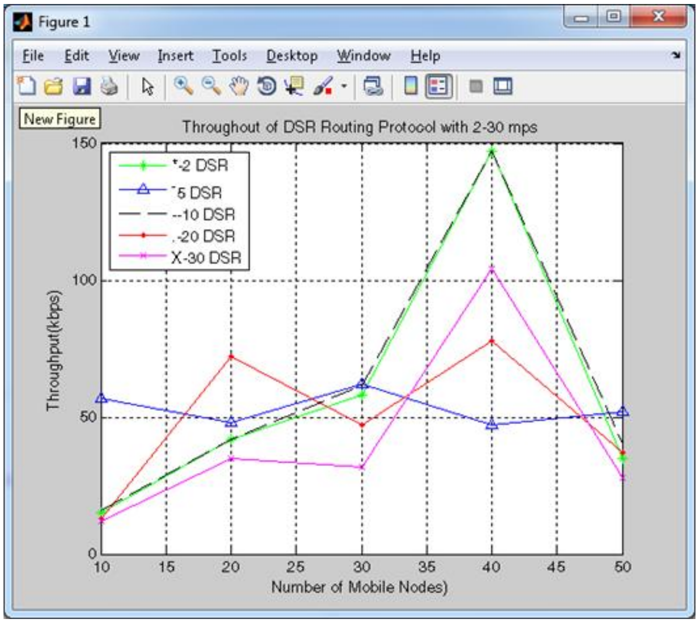

Fig. 15. The diagram of Average Throughput of DSR for different nodes at various mobility speeds

The diagrams of performance comparison for two ad hoc routing protocols at different mobility speed using realistic mobility model are shown in Figure. 16, 17, 18, 19 and 20.

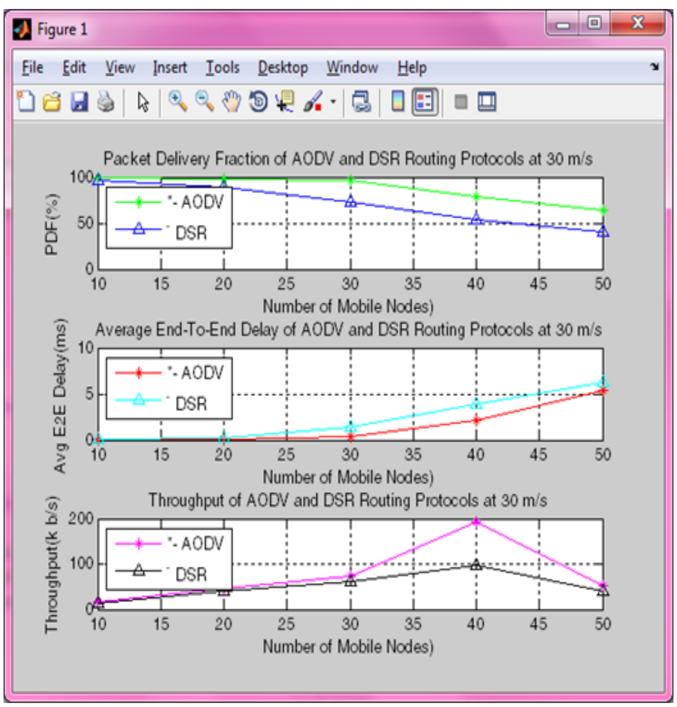

Fig. 16. Figure 16. The diagram of Packet Delivery Fraction of AODV and DSR for different nodes at 30 m/s mobility speed

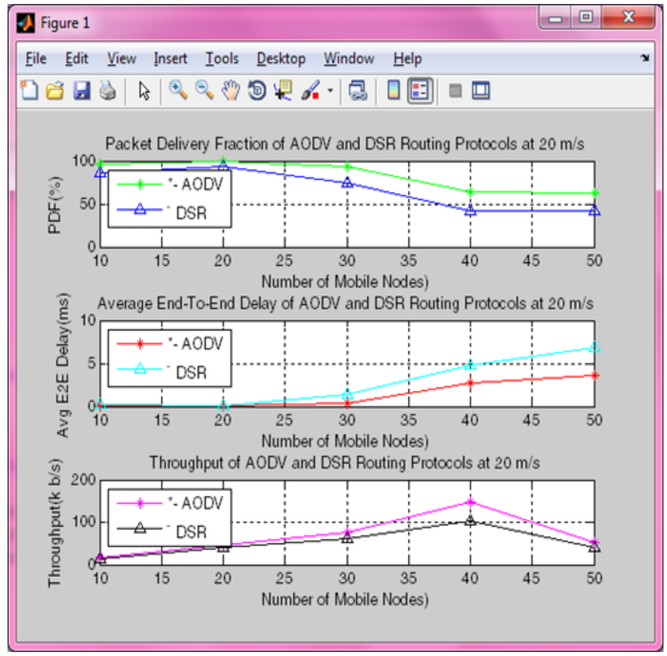

Fig. 17. The diagram of Packet Delivery Fraction of AODV and DSR for different nodes at 20 m/s mobility speed

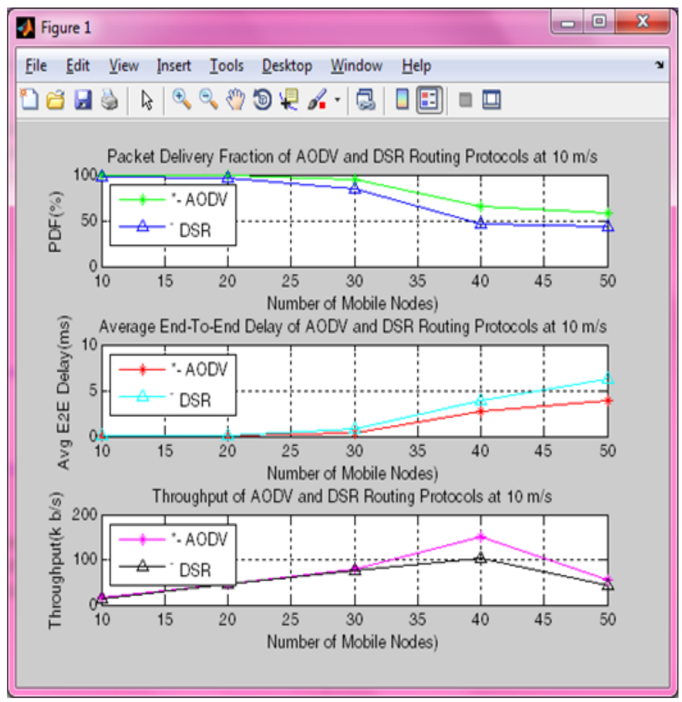

Fig. 18. The diagram of Packet Delivery Fraction of AODV and DSR for different nodes at 10 m/s mobility speed

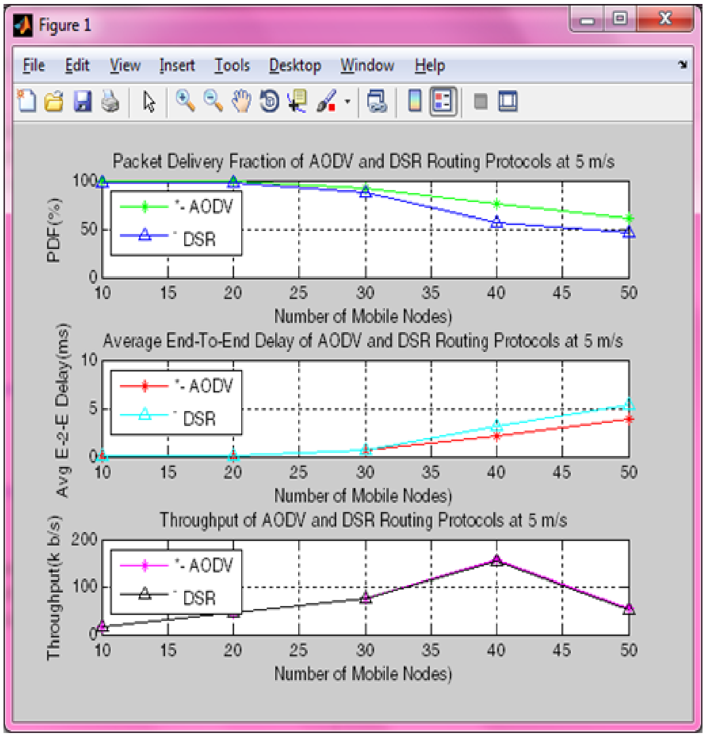

Fig. 19. The diagram of Packet Delivery Fraction of AODV and DSR for different nodes at 5 m/s mobility speed

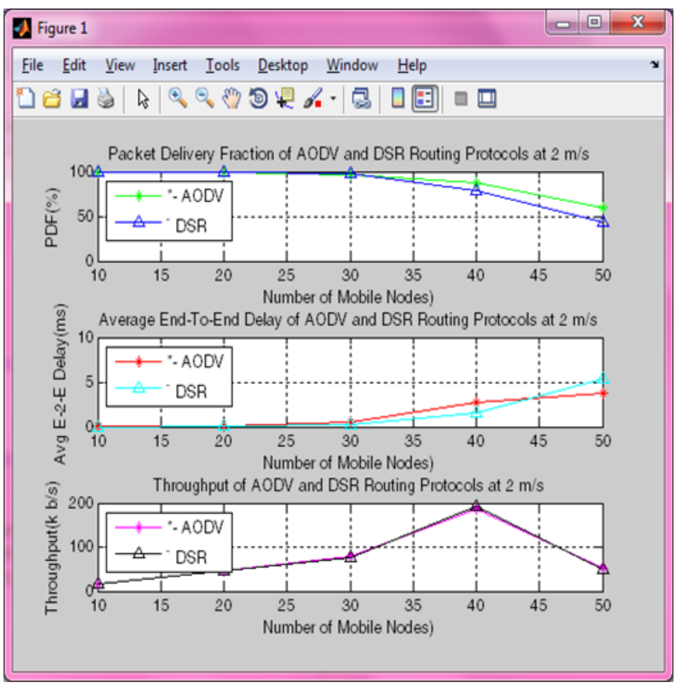

Fig. 20. The diagram of Packet Delivery Fraction of AODV and DSR for different nodes at 2 m/s mobility speed

6 Conclusion

The performances of two reactive routing protocols (AODV and DSR) for mobile ad hoc network have been simulated in this research. Network Simulator (NS 2.35) has been used as a core simulator for this research and MATLAB programming language has also been used to generate the output graphs. The performance metrics utilized in this research are packet delivery fraction (PDF), average end-to-end delay and throughput. The simulation area of the network is 800 × 800 m^2 and simulation time is 500 seconds with 1 second pause time. This is simulated with different node numbers (10, 20, 30, 40, 50 nodes) and at different mobility speeds (2, 5, 10, 20, 30 m/s). The packet size which is used in this research is 512 bytes and the traffic load used is 4 packets/s. The performances of two ad hoc routing protocols have been experimented by using Random Waypoint Mobility Model and Manhattan Mobility Model. In the experiment with Random Waypoint Model, both AODV and DSR routing protocols can perform very well at low mobility speeds. However, at high speed, AODV can perform better than DSR for all performance metrics. AODV routing protocol outperforms DSR routing protocol at all mobility speeds. The network size with 40 node numbers is appreciably better than other network sizes. In the experiment of the network using Manhattan Mobility Model, the performance of AODV and DSR routing protocols are not quite different at low mobility speeds. However, it can be seen that AODV can also perform better than DSR at high mobility speeds. Therefore, AODV routing protocol should be selected for this network scenario. According to this research, the performances of two routing protocols using Manhattan Mobility Model are significantly better than those of that using Random Waypoint Mobility Model. After all, AODV routing protocol and Manhattan Mobility Model should be used for the proposed network area.

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