Simulation Based Performance Analysis of IEEE 802.11b Based MANETs

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Abstract
The IEEE 802.11b standard is a protocol for proper interconnection of data communication tool using the wireless transmission in the Local Area Network (LAN). It includes the physical and the Media Access Control (MAC) layers of the ISO seven-layer network model. Therefore, investigating its performance with different ad-hoc network environment is necessary. Previously, a number of studies investigate the performance of various routing protocols using different evaluation methods with simulators, resulting to different outcomes. Thus, there is a need to expand the spectrum to take into consideration the effects of file size, numbers of nodes and mobility that were neglected in a specific environment and compare them with real life scenario MANET network. This paper present analysis results for the performance evaluation of transmitting FTP file with AODV routing protocol in OPNET modeler and real life network for several scenarios with 802.11b wireless networking transmission method. Simulation results demonstrate that the scenarios with small amount of fixed and mobile nodes shows better performance. The overall network performance automatically degrades with the increment of number of nodes as well as increment of packet size.

Keywords
MANET, AODV, OPNET, real life scenario, FTP, 802.11b

I. Introduction
Wireless network is one of the most wide spread computer networks which utilizes the radio frequency channels to communicate between the nodes in the network without using a physical medium. One of the most important benefits of wireless networks is the absence of physical medium to connect the nodes to each other. The Mobile Ad-Hoc Network (MANET) is an ad hoc wireless network that can be formed either by fixed or mobile nodes. The nodes randomly associate with each other forming arbitrary topologies and the node acts as both router and Access Point (AP). An ad hoc wireless network enables the users of the network to immediately communicate with each other. This means that ad hoc wireless networks do not require any routers or AP to be utilized in the network. Since, there is no wire and no fixed router, it is not difficult to enable mobility in the network due to the arbitrarily arrangement of the nodes with respect to topology changes. The transmission area of each node is limited. Hence, in order to reach a node that is out of its transmission area, another node should be used as an intermediate node in order to forward the needed information. Due to the absence of a router or an AP, every node inside the network can work as a router and accomplish the duty of forwarding data, which results to a multi hop wireless link between the sender and receiver.
In previous studies, most researchers focus on performance by keeping constant message size, constant node speed, limited variation in network sizes and a fixed network topology[9, 10, 11]. In most cases, they considered the network metrics such as throughput, latency, etc.
In this paper, one reactive routing protocol, AODV has been considered for the performance analysis of IEEE 802.11b. In order to do that different MANET scenarios are modeled by number of nodes. We measure a number of network metrics such as number of hop count, route discovery time, total route request sent, download response time, and upload response time by varying the message size. The main contribution of this paper is taking a new perspective by comparing real life scenario with identical simulated scenario with using AODV by varying the message size along with considering some other important network metrics. Here, in the designed scenarios the considered mobility nodes is closer to human speed synonymous with a human random movement.
The rest of the paper is described as follows. In Section II a brief overview about routing protocols followed by a description of AODV protocol, in section III the mobility models used in the simulations and real work are presented.Section IV includes the performance metrics used to capture, the analysis of the result presented in Section V. This paper concludes at Section VI.

II. Routing in MANET and Mobility Models
The MANET routing protocols are classified as reactive, proactive andhybrid(combination of both of them). The proactive routing protocols build and maintain routing data to the entire nodes, regardless whether the route is needed or not [1]. One of the main advantages is that the nodes can easily receive routing data and can easy build a session. The disadvantages are keeping excessive information in the nodes for route maintenance and when a specific link fails the restructure can be slow. On other hand, the proactive routing protocols are known also as on-demand protocol which has the capability of finding a route from a source node to a destination node(s) when a source node wants to send a packet. The advantage of a proactive protocol is that it gives lower route overhead and a high latency when discovering the routes [2]. Among this proactive and reactive protocol, a reactive protocol is more suitable for ad hoc network. Therefore, in this paper we have chosen a reactive routing protocol, known as AODV.
In AODV [3-4] protocol, routes are determined only when needed. A Hello message is used to detect and monitor the links between the neighbors. Each active node periodically broadcasts a Hello message and all neighbors' nodes receive it. Due to periodical broadcastsof the Hello messages, if a node fails to receive several Hello messages from a neighbor, a link break is detected. When a source has data to transmit to an unknown destination, it broadcasts a Route Request (RREQ) for that destination. At each intermediate node, when a RREQ is received a route to the source is created. If the receiving node has not received this RREQ before, that mean it is not the destination and does not have a current route to the destination, it rebroadcasts the RREQ. If the receiving node is the destination or has a current route to the destination, it generates a Route Reply (RREP). The RREP is unicast in a hop-by hop fashion to the source. As the RREP propagates, each intermediate node creates a route to the destination. When the source node receives

the RREP, it records the route to the destination and can begin sending data. If multiple RREPs are received by the source, the route with the shortest hop count is chosen. As data flows from the source to the destination, each node along the route updates the timers associated with the routes to the source and destination, maintaining the routes in the routing table. If a route is not used for some period of time, a node cannot be sure whether the route is still valid; consequently, the node removes the route from its routing table. If data flows and a link break are detected, a Route Error (RERR) is sent to the source of the data in a hop-by hop technique. As the RERR propagates towards the source, each intermediate node invalidates routes to any unreachable destinations. When the source of the data receives the RERR, it invalidates the route and reinitiates route discovery if necessary. The process of route discovery is presented in fig. 1.

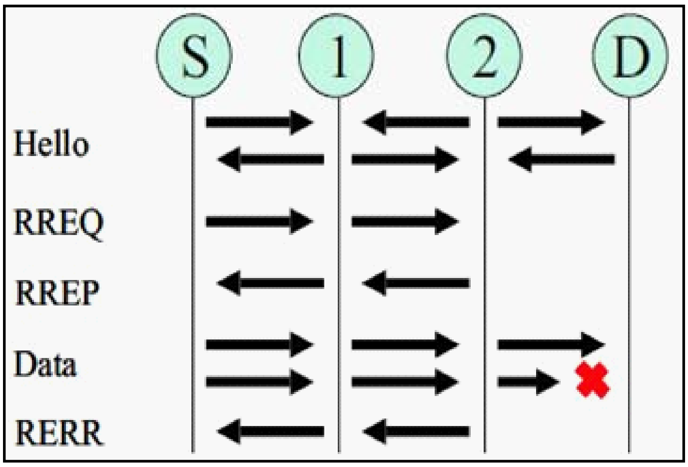

Fig. 1: The Process of Route Discovery in AODV

The mobility model is defined in the mobility configuration of nodes. In the MANET, the nodes movement is described by changing rate in speed or direction. A number of mobility models are tested for different scenarios [5-7]. However, in this paper the Random Waypoint mobility model (RWP) has been chosen. In general, the mobile nodes are moving randomly in a network and reach random destinations. Furthermore, random mobility model is more suitable for simulation studies [8].

III. Performance Metrics

In order to analyze the performance of routing protocol a number of network metrics are used including number of hops per route, route discovery time, and total route request sent, download response time, upload response time and delivery ratio.

A. Number of Hops Per Route

The number of hops per route is a statistic that represents the number of hops in each route to every destination in the route table of all nodes in the network.

B. Route Discovery Time

This statistic presents the time to discover a route to a specific destination by all nodes in the network. It is the time when a route request is out to discover a route to that destination until the time a route reply is received with a route to that destination.

C. Total Route Request Sent

This statistic represents the total number of route request packets sent by all nodes in the network during route discovery.

D. Download Response Time

Download response time is the time to elapse between sending a request and receiving the response packet. Measured from the time a client application sends a request to the server to the time it receives a response packet. The Download response time is measured by seconds.

D. Upload Response Time

Packet delivery ratio consists of two parts, traffic received and traffic sent, which can be defined as follows: the traffic received is the average number of packets forwarded to all FTP applications by the transport layer in the network. The traffic sent is the average number of packets submitted to the transport layers by all FTP applications in the network. The packet delivery ratio is found by the equation (1):

$$\text{Packetdelivery ratio} = \frac{\text{(Number of received packet in application layer)}}{\text{(Number of sent packet from the application layer)}} \quad (1)$$

IV. Scenario Description and Simulation Environment

This study consists of two parts. The first part includes the simulation work where various scenarios has been done with different number of nodes such as 9, 30, 60, 90 nodes and the transmitting FTP files size are been changed uniformly within 500 to 6000 bytes. The second part is the real life scenario, where nine nodes implemented with the same file size as the simulation work.

Table 1: OPNET Simulation Parameters

SIMULATION PARAMETERS	
Number of nodes	9, 30, 60, 90
area size	500x500
Simulation time	300 sec
Routing Protocol	AODV
MAC	802.11b
Data Rate	11 Mbps
Mobility type	Random way point
Speed	1.3 m\s
Transmitted Power	5mW
Packet Reception Power Threshold	-95dBm
Start Time	10 sec
Packet Size	500, 1000, 1500, 2000, 2500, 4000, 6000

Table 2: A List of Simulation Parameter in Different Scenarios

Real Life Scenario Parameters	
Number of nodes	9
Area size	500x500
Real life time	Between (3-30) min.
Routing Protocol	Pure flooding
MAC	802.11b
Data Rate	11 Mbps
Mobility type	Random way point
Speed	1.3 meter\sec
Packet Size	500, 1000, 1500, 2000, 2500, 4000, 6000

Both scenarios are done with area size of 500x500 with two speeds 0 and 1.3 meter/sec. Table 1 and Table 2 demonstrate the statistics of different parameters used in the experimental part.

V. Evaluation Results

The routing protocol performance of this study is analyzed by designing a number of network scenariosvarying number of nodes. The Figure 2 to Figure 7 illustrates the results for numerous amounts of fixed nodes. Among these scenarios, the scenario with nine nodes are the most effective size with all the performance metrics comparing with the 30, 60 and 90 nodes scenarios due to the small number of nodes. The AODV protocol is constantly searching for a new route when it needs, due to its on-demand approach; thus, it does not save all routes to the destination and also, it is unable to preserve the unused routes in the network. This strategy helps it to control traffic. However, the route discovery time increases when the node size increases, because the files are waiting in buffer up to send by a new route. The AODV maintains one route only per destination in routing table.
The fig. 8 to fig. 13 show that similar to the different fixed node scenarios, the scenarios with nine mobile nodes are the most effective one with all the performance metrics comparing to the 30, 60 and 90 nodes scenarios, due to the small number of nodes.

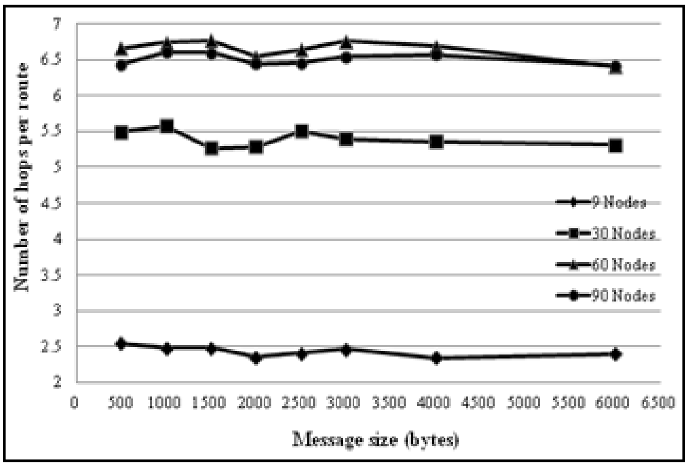

Fig. 2: Number of Hops Per Route for Scenarios With Different Number of Fixed Nodes by Varying Message Size

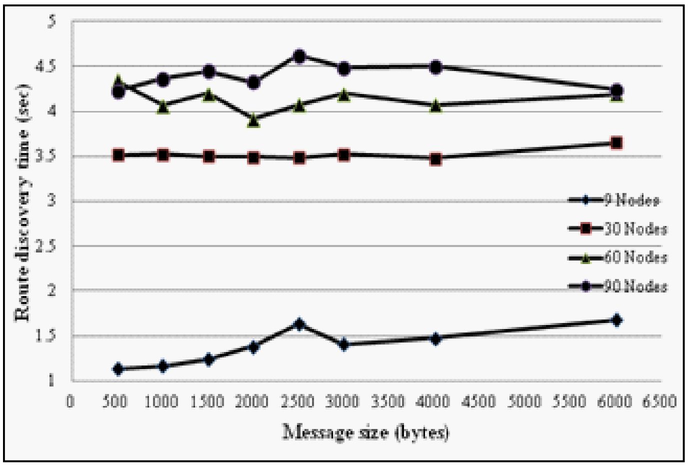

Fig. 3: Average Route Discovery for Scenarios With Different Number of Fixed Nodes by Varying Message Size

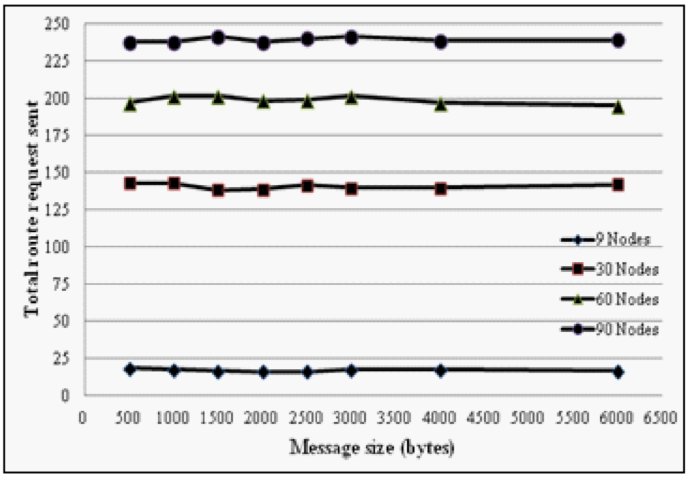

Fig. 4: Total Route Request Sent for Scenarios With Different Number of Fixed Nodes by Varying Message Size

The AODV protocol does not maintain any cache routes. Therefore, when network topology changes due to mobility, the AODV sets-up new routes depending on the route requests which helps the AODV to avoid loss of files and makes the network load small.

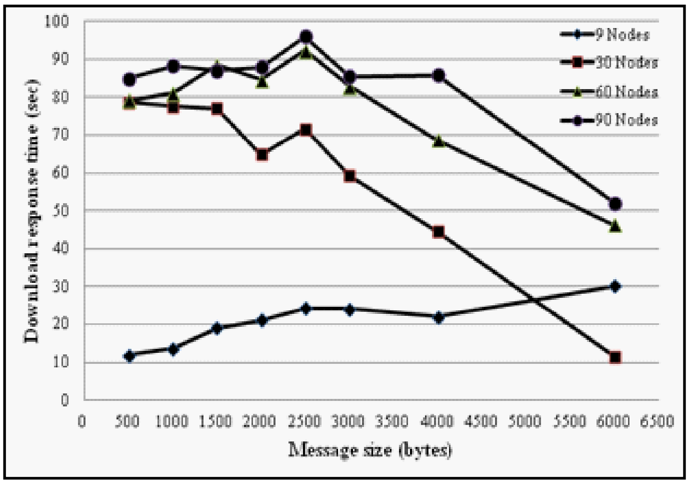

Fig. 5: Download Response Time (sec) for Scenarios With Different Number of Nodes by Varying Message Size

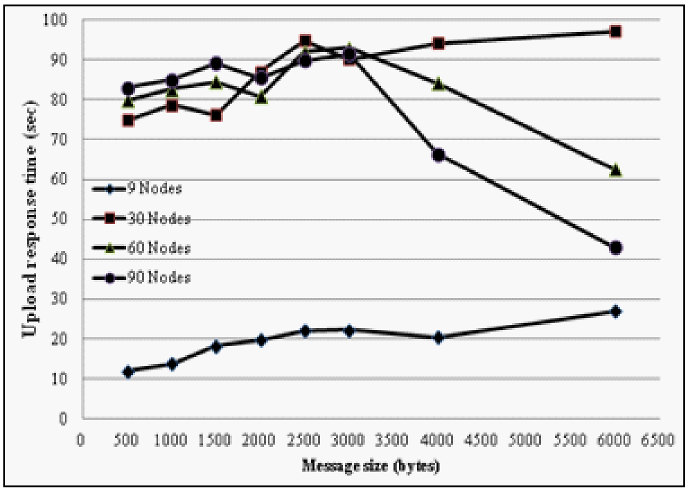

Fig. 6: Upload Response Time (sec) for Scenarios With Different Number of Fixed Nodes by Varying Message Size

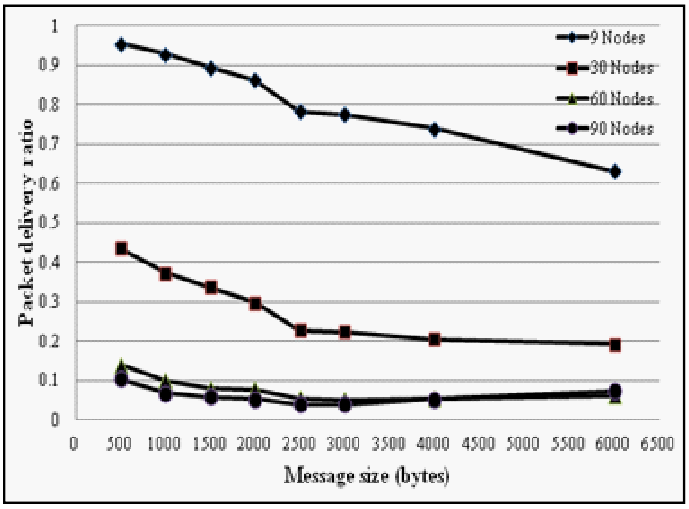

Fig. 7: Packet Delivery Ratio for Scenarios With Different Number of Fixed Nodes by Varying Message Size

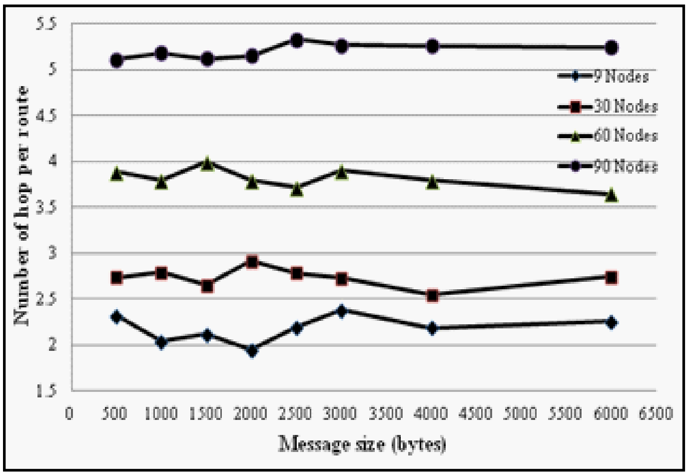

Fig. 8: Number of Hops Per Route for Scenarios With Different Number of Mobile Nodes by Varying Message Size

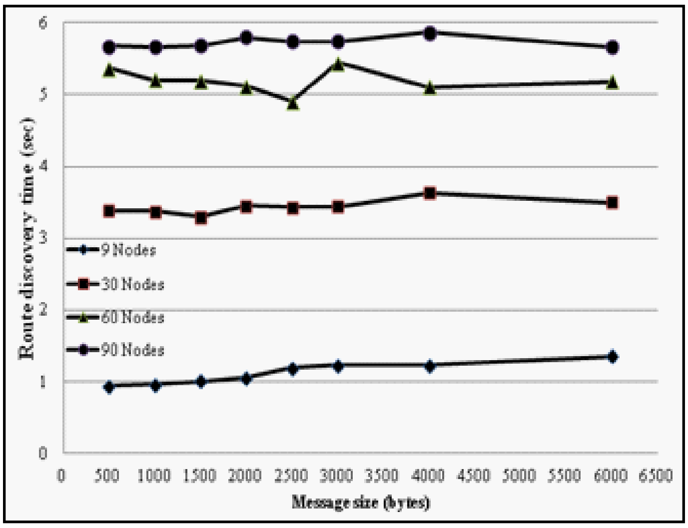

Fig. 9: Route Discovery Time for Scenarios With Different Number of Mobile Nodes by Varying Message Size

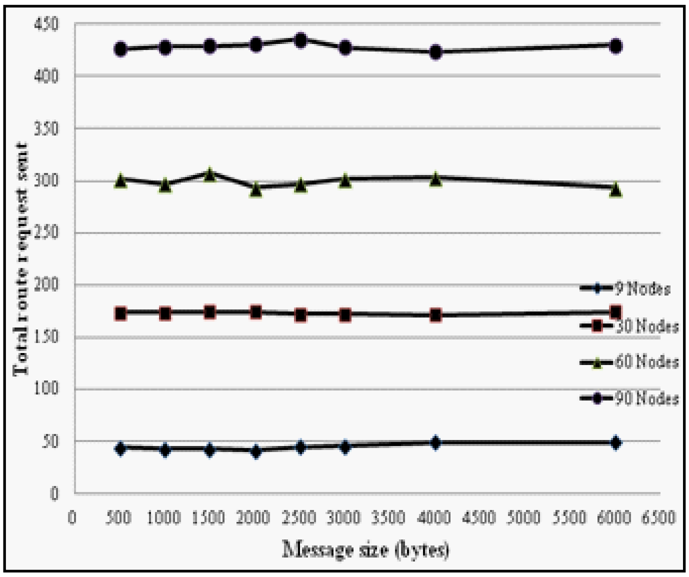

Fig. 10: Total Route Request Sent for Scenarios With Different Number of Mobile Nodes by Varying Message Size

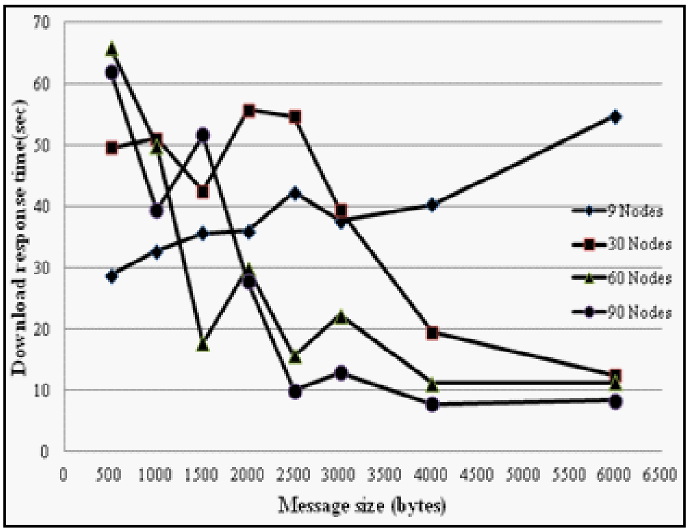

Fig. 11: Download Response Time (sec) for Scenarios With Different Number of Mobile Nodes by Varying Message Size

In order to collect the real life simulation result, only nine nodes are applied due to the small resources and participants for analyzing the other amount of nodes. The pure flooding mechanism is used for transmitting the messages.

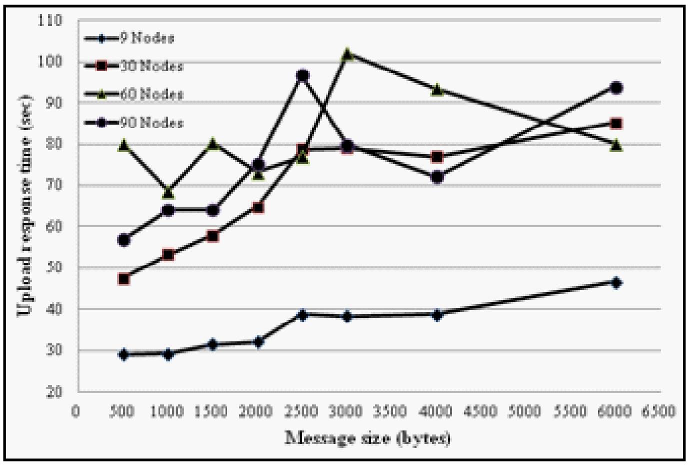

Fig. 12: Upload Response Time (sec) for Scenarios With Different Number of Mobile Nodes by Varying Message Size

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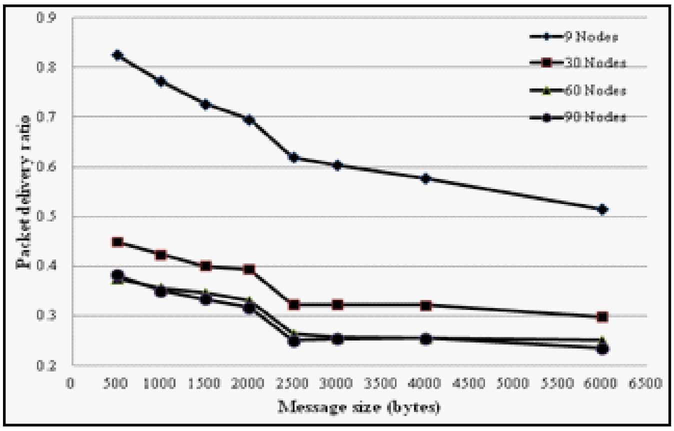

Fig. 13: Packet Delivery Ratiosfor Scenarios With Different Number of Mobile Nodes by Varying Message Size

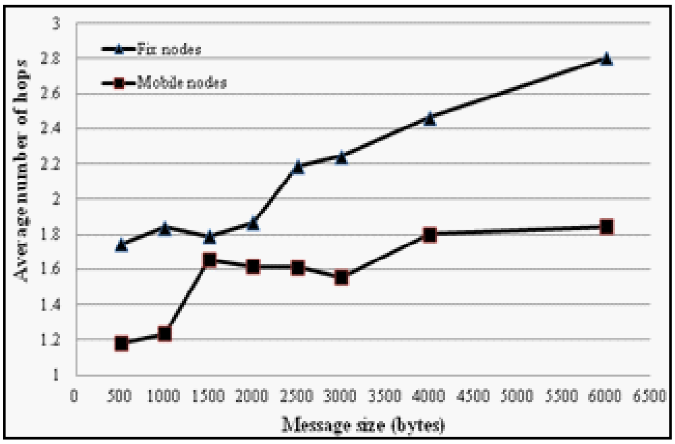

Fig. 14: Average Number of Hops for Fixed and Mobile Nodes

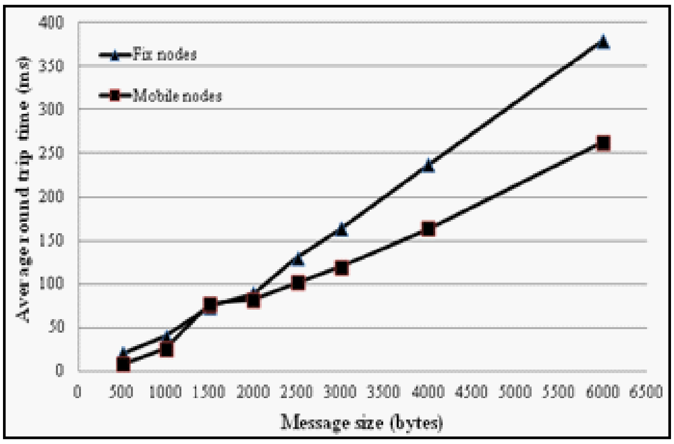

Fig. 15: Average RTT (ms) for Fixed and Mobile Nodes

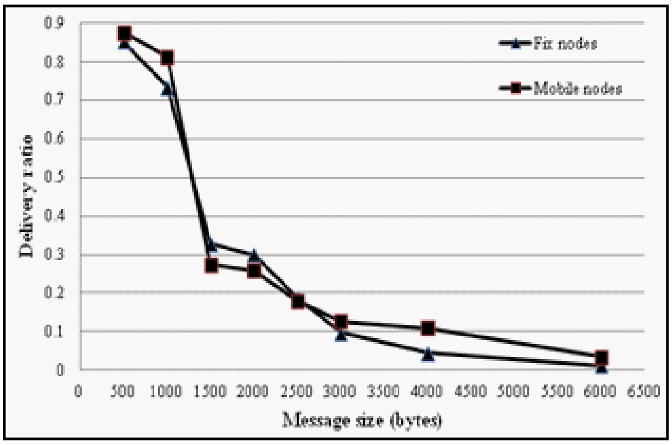

Fig. 16: Delivery Ratio for Fixed and Mobile Nodes

The Figs. 14-16 show the experiment result of different network metrics for various message sizes with different amount of fixed and mobile nodes. For both fixed and mobile node the network parameters average number of hopes and average round trip time show increasing trend with increment of the message size. However, the delivery ratio graph shows decreasing trend with the increment of message size as depicted in fig. 16.

VI. Conclusion

In this paper, performance analysis of several scenarios of Ad-hoc On-demand Distance Vector (AODV) routing protocol using the OPNET simulator is done to investigate the behavior of 802.11b with low load traffic size in FTP protocol.

A various number of simulation scenarios are performed by using OPNET 17.1 simulator to determine and evaluate the performance of fixed and mobile ad hoc networks. The random waypoint mobility model is used as pattern of mobility. The performance metrics number of hops per route, route discovery time, total route request sent, download response time, upload response time and delivery ratio are studied for various number of nodes and file sizes.

According to simulation results, the scenario with nine nodes for both fixed and mobile perform better in most of the performance metrices. Notably, the performance automatically degrades with the increment in number of nodes. This primarily is due to the requirement of more time to do the transmission or to find the destination of the network between the large numbers of node in the network. The variation of packet sizes also causes high impact on different network metrics as network congestion increases with the increment of message size.

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