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The Effects of MANET's Parameters on the Scalability of the AODV Routing Protocol

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Abstract: Mobile Ad hoc Network (MANET) can be known as an assortment of wireless mobile devices like (Laptops, wireless phones, Personal Digital Assistants (PDAs), devices, printers, etc.) are combined by wireless link with feature Bluetooth and/or IEEE 802.11 (WiFi). In this study, the scalability issue considers the main problem. This issue is evaluated over different network areas sizes and different node's speeds, circular configurations for the network and one type of traffic FTP. The evaluation was done through the simulation experiments using OPNET 14.5 simulator depending on the throughput, routing overhead and delay.

Key words: MANET, OPNET, AODV, throughput, routing overhead, delay

INTRODUCTION

The wireless arena has experienced phenomenal growth in the last decade. A significant progress in networks infrastructures has been tangible. The increasing availability of wireless applications and the appearance of omnipresent wireless devices such as handheld computers, cell phones and PDA devices are now playing an increasingly important role in our lives.

MANET works without any infrastructure; it usually refers to an autonomous system without any centralized management. The expression "Ad Hoc" means that this type of networks can take different forms and it can stand alone networked or mobile. The deployment of such type of networks can be done easily and quickly. This is the reason behind making it feasible to use in search, military and rescue operations, sensor networks and meeting rooms (Walia, 2013).

There are many challenges facing MANETs, like: scalability, energy, security and routing process. Scalability issue of the network can be defined as the network ability of providing a proper level of service when the network size grows, i.e., the network performance doesn't deteriorate when it becomes large-size (increasing the number of its nodes). This means that it has the same performance regardless the network size issue. This requires minimization to the overhead (Sankar and Sankaranarayanan, 2010; Nyirenda, 2009).

This study focuses on the scalability of the MANET's routing protocols with respect to the increasing in node's speed. These were done through the simulation experiments.

Literature review: Singh and Lobiyal (2010) used GloMoSim simulator in order to conducted simulations to evaluate the scalability for AODV, DSR and LAR protocols by using prediction based link availability model. Also, they proved if this model added up to the routing protocol's scalability. The result showed that the routing protocols performance were scalable with this model from 100-1000 nodes using (number of route failures, throughput, delay, delivery ratio) as a performance metrics (Singh and Lobiyal, 2010).

Singh and Singh (2012) studied scalability issues in OLSR routing protocol with different number of nodes. They referred that in OLSR routing protocol, the overhead generated didn't increase with the number of nodes. The multipoint relay reduced the retrans missionin the same area. They used NS2 simulator to apply the simulation experiment. They found after selecting 50 nodes with varied number of connection with 10 m/sec that OLSR routing protocol didn't scalewell because the number of connection independent on the number of node (Singh and Singh, 2012).

Hong *et al.* (2002) analyzed the scalable routing protocols in MANET with respect to the mobility, traffic and network size. He calculated the total routing overhead and the relation between it and scalability of routing protocol (Hong *et al*., 2002). This research gave asimulation study for scalability in MANET with respect to the performance metrics.

MANET routing protocols types: MANET's routing protocols have been classified depending on the strategies of discovering the routes and maintaining it into five types as shown in Fig. 1: proactive, reactive, hybrid, hierarchical and geographical. Naturally, each

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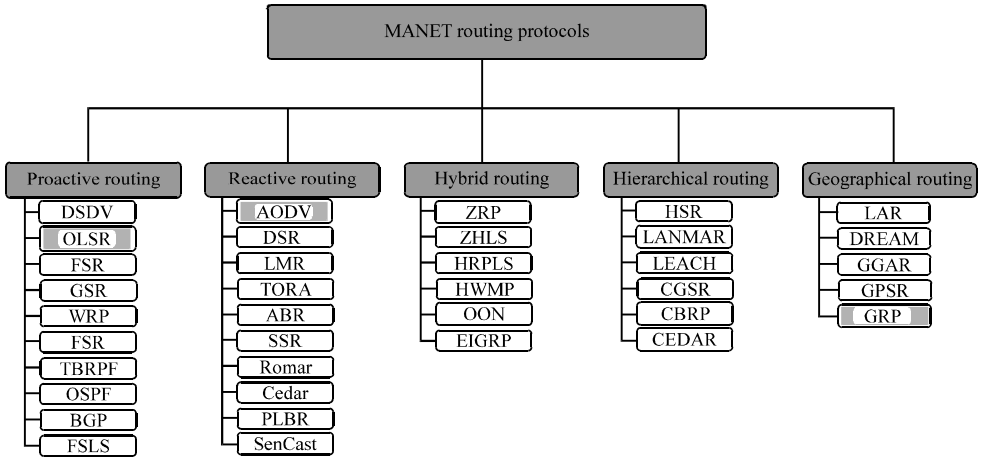

Fig. 1: MANET routing protocols

routing protocol react differently too many parameters. A routing protocol was usually assessed in terms of the performan cemetrics that we refer to later. This study outlines the key features of each type. As well as, a brief summary about the routing protocols those have been used in the simulation experiments (Haboub and Ouzzif, 2013).

MATERIALS AND METHODS

OPNET modeler: OPNET uses project and scenario process to model the network where the project includes at least one scenario and each scenario represents a different aspects of the network style. OPNET modeler has the ability to save the resultsinto many file formats like the excel sheets, HTML files and tables. It has also animation viewer and debugger tools used to examine the results step by step and detect any errors that may happenas shown in Fig. 2 (Yamsani, 2010).

AODV: One of the reactive routing protocols is the AODV ("Ad hoc On-demand Distance Vector"). It uses a control message to find the route between the sender and destination nodes in the network when it need only. As shown in Fig. 3 when the node (A) needs to send data to the node (F), for example, it sends (RREQ) Route Request message to all itsattainable neighbors. Then, all those nodes, if there is no one of them is interested node (destination), forward this message (i.e., RREQ) to their neighbors until the source node or the intermediate node that has a route to the destination node is found, the another message called Route Replay message (RREP) will be sent to the source node 'A'. Finally, the route between 'A' and 'F' will be generated

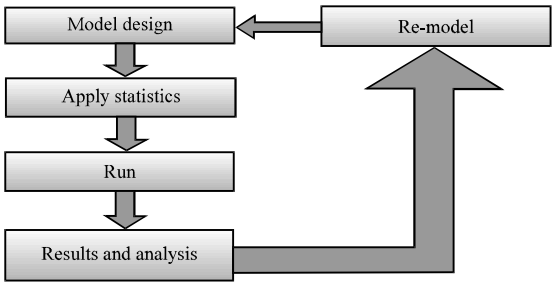

Fig. 2: OPNET modeler editors (Yamsani, 2010)

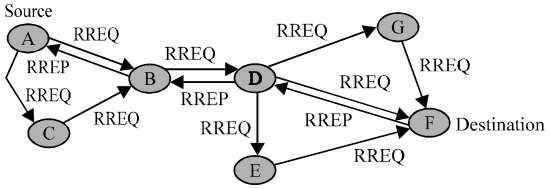

Fig. 3: Message routing in AODV

and they communicate with each other. This approach is important in decreasing the overhead (Nehra and Singh, 2013).

The performance metrics: There are numerous performance metrics were used in evaluating the behavior of the routing protocols. In this research, we evaluated the network throughput, routing overhead (routing traffic sent) and delay according to the node's speed increasing (Tahir, 2010). Each of this metrics will be discussed in the following.

Throughput: Throughput is a "ratio between the total amounts of the received data to the time taken in order to receive the receiver node the last packet". In MANET there are many parameters that influence this

metric, like limited bandwidth, unreliable communication, MANET's dynamic topology, etc. MANETs need to have high throughput. Throughput can berepresented by the following mathematical (Eq. 1) (Tahir, 2010):

$$\text{Throughput (packet/sec)} = \frac{\text{Number of delivered packets}}{\text{Total simulation time}} \quad (1)$$

Routing overhead: The behavior of MANET routing protocols was found to be different. Because the routing traffic increases with the network size increasing, routing overhead is an important metric to measure the scalability. It was defined as "the total number of routing packets transmitted over the network, expressed in bits per second or packets per second". The sources of routing overhead in a network may be "the number of neighbors to the node and the number of hops from the source to the destination". Other reasons of routing overhead are network route error packets and congestion there are many causes to fail the direct connection between the source and destination from this: radio power limitation, channel utilization and increasing the network size. When the network size increases, the communication between the source and the target depends on the intermediate nodes. Most of the MANET routing protocols depends on its neighbors in order to route the traffic. This cause more traffic in the network due to the increasing the broadcasting traffic. For these reasons, the routing overhead is good metric for measure the routing protocols effectiveness (Maheswara and Naik, 2013). In this study, the routing overhead is considered as (Routing traffic send statistic) using OPNET 14.5 Modeler as by Kaur and Singh (2012).

End to end delay: Thepacket needs time to pass through thenetwork; this time was called end to end delay. It is the time of transfer thepacket from the source node to the destination node's application layer. There are many delay levels according to the sensitive application for example: "the voice application requires low average of delay". There aremany parameters may increase the delay in the network. Thus, thecalculation of the delay depends on" how the routing protocol accepts thevarious constrains of network and shows the reliability". The followingequation can be used to represent the end to end delay:

$$D_{end\text{-}end}(sec) = N\ (D_{Trans} + D_{Prop} + D_{Proc}\ I) \quad (2)$$

Where:

D_{trans} = The transmission delay
D_{prop} = The propagation delay
D_{proc} = The process delay
N = A scalar number

Table 1: Simulation environment

Title	Details
Simulation tool	OPNET 14.5
Network area	500×500, 1000×1000, 1500×1500, 2000×2000 m^2
Number of nodes	100 nodes
Nodes distribution	Ring
Speed of nodes	2, 5, 10, 15 m/sec
Pause time	5 sec
Standard	IEEE 802.11 g
Data rate	11 Mbps
Transmission power	0.005 W
Simulation time	100 sec
Routing protocols	AODV
Buffer size	1024000 bit
Mobility	Default random waypoint
Traffic type	FTP-medium load
Target buffer	0.02

From Eq. 2, it is learnt that the end to end delay is a combination of N time of transmission, propagation and process delay (Tahir, 2010).

Simulation environment: In this study, there are 16 scenarios were built. Table 1 shows the simulation environment used in building this study simulation scenarios.

Case study (The effects of increasing node's speed over differentareas sizes): In this case, the effects of increasing the network node's speed on thenetwork behavior were studied under Ftp traffic. The different speeds in this study were suggested to be 2, 5, 10 and 15 m/sec. The different networkareas dimensions were also suggested to be 500×500, 1000×1000, 1500×1500 and 2000×2000 m^2. Due to the study aim, we selected certain required network performance metrics in this study (i.e., routing overhead, delay and throughput).

RESULTS AND DISCUSSION

Figure 4 shows the performance metrics of AODV in different node's speeds in OPNET viewer. We can find that the high overhead are achieved when the speeds are 5, 10, 15, 5 m/sec, respectively but the high delay was achieved when the speeds, 5, 10, 15, 10 m/sec, respectively with the area sizes, 500×500, 1000×1000, 1500×1500 and 2000×2000 m^2 and the throughput are moderate in all the taken area. The high speed for the nodes effects in the network scalability due to the high overhead with this routing protocol. The best scalable speed is 2 m/sec because the routing overhead reduces with respect to increasing the network size as shown in Fig. 5.

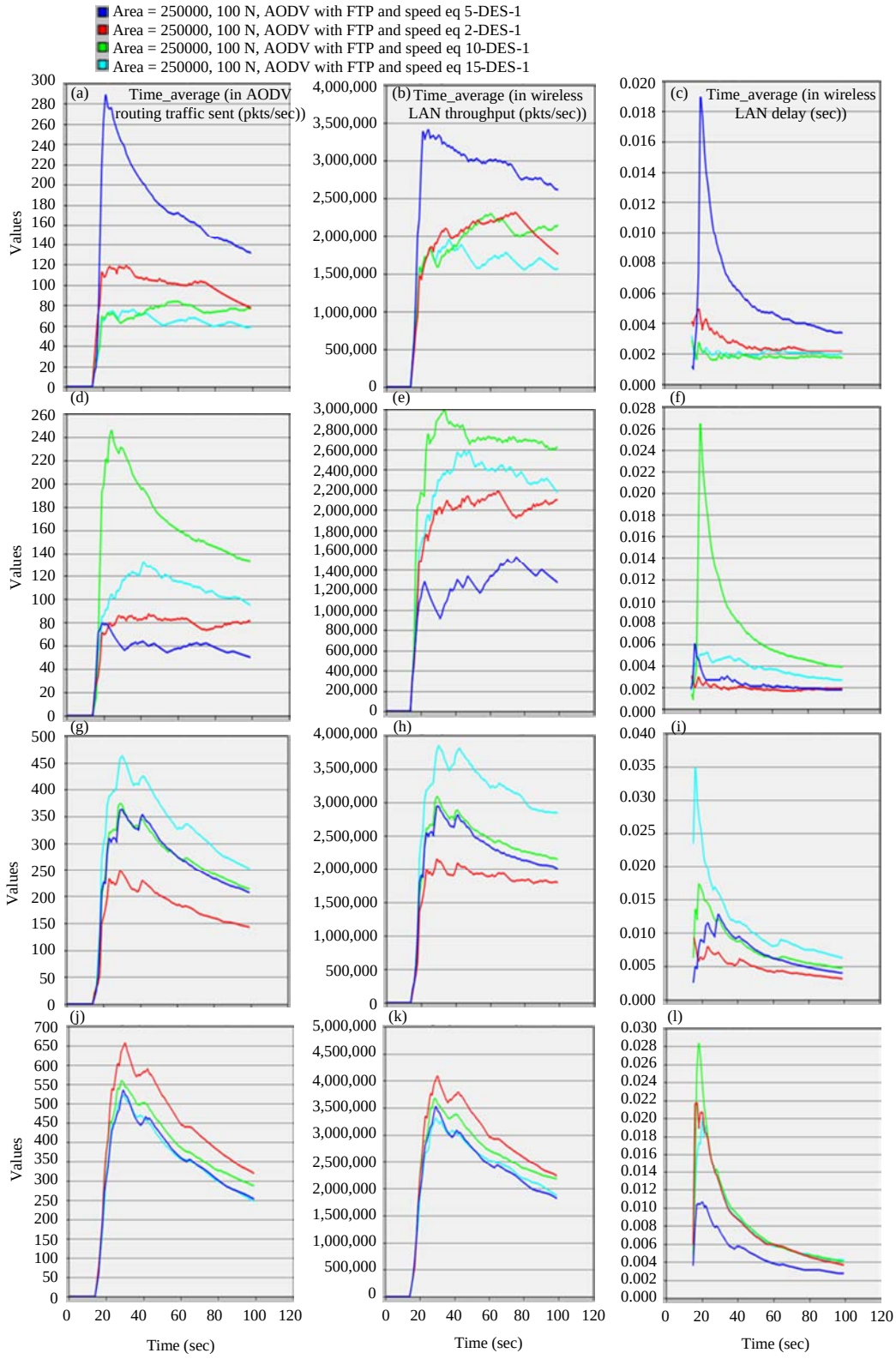

Fig. 4: Results of simulation using OPNET editor: a-c) Area is 500×500 m^2; d-f) Area is 1000×1000 m^2; g-i) Area is 1500×1500 m^2 and j-l) Area is 2000×2000 m^2

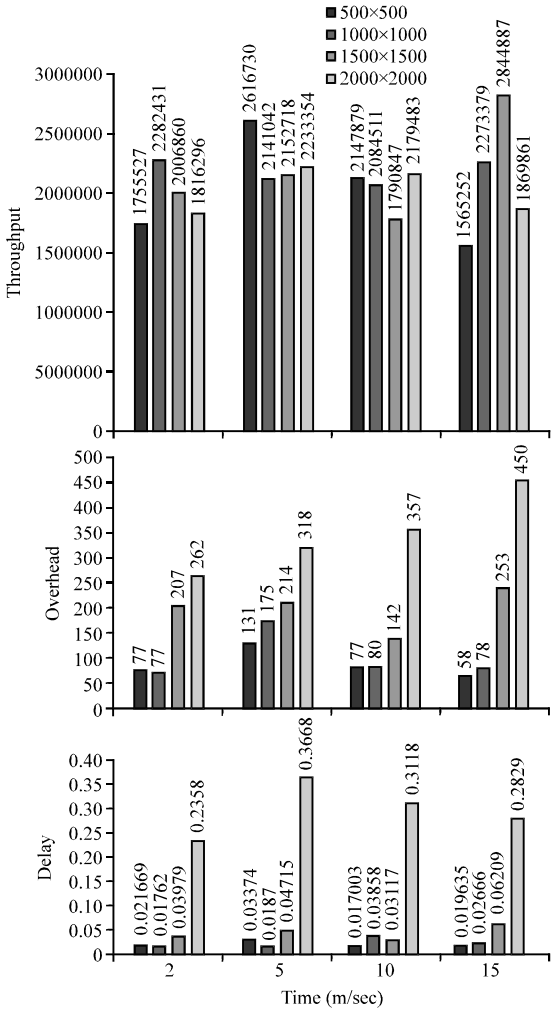

Fig. 5: Comparison among the four scenarios in each network area size

CONCLUSION

Through the implementation of our simulation experiments and after the performance study for AODV routing protocol, we have reached new conclusions and ideas if it is applicable, we can measure the scalability issue with respect to increasing the node's speed. In AODV, the high speed for the nodes effects in the network scalability due to the high overhead with this routing protocol. In order to achieve high scalability, it must use a low or modest node's speed.

SUGGESTIONS

While this study shows the effects of increasing nodes speed in the AODV scalability, there are many ideas for extending the scope of this study. It can use different network sizes (number of nodes) in order to estimate the scalability of AODV with specific network area size. We can use different distribution for the nodes in the network like grid or random, then compare the performance metrics results with the circular distribution that taken in this paper. Also, it can study the effects of changes the pause time in AODV performance.

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