Performance Evaluation of DSDV, DSR, AODV and TORA MANET Routing Protocols for Body Monitoring in Free Space Environments

Majda Omer Elbasheer Ali
College of Computer Science and Information Technology
Sudan University of Science and Technology
Khartoum, Sudan
E-mail: majda.omer@gmail.com

Jaime Lloret
Universidad Politécnica de Valencia,
Camino Vera s/n, 46022
Valencia, Spain
E-mail: jlloret@dcom.upv.es

***Abstract*— A Mobile Ad hoc Network (MANET) is a constantly self-configuring and no-centralized stationary infrastructure network, in MANET, the mobile nodes connected via wireless channels. Routing protocols considered as important elements to forward data in such a dynamic network topology. They are needed when it is required to gather information from people like in health monitoring. This paper firstly introduces a concise overview about the MANET. Then, it shows the study of four routing protocols in terms of their capability scaling with the network growth and intensity of nodes, in addition to examine how they behave in two mobility models (regular cases of patients monitoring). It presents dissections and assessment of each protocol performance.**

***Keywords*— MANET; DSDV; DSR; AODV; TORA; Random mobility model; Grid mobility model.**

I. INTRODUCTION

Nowadays, there has been a continuous evolution in the technology of mobile devices, such as smart mobile phones, Personal Digital Assistants (PDAs), mobile sensors, and vehicles. This technology comes with a huge advantage, such as flexibility of using the mobile device anytime and anywhere despite of time and location constraints. On the other hand, the mobility feature of these devises lead to limitations in their resources in terms of memories, hard drives and the volume of batteries [1]. Although of these limitations, there are new applications came up rapidly to take benefit of mobile devices. This technology is mainly being used in personal and business, for example games, maps navigation, entertainment, banking/finance, and shopping. The considerable revolution of these mobile devices is the capability of connecting to networks, nevertheless, because of their limitations they require and efficient routing protocols. These mobile devices or nodes connect with each other's by a mobile ad-hoc network (MANET), which is a network of wireless stations without centralized or fixed infrastructure. These networks encounter periodically changes in its topologies. Each node in this network performs as peer router with other, all nodes represents routing stations and they collaborate to transfers data. Because of the absence of the base station and dynamic changing of topology, the process of forwarding data among these nodes depends on the efficient performance of routing protocols [2][3].

MANET routing protocols can classified as reactive, proactive or hybrid protocols. The reactive protocol does not preserve any routing information or state of the network until it get request of transmission, at that moment, lookup for a route and establish connection, for the reason that it called on-demand protocol. On the other hand, the proactive calculate and maintain all routes previously, and make periodic update of its routing tables. Finally, the hybrid protocols came to take advantages of the proactive and reactive algorithms, initially it set up routing proactively, and when there are newly joining nodes it deal with them through reactive flooding [4].

MANET routing protocols used with several applications, such as house monitoring (smart home), habitat monitoring, which it help ecologists to gather environmental data that affecting people, animals, and plants, in addition to healthcare applications, that provide healthcare anywhere and in any time. This work concentrates to study MANET routing protocols, for facilitating people monitoring, which is an important factor in healthcare applications. Ad hoc network routing protocols are required to send data to patients and receive information from them. People mobiles in different patterns and the density of them changed from location to another, for example, in healthcare monitoring, the number of monitored people increased in and near to the hospital and health centers, as a result, it is important to know the behavior of each MANET routing protocol to built the proper healthcare systems.

This paper performs a performance evaluation of the following four mobile ad hoc network protocols, destination-Sequenced Distance-Vector Routing Protocol (DSDV), Dynamic Source Routing (DSR), Ad-hoc On-demand Distance Vector routing (AODV) and Temporally Ordered Routing Algorithm (TORA), for body monitoring in free space. The approach of assessment includes two scenarios; the first one is used to examine the behavior of each protocol according to the density and scaling in numbers of nodes, the second one is used to study how these routing protocols will react in two different mobility models.

Rest of this paper organized as follows. Section 2 gives a brief description about MANET routing protocols under study. Related work is addressed in Section 3. Section 4 shows the scenarios and simulations environment. While Section 5 presents the results and discussions of them. Finally, Section 6 concludes this paper and gives a glance about future work.

II. MANET ROUTING PROTOCOLS UNDER STUDY

A. *Destination-Sequenced Distance-Vector Routing Protocol (DSDV)*

One of Ad-hoc proactive protocols, it is a table-driven routing scheme; all node of the network maintains a routing table contains of all destinations and the number of hops that a packet would need to reach to the destination. The DSDV solves the routing loop problem (loop paths), by providing a sequence number for each entry in routing table. This algorithm send a periodic updates of entire routing table, between these periods it send smaller routing updates between nodes frequently [3][5].

B. Dynamic Source Routing (DSR)

DSR one of reactive routing protocols. In this protocol, the source node overflows the entire network with a route discovery request, it identify each route request with the packet source and destination of this route. The target node (destination) respond to the route request, by scans its own cache for a route before sending route reply to the initiator of route request. If there no route found, the destination execute its own route discovery mechanism in order to reach to the source [6].

C. Ad hoc On Demand Distance Vector (AODV)

One of Ad-hoc On-demand a routing protocol, it builds routes between nodes only when it required by source nodes, and does not allow the nodes that not founded in the active path to preserve information about this route. AODV develop trees to connect multicast group members. Moreover, it uses the sequence numbers to guarantee the free route loop problem. AODV builds routes using a route request and route reply query cycle, when a source node desires a route to a destination; it distribute a route request (RREQ) packet across the network. Nodes receiving this packet update their information for the source node and set up backwards pointers to the source node in the route tables [3] [5].

D. Temporally Ordered Routing Algorithm (TORA)

TORA is hybrid routing protocol; the paths establish with proactive routes initially, and then servers request additional routes through reactive flooding. This protocol has high energy consumption in contrast with other protocols of its type [3]. The main objective of TORA is to limit control message propagation in the highly dynamic mobile computing environment. Each node explicitly initiates a query when it needs to send data to a particular destination [7].

III. RELATED WORKS

R. Lacuesta et al. presented a comprehensive investigation in ad hoc networks routing protocols [3]. Their chapter deliberates the protocols in term of secure and non-secure routing protocols, addition to analyze protocols performance with different metrics. They use OPNET (Optimized Network Engineering Tool) simulator to emulate the DSR, OLSR (Optimized Link State Routing Protocol), and AODV protocols, the simulated topologies contain 50, 100, and 250 nodes, moreover, there are two scenarios, one with movable nodes with failures and the other consists of fixed node. Their results present the OLSR and AODV as superior in performance than DSR; however, OLSR is worst protocol in the performance of data link layer.

A comparative analysis of four MANET routing protocol in different mobility models of ad hoc network was introduced by N. S. Samshette and others [8]. They simulated three mobility models, Random Walk, Random waypoint, Random direction. The routing protocols under test are DSR, DSDV, AODV, and AOMDV (Ad-hoc On-Demand Multipath Distance Vector routing). Their results had shown that the AODV as best throughput in Random Walk mobility model, and DSR smallest throughput for all mobility models. However, they use only TCP traffic and 25 nodes.

Rahman et al intend to evaluate the performance of three routing protocols by using The Network Simulator (NS2) [5]. Their study includes AODV, DSDV, and Improvement of DSDV (I-DSDV) protocols. The number of simulated nodes set in 5, 10, 15, 20, 25, 30, and 35 nodes. Their results demonstrate that the AODV has better performance than other, while I-DSDV reduces the number of dropped data packets compared DSDV, however it produces more computation overhead.

In 2008, J. Lloret et al. try to take advantage by designing a group-based ad-hoc network in order to gain flexibly and efficiently. In addition, splitting the network in groups, it also improves the fault tolerance and gains more other benefits. They studied the DSR, OLSR, and AODV MANET routing protocols behavior when these protocols work in groups, compared to an individually-based network [9]. In this case, OPNET simulator was used to create the suggested topologies. The results show that grouping nodes in ad-hoc network lead to achieving better performance, in addition to decrease the extra and overhead traffic of network. OLSR appeared as the best protocol in group-based topologies [9]. In the same year, Garcia and others studied the three MANET protocols mentioned above. In this case, they examined the performance of protocols in Wireless Sensor and Actor Networks (WSAN). The experiment proves the possibility of implementing these protocols in WSAN. OLSR appeared as most suitable protocol for WSAN than AODV and DSR, however OLSR was the worst in terms of consumed throughput rate.

N. Meghanathan investigated the performance of stability-oriented MANET routing protocols [11]. His study included the Associativity-Based Routing (ABR) protocol, Flow-Oriented Routing (FORP) Protocol and Route Assessment Based Routing (RABR) protocol. This findings show that FORP has the best routes stability than others, however, this demand higher end-to-end delay and higher energy consumption per packet.

Moreover, M. Tarique et al suggested studying the MANETs network according to other performance metrics rather than network throughput [12]. They examined packet delay, overhead control packets, energy consumption, connectivity, and shadowing effects. Their study was performed under short-hop and long-hop routing by using DSR routing protocol, because, it is important for routing protocol is to decide whether a mobile node should use many short-hops or a few long-hops. The results show that the long-hop routing is better in term of reducing the delay per packet and packet loss, while short-hop routing is better in keeping network life as long as possible.

In field of people monitoring, M. Garcia and others propose soccer team players' remote monitoring system through using wireless sensor network [13]. Their procedure intended to use the Wireless Body Area Networks (WBANs) to know the physical state of players during matches. They studied the network topology and mobility models of the soccer players. ZigBee Routing Protocol (ZRP) was used for the communication between nodes. The routing protocol was AODV. The results clarify that the additional routing hops is required in case of high mobility to achieve lower network load, however, the management traffic is low in their proposal. The same authors proposed a wireless body sensors network for soccer team in [14], which it is a continuous work of the previous study. The routing of information can be done via the nodes of the same team or through the nodes of the other team; therefore, they added a security system to let the information be decrypted only by players and coach of the same team. In addition, they narrow radio coverage area to be no longer than four meter to avoid eavesdropping from any place of the stands. Furthermore, they improved the mobility model and increased the number of simulations. Additionally, they proposed an energy harvesting system to provide enough energy for that very low transmission range. Simulations results show that the management traffic is low, which in all cases of high and low mobility is below than 250 Kbps.

IV. SCENARIOS AND SIMULATIONS

Studying routing protocols and identify their behavior, is important to forward data, and to gather information from people in health monitoring. This part gives brief descriptions about the methods followed to compare the four mentioned MANET protocols. The approach includes two fundamental scenarios. The first one is used to study the behavior of each protocol according to the density and scaling in numbers of nodes in three different cases. The initial case contains 50 nodes, which it has six nodes send traffic by TCP and UDP transport layer protocols. While case two created by hundred nodes, besides, to raising the packet size and number of sending nodes, to send more flow in network. The last topology has two hundred nodes as well as increasing in packet size. All topologies have same set of some nodes moving around in different times, and some others are static for whole time of simulation. In each case study, the four protocols have been tested in the same environment and all the parameter is same except the type of protocols. The second one is used to examine how these routing protocols will react in different mobility models, this study analyses two models, Random Walk and Manhattans Grid Mobility (MGM). In random walk mobility model, nodes moves randomly by any speed or direction [8], such as movement of users in public parks and playgrounds or large hypermarkets. While the grid represents transitions of mobile nodes in streets, every node permitted to move horizontal or vertical. Further, the two topologies of the second scenario are set up with same parameters and size of network. Figures 1 and 2 show these topologies configured in the simulation. The connections inside the figures are just to demonstrate the intersections between nodes, addition to sources and destinations of network flow.

In order to measure the performance of the routing protocols in each scenario, data are collected from the simulation. Then throughput and normalized routing overhead metrics are chosen for the performance assessment. The throughput in communication networks is the average of successful message delivery over a communication channel and it is measured by the number of bits delivered per second or data packets per time unit. While normalized routing overhead (also called normalized routing load) is the total number of routing packet transmitted per data packet, it examines the cost of routing vs. success receiving of application data.

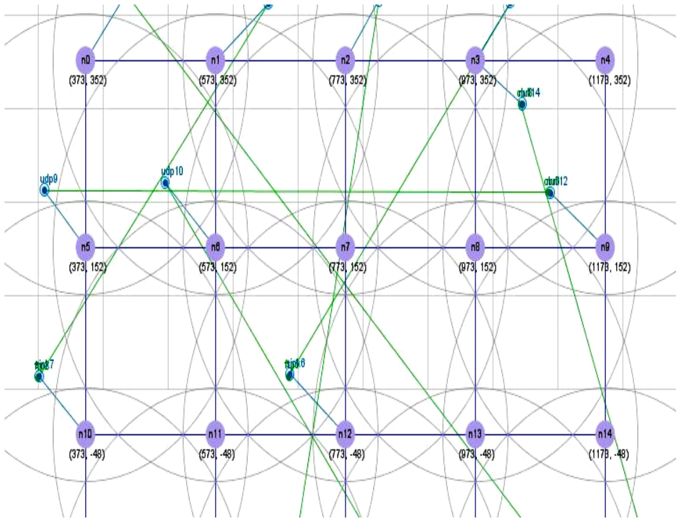

Figure. 1. The Grid Mobility Model

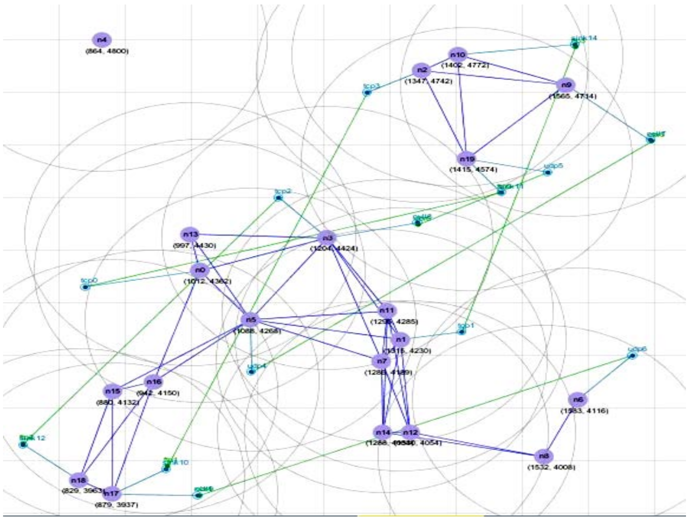

Figure. 2. The Random Mobility Model

A. Simulation environment and flow parameters

The experiments have been performed using NS2 simulator, NS2 is a discrete event open source simulator [15]. It supports different types of wired and wireless network protocols. In addition it has been used in many networking researches. NS2 use TCL scripting language to set and draw the network topology, NS2 scenarios generator 2 (NSG2) is a Java based tool used to create TCL programs of examined scenarios. NSG2 reduces the time of writing TCL scripts by using an easy GUI interface [16].Table 1 shows the parameters applied in the simulation tests. Awk scripting language is used to calculate the throughput and routing load. The graphs of the data gathered have been created using Microsoft Excel.

TABLE I. SIMULATION PRAMATERS

Prompters	Topology _50	Topology _100	Topology _200	Random and Grid
Number of nodes	50	100	200	200
TCP packet size/bytes	1500	3000	4000	2000
UDP packet size/bytes	1000	1500	2000	2000
Application level data	FTP and CBR	FTP and CBR	FTP and CBR	FTP and CBR
Simulation time /s	0-15 s	0-15 s	0-15 s	0-10s
Others	Others parameters such as channel type, MAC protocol, etc are same for all topologies			

V. RESULTS AND DISSECTION

This section explains and discusses the results gathered from simulation in term of throughput and routing overhead for the two scenarios stated above.

A. *First Scenario Dissections*

Figure 30 shows the throughput of the protocols when the number of nodes is 50. In this graph the DSR protocol obtains very good throughput in comparison with other protocols. It has average throughput of 761.0 kbits/s. While DSDV takes a lot of time in control before it began to deliver applications data and get 130.3 kbits/s as average. As observed in Figure 3, AODV has an average throughput of 434.8 kbits/s, which places it between the others. In this case, TORA is the worst one because its throughput is zero; furthermore, during the simulation it is just sending information to discover neighbors. TORA behave as same with scaling number of nodes and the data traffic dropped in the intermediates nodes.

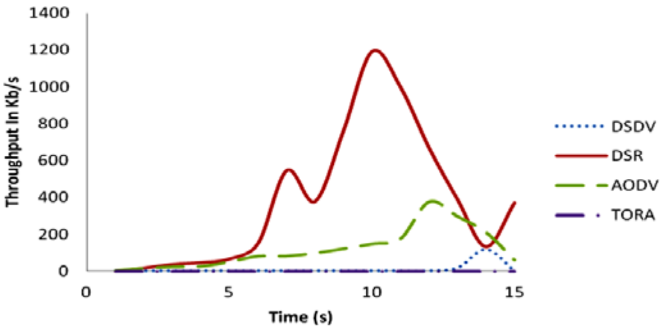

Figure. 3. Throughput in 50th nodes topology.

The throughput given when there are 100 nodes is illustrated in Figure 4. In this situation the flow of application data also increased. As shown in the figure, AODV has a good throughput with the expansion of the network than others protocols. It has 369.8 kbits/s of average throughput. In spite of the growth of the network, DSR is still well behaved which has an average throughput of 351.2 kbits/s. While DSDV witness some reduction in its average throughput and has 99.0 kbits/s. TORA has the worst average throughput.

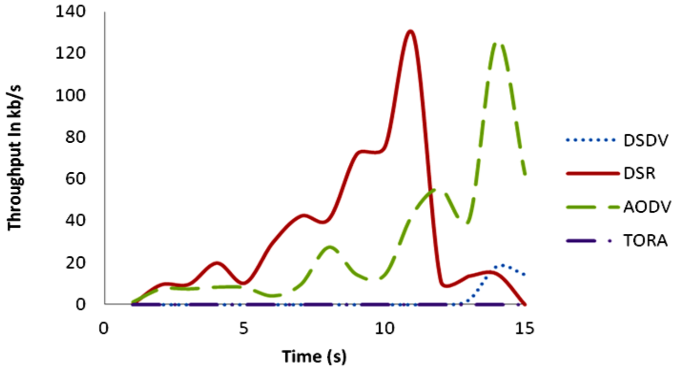

Figure. 4. Throughput in 100-nodes topology.

As noticed in Figure 5, the throughput is degraded for all protocols with the network growth. In this case, TORA situation not changed at all. In contrast, DSDV had some improvements compared with previous results with an average throughput of 118.5 kbits/s, while DSR and AODV has similar result, their throughput is 355.2 and 235.0 kbits/s in average respectively.

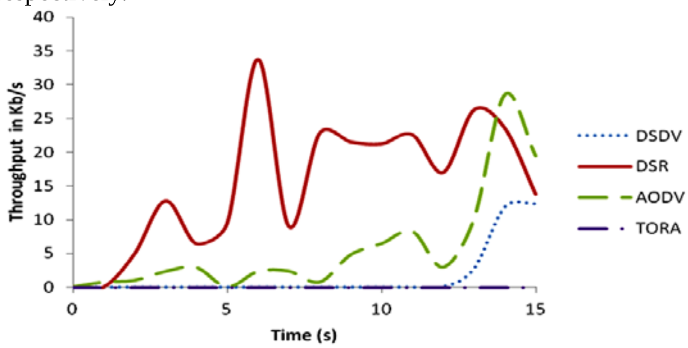

Figure. 5. Throughput in 200-nodes topology.

Figure 6 shows the normalized routing load for the case of 100 nodes. We can observe in this graph that TORA has higher routing load than the others when it starts forwarding routing packets and remains that the highest one until it finishes. Moreover, DSDV achieves high routing overhead in the beginning of the simulation time, after that, it acquires few overhead. DSR and AODV have similar moderate routing overhead.

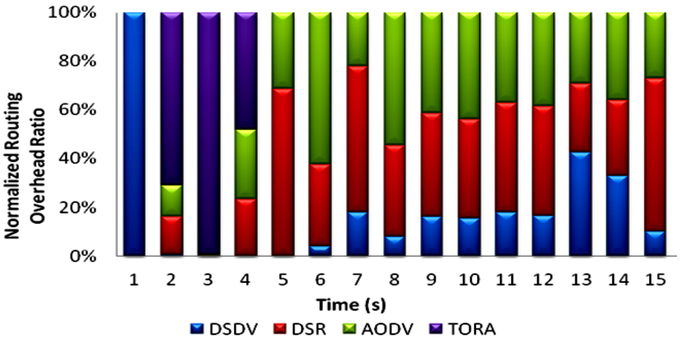

Figure. 6. Normalized Routing Overhead in 100-nodes topology.

B. Random and Grid Mobility model Dissections:

The next graphs explain the throughput according to the two mobility models. Figures 7 and 8, show that DSR protocol performs better than other protocols in both models, and it has an average throughput of 681.0 kbits/s in random model and 615.5 kbits/s in Grid model. AODV's throughput is better in Random (where average throughput is 668.3 kbits/s) than Grid, which has 598.4 kbits/s. DSDV and TORA are the worst protocols, DSDV is bad one with average throughput because the number of nodes is small. As shown earlier, it achieves better performance with the increase of nodes, but this does not guarantee it in case of massive intensity of nodes. TORA protocol gains better throughput in Grid than Random model. However, it very trivial to be represented in the graphs with other protocols, actually it works bad even with small number of nodes. It forwards negotiable bytes in contrast of others. It has from 0.00 to 0.28 kbits/s in Random, and 0 to 32.6 kbits/s in Grid.

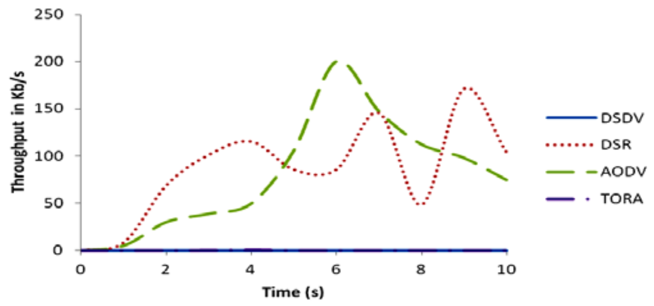

Figure. 7. Random Mobility model.

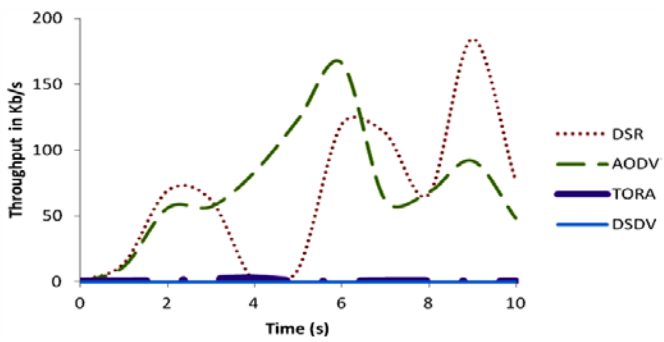

Figure. 8. Grid Mobility model.

Finally, Figure 9 shows the evaluation of normalized routing load for the four routing protocols in the grid topology. Routing overhead in random model is studied in the first scenario. The mobility model is the same although there is different number of nodes. The normalized routing load represented in Figure 9 confirmed what declared before: DSR and AODV have lowest and moderate load, while DSDV has very huge overhead when it starts, after that it preserves small load. Lastly, TORA has the vast normalized routing overhead.

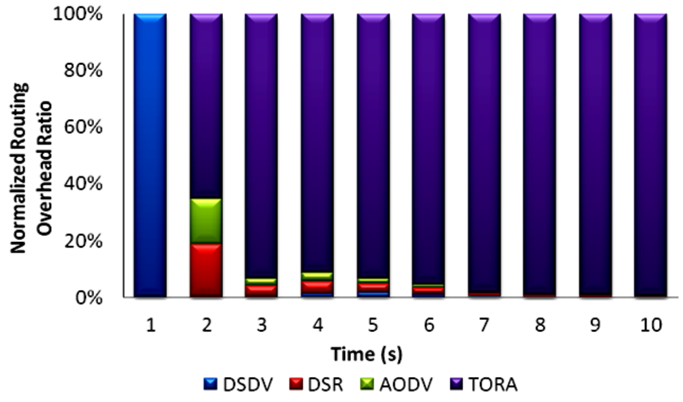

Figure. 9. Normalized Routing load in Grid Mobility model.

VI. CONCLUSIONS

The behavior of MANET routing protocols in different mobility models, and their scalability have been an issue of concern in many applications areas. This increases with the type of application area, such as people monitoring in healthcare systems. This paper studies DSDV, DSR, AODV, and TORA protocols, with different number of nodes and packets size. In addition, their performance in two mobility models is assessed. As summary, DSR obtains better throughput in comparison with others, while AODV achieves higher throughput with the growth and intensity of the network. TORA protocol is the worst one in terms of routing overhead and throughput.

Finally, in our future work, these four MANET routing protocols will be analyzed by moving all nodes around in order to show which one has better performance. Furthermore, we will continue this work, by adding Optimized Link State Routing Protocol (OLSR) [17], as well as we will study other mobility models. .

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