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Energy Consumption Efficiency and Performance Evaluation of DSDV and AODV Routing Protocols

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Abstract— **This research paper studies the Mobile Ad-hoc Networks (MANETs) performance metrics which are mainly: The throughput, the energy consumption and the routing overhead. The reactive Ad-hoc On-Demand AODV routing protocol was compared to the proactive Destination Sequenced Distance Vector DSDV according to the proposed performance metrics. The simulation was performed using the academic simulator for MANETs: GloMoSim under two main scenarios: The first is MANET scalability represented by number of mobile nodes and the second is users mobility represented by the mobile nodes maximum and minimum speeds and their pause time. This research focuses on the critical performance metrics especially the energy consumption in order to measure the energy consumption efficiency of reactive versus proactive routing protocols in MANET under different MANET size and users mobility conditions.**

Keywords- ***MANET; AODV; DSDV; throughput; Energy Consumption Efficiency; Routing Overhead; MANET size; Users Mobility; GloMoSim***

I. INTRODUCTION

A Mobile ad hoc Network (MANET) is a special type of wireless network in which a collection of mobile network interfaces may form a temporary network without the aid of any established infrastructure or centralized administration. Ad hoc wireless network has applications in emergency search-and-rescue operations, decision making in the battlefield, data acquisition and operations in hostile terrain. It is featured by dynamic topology (infrastructureless), multihop communication, limited resources (bandwidth, memory, battery) and limited security. These characteristics put special challenges in routing protocol design [1]. The most challenging objective of MANET routing protocol is to maximize energy efficiency, since the mobile nodes in MANET depend on limited energy resources. Several routing protocols for MANETs have been introduced since the late 90’s such as: DSR, AODV, DSDV, TORA, ZRP and others for multicast or for unicast communication or for improvement of protocols performance.

Although many MANET routing protocols have focused on solving the routing mechanism problem and discovering the routes between the specified source and destination nodes, they have rarely considered the impact of the routing process on the MANET nodes energy consumption beside other performance metrics such as: the MANET throughput and the routing overhead. This research paper studies the AODV as a reactive routing protocol and the DSDV as a proactive routing protocol from a performance and energetic point of view.

This research was organized as follows: the second section will present briefly the MANET routing protocols classification. Then, the third section will highlight the difference in the routing mechanism between the AODV and DSDV. The simulation environment and results are discussed and analyzed by the fourth section. Finally, the fifth section concludes the research comparative study and the sixth suggests some related future research work.

II. ROUTING PROTOCOLS CLASSIFICATION

MANET Routing protocols are classified into four main categories. The following block diagram drawn in figure 1 [3] [7] shows these four categories of unicast routing protocols and some of their common examples.

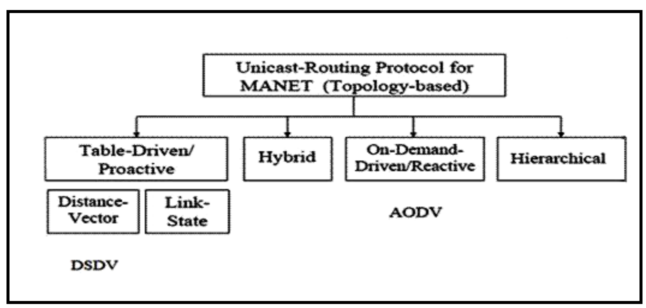

Figure1. Classification of routing protocols in MANET

A. *Proactive Routing Protocols*

Proactive routing protocols are table driven routing techniques based on the periodic exchange of control messages to periodically update the routing tables. Each node maintains a routing table or topology graph representing the whole network and can find easily the best route to the required destination. The major drawback of proactive routing protocols is that they use almost all the available bandwidth to generate the control messages between the nodes. They also cause a routing overhead on all the MANET nodes. There are two types of proactive routing protocols: distance vector and link state. In Distance Vector technique, every router saves in his routing table all the known routers and the distance to it (usually in hops). Periodically the whole routing table must be updated. The DSDV as the most popular distance vector proactive routing protocol is briefly presented. While in Link State technique, every router saves the whole network topology (in the form of a graph). Updates are only needed if there is a new link. There are many examples on the link state proactive routing protocols. One link state proactive routing protocol is the Global State Routing GSR described below in order to underline its routing algorithm base.

B. Reactive Routing Protocols

Reactive routing protocols are on demand driven routing techniques that only find the required path demanded by the source to communicate with the destination. The source node floods the network with a route request packet to find the proper path to reach its destination. Reactive routing protocols in MANET do not support or update routing tables every time the topology changes as the users move. Therefore, they are better in energy consumption than proactive protocols. The major drawback of reactive routing is the significant delay it causes to determine the required path (or the alternative one) between the source and the destination if any link break(s) occurs during the connection. There are many reactive routing protocols in MANET, the most commonly known are the DSR and the AODV.

C. Hybrid Routing Protocols

Hybrid routing protocols have developed a new generation of protocols that combines proactive and reactive routing techniques [8]. These protocols are mainly designed to increase the MANET's scalability by allowing the mobile nodes with close proximity to work together to form some sort of a backbone to reduce the route discovery overheads. This is mostly achieved by proactively maintaining routes to nearby nodes (proactive) and determining routes to far away nodes using a route discovery strategy (reactive). Most hybrid routing protocols are also zone-based or cluster-based. The most commonly used hybrid routing protocols: DST and ZRP. ZRP is a hybrid routing protocol that divides the MANET into a number of overlapping zones. ZRP runs independent protocols [12] within and between these zones: IARP (IntrA zone Routing Protocol) for routing between nodes within the same zone, IERP (IntEr zone Routing Protocol) for routing between nodes from different zones and it uses the BRP (Border-cast Resolution Protocol) to optimize the routing process between perimeter and gateway nodes.

III. ROUTING MECHANISM

The routing mechanism of the proactive routing protocol DSDV and the reactive protocol AODV are discussed by the following sub-sections.

A. Destination Sequenced Distance Vector (DSDV)

The DSDV algorithm is a table-driven routing scheme that was developed as a modification of DBF (Distributed Bellman Ford) for MANETs [2] [5] by C. Perkins and P. Bhagwat in 1994 [9]. DSDV guarantees loop free routes. Each node maintains a routing table for its neighboring nodes that should be periodically updated. DSDV provides a single path between a certain source and a specific destination that is selected using the distance vector shortest path routing algorithm. In order to reduce the amount of overhead transmitted through the network, two types of update packets are used. These are referred to as a ‘‘full dump’’ and ‘‘incremental’’ packets. The full dump packet carries all the available routing information and the incremental packet carries only the information changed since the last full dump. The incremental update messages are sent more frequently than the full dump packets. However, DSDV still introduces large amounts of overhead to the network due to the requirement of the periodic update messages, and the overhead grows as the network density increases. Therefore this protocol will not scale in large networks since a large portion of the network's bandwidth is used in the updating procedures.

B. Ad-hoc On-Demand Distance Vector AODV

The AODV routing protocol is a MANET routing protocol that is capable of both unicast and multicast routing [10]. AODV discovers routes on demand; it builds routes between source and destination nodes only when required by source nodes. It maintains these routes as long as they are needed by the sources for communication. AODV uses sequence numbers to ensure the freshness of routes [11]. It is loop-free, self-starting, and scales to large numbers of mobile nodes [9]. It builds routes using a route request / route reply query cycle. When a source node desires a route to a destination for which it does not already have a route, it broadcasts 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. In addition to the source node's IP address, current sequence number, and broadcast ID, the RREQ also contains the most recent sequence number for the destination of which the source node is aware. A node receiving the RREQ may send a route reply (RREP) if it is either the destination or if it has a route to the destination with corresponding sequence number greater than or equal to that contained in the RREQ. If this is the case, it sends a RREP back to the source. Otherwise, it rebroadcasts the RREQ. Nodes keep track of the RREQ's source IP address and broadcast ID [9]. If they receive a RREQ which they have already processed, they discard the RREQ and do not forward it. As the RREP propagates back to the source, nodes set up forward pointers to the destination. Once the source node receives the RREP, it may begin to forward data packets to the destination. If the source later receives a RREP containing a greater sequence number or contains the same sequence number with a smaller hop count, it may update its routing information for that destination and use the shorter route after the update. The major advantage of AODV is that it is adaptable to highly dynamic networks [7]. However, the nodes in AODV may experience large delays during route construction, and link failure may initiate another route discovery, which introduces extra delays. But, it consumes more bandwidth as the size of the network increases.

IV. Protocols Simulation and Analysis

The free academic Global Mobile Networks Simulator GloMoSim [6] was used to simulate the reactive on-demand AODV and the proactive distance vector DSDV routing protocols in order to evaluate their performance according to some MANET performance metrics as discussed by the following sub-sections.

A. Performance Evaluation Parameters

The performance of the reactive AODV and the proactive DSDV routing protocols will be evaluated using some MANET performance parameters:

- ***The Throughput*** (in bits/second or bps)***:*** It measures the number of bits passing through the network in a unit of time. This performance metric reflects the number of bytes that have been successfully delivered to the destination nodes.
- ***The Routing Overhead*** (in number of packets): This performance metric was calculated for the reactive on-demand routing AODV as the number of control packets used for path discovery, while for the proactive table-driven routing DSDV, it was calculated as the number of packets used for table updates since the users are mobile.
- ***Energy Consumption*** (in milli-watts): The average of energy consumed by the mobile nodes while routing and communication under the studied scenario described below.

These performance metrics are deduced and compared over two simulations scenarios: The first scenario concerns the protocol's ***scalability*** by increasing the number of nodes involved. The second simulation scenario concerns the protocol's ***mobility impact*** on MANET's performance including: The effect of the variation of the mobile nodes pause time, minimum speed and maximum speed.

The following table, Table 1, presents the simulation environment configuration parameters and their values used constantly for the network size and mobility scenarios.

TABLE 1. THE SIMULATION ENVIRONMENT GENERAL CONFIGURATION PARAMETERS AND VALUES

Configuration Parameters	**Value**
Simulation time	30 Minutes
Seed	1
Terrain-Range (X,Y)	1000*1000
Node Placement	Random
Mobility Model	Random-waypoint
Propagation Function	Free-space
Radio Type	Radio-capture
Power Range	250 meters
Data Rate	2 Mbps
MAC Protocol	802.11

B. Network Size and Scalability Scenario

In this scenario, as the number of mobile nodes increases from 10 nodes to 50 nodes, the AODV versus DSDV performance parameters or metrics are studied and analyzed. Table 2 indicates the specific scenario mobility parameters constant while the number of nodes varies.

TABLE 2. MOBILITY PARAMETERS VALUES FOR SCALABILITY SCENARIO

Configuration Parameters	**Value**
Minimum Speed	0 m/sec
Maximum Speed	10 m/sec
Pause Time	10 sec

1) Throughput

In figure 2, the throughput achieved by the reactive routing protocol AODV, measured in number of bits per second, from 10 to 20 mobile nodes is apparently increasing from 60Kbps to 130Kbps approximately, while the proactive protocol DSDV also increases from below 20Kbps to 70Kbps. In the range from 20 to 30 nodes, both protocols throughput has decayed, but DSDV's throughput has been increasing in the range from 30 to 50 nodes over AODV's throughput. For small size MANETs, DSDV is preferable. For medium size MANETs (e.g. 30 nodes), AODV will provide a satisfying throughput. However, DSDV will maintain a relatively satisfying throughput than AODV larger size MANETs (over 30 nodes).

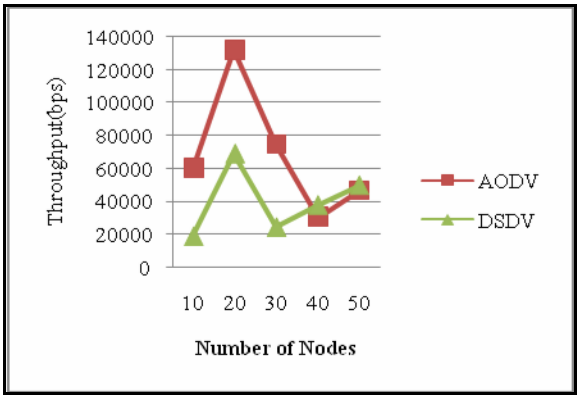

Figure 2. Impact of network size on the throughput

2) Routing Overhead

In figure 3, it is obviously depicted that the reactive routing protocol AODV has maintained a nearly negligible routing overhead in terms of the number of control packets exchanged for route discovery in the experimented range from 10 to 50 mobile nodes since routes are only demanded when a source and a destination need to communicate. On the other hand, the proactive routing protocol DSDV has shown an increasing routing overhead directly proportional to the number of nodes in terms of the number of control packets used mainly to update the routing tables at each node periodically since this process should be achieved even without data exchange.

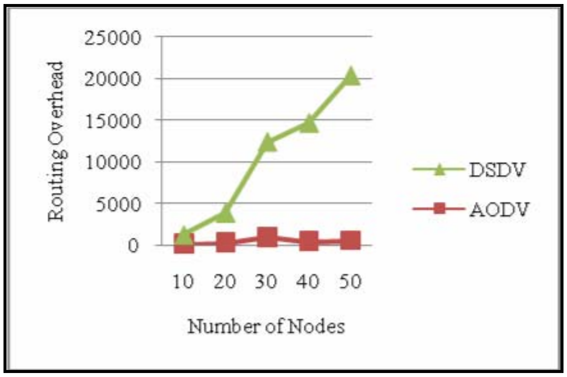

Figure 3. Impact of network size on the routing overhead

3) *Energy Consumption*

In figure 4, the proactive protocol DSDV has maintained approximately constant energy consumption in terms of the average battery power consumed by the mobile nodes as the number of nodes increases from 10 to 50 nodes. On the other hand, the reactive protocol AODV energy consumption was similar to DSDV in the range from 10 to 20 nodes, then it increased from 20 to 30 nodes to reach the highest consumption at 30 nodes, then it decreased from 30 to 40 nodes and finally, it tends to increase once more from 40 to 50 nodes over DSDV. For medium size MANETs, AODV consumed more energy before decreasing for larger MANETs, while DSDV consumed a relatively lower energy for small, medium and larger MANETs.

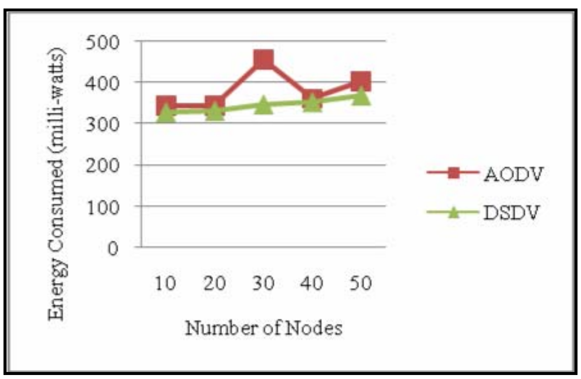

Figure 4: Impact of network size on the energy consumption

C) *Node Mobility Scenario*

In this scenario, the impact of the users mobility model parameters: the maximum mobile node speed, minimum speed and pause time on the performance parameters or metrics is inspected as follows.

1) *Node Maximum Speed (in meters per second)*

Table 3 shows the constant configuration parameters used in simulation as the mobile node's maximum speed varies.

TABLE 3: CONFIGURATION PARAMETERS VALUES FOR MAXIMUM SPEED MOBILITY SCENARIO

Configuration Parameters	Value
Number of nodes	40 nodes
Minimum speed	0 m/sec
Pause time	10 sec

- *Throughput*

According to figure 5, it is clearly inspected that the throughput increased for both protocols: AODV and DSDV as the mobile node's speed increased from 10 to 20 m/sec. It is noteworthy to mention that the throughput achieved by AODV was in higher range from 100Kbps to more that 110Kbps. Then, as the maximum speed increases from 20 to 45 m/sec, the mobility becomes more dynamic, both protocols throughput decreases.

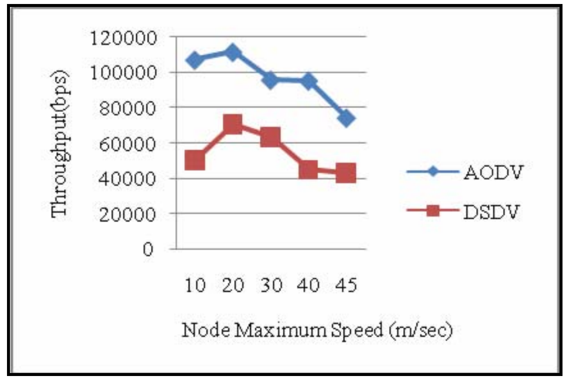

Figure 5. Impact of the node's maximum speed on the network throughput

- *Routing Overhead*

It is obviously shown in figure 6 that the on-demand reactive AODV has successfully maintained a nearly negligible routing overhead even at higher node's maximum speed (45 m/sec). The proactive DSDV protocol has shown an unexpected behavior since its routing overhead reached its higher average of more than 22000 routing table update overhead at the lower maximum speed of 10 m/sec, then, it drops to below 10000 updates at 20 m/sec, it raised up to 14000 at 30 m/sec before decreasing at higher speeds to reach a relatively lower overhead at 45 m/sec.

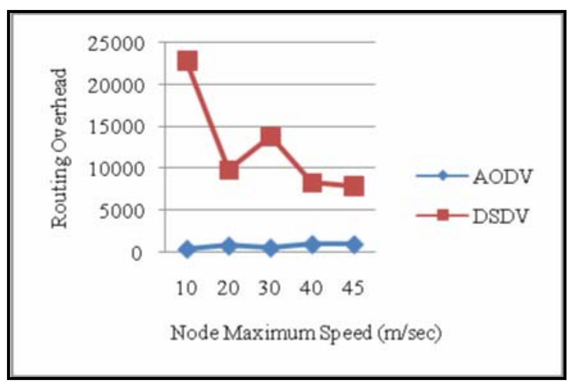

Figure 6. Impact of the node's maximum speed on the routing overhead

- *Energy Consumption*

According to figure 7, the proactive DSDV has consumed a relatively lower average battery power at various node maximum speeds varying from 10 to 45 m/sec compared to the reactive AODV.

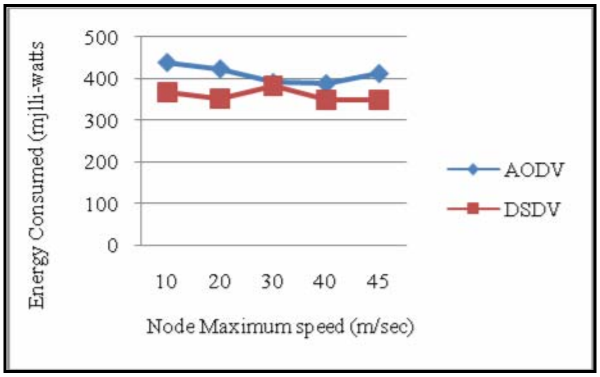

Figure 7. Impact of the node's maximum speed on the energy consumption

2) *Node Minimum Speed (in meters per second)*

Table 4 shows the constant configuration parameters used in simulation as the mobile node's minimum speed varies.

TABLE 4. CONFIGURATION PARAMETERS VALUES FOR MINIMUM SPEED MOBILITY SCENARIO

Configuration Parameters	Value
Number of nodes	40 nodes
Maximum speed	10 m/sec
Pause time	10 sec

- *Throughput*

According to figure 8, as the node's minimum speed increases, both protocols show a decreasing throughput. But although DSDV drops to 10 Kbps approximately at 30 m/sec, it could climb back up to reach a relatively high throughput of 70Kbps approximately at 40 m/sec minimum speed. Also, the AODV showed a relatively higher throughput at the same speed.

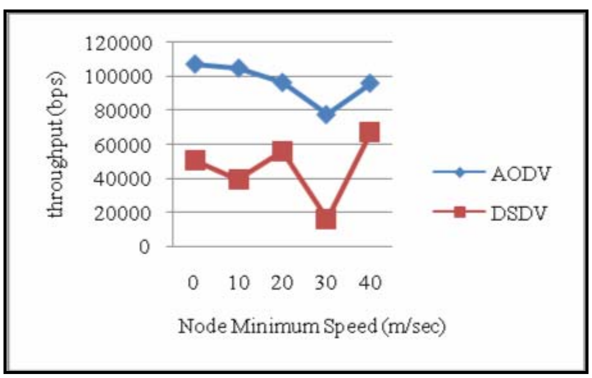

Figure 8. Impact of the node's minimum speed on the network throughput

- *Routing Overhead*

In figure 9, the reactive AODV has maintained a negligible routing overhead while DSDV has unexpectedly shown an inversely proportional routing overhead with the node's minimum speed.

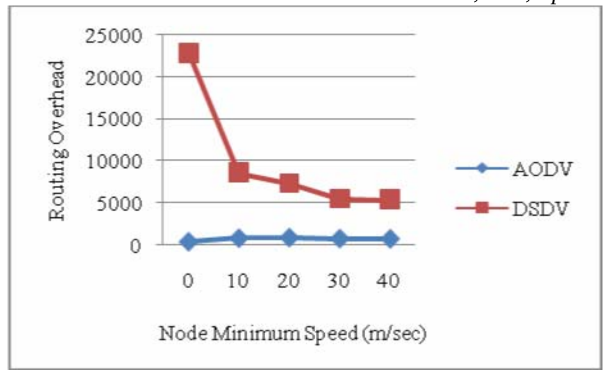

Figure 9. Impact of the node's minimum speed on the routing overhead

- *Energy Consumption*

According to figure 10, the proactive DSDV has consumed a relatively lower average battery power at various node minimum speeds varying from 0 to 40 m/sec compared to the reactive AODV.

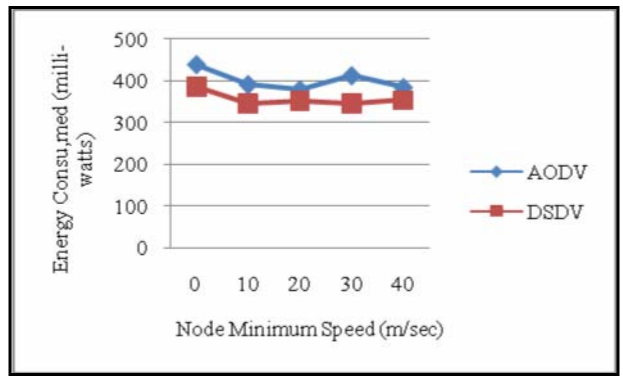

Figure 10. Impact of the node's minimum speed on energy consumption

3) *Node Pause Time (in seconds)*

Table 5 shows the constant configuration parameters used in simulation as the mobile node's minimum speed varies.

TABLE 5. CONFIGURATION PARAMETERS VALUES FOR PAUSE TIME MOBILITY SCENARIO

Configuration Parameters	Value
Number of nodes	40 nodes
Minimum speed	0 m/sec
Maximum speed	30 sec

- *Throughput*

According to figure 11, it is clearly depicted that AODV maintained a stable throughput in the range from 0 to 20 sec pause time, while DSDV's throughput has been dramatically dropped to below 40Kbps at 20 sec pause time. However, from 20 to 30 sec, AODV's throughput decayed to below 70Kbps before increasing once again to above 80Kbps at 40 sec pause time.

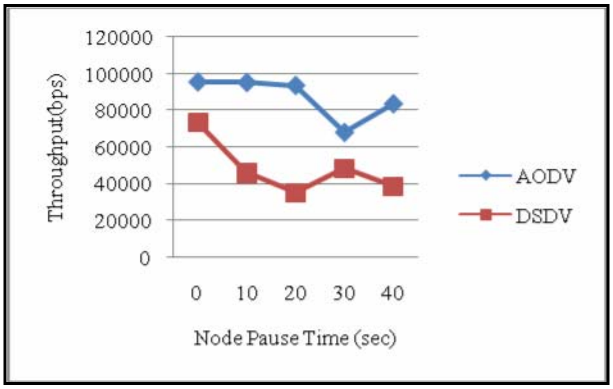

Figure 11. Impact of the node's pause time on the network throughput

- *Routing Overhead*

As shown by figure 12, AODV has maintained a stable and small average routing overhead below 2000 control packets for the various node's pause time values from 0 to 40 sec. On the other hand, DSDV had an increasing routing tables updates although it has decreased from 0 tho10 sec pause time, it raised once more from 10 to 40 sec.

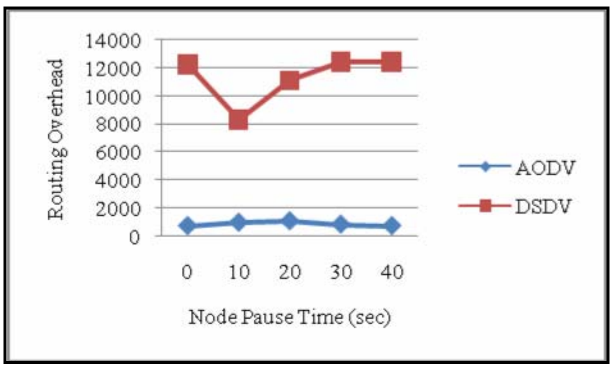

Figure 12. Impact of the node's pause time on the routing overhead

- *Energy Consumption*

According to figure 13, the proactive DSDV has consumed a relatively lower average battery power at various node pause time varying from 0 to 40 m/sec compared to the reactive AODV.

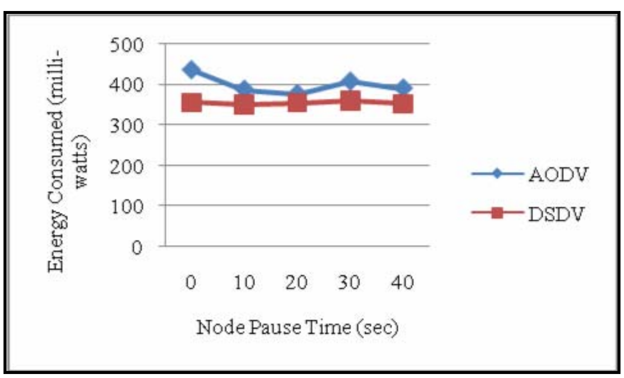

Figure 13. Impact of the node's pause time on energy consumption

V. Conclusion

This research paper has studied the AODV and DSDV performance in terms of three essential metrics: The MANET throughput, the routing overhead and the energy consumption. The extensive simulation, using the academic simulator GloMoSim [6], was performed under two main simulation scenarios concerning the protocol's network scalability and nodes mobility parameters variation. The simulation results demonstrated that although the reactive routing protocol AODV has achieved a higher throughput and lower routing overhead for both simulated scenarios than the proactive DSDV, but for energy consumption performance parameter, DSDV has consumed less energy than AODV.

References

[1] W. Stallings, "Data and Computer Communications", Chapter 19 "Internetwork Operation", Eighth Edition, 2007

[2] Rajeev Shorey, A. Ananda, Mun Choon Chan and Wei Tsang Ooi, "Mobile, Wireless and Sensor networks, Technology, Applications and Future Directions", A. John Wiley & Sons publication, WILEY INTERSCIENCE, IEEE PRESS, 2006.

[3] Christophe Ronkar, "Ad hoc Workshop 2004", University de Luxembourg, Faculty of science, Technology and communication, 2004

[4] Xiaoyan Hong, Kaixin Xu, and Mario Gerla, "Scalable Routing Protocols for Mobile Ad Hoc Networks", University of California at Los Angeles, IEEE Network, August 2002.

[5] Mehran Abolhassan, Taedeusz wysocki and Eric Dutkiewicz, "A Review of Routing Protocols for Mobile Ad hoc Networks", Telecommunication and Information research institute, University of Wollongong, Australia, June 2004.

[6] Lokesh Bajaj, Mineo Takai, Rajat Ahuja, Ken Tang, Rajive Bagrodia and Mario Gerla, "GloMoSim: A Scalable Network Simulation Environment", Computer Science Department, University of California, Los Angeles, 1999.

[7] Imane M. Amin, Sanaa H. Ahmed, Imane Aly Saroit, Laila Nassef, « Improvement of Quality of Service Parameters in Wireless Networks Environment", M. Sc. Thesis, April 2009.

[8] C. Siva Ram Murthy and B.S.Manoj, "Ad Hoc Wireless Networks Architectures and Protocols", Prentice Hall Professional technical reference, New Jersey, 2004.

[9] C.E. Perkins & E.M. Royer, Ad-hoc On-Demand Distance Vector Routing, Proceedings of the 2nd IEEE Workshop on Mobile Computing Systems and Applications, New Orleans, LA, February 1999, pp. 90-100

[10] Azizol Abdullah, Norlida Ramly, Abdullah Muhammed, Mohd Noor Derahman: Performance Comparison Study of Routing Protocols for Mobile Grid Environment, pp 82-88, IJCSNS International Journal of Computer Science and Network Security, VOL.8 No.2, February 2008

[11] Abdul Hadi Abd Rahman and Zuriati Ahmad Zukarnain, « Performance Comparison of AODV, DSDV and I-DSDV Routing Protocols in Mobile Ad Hoc Networks.", European Journal of Scientific Research ISSN 1450-216X Vol.31 No.4 2009, pp.566-576

[12] Imane M. A. Fahmy, Laila Nassef, Imane A. Saroit, S. H. Ahmed, "QoS Parameters Improvement for the Hybrid Zone-Based Routing Protocol in MANET", The 7th International Conference on Informatics and Systems (INFOS 2010), Next Generation Broadband Networks Track, 28-30 March 2010