Detailed Performance Analysis of Energy based AODV Protocol in Comparison with Conventional AODV, and DSDV Protocols in MANET

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ABSTRACT
A mobile ad-hoc network (MANET) is a collection of self configuring mobile devices, capable of moving randomly and connected through wireless physical medium without having any fixed infrastructure. All the nodes in a MANET act both as a router and as a host. However, in today's scenario the biggest challenge in MANET is to reduce energy consumption and overhead of each node, and to give a better packet delivery ratio. This paper gives the new energy based AODV (EBAODV) protocol that will not only reduce the energy consumption but also takes node's remaining energy. Based on this it will forward the packets in MANET. Simulation results (using Network Simulator NS-2.34) show that significant performance enhancements of energy based AODV (EBAODV) protocol over the original AODV and DSDV protocols in terms of energy consumption and network overhead. Proposed EBAODV gives the acceptable level of packet delivery ratio.

General Terms
Network routing algorithms and protocols.

Keywords
Mobile Ad-hoc networks (MANET), ad-hoc on-demand distance vector (AODV), Energy Based AODV, Distance Sequence distance Vector (DSDV).

1. INTRODUCTION
In mobile ad-hoc networks (MANET) energy conservation is a prime design issue in recent years. There are different types of routing protocols to provide communication among mobile nodes used in MANET in which reactive protocols (ex AODV) and proactive protocols (e.g., DSDV) are the broad classification among them. One critical issue for almost all kinds of mobile nodes is the minimum energy consumption i.e., saving power. Without power any mobile node will become useless. Hence, how to extend the lifetime of batteries is an important issue, especially for MANET, which is totally supported by batteries [1]. In the related work, M. Frikha and F. Ghandour [2] have proposed an energy constraint routing protocol in which the intermediate node forward the RREQ packets based on the current energy status of the node. The node will drop the packet if its energy is less than the set threshold energy. On the other hand D. Nitnaware, and A. Verma [3] have proposed gossip technique to reduce the number of RREQ packets and to increase the performance of the network. Although, there have been several works reported in literature on performance analysis of AODV and DSDV protocols [1-15], this paper proposes a new energy based ad-hoc on-demand distance vector (EBAODV) protocol in which node uses remaining energy as control condition. Based on this constraint it will forward the packets. This new protocol is compared with original AODV and proactive DSDV routing protocol. The parameters used for comparisons are consumed energy, packet delivery ratio, and the network overhead. A brief description of existing AODV, DSDV protocol, and the proposed energy based AODV are discussed in Section 2. Simulations results using NS-2 are presented in Section 3 followed by conclusions in Section 4.

2. MANET ROUTING PROTOCOL
This section gives the brief description of existing AODV, DSDV, and the proposed Energy Based AODV protocols.

2.1 Adhoc On-Demand Distance Vector (AODV) Routing Protocol
Ad-hoc on-demand distance vector (AODV) routing protocol is a pure on demand routing protocol, which is also refereed as reactive protocol. In AODV, route is discovered only when it is required by a source node. A node does not have to keep route or reserve bandwidth that is not needed. Therefore, AODV is a very suitable for energy conservation and bandwidth constrained routing. AODV is superior to Destination-Sequenced Distance Vector Algorithm (DSDV) and DSR, and was first proposed in 1999 [4]. In July 2003, the latest version of AODV was recommended as an experimental routing protocol for ad hoc networks by IETE [5].

In AODV when a source code wants to send data, it initiates a route discovery process by broadcasting a route request (RREQ) message to its neighbors until it reaches the destination. Each node records the RREQ packets that it has received. When it receives duplicate RREQs (with the same RREQ ID and source address) from neighbor nodes, they are discarded and not rebroadcast, which reduces the routing overhead caused by "flooding" broadcasts. The RREQ information recorded in each node must be kept a certain amount of time to ensure that no other node in the network is still processing request packets resulting from the same route discovery. Either the destination or any intermediate nodes having a fresh route to the destination generates a route reply (RREP) in response to the RREQ.

2.2 Destination Sequenced Distance Vector Routing (DSDV) Protocol
DSDV is also called as proactive protocol. DSDV is a table-driven routing scheme for ad hoc mobile networks. It is based on the Bellman-Ford algorithm. It was first developed by C. Perkins and P. Bhagwat in 1994. The main aim of this

algorithm was to solve the routing loop problem. Routing information is distributed between nodes by sending full dumps infrequently and smaller incremental updates more frequently [6, 7].

The main disadvantages of DSDV requires a regular update of its routing tables, which uses up battery power i.e., node energy and bandwidth even when the network is idle .DSDV gives very high overhead as compare to AODV protocol. In DSDV whenever the topology of the network changes, a new sequence number is necessary before the network re-converges; thus, DSDV is not suitable for highly dynamic networks.

2.3 Proposed Energy Based AODV

Based on AODV, we propose the energy based AODV (EBAODV) protocol which takes node's remaining energy with consumed energy as a control condition and based on this it will avoid the continuous rebroadcasting of the route request packets. Route request packet unnecessarily creates overhead in the network as it consumes network bandwidth as well as it requires node energy to rebroadcast. Intermediate nodes forward the RREQ packets on the basis of current energy status of that node.

For route discovery, when the source nod requires a route to a destination node with specified energy requirements, it broadcasts a RREQ packet on the basis of node current energy to its neighbor nodes. When a node receives a RREQ packet, it first checks if it has enough available energy for the request. A node which does not satisfy the energy constraint will avoid rebroadcasting of RREQ packet. If required energy is available, a reverse route entry is created with the specified session ID and used to forward the RREP to the source node. Once the route discovery packet arrives at the destination, a route reply is generated.

In packet forwarding process every node along the path check its remaining energy as control condition and based up on this it will forward the packets otherwise drop the packets.

3. RESULTS AND DISCUSSIONS

Three routing protocols are compared in six different scenarios as shown in Table 1 and the common simulation parameters are shown in Table 2.

3.1 Various Pause Times

As mentioned in earlier paragraph, all the three routing protocol are evaluated based on the three performance metrics which are energy consumption, packet delivery fraction, and the routing overhead. The simulation parameters for this scenario are (other values are listed in Table 2):

- Pause time values: 30, 50, 60, and 70 sec.
- Area size (mm^2): 500m x 500m.
- Number of nodes: 50
- Node sending rate: 90 Kbps

In this scenario we measure performance metrics with different pause time 30, 50, 60 and 70sec and mobility speed of 5 m/s which gives more stable route for that time duration. This requires less energy to setup route and for maintaining route. The speed and pause time defines mobility of nodes, both are inversely proportional to each other. Fig 1(a) shows that the proposed EBAODV consumes less energy as compared to AODV and DSDV protocol. As shown in Fig 1(b) when the number of pause time increases EBAODV gives slight changes but stable packet delivery ratios where as AODV gives good packet delivery ratio for pause time 50 and for 30, and 60 packet delivery ratio is less as compared to EBAODV and DSDV.As EBAODV protocol control the routing of unnecessary control packets it will create less overhead in the network as compared to AODV and DSDV which is shown in Fig 1(c).

Table 1. Six different simulation scenarios

Sr. No.	Scenario	Various values
1	Pause Time (Sec)	30,50,60,and 70 sec.
2	Node movements Speed(m/s)	0,1,10,15,20,and 25 m/s.
3	Number of Nodes	40, 50, 60, 70, 80, and 90.
4	Number of Sources	20, 30, 40, 50, and 60.
5	Simulation Area Sizes (m.)	500m x 500m, 750m x 750m, 1000m x 1000m, and 1250m x 1250m.
6	Sending Rate(Kbps)	48, 64, 80, 96, 112, and 128 kbps.

Table 2. Common simulation parameters

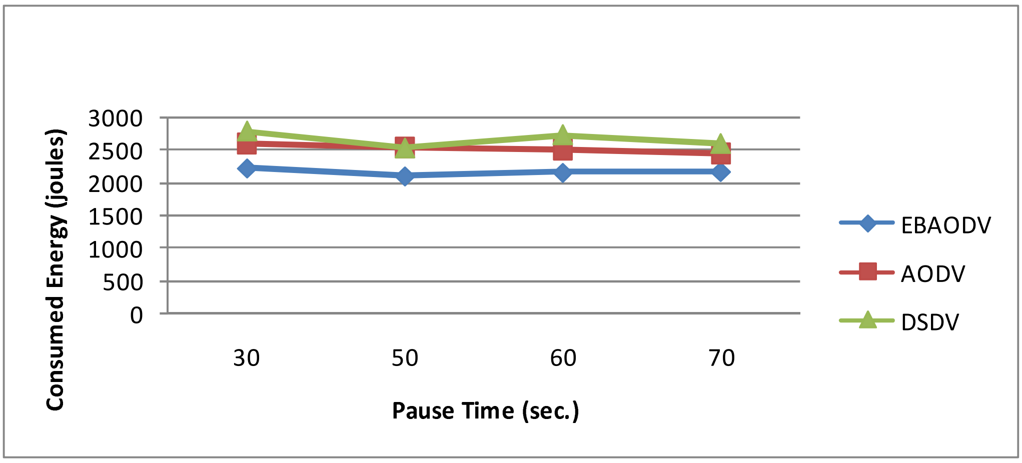
Parameter	Value
Simulator	NS 2.34
Operating System	Linux (Fedora 13)
Protocols	EBAODV, AODV, and DSDV
Simulation Time	1500 Sec
Moment Model	Random way point mobility model
MAC Layer	IEEE 802.11
Traffic Type	CBR
Data Payload	1024 bytes
Energy Model	3000 Jules

3.2 Various Node Mobility Speed

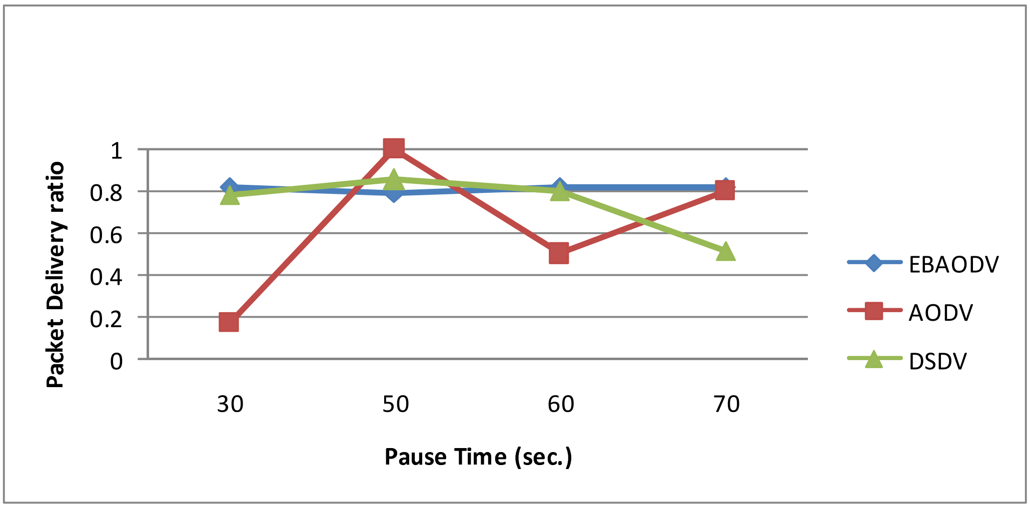
In this scenario, all three routing protocols are evaluated based on the three performance metrics which are energy consumption, packet delivery fraction, and the routing overhead. The simulation environments for this scenario are (other values are listed in Table 2):

- Node mobility speed values: 0, 1, 5, 10, 15, 20 and 25 m/s
- Area size: 500m x 500m
- Number of nodes: 50
- Node sending rate: 90 Kbps

(a) Consumed energy of AODV, EBAODV and DSDV with various pause times



(b) Packet delivery ratio of AODV, EBAODV and DSDV with various pause times



(c) Network overhead of AODV, EBAODV and DSDV with different pause time

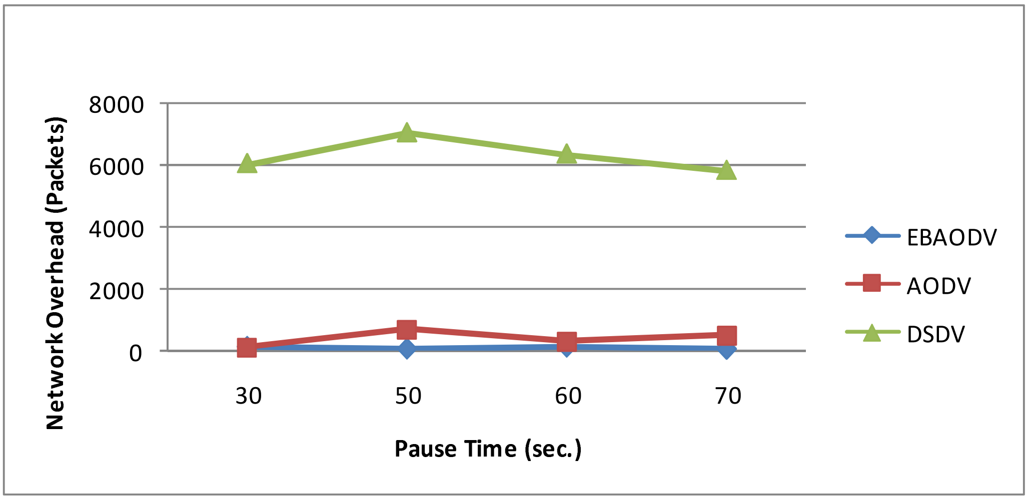
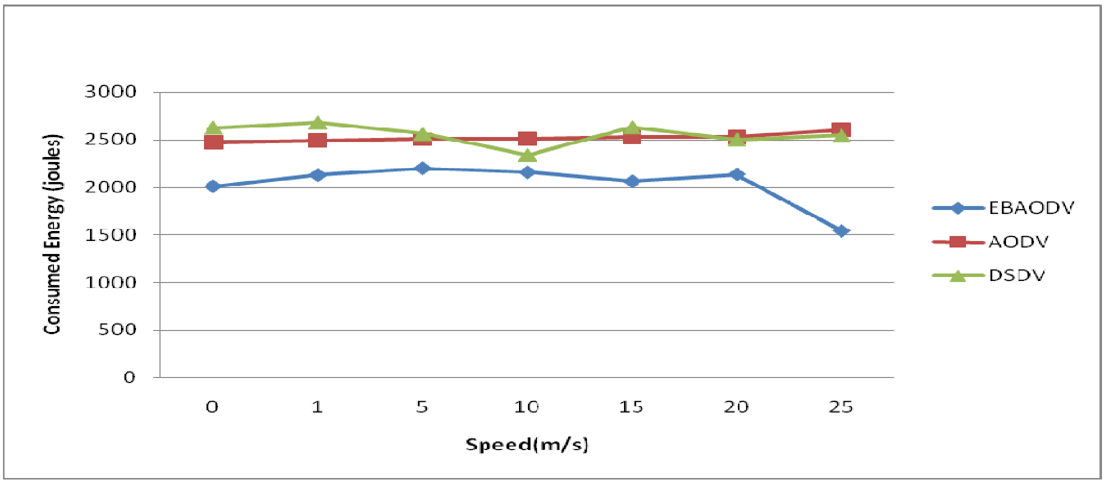
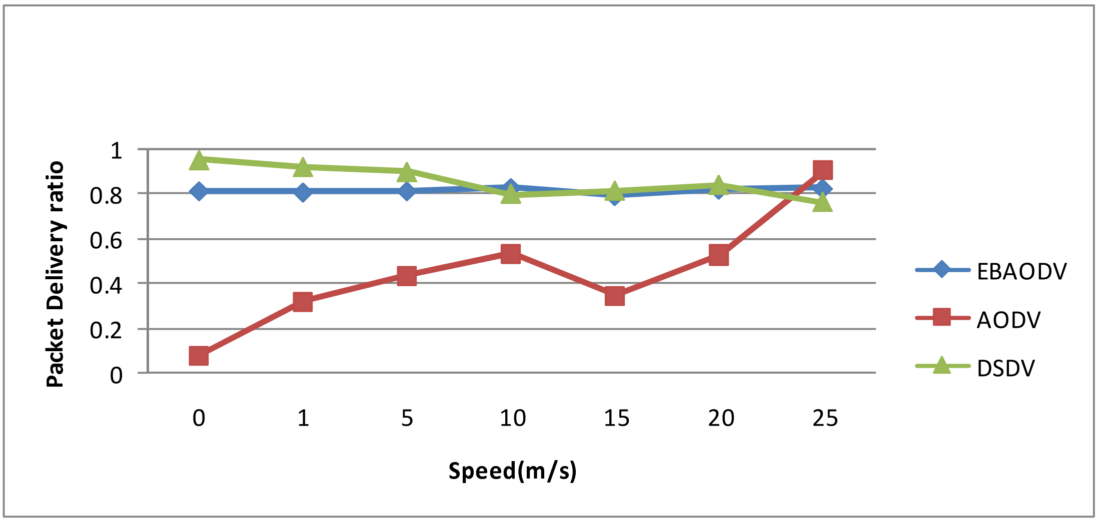


Fig 1: Comparison of AODV, DSDV, and the proposed EBAODV for different network parameters vs. pause time in seconds.

(a) Consumed energy of AODV, EBAODV and DSDV with various node mobility speeds (m/s)



(b) Packet delivery ratio of AODV, EBAODV and DSDV with various node mobility speed (m/s)



(c) Network overhead of AODV, EBAODV and DSDV with various node mobility speed (m/s)

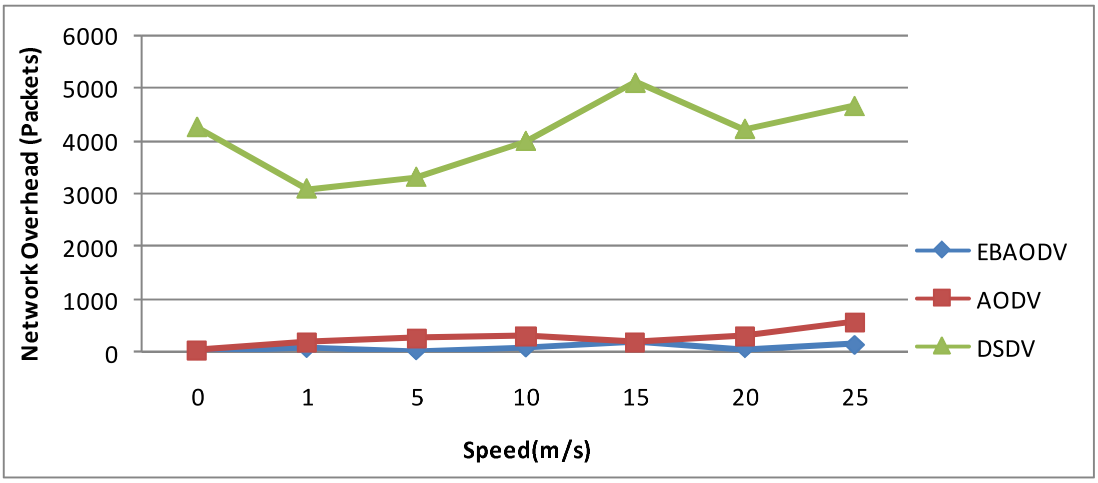


Fig 2: Comparison of AODV, DSDV, and the proposed EBAODV for different network parameters vs. node mobility speed (m/s).

In this scenario we measure performance metrics with different mobility speed of 0, 1, 5, 10, 15, 20 and 25 m/s and pause time of 100 sec. Fig 2(a) shows that EBAODV consumes less energy in contrast to AODV and DSDV protocols. As shown in Fig 2(b), EBAODV gives slight changes but stable packet delivery ratios as compared to AODV and DSDV. As DSDV is a table driven protocol, the performance of DSDV decreases with increase in node mobility because updating the routing table is a time consuming task when nodes are moving at high speed in MANET. As EBAODV protocol controls the routing of unnecessary control packets, it will create less overhead in the network as compared to AODV and DSDV which is shown in Fig 2(c).

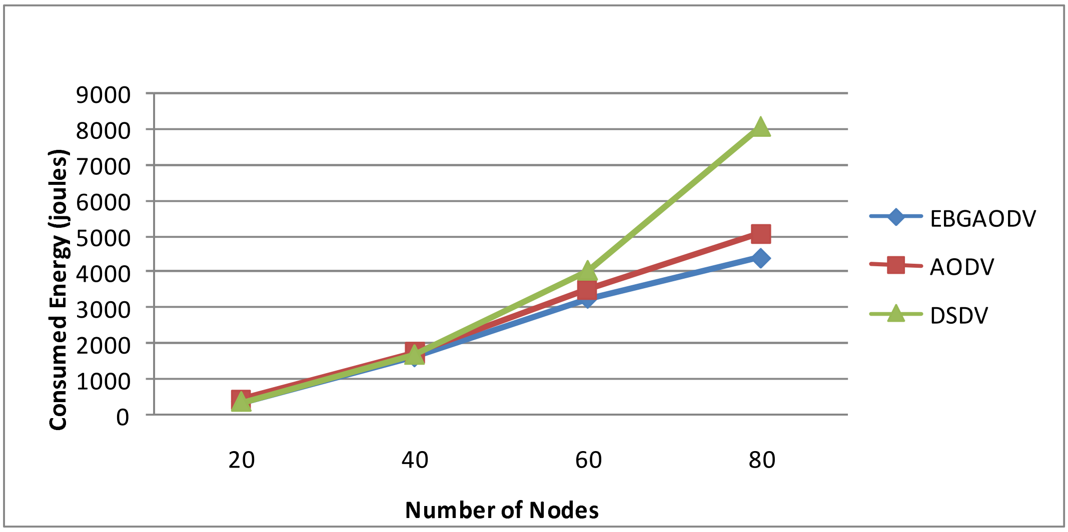
3.3 Various Number of Nodes

In this scenario, all the three routing protocol are evaluated based on the three performance metric which are energy consumption, packet delivery fraction, and the routing overhead. The simulation environments for this scenario are (other values are as listed in Table 2):

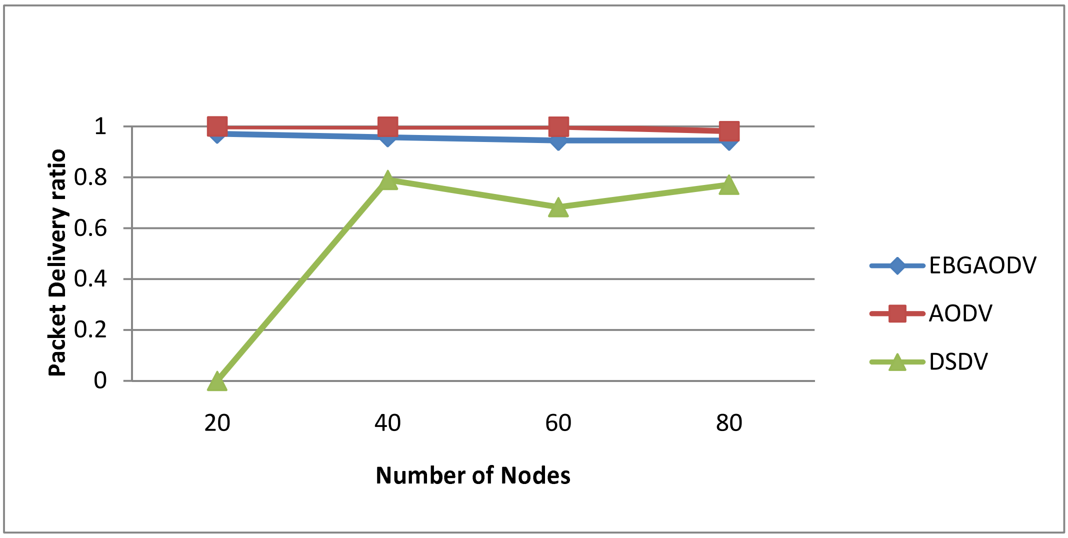
- Number of nodes: 40, 50, 60,70, 80 and 90
- Area size: 500m x 500m
- Node sending rate: 90 Kbps

Here we measure performance metrics with different number of nodes. Fig 3(a) shows energy consumed in joule involved in transmitting and receiving the control and data packets with increasing number of nodes. EBAODV consumes less energy as compared to AODV and DSDV protocol. As shown in Fig 3(b), EBAODV gives less but acceptable level of packet delivery ratios as compared to AODV and gives good packet delivery ratio as compared to DSDV. EBAODV and AODV are performing equally in terms of routing overhead factor. As EBAODV protocol control the routing of unnecessary control packets it will create less overhead in the network .DSDV givers less overhead when number of node increases in the network as compared to AODV and EBAODV which is shown in Fig 3 (c).

(a) Consumed energy of AODV, EBAODV and DSDV with various number of nodes



(b) Packet delivery ratio of AODV, EBAODV and DSDV with various number of nodes



(c) Network overhead of AODV, EBAODV and DSDV with various numbers of nodes

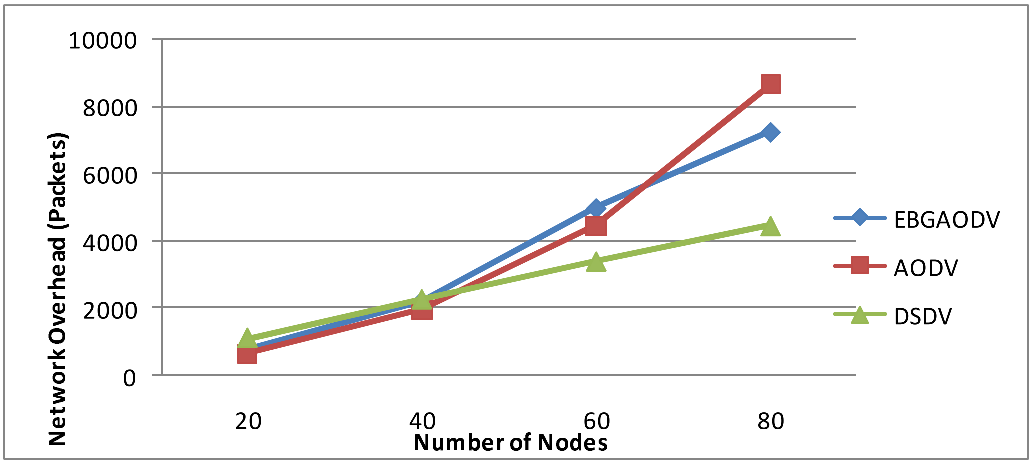


Fig 3: Comparison of AODV, DSDV, and the proposed EBAODV for different network parameters vs. number of nodes.

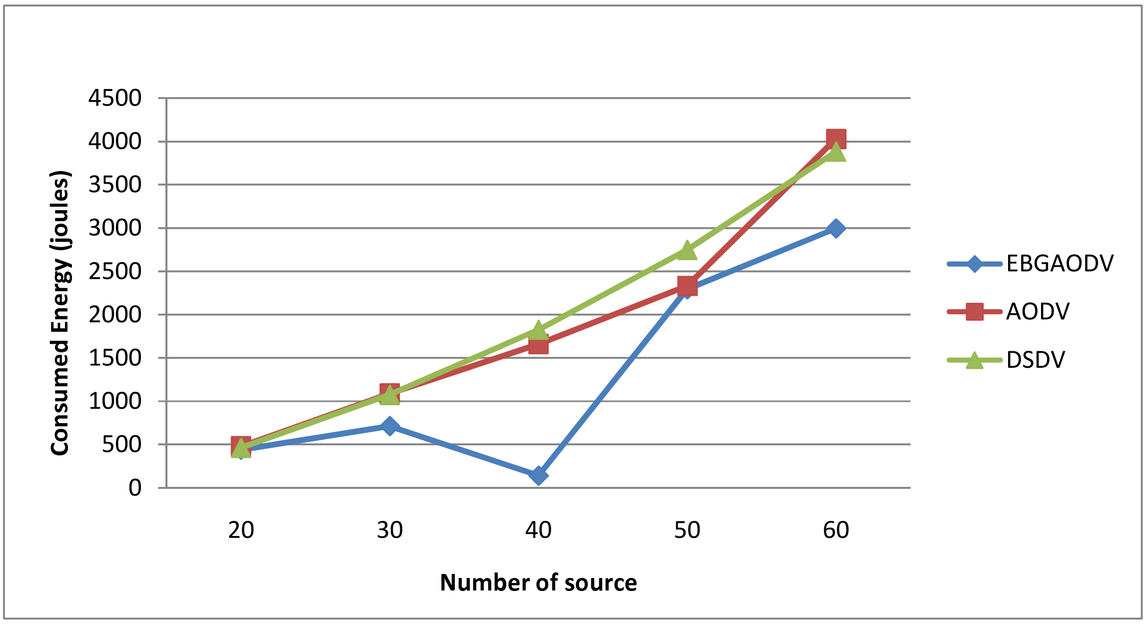
3.4 Various Number of Sources

In this scenario, all the three routing protocol are evaluated based on the three performance metric which are energy consumption, packet delivery fraction, and the routing overhead. The simulation environments for this scenario are (other values are as listed in Table 2):

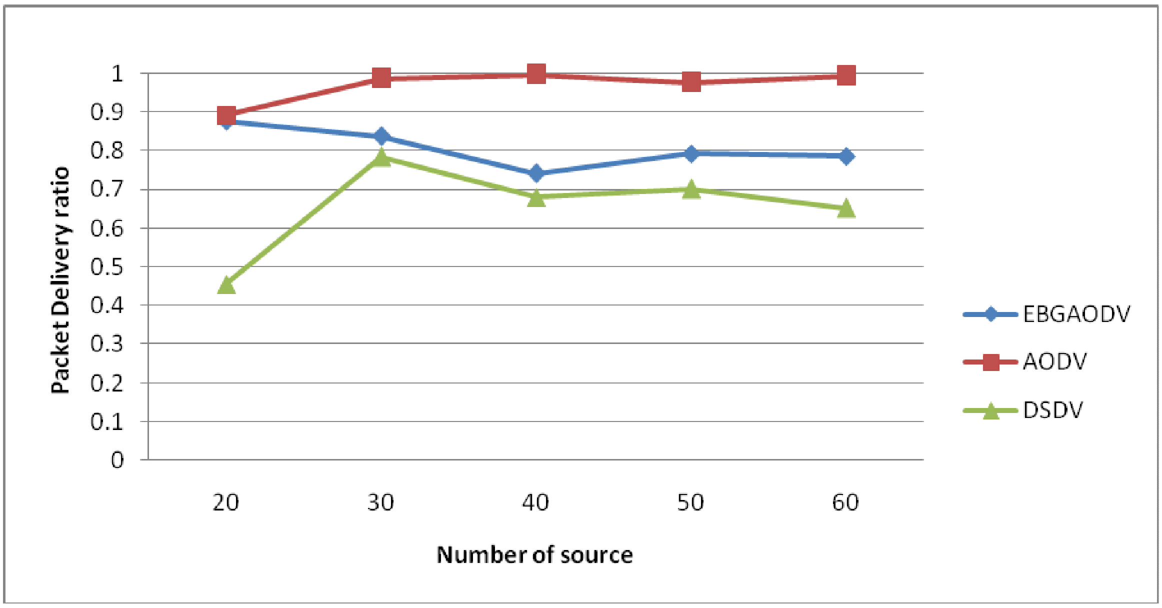
- Sources: 20, 30, 40, 50, and 60
- Simulation time: 1500 Sec.
- CBR packet size: 1024 bytes
- Area size: 500m x 500m

As shown in Fig 4(a) EBAODV performs better when the number of sources is less. EBAODV consumes less energy than AODV and DSDV Protocols in Mobile Ad Hoc Networks. It may be noted from Fig 4(b) that EBAODV gives less but acceptable level of packet delivery ratios as compared to AODV and gives good packet delivery ratio as compared to DSDV. From Fig 4(c), as number of sources increase it will introduce overhead in the network. EBAODV generates less routing overhead compared to AODV. In DSDV as sources increase routing table and the periodic update messages also increase, this introduces overhead in the network.

(a) Consumed energy of AODV, EBAODV and DSDV with various number of sources.



(b) Packet delivery ratio of AODV, EBAODV and DSDV with various number of sources.



(c) Network overhead of AODV, EBAODV, and DSDV with number of sources

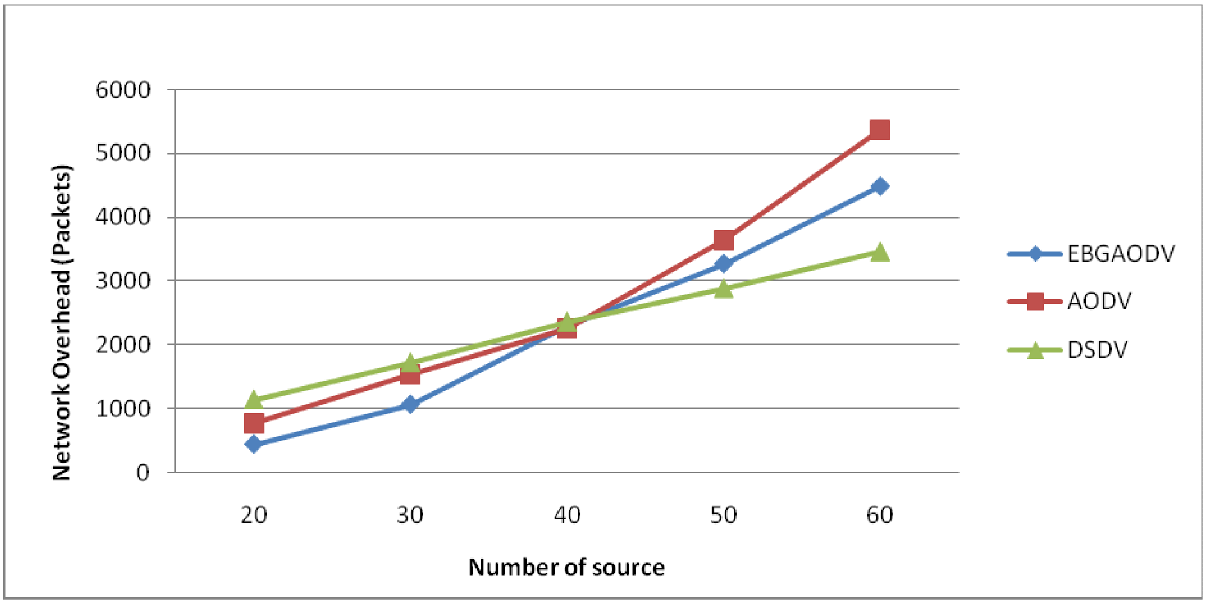


Fig 4: Comparison of AODV, DSDV, and the proposed EBAODV for different network parameters vs. number of sources.

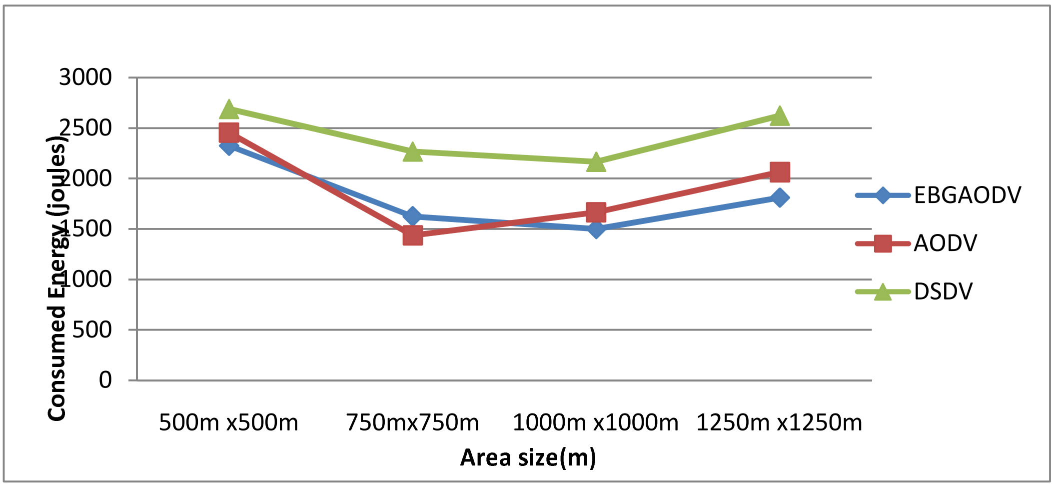
3.5 Various Area Sizes

In this scenario, all the three routing protocol are evaluated based on the three performance metric which are energy consumption, packet delivery fraction, and the routing overhead. The simulation environments for this scenario are (for other values pl. ref. Table 2):

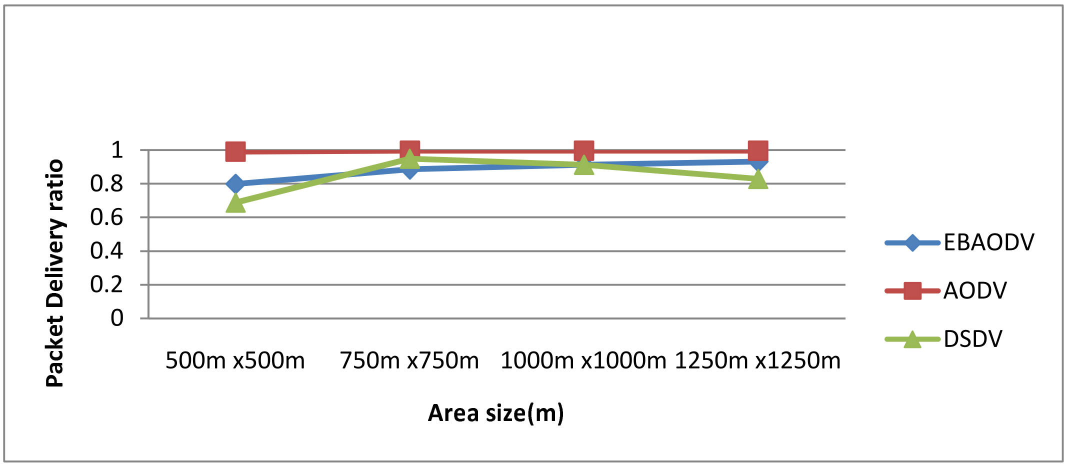
- Flat area sizes: 500x500, 7500x7500, 1000x1000 and 1250x1250
- Numbers of nodes: 50
- Node sending rate: 90 Kbps

During the simulation we have increased the network size and recorded the performance of all three protocols. Fig 5(a) shows that EBAODV consumes less energy when the simulation area is larger and energy consumption decreases as simulation area increases with fixed number of nodes. In dense area energy utilizations increases because nodes are nearer to each other. EBAODV consumes less energy than AODV and DSDV Protocols in Mobile Ad Hoc Networks. Based on Fig 5(b) it is shown that EBAODV performs better than DSDV but gives less packet delivery ratio as compared with AODV this is the main drawback of EBAODV because EBAODV transfer the packet by calculating remaining node energy as control condition that's why it limits the packet transmission which lead to less packet delivery ratio. From Fig 5(c), EBAODV generates less routing overhead compared to AODV and DSDV because In dense area number of nodes present in path are more from source to destination as compared with larger area where nodes are far away from each other so that path consist of less node from source to destination and require less number of control packet, this will introduces less overhead in the network.

(a) Consumed energy of AODV, EBAODV, and DSDV with various area sizes



(b) Packet delivery ratio of AODV, EBAODV, and DSDV with various area sizes



(c) Network overhead of AODV, EBAODV, and DSDV with various area sizes

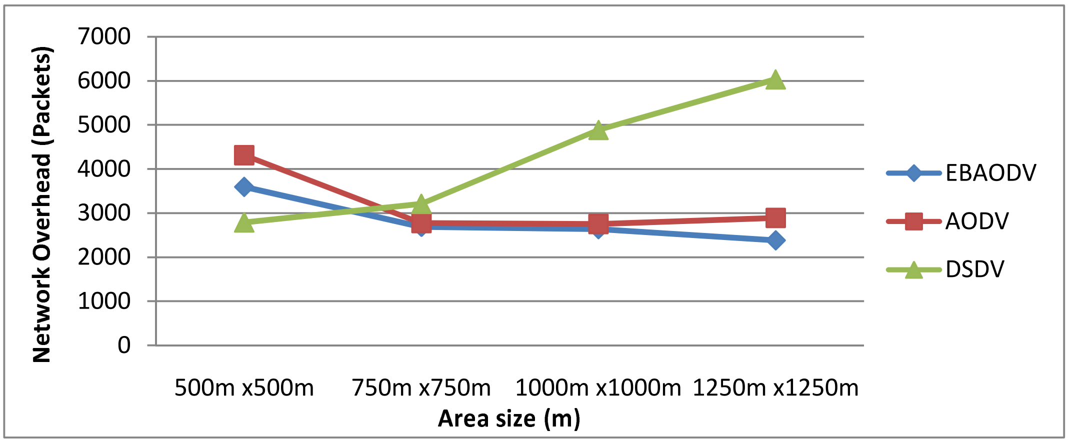


Fig 5: Comparison of AODV, DSDV, and the proposed EBAODV for different network parameters vs. different area sizes.

3.6 Various Sending Rate

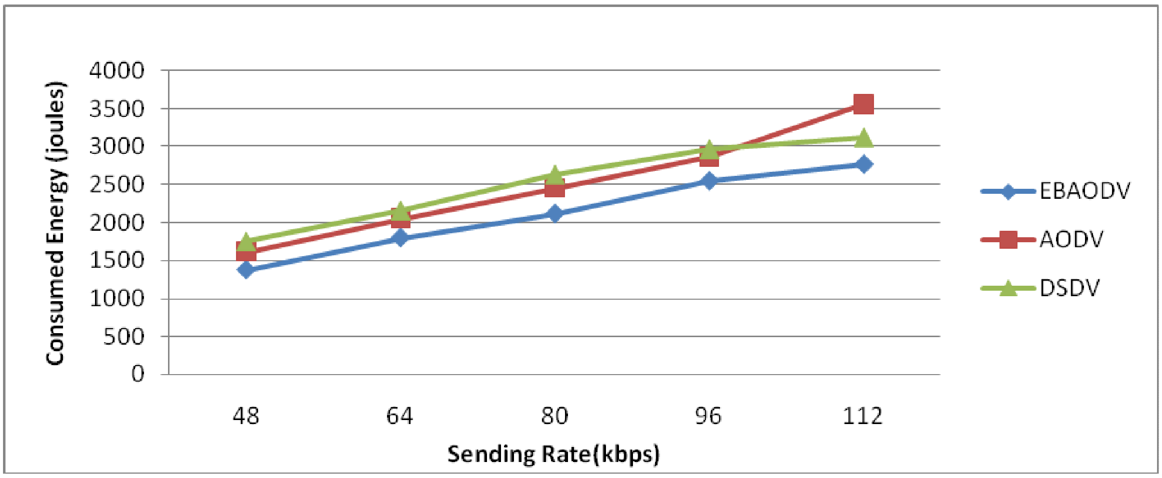
Here, all the three routing protocol are evaluated based on the three performance metric which are Energy Consumption, Packet Delivery Fraction, and the Routing Overhead. The simulation environments for this scenario are (Pl. see. Table 2 for other parameters):

Fig 6(a) shows that EBAODV consumes less energy when the sending rate is less and energy consumption increases as sending rate increases. It is well known fact that node consumes more energy with increase in the sending rate of that node because it utilizes more battery power as we increase sending rate. EBAODV consumes less energy than AODV and DSDV Protocols in Mobile Ad Hoc Networks. Result shows that energy consumption increases as sending rate increases with fixed number of nodes. Based on the Fig 6(b), shown that EBAODV perform better then DSDV but less than AODV because here also EBAODV uses remaining energy as control condition when forwarding packets but AODV douse not see the node energy, it continuously forward the packet until node energy becomes zero. Nodes in the route do not have large queuing capacity as soon as node buffer full it will start dropping packet. As sending rate increases packet dropping increases due to this packet delivery ratio decreases. From Fig 6(c), EBAODV performs better then AODV and DSDV when sending rate increases, generates less routing overhead compared to AODV and DSDV.

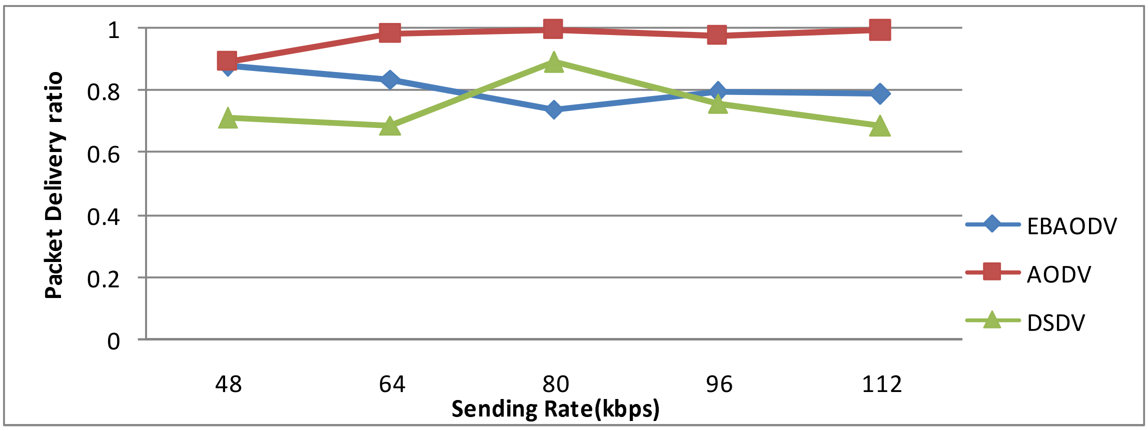
4. CONCLUSIONS

EBAODV has been simulated and compared with AODV and DSDV using the NS-2.34 network simulator. It may be noted that the new proposed algorithm EBAODV shows better performance in terms of consumed energy and network overhead than the existing AODV and DSDV under all scenarios but slight lower packer delivery ratio for some scenarios however better than DSDV. Therefore, EBAODV protocol presented in this paper proves to be the best one as it requires less energy consumption and reduces network overhead to find and maintain routes. In future it is planned to improve packet delivery ratio in some of the above presented scenarios and to upgrade EBAODV protocol as bandwidth efficient EBAODV protocol.

(a) Consumed energy of AODV, EBAODV and DSDV with various sending rates (kbps)



(b) Packet delivery ratio of AODV, EBAODV and DSDV with various sending rate (kbps).



(c) Network overhead of AODV, EBAODV and DSDV with various sending rate (Kbps.).

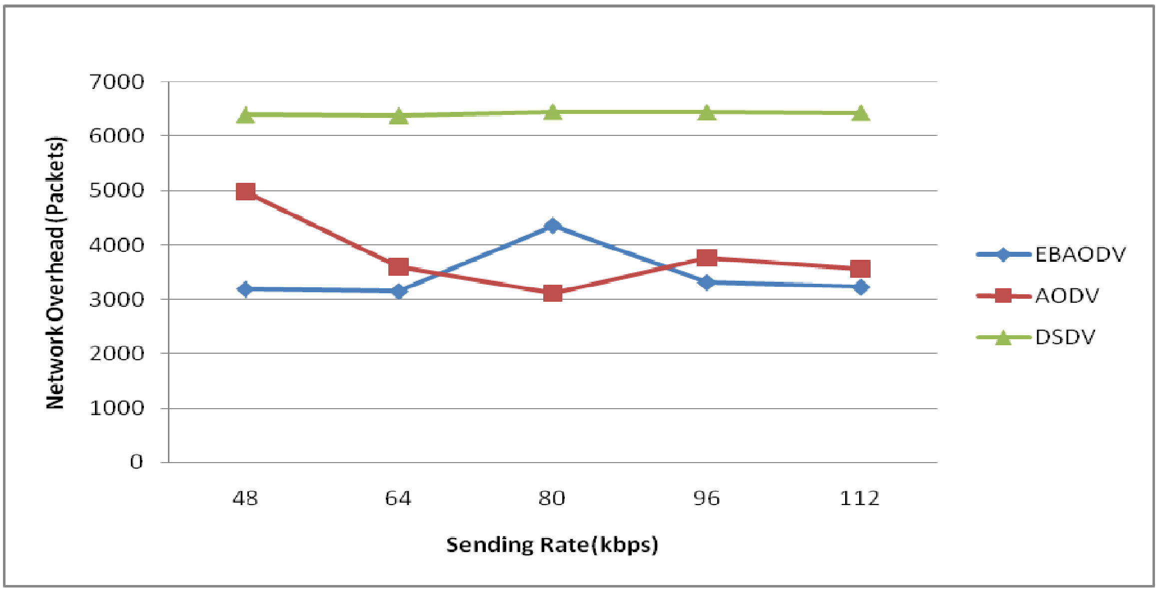


Fig 6: Comparison of AODV, DSDV, and the proposed EBAODV for different network parameters vs. different sending rates.

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