# Performance Analysis of Energy Aware Ad hoc on Demand Distance Vector Routing Protocol for Wireless Sensor Networks

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## ABSTRACT
Wireless Sensor Networks have been considered as an incarnation of ad hoc networks for hostile environment. Sensor nodes of WSNs are modeled to have the limited capabilities in terms of computation, communication, energy, storage, and reliability. Since sensor nodes have limited battery power, it is required to develop energy efficient routing protocols to optimise the performance of the network. In this paper, energy aware ad hoc on demand source routing protocol is developed for wireless sensor networks by appending energy aware algorithm in the ad hoc on demand routing protocol. The performance of the proposed protocol has been evaluated and analysed in terms of delivery ratio and delay.

## Keywords
WSN, DSN, AODV, RREQ, RREP, EAODV

## 1. INTRODUCTION
Recently, Wireless Sensor Networks (WSNs) have drawn a lot of attention due to broad applications in military and civilian wildlife monitoring and disaster management. Sensor network consists of hundreds to thousands of small, low cost multifunctional sensors powered by low-energy batteries [1]. The nodes have absolute control over the data that passes through it. Since each node in the network plays both terminal node and routing node roles, a node cannot participate in the network if its battery power runs out [2]. The increase of such dead nodes generates many network partitions [3] and consequently, normal communication will be impossible as a sensor network. Thus, an important research issue is the development of an energy efficient routing protocol to have well-organized batter-power management to increase the life time of a wireless sensor network. Hence, an attempt has been made to implement energy aware ad hoc on demand distance vector routing protocol for WSN by incorporating rate of energy consumption and fraction of energy consumption in ad hoc on demand distance vector routing which is discussed in this paper. This energy aware ad hoc on demand routing protocol is simulated by using ns-2.32 for different coverage areas of 300m×300m and 500m×500m with 150 nodes considering mobile nodes in the network. The paper is organized as follows: Section 2 explains about the ad-hoc on demand distance vector routing. Section 3 describes about the proposed energy aware ad-hoc on demand distance vector routing of wireless sensor network. Simulation results are discussed in Section 4 and conclusions are drawn in Section5.

## 2. AD HOC ON DEMAND DISTANCE VECTOR ROUTING
Ad hoc on demand Distance Vector Routing (AODV) is an on-demand routing protocol which accomplishes the route discovery whenever a data transfer is requested between nodes [4]. AODV is a reactive routing protocol which achieves better performance for the nodes having dynamic configuration. It uses traditional routing tables, one route entry per destination and Destination Sequence Number (DSN) to ensure the freshness of routes and avoid the routing loops [5]. This will greatly increase the efficiency of routing processes. The protocol forwards the packet by using two routing phases along with the help of control messages which are described below.

### 2.1 Control Messages in AODV

Control messages are used for the discovery and breakage of routes in AODV. The various types of control messages used in the routing process of AODV are Route REQuest message (RREQ), Route REPly message (RREP), Route ERRor message (RERR) and HELLO messages.

### 2.2 Route Discovery and Route Maintenance
AODV has two basic operations such as route discovery and route maintenance used for transmitting the packet from the source to the required destination [6].

#### *2.2.1 Route Discovery*

Route discovery is initiated when a source node wants to find a route to a new destination or when the lifetime of an existing route to the destination has expired. The process is initiated by broadcasting the RREQ as shown in Figure 1. The source node broadcasts a RREQ packet to its neighbours until the sought route is discovered. Upon receiving a RREQ, neighbour node checks whether the sought route is a 'fresh enough' route using its DSN. If the DSN of the sought route is greater than DSN of RREQ, the route is said to be a 'fresh enough' route. Then the neighboring node replies with a RREP packet to the source node. The RREP is traveled through the reverse path noted by each node during the transmission of RREQ [7]. Then the source node establishes the forward path for the data transmission during the transmission of the RREP message.

### *2.2.2 Route Maintenance*

To maintain connectivity, nodes either periodically broadcast HELLO packets to their neighbours or use acknowledgement based mechanisms at the link or network layers [8]. Upon detecting a link break, a node could choose to repair the link locally (if the destination is no farther than MAX_REPAIR_TTL hops away) or send a RERR packet to notify its upstream nodes. A RERR message contains the list of those destinations which are not reachable due to the loss of connectivity.

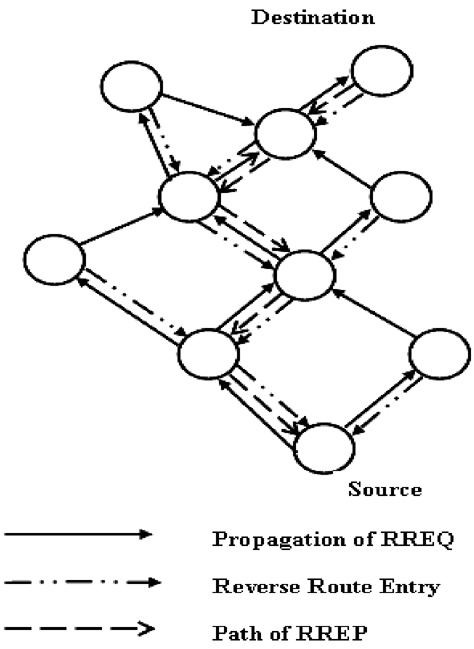


**Figure 1 Discovery of route**

## 3. ENERGY AWARE AD HOC ON DEMAND DISTANCE VECTOR ROUTING

In EAODV algorithm, each node broadcasts HELLO packets to all its neighbours that are in its communication range. The HELLO packet contains the information of the node, rate of energy consumption and fraction of energy consumption. The rate of energy consumption ($R_{in}$) of $i^{th}$ node after $n^{th}$ periodic interval is calculated by equation (1).

$$R_{in} = \frac{(E_{i0} - E_{in})}{(n-1)H_p} \qquad (1)$$

where, $E_{i0}$ is the initial energy of the $i^{th}$ node.
$E_{in}$ is energy of $i^{th}$ node at the start of the $n^{th}$ periodic interval.
$H_p$ is the HELLO period.

Then the fraction of energy consumption ($F_{in}$) of $i^{th}$ node after $n^{th}$ periodic interval is also calculated by equation (2).

$$F_{in} = \frac{E_{i0} - E_{in}}{E_{i0}} \qquad (2)$$

The node also maintains the table of its direct neighbours to forward packets to the required destination [9]. Each row of the table contains following information of a neighbour node such as IDentification number (ID), rate of energy consumption and fraction of energy consumption [10]. The node updates the information of the neighbour after receiving the HELLO packet from the neighbour, if neighbour ID is already present in table. Otherwise, it adds the details of neighbour in the neighbourhood table, if the node is a new neighbour. The rate of energy consumption and fraction of energy consumption are used to determine the energy level needed for neighbour node to transmit the packet in EAODV scheme. The adjacent neighbour who has minimum energy level requirement and shortest route for forwarding the packet is selected from node's neighbourhood table in EAODV. This procedure is continued until the packet reaches the destination.

## 4. SIMULATION RESULTS

The energy aware algorithm is appended in AODV to obtain the EAODV protocol. EAODV is simulated by using ns-2.32.The performance parameters such as delivery ratio and delay are calculated for 150 nodes by varying the pause time from 10s to 50s with various coverage areas such as 300×300 $m^2$ and 500×500$m^2$.The parameters used in the simulation are listed
in Table 1.

**Table 1. Simulation Parameters**

| Simulation parameters | Values |
|---|---|
| Number of nodes | 150 |
| Geographical area($m^2$) | 300×300, 500×500 |
| Packet Size(bytes) | 64 |
| Traffic Type | CBR |
| Pause Time(s) | 10 to 50 |
| Mobility model | Random way point |
| Simulation time(s) | 50 |

## 4.1 Delivery Ratio

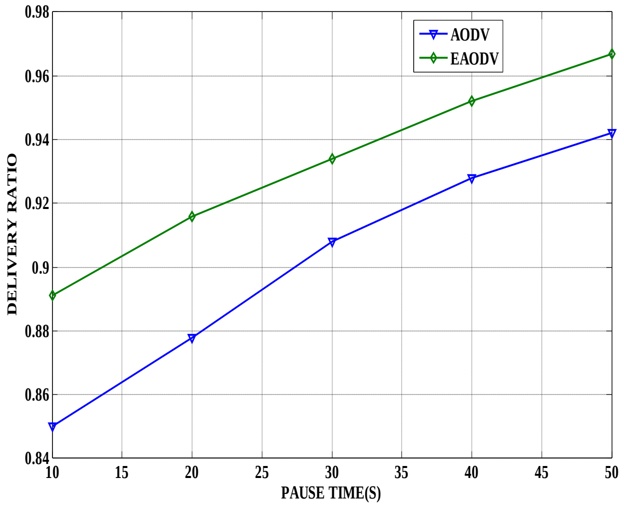


**Figure 2(a) Delivery ratio with respect to pause time for 150 nodes with coverage area 300x300 $m^2$**

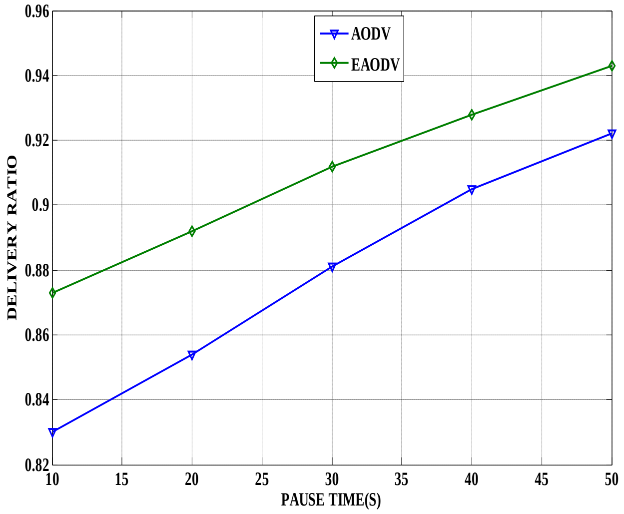


**Figure 2(b) Delivery ratio with respect to pause times for 150 nodes with coverage area 500x500 $m^2$**

EAODV outperforms AODV by achieving higher delivery ratio for different coverage areas of 300x300$m^2$ and 500x500 $m^2$ with 150 nodes as illustrated by the Figure 2(a) and Figure 2 (b). Figure 2(a) depicts that EAODV provides higher delivery ratio of about 5% than that of AODV considering pause time of 10s. The improvement in delivery ratio is due to the fact that EAODV selects neighbour node having minimum energy level as well as shortest path. The delivery ratio of EAODV is reduced for larger coverage area of 500x500$m^2$ which is observed from the simulation results described in Figure 2(b). The reduced delivery ratio is due to the increased packet loss obtained through EAODV for coverage area of 500x500 $m^2$ compared to that of 300x300$m^2$.

## 4.2 Delay

It is verified through simulation results shown in Figure 3 (a) and Figure 3 (b) that delay of EAODV protocol is higher than that of AODV protocol. EAODV increases the delay of about 20% than that of AODV protocol considering the pause time depicted in Figure 3(a). The increment in delay is due to the fact that EAODV selects intermediate nodes based upon their energy levels in addition to the shortest route.

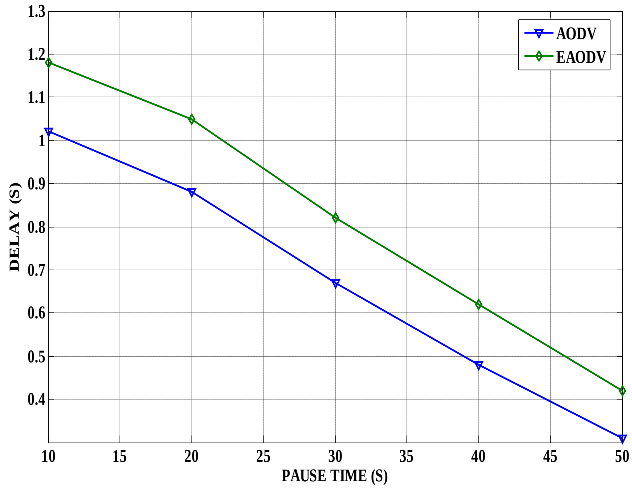


**Figure 3(a) Delay for various pause times for 150 nodes with coverage area 300x300 $m^2$**

The end to end delay of EAODV of coverage area 500×500 $m^2$ is higher than the coverage area of 300×300$m^2$ demonstrated in Figure 3(b). The higher delay attained by EAODV for larger coverage area is due to the more number of hops taken by path to transfer the packets from source to target node.

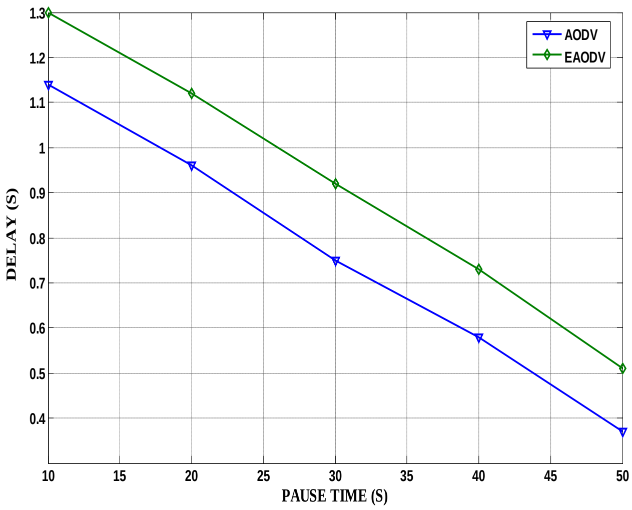


**Figure 3(b) Delay for various pause times for 150 nodes with coverage area 500x500 $m^2$**

## 5. CONCLUSION

EAODV protocol is implemented for mobile sensor ns-2.32. The performance parameters such as delivery ratio and delay of EAODV are determined and also compared with AODV protocol by varying the pause times from 10 to 50s considering 150 nodes for different coverage areas of 300×300 $m^2$ and 500×500 $m^2$. The results show that an improvement of 2% to 3% in delivery ratio is achieved by using the EAODV protocol than the standard AODV. This is mainly due to the successful transmission of packets from source to destination by considering path having minimum energy level nodes and shortest route. However, the delay of EAODV protocol is higher than that of AODV.

## 6. RfpEFERENCES

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## BIBLIOGRAPHY

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