

# The literature review on energy conscious Alternatives for AODV and AOMDV protocols for Mobile Ad hoc Networks

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## ABSTRACT

**In the non-existence of network infrastructure and using distributed administration the group of mobile nodes form a dynamic and temporary network is known as wireless Mobile Ad Hoc Network (MANET). Energy in routing protocols of mobile adhoc network becomes indispensable parameter for the consideration of performance measurement as MANET will become the part of network in near future. Hence forth this is high time to design and develop energy efficient routing protocol due to limited bandwidth and battery life. This paper covers the rigorous literature review on all AODV (Ad hoc On demand Distance Vector) and AOMDV (Ad hoc On demand Multipath Distance Vector) variants and energy models and protocols along with their characteristics, functionality, merits and demerits.**

**Keywords** - MANET, AODV, AOMDV, Energy Efficient

## INTRODUCTION

Mobile computing is now a day evolving very fast with advances in wireless communications and wireless networking protocols. As we know the fact that future devices are getting smaller and more efficient, advances in battery technology yet not reached the stage where a mobile computer can operate for days without recharging the battery. So as of one important aspect of ad-hoc networks is energy efficiency since only a simple battery provides nodes autonomy. Thus, minimizing energy consumption is a major challenge in these networks. Hence, in this document, we will discuss power management at the device, protocol, models and application layers.

This paper is divided into four sections. First section contains detail of why we need energy conservation, second section shows details about different energy consumption models, third section describes different

energy efficient protocols and finally fourth section shows comparative analysis of energy efficient protocols and conclusion.

### I. Need For Conservation Of Energy

Energy consumption is a significant parameter in ad hoc networks. This indicates how much power is required by the nodes to transmit the packets. The main reasons for energy conservation in ad hoc networks are as follows:

**Limited energy reserve:** Each node has limited remaining energy so we have to save as much energy as we can.

**Difficulties in replacing the batteries:** As we know that Ad Hoc network is basically used In battlefields, natural Disasters (i.e. earthquakes), and so it is very hard to replace or recharge the batteries. Thus, in such scenarios, the energy conservation is very important.

**Lack of central coordination:** Because an ad hoc network is a distributed network and there is no central coordinator, some of the nodes it self act as a router to forward data. If traffic is more than power consumption at the respective relay node will be high.

**Constraints on the battery source:** The weight of the nodes may increase with the weight of the battery at that node. If the weight of the battery is decreased, that in turn will lead to less power of the battery and thus decrease the life span of the battery. Thus, energy management techniques must deal with this issue.

**Selection of optimal transmission power:** The increase in the transmission power increases the battery consumption. Because the transmission power decides the reachability of the nodes, an optimal trans-

mission power should be selected in turn of transmit the data.

## II. Energy consumption models

A wireless network interface nodes can be in one of the following four states: Transmit, Receive, Idle or Sleep[2]. Each state represents a different level of energy consumption.

- Transmit: node is transmitting a frame with transmission power  $P_{tx}$ .
- Receive: node is receiving a frame with reception power  $P_{rx}$ . That energy is consumed even if the frame is discarded by the node.
- Idle (listening): no transmission happens in this mode, the nodes still stay in idle state and keep listening the medium with  $P_{idle}$  power;
- Sleep: No communication is possible, no listening of channel. The node uses  $P_{sleep}$  that is smallest power.

In Table 1, typical values of consumption for a wireless interface (measured for a Lucent Silver Wavelan PC Card) are reported.

Table 1. Value of power in every states

State	Power value
Transmit $P_{tx}$	1.3W
Receive $P_{rx}$	0.9W
Idle $P_{idle}$	0.74W
Sleep $P_{sleep}$	0.047W

The energy consumed in transmitting ( $E_{tx}$ ) or receiving ( $E_{rx}$ ) one packet can be calculated as:

$$E_{tx} = P_{tx} \times \text{Duration}$$

$$E_{rx} = P_{rx} \times \text{Duration}$$

Where, Duration denotes the transmission duration of the packet.

When a transmitter transmits a packet to a node, due to broadcast nature of network, all its neighbors receive this packet though it is intended to one of them. Due to these problems energy loss generates. So to calculate the energy consumption by one transmission, we must take into account these losses as follows:

$$\text{cost}_{tx}(i) = E_{tx} + n \times E_{rx}$$

Where  $n$  represents the number of non-sleeping nodes belonging to the interference zone of the transmitter  $i$ .

## III. Existing Power-Efficient Protocols

The energy required by mobile nodes can be divided into two types:

- Communication-related power
  - Processing power
  - Transceiver power
- Non-communication-related power

Every mobile nodes consume some processing power to execute algorithms and run applications. Transceiver power refers to the power used by the radio transceiver to communicate with the other mobile hosts. In mobile power consumption, each protocol layer is closely coupled.

### A. Minimum Total Transmission Power Routing (MTPR)

At the starting in energy-efficient routing the idea implemented was known as MTPR (Minimum Transmission Power Routing)[4]. In this they are uses a simple energy metric, which gives total energy consumed to send the information in wireless network along the route.

Algorithm:

- Calculate the total transmission power for all routes between source and destination.
- Select the route with minimum total transmission power among all routes.

In this wireless network communications, wave propagation can be modeled effectively with a  $1/d^n$  transmit power roll off (mostly  $n = 2$  for short distance and  $n = 4$  for longer distance). For successful transmissions, the signal-to-noise ratio (SNR) received at a host  $n_j$  should be greater than a specified pre-detection threshold  $Y_j$ . This threshold  $Y_j$  is closely related to the bit error rate (BER) of the received signal. For successful transmissions from a host  $n_i$  to  $n_j$ , the SNR at host  $n_j$ .

where  $P_i$  is the transmission power of host  $n_i$ ,  $G_{i,j}$  is the path gain between hosts  $n_i$  and  $n_j$  and  $h_j$  is the thermal noise at host  $n_j$ .

Therefore, the minimum transmission power is dependent on interference noise, distance between hosts, and desired BER. To obtain the route with the minimum total power, the transmission power  $P(n_i, n_j)$  between hosts  $n_i$  and  $n_j$  can be used as a metric [6]. The total transmission power for route  $l$ ,  $p_l$ , can be derived from

$$P_k = \min_{k \in A} P_k, \quad (2)$$

Where, A is the set containing all possible routes.

The required path k can be computed from the above function can be solved by a standard shortest path algorithm such as Dijkstra or Bellman-Ford. However, since transmission power depends on distance proportional to  $d_n$ , this algorithm will select paths with more hops than other routing algorithms. End to end delay increases with increasing nodes. In addition, a route consisting of more nodes is more likely to be unstable, because the probability that intermediate nodes will move away is higher. Hence, if we consider minimum number of hops, the routes we obtained from the above algorithm is not effective.

To overcome this problem, transceiver power (the power used when receiving data) and transmission power were combined as a cost metric, and the distributed Bellman-Ford algorithm was used. At node  $n_j$ , it computes

$$C_{i,j} = P_{\text{transmit}}(n_i, n_j) + P_{\text{transceiver}}(n_j) + \text{Cost}(n_j), \quad (3)$$

Where  $n_i$  is a neighboring node of  $n_j$ ,  $P_{\text{transceiver}}(n_j)$  is the transceiver power at node  $n_j$ , and  $\text{Cost}(n_j)$  is the total power cost from the source node to node  $n_j$ . This value is sent to node  $n_i$ . Subsequently, at node  $n_i$  it computes its power cost by using the following equation:

$$\text{Cost}(n_i) = \min_{j \in \text{NH}(i)} C_{i,j}, \quad \text{where} \quad (4)$$

$$\text{NH}(i) = \{j; n_j \text{ is a neighbor node of } n_i\}.$$

The path with lowest cost is selected from the source node to node  $n_i$ . This procedure is repeated until the destination node is reached. In this algorithm,  $P_{\text{transceiver}}(n_j)$  helps the algorithm to find routes with fewer hops than the MTPR algorithm.

This way, MTPR reduces the overall transmission power consumed per packet, but it does not directly affect the lifetime of each node because it does not take into account the available energy of network nodes.

#### B. Minimum Battery Cost Routing (MBCR)

Total transmission power is an important metric because it concerns the lifetime of mobile hosts. However, it has a critical disadvantage. Although

this metric can reduce the total power consumption of the overall network, it does not reflect directly on the lifetime of each host. If the minimum total transmission power routes (MTPR) are via a specific host, the battery of this host will be exhausted quickly, and this host will die of battery exhaustion soon. Therefore, the remaining battery capacity of each host is a more accurate metric to describe the lifetime of each host[4].

Let  $c_t$  be the battery capacity of a host  $n_i$  at time  $t$  ranging between 0 and 100. We define  $f_i(c_{it})$  as a battery cost function of a host  $n_i$ . Now, suppose a node's willingness to forward packets is a function of its remaining battery capacity. The less capacity it has, the more reluctant it is. As proposed, one possible choice for  $f_i$  is

$$f_i(c_{it}) = 1 / c_{it}^{\alpha} \quad (5)$$

As the battery capacity decreases, the value of cost function for node  $n_i$  will increase. The battery cost  $R_j$  for route  $i$ , consisting of  $D$  nodes, is

$$R_j = A \sum_{i \in D} f_i(c_{it}) \quad (6)$$

Therefore, to find a route with the maximum remaining battery capacity, we should select a route  $i$  that has the minimum battery cost.

$$R_i = \min\{R_j | j \in A\}, \quad (7)$$

Where, A is the set containing all possible routes.

Since battery capacity is directly incorporated into the routing protocol, this metric prevents hosts from being overused, thereby increasing their lifetime and the time until the network is partitioned [4]. If all nodes have similar battery capacity, this metric will select a shorter-hop route. However, because only the summation of values of battery cost functions is considered, a route containing nodes with little remaining battery capacity may still be selected. For example, in Fig. 2 there are two possible routes between the source and destination nodes. Although node 3 has much less battery capacity than other nodes, the overall battery cost for route 1 is less than route 2. Therefore, route 1 will be selected, reducing the lifetime of node 3, which is undesirable.

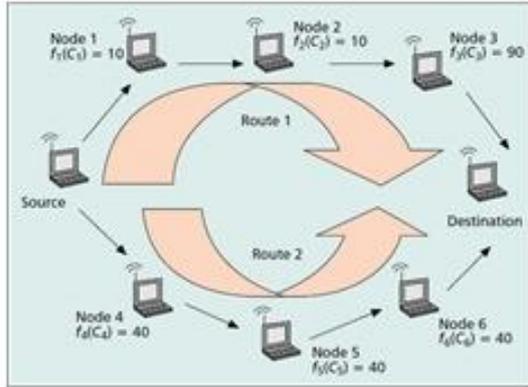


Figure 2 An example of shortest hop routing[4].

### C. Min-Max Battery Cost Routing (MMBCR)

To make sure that no node will be overused, the above objective function (Eq. 3) can be modified, as indicated in [8]. Battery cost  $R_j$  for route  $j$  is redefined as

$$R_j = \max\{R_i | i \in A\}, \quad (8)$$

Similarly, the desired route  $i$  can be obtained from the equation

$$R_i = \min\{R_j | j \in A\}, \quad (9)$$

Algorithm:

- For each route, select battery cost function which having maximum value among all nodes in the route.
- Now select the route with minimum battery cost among all routes.

Since this metric always tries to avoid the route with nodes having the least battery capacity among all nodes in all possible routes, the battery of each host will be used more fairly than in previous schemes. Initially, it seems that the lifetime of all nodes will be elongated. However, on closer examination, since there is no guarantee that minimum total transmission power paths will be selected under all circumstances, it can consume more power to transmit user traffic from a source to a destination, which actually reduces the lifetime of all nodes.

Advantages MMBCR is that the battery of each host will be used more fairly than in previous scheme. Drawback of MMBCR is that it does not provide guarantee that minimum total transmission path will be selected, it can consume more power to transmit user traffic and reduces lifetime of all nodes.

### D. Conditional Min-Max Battery Cost Routing (CMMBCR)

Our goal is to maximize the lifetime of each node and use the battery fairly. However, these two goals cannot be achieved simultaneously by applying MTPR or MMBCR schemes. MMBCR can only fulfil both of them sometimes. It is still not clear at this stage if we can achieve these two goals simultaneously. To resolve this problem, they [3] use battery capacity instead of cost function as a route selection metric, and introduce the conditional max-min battery capacity routing (CMMBCR) scheme.

The basic idea behind CMMBCR is that when all nodes in some possible routes between a source and a destination have sufficient remaining battery capacity (i.e., above a threshold), a route with minimum total transmission power among these routes is chosen.

They [3] define the battery capacity  $\gamma$  for route  $j$  at time  $t$  as

$$R_j = \min\{R_i | i \in A\} \geq \gamma \quad (10)$$

Where,  $c_i$  is the residual battery capacity of node  $i$  on the route  $j$ .

If a set of routes  $Q$  between a source and destination pair has each node's residual power above a threshold value  $\gamma$ , i.e.,

$$R_j \geq \gamma$$

a path is selected from  $Q$  by applying MTPR for optimal total transmission power. In this case, all nodes along the paths in  $Q$  are expected to have sufficient remaining battery capacity, hence minimizing the overall transmission power for each packet and reducing the end-to-end latency are the focus. Reducing the overall power consumption for packets transmission effectively extends the network lifetime of most nodes.

$$R_i = \max\{R_j | j \in Q\} \quad (11)$$

If for all possible paths, there is at least some node on each having energy level below  $\gamma$ , then the routing path is determined by choosing a route whose minimum remaining battery capacity is the maximum among all paths, similar to MMBCR.

In this later situation, maintaining weak nodes' battery capacity is critical. The routing path selection criterion avoids path assignments involving weak nodes, instead, it allocates the workload to nodes with more remaining battery capacities, so that the weak nodes can sustain longer and therefore prolonging the node and network lifetime. Note that the three-

should  $\gamma$  acts as a protection margin. It implicitly assigns network level and node level weight distribution in determining routes. If  $\gamma$  gives total emphasis on network level consideration, CMMBCR reverts back to MTPR. On the other extreme, if  $\gamma$  gives total emphasis on node level consideration, CMMBCR degenerates to MMBCR. Therefore the performance of CMMBCR depends greatly on the chosen value of  $\gamma$ .

#### E. *Min-Max Residual Energy in AOMDV (MMRE-AOMDV)*

Yumei Liu, Lili Guo, Huizhu Ma, Tao Jiang[1] proposed a new routing protocol MMRE\_AOMDV in order to balance the traffic load among different nodes according to their nodal residual battery and prolong the individual node's lifetime and hence the entire system lifetime.

The MMRE-AOMDV protocol has two main components.

- Finding minimal nodal residual energy of each route in the route discovery process:
- Sorting multi-route by descending nodal residual energy and use the route with maximal nodal residual energy to forward data packets.

#### **Finding minimal nodal residual energy**

Several changes are needed in the AOMDV route discovery procedure to enable computation minimal nodal residual energy of each route between source-destination pairs. Each RREQ and RREP now carries an additional field called **min\_re\_energy** to indicate that all of nodes in the route have the minimal nodal residual energy. When intermediate node receives RREQ packet, only if the sequence number of just received packet is greater than this node's, its residual energy should be compared with the min\_re\_energy of RREQ. If the residual energy of this node is less than the min\_re\_energy of RREQ, we update the min\_re\_energy field with it, in order to keep the value of min\_re\_energy lowest among all the nodes in this route.

#### **Sorting multi-route by descending nodal residual energy**

Same as finding minimal nodal residual energy phase, we still add another additional field **min-re-energy** in the route\_list. The node with route\_list sorted by the descending value of min-re-energy can send data packets using the route with maximal nodal residual energy when needed. When the source node receives a new route message containing information of maximal nodal residual energy, this new route should be adopted to forward rest data packets. Such process can prevent one or some critical nodes dep-

leting their energy earlier and prolong network's lifetime.

## IV. SUMMARY

Many researchers worked [2][4][6][7][10] on this area of to find an optimum energy aware routing protocol.

In [5] Singh S., And Ragavendra C.S. tried to achieve the energy consumption by finding the lowest nodal energy for each path and sorting these paths in decreasing order based on energy, but due to additional calculation routing overhead increases.

In [3] C. K. Toh used battery capacity as cost function, choose route with minimum total transmission power which is less than a threshold value. As they[3] include threshold value, the performance of the protocol depend upon effective threshold value.

In [8] Chen, K. Jamieson, H. Balakrishnan And R. Morris saves energy by Turning off a node's radio when it is overhearing the packet not addressed to it. This protocol is only suitable for nodes who's processing of receiving packet is more than being in idle state. The performance parameters they[8] concentrated on are Packet Delivery Ratio, Packet loss, Fraction of energy remaining and Energy saving function.

In [13] Yuhua Yuan, Huimin Chen, And Min Jia proposed that each node makes local decision whether to sleep or join a forwarding backbone as a coordinator but the decision power to node increases the overhead to particular node. The performance parameters they[13] concentrated on are Route discovery frequency, Packet loss, Routing overhead and Average end-to-end delay.

In [1] Yumei Liu, Lili Guo, Huizhu Ma, Tao proposed a model based on nodal energy that to find the maximal nodal surplus energy along the best paths, sort the multipath in descending order using the nodal surplus energy and forward the data packets through the path with maximal nodal surplus energy. advantage of this[1] protocol is that it prevents the critical nodes from depleting their energy earlier and avoids route rediscovery for every route break.

In [9] Getsy S Sara, Neelavathy Pari.S, Sridharan.D presented Energy Efficient aomdv( $E^2$ aomdv) to solve the "route cutoff" problem in aomdv and simulations show that the routing overhead is decreased.

In [11] Rajgopal G, Manikadan .K, Sivakumar .N says that nodes which are having less energy will not forward the RREQ packet. They[11] mainly focused on Remaining Energy of nodes.

In [12] Ting Zhu, Don Towsley proposed Energy Efficient Routing ( $E^2$ R) for Multi-hop Green Wireless Networks uses broadcast based algorithm that significantly reduces the number of control packets

which in turn reduces energy consumption on transmitting these packets. The performance parameters they [12] concentrated on are Packet Delivery Ratio, Control Overhead and Packet Delivery Delay.

### V. Conclusion

Having read various research papers for energy models various ways of energy saving methods have been used. Some papers have emphasized on saving of battery life by reducing the transmission power. Some authors have suggested various techniques on deciding sleeping node. Some authors have suggested change in routing decisions for saving energy of nodes. This review concludes that life time of routing path in routing table is of utmost important as energy is the constraint in mobile nodes. The existing methods have improved reliability by measuring packet delivery fractions and measuring the remaining energy of nodes.

### VI. Future Work

Having reviewed different methods for improving energy efficiency of nodes, the control overhead of AODV or AOMDV can be altered for saving energy by reducing routing process. Research for increasing life time of existing route also can be improved by choosing appropriate energy level while calculating routing path. There is wide scope in devising the roll of sleeping node selection in routing process so that when nodes are not participating can remain in the route for longer time.

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