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EER-Energy-Efficient Routing In MANET with Max-Energy Node Selection and Average Path Energy Optimization

Deepti Chaturvedi* Dr. B.L. Rai**

***M.Tech Scholar, Department Of Computer Science JNCT, Bhopal (M.P.) INDIA**
**** Associate Professor, Department Of Computer Science JNCT, Bhopal (M.P.) INDIA**

Abstract : Power-efficient routing is a key challenge in flying ad hoc networks (FANETs), where unmanned aerial vehicles (UAVs) establish temporary links with nearby UAVs. These UAVs operate freely within their vicinity, collecting and transmitting data across the network. A major issue in FANETs is the high power consumption during data transmission, which limits the ability to recharge or replace power sources. Efficient power management is critical for extending both node and network lifespans, given the constrained battery capacity. Additionally, UAVs often face instability due to the unpredictable mobility of other nodes, and this limited power supply negatively impacts routing performance.
Keywords: MANET, Energy awarerouting, MAX Energy,Averageenergy, Reliable routing.

Introduction - In a Mobile Ad Hoc Network (MANET), each node autonomously establishes network connections, forwarding data packets on behalf of other nodes within the network. These networks can be deployed quickly without the need for wired base stations or fixed infrastructure. However, MANETs face several challenges, such as lower capacity, limited security, higher packet loss rates, increased delays, and greater jitter compared to fixed networks. A major issue in MANETs is that node activity is constrained by energy limitations, as the nodes are typically powered by batteries or other finite power sources. Battery depletion in nodes can significantly impact the network's overall performance, making energy conservation a crucial design consideration.

Since nodes in MANETs have limited battery life, excessive energy consumption can lead to early node failure, which disrupts communication. To address this, it is essential to balance the energy consumption across nodes, enhancing the network's energy efficiency. A proposed solution involves utilizing the energy status of each mobile node and identifying alternate paths for communication. This strategy can be integrated into any on-demand routing protocol to improve reliable packet delivery, especially in scenarios where nodes move and routes are frequently broken. Alternate routes are utilized only when data packets cannot be delivered through the primary route. As a case study, this approach has been applied to AODV, and its performance has been studied through simulations [1].Routing protocols [4] play a critical role in suggesting the most efficient path from source to destination for effective data transfer. For any application, factors such as node mobility and limited battery resources must be considered to achieve optimal network performance. It is particularly challenging to ensure reliable data delivery under mobile conditions while conserving node energy. Based on how routing protocols maintain route information, they can be categorized into Proactive, Reactive, and Hybrid types. Proactive protocols maintain all routes continuously, regardless of their current use. The rest of this paper is organized as follows: Section 2 presents the related work, Section 3 outlines the problem statement, Section 4 discusses the proposed scheme, Section 5 analyzes network behavior using Network Simulator-2 (NS-2), and finally, Section 6 concludes the paper with suggestions for future work.

Related Work: This section reviews the related work in the field, highlighting the efforts made by researchers. In one study [5], a novel method based on energy estimation is proposed to restore broken links and reconstruct paths. The research investigates the effect of broken links on topology control and the routing process in Ad Hoc networks, showing that these effects can be detrimental to various network portions. A hardware-based method for energy estimation in ad hoc nodes was employed due to its high speed. The study finds that broken links negatively impact both routing algorithms and topology control, potentially leading to network disruption. These disruptions can cause serious problems in data transfer and reduce network efficiency. A strategy was proposed to prevent link breaks and network disruption by predicting and estimating the timing of link failures. In another study [6], several new routing and MAC layer protocols, along with various techniques, were introduced for wireless sensor networks (WSNs). These approaches aim to address the resource constraints in unattended wireless sensor environments. Many of these protocols focus on optimizing resource use to improve network performance. In [7], the research discusses how the M Channel group communication middleware for Mobile Ad Hoc Networks (MANETs) was enhanced to be both delay- and energy-aware. M Channel utilizes the Optimized Link State Routing (OLSR) protocol, which originally selects routes based on a hop-count metric using Dijkstra's algorithm. A new module was added to M Channel to enable unicast routing based on two alternative metrics: end-to-end delay and overall network lifetime. The study shows that with this module, network lifetime and average end-to-end delay are significantly improved compared to the original OLSR protocol.

The research in [8] proposes a new reliable protocol called Enhanced Power Control MAC Protocol (EPCMAC) for wireless ad hoc networks. The key concept of EPCMAC is to improve throughput and save energy by transmitting packets with optimal power. This approach promises better throughput and delay performance by utilizing spatial diversity effectively. The transmit power of data packets is periodically raised to a suitable level (but not the maximum) to avoid interference and reduce unnecessary contention between nodes.

Another study [9] introduces the Energy Efficient Location Aided Routing (EELAR) Protocol for MANETs, which is an enhancement of the Location Aided Routing (LAR) protocol. EELAR significantly reduces energy consumption in mobile nodes by limiting the area for route discovery to a smaller zone, which reduces control packet overhead. Simulation results using NS-2 demonstrate that EELAR improves control packet overhead and delivery ratio compared to AODV, LAR, and DSR protocols. The study concludes that EELAR successfully reduces energy consumption and prolongs the lifetime of mobile nodes.

In [10], the research focuses on energy conservation in heterogeneous MANETs, which consist of powerful nodes (P-nodes) and normal nodes (B-nodes). The study proposes a cross-layer designed framework called Device-Energy-Load Aware Relaying (DELAR), which aims to achieve energy conservation through power-aware routing, transmission scheduling, and power control. A multi-packet transmission scheme is also introduced to enhance end-to-end delay performance.

Lastly, the research in [11] introduces a new energy-aware routing protocol called EDSR, which is based on the Dynamic Source Routing (DSR) protocol. Simulations with NS-2 compare EDSR to the traditional DSR, showing that EDSR consumes less energy and offers larger link capacity. The analysis demonstrates that EDSR performs better than the classic DSR in terms of energy efficiency and network performance. Can save more energy, delay the network split. The EDSR routing which spends less energy and own larger link capacity, be synthetically analyzed and then selected, so it can save more energy, delay the network split.

In this research [12] have distinguished three families of energy efficient routing protocols. Few proposals especially focused on the design of routing protocols providing efficient power utilization are dealt in depth by [13]. The techniques are, Minimum Total Transmission Power Routing (MTPR), Minimum Battery Cost Routing (MBCR), Min-Max Battery Cost Routing (MMBCR), and Conditional Max- Min Battery Capacity Routing (CMMBCR). In addition to above techniques, minimum drain rate mechanism also needs to be considered for power saving. The drain rate is the rate at which energy gets dissipated at a given node. Each node monitors its energy consumption and maintains its battery power drain rate value during the given past interval.

In This paper [14] tried to make the OLSR energy efficient by making effective neighbor selection based on residual battery energy of a node and traffic conditions that influence the drain rate of the node in the network. We have considered the multipath and source routing concept for route selection and a route recovery technique to tackle mobility issue efficiently. Modifications make the protocol energy efficient and at the same time achieve balancing of network load.

Problem Statement: The problem of node failure is the major problem. The problem of node failure occur due to loss of energy, if node can loss their energy then it will do nothing in the network means it will be loss their communication capability their results in network partitioning, is serious in ad hoc networks.

Network portioning or suddenly loss of session is the problems that will be occur due to we are not known at what time nodes will goes to sleep mode. Those nodes which are loss there energy they are not being a part of network, but nodes having a capability to take part in communication having a sufficient energy to do communication in the network. Due to suddenly loss of session following problems are occurring:

1. Maximize the loss of packets.
2. Maximize the routing load.
3. Minimizes energy utilization

Proposed Work: Our proposed scheme, the Energy Efficient Depletion Routing Scheme, focuses on optimizing energy resource utilization in ad hoc wireless networks. The challenges and existing solutions highlight the need for energy-efficient routing in these networks.

This work addresses the issue of "sudden session loss" by employing a maximum energy concept to achieve energy-efficient routing. Nodes with energy levels below or equal to a defined threshold are excluded from communication.

Additionally, the scheme calculates the average energy of all possible paths and selects the path with the highest average energy level. By preventing early battery depletion, the system adjusts energy levels to determine the appropriate energy state of each node. It also integrates low-power strategies into the protocols used across various layers of the protocol stack.

This proposed solution will significantly improve the following:

1. Maximizes energy utilization.
2. Reduces packet loss.
3. Reduces routing load

A. Algorithm for Maximum Energy Base routing Under MANET

Step 1: Create mobile node = N;

Step2: Set routing protocol = AODV; **// for Routing Protocol**

Step3: Set of N = { V_s, V_d, V_i, V_j, V_k, V_l, ... V_n} //Number of mobile node's

Step4: Set of Intermediate vertex or node's V_i, V_j, V_k, V_l, ...

V_n • N , but not

Step5: Set sender = V_s ; **// V_s • N**

Step6: Set Destination = V_d; **// V_d • N**

Step7: Initialize radio range = 550m;

Step8: Set MAC = 802.11 **//** WiFi Tecnology

Step9: Set initial energy of each node E = { e_s, e_d, e_i, e_j, e_k, e_l, ... e_n }

Step10: Compute Route (V_s, V_d, E, rr)

Step11:{if (radio-range <= rr && next-hop != V_d && E > 0)

{

Step12: If (path exist from V_s to V_i, && V_i **!=** V_d,) Increment pointer V_i as V_j and V_s as V_i Broadcast route packet to next hop

Step13: While (path exist from V_i to V_j && V_j != V_d)

{

Broadcast route packet to next hop Increment pointer V_i and V_j

Goto step 13;

}

Step14: If (V_j == V_d)

{

Create rtable in V_d Node Create energy table V_s-V_i-V_d

}

Step15: If (path > 1)

Step16:{ if (path V_{sijd} from S to D && path V_{skld} from S to D)

{

Create rtable V_s via path V_{ij} to V_d Create energy table e_s via path e_{ij} to e_d Create rtable V_s via path V_{kl} to V_d Create energy table e_s via path e_{kl} to e_d

}

Step17: Find min-energy (e_i, e_j) if e_j energy minimum

Step18: Find min-energy (e_k, e_l) if e_k energy minimum

Step19: Find Max-eng (e_j, e_k)

Step20:{ if (ej

max-eng)

Select route V_s via path V_{ij} to V_d

}

Step21: End

}

On the basis of proposed algorithm any node in the network are always select the nodes that has a maximum energy value. It means that it solves the problem of link breakages in network. The problem in normal energy efficient routing is that nodes in the network are not aware about the energy values of nodes. If the sender has selected the low energy value node which has not trustful for communication then in that case the session between the nodes are suddenly expire by that the huge amount of energy is wasted. But in this proposed algorithm these chances are negligible it means that sender are not do the normal routing in network it apply the maximum (MAX) energy selection method and ignores minimum (MIN) value of nodes in network. And if the path in between the sender and destination is established then also compare the energy value of alternative path and select the best one on the basis of MAX energy value.

Simulation Environment: A simulation is defined as the process of creating a model of a real system and performing experiments with that model to either understand the system's behavior or evaluate different strategies for its operation, adhering to specific criteria0150. In this research, modeling and simulation played a crucial role, involving the development and application of various simulation techniques using the Network Simulator 2 (NS-2). All simulation tests were carried out with this widely recognized simulator in the research community, employing different topologies and methodologies.

A. Simulation Parameters Used: Table 1 are represents the following simulation parameters to make the scenario of routing protocols. On the basis of these parameters the simulation has done in this work.

Table 1 Simulation Parameters

Simulator Used	NS-2.31
Number of nodes	10,30
Dimension of simulated area	800m×600m
Routing Protocol	AODV
Simulation time	100 sec.
Traffic type (TCP & UDP)	CBR (3pkts/s)
Packet size	512 bytes
Number of traffic connections	5,30
Node movement at maximum Speed	random (20 m/s)
Transmission range	250m
Transmission Energy Consumption	1.5 joules
Receiving Energy Consumption	1 joules
Idle Energy Consumption	.17joules
Sleep Energy Consumption	.047

B. Performance Evaluation: There are following different performance metrics [4] have been considered to make the comparative study of these routing protocols through simulation.

1) Routing overhead: This metric describes how many routing packets for route discovery and route maintenance need to be sent so as to propagate the data packets. The lower value of routing load are represents the better network performance.

2) Packet Delivery Ratio: The ratio between the amount of incoming data packets and actually received data packets. The higher value of PDR is represents the better performance.

3) Average Delay: This metric represents average end-to- end delay and indicates how long it took for a packet to travel from the source to the application layer of the destination. It is measured in seconds.

4) Remaining Energy Analysis: This metric represents the energy utilization of each node in network. The more remaining energy represents the higher energy efficient utilization.

C. PDR Analysis in case of without Average Energy and Average Energy Scheme: The Packet Delivery Fraction (PDF) analysis is represents the successful percentage of data received at destination. This graph is represents the packet percentage in case of proposed average energy path section MAX energy based routing and previous normal energy shortest path selection routing. Here this graph represents the slightly more PDF in normal energy based routing or without average energy based routing but the routing load in that case are more shown in figure 2. If the routing load in network are more it means energy consumption are more by that the life of nodes are lost early as compare to proposed. It means PDF value is good not show that the overall performance of network are also better. The better PDF represents the better performance.

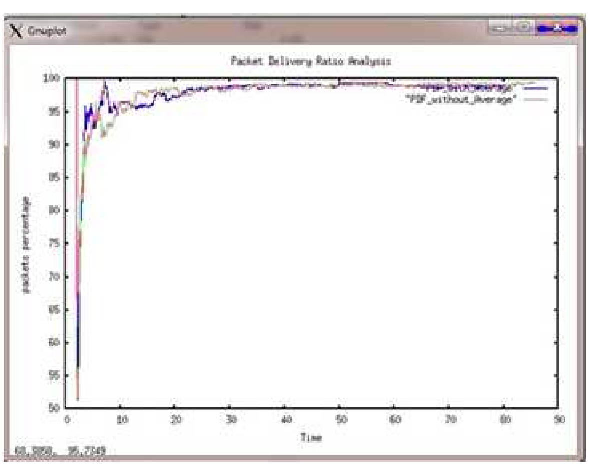

Fig. 1Packet Delivery Ratio Analysis

D. Routing Packets Analysis in case of without Average Energy and Average Energy Scheme: Routing packets in network are required to established connection in between source and destination. First routing packets are established connection with destination if destination replies to sender by connection confirmation packet. The routing packets in network are consumes energy it means minimum number of routing packets are deliver maximum amount of data packets in efficient routing. In this graph in case of previous without energy based or normal shortest path routing with energy factor the routing load are more it means the problem of connection failure are occur more hereby that the more routing packets are required then energy also required for routing packets transmission and in proposed work the route has selected on the bases of maximum energy and path selection is based on average energy of path in between sender and receiver by that energy consumption are reduces and minimizes the routing overhead.

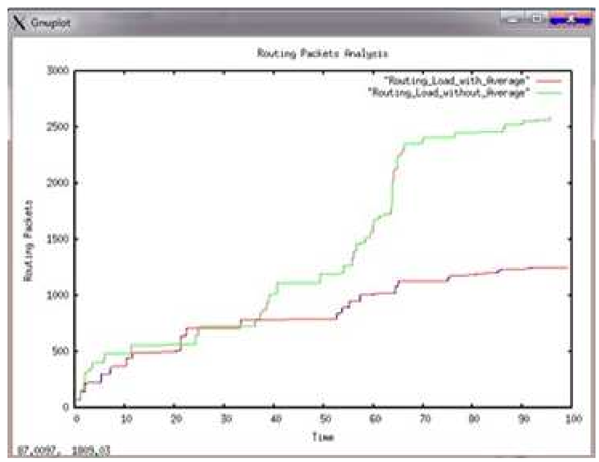

Fig.2 Routing load analysis

E. Energy Depletion in case of Average Energy Scheme

This graph represents the energy depletion of nodes in case of proposed scheme. In this graph we clearly notice the smooth depletion of energy from initial energy to energy remain in nodes after the end of simulation time. It means the proposed scheme based routing selection strategy are maintained the reliability in network.

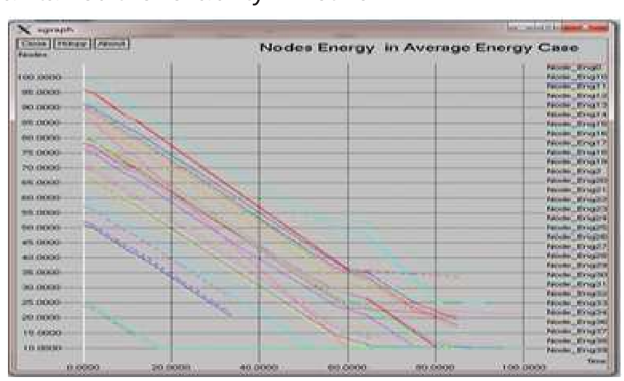

Fig. 3 Nodes energy depletion in Average energy based routing

F. Energy Depletion in case of without Average Energy: This graph represents the energy depletion of mobile nodes in case of without average energy based scheme. Here we clearly visualized that the lot of variations in energy graph it proves that the normal shortest path selection routing with energy factor are not sure to provide reliable connection in network.

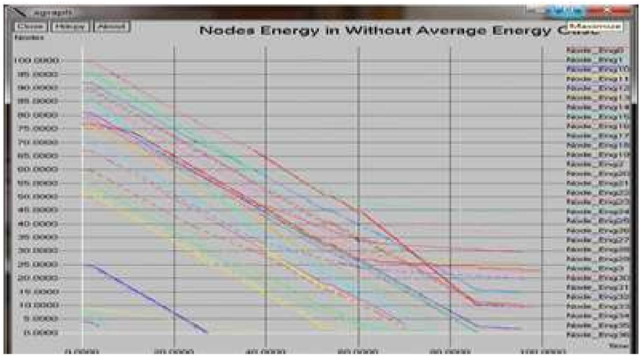

Fig. 4 Nodes energy depletion in without Average energy based routing

G. Nodes Remaining Energy Analysis in case of Previous and Proposed scheme: The remaining energy analysis of each node is discussed in table 2. Here the three column are represents the node number, remaining energy in without average case and remaining energy in case of average energy based path selection scheme. Here the remaining energy of nodes are represents the life time of network. In case of proposed scheme all nodes are secure their energy more as compare to normal energy scheme or previous scheme except node number 24, 29, 30. The entry of node energy 1,3,4,5 and 35 are written not consider means these energy in network are not utilizes for communication.

Table 1: Remaining Energy Analysis

Nodes	Node Energy Without Average	Node Energy With Average
0	10.216399	17.74694
1	1.90485	Not Consider
2	1.315566	14.18527
3	3.872496	Not consider
4	2.297087	Not consider
5	0.765903	Not consider
6	0.15649	12.19163
7	25.310699	20.8907
8	7.583608	10.16041
9	14.260953	19.48528
10	1.320336	14.2825
11	1.293378	20.67857
12	3.243234	10.09908
13	4.986916	10.52112
14	22.258056	24.60506
15	3.931185	9.999915
16	9.430502	24.57971
17	0.002004	9.995028
18	14.899458	35.50516
19	0.94109	9.993236
20	0.439222	10.00147
21	2.539103	15.43135
22	0.750769	9.994654
23	1.586133	14.91732
24	43.760524	33.70311
25	0.010526	9.996716
26	0.589155	21.70543
27	19.851297	10.01578
28	1.967195	26.671
29	36.247239	28.66886
30	22.871192	21.61472
31	0.075592	10.07274
32	9.315185	16.75454
33	23.721248	25.6697
34	0.002075	14.51893
35	1.861165	Not consider
36	0.876278	19.58919
37	5.650517	13.03849
38	29.617427	21.72932
39	0.427492	24.6721

Conclusion And Future Work: This table presents an overall analysis comparing the previous and proposed schemes. It is evident that the proposed average energy-based scheme enables a significantly higher number of packets to be transmitted across the network compared to the traditional routing method. The value of PDF are slightly low that also discuss Before but routing load and delay are definitely minimized which is the major unnecessary consumption of energy.

Table 2: Overall analysis

Parameters	Previous	Proposed
SEND=	5074.00	5532.00
E RECV =	5036.00	5472.00
ROUTINGPKTS=	2596.00	1254.00
PDF=	99.25	98.92
NRL=	0.52	0.23
Average e-e delay(ms)=	469.04	272.81

In future we apply this energy based scheme with location coordinated based routing and compare their performance with this research.

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