ENERGY-EFFICIENT POSITION BASED ROUTING PROTOCOL USING BACKPRESSURE TECHNIQUE FOR MOBILE AD HOC NETWORKS

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ABSTRACT

A mobile Ad-Hoc network is an infrastructure less temporary network without any centralized administration. In such network, all nodes are mobile and can be connected dynamically in an arbitrary manner. In mobile Ad-Hoc networks, limited power supply is a challenge. So energy efficient mechanisms should be combined with existing routing protocols to reduce node failure and improve the network lifetime. This paper presents an Energy-Efficient Position Based Routing protocol (EEPBR) using Backpressure technique for Mobile Ad Hoc Networks. The protocol deals with four parameters as Residual Energy, Bandwidth, Load and Hop Count for route discovery. The problem of the link failure in the channel during the call in progress thus leads to the degradation of the QoS (Quality of Service). To deal this we are using a Backpressure Technique. The simulation results show that the proposed algorithm is able to find a better solution, fast convergence speed and high reliability. The simulation results shows that the proposed EEPBR protocol achieve the above objectives and gives the better results than previous schemes like DSR. Our proposed scheme is useful for minimizing the overheads, maintaining the route reliability and improving the link utilization.

Keywords: *Bandwidth, Load, MANET and Residual Energy.*

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1. INTRODUCTION

Mobile ad hoc network is a collection of mobile devices which can communicate through wireless links. The task of routing protocol is to direct packets from source to destination. This is particularly hard in mobile ad hoc networks due to the mobility of the network elements and lack of central control. Source routing is a routing technique in which the sender of a packet determines the complete sequence of nodes through which it forwards the packet; the sender explicitly lists this route in the packet's header, identifying each forwarding "hop" by the address of the next node to which to transmit the packet on its way to the destination host. Source routing has been used in a number of contexts for routing in wired networks, using either statically defined / dynamically constructed source routes. The protocol presented here is explicitly designed for use in the wireless environment of an ad hoc network. When a host needs a route to another host, it dynamically determines one based on cached information and on the results of a route discovery protocol. Dynamic source routing protocol offers a number of potential advantages over conventional routing protocols such as distance vector in an ad hoc network. Source routing

is a technique in which the source node determines the entire sequence of nodes through which a packet has to pass. The source node puts the list of addresses of all nodes in the header of the packet, so that the packet is forwarded to the destination through those specified nodes. However source routing can be done statically or dynamically. Here it does dynamically. This is done using a procedure called route discovery. Whenever a node has packet to send to some other node, the first node initiates the route discovery. Each node maintains a cache called route cache to store the routes it has gathered to different destinations. To support efficient routing in energy constrained ad hoc networks, power-aware routing policies can be integrated and evaluated with existing features of routing protocol. Unlike conventional routing protocols, our protocol uses no periodic routing advertisement messages, thereby reducing network bandwidth. The proposed protocol enhances Dynamic Source Routing protocol with some Energy constraints to improve its performance [1] [12]. As the residual energy of nodes in an ad hoc network goes below threshold, some of the existing links break and the routes in the route caches of the nodes must be modified and alternative route may be used. The rest of the paper is organized as follows: we have given design space and related works in Section 2, Section 3 presents the proposed protocol, Section 4 discusses Simulation results and finally Conclusion and Future work is discussed in Section 5.

2. DESIGN SPACE AND RELATED WORK

The routing concept basically involves two activities first, determining optimal routing routes and secondly, transferring the information packets through network. There are various Energy-Efficient routing protocols which deal with the following constraints:

- Switching on/off radio transmitters to conserve energy [2][3],
- Power and topology control by adjusting the transmission range (power) of transmitters [4][5],
- Routings based on the energy efficient metrics [6][11].

The radio transmitters are turned off for an adaptively varying period to save power when there is no traffic [2]. In order to adapt to operational environment, several algorithms are proposed, for examples, using application level information and node density [2], and routing fidelity and location information [3]. Topology control is another approach, in which the transmission power is adjusted to achieve energy efficiency. For instance, the transmission power is changed while maintaining a connected topology by observing local and global topology information [4]. The node battery life is extended by using the radio's minimum power level. A distributed power control scheme is proposed, in which power control level is established by exchanging control messages, according to the estimated minimum and maximum power level [5]. There will be frequent link ups and downs, causing more link errors. Retransmission due to link breakage will consume extra energy and network bandwidth. For Metric-based routing [6] [7], different kinds of metrics are used to maximize the lifetime of networks by evenly distributing the energy consumption among all nodes. MBCR (Minimum Battery Cost) algorithm incorporates the battery capacity into the metric. In addition, the expected energy spent in reliably forwarding a packet over a specific link is considered in [8] [11]. In order to maximize the network life time, the cost function defined in [9] takes into account energy expenditure for one packet transmission and available battery capacity. Furthermore in [10], the queue load condition and the estimated energy spent to transmit all packets in the queue are considered.

2.1 Dynamic Source Routing Protocol (DSR)

The Dynamic Source Routing (DSR) protocol is an on-demand routing protocol. Mobile nodes are required to maintain route caches that contain unexpired routes and are continually updated as new routes are learned. The protocol consists of two major phases: **route discovery and route maintenance**.

Route Discovery is done by the source if it doesn't found any route for the destination in its route cache. It is done by broadcasting a RREQ packet to all the neighbors initiated by source then by every node that receives the RREQ packet, till the destination is found. When destination receives a RREQ packet, it replies source with a RREP packet along the reverse of the route recorded in RREQ. **Route maintenance:** Route maintenance is done by the use of route error packets and acknowledgments. RERR packet is send by a node to the source when the data link layer met a fatal transmission problem. When a RERR packet is received, the erroneous hop is removed from the node's route cache and all routes that contain that hop are truncated at that point [6].

3. PROPOSED ENERGY EFFICIENT ROUTING PROTOCOL

DSR is selected as the baseline routing protocol because it is an On-Demand routing protocol. It consists of two main phases: Route Discovery and Route Maintenance. Consider a Mobile Ad-Hoc network (MANET) with a collection of mobile nodes connected with each other through some routes shown in Fig 3.

3.1 Proposed Model for Route Discovery

The specific goal of this approach is to select a route that contain underutilized nodes so that the energy usage among all nodes can be balanced because underutilized nodes usually have more energy than utilized nodes. The approach compares not only energy but other parameters also for the route selection so this may result in shorter, best and energy-rich routing. Thus, ensures longevity of network lifetime.

Route Discovery: In this protocol the procedure of broadcasting the RREQ packet for Route Discovery is same as the DSR; the difference is in the **RREQ packet format**, shown in fig1:

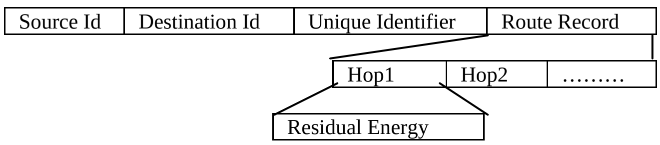

Fig 1. RREQ packet format

The intermediate node which receives the RREQ packet does the following:

a) It checks in its Route Cache for the existence of a route for the destination, if found it appends that route in a RREP packet and sends it to the source.

b) If the node had already received the request with the same Unique Identifier, it drops the arrived request packet.

c)If the node recognizes its own address as the Destination, then the packet reached the target. d)Otherwise, the node appends its own address in the Route Record and its residual energy in RREQ and rebroadcasts it to all its neighbors.

The destination selects the best route on the basis of different parameters like max Energy, max Bandwidth, min Load and min Hop Count among the entire route requests arrived. The destination replies to the source by sending a RREP packet (Fig. 2). The RREP packet goes along the reverse hop sequence of the best route and also contains the Final Route Table (Table 4). The Final Route Table is saved by each intermediate node and the source node in its route cache. The **RREP packet format** will be as

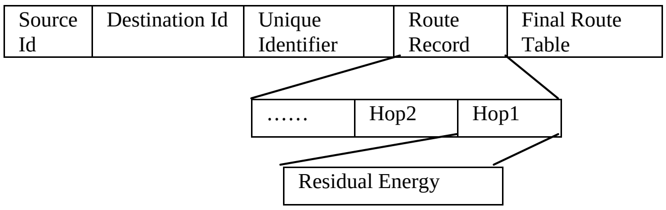

Fig 2. RREP packet format

3.2. Proposed Algorithm and Analysis

Let us consider few parameters as for a MANET shown in Fig 3:

H = Hop Count i.e. no. of edges in a route between source and destination

D_{ij} = Distance between any two nodes i and j

L = Load at a node

BW = Available Bandwidth at each node

E = Energy at each node

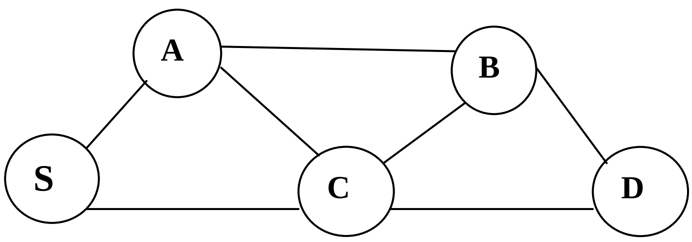

Fig 3. A mobile Ad-Hoc network

Table 1 show the total number of routes available between source S and Destination D with their Hop Count are:

Table 1: Routes with their Sequence and Hop Count

Routes	**Complete Route Sequence**	**Hop Count**
R1	S - A - B – D	3
R2	S – C – D	2
R3	S – A – C – B – D	4
R4	S – C - B – D	3
R5	S – A - C – D	3
R6	S – C – A – B – D	4

The load at the each node (Traffic Load) is:
L(S)=30, L(A)=10, L(B)=15, L(C)=20, L(D)=25

The Bandwidth of each node is:
BW(S)=40, BW(A)=25, BW(B)=20, BW(C)=30, BW(D)=35

The Energy of each node is:
E(S)=45, E(A)=40, E(B)=35, E(C)=30, E(D)=25

Now combined representation of all the routes with minimum possible values of all the parameters on each route is shown in Table 2.

Table 2: Minimum Value of all Parameters in each Route

Routes	**Load**	**Bandwidth**	**Energy**	**Hop Count**
R1	10	20	35	3
R2	20	30	30	2
R3	10	20	30	4
R4	15	20	30	3
R5	10	25	30	3
R6	10	20	30	4

For choosing an optimal route, following **Rule Set** should be taken into account:

Rule 1: If the routes are of equivalent Energy
Then
Route with maximum available Bandwidth will be considered.
Rule 2: If the routes are of equivalent Energy and equivalent Bandwidth:
Then
Route with minimum Load will be considered.
Rule 3: If the routes are of equivalent Energy, equivalent Bandwidth and equivalent Load also
Then
Route with minimum Hop Count will be considered
Rule 4: If the routes are not of equivalent Energy:
Then
1)Route with maximum Energy should be given preference
2)Route with maximum bandwidth should be given preference
3)Route with minimum Load should be given preference.
4)Route with minimum Hop Count should be given preference.

The preference order for selecting optimal route is as follows

Energy > Bandwidth > Load > Hop Count

Now tabular arrangement of the routes on the basis of above rule set and their positions is shown in Table 3:

Table 3: Position Based Arrangement of all Routes

Position	Hop Count	Load	Bandwidth	Energy
1	R1	R2	R2	R1
2	R3	R1	R5	R2
3	R5	R4	R1	R3
4	R6	R5	R3	R4
5	R4	R3	R4	R5
6	R2	R6	R6	R6

Now calculating the sum of positions of routes for all the different parameters (Hop Count, Load, Bandwidth and Energy) shown in Table3:

For R1: 1+2+3+1 = 7
For R2: 6+1+1+2 = 10
For R3: 2+4+4+3 = 14
For R4: 5+3+5+4 = 17
For R5: 3+4+2+5 = 14
For R6: 4+6+6+6 = 22
Now the **Final Route Table** (FRT) that will suggest the best and all the alternative routes:

Table 4: Final Route table

S. No.	Routes	Complete sequence	Position Count
1	R1	S - A - B – D	7
2	R2	S – C – D	10
3	R3	S – A – C – B – D	14
4	R5	S – A - C – D	14
5	R4	S – C - B – D	17
6	R6	S – C – A – B – D	22

From the Table 4, it is clear that the position count for route R1 is lowest. So R1 will be selected as the best route for sending data packets and the remaining routes will be used as backup routes. This table is send to the source node and will be used to select alternate routes for sending data packets whenever a link failure occurs in current route.

3.3 Route Maintenance Model

The Route maintenance is required when residual energy of any node goes below the threshold. After each transmission of packet, the energy factor is computed.

Energy consumed in one Transmission = (Available Energy before transmission - Remaining Energy after transmission)

The energy available for next transmission is computed as

Residual energy = (Remaining Energy after transmission - Energy consumed in one transmission)

```
If    (Residual energy > Threshold)
Then
   {
        The node is capable of transmitting the next packet.
}
Else
{
The node is unable of transmitting the next packet;
send a RERR packet to source.
   }
```

If any node tries to send the packet even when its energy is below threshold of the required energy then data packet will definitely be lost.

3.3.1 Proposed model using Backpressure technique for Route Maintenance

The Route maintenance procedure monitors the operation of a route in use and informs the source of any routing errors. When any node detects that its energy is not sufficient and it is not capable of transmitting the next packet resulting in link failure then in such condition following steps will take place.

a) The RERR packet is generated by the sinking node and sends to the source node by back tracking the route informing it about the link failure due to min residual energy. The RERR packet contains the addresses of the nodes at both ends.

b) On receipt of a RERR packet by intermediate nodes, all the routes to Destination node that will contain the sinking node are removed or truncated.

c) No need of the rediscovery of the route else alternate route from the Final Route Table is adopted by Source node if it still wants to communicate to Destination node.

Thus, the communication between source node and destination will not face link failure and time delay in next transmission of data packet (between the same source and destination) due to the loss of node’s energy.

3.5 Validation and Testing

Case 1: Let us consider above network and the route selected as R1 (S - A - B – D) for sending data packet, the residual energy of the node B is less than Threshold then B generates a RERR packet and send it to its predecessor which forward it to its predecessor and so on, till RERR reaches to the source. The source node truncate all the routes in its Final Route Table that will contain node B and updates this table with all possible alternate routes that will not contain node B for sending the next data packet. The updated Final Route Table is shown in Table 5. Now table 5 show that route R2 has the lower position count than R5, so R2 will be chosen as the alternate route, thus preventing the network failure.

Table 5: Table with alternate routes without node C

S. No.	Routes	Complete sequence	Position Count
1	R2	S – C – D	10
2	R5	S – A - C – D	14

Case 2: Let us Consider Case 1, after transmission of a data packet, if residual energy of node C of route R2 (Table 5) become less then threshold, then it will send a RERR packet to its predecessor node S. Now S will check table 5 for alternative routes that will not contain node C, but no such route exist. Then in this case, source S will rediscover the routes by retransmitting the CTS/RTS.

4. SIMULATION RESULT

The performance of the protocol is evaluated using simulation experiments with C++, Ns-2 simulator with Mobility Framework. A flat network is assumed as clusters Networks. A Node sends a packet, to set RTS (Request-to- Send) flags of its neighbors and the intended receiver sets CTS (Clear-to-Send) flags of its neighbors. Nodes whose RTS or CTS flag is set cannot transmit data, except the sender. Control packets have higher priority over data packets in simulations, Propagation delay is assumed to be negligible, and it is assumed that packets always arrive without any bit error. The source Node generates packets at a constant rate. Extensive simulation results obtained by varying several network parameters and workload configuration. The values of the network parameters used in simulations are those specified in the IEEE 802.11. We evaluate the performance improvement in terms of throughput due to the use of a densely populated network. Specifically, we consider a network of 5 to 40 Nodes with an increasing number of neighbors from 5 to 10 nodes. Each Node has a traffic flow with infinite demands towards one of its neighbors. Fig 4, Fig 5 and Fig 6 shows the throughput of all traffic flows, with available Energy and Channels Bandwidth.

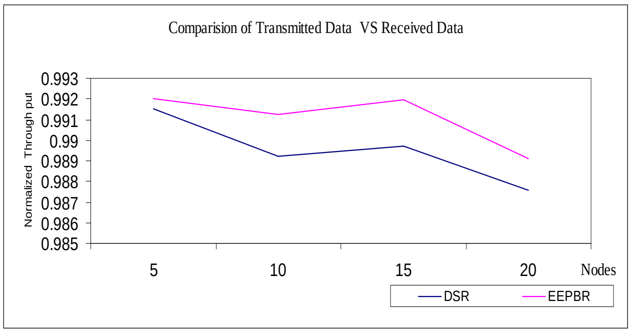

Fig 4. Comparison of Transmitted data with Received data

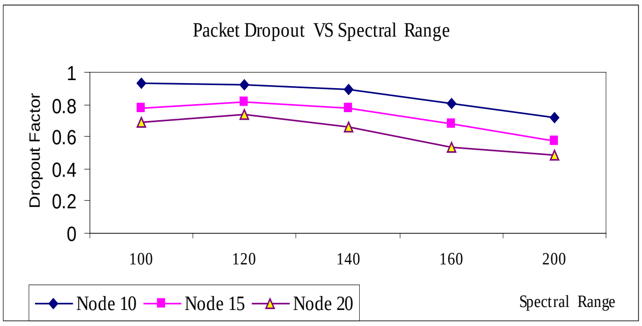

Fig 5. Comparison of Packet Dropout with Spectral Range

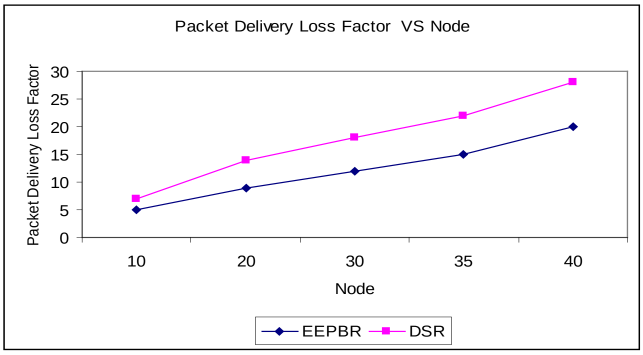

Fig 6. Comparison of Packet Delivery loss factor with node

5. CONCLUSION

The proposed energy efficient routing protocol works on DSR minimizes the overhead of source of rediscovering the routes whenever a network failure occurs due to a node's mobility or a node's failure by providing alternative route information to the source node and giving it a control of selecting the alternative route. It reduces network failure due to loss of node's energy and minimizes loss of data packets. It also balances the consumption of energy between utilized nodes and the underutilized nodes.

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