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ENERGY MANAGEMENT SCHEME WITH LOAD BALANCING FOR PREEMPTIVE DYNAMIC SOURCE ROUTING PROTOCOL FOR MANET

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ABSTRACT

Energy management issues are very important in the context of ad hoc networks. Energy needs to be optimally utilized so that the nodes can perform their functionality satisfactorily. MANETs are energy constrained as most ad hoc nodes to day operate with limited battery power. So, it is important to minimize energy consumption of the entire network in order to maximize the life time of the network. In this paper we proposed load balancing method for the new on-demand routing protocol (Preemptive DSR). As per the method, the PDSR selects a route at any time based on the minimum energy availability of the routes and the energy consumption per packet of the route at that time. The Simulation results shows that PDSR has increased packet delivery ratio and decreased delay compared with existing DSR.
Keywords:- *Load Balancing, MANET, DSR, PDSR, Energy Management, Overhead Reduction.*

1. INTRODUCTION

MANET is a temporary wireless network formed by a group of mobile nodes which may not be within the transmission range of each other. The nodes in MANET are self-organizing, self-configuring, self-maintaining and characterized by multi-hop wireless connectivity and frequently changing topology. MANET usually consists of battery-operated computing devices which cooperate with each other to transmit packet from a source node to a destination node.[5] The availability of each node is important for the enforcement of such cooperation. The failure of a single node can greatly affect the network performance. Since mobile nodes are usually battery-operated, one of the major reasons of node failure is battery exhaustion. In order to maximize the life-time of a mobile node, it is important to reduce the energy consumption of a node while transmitting packet. In this paper, we proposed an energy aware mechanism for on-demand protocol i.e Preemptive DSR which is the load balancing approach in which On-demand protocols select a route at any time based on the minimum energy availability of the routes and the energy consumption per packet of the route at that time.[8][9]

2. DYNAMIC SOURCE ROUTING

The DSR protocol consists of two mechanisms: Route Discovery and Route Maintenance. Route Discovery is the mechanism by which a node S wishing to send a packet to a destination D obtains a source route to D. To perform a Route Discovery, the source node S broadcasts a ROUTE REQUEST packet that is flooded through the network in a controlled manner and is answered by a ROUTE REPLY packet from either the destination node or another node that knows a route to the destination. To reduce the cost of Route Discovery, each node maintains a cache of source routes it has learned or overheard, which it uses to limit the frequency and propagation of ROUTE REQUESTs.[1][9]

Route Maintenance is the mechanism by which a packet's sender S detects if the network topology has changed such that it can no longer use its route to the destination D because two nodes listed in the route have moved out of range of each other. When Route Maintenance indicates a source route is broken, S is notified with a ROUTE ERROR packet. The sender S can then attempt to use any other route to D already in its cache or can invoke Route Discovery again to find a new route.[1]

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3. PREEMPTIVE DSR

Preemptive DSR is the modification to the existing DSR for MANET. Preemptive DSR can support very rapid rates mobility. The following steps explains the concept.[4]

A. Route Discovery

Step 1: When a source node S wants to send a data, it broadcast the RREQ packet to its neighbor nodes.
Step 2: When an intermediate node on the route to the destination receives the RREQ packet, it appends its address to the route record in RREQ and re-broadcast the RREQ.
Step 3: When the destination node D receives the first RREQ packet, it starts a timer and collects RREQ packets from its neighbors until quantum q time expires.
Step 4: The destination node D finds multiple, one will be primary (best route) and remaining will be backup routes from the collected paths (Step 3) within the quantum q time.
Step 5: The destination node D sends RREP packet to the source node S by reversing (RREQ) packets which includes multiple routes for further communication.

B. Route Monitoring

Step 1: Each intermediate node on the route starts monitoring the signal strength.
Step 2: If signal strength falls below the specified threshold T, it will send a warning message "Path likely to be disconnected", to the source node S.

C. The Source node S Communicates with destination node D

Step 1:The source node S starts Communicating with destination node D using primary path.
Step 2: On receiving the warning message from the intermediate node, it starts communicating destination node D with the second best route(determine from backup routes) also.
Step 3: If source node S receives acknowledgement form the destination node D go to step 4 else step 5.
Step 4: Preemption, switch over from Primary to Secondary.
Step 5: Initiates Route Discovery Process.

4. MATHEMATICAL ANALYSIS

A. Node Stability : Let g_i be the probability that node i is unstable.

$$g_i = \frac{\text{Total Motion time of node i}}{\text{Total motion time of i} + \text{total pause time of i}} \le 1$$

Pause time is the time duration that the node remains stationary. The node stability is defined as:

$$S_i = 1 - g_i$$

B. Link Stability : It is the Probability of the link i-j formed by nodes i and j is stable. Let S_i and S_j respectively denote the stability of nodes i and j. Then the link stability is given by

$$S_{ij} = S_i * S_j = (1 - g_i) * (1 - g_j)$$

C. Path Stability: A path is stable if all the intermediate links are stable. Let F_l denote the stability of the path l and S_{lij}. Be the stability of the link i-j along the path l. then we have.

$$Fl = Sl_{12} * Sl_{23} * \ldots\ldots Sl_{(n-1)n} = \prod_{\substack{i-1 \\ j=i+1}}^{n-1} S_{lij}$$

D. Assumptions :

We Assume the following to show that the use of multiple routes provide increased stability.

1. Number of intermediate nodes between S(Source) and D(Destination) is always n (fixed).
2. Same mobility for each node and hence every link has same probability of breakage.
3. Each node moves for a fixed period of time say m, randomly and then remains in rest for a fixed period of time P, which is the pause time. The probability of a node being stable at time T is given by.

Stability = Total Pause time up to time T/T. The in stability of a node is, Instability = 1-stability.

E. Mathematical Model

Consider a source node S and a destination node D, and a route R_o from S to D.

Probability that R_o will not fail (F_o) = Probability that all of the intermediate links will be stable.

$$F_o = \prod_{\substack{i=1 \\ j=i+1}}^{n-1} S_{oij} = \prod_{\substack{i=1 \\ j=i+1}}^{n-1} S_{oij} * S_{oj}$$

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Hence, the probability that R_o will fail = the probability that communication link will break.

$$\Rightarrow G_1 = 1 - F_o = F_o = 1 - \prod_{\substack{i=1 \\ j=i+1}}^{n-1} S_{oij}$$

$$= 1 - \prod_{\substack{i=1 \\ j=i+1}}^{n-1} S_{oi} * S_{oj}$$

Consider two parallel routes R_1 and R_2 between S and D.

Probability that R_1 will not fail,

$$F_1 = \prod_{\substack{i=1 \\ j=i+1}}^{n-1} S_{1ij}$$

$$= \prod_{\substack{i=1 \\ j=i+1}}^{n-1} S_{1i} * S_{ij}$$

Probability that R_2 will not fail,

$$F_2 = \prod_{\substack{i=1 \\ j=i+1}}^{n-1} S_{2ij}$$

$$= \prod_{\substack{i=1 \\ j=i+1}}^{n-1} S_{2i} * S_{2j}$$

Hence, probability that both R_1 and R_2 will fail.

$$\Rightarrow \; G_2 = (1 - F_1) * (1 - F_2)$$

$$= \left(1 - \prod_{\substack{i=1 \\ j=i+1}}^{n-1} S_{1ij}\right) * \left(1 - \prod_{\substack{i=1 \\ j=i+1}}^{n-1} S_{2ij}\right)$$

For simplicity, we assume that the stability of each link is S. So we have

$$S_{lij} = S, \; \forall_{i,j,k}$$

Therefore we have the probabilities

$$G_1 = 1 - \prod_{i=1}^{n-1} S = 1 - S^{n-1}$$

and

$$G_2 = \left(1 - \prod_{i=1}^{n-1} S\right) * \left(1 - \prod_{i=1}^{n-1} S\right)$$

$$= \left(1 - S^{n-1}\right) * \left(1 - S^{n-1}\right)$$

$$= \left(1 - S^{n-1}\right)^2 = (G_1)^2 \leq G_1$$

$$\left(Q 1 - s^{n-1} \leq 1\right)$$

In general, for the such parallel routes we would have

$$G_k = (G_1)^k$$

So, the probability of communication link breakage between source and Destination reduces exponentially if parallel routes are used. In other words, communication becomes more stable when multiple routes are used.

5. ALGORITHM FOR OVERHEAD REDUCTION

Step1: Source broadcasts Route Request packets which are heard by nodes within the coverage area
Step2: The neighboring nodes re-broadcast the route request
Step3: Destination sends Route Reply only to the first received Route Request.
Step4: Source address, destination address and previous node addresses are stored during route reply.
Step5: The data packet contains only source & destination addresses in its header.
Step6: When the data packet travels from source to destination, through intermediate nodes, for re-broadcasting of data packet, the node verifies

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source and destination addresses in its cache. If it is present, the data packets are forwarded, otherwise it is rejected.
Step7: After re-broadcasting the data packet, acknowledgement will be sent to the previous node[3]

4. LOAD BALANCING METHOD

In Load balancing method On-demand protocols select a route at any time based on the minimum energy availability of the routes and the energy consumption per packet of the route at that time. It is illustrated in the figure 1.

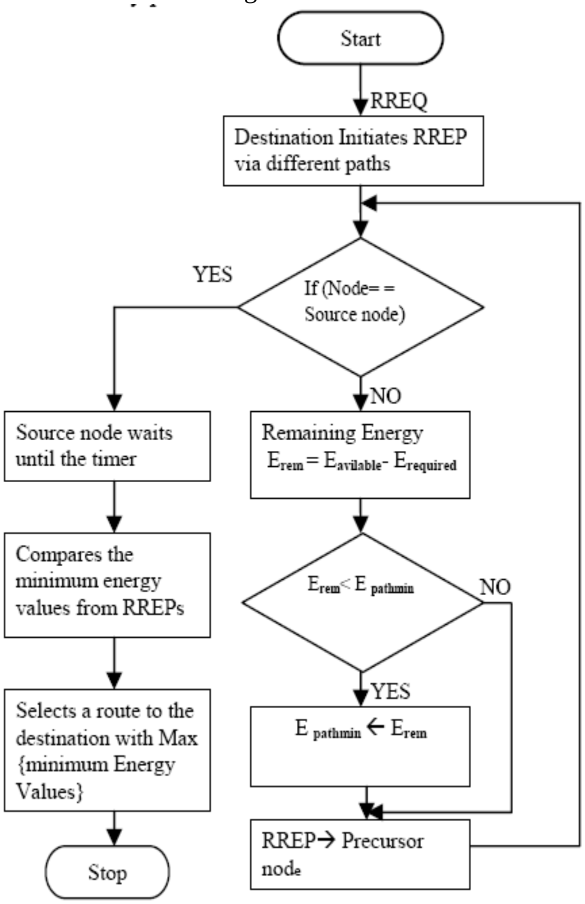

Figure 1: Flow Chart For Finding Highest Minimum Energy Node.

The available energy level and the required transmit power level of a node are taken into account while making routing decision. The subtraction of current available energy levels and the required transmit power levels of nodes indicate how likely these nodes will deplete battery energy. In order to do that a source node finds a minimum energy route at time t such that the following cost function is maximized.

C (E, t) = max {Erem} (1)
Erem=Eavailable(t) - Erequired(t) (2)

Where, Erem is the remaining energy of node, Eavailable(t) is the available energy of node, Erequired(t) is the required transmit power of a packet at node. The energy required in sending a data packet of size D bytes over a given link can be modeled as:

E (D) =K1 D+K2 (3)
K1= (Pt Packet +P back) ×8/BR (4)
K2= ((Pt MAC DMAC + Pt packet D header) × 8/BR) +E back (5)

Where, Pback and E back are the background power and energy used up in sending the data packet, Pt MAC is the power at which the MAC packets are transmitted, DMAC is the size of the MAC packets in bytes, Dheader is the size of the trailer and the header of the data packet, Pt packet is the power at which the data packet is transmitted and BR is the transmission bit rate [8]. Typical values of K1 and K2 in 802.11 MAC environments at 2Mbps bit rate are 4µs per bytes and 42µs respectively.

6. SIMULATION RESULTS

The proposed algorithm for Preemptive DSR is simulated to verify the predicted changes in parameters of packet delivery ratio and end to end delay at different pause times, with respect to the number of nodes in the network. The packet delivery ratio is the ratio of the number of packets received by the destination to the number of packets transmitted by the source. Packet Delivery Ratio reduces as the pause time decreases from 600 seconds to 300 seconds. This is due to the mobility of the network and the probability of link failures increases as the pause time decreases. It is observed that the Preemptive DSR maintains a better Packet delivery Ratio than the existing DSR.

The end-to-end delay is the time taken by a data packet to reach destination from the source. As the number of nodes increases, the complexity of the network increases and hence the end-to-end delay increases. As the pause time decreases, the mobility increases, which increases the probability of link failures and hence the end-to-end delay increases.

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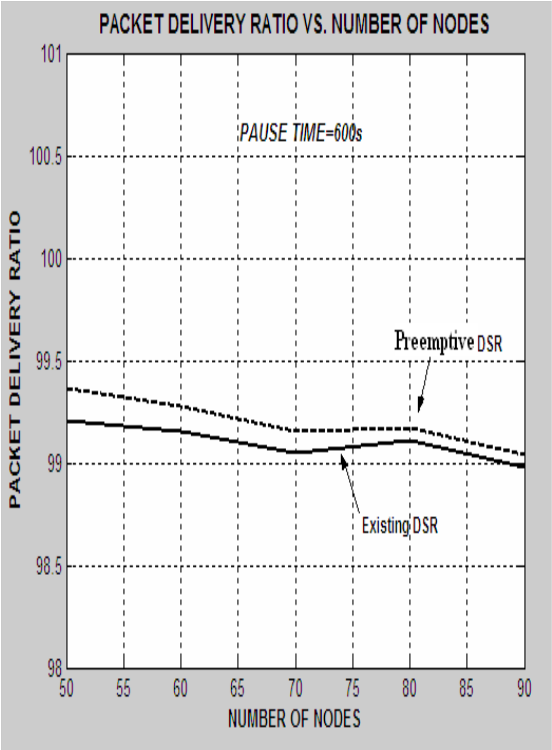

Figure 2: Packet Delivery Ratio Vs Number of Nodes (Pause Time=600s)

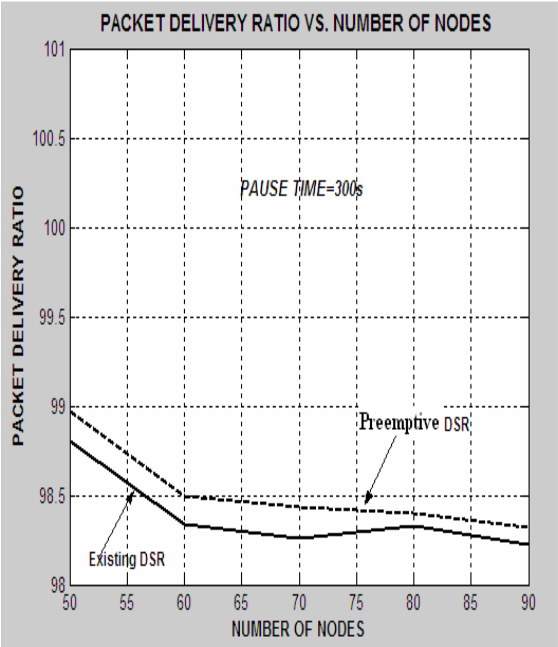

Figure 3: Packet Delivery Ratio Vs Number of Nodes (Pause Time=300s)

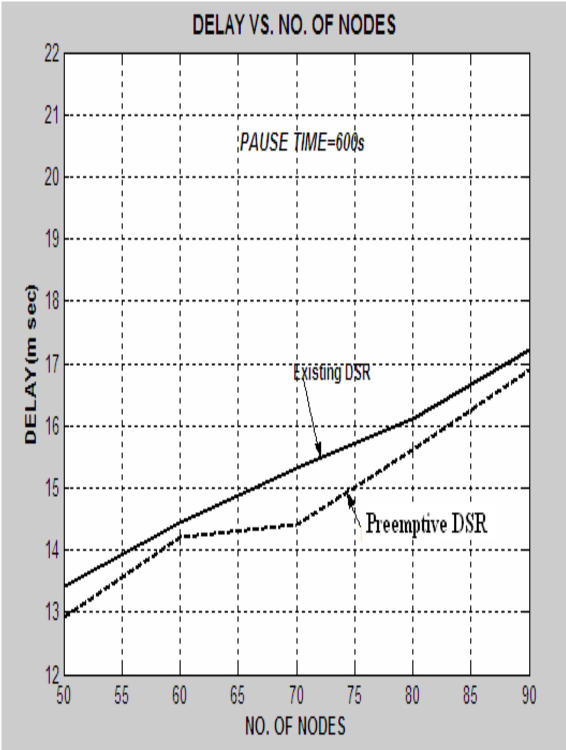

Figure 4: Delay Vs Number of Nodes (Pause Time=600s)

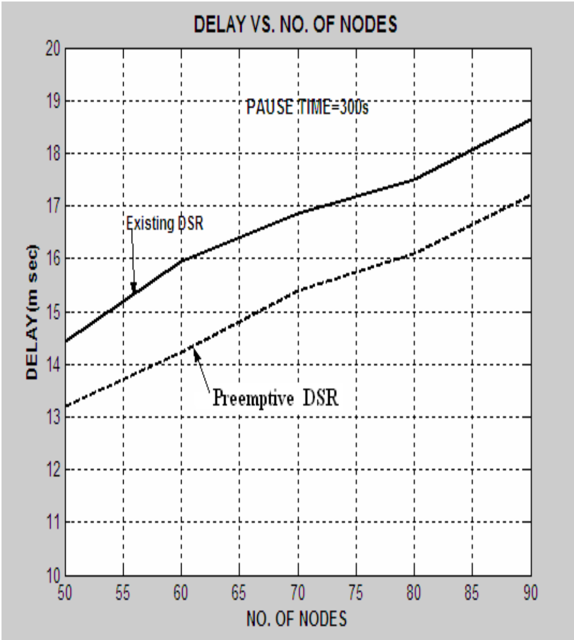

Figure 5: Delay Vs Number of Nodes (Pause Time=300s)

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7. CONCLUSION

It is observed that PDSR increases packet delivery ratio and end to end delay. The average percentage of energy saved per node is around 40%. This mechanism can be applied to any reactive routing protocol with minor modifications.

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