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A Novel Power Aware Routing Protocol for Mobile Ad-Hoc Networks

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Abstract: Mobile Ad-hoc NET work (MANET) is an autonomous system of mobile hosts connected by wireless links. The nodes in these networks have several constraints such: limited bandwidth, transmission range and mobility. Another parameter that significantly affects the network performance is the limited battery power of the nodes. This paper proposes a novel routing protocol that considers two parameters: Hop count and Total Transmission loss. On the basis of these two route metrics an optimal path is proposed. The proposed protocol is implemented in MATLAB-7.0 and our result also shows that our proposed protocol is better than other standard protocols such as MTPR (Minimum Total Transmission Power Routing) and AODV (Ad-hoc On-demand Distance Vector routing).

Keywords: MANET, MTPR, AODV, Hop Count, Transmission loss, Routing Protocols, Power Saving.

I. INTRODUCTION

Mobile ad hoc networks are multi-hop, wireless, infrastructure less collection of self-organizing mobile hosts that form a temporary cooperative network without the aid of any base station. The hosts are dynamic in nature i.e., they are free to move randomly, join or leave the network without notice and without disrupting the existing communication links. These networks can be created and used anywhere and anytime and intrinsically fault-resilient as they do not operate under a fixed topology.

Some features of MANET are listed below:

- MANET can be formed without any preexisting infrastructure.
- It follows dynamic topology where nodes may join and leave the network at any time and the multi-hop routing may keep changing as nodes join and depart from the network.
- It does have very limited physical security, and thus increasing security is a major concern.
- Every node in the MANET can assist in routing of packets in the network.
- Limited Bandwidth & Limited Power.

Regardless of the attractive applications, the features of MANET introduce several challenges that must be studied carefully before a wide commercial deployment can be expected. These include: Routing, Security and Reliability, Quality of Service, Inter-networking, Power Consumption, Multicast, Location-aided Routing, Congestion.
The objective of this paper is to design a routing scheme which chooses the most suitable path for communication among all the possible paths between source and destination in the ad-hoc environment. The nodes are randomly distributed in the simulation region. The selection of the path is made on the consideration of following parameters, Proper Hop_Count, Power optimization, Reduced congestion, Less end-to-end delay.
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II. TECHNIQUES USED FOR ROUTING UNDER CONSIDERATION

A. Minimum Total Transmission Power Routing (MTPR)

Due to considerations such as radio power limitations, power consumption, and channel utilization, a mobile host may not be able to communicate directly with other hosts in a single-hop fashion. Most ad hoc networks today operate on battery; the power-consumption problem becomes an important issue. To maximize the lifetime of ad hoc networks, the power consumption rate of each node must be evenly distributed and the overall transmission power for each connection request must be minimized. To support the lightweight, compact, portable computing devices, the power consumption problem is the critical issue for almost all kinds of portable device, including MANET. Power-aware routing protocols have been proposed based on various power cost functions. MTPR protocol to minimize the total transmission power consumption for the multi-hop communication. Since the transmission power is proportional to the transmission distance between two neighboring nodes, therefore MTPR protocol always selects a route with minimum total transmission power but with more hops, although the Dijkstra's shortest path algorithm was attempted to be used in MTPR protocol. However, MTPR protocol suffers longer end-to-end delay from the greater number of hopes [9].

B. Ad hoc On-demand Distance Vector routing (AODV)

AODV is an on-demand routing algorithm that determines a route only when a node wants to send a packet to a destination [23].It uses shortest path scheme which is based on Dijkstra algorithm [6]. Dijkstra algorithm is a solution to the single-source shortest path problem in graph theory. Works on both directed and undirected graphs. However, all edges must have nonnegative weights. It follows Greedy Approach. There are two types of routing-Link State routing and Distance Vector routing. Dijkstra is based on Link State routing. In Link State routing each router keeps track of its incident links and cost on the link, whether the link is up or down. Each router broadcasts the link state to give every router a complete view of the graph. Each router runs Dijkstra's algorithm to compute the shortest paths and construct the forwarding table. Thus, it chooses the path with min hops and topology changes can be detected with the help the help of beacons this algorithm is based on iterations.

III. PROBLEMS DEFINED

Initially MTPR was designed to reduce the total transmission power consumed per packet regardless of the remaining battery power of nodes. Since the transmission power required is proposal to the d^{α}, where d is the distance between two nodes and α is constant depends upon physical environment and lies between 2 and 4 [14]. MTPR prefer routes with more hops having short transmission ranges to those with fewer hopes but having long transmission ranges with the understanding that more nodes are involved in forwarding packets will increase the end-to-end delay. Since MTPR does not consider the remaining power present in the nodes so the nodes with low battery power will quickly run out if they participate in forwarding packets.
Limitations

- Doesn't bother about residual battery of a node
- Large number of Dead nodes
- Large end-to-end delay

The lifetime of a network is defined as the time it takes for a fixed percentage of the nodes in a network to die out. Since battery capacity is fixed thus a wireless mobile node is extremely energy constrained. Hence all network related transactions should be power aware to be able to make efficient use of the overall energy resources of the network. Thus a critical issue for MANET is that nodes are normally power constrained and leads to huge congestion in network. The power control problem in wireless ad hoc networks is that of choosing the transmit power for each packet in a distributed fashion at each node. The problem is complex since the choice of the power level fundamentally affects many aspects of the operation of the network [3]. It determines the range of a transmission. Thus determines the magnitude of the interference it creates for the other receivers which causes congestion. Power control affects the contention for the medium, as well as the number of hops and, thus, the end-to-end delay and throughput capacity. In AODV, due to less number of inter mediate nodes, the transmission power loss is reduced but leads to large overheads as:

- Overhead on the bandwidth, because RREQ & RREP packets needs to carry a lot information to validate a route.
- If the intermediate node does not have the latest destination sequence number it can lead to stale entries.
- Multiple RREP packets in response to a single RREQ packet can lead to large control overhead.
- The hello messages add a significant amount of overhead to the protocol.

IV. PROPOSED ROUTING SCHEME

This paper proposes a novel routing protocol that considers two parameters: Hop count and Total Transmission loss. On the basis of these two route metrics an optimal path is proposed. Our proposed protocol is better than other standard protocols such as MTPR (Minimum Total Transmission Power Routing) and AODV (Ad-hoc On-demand Distance Vector routing).

There are various issues in MANET; among all these issues routing has been one of the critical issues in the last decade. Various routing strategies have been developed to resolve these all issues. Here we also proposed a routing scheme which is hybrid of MTPR and AODV. We are of the opinion that MTPR strategy decreases total transmission power but at the same time introduces congestion that can be avoided by AODV routing protocol.

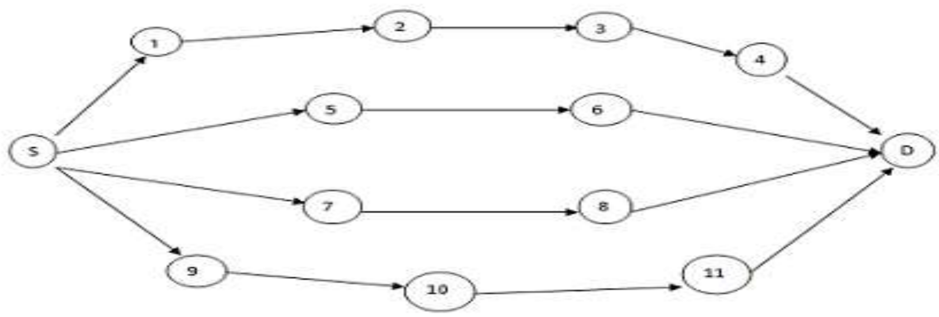

Figure 1: Various available paths between source and destination

Let us consider the above given Figure 1, here S is SOURCE node and D is DESTINATION node where we want to forward the packet. All 1-2-3-4-5-6-7-8-9-10-11 are various intermediate nodes for various possible paths. Let the distances between various nodes are given by a path matrix Table 1.

Table 1: Path matrix for giving distances between various nodes

Nodes	S	1	2	3	4	5	6	7	8	9	10	11	D
S	0	10	--	--	--	10	--	20	--	10	--	--	--
1	--	0	5	--	--	--	--	--	--	--	--	--	--
2	--	--	0	5	--	--	--	--	--	--	--	--	--
3	--	--	--	0	5	--	--	--	--	--	--	--	--
4	--	--	--	--	0	--	--	--	--	--	--	--	5
5	--	--	--	--	--	0	15	--	--	--	--	--	--
6	--	--	--	--	--	--	0	--	--	--	--	--	20
7	--	--	--	--	--	--	--	0	10	--	--	--	--
8	--	--	--	--	--	--	--	--	0	--	--	--	15
9	--	--	--	--	--	--	--	--	--	0	10	--	--
10	--	--	--	--	--	--	--	--	--	--	0	10	--
11	--	--	--	--	--	--	--	--	--	--	--	0	15
D	--	--	--	--	--	--	--	--	--	--	--	--	0

It is well known that the total transmission power scales with transmitted distance as d^2 to d^4 depending on environmental conditions. Here we consider total transmission loss is taken as kd^2. The losses of selected paths from source to destination may be as follows:

- The path1 (S-1-2-3-4-D) has total transmission loss as =k (10 * 10 + 5 * 5 + 5 * 5 + 5 * 5+ 5 *5) =200k units
- The path2 (S-5-6-D) has total transmission loss as =k (10 * 10 + 15 * 15 + 20 * 20) =725k units
- The path3 (S-7-8-D) has total transmission loss as =k (20 * 20 + 10 * 10 + 15 * 15) =725k units
- The path4 (S-9-10-11-D) has total transmission loss as =k (10 * 10 + 10 * 10 + 10 * 10 + 15 * 15) =525k units

Here we will find mean between MTPR path and AODV path i.e. mean of a path with maximum number of intermediate hops and a path with minimum number of intermediate hops. Here MTPR path is path1 and AODV path is path2 and path3 (any one of them can be consider). Thus mean is given as [(4+2)/2] = 3
Now again difference between number of intermediate node for an adopted path and mean value calculated is considered to select the proposed optimal path. We can easily understand with a Table 2 as given below:

Table 2: To select optimized path with proper Hop_count and min. transmission loss

Path available	Number of intermediate nodes existed	Mean calculated	Required difference
Path1	4	3	| 4-3 |= 1
Path2	2	3	| 2-3 |= 1
Path3	2	3	| 2-3 |= 1
Path4	3	3	| 3-3 |= 0

Thus path4 with "0" calculated difference is proposed path with minimum power transmission loss as there is proper Hop_count. This path also reduces congestion problem of a network also.

V. SIMULATION SET UP

Table 3 shows the values of various set up parameters used for simulation purpose in our paper.

Table 3: Set Up Parameters

Set up parameter	Value
Area of simulation Region	2000x2000 sq units
Nodes position	Random
Number of nodes	Varied from 40 to 60 Step size of 10
Routing algorithm	Dijkstra's Shortest Path
Transmission Range	300m
Packet transmission interval	0.1sec
Mobility Model	Random Walk
Number of packet sent	50
Number of iteration	4
Routing Protocol used	MTPR

A. PERFORMANCE METRICS

The following metrics has been used to evaluate the performance of MANET in the idealistic and realistic ones.

- **Packet Delivery Ratio (PDR)-**Defined as the ratio of total packets received by different destinations to the total number of packets transmitted by various source nodes.
- **Hop_Count-**Defined as the number of intermediate hops from source to the destination for successful transmissions.
- **Probability of reach ability (PoR)-**Defined as the ratio of total number of path actually formed by the network to the total number of path in the network.

B. SNAP SHOT

Snap shot for various numbers of nodes have been taken, as shown by the figures.

- As Figure 2 shows snap shot for 40 numbers of nodes.
- Figure 3 shows snap shot for 50 nodes
- Figure 4 shows snap shot for 60 nodes (A step size of 10 is taken)

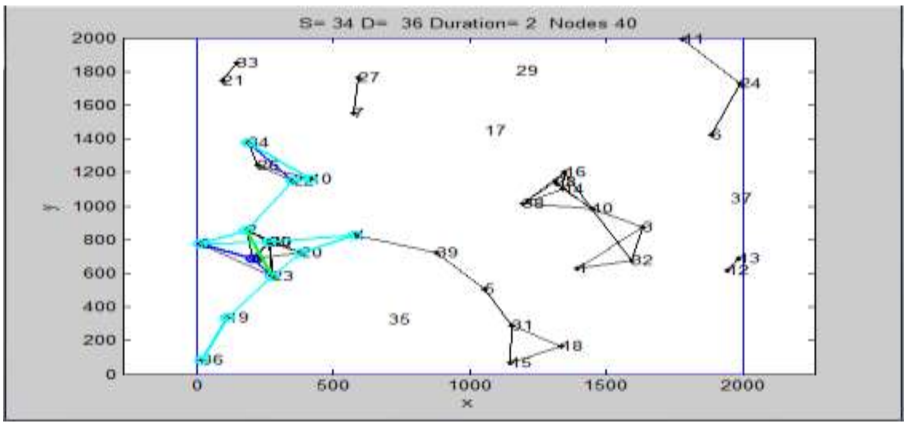

Figure 2: Snap shot for 40 nodes

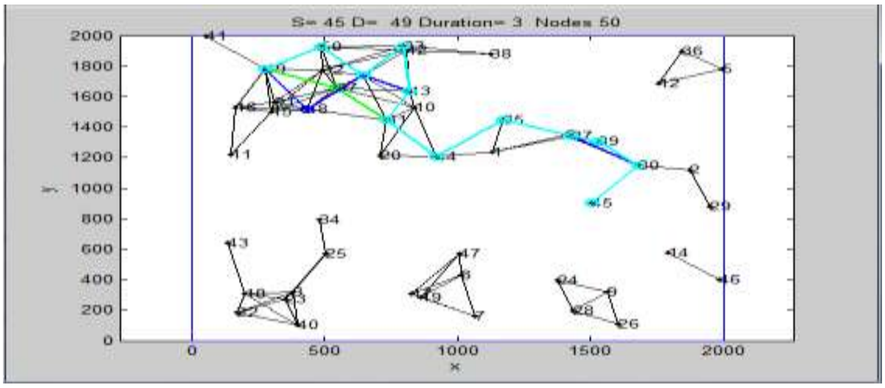

Figure 3: Snap shot for 50 nodes

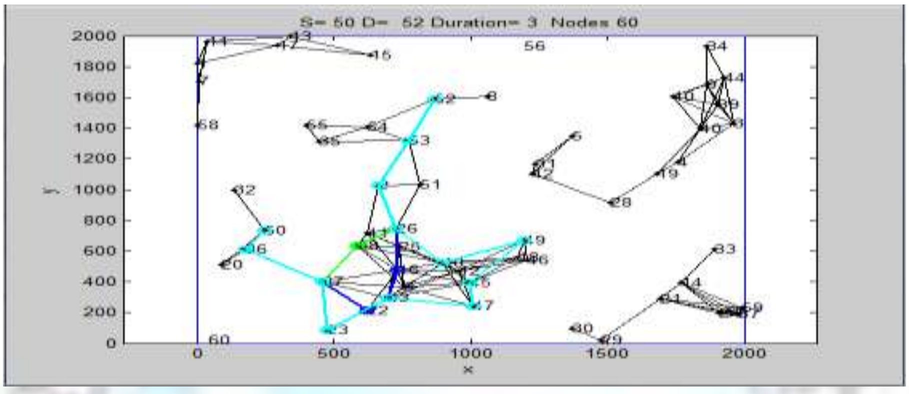

Figure 4: Snap shot for 60 nodes

C. SIMULATION RESULTS

- **Probability of Reach ability (PoR):** Figure 5 shows the change in PoR with increase in the nodes concentration.

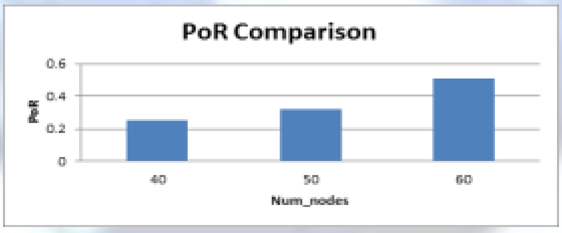

Figure 5: PoR Comparison

Inferences

- Value of PoR increases as the concentration of nodes increases in the simulation region.
- As the number of nodes increases, the likelihood of path formation between the nodes those are largely separated increases.

- **PDR Comparison:** Figure 6 shows the change in PDR values for different paths with the increase in the node concentration.

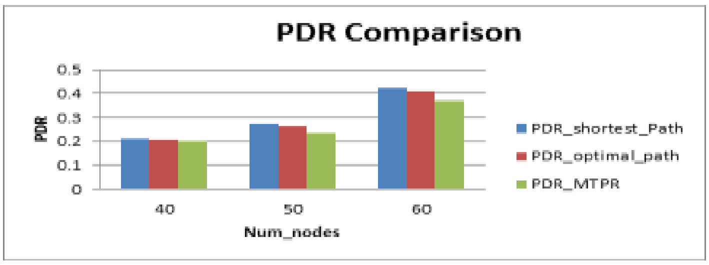

Figure 6: PDR Comparison

Inferences

- As the concentration of the nodes increases the PDR value enhances.
- The PDR values for different paths are approximately same for node concentration equal to 40.

The difference in the PDR values for shortest path and optimal path is small in comparison to the difference in the PDR values of optimal path and MTPR path.

- ❖ **Hop Count Comparison:** Figure 7 shows the change in Hop Count values for different paths with the increase in the node concentration.

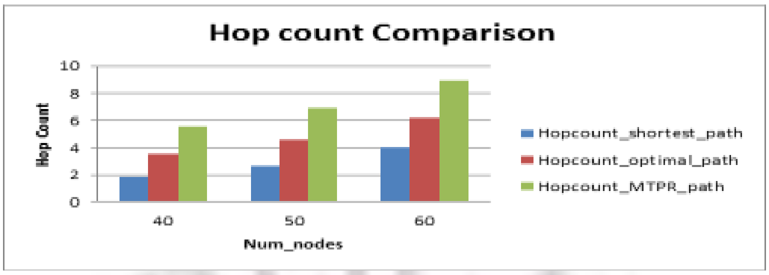

Figure 7: Hop_count comparison

Inferences

- Value of hop count for each node concentration is minimum for shortest path and highest in the case of MTPR path and hop count value for optimal path lies between the two.

With the increase in the node concentration the value of intermediate nodes (Hop count) involved in the path increases.

VI. CONCLUSION AND FUTURE SCOPE

In simulation part, we make a comparison among MTPR, AODV and our proposed scheme using various metrics such as Packet Delivery Ratio (PDR), Hop_Count, Probability of Reachability (PoR). As MTPR follow the path with maximum hops and leads to minimum loss of transmission power but leads to congestion. On the other hand AODV follows shortest path which maximize power loss but less congestion problem is introduced. Thus we proposes a hybrid scheme which follow an intermediate path among these two and leads to minimum transmission power loss along with the congestion problem. As the results shows this work have achieved all the objectives.

Ad-hoc networks, the most provoke term in wireless technology, approach to be the emperor of future airs provided the vision of “anytime, anywhere” communications. As the evolvement goes on, especially the need of dense deployment such as battlefield and sensor networks, the nodes in MANET will be smaller, cheaper and capable. Till today there are various issues in MANET, but at what speed new routing strategies are growing, soon ad-hoc networks will reach to its advance stage.

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