Constructing Minimum Spanning Trees in MANETs by Using Prim's Algorithm to Conserve Energy

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***Abstract*: Constructing routes with nodes of minimum energy is one of the fundamental functionalities of MANETs. Ensuring routes with no link failures has been a herculean task of MANETs. Utilizing the available battery levels in an effective way has been an in-built feature of MANETs. The route construction is based on the assumption that no link failure occurs. Because of the high dynamic nature of MANETs, it is very difficult to ensuring no route failures. With a view to minimize energy utilization in MANETs, a Minimum Spanning Tree construction by using Prim's algorithm can be considered.**

***Index Terms*: Minimum Spanning Tree, MANETs, Prim's algorithm, energy consumption levels, routes, link failures, nodes**

I. INTRODUCTION TO MANETS

Mobile ad-hoc (Wireless) networks (MANETs) have been much popular because of their infrastructure independent features and less cost[1][2][3][4]. These networks are very dynamic in nature because the network topology always changes from moment to moment as any node in the network may go out of the range at any time or any new node may join the network at any moment. The network topology changes the existing route paths correspondingly. And also the available battery energy is very limited so MANETs have to draw a small amount of energy from the battery[2][3][4]. In this scenario, route construction has been a prominent issue in MANETs. So many procedures have been in force to construct route paths in MANETs between the source and destination nodes. So in this paper Prim's algorithm in constructing Minimum Spanning Tree by using minimum energy units is proposed. Route strangeness is required in all the way to support reliable data transmission at any moment of time in MANETs. This increases the longevity of the network which is necessitated to make the network a hassle-free[4][5].

A simple MANET of 20 nodes between the source and destination nodes is considered with a battery of 60 joules. All these nodes can be called as intermediate nodes. This implies that each node gets a share of 3 joules. These MANETs can be created by using simulations like NS-2. A small range 20 meters is taken into consideration. Assuming all nodes are within the range of the network initially. By using energy savings algorithms, the energy levels of all nodes in the network are computed by NS-2 simulator. The following table contains the information of energy levels consumed by nodes.

Table 1: Energy consumption of intermediate nodes by NS-2, (these are energy levels of intermediate nodes)

Nodes	Energy Consumption in joules	Nodes	Energy Consumption in joules	Nodes	Energy Consumption in joules	Nodes	Energy Consumption in joules
Node1	2.92 j	Node6	2.85 j	Node11	2.91 j	Node16	2.84 j
Node2	2.86 j	Node7	2.81 j	Node12	2.88 j	Node17	2.90 j
Node3	2.91 j	Node8	2.86 j	Node13	2.90 j	Node18	2.89 j
Node4	2.79 j	Node9	2.83 j	Node14	2.94 j	Node19	2.78 j
Node5	2.75 j	Node10	2.82 j	Node15	2.77 j	Node20	2.87 j

Some energy levels are conserved by using efficient energy savings algorithms. From the Table 1 it is noticed that a total of 56.08 joules of energy is utilized by the MANET. The following algorithm is used to keep all energy levels of nodes in an ascending order.

```
Algorithm    AscendingOrder: (nodes, i, j)
             for i  ←  0 to n-1
               {
                 for j ← i + 1 to n-1
                   {
                      if  node(i) > node (j)
                         {
                                tempNode = node(i)
                                node(i) = node (j)
                                 node (j) = tempNode   }    }     }
                // displaying all elements n ascending order
                       for  i  ←  0 to n-1  print (i)  // End of the Algorithm
```

The MANET maintains a STACK to keep all energy levels of nodes in an ascending order i.e., the highest value is in bottom of the STACK and the lowest value is on the top of the STACK. Whenever there is a requirement to build a new path then the MANET makes use of this STACK and gets the related node by pop operations. If a new node joins the network then the STACK immediately executes the above algorithm to keep all energy levels of nodes in an ascending order in the STACK..Assuming all the nodes are divided into 4 zones or layers in the network. Again assuming zone-1 contains nodes from n1 to n5, zone-2 contains nodes from n6 to n10, zone-3 contains nodes from n11 to n15 and zone-4 contains nodes from n16 to n20 respectively. The following zone set up shows the layered division of nodes between the source and destination nodes

	n1 O 2.92	n6 O 2.85	n11 O 2.91	n16 O 2.84	
O source_node	n2 O 2.86	n7 O 2.81	n12 O 2.88	n17 O 2.90	O destination_node
	n3 O 2.91	n8 O 2.86	n13 O 2. 90	n18 O 2.89	
	n4 O 2.79	n9 O 2.83	n14 O 2.94	n19 O 2.78	
	n5 O 2.75	n10 O 2.82	n15 O 2.77	n20 O 2.87	

Here, n1 indicates node-1, n9 indicates node-9 etc., and the symbol O indicates node and the numbers after O indicates the energy consumed by the particular node[5][6]. Correspondingly, every zone maintains its own STACK such as STACK1, STACK2, STACK3 and STACK4 are individual STACKs of zon1, zone2, zone3 and zone4 respectively. Here, in the STACK1, nodes are arranged in the order n5, n4, n2, n3 and n1 respectively from top to down.. In the STACK2, nodes are arranged in the order n7, n10, n9, n6 and n8 respectively from top to down. In the STACK3, nodes are arranged in the order n15, n12, n13, n11 and n14 respectively from top to down and finally in the STACK4, nodes are arranged in the order n19, n16, n20, n18 and n17 respectively from top to down.

II. MINIMUM SPANNING TREES

In any given graph the minimum cost needed to reach from the source node to the destination node can be calculated by using the Minimum Spanning Trees[8][9]. They are very much useful in finding the minimum path route when weights are assigned to paths or nodes. Kruskal's and Prim's algorithms have been very popular algorithms to find the minimum cost routes from the source to the destination nodes. Between these two algorithms, Prim's algorithm has good performance efficiency than that of Kruskal's algorithm. In this paper, Prim's algorithm is applied to the MANET by using zones of the network and its STACK.. Prim's algorithm considers the weights assigned to the nodes[8][9]. This algorithm does not give any importance to the paths between nodes and always concentrates only on the weights attached to the nodes. To implement this algorithm assuming that a path is to be built between the source and the destination nodes by taking two nodes of every zone into consideration.

Now to construct a route which starts from the source to the destination, the MANET takes all the STACKs into consideration, thus on top of the STACK1, nodes n5 and n4 are available. From the STACK2, nodes n7 and n10 are available. From the STACK3, nodes n15 and n12 are available and finally from the STACK4, nodes n19 and n16 are available. As per this, the path can be, by using Prim's algorithm[9] :

O source_node → O node5 → O node7 → O node15 → O node19 → O destination_node

There is a back up node in every STACK of the MANET i.e., node4, node10, node12 and node16 are back up nodes of the STACKs from 1 to 4 respectively. For example, assuming, the node15 suddenly moves out of the radius of the MANET, then the previous node node7 sends an information to the source node about the route breakage with the node 15. Then, immediately the source node provokes the STACK3 to pop another node node12 into the network that will make an immediate connection with the nodes node7 and node19 to stabilize a new path without making any losses to the network. Then the route path is:

O source_node → O node5 → O node7 → O node12 → O node19 → O destination_node

Again assuming, if the nodes node7 and node19 are suddenly go out of the region then immediately, node5 and node15 send two separate messages to the source nodes. After receiving upon the respective messages, the source node then wake up the STACKs STACK2 and STACK4. Then STACK2 pops node10 and STACK4 pops the node16 respectively.

O source_node → O node5 → O node10 → O node12 → O node16 → O destination_node

If the node node5 suddenly drops from the link with the node7 and the source node then the node10 sends a message the source node regarding the link failure. Then the source node immediately wakes up the STACK1 for the node. In turn, the STACK1 pops the node4. Thus the node4 makes a connection between the source node and the node10. The new path has links as follows:

O source_node → O node4 → O node10 → O node12 → O node16 → O destination_node

This is the way how prim's algorithm works out by introducing a STACKs concept into MANETs. In finding the time complexity of Prim's algorithm both the edges and vertices are to be considered. It is O (E log V), here O is Big-oh notation, E is the number of edges and V is the number of vertices in the network. If the number of new nodes are joining the MANET, then the volume of the MANET enlarges proportionately. Even the volume is very high, the time complexity of Prim's algorithm remains same. Its efficiency can never be degraded. But the time complexity of Kruskal's algorithm increases as volume of the MANET increases accordingly. Even though both the Kruskal's and Prim's algorithms have the same time complexity of O (E log V), Prim's algorithm is always efficient and reliable than Kruskal's algorithm[9]. Thus in MANETs, construction of routes can be on the basis of the Minimum Spanning Trees of the network. Here more memory may be needed to accommodate the sub-STACKs but they always help the routes to continue with less number of link failures. This improves the rate of transmission of the network, in turn the quality of the MANET is improved. Also maintaining more sub-STACKs is far better than maintaining a single large STACK, which needs more energy than small STACKs. If a single large STACK is maintained, then it needs more push and pop operations so more energy can be consumed to maintain those operations. Less number of operations are expected from small STACKs this implies a few amount of energy can be spent on these operations.

This is a sample network (MANET) by taking the transmission rate and the size of the data packets are constant. Even though if a few fluctuations take place[5][6][7], Prim's algorithm gives the standard results as it won't take the external conditions into considerations. By applying the Prim's algorithm, it is understood that, the nodes with high energy levels will be handled at last transmissions. So this principle helps MANETs to retain the maximum energy levels in the MANET itself[3][4][8]. These energy reserves make fuel to the increase the transmission durations of the network as a whole. This shows, practically, the working efficiency and functioning of Prim's algorithm in making route building in MANETs[[8][9].

III. APPLICATINS OF PRIM'S ALGORITHM

Since, it belongs to the family of Greedy Technique it is more conduce on its part in searching routes or paths in Graphs. The same mechanism can be applied to all situations where Optimization (minimum) is needed. Prim's algorithm is purely based on weights assigned to nodes and it never considers the length of the edges in the network unlike Kruskal's algorithm which always considers the lengths of the edges. Some amount of energy may be consumed in traversing through the edges to reach the node, but the energy it consumes is within the permissible limits of available energy[5][6][7][8].

IV FUTURE SCOPE OF THE PAPER

Prim's algorithm always makes use of small energy levels of available nodes. The nodes with high energy levels will be used at last. In case, all minimum energy levels of nodes are utilized and only nodes of high energy levels are remaining then, if these energy levels will be used to transfer some amount of energy to nodes on the top of the STACKs, then nodes can always have certain amount of energy but not more than that limit[5][6][7][8]. If this concept prevails in MANETs, then the lifetime of MANETs will be increased to a maximum extent. It can be like maximum utilization of limited battery levels to extend the duration of MANETs to a maximum level.

REFERENCES

[1] B. L. Sun, C. Gui, Q. F. Zhang, H. Chen, "Fuzzy Controller Based QoS Routing Algorithm with a Multiclass Scheme for MANET, "International Journal of Computers, Communications & Control, Vol. IV, No. 4, 2009, pp. 427-438.

[2] Banner R., Orda A.. Multi-path Routing Algorithms for Congestion Minimization. IEEE/ACM Transactions on Networking,vol. 15(2), April 2007, pages 413-424.

[3] B. L. Sun, C. Gui, Q. F. Zhang, et al, "A Multipath on-Demand Routing with Path Selection Entropy for Ad Hoc Networks, " Proceedings of The 9th International Conference for Young Computer Scientists (ICYCS 2008), Zhang Jiajie, Hunan, China, 18-21 November, 2008, pp. 558-563.

[4] P Ng, S Liew. Throughput Analysis of IEEE 802.11 Multi-hop MANETs Networks. IEEE/ACM Transaction on Networking, June 2007.

[5] Multipath Routing As a Tool To Improve Quality of Services In MANETs, by Mr.DVSS. Subrahmanyam and Dr. T.Ch. Malleswara Rao, in International Journal of Advanced Research (IJAR), UGC Recognized Journal with ISSN 2320-5407, Int.J.Adv.Res.1669-1673 , vol 5, issue 4, April, 2017 www.journalijar.com

[6]: Performance Betterments of Disjoint Paths in Designing an Efficient Multipath Routing In MANETs, by Mr.DVSS.Subrahmanyam and Dr.T.Ch.Malleswara Rao, in International Journal of Innovative Research In Computer And Communication Engineering (IJIRCCE), UGC Recognized Journal with ISSN 2320-9801, volume 5, issue 4, April 2017 www.ijircce.com

[7] Forecasting Energy Requirements of Intermediate Nodes in MANETs, by Mr.DVSS.Subrahmanyam and Dr.T.Ch. Malleswara Rao, in International Journal for Research in Applied Science & Engineering Technology (IJRASET),UGC Recognized Journal with ISSN 2321 – 9653, volume 7, issue 1, January 2019, www.ijraset.com

[8]:Correlation Techniques To Measure The Degree Of Association Between Nodes Of Different Protocols In MANETs, In Terms Of Their Energy Consumption In Data Transmission, by Mr.DVSS.Subrahmanyam and Dr.T.Ch. Malleswara Rao, In International Journal of Scientific Research in Science, Engineering and Technology (IJSRSET), UGC Recognized Journal with ISSN 2394-4099, www.ijsrset.com

[9] Wikipedia- Greedy Technique / Prim's Algorithm