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Energy Efficiency in Wireless Network: Through Alternate Path Routing

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***Abstract*—Energy is a critical resource in the design of wireless networks. Since wireless devices are usually powered by batteries. Battery capacity is finite and the progress of battery technology is very slow with capacity expected to make little improvement in the near future. Under these conditions many techniques for conserving power have been proposed to increase battery life. In this dissertation we consider energy consumption cannot be achieved by routing through shortest path. By taking the shortest path energy of a small set of nodes decreases very rapidly as compare to other nodes, making the nodes to die which leads network to partition. So to maximize network life instead of using the shortest path try to use alternate path to avoid congestion. In this paper we propose one algorithm of finding alternate routes in wireless network which may decrease energy consumption by sharing the load and avoiding congested path and retransmission.**

I. INTRODUCTION

Ad hoc networks are dynamically formed, infrastructure-less, wireless multi-hop networks. They can be deployed anywhere without the need for any fixed infrastructure like base stations. The nodes configure themselves into a network and cooperatively maintain network connectivity. An intermediate node is used to forward packets if two nodes wishing to communicate are not within transmitting range of each other. Hence each node acts as a router and a host. The nodes discover multi-hop routes to each other by exchanging topology information in the form of control messages. These networks are typically deployed where there is no infrastructure available or reliable, and fast network establishment and self-reconfiguration are required. The nodes can be deployed in a large scale to establish network dynamically. These networks can withstand harsh environmental conditions. For example, soldiers in a battlefield can have handsets to communicate with each other, or in emergency situations like earthquakes where the existing infrastructure has been destroyed, an ad hoc network can instantly be deployed to aid in disaster recovery, meetings or conventions in which persons wish to quickly share information, and data acquisition operations in inhospitable terrains. Sensor networks are a subclass of ad hoc networks wherein a group of sensors capable of making various measurements exchange information with each other. Routing in ad hoc networks has been extensively studied over the past several years. Traditional routing protocols can be broadly classified into three groups [5]: source initiated (reactive/on demand), table driven (proactive) and hybrid. In the source initiated protocols, the routes are not computed until needed. This introduces a route-computation delay for the packets. In cases where this latency is not acceptable, table-driven protocol is used. In these protocols, routes to all destinations are pre-computed and stored as routing tables. The nodes update their routing tables periodically by exchanging routing table update packets. These initial routing protocols are only concerned with maintaining network connectivity in a highly dynamic environment and mainly deal with issues like route discovery and route maintenance. The routing decision is based more on the position of the node in the topology thus has the tendency to burden certain nodes with forwarding packets.

In order to facilitate communication within the network a routing protocol is used to discover routes between nodes. The primary goal of such ad hoc network routing protocol is correct and efficient route establishment between a pair of nodes so that packets can be delivered in a timely manner [2]. Along with that energy efficiency is a critical issue in ad hoc network for longer network connectivity.

Energy conservation is an important issue in ad hoc networks as nodes are usually battery powered. Even though a node may not have any message of its own to transmit, its battery is drained when it acts as a router and forwards packets for other nodes. In ad hoc network, all nodes are deployed anywhere where fast network establishment is required. All nodes take part in route selection. During route selection procedure a typical mobile node may exist in three modes: (a) transmit, (b) receive and (c) standby. In transmit mode a mobile unit uses its maximum power level to transfer packet to another node, wherever in standby mode a node has nothing to do. Still least amount of energy is consumed as it is in ideal mode. The sources of power consumption, with regard to network operations, can be classified into two types: (a) communication related and (b) computation related. Communication involves the cost of sending data along with control packet from source, routed through intermediate node and cost at receiving at destination end. It mainly deals with the cost of routing in network or in path establishment. Whereas computation

mainly involves the cost of using cpu, main memory, disk drives and other components of computer for calculating computation related cost.

The design objectives of energy aware routing are two folds: (a) Selecting energy-efficient paths and (b) Minimizing the protocol overhead incurred for acquiring such paths [6]. Since at each time we are taking the shortest path, so the nodes along this path are continuously used. By this, energy of these particular nodes drain rapidly than any other nodes, causing node to die before other nodes of network. By this network get partitioned and connectivity is decreasing. For this reason energy conservation is an important issue from several years. The energy efficiency should be obtained at each layer of network.

To make energy conservation we use shortest path in a view to use less number of nodes to describe path. But by doing such energy of a particular group of nodes are decreasing rapidly causing network to lose connectivity. To overcome such situation we use alternate path scheme by assuming that by taking alternate paths energy of a group of nodes are using at a particular instant in a respective way. By this all nodes of a network take active participation in route selection; overall energy expenditure of a network is minimized, causing maximization of network life.

The remainder of this paper is organized as follows. Section II discusses about the previous work. Section III gives idea about proposed plan, where section IV describes the algorithm for alternate path finding in wireless network. Finally we conclude our paper in section V.

II. PREVIOUS WORK

While a network is set up, each node is leveled with a threshold value of energy. The node's energy is decreasing gradually as it is used in network connectivity. The remaining energy left with the node gives the idea of its cost.

$$\text{Cost of a node} \quad \alpha \quad \frac{1}{\text{Re}\,sidual_Energy} \quad . \qquad (1)$$

So the less is the energy the more is the cost of using that node in a network. All mobile should drain their power at equal rate as a minimal set of mobile exists such that their removal cause network to partition. Such node is called as a critical node. The route between these two partitions must go through one of these critical nodes. A routing procedure must divide the work among these nodes to maximize the life of the network. This problem is similar to load balancing problem. A packet to be routed through a path contains mobiles having grater amount of energy though it is not a shortest path. Delay is minimized as there is no congestion and nodes having less number of loads. For example if in a network to forward our packet we have chosen the shortest path to transfer my packet. But let my packet number is 11 to transfer it through the shortest path. Then my packet gets a chance after sending 10 numbers of packets which are already there in node's queue. So there is a serious delay while using shortest path as it is heavily loaded as compare to longest path, which may not be loaded as much as the shortest path. However each node in a network has definite period of life i.e. it is actively participate in n number of paths to transfer n number of packets. If we are using that particular node in n+1 number of paths then it will reduce energy and tend to die earlier than other node in the network. So all the nodes in a network should give an equal chance, or the node is to be selected in round-robin fashion. Because death of one node causes network to lose its connectivity which leads a serious delay in packet receiving. So all the nodes in a network are equally important and no node must be penalized more than any of the others. It ensures that all nodes in a network will remain up and running together for as long as possible, by increasing the longevity of our network which is our main criteria.

III. PROPOSED PLAN

In a network while calculating the path between the source and destination, the care should be taken such that all mobiles should drain their power at equal rate, as a minimal set of mobiles exist such that their removal cause network to partition. While establishing a path the cost of a node is inversely proportional to their residual energy. So by taking the shortest route rapidly the energy of a particular set of nodes decreases at a faster rate as compare to the other nodes. So finally one situation may arise in which these nodes are having no power and tend to die soon as compare to other nodes. So network connectivity is minimized. So to avoid this packets to be routed through a path contains mobiles having grater amount of energy through it is not a shortest path. That means in one instance we are taking the shortest path and in another time we go for longer path. If this path consideration is to be taken in alternative way then all nodes take in active participation in route selection causing no node to die first as compare to other nodes. Delay is minimized as there are no congestion paths in network and nodes having less number of loads.

So our proposed plan is to select the alternate routes in a network by avoiding critical node in route selection. Their advantage is that the traffic load is shared and congestion paths are avoided. By finding the alternate routes if one path fails then routing takes place through the second path avoiding delay in packet receiving. By doing such energy expenditure in contention and retransmission is minimized. No node depletes their power rapidly as compare to any other node in the network. So there is no network partition causing maximization of network life. If there is more than one path then one path acts as primary path and other as backup paths. If primary path fails then load is transferred to backup paths. Fig 1 shows a network structure. In this network node 6 is used rapidly for any route 0-3, 1-4 and 2-5. Since in any route selection node 6 is used for shortest route, so its battery power decreases rapidly as compare to

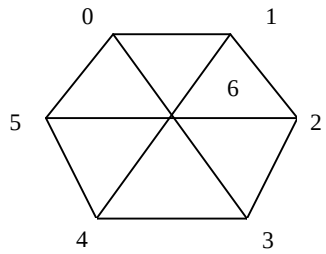

Figure 1. A network illustrating the problem with energy/packet as a metric

other node. As a result node 6 will spend its battery resources at a faster rate than any other nodes in the network and will be the first to die as compare to the other node causing minimization of network life. To avoid this situation if while establishing the route from source to destination we go for alternate route selection then node is penalized more as compare to other node in the network. For example to establish route between 0-3 we can go in the path 0→6→3 or 0→1→2→3 or 0→5→4→3. By transferring the packets through these three alternate paths no node is used rapidly as compare to other node in the network. So network life time is maximized by sharing traffic load and minimizing congested paths. Now the next task is to find the procedure which will help to find all possible paths in a network. For finding the alternate paths we are taking the help of queue and the procedure is explained in section IV.

IV. ALGORITHM FOR FINDING ALTERNATE PATH

In this section we propose our algorithm to find out alternate routes in a network to maximize network life. By running the algorithm all possible paths are determined in a network, then packet is routed through alternate paths. Before going to the algorithm find out list of neighbor's of all nodes. For evaluation of algorithm a priority queue is considered. Considering that the front node of a queue has to be processed first as it has highest priority than other. In a queue if front=rear=1, then queue contains one item.

The nodes of network are assumed to be in various state defined by their statuses.

Such that:

- Status 0: Switch off state
- Status 1: Ready state
- Status 2: Waiting state
- Status 3: Processed state

Algorithm for shortest path():

1. Initialize all nodes of network to ready state (Status=1).
2. Put the source node in queue and change its status to waiting state (status=2).
3. Repeat step 4 to 6 until queue is empty or destination is reached.
4. Process front node N of queue and change its status=3. front=front+1
5. Add at rear end of queue all the neighbor's of N that are ready state and change their status to waiting state (status=2). rear=rear+1
   Don't add repeated nodes.
6. As neighbors are added keep track of their origin. End of step 3.
7. As destination is reached stop and find the path traversing from destination in a reverse order by tracking the origin till source node at origin is reached. Then switch of all nodes coming in the path for energy conservation due to idle state.
8. Go to step 3 and process to front node.
9. Exit.

Initially all the nodes are in switch off state or in status 0. After the network is set up all nodes are ready state or in status 1. Then the source node 1 is put in a queue by changing its status to 2. In a queue, process the front node of a queue by changing its status to 3 and adding its neighbor nodes as given in adjacent list in table 1. The adding of new nodes and processing the front node is continued till the destination node 11 is reached. After getting the destination node the path is finding out by traversing in backtrack till getting the source node. After getting one path the nodes in that particular path are go to idle state i.e. to status 0 or to switch off state to minimize energy consumption due to idle state. Then process is continued starting from the next front node of queue to get another path. By running this method all possible paths are computed which make maximization of network life.

Fig.1 gives an example of a network structure, in which we are going to apply our algorithm. But before that we have to first find out the adjacency list of each node, which is given in Table I. After getting the adjacent list of each node path finding procedure begins by entering the source node 1 in queue and processes it to get all available paths in network.

After getting the adjacent list finding the path starting from the source node. By taking network structure in fig.1 we get three paths, such as:

1→2→3→4→11
1→5→6→7→11
1→8→9→10→11

In these three paths no node is repeated or duplicated i.e. all nodes are given with equal priority in route selection procedure. They deplete their energy at equal level, so no node die before any other node in the network. Since packet is routed through alternate paths the traffic load is shared. So there is no unnecessary delay in forwarding packets. As different paths are considered so there is a little chance of collision in packet forwarding, and hence no energy consumption due to retransmission.

In our algorithm, we propose that after getting one path the nodes of that path are going to the sleep mode to avoid unnecessary energy consumption. In their next requirement

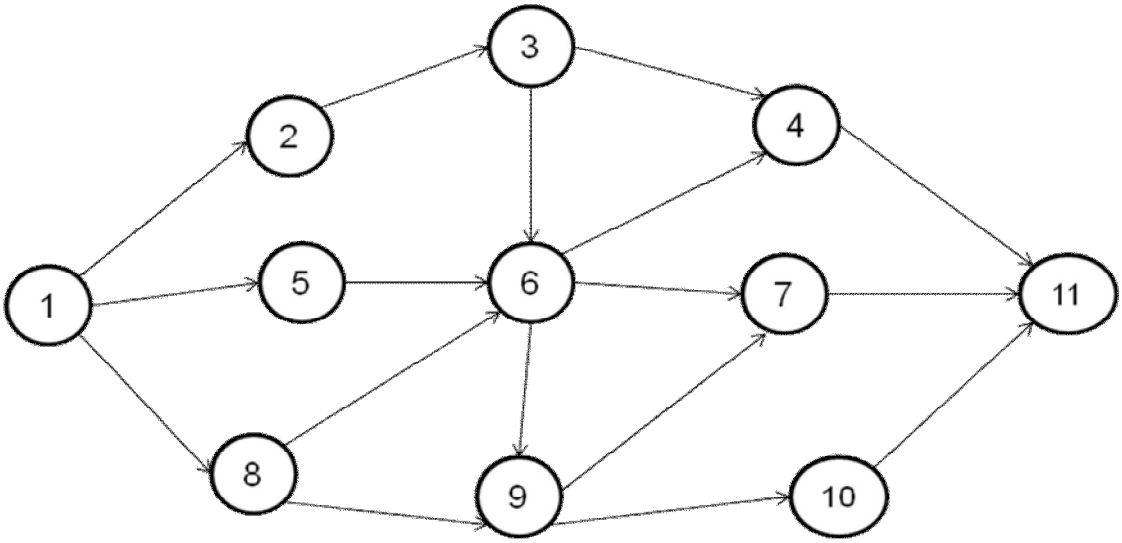

Figure 2. Example of a network structure

they will wake up and participate in path finding procedure. This can be well described by Node Finite State Machine as described in [10]. This state machine deals with network synchronization. Fig.3 gives an idea about node's duty cycle. The concept behind this duty cycle is to make a node synchronized with its neighbor's node in order to achieve reliable message forwarding, as well as, energy conservation. Having knowledge of its neighbor's duty cycle a node if in an idle state can be changing its state to sleep mode in order to reduce energy consumption. During sleep mode a node stops any computation and communication with its neighbor's node.

As shown in the finite state machine, a communication node first listens for incoming message. In our algorithm the control message is sent to all neighbor nodes of a particular node according to its adjacent list. A node listens

TABLE 1. Adjacent list of nodes

Node	Adjacent list
1	2, 5, 8
2	3
3	4, 6
4	7, 11
5	6
6	4, 9, 7
7	11
8	6, 9
9	7, 10
10	11
11	—

to this message and receives it. After receiving it will decide which nodes are its neighbor node as given in adjacent list and send the control messages to those nodes. This process is repeated till we get the destination node and finding the path. The nodes which have already participated in this path finding procedure go to idle state, or to Status=0 state, from which node then go to sleep mode in order to reduce energy consumption.

V. CONCLUSIONS

In this paper we have proposed an algorithm to find out alternate paths as possible as in number in a network, without duplicating a particular node. By taking the alternate paths traffic load is shared and congested paths are avoided which may cause in retransmission due to collision. Since no node is duplicated, all nodes take in active participation in route selection. No node is penalized more as compare to other nodes in network. So there is no network partition which causes maximization of network life. When packet is routed in one path the other nodes are in idle state. To minimize energy consumption due to idle state the nodes change their states to sleep mode.

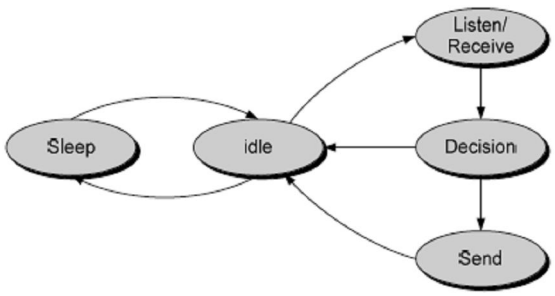

Figure 3. Node's duty cycle

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