Abstract

The nodes of the Wireless Sensor Network are very small and equipped with transceiver, small CPU, memory and an array of sensors. Thanks to advances in MEMS technology, now it is possible to integrate these devices in very compact form on a small chip. Once deployed, these nodes can gather information about the area and event of interest. Subsequently they can network themselves to aggregate the data and send the same to the desired location. These nodes can be deployed in very hazardous location which is not accessible by human being. Applications of sensor network anywhere anytime are unique in nature. In not so distant future this technology is going to change the way we live.

These sensor nodes are battery powered. It is not always possible to recharge their battery once it is deployed. In this case once the battery of a node gets discharged then the node itself is considered to be dead. The lifetime of the sensor network is equal to the time when first node or first few nodes run out of battery. It is very desirable that sensor network should have prolonged lifetime. The lifetime of the sensor network can be enhanced by using specific power efficient design. However all the power efficient design does not correspond to the maximum lifetime design too. In this thesis we are presenting some new approaches of lifetime maximization.

The first contribution of this thesis is an algorithm for maximum lifetime routing using multicommodity flow. In a typical multicommodity flow based routing, the data is first distributed among the tails of all adjacent edges of a node and then data is balanced across those edges. Continuous distribution of the data among the tails of the edges, balancing it across the edges and subsequently vacating it from the sink makes a natural routing. This is the original algorithm of multicommodity flow based on liquid flow model. However in this thesis we have modified this algorithm: we are choosing only those edges for edge balancing which have maximum differences of accumulated data across the edges.

If we increase the flow of the data through a node, the consumption of energy per unit time will increase and hence the lifetime of that node will be decreased, the vice versa is also true. Thus to increase the lifetime of a node, we have to decrease the flow through it. Beyond a particular low value of flow, the required demand will not be satisfied. In this

thesis we have developed a golden ratio based optimization technique that optimizes the flow through each node in such a way that the flow itself makes the lifetime of the node at its maximum value and required demand is still satisfied. We have proved that our optimization algorithm is more energy efficient, converges at a faster rate, its feasibility region is larger and it reaches closer to the maximum lifetime in comparison to the existing algorithm. Additionally our algorithm always keeps the system stable while balancing the load better.

Most of the routing protocols use idealized battery model with linear properties. However the realistic battery is more complex and shows many non linear properties. The capacity of the battery is measured in ampere-hour. However the relationship between current and lifetime is not linear in nature. If we drain high current its capacity decreases non-linearly. This is known as rate capacity effect. If we put the battery in rest after sustained draining of current then it regenerates some of the charge capacity and thus its lifetime is increased. This is known charge recovery effect. We have modified the existing DSR algorithm to discover multiple delayed routes. Instead of sending bulk of data through a single route we have proposed that data should be distributed and send through all these routes. Thus a particular node will forward only small chunk of data and current drawn from the battery of that node will be lesser. Therefore due to rate capacity effect it will have increased capacity and thus the lifetime of the node is increased. Additionally we have proposed that the worst node of each route must be replaced by its neighbors after regular interval of time and thus they will regain some of their charge capacity due to charge recovery effect. Using the Puekert's formula of the capacity of realistic battery model we have proved with analysis and simulation that under our algorithm the same battery we can ensure enhanced lifetime of the network.

The distant nodes communicate to the Base Station (BS) via those nodes which are closer to it. Actually the closer will be a node more load will be imposed on it and sooner will it die. Thus the nodes which are in the proximity of BS create bottleneck for communication for distant nodes. We have proposed two solutions for it. Firstly, if more forwarding nodes are placed near the base station then communication responsibilities will be distributed among these forwarding nodes and bottleneck can be avoided. Secondly, if the transmission ranges of the nodes closer to BS is made smaller and nodes are placed accordingly then these nodes will save some transmission energy so that they can compensate the extra load imposed on them in relaying data of distant nodes. We have proved that the lifetime offered per unit cost of deployment in both the cases is very high if our proposed topology is used.