An Innovative Algorithm for Energy Efficient Routing in Wireless Sensor Networks

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Abstract— The popularity of Wireless Sensor Networks (WSN) has increased tremendously in recent time due to growth in technology. WSN has the potentiality to connect the physical world with the virtual world by forming a network of sensor nodes. Here, sensor nodes are usually battery-operated devices, and hence energy saving of sensor nodes is a major design issue. To prolong the network's lifetime, minimization of energy consumption should be implemented at all layers of the network protocol stack starting from the physical to the application layer including cross-layer optimization. The gravity of energy in sensor networks is much more important than in conventional wire networks. It is necessary to optimize the energy consumption on all layers of the protocol stack, from Physical layer up to Application layer. For example, on Physical layer, by switching passive mode on and off moderately, we can save unnecessary radio power consumption and lengthen the network life time. On MAC layer, a smart scheduling mechanism takes traffic loading and collision probability into account with the result that it reduces the chance of retransmission. The energy consumption will not waste on the packet retransmission. On application layer, we can apply content-based data aggregation to avoid redundant and duplicate packets in the network. In this paper, we propose the routing algorithm for Energy Efficiency in Wireless Sensor Network.

Keywords— Clustering, Cluster Head, Energy Efficient, Wireless Sensor Network

I.   INTRODUCTION

In cluster-based routing, special nodes called cluster heads form a wireless backbone to the sink. Each cluster heads collects data from the sensors belonging to its cluster and forwards it to the sink. In heterogeneous networks, cluster heads have powerful energy devices in contrast to homogeneous networks where all nodes have uniform and limited resource energy. So, it is essential to avoid quick depletion of cluster heads. Hence, the cluster head role rotates, i.e., each node works as a cluster head for a limited period of time. Energy saving in these approaches can be obtained by cluster formation, cluster-head election, data aggregation at the cluster-head nodes to reduce data redundancy and thus save energy. The first part of this paper discusses algorithm for clustering to improve energy efficiency of homogeneous WSN.[1]

In wireless sensor networks, the routing behavior is inevitably multi-hop forwarding. It means that a node in wireless sensor network consumes energy not only on its self traffic flow but also on passing other nodes' traffic flow. Give an extreme example, a node locating on the traffic artery may spend all its energy on forwarding. As more and more nodes use up their energy, the connectivity or radio coverage decrease and the network partition will happen finally. In this case, the network no longer offers services for the original purposes. Because forwarding traffic consumes considerable energy in wireless sensor network, the energy aware routing (EAR) protocol was presented to extend the network life time [2][3][4]. The EAR belongs to the class of on-demand routing, where the energy utility is contained in the routing information. There are two policies respect to route discovery phase, which are on-demand and Table-driven. First one is suitable for the network with high topology change rate; the other is suitable for the network which topology and traffic pattern are static [5]. Section II gives the general information about the energy efficient routing. Section III gives the clustering hierarchy for proposed algorithm. Section IV gives pseudo code for proposed routing algorithm and finally we conclude in section and give future directions for this work.

II.   ENERGY EFFICIENT ROUTING

In the wireless sensor network, the topology changes because nodes use up their energy, enter passive mode, or the communication channel is suffered form Interference and signal fading. Note that the sensor is without mobility and this is the main difference between sensor networks and ad-hoc networks. In this paper, we propose an energy efficient routing algorithm to maximize the network life time in sensor networks. So as to avoid consume too much energy on broadcasting route discovery packets if the routing protocol belongs to the on-demand policy, we choose table-driven routing policy and will apply distance vector based algorithm, e.g. Distributed Bellman-Ford (DBF) algorithm.[6]

We focus on the discussion of energy routing algorithm that is composed of four kernel modules as shown in Fig 1: performance assurance & optimization, network monitoring & traffic analysis, capacity management and network servicing. The definition and more details are given as following:

A. *Performance assurance & optimization module:*

To optimize the system current performance. Based on DBF, this module is responsible to adjust the network configuration and parameters, such like link weight, to achieve better energy utility and satisfy with the given constraints and capacity constraints.

B. *Network monitoring & traffic analysis module:*

To monitoring the traffic in the network at real time. This module continually detects the system status, such as traffic load on each node, congestion and collision in order to catch any exceptions as the triggers of other modules.

C. *Capacity management module:*

To expand or shrink the traffic capacity of each node. In wireless sensor networks, this function can be operated by passive mode management. We model the fraction of node life time as a parameter between 0-1, which represents the ratio of maximal capacity the node applies.

D. *Network servicing module:*

To make decision how many resources are needed to resume the network application economically when the sensor network is unable to service routines normally. In wireless sensor network, it is usually done by re-spreading sensor nodes.

We formulate the energy efficient routing problem as a nonlinear optimization problem. To fulfill the timing and the quality of the optimal decisions, the solution approach to the mathematical problem is Integer Linear Programming Problem. In the future computational experiments, our proposed routing algorithm is expected to be efficient and effective to deal with each complexity problems.[7]

Main intent of this paper is to describe the complete procedure for Cluster head formation as well as optimized routing algorithm.

Energy efficient routing algorithm is divided into two parts.

The routing layer in the protocol stack can be hierarchically subdivided in two parts:

- A static route scheduling performed at cluster level.
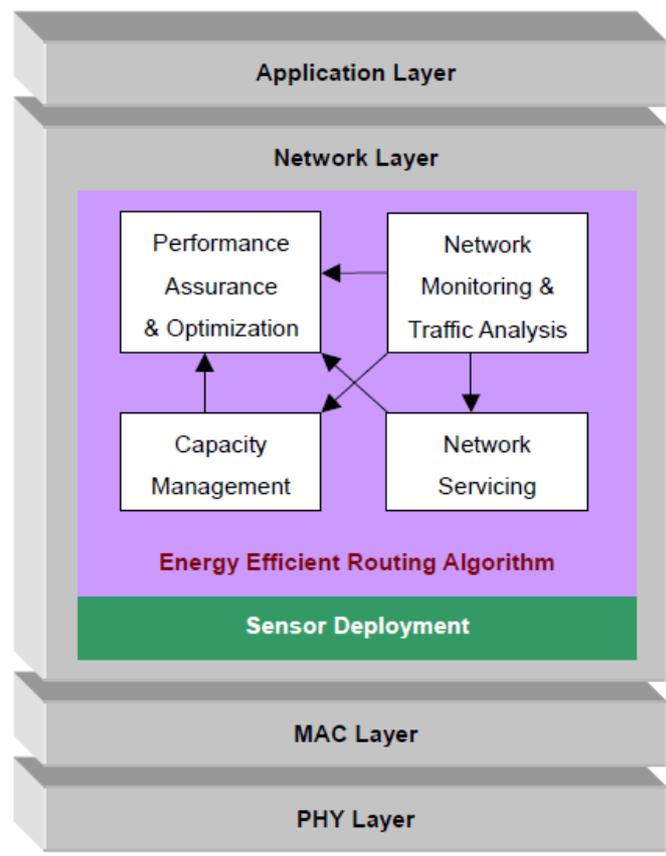- A dynamical routing algorithm at node level for given wireless sensor network.

Fig. 1   The protocol stack of Wireless Sensor Network

III.   CLUSTERING HIERARCHY IN PROPOSED ALGORITHM

Same as LEACH, proposed algorithm also operates in several rounds, each consisting of a set-up and a steady-state phase [8][9]. Each node transmits sensed data to its closest CH. The CH for each cluster receives and aggregates the data from cluster members and then transmits the aggregated data to the BS through a single-hop relay proposed algorithm creates a set-up phase for CHs' selection, and a steady-state phase for time slot scheduling and transmission. Each sensor node s decides independently of other senor nodes whether it will claim to be a CH or not, by picking a random r between

0 and 1 and comparing r with a threshold T(s) based on a user-specified probability p. Threshold energy levels are used to determine the eligibility of a sensor node for participating in given route. The Threshold is defined as follows:

T(s) =   (p/ 1-p (r mod (1/p)))   if s belongs to G.
                    0   otherwise

where G is the set of nodes that have not been CHs in the last 1/p rounds. When a node decides to be a CH, it broadcasts an advertisement message, with the node's ID and a header, using a non-persistent carrier-sense multiple access (CSMA) MAC protocol to ensure the elimination of collisions, to the entire sensor field. The size of the message is small, so that it can be efficiently broadcasted to reach all of the nodes in the network. Non-CH nodes (or member nodes) decide to join the cluster defined by the CH with the strongest received signal. Next, each non-CH sends a join-request containing their ID, to the closest CH using CSMA [10].

IV. PSEUDO CODE FOR PROPOSED ALGORITHM

A first step of the routing algorithm consists of Cluster formation for given network. Then calculating the shortest path from every cluster to the Controller and generating the minimum spanning tree. (MST or Minimum Weight Spanning Tree means if a connected, directed or undirected graph is considered for a given wireless sensor network, a spanning tree of that graph is a subgraph that is a tree and connects all the vertices together. MST or MWST is then a spanning tree with weight less than or equal to the weight of every other spanning tree.)

A. *Proposed Algortihm for Cluster Formation:*
   This process has been divided into three phases.
   BEGIN
      1: Specify the probability (pset), number of nodes (n);
      2: E init(s)=E0, s=1,2, …, n;

(I) CLUSTER FORMATION PHASE

1: if (Einit(s)>0 & r mod(1/pset)≠0) then //pset can set≥0.5
   (because probability of being & not being a head is same. i.e 0.5)
2: r←generate_random(0,1) and compute T(s); // To generate random number System time is used.
3: if (r < T(s)) then
4: CCH{s}=TRUE; //node s be a candidate CH
   5: else
6: CCH{s}=FALSE; //node s not be a candidate CH
7: end if
8: end if
9: SendToBS(IDu, (xu,yu), CCH(u)) ← All nodes send messages to BS;
10: OP_BS(popt)
   Optimal probability is determined, OP_BS function will have the optimal probable value for Cluster Head.;
11: BC (popt) ← BS broadcasts a message back to all nodes;

(II) SET-UP PHASE

1: do { //repeat for r rounds
2: r←generate_random(0,1);
3: if (Einit(s)>0 & r mod(1/popt)≠0) then
4: compute T(s); //given by (1)
5: if (r < T(s)) then
6: CH{s}=TRUE; //node s be a CH
7: else
8: CH{s}=FALSE; //node s not be a CH
9: end if
10: end if
11: if (CH{s}=TRUE) then
12: BC (ADV) ← broadcast an advertisement message;
13: Join(IDi); //non-cluster head node i join into the closest CH
14: Cluster(c); //form a cluster c;
15: end if

(III) STEADY-STATE PHASE

1: If (CH(s)=TRUE) then
2: Receive(IDi , DataPCK) //receive data from members;
3: Aggregate(IDi , DataPCK) //aggregate received data;

4: TansToBS(IDi ,DataPCK); //transmit received data;
5: else
6: If (MyTimeSlot=TRUE) then
7: TansToCH(IDi , DataPCK); //transmit sensed data;
8: else
9: SleepMode(i)=TRUE; //node i at a sleep state
10: end if
11: end if
12: } // one round is completed
END

V. CONCLUSIONS

Currently, the complete pseudo code is formatted for Cluster formation for minimum energy consumption in WSNs. Next focus will be on choosing appropriate optimized path finding algorithm and implementing the mathematical model that can determine the optimal locations to installed relay stations and the packet transmission path from sensor nodes to the base station using Linear Programming Problem. In future, the algorithm will be implemented practically and studying its performance issues.

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