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Energy Conservation Protocol Works in Physical Layer of WSN

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ABSTRACT: *Wireless Sensor Networks (WSNs) made up of a great number of small and inexpensive sensor nodes powered by small batteries. As each sensor node has limited energy, these sensor nodes are send in sleep mode to save energy, this helps to increase the network lifetime. There are two key approaches for sleep scheduling of sensor nodes that are randomized and synchronized. Any Sleep scheduling scheme we are using should be ensure that data can always be routed from nodes to sink. In this paper, we propose a novel approach for sleep scheduling of sensor nodes using a tree and an energy aware routing protocol which is integrated with the proposed sleep scheduling scheme. In tree sink node act as root node and the nodes with higher energy acts as branch node and node with low energy acts as leaf node. The leaf nodes are put to sleep and branch node remains awake and the leaf nodes are made to sleep. This provides a guaranteed path from any node to the sink node. The tree is reconstructed periodically to balance energy in all nodes. The proposed approach also considerably reduces average energy consumption rate of each node as we are able to put more number of nodes to sleep in comparison to other approaches. Fault-tolerance is assured by maintaining two paths from each node to the sink. The most important issue that must consider in designing a data gathering algorithm for WSN is how to save sensor node energy while meeting the needs of users. In this paper, we propose an energy-aware routing protocol (EAP) for a long-lived sensor network. This ensures a good performance in terms of lifetime by minimizing energy consumption for in-network communications and balancing the energy load among all the nodes. EAP introduces a new clustering technique for cluster head election, which can handle the various energy capacities. Additionally, it also introduces an efficient approach named intra cluster coverage to cope with the area coverage problem.*

Keywords: *wireless sensor network, Energy conservation, Broadcast Tree.*

I. INTRODUCTION

A Wireless Sensor Network (WSN) consists of hundreds or thousands of sensor nodes or motes equipped with various sensing devices to observe events in the real world. Sensor nodes usually communicate among themselves using wireless only. Sensor nodes are generally powered by battery, and therefore have limited energy. Besides each sensor node has limited computation power and memory again due to constraints imposed by the available supply of energy. The major function of WSNs is to observe and record events in the environment and report them to the sink if necessary. In the process, the sink node may also need to broadcast messages to each node of the WSN, and sensor nodes may need to communicate with each other as well.

Wireless sensor network are usually deployed, possibly in extreme conditions such as mountainous region, and left unattended to function for long time. In order to increase the network lifetime, it is must to minimize the consumption of energy by individual nodes. Additionally, it is also important to ensure that the average rate of consumption of energy by each node is also the same. This would ensure that the connectivity needed to transmit data from a sensor node to sink can always be maintained. A third requirement of WSNs for applications such as tracking of intruders, detection of fire etc. is that the delay to transmit data from sensor node to the sink should be as less as possible. These are complex set of requirements which a routing protocol for wireless sensor networks needs to fulfill. Moreover, the transceiver is the major unit that consumes lots of energy in each sensor node even when it is idle. Therefore, sensor nodes are usually put to sleep if they are not required to transmit data and/or sense environment, and the challenge is to integrate sleep scheduling scheme with routing protocols for WSNs so that the objective of routing protocols as given above are also met. We assume that the transceiver, processor, and sensing units can be put to sleep independently [1] and then we can say that the sensor node is entered in sleep mode. The sleep scheduling of sensing units can be done independently to ensure sensing coverage. In this paper, we propose a novel sleep scheduling scheme using a tree, and an energy aware routing protocol that is appropriately integrated with the above sleep scheduling scheme with a view to meet the objectives for routing protocols as given above.

The rest of the paper is organized as follows. In section II, we give a survey of related works, and motivation for our work. The details of the proposed sleep scheduling scheme and energy aware routing protocol are described in section III. Result of the performance evaluation of the proposed routing protocol and gossip based energy efficient Procedure for Paper Submission Review Stage Submit your manuscript electronically for review. Routing protocol with sleep scheduling (GSP) [2] and their comparisons are given in section IV. And we conclude with section V with future work.

II RELATED WORK

In general, routing in WSNs can be divided into three types, viz. flat structure based routing, hierarchical structure based routing and location-based routing [3][4]. In flat structure based routing [5][6], all nodes are typically assigned equal roles or responsibilities. In typical hierarchical structured based routing [7][8][9], however, nodes play different roles in the network depending on their position in the hierarchy In location-based routing [10] [11], sensor nodes' positions are exploited to route data in the network. In the recent past, many routing protocols have been proposed for sensor networks. The descriptions of some of these protocols are as given below. Heinzelman, Kulik, and Balakrishnan have proposed a protocol, called Sensor Protocols for Information via Negotiation (SPIN) [12], that provides data-centric routing approach where the data should be named using high level descriptors or metadata. The SPIN is a family of many protocols. The two main protocols are called SPIN-1 and SPIN-2. The SPIN-1 protocol is a 3-stage protocol, but does not consider any energy aware technique. However, in SPIN 2, when energy in the nodes is abundant, it communicates using the 3-stage protocol of SPIN-1 . However, when the energy in a node starts approaching a low energy threshold it reduces its participation in the protocol, that means, it will participates only when it believes that it can complete all the other stages of the protocol without going below the threshold energy level. Ye, Chen, Lu, and Zhang have proposed an algorithm, called Minimum Cost Forwarding Algorithm (MCFA) [13] that sets up a back off based cost field to find the optimal cost path from all the nodes to the sink. Once the field is formed, the message, carrying dynamic cost information, goes along with minimum cost path in the cost field. This protocol consists of two phases. First phase is a setup phase for setting up the cost value in all nodes. In the second phase, the source broadcasts the data to its neighbors nodes. To minimize the number of broadcast messages, the MCFA was modified to run a back off algorithm at the setup phase. The back off algorithm dictates that a node will not send the updated message until back off time units have elapsed from the time at which the message is updated. Problems with the algorithm are high consumption of bandwidth and it may cause duplicate copies of sensor messages to arrive at the sink. In Power Aware Chain (PAC) [14] routing protocol proposed by Pham, Kim, Doh, and Yoo, all nodes organize themselves into the energy efficient chain with the help of MCFA protocol and depth first search. One node, elected as leader node, transmits data back to sink on behalf of all other nodes. Leader node election is based on the power available and the power needed for transmission from the node to sink. Each node aggregates received data from the previous node in the chain with its own collected data to produce an aggregated data packet.

In the recent past, Hong and Yang have proposed an energy balanced multipath routing protocol for sensor network [8] which is based on rumor routing technique. In this protocol, authors consider a probabilistic approach to find multipath from source to sink by considering the residual energy and hop count from source to sink. Chakchouk, Hamdaoui, and Frikhax also have proposed a protocol [9] that uses remaining energy and the hop count from sensor node to the sink in order to make hop-by-hop energy-aware routing. There are some energy aware routing protocol like [7][14] which use hierarchical or cluster based approach by considering the residual energy or remaining energy to distribute the traffic over the whole network and also prolong the network lifetime. S. Lindsey *et al.* proposed an algorithm related to LEACH, called PEGASIS [4]. According to these authors for a node, within a range of some distance, the energy utilized for sending or receiving circuits is greater than that consumed for amplifying circuits. To reduce this energy consumption, PEGASIS uses the GREED algorithm to make all the sensor nodes in the system in a chain. According to the simulation results, the performance of PEGASIS is better than LEACH, particularly, when the distance between sink node and sensor network is too large. In [5], to deal with the heterogeneous energy condition, node with the higher energy should have the larger probability to become the cluster head. Each node must have information of energy level of all nodes in the network to verify the probability of its becoming a cluster head. So, each node will not be able to make a decision to become a cluster head if only its local information is known. In such conditions, the scalability of this protocol will be influenced. Sh. Lee *et al.* proposed a new clustering algorithm CODA [6] in order to relieve the imbalance of energy run down caused by different distances from the sink.

CODA divides the whole network into a groups based on node's distance to the base station and the routing policies. All groups have its own number of clusters and member nodes. CODA Algorithm differentiates the number of clusters in terms of the distance to the base station. As longer as distance between the member node and the base station, the more number clusters are formed in case of single hop with clustering. It gives better performance in terms of the network lifetime and the dissipated energy than those protocols that apply the same probability to the whole network. However, the functioning of CODA depends on global information of node position, and thus it is not scalable. All the routing protocols discussed above are based on energy-aware technique. But, to minimize energy consumption and prolong the lifetime of the network, the routing protocols have to support sleep scheduling schemes so that most of the nodes are put to sleep, and the remaining nodes are active. There are very less routing protocols that support sleep scheduling and some of them are described below. Hou and Tipper have proposed flat structure based employs probabilistic based sleep modes. At the beginning of a gossip period, each node chooses either to sleep with probability p or to stay awake with probability 1- p for the period, so that all the sleep nodes will not be able to transmit or receive any packet during the period. When an active node receives any packet, it must retransmit the same. All sleeping nodes wake up at the end of each period. All the nodes repeat the above process for every period.

III PROPOSED ROUTING PROTOCOL WITH WSN

The routing protocol proposed in this section is intended for WSNs in which sensor nodes are static. Beside the applications running in the WSN require that the information gathered by the sensor nodes have to be transmitted immediately to the sink. Also it is assumed that each node has a unique *ID*, and the communication between neighboring nodes is bidirectional and symmetric. It is also assumed that the clocks of the sensor nodes in the WSN are synchronized so that nodes can be woken up nearly at the same time, and they can execute the proposed protocol. The objectives of the proposed routing protocol with sleep Scheduling are as follows.
i. Most sensor nodes should be asleep most of the time so that the energy consumption by each node is reduced. ii. Consumption of energy by all the sensor nodes remains balanced, i.e., at any time, every node should have consumed nearly the same amount of energy. iii. Time required to transmit data from a sensor node to the sink is as minimum as possible subject to the constraints given in (ii) above. A.Informal Description of the Algorithm We first construct a broadcast tree using the approach similar to the one given in [13]. During the construction of the tree, the following needs to be ensured in order to minimize energy consumption during the tree construction phase and provide support for fault-tolerance. (i) Number of broadcasts is as less as possible. (ii) There are two branches from each node of the tree towards the sink to ensure fault-tolerance. After the construction of the tree is complete, each node can identify itself either as internal node or as leaf node. All leaf nodes are set to sleep mode and internal nodes remain awake. A node want to send data to the sink can send it along the edges of the tree towards the sink. The tree is constructed in such a way that the internal nodes have higher remaining energy compared to the other nodes. This is required to ensure that the consumption of energy by all nodes remains balanced. The tree is reconstructed periodically to ensure balanced consumption of energy by all the nodes. As outlined above, the proposed routing protocol with sleep scheduling consists of the following. (i) Construction of the broadcast tree at the beginning of the every period. (ii) Transmission of the data from source to sink whenever required. Construction of the Broadcast Tree (BTC) Each node in the WSN stores the IDs of two parent nodes with associated least cost of the paths to the sink through them. Nodes which are directly reachable from the sink have both the parent nodes set to sink node. Besides, each node also stores its node ID, its remaining energy, the cost to be added to a path to sink that passes through this node. These variables at each node j are represented as follows.

CFj, 1 = Value of first cost field of node j
CFj, 2 = Value of second cost field of node j
PFj, 1 = Value of first parent node field of node j
PFj, 2 = Value of second parent node field of node j
Nj = jth node
REj = Remaining energy of Nj
Cj =1 REj
= cost of each node to be added to a path.

Following is the informal description of BTC algorithm.
Procedure *BTC-phase1*
begin
CFj, 1 = CFj, 2 = ∞;
if *(First period)* then

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PFj,1  = PFj,2 = −1 ;
end if
is Active = is Broadcasted = false;
timer Flag = RESET;
while (node j receive ADV 1 (CFi,Ni,1 , PFi, 1 )message from node i) do
if (timer Flag = RESET) then
                          Set back off timer to ɣ;
timer Flag = SET;
end
if (is Broadcasted=false) then
if (Ni is sink) then
CFj, 1  = CFj, 2 = CFi, 1  + Cj;
PFj, 1  = PFj, 2 = Ni;
      else if ((PFj, 1  is sink and CFj, 1  = ∞) or(PFj, 1  is not sinking)) then
                                      if ((CFi, 1  + Cj) < CFj, 1 ) then
        CFj, 1  = CFj, 2 = CFi, 1  + Cj;
                     PFj, 1  = PFj, 2 = Ni;
                          end
end
else if ((Nj = PFi, 1 )) then
is Active=true;
end
end
if (Back off timer expire and is Broadcasted=false) then
is Broadcasted=true;
Broadcast ADV 1 (Nj, CFj, 1 , PFj, 1 )
message;
    end
    if (Construction phase completed) then
Break;
    end
end
if (is Active) then
Nj is an internal node;
else
Nj is a leaf node;
end
end
```

Node declares itself as an internal node. If a node does not receive any *ADV1* message where its own *ID* is equal to the parent node *ID* stored in the broadcast message, then the node declares itself as a leaf node. The algorithm to add second parent to each node of the tree constructed in phase 1 is given in the procedure *BTCphase2* which performs its task as follows. At the beginning of this phase, sink node broadcasts an *ADV2* message to all its neighbors. When a node receives the first *ADV2* message, it sets back off timer. When a node receives an *ADV2* message, and the node has already stored the sink node *ID* in its parent node fields or the node *ID* stored in the received *ADV2* message is equal to the node *ID* stored in its first parent node field, it will discard the *ADV2* message. Otherwise, the node executes the following steps. 1)If the node receives the *ADV2* message from the sink node, then it computes the new cost by adding reciprocal of its remaining energy to the received cost, and sets its two cost fields to new cost and stores the sink node *ID* in its both parent node fields. 2)If both the parent node fields of the receiving node are equal, then it stores the new cost value as computed in *step* 1 in the second cost field and stores the received node *ID* in the second parent node field. 3)If both the parent node fields of the receiving node are not equal, then it compares the new cost with the cost stored in the second cost field, and if the new cost is less than the value stored in the second cost field, then it stores the new cost value in the second cost field and stores the received node *ID* in the second parent node field. After receiving the first *ADV2* message, if a node has declared itself as an internal node in the first phase of the algorithm, the node broadcast its own *ADV2* message that contains its own *ID* and the value stored in the first cost field. Upon receipt of further *ADV2* message from any other node, it will not broadcast any more advertisement message. Once the back off timer expires, if a node has declared itself as a leaf node in the first phase of the algorithm, then the node goes to sleep mode. After completion of BTC phase, each node is classified either as an internal node or as a leaf node. Since a leaf node will not receive any data packets from any other node for onward transmission, it can go to sleep till the beginning of next period or till it detects an event. The leaf nodes will again participate in the BTC phase at the beginning of next period. When an event occurs at an internal node, data will be transmitted to a parent node in the tree. If an event occurs at a leaf node, the node will wake up and transmit data and again go to sleep till next event or next period whichever is earlier. Each data packet consists of *ID* of node which would receive the data, *ID* of node which sends the data, and the data itself. Data will be transmitted from source to sink via minimum cost paths computed in the BTC phase. The first packet received by any internal node is forwarded to its parent that is in the first parent node field, and the next packet is forwarded to the parent that is in the second parent node field. Similarly, for subsequent data packets, it chooses one of the parents from parent node fields alternately. A periodic check is also done using hello packet to find out if any of the parent is dead. Packets are forwarded to active parent only, if any parent is dead.

IV. CONCLUSIONS AND FUTURE WORK

In this paper, we have presented an energy aware routing protocol with sleep scheduling for WSNs. The core of the routing protocol is the efficient construction of the broadcast tree with two paths from each node towards the sink with higher remaining energy at each internal node of the tree. The tree is reconstructed at the beginning of each period so that none of these nodes die before other nodes, which means that all nodes will die at around the same time. Consecutive packets are routed through alternative path to reduce traffic in individual paths. Sleep mechanism of leaf node is highly energy efficient as more number of nodes is able to sleep, and this helps to prolong the network lifetime. We have evaluated the performance of our protocol through simulation studies for different number of nodes and rounds. Simulation results show that data packet delivery in our multipath protocol is more than that using unipath, and energy consumption of nodes is also balanced. Comparison with GSP shows that our protocol has more number of sleep nodes, and therefore provides longer network lifetime. We use very high data rate in our simulation studies. Future work includes adaptively adjusting the reconstruction period of tree is depending on the input data rate with a view to further increase the network lifetime

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