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Energy Efficient Routing Algorithm with sleep scheduling in Wireless Sensor Network

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Abstract-- In wireless sensor network most of the devices operate on batteries. These devices or nodes have limited amount of initial energy that are consumed at different rates, depending on the power level and intended receiver. In sleep scheduling algorithms most of the nodes are put to sleep to conserve energy and increase network life time . There are to main approaches to sleep scheduling i) random ii) synchronized. Main purpose of any sleep scheduling algorithm is to maintain network connectivity. In this paper, 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. The tree is rooted at the sink node .The tree is periodically reconstructed considering the remaining energy of each node with a view to balance energy consumption of nodes, and remove any failed nodes from the tree. 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 such as GSP, which incorporates sleep scheduling using random approach.

Kewords---**Sensor network ; battery power; energy efficient routing; duty cycling; sleep scheduling.**

I. INTRODUCTION

A distributed wireless sensor network (WSNs) have been increasing in popularity for a wide range of applications [11]. A WSN consist of large number of sensor nodes equipped with various sensing devices to observe different phenomenon changes in the real world. A sensor node is composed of typically four units- a) sensing unit: - sense the desired data from the interested region. b) Memory unit: - store the data until it is sent for future use. c) Computation unit: - computes the aggregated data d) power unit: - provides power supply for entire process. Since sensor nodes are battery powered devices therefore they have limited energy. WSN are usually deployed in inhospitable terrain such as mountainous region where it's very difficult to recharge or replace batteries. Therefore the main aim of any energy efficient routing protocol is to prolong the network lifetime which is possible by minimizing energy consumption of individual nodes. In addition it is also necessary to ensure that the average rate of consumption of energy by each node is also same. This would ensure that the connectivity needed to transmit data from a source node to sink node is also maintained. Since lifetime of a network is defined as time in which a single node losses its energy and get exhausted. More ever, the transceiver is the major unit of energy consumption in sensor node even when sensor nodes are in idle state. Therefore sensor nodes must be put to sleep (radio off) if they are not required to transmit or receive data. It is assumed that transceiver, processor and sensing unit can be put to sleep independently [12]. It is assumed that when sensor nodes are put to sleep it means that the transceiver and processor are put to sleep. The challenge is to integrate sleep scheduling scheme with routing protocols for WSNs. The rest of the paper is organized as follows sections 2 discuss various energy efficient routing protocol with sleep scheduling scheme. In section 3 proposed routing algorithm. Section 4 some conclusion are made.

II. RELATED WORK

Basically, there are two classes of energy efficient ad hoc and sensor network routing protocols employing a sleep mode in the literature, cluster-based and flat[1][2]. Both of them achieve energy efficiency by employing different topology management techniques. This section presents a brief review of these two classes of routing to provide a better understanding of the current research issues in this area.

In cluster-based routing protocols, all nodes are organized into clusters with one node selected to be cluster-head for each cluster. This cluster-head receives data packets from its members, aggregates them and transmits to a data sink. In some cluster-based routing protocols, the cluster-head assigns TDMA slots to its members to schedule the communication and the sleep mode. Low-Energy Adaptive Clustering Hierarchy (LEACH) [3] is designed for proactive sensor networks, in which the nodes periodically switch on their sensors and transmitters, sense the environment and transmit the data. Nodes communicate with their cluster-heads directly and the randomized rotation of the cluster-heads is used to evenly distribute the energy load among the sensors. Threshold sensitive Energy Efficient sensor Network protocol (TEEN) [4] is designed for reactive networks, where the nodes react immediately to sudden changes in the environment. Nodes sense the environment continuously, but send the data to cluster-heads only when some predefined thresholds are reached. Adaptive Periodic Threshold sensitive Energy Efficient sensor Network protocol (APTEEN) protocol [6] combines the features of the above two protocols by modifying TEEN to make it send periodic data. The cluster-based routing protocols can arrange the sleep mode of each node to conserve energy. However, the high complexity and overhead are incurred.

Hou and Tipper have proposed flat structure based protocol called Gossip-based Sleep Protocol (GSP) [10] that 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.

In [13], the author proposed a centralized scheme for extending the lifetime of densely deployed wireless sensor networks by keeping only a necessary set of sensor nodes active. It presents an algorithm for finding out which nodes should be put into sleep mode depending upon their location in sensing area. After deciding which nodes should be in sleep mode, and which nodes should be in active mode, the sink node generates a tree structure for routing purpose by using a breadth-first search (BFS) over the connective graph of active nodes. The whole process runs periodically. In this case, if the period is large and any node goes down in the middle of this period, then the whole routing structure can be disturbed. However, if we reduce the period, the operation performed at the beginning of each period is more, and hence, the energy consumption over whole network is also increased.

From the above, it is clear that the equal consumption of energy and sharing of load by all nodes is an important requirement to prolong the network lifetime. However, if the nodes for sleeping are chosen randomly as in [10], a path from source to sink may not always be present, and sufficient numbers of nodes have to remain awake to ensure the existence of such a path. Alternatively, data can be stored at a node till a neighboring node towards the sink is found, but this approach would delay the delivery of the message to the sink considerably.

Alternatively, a fixed path may be chosen from a node to the sink as in [13]. The problem with the approach in [13] is that the whole process is centralized, and the decisions of the sink node need to be conveyed to all the nodes. However, in this approach, delay to transmit data from source to sink will be less as such a path will always exist. In this paper, we have proposed a distributed algorithm for constructing such a tree using the approach given in [5]. The algorithm is energy aware and always chooses the paths whose nodes have higher remaining energy and minimum load shared

III. PROPOSED ROUTING ALGORITHM WITH SLEEP SCHEDULING

The routing protocol proposed in this section is intended for WSNs in which sensor nodes are static. Besides the applications running in the WSN require that the information gathered by the sensor nodes have to be transmitted immediately to the sink . Furthermore, it is also assumed that each node has a unique id, and the communication between neighboring nodes is symmetric and bidirectional. 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 algorithm.

The objectives of the proposed routing algorithm with sleep scheduling are as follows

(i) Most sensor nodes should be in sleep mode 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) Load shared by each node must be same so that no node is over used.

(iv) Time required to transmit data from a sensor node to the sink is as minimum as possible.

A. Description of the Algorithm

In proposed algorithm a broadcast tree is constructed using the approach given in[5]. During the construction of the tree number of broadcast is kept as minimum as possible to ensure minimum energy consumption during tree construction.

After the completion of tree construction, each node determines their parent node. Now each node is put into sleep mode. Whenever a node detects an event it transit in active mode and transmit their data to their parent node and after transmission they again transit into sleep mode. This way data is transmitted from source to sink node whenever a source node wants to send its data to sink node. The tree is reconstructed periodically to ensure balanced consumption of energy by all the nodes. As outlined above, the proposed routing algorithm 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.

B. Construction of the Broadcast Tree (BTC)

Each node in the WSN stores the id of their parent node along with the associated least cost of the paths to the sink through them. Besides, each node also stores its node id, its remaining energy, load shared by the node, the cost to be added to a path to sink that passes through this node. These variables at each node i are represented as follows.

NNi = Number of neighboring nodes of node i
Pid = id of parent node of a node
CFi = Cost function of ith node
Nid = id of ith node
REi = Remaining energy of ith node
Ci = NNi / REi

The Broadcast tree is constructed as. In the first step the sink node broadcast an advertisement message ADV. Upon reception of this ADV message each node in the WSN executes the algorithm given in procedure BTC, and set its parent id so that the path to the sink node through it has least cost. The ADV message broadcasted by node i has following parameters.

ADV= (Nid , Pid ,CFi)

The algorithm to construct tree is executes as follows. At the beginning of first period, each node except the sink node sets it cost field to ∞ and Parent id to -1, but at the beginning of each subsequent period each node only set it cost field to ∞ and no change to Parent id which is updated after the execution of Procedure BTC. The sink node sets its cost field to 0 and Parent id as its own id.

At the beginning sink node broadcast an ADV message to all its neighbors. When a node receives an ADV message, it does not broadcast its own ADV message immediately. Before broadcasting ADV message it executes following steps.

1. When a node receives ADV message, it sets backoff timer.

2. If the ADV message comes from sink node, then the node updates its Parent id as sink node id, and computes

new cost by adding ratio of its load shared and remaining energy and stores new cost in its cost field. If ADV message comes from any other node, then the node compares the new cost with the existing cost stored in costfield. If the new cost is less than existing cost, then the new cost value is stored in costfield and received id as Parent id.

Upon reception of any further ADV message from other neighbors, it computes the new cost as in step 2. If the node has already stored the sink node id as its Parent id, then it will discard the ADV message, otherwise, it compares this new cost with the existing cost stored in its costfield and updates its costfield and parent id as in step2.

```
Procedure:  Construction of BTC
begin
CF = ∞    for other nodes
CF = 0    for sink node
if (first period) then
Pid= -1;
end
is Active = is Broadcasted = FALSE;
timer Flag=RESET;
while (node j receive ADV(Nid, CF, Pid)
message from node i) do
if (timer Flag=RESET) then
set Backoff timer to α;
  timer Flag = SET
end

if (is Broadcasted= FALSE) then
        if (Ni is sink) then
                CFj= CFsink + Cj;
                        Pid= Ni;
else if ((Pid is sink and CF= ∞)or (Pid is not sink))      then
                        if(min(CFj,CFn) = CFn)
if ((CFn + Co) < CFo) then
CFo= CFn + Co;
Pid= No;
end
end
if (Backoff timer expire and is Broadcasted =FALSE) then
is Broadcasted = TRUE;
Broadcast ADV (Nj, CFj. Pid)
message;
end
if(construction phase) then
Break;
end
end
if ((node i detects an event )  or ( time period expire ))
node i= active
transmit data;
end
else
node i= sleep mode;
end
```

Once the Backoff timer expires, the node broadcast ADV message that contains its own id, Parent id and value stored in cost field.

After completion of BTC phase all nodes put to sleep mode till they detect any event. The nodes will again participate in BTC at the beginning of next period.

C. Transmission of Data from Source to Sink

When an event occurs at node, the node will wake up and transmit data to its Parent node 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 generated the data, and the data itself. Data will be transmitted from source to sink via minimum cost paths computed in the BTC phase.

IV. CONCLUSIONS AND FUTURE WORK

In this paper, an energy efficient routing protocol with sleep scheduling for WSNs. The core of the routing protocol is the efficient construction of the broadcast tree with a path from each node towards the sink, and with higher remaining energy at each 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. Node sleep mechanism is highly energy efficient as more number of nodes is able to sleep, and this helps to prolong the network lifetime. Comparison with GSP shows that our protocol has more number of sleep nodes, and therefore provides longer network lifetime. We have used very high data rate in our simulation studies. Future work includes adaptively adjusting the period of tree reconstruction depending on the input data rate with a view to further increase the network lifetime

REFERENCES

[1] S. Murthy and J. J. Garcia-Luna-Aceves, (1996) “An efficient routing protocol for wireless networks,” ACM Balzer Mobile Networks and Applications Journal.

[2] E. M. Royer and C.-K. Toh,(1999) “A review of current routing protocols for ad hoc mobile wireless networks,” IEEE Personal Communications.

[3] W. R. Heinzelman, A. Chandrakasan, and H. Balakrishnan,(2000) “Energyefficient communication protocol for wireless microsensor networks,” in IEEE Hawaii International Conference on System Sciences.

[4] A. Manjeshwar and D. P. Agrawal,(2001) “TEEN: A routing protocol for enhanced efficiency in wireless sensor networks,” in IEEE International Parallel Distributed Processing Symposium.

[5] F. Ye, A. Chen, S. Lu, and L. Zhang,(2001) “A scalable solution to minimum cost forwarding in large sensor networks,” in Computer Communications and Networks, Proceedings.Tenth International Conference on, 2001, pp. 304–309.

[6] A. Manjeshwar and D. P. Agrawal,(2002) “APTEEN: A hybrid protocol for efficient routing and comprehensive information retrieval in wireless sensor networks,” in IEEE International Parallel Distributed Processing Symposium.

[7] R. Shah and J. Rabaey,(2002) “Energy aware routing for low energy ad hoc sensor networks,” in Wireless Communications and Networking Conference, 2002. WCNC2002. 2002 IEEE,vol. 1 pp. 350–355 vol.1.

[8] J. Al-Karaki and A. Kamal,(2004) “Routing techniques inwireless sensor networks: a survey,” Wireless Communications, IEEE, vol. 11, no. 6, pp. 6–28.

[9] M.-L. Pham, D. Kim, Y. Doh, and S. eun Yoo,(2004) “Power aware chain routing protocol for data gathering in sensor networks,” in Intelligent Sensors, Sensor Networks and Information Processing Conference, 2004. Proceedings of the 2004, pp. 107–112.

[10] X. Hou and D. Tipper,(2004) “Gossip-based sleep protocol (gsp) for energy efficient routing in wireless ad hoc networks,” in Wireless Communications and Networking Conference, 2004. WCNC. 2004 IEEE, vol. 3, pp. 1305–1310 Vol.3.

[11] K. Akkaya and M. F. Younis,(2005) "A survey on routing protocols for wireless sensor networks," Ad Hoc Networks, vol. 3, no. 3, pp. 325–349.

[12] L. Wang and Y. Xiao,(2006) "A survey of energy-efficient scheduling mechanisms in sensor networks," Mob. Netw. Appl., vol. 11, no. 5, pp. 723–740.

[13] E. Bulut and I. Korpeoglu,(2007) "Dssp: A dynamic sleep scheduling protocol for prolonging the lifetime of wireless sensor networks," in Advanced Information Networking and Applications Workshops, 2007, AINAW '07. 21st International Conference on, vol. 2,pp. 725–730.

[14] L. Hong and J. Yang,(2009) "An energy-balance multipath routing based on rumor routing for wireless sensor networks," in Natural Computation, 2009. ICNC '09. Fifth International Conference on, vol. 3, pp. 87–91.