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RESEARCH ARTICLE

POWER AWARE DATA GATHERING TREE FOR HETEROGENEOUS WIRELESS SENSOR NETWORKS

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ABSTRACT

In Wireless sensor networks the sensed data is collected and transmitted to the base station in the form of tree known as Data Gathering tree. If the number of Data Gathering Trees created for each cycle in wireless sensor networks is more it affects the performance of the entire network. Here only one data gathering tree for each cycle is constructed, so optimizing the network performance. Power optimality is achieved by considering heterogeneous sensors for construction of Data Gathering Tree. A data gathering tree is constructed using proposed algorithm which is a modification of Efficient Data Gathering (EDGE) protocol. It conserves the limited resources of the sensors and avoids both flooding and periodic updating of routing packets. The Tree will be reconstructed upon node failures or addition of new nodes. Simulation results show that the proposed algorithm is enhanced EDGE which deals effectively for loops and optimizes the network performance.

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INTRODUCTION

A WSN can be generally described as a network of nodes that cooperatively sense and may control the environment enabling interaction between persons or computers and the surrounding environment (Verdone *et al.,* 2008). The underlying idea is to decide in each round (approximately) k data reporters (sensors) which can meet the desired sensing coverage specified by the users/applications. The selected k data reporters for a round form a data gathering tree to get rid of wait-and-forward delay which may result from the random sensor scheduling and are scheduled to remain active (with transceiver on) during that round only, thus saving energy. All sensors have an equal opportunity to report sensed data periodically so the entire monitored area is covered within a fixed delay (Wook Choi and Sajal K. Das, 2006). In (Niwat Thepvilojanapong and Kaoru Sezaki, 2005) author described a wireless sensor network can be an effective tool for gathering data in a variety of environments. The data gathering process must be designed to conserve the limited resources of the sensors. This paper propose an algorithm which is modification of Efficient Data Gathering (EDGE) protocol (Niwat Thepvilojanapong and Kaoru Sezaki, 2005) which avoids both flooding and periodic updating of routing packets. In (Wook Choi, 2005) author describe the two failure detection mechanisms, implemented at the MAC layer for nodes used in wireless sensor networks, in order to cope with transient or permanent node failures. Specifically, the failure detection mechanisms are particularly suited for periodic workload applications and MAC protocols that employ four-way handshaking (RTS/CTS/DATA/ACK) for collision avoidance. One failure detection mechanism is reminiscent of the Hello protocol that is sometimes implemented at the Network layer, and uses a fixed time threshold, while the other mechanism uses the RTS packets count as a metric for determining that a failure has occurred. In (Wataru Uemura and Masashi Murata, 2011) author clear way of explaining the (Wook Choi, 2005) concepts helped to understand it. Based on the above papers and some regarding coverage issues. we derived the algorithm. In (Amir Hossein Mohajerzadeh and Mohammad Hossein Yaghmaee, 2008) author explain future scope of MAC layer protocol that is avoiding collision using RTS/CTS. So it will serve as future scope of broadcasting collision avoidance for this derived algorithm.

In (Metin Inanc, Malik Magdon-Ismail and Bulent Yener, 2006) Sensor networks and ad-hoc networks, which do not require a base station such as an access point, have a hidden node problem because nodes communicating at the same time cannot know each other's communication status. On other hand, in a wireless infrastructure network the access point manages the communication with the node using RTS (request to send) and CTS (clear to send). However, we cannot use the RTS/CTS method in broadcasting because the number of target nodes is not one but more than two. In this paper, we propose a broadcasting method based on RTS/CTS to avoid this problem. In this method the sender node selects the target node, and they communicate with each other. Neighboring nodes can listen to these packets. Then the sender node can broadcast its information to multiple nodes. Finally ,the future scope of this algorithm is Broadcasting with collision avoidance protocol. With help of CSMA (Carrier Sense Multiple

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Access)/CA(Collision Avoidance) (Wataru Uemura and Masashi Murata, 2011).

MATERIAL AND METHODS

Data Gathering Tree (DGT)

In this paper, we focus on and study the problem of efficiently maintaining a tree structure in the sensor network. Sensed data is collected and transmitted to the base station in the form of tree known as Data Gathering tree. Tree structure is efficient as it avoid loops. Mostly communication is done based on tree structure. The set of active sensors form a tree structure with base as root. So the information sensors received will be forwarded to the base station. The procedure of constructing DGT is in such a way that there will be no need for periodic updating of table. No need of exchanging table to know the neighbors (Verdone *et al.,* 2008). The way we are constructing DGT and optimization parameter that we are giving as input to DGT is also important to conserve energy (Wook Choi and Sajal K. Das, 2006).

Example

Suppose Number of sensors are randomly deployed in a given area. Out of N we have to choose K sensors in such a way that it should cover the desired area specified by the user. Here k act as optimization parameter. Reporting Cycle of sensor Si is divided in to data reporting rounds each with k Sensors (data reporters) which can meet the desired sensing coverage specified by the use/application. So if K is larger then the height of Tree increases. So from sink to Leaf packet has to traverse a long path. The selection of these k data reporters is based on a geometric probability theory and a randomization technique without exchanging control (location) information with local neighbors (Wook Choi and Sajal K. Das, 2006).

Proposed way of Design

Generally the number of Data gathering trees that will be generated is depend upon the number of data reporting rounds (Wook Choi and Sajal K. Das, 2006). So we are presenting the idea of only one Data Gathering Tree with heterogeneous sensors.

System model

Here we are considering the 3 types of sensors based on energy.

- Sensor
- Transmitter
- Aggregator

Sensor is of less energy compared to Transmitter then Aggregator has maximum energy. The Proposed algorithm here is localized algorithm it mean many or all of the nodes run the algorithm separately on the information each has gathered.

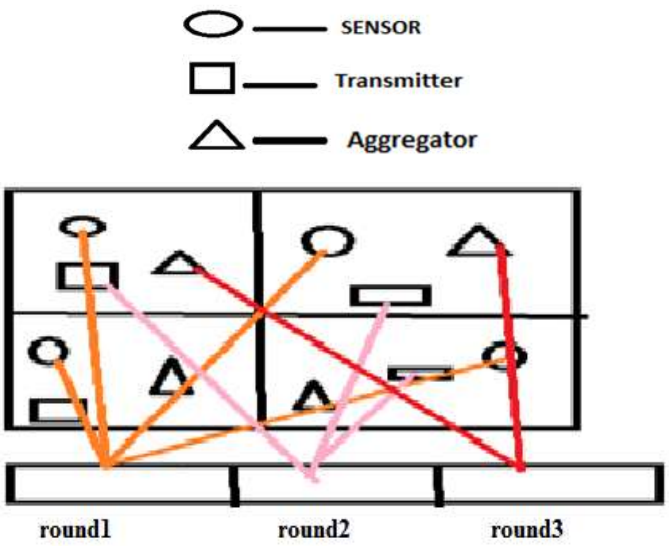

Fig.1. Choosing Different kinds of Sensors in each round

In the above diagram for three data reporting rounds only one Data gathering tree is constructed. First we activate sensor which consume less energy then transmitter in second round and finally Aggregator activate at final round like that we conserve energy by activating Highest energy sensor at final round. Here the goal of power optimality is achieved. Now for coverage we proposed an algorithm for efficient data gathering tree.

Problems in existing Literature

Effective Data Gathering Tree is Generalized algorithm (Niwat The pvilojanapong and Kaoru Sezaki, 2005). At specific situations doesn't provide suitable solutions. suppose if we consider this situation. Suppose if node4 receive CAC (Child Acceptance) packet from node2 and node5.In (Niwat The pvilojanapong and Kaoru Sezaki, 2005) it is mentioned that once child receives CAC it act as acknowledgement confirming the node which send it as parent and node which receive it as child. So according to this node4 is child of node 2 and node 5. It doesn't satisfy the property of tree because of Loop. Number of Data Gathering trees is equal to number of data reporting rounds in a cycle. So if there are more reporting rounds then the network performance will be decreased.

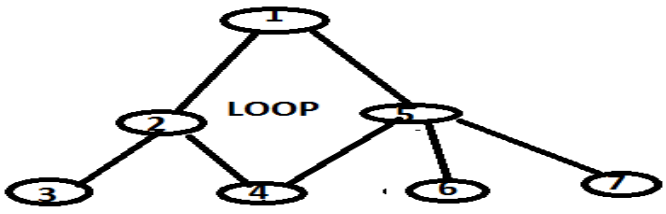

Fig.2. Possible Occurrence of Loop

Proposed Algorithm

It is the modification of Efficient Data Gathering (EDGE) protocol ,it deal effectively with loops. In static network the node positions are fixed there is no need of updating PC Table for Member of tree. In (Niwat Thepvilojanapong and Kaoru Sezaki, 2005) it doesn't mention what procedure to follow after

Member update its PC Table. So here we consider two conditions to avoid loop.

- 1.Parent can have any number of children
- 2 Child should have only 1 parent

RESULTS

Assumptions

Sensors are deployed in a square area. Divide the area in to 3 parts dimensionally, based on the one hop and two hop respective distances to ensure connectivity among all the deployed nodes. Sending/Receiving CRP(Child Reply), CAC (Child Acceptance) is used for choosing the minimum distance of any sensor from the particular sensor. Each sensor is assigned a broadcasting range and the sensor compares it with its neighbors and selects the minimum distance one. Two sensors A and B are said to be neighbors. If B is with in the communication range of A. So here communication range is assumed to be the difference between the broadcasting ranges of two sensors. If difference is less than or equal to 10 then sensors are said to be neighbors. Among neighbors choosing minimum distance mean selecting the less difference sensor from its neighbor list.

Existing Literature Output

Effective Data Gathering Tree is Generalized algorithm (Niwat Thepvilojanapong and Kaoru Sezaki, 2005). At specific situations doesn't provide suitable solutions. Suppose if we consider this situation shown in Fig.2. Suppose if node4 receive CAC packet from node 2 and node 5. In (Niwat Thepvilojanapong and Kaoru Sezaki, 2005) it is mentioned that once child receives CAC it act as acknowledgement confirming the node which send it as parent and node which receive it as child. So according to this node4 is child of node2 and node5.It doesn't satisfy the property of tree because of Loop. Similarly If we consider 7 nodes with the following broadcasting ranges 80,5,100,110,90,120,130. With node id's 0,1,2,3,4,5, 6 then we obtain 2 is child of 4 and 3, Similarly 5 is child of 3 and 6.So there is possibility of loop as explained above.

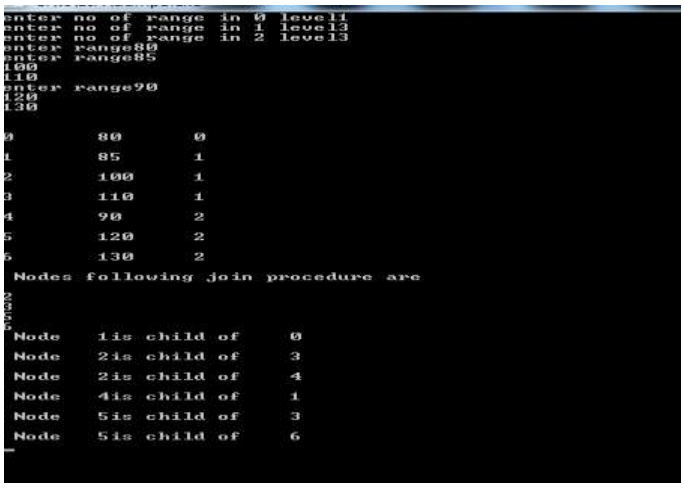

Fig.3. Executed Existing Literature output

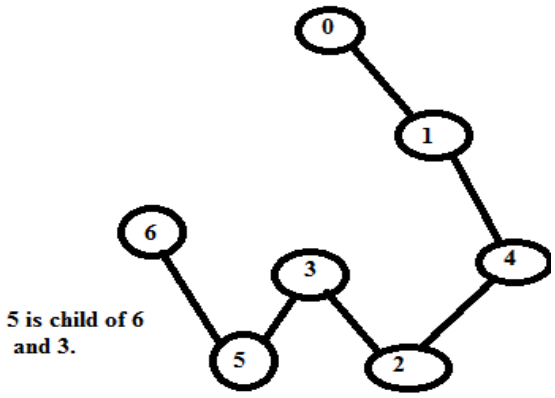

Fig.4. Graphical Representation of output with possibility of loop

In this program input is sensors broadcasting range at each level by default we are assuming it as 3 levels. Then at first column node Id will be generated to each node randomly, second column broadcasting ranges and at last column the level to which it belong. Nodes that follow the join procedure is displayed and after following join procedure the final result is Proposed algorithm Data Gathering tree.

Constraints in proposed algorithm

So in proposed algorithm we consider two conditions to avoid loop.

- Parent can have any number of children
- Child should have only 1 parent

Output of the proposed algorithm

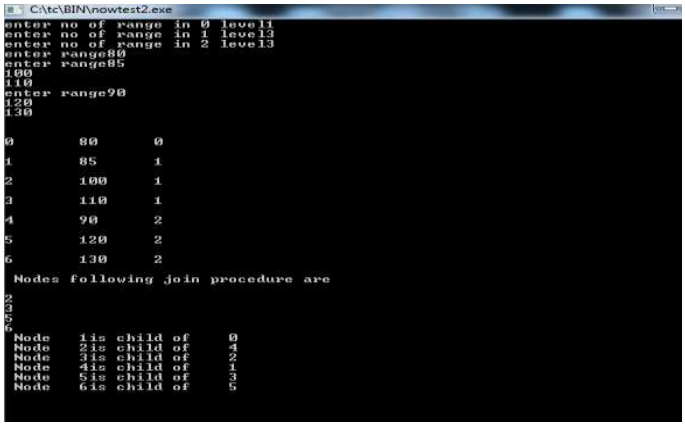

Fig.5. Executed Output of the Proposed Algorithm

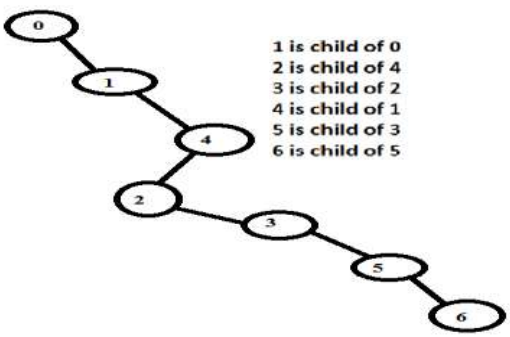

Fig.6. Graphical representation of Output without possibility of loop

The above mentioned figure (Fig.6) satisfies two conditions to avoid loop.

- Parent can have any number of children
- Child should have only 1 parent

Periodic updating of routing packets and generating minimum spanning tree. Which is again conserving the energy. Finally, The future scope of work in respect in this research is Broadcasting with collision avoidance protocol with help of CSMA/CA.

Table 1. Comparison of Proposed DGT with EDGE and Normal DGT

System Parameters	Normal Data Gathering Tree	Efficient Data Gathering Tree	Proposed Data Gathering Tree
Number of Packets	More packets transferred	Less packets transferred.	Same as EDGE.
Number of DGT's	Equal to number of reporting rounds.	Same as Normal DGT.	Only 1 DGT for each cycle.
Type of Sensors	Homogeneous	Same as Normal DGT.	Here Heterogeneous Sensors.
Frame Size	Large frame	Small frame	Same as EDGE
Power Optimality	some extent by turning of the sensors at each round	Same as Normal DGT.	Power conserving is high as we are using heterogeneous sensors and activating the higher energy consuming sensors at last round in each cycle.
Network Performance	< EDGE.	< Proposed DGT.	Proposed DGT >EDGE >Normal DGT(because the number of DGT generated is less and by considering heterogeneous sensors).

Comparison of previous algorithms

In Existing literature the number of Data gathering trees generated is equal to the number of reporting rounds for each cycle. Here only one Data Gathering tree is generated for each cycle. Generally in existing literature sensors are homogeneous. Here we consider the heterogeneous sensors they are Sensor, Transmitter, Aggregator. Sensor has less energy whereas Aggregator has more energy and Transmitter has less energy compared to Aggregator and more energy compare to Sensor. By activating the highest energy Sensor at last round of cycle. we are conserving the energy.

Conclusion

The Goal of Power Optimality is achieved by considering heterogeneous sensors i.e. activating high energy sensors at last reporting round of each reporting cycle. The network performance is improved by constructing only one Data Gathering Tree for each reporting cycle instead of for each reporting round. Finally the proposed algorithm which we are using to construct Data Gathering Tree avoids Flooding and

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