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Survey on Tree Based Energy Balanced Routing Protocols in WSNs

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Abstract: **This paper presents a review of tree based energy balanced routing protocols in wireless sensor networks. General self-organizing tree branching energy balance (GSTEB) routing protocol outperforms many protocols in terms of network lifetime and energy consumption per round. In GSTEB, BS assigns a root node and broadcasts its ID and coordinates in the selected network of sensor nodes. Here leaf node makes use of beacon instead of packets thus decreasing the number of bits. Subsequently, each node selects its parent node by considering its own information or considering the neighbors information thus it makes GSTEB a dynamic routing protocol. Also make efforts to overcome load balancing problem as it is much difficult to attain the load balance on each and every node.**

Keywords: **Energy-balance, routing protocol, network lifetime, self-organized, wireless sensor network.**

I. INTRODUCTION

A wireless sensor network (WSN) means a wireless network which consists of spatially distributed autonomous nodes that use sensors to monitor physical conditions. These nodes may be hundreds and thousands to combine with routers and a gateway thus to create a typical WSN system. These nodes actually meant for processing, data gathering and aggregation capability along with the communication with other nodes. Each node has its own processing capability that can include one or more microcontrollers which is having system on chip capability, CPUs or DSP chips, may contain multiple types of memory, and also makes use of external memory known as flash memory and have a RF transceiver (usually with a single Omni-directional antenna), have various batteries and solar cells as a power source, and accommodate various actuators as these nodes can't use mains supply as power supply. The nodes communicate wirelessly and often self-organize after being deployed in an ad hoc fashion thus it favors inter nodes communication [1]. The features of WSN include: constrained resources (bandwidth and energy), data-centric application and dynamic configuration and many more. There are many technical challenges associated with sensor networks, such as self-organizing algorithm, energy-efficient routing protocols, data aggregation technology, data fusion technology and network lifetime improvements. The energy for sensor networks is very important. It is infeasible to replace battery of sensor, thus it's our prime objective to save the nodes to die off from more energy consumption. Therefore, conserving energy so as to prolong the network lifetime is becoming one of the key challenges [2].

A. Classification of Routing Protocols in WSN

Different routing protocols are designed to fulfill the shortcomings and needs of the recourse constraint nature of the WSNs. The deployed WSN can be differentiated according to the network structure or layout and intended operations. Therefore, routing protocols for WSN needs to be categorized according to the nature of WSN operation and its network architecture. WSN routing protocols can be subdivided into two broad categories, network architecture based routing protocols and operation based routing protocols.

Network structure based protocols are divided in three categories: Location based routing, Hierarchical network routing and Flat network routing.

Protocol Operation based protocols are divided into five categories: Negotiation Based routing, Multi-path based routing, Query Based Routing, QoS Based Routing and Coherent Based Routing.

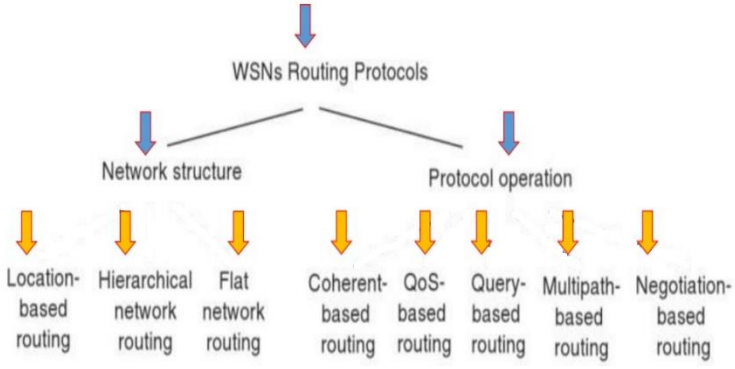

Fig.1 Classification of Routing Protocols in WSN

B. Hierarchical-Based Routing

Hierarchical-based routing protocols are used in the applications where their high energy-efficiency, data aggregation and good expandability is needed the most. These protocols work on the basic idea to select some nodes in charge routing in particular regions. The selected nodes possess greater responsibility relative to other nodes of the network which leads to the incompletely equal relationship between sensor nodes and only the selected nodes will communicate and monitors the channel. LEACH (Low Energy Adaptive Clustering Hierarchy), PEGASIS (Power-Efficient Gathering in Sensor Information System) is the typical hierarchical-based routing protocols [4].

II. RELATED WORKS

A main task of WSN to collect or one can say gather the required information and within the particular time, the aggregated data should reach the BS. Earlier direct transmission occurs means all the nodes directly have contact with the BS and send the required data to it which leads to premature die of many nodes as it takes large energy for communication purpose i.e. unbalanced energy consumption.

To solve the problems faced in Direct transmission many protocols have been proposed like LEACH, HEED, PEGASIS, TBC and PEDAP can fulfill the satisfactory results.

In LEACH [3] [4], for the whole network the nodes are selected and from the selected nodes cluster head is selected which depends upon the p parameter i.e. design parameter. The probability of becoming cluster head again from the selected nodes can be after 1/p rounds. The design parameter for LEACH is 5% means 20 rounds. It involves two phases one is set-up phase and other is steady state phase. In the set-up phase cluster head is chosen and in the steady state phase aggregated data is send to base station. Its performance is better about 8 times to that of direct transmission.

In HEED (Hybrid Energy Efficient Distribution), the selection of the cluster head in each round primarily depends upon the residual energy of the nodes means the node with the highest energy among all selected nodes will be chosen as cluster head. The secondary parameter is nodes proximity (near-by nodes) or Node degree. As compare to LEACH HEED performs better in network lifetime and where all the nodes are having different initial energy [5].

In PEGASIS (Power Efficient Gathering sensor information system), though LEACH & HEED were efficient in low energy consumption but most of load is on cluster heads and thus they die quickly. Lindsley *et. al* proposed a protocol named as PEGASIS which forms a chain like structure. It supports two approaches one is GREEDY algorithm which means if any of the node dies, the whole chain is reconstructed. Second approach is token passing, in leader node got all the tokens from the native members in chain and send this fused data to the base station. It actually sharply reduces the total amount of data for long distance transmission thus more efficient than LEACH as well as HEED [6].

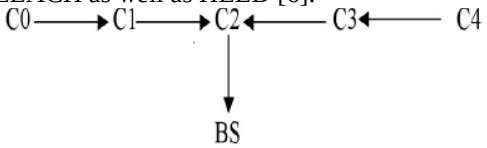

Fig. 2 Chaining in PEGASIS [6]

In TBC (Tree-Based Clustering), it forms several clusters just like LEACH it also forms several clusters and within a cluster construct a routing tree where cluster head is a root. At level 0 root is placed and a node in level L(i) will choose the node in level L(i)-1 and nearest to itself as its parent node. For tree configuration, cluster-head uses the distance information between itself and other nodes. In this every node is location aware means it can estimate the distance between root and itself as well as with its parent node. In this two neighboring levels will fuse the data and this fused data to its parent node. It is an excellent protocol which records the information of its neighbors and builds the topography by making computations.[7]

In the traditional tree branching, first of all the root node send ready packets to the selected sensor nodes which contains the root ID and its energy. All the nodes which are interested to become its child node send engagement packet to root node and if Cmax value is less then root node will send engagement acceptance packet. This process continues until every child node gets its parent node according to the offered ID which contains the number of m bits means if Cmax value < 100 it contains 2 digits are needed 0-99. And routing tables are also updated according to it [8].

In PEDAP (Power Efficient Data Aggregation Protocol), it is a tree based routing protocol which forms a minimum spanning tree means loop free topology, which costs minimum energy for data transmitting. It is also having another version known as PEDAP-PA where PA stands for power aware which consumes more energy for data transmitting than PEDAP but balances energy consumption per node. It takes same network assumptions as PEGASIS as it also works on data fusion. Here BS is meant for making topography and computations which leads to high energy wastage because BS have to send lot of information to sensor nodes as well as time division multiple access slots.[9]

The main aim of GSTEB (General Self-organizing Tree Branching Energy Balancing Protocol) is to achieve a longer network lifetime for different applications in WSN environment [10]. In each round, BS assigns a root node which is away from BS according to predetermined criterion and broadcasts its ID as well as coordinates to

all the sensor nodes. Then network computes the path according to the path information from BS to selected sensor nodes or by having the same tree structure being dynamically built by each node. GSTEB can reconstruct the routing tree with lesser delay and low energy consumption.

The GSTEB includes following phases:

a) Initial phase
b) Tree constructing phase
c) Self-Organized data collecting and transmitting phase
d) Information exchange phase

In the initial phase, the network parameters are initialized after that BS broadcasts a packet to all the nodes which contains the information of beginning time, the length of time slot and the number of nodes 'N'. When all the nodes receive the packets, comparison of energy level occurs with its own energy. In this phase each node sends its packet within a certain radius R_c, but during its own timeslot. Packet consists of preamble and information regarding coordinates and load balancing parameter of the desired node. All other nodes will monitor the channel if any neighboring nodes in the closest proximity to it will receive the packet and record the information of the desired node in its table. The nodes which are not in the range of certain radius will turn off their radios to save energy in the same time slot.

In the tree constructing phase, within in each round, GSTEB performs the following steps to build a routing tree.

Step 1: BS assigns a root node considering some parameters and broadcasts the root ID and coordinates to all selected sensor nodes. The node which is having largest residual energy is chosen as root.

Step 2: Each node tries to select a parent in the neighborhood using load balancing parameter EL and coordinates which are recorded in the table. If the sensor node itself has the largest EL, it can also be considered to be an imaginary relay node and the relay node with minimum energy consumption is chosen as parent node. GSTEB chooses the nodes with more residual energy to transmit data for long distance. If the sensor node unable to find a suitable parent node, it will transmit its data directly to BS.

Step 3: Because every node chooses its parent node from its neighbors and every node records its neighbors information, and each node can have the information of its parents by making computations. If all the nodes joins always to its nearest neighbor it won't form a tree.

In Self-Organized data collecting and transmitting phase, after the construction of routing tree, each node collects information to generate a data packet which is to be transmitted to BS.

TDMA and FHSS schemes are applied. This phase is divided into several TDMA slots. In a time slot, only the leaf node is supposed to send their data packets. When the leaf node collects all the data from its child nodes then the fused data is transmitted from the one leaf node to another leaf node in the next time slot. Each node knows the ID of its parent node and to reduce communication interference with its parent node frequency hopping sequence is used which is determined by its parent node ID. Each TDMA timeslot is divided into three segments

Segment 1: Communication interference is checked in the first segment for a parent node. In this segment, each leaf node sends a beacon which contains ID of the parent node at same time. Particularly, three situations occur and they divide all the parent nodes into three kinds:

1. For the first situation, if none of the leaf nodes need to transmit data to the parent node in this timeslot, it receives nothing.
2. For the second situation, an incorrect beacon is received if more than one leaf node need to transmit data to its parent node.
3. For the third situation, a correct beacon is received as only one node needs to transmit to its parent node, so there is no chance to receive an incorrect beacon as in second situation.

Segment 2: During the second segment, the leaf nodes are confirmed to transmit their data.

1. Until next timeslot starts, the parent node turns to sleep mode.
2. All of the child nodes will receive control packets from its parent node.
3. Only one of the child node will receive the packets.

This control packet will tell the child node to transmit the data in the next segment.

Segment 3: Only the permitted leaf node will send data to its parent node other nodes will turn their radios off and switch to sleep mode. Each node selects its parent considering its total energy consumption but neglecting distance parameter. BS uses the same approach in each round for constructing the routing tree, then tells the sensor nodes when to send or receive the data. In each and every TDMA time slot, the nodes work in turns as per defined by BS. When all the data is received by BS, the network will start the next phase.

In information exchange phase, if each node needs to transmit and generate a data packet in each round, it may die due to exhausted energy. The topography can be influenced by the dying of any node that's why nodes that are going to die need to inform other nodes. The process is divided into timeslots and in each timeslot, the nodes whose energy is going to be exhausted will compute a random delay i.e. only one node can transmit in this time slot. When this random delay is ended, these nodes will try to broadcast a packet to the whole network while the other nodes are monitoring the channel. They will receive this packet and performs ID check and

modify their tables according to it. The network will start next round if no such packet is received in the timeslot.

If BS can collect the initial EL and coordinates information of all the sensor nodes in initial phase. BS builds the routing tree and the schedule of the network by using EL and coordinates information for each round. Once the routing tree is built, the energy consumption for each sensor node can be calculated by BS in this round, thus information needed for calculating the topology for the next round can be known in advance. As WSN may be deployed in an unfriendly environment, the actual EL of each node may be different from the calculated EL by BS. To work against this problem, each sensor node calculates its EL and detects its actual residual energy in each round. Calculated EL is defined as EL1 and the actual EL is defined as EL2. When ELs of a sensor node are different, the node will generates an error flag and packs the information of actual residual energy into data packet, which needs to send to BS. When this data packet is received BS will get the actual residual energy of this sensor node and use it to calculate the topography for next round.

III. DISCUSSION

It consumes little energy and this only causes a shorter delay in the Tree constructing phase because the topography is built by self-Organizing, each node is able to choose its parent simultaneously. In the third phase o.e. self-Organized data collecting and transmitting phase, the parent node will receive a packet form the respective leaf node as each leaf node is transmitting to its parent node. The beacon frame is send which only contains the ID of the leaf node. Beacon length is much shorter than the data packets thus reducing the number of bits. The delay is shorter than that of the PEGASIS and PEDAP. In paper [10], it has given that GSTEB performs far better than HEED and the network lifetime is also prolonged up to 100%.

IV. CONCLUSION

GSTEB outperforms many protocols LEACH, PEGASIS, TREEPSI and TBC. Because GSTEB is a self-organized protocol which only consumes a small amount of energy in each round to change the topography for the purpose of balancing the energy consumption. Transmitting delay is short because all the leaf nodes can transmit data in the same timeslot. When the data collected by sensors cannot be fused, GSTEB does a tremendous job by introducing a simple approach to balancing the network load. Though its difficult to balance the load on each node and even GSTEB needs BS to compute the topography which leads to an increase in energy wastage and longer delay are acceptable when it is compared with the energy consumption and the time delay for data transmitting.

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