Routing Protocols For WSN

(General Self Organized Tree Based Routing Protocols)

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***Abstract*— Wireless Sensor Network consists of low cost and low power, small in size and multifunctional sensor nodes. These sensor nodes sense the target area, monitor the area, gather information and transfer it to base station. The main requirement of wireless sensor network is to prolong network lifetime and energy efficiency. The design of energy aware protocol is essential. Many routing protocols have been developed by researchers like LEACH, HEED, PEGASIS, and TREEPSI to achieve energy balancing. In this paper, about GSTEB (General Self-Organized Tree Based Energy-Balance Routing Protocol) has been discussed. This protocol uses routing tree technique. GSTEB creates a routing tree whose root has been selected by the base station and base station broadcasts its information to all nodes in the network which than selects their respective parents by some criteria.**

***Index Terms*-Wireless Sensor Network, Network Lifetime, Energy Balance, Routing Tree, Routing Protocols.**

I. INTRODUCTION

A wireless sensor network is a collection of nodes organized into a cooperative network. Each node consists of processing unit (one or more microcontrollers, CPUs or DSP chips), it also contain multiple types of memory (program, data and flash memories), have a RF transceiver, have a power source (e.g., batteries and solar cells), and have various sensors and actuators. The nodes communicate wirelessly and often self-organize after being deployed in an ad hoc fashion. Systems of thousand's or even lakh's of nodes are evaluated. Such systems can overturn the way we live and work. All sensor nodes have to coordinate with each other in order to produce high quality information about physical environment. All nodes communicate with each other at same time and route the information to base station which is a master node. Sensor nodes are deployed either randomly (dropped by helicopter) or uniform (deployment are well planned). Once sensor nodes are deployed it cannot work properly unless there is sufficient power supply. And once the node's battery drains the network will not work properly and hence there is a need of highly adaptive and resource aware routing techniques. Researchers have developed many routing techniques like LEACH, HEED, PEGASIS, and TBC. WSN produces substantial amount of data and if data fusion technique is used the throughput can be reduced. This technique is applied by many well known protocols like PEGASIS [6], PEDAP [7], TBC [8] but all assumes that the length of message transmitted by each node must be constant which means the same amount of data is transmitted by each node disregard of the amount of data node receives from respective child node.

Energy consumed by transmitting and receiving of data messages are useful energy consumption and the energy required for data overhearing, routing tree construction are wasteful consumption. In this paper about GSTEB (General Self Organized Tree Based Energy efficient Routing Protocols) is discussed. GSTEB assumes that all nodes senses the environment periodically and transmits the information to base station. The lifetime of a network can be defined by two ways:
1: The time from the start of network till the death of first node.
2: The time from the start of the network till the death of last node.

In this paper the first definition is discussed. The remainder of the paper is organized as follows: Section II Literature Survey, Section III GSTEB, and Section IV Conclusion of the paper.

The following figure shows the basic architecture of WSN.

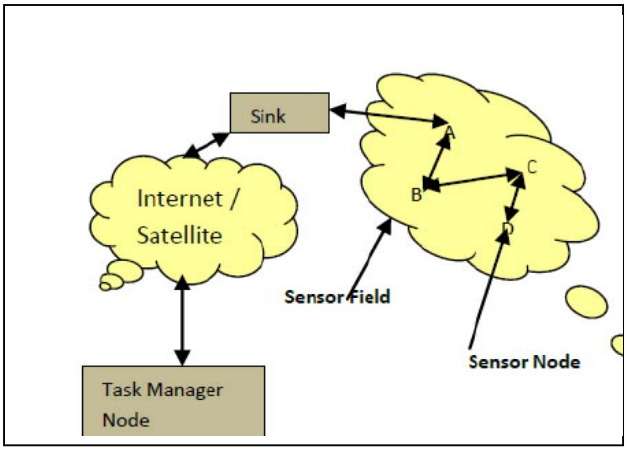

Figure 1: Architecture of WSN's

II. LITERATURE SURVEY

WSN is a network of many tiny, low power devices called nodes, which provides opportunities in several application domains ranging from military to civil use. Considering the fact that longitivity of wireless sensor network is usually limited due to their non-rechargeable energy resource thus there is a need of careful plan to enhance network lifetime. The main source of power consumption is communication, hence a high performance routing technique is an important part in WSNs. According to the structure of network topology, routing techniques are divided into three categories flat architecture, hierarchical and location based routing technique.

Researchers has proposed many protocols under this three category like Flooding, direct diffusion, Gossiping, LEACH, HEED, PEGASIS, TBC, TREEPSI etc. Of the proposed protocols hierarchical protocols achieves satisfactory result.

I. LEACH And HEED

LEACH is a first hierarchical routing protocol which uses data fusion technique. Many routing protocols are improved based on LEACH protocol only. LEACH protocol is based on cluster formation where all nodes in a network organizes themselves in a local cluster and selects a cluster head which collects information from non-head node and transmit it to the base station. LEACH uses randomized rotation of the cluster heads to evenly distribute the energy load among the sensor nodes in a network [4] [5]. Once the clusters are constructed, the cluster head broadcasts TDMA schedule providing the order of transmission for members in the order. Each node has its own time slot and will transmit in its time slot only. When last node has transmitted its data, cluster head will fuse all data and transmit it to base station. Again for the next round cluster head will be randomly elected. It employs localized coordination to improve scalability and balance energy usage of the network among all nodes. HEED (Hybrid Energy Efficient Distributed Clustering) protocol is an energy efficient clustering protocol. It extends the basic schema of LEACH protocol. It uses residue energy as its primary parameter for cluster selection and node degree and distance to neighbors as secondary. The clustering process is divided into number of iterations and in each iteration the node that are not covered by any cluster head; it doubles the probability of becoming a cluster head. HEED does not guarantee optimal elected set of cluster heads [6] [7]. LEACH, HEED protocols effectively increases the network lifetime but greatly reduces total energy consumption since they consume more energy in cluster head node due to which node dies early and once head node dies all other nodes associated with it becomes isolated.

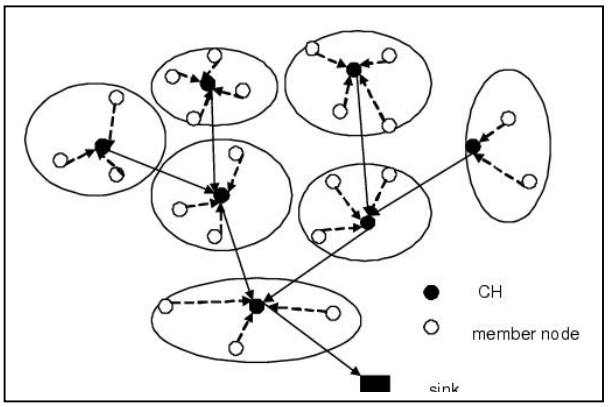

Figure 2: Clustering in WSN's

II. PEGASIS

PEGASIS (Power Efficient Gathering in Sensor Information System) is a chain based power efficient protocol [8]. Greedy algorithm is used for chain construction, where each node selects their closest neighbor as next hop in the chain. It considers that each node has global knowledge about the network and chain construction starts from the node which is farthest from the sink. Communication within chain is carried out sequentially. Each node within the chain collects data from its neighbor until all data are gathered at one sensor node called chain leader. Chain leader is selected by (i mod N) where i is current round and N is the total number of nodes. Chain leader manages the communication order by passing tokens among nodes [3]. This protocol may not be approachable to event based application, where information is communicated only when certain events occur.

III. TBRP

TBRP (Tree Based Routing Protocol in wireless sensor network) is a distributed and energy efficient protocol, which elects cluster head by considering the distance to neighbor and residue energy of node, and so defines new algorithm for cluster head election. TBRP handles heterogeneous energy circumstances better than many clustering algorithm which elects cluster head based on node's own residue energy only. Base station forms the **primal** cluster and it will not change much because all nodes are immobile but the selected cluster head in the same cluster may be different for each round. After cluster formation phase, a fuzzy spanning tree is constructed for all cluster heads and through single-hop communication only tree's root node communicates with the sink node. Free space model computes the energy consumed by communication so the energy will be saved and lead to sensor node longitivity. In TBRP protocol each node stores information about its neighbor in neighborhood table. At the beginning of each round, ECH_MSG message containing residue energy all node is broadcasted by each node within the radio range r. All nodes within this radio range are neighbors to

each other. ECH_MSG is received by all nodes from its neighboring node and all nodes update its neighborhood table and generate a fuzzy number (FEN). In TBRP, there is uniform energy consumption among all nodes, because the cluster head always keeps rotating in whole lifespan of network. In TBRP, after clustering base station broadcasts the criteria message to all cluster heads, which contains decision criteria and its values. All cluster head receives a message and generates a fuzzy number for itself. During next stage cluster head broadcast this CRT_MSG message, containing node ID and FEN within range R, than this two FEN one received from neighboring cluster head and other cluster head's own are compared and if cluster head's FEN is small then it will select a node having higher FEN as its parent node and will send CHILD message to notify parent node. After a specific time period, a fuzzy routing tree is generated and the root of tree will have largest weight among all cluster head's. After routing tree construction, cluster head broadcasts a TDMA schedule to their active member nodes to be ready for data gathering. When compared other schema TBRP outperforms in optimizing cluster heads energy consumption, amount of data gathered and improves system lifetime [9]

Node	Distance from neighbors	Residual Energy of	Residual Energy

Figure 3: Information stored in neighborhood table.

IV. TREEPSI

TREEPSI (Tree Based Energy Efficient Protocol for Sensor Information) is a tree based protocol. In this protocol WSNs will elect a root node in all sensor nodes, there are two ways to build tree path. One is computing the path centrally by sink node and broadcasting the path information to network and the other can be same tree structure locally generated by using a common algorithm in each node. Initially root creates the data gathering process to their child nodes. The next step is data gathering after forming a tree. All leaf nodes will start sending data towards their parent nodes. The parent node will collect the received data with their own data, and then send the collected data to their parent, the transmission process repeated until all data received by root node. The data aggregation will take place at root node and after aggregation root node sends the collected data to sink node. The process will go until the root node dies. WSN will reselect a new root node and initial phase is again repeated. The tree path will not change until root node dies. The length of path from end leaf node to root node /chain node is shortest. The data will not send for longer path for this reason, TREEPSI can reduce power consumption in transmission compared with other existing protocol. [10]

GSTEB (GENERAL SELF-ORGANIZED TREE BASED ENERGY BALANCE ROUTING PROTOCOL)

The main focus of GSTEB is to increase the lifetime of network. For this GSTEB assigns a root node in each round and broadcasts the root node ID, coordinates and other required information to all other node in the network. Then the network computes the path either by transmitting the path information from BS to sensor nodes or by having the same tree structure being dynamically and individually built by each node.

GSTEB has following phases Initial Phase, Tree construction Phase, Self Organized Data Collecting and Transmitting Phase and Information Exchange Phase. [1]

I. Initial Phase

All new parameters are initialized in initial phase. This phase has following three steps.

Step1: In this step Energy level is computed using

$$EL(I) = \lceil \text{residue energy } (I)/\alpha \rceil \quad (1)$$

Where **EL** is a parameter for load balance which is an estimated value rather than true one and **α** is a constant which reflects minimum energy unit and can be changed on our demand. For this whenever the phase begins a packet containing information about the time start, time slot length and total no of nodes is broadcasted by the base station in the whole network. Energy level is a load balancing parameter and it's an estimated value rather than true one

Step2: After step1, each node will send a packet containing preamble, coordinate information, Energy Level of a node to its neighboring nodes in a circle with certain radius Rc, during nodes own time slot. For example: during i^{th} time slot node whose ID is I will send out its packet to its entire neighboring node. At this time all other node will monitor the network and the nodes who are neighbors of I will receive this packet and record information transferred by i in their memory. All nodes which are not in Rc range will turn off their radio and switch to sleep mode in order to save energy. Likewise all other node will transfer this packet and each node will have a table containing information about neighbors in their memory.

Step3: After Step2, each node has a table containing its neighbor's information and will broadcast this table in their time slot. After this phase each node will have two tables in their memory one containing information about neighbors and other contains information about neighbor's neighbor.

II. Tree Construction Phase

The following two steps are done to form routing tree in each round.

Step1: Root node is selected by BS and the root node ID is broadcast to all other node in network. The node which has largest energy residue is chosen as root node. This node will collect all data, combine them and transmit the fused data to BS. As it uses data fusion technique the node which communicated with BS transmit the data with the length so its own, which results in much less energy consumption.

Step2: After node selection each node will select their respective parent node using EL and coordinates recorded in table 1.

1. A node will select parent with the criteria that the distance between its parent node and root node should be less than the distance between itself and root.
2. The node which satisfies the criteria will be selected as parent node if it is nearer to node itself and if node cannot find a nearest neighboring node which satisfies above criteria than the node will select root as its parent. Generally criteria 1 are

used because if all nodes choose their nearest neighbor the network may not be able to build a tree.

Step 3: As all node selects their parent from neighborhood and has a record of neighbor and neighbor's information so a node can compute parents of every other node and will also know the child nodes.

III. Self-Organized Data Collecting and Transmitting Phase

After constructing a routing tree, all sensor nodes gathers information in order to generate a DATA_PKT will be transmitted to base station. For this phase TDMA and FHSS techniques are used. The phase is divided into several time slots and during each time slot only leaf node will send their DATA_PKT to respective parent node. Parent node will receive all data from its child nodes and fuse them and will send this packet in next time slot acting itself as a leaf node.

In each time slot we apply FHSS at which using frequency hopping sequence determine by a parent node a child will communicate with parent node so that the communication interface can be reduced.

TDMA time slot is divided into three segments

Segment 1: This segment is used to check the communication interference for parent node for this a beacon having leaf node ID is sent by a leaf node to parent node. Due to these three kind of situation will arise and will divide a parent into three types. For first situation, at particular time slot if no leaf node want to send data to parent node than the leaf node will receive nothing. For the second situation an incorrect beacon is received by leaf nodes if more than one node wants to send data to parent node and in third situation a leaf node receives a correct beacon if only one leaf node wants to transmit data to parent node.

Segment 2: During this segment. a leaf node which can communicate with parent node are confirmed and the parent node turns to sleep mode for first situation and a control packet which will choose a child node to transmit in next slot is sent by a parent node to all child nodes for second situation. And for third situation a control packet telling to transmit data is sent to leaf node.

Segment 3: Parent node receives data from permitted leaf node and all other leaf nodes switch to sleep mode.

IV. Information Exchange Phase

Since all nodes are battery operated and they need to create and send a DATA_PKT in each round so their energy will exhaust and node will die due to which the network topology may get affected. Therefore a dying node must inform all other node about its status, this process is also divided into time slot and a dying node will compute a random delay in each time slot which make only one node broadcast in this slot. These nodes will broadcast this packet to whole network when the delay is ended. During this time slot all other nodes are monitoring the channel and they modify their table when they receive this packet and modify their table and next round will get started if no such packet is received.

V. COMPARATIVE ANALYSIS OF PROTOCOLS

If GSTEB and PEGASIS protocols are compared using same radio model as PEGASIS [8] than GSTEB performs better compared with PEGASIS. As PEGASIS uses GREEDY algorithm for chain construction there may exists a long link between parent node and child node causing unbalance load but GSTEB chooses nearest neighbor as parent long links are avoided and hence GSTEB prolong network lifetime by 100 to 300 %. GSTEB performs better than all listed protocol. GSTEB and TBRP both protocol use similar approach for data transmission and both protocols require each node to keep information of its neighboring nodes. GSTEB requires more memory because in GSTEB each node needs to record information of its neighbor's neighbor. But GSTEB outperforms TBRP in energy saving as in GSTEB each node has more opportunity to choose nearest neighbor as its parent.

If GSTEB and HEED are compared than GSTEB improves network lifetime by 100% and outperforms HEED. Both GSTEB and HEED protocol focuses on load balancing. In HEED cluster heads are selected using residue energy but it achieves only local energy balance, because in HEED CH's cannot decide a dynamic communication with base station using single hop or multi hop communication. If multi hop communication is selected than CH's nearer to BS will have more data to transmit and will consume more energy on the other hand if single hop is chosen than CH's away from BS will consume more energy. But in GSTEB, nodes can dynamically communicate with BS. In GSTEB all nodes selects a neighbor with higher EL as parent and in every round, node having higher EL consume higher energy and leads to energy balance.

VI. CONCLUSION

GSTEB is a self-organized protocol so it requires only little energy to change the topology in each round for the purpose of energy balance. GSTEB has short transmission delay since all leaf nodes can transmit data only in TDMA time slot. GSTEB prolongs the lifetime of network when the lifetime is defined as "time required from start of network operation till death of first node." than other protocols. Therefore GSTEB is nearly an optimal protocol for WSN energy balance when the data fusion technique is used.

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