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A Systematic Overview of Routing Protocols in WSNs

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Abstract—Latest research on Wireless Sensor Networks (WSNs)bring forward multiple routing protocols in literature. These protocols enhance network life time and improve the Quality of Service (QoS) of the underlying network. In this paper, we discussvarious protocols in the aforementioned context. The main focus of our research is on cluster-based hierarchical routing protocol,which are examined and comparedfrom several aspects and characteristic. In this paper, we also discuss General Self-Organized Tree Based Energy-Balanced Routing Protocol (GSTEB). This protocol creates a routing tree in which the roots are being selected by the base station which broadcasts its information to all the nodes in the network and selects their respective parents by using a specific criteria.

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

1. INTRODUCTION

Technological advancements has brought forwardtiny, low-cost, low-powered, and intelligent sensor nodes in the field of Wireless Sensor Network [1]. WSNsare a collection of nodes which communication with each other to capture various phenomena of interest. Each node consists of a processing unit which can be a microcontroller, CPU or a DSP chip. Each node also consists of various types of memory (program, data and flash memories), has an RF transceiver, has a power source (i.e., battery or solar cell), and has various type of sensors and actuators. The nodes are deployed to form a wireless network for data communication. There are thousands of nodes which coordinate with each other and produce high quality of information about an area of interest. The sensor nodes capture the data and send information to a base station. The nodes are deployed either randomly or uniformly. These nodes are left unattended to sense the environment. These nodes are usually non-chargeable and non-replaceable. As a result, energy constraint is a major concern in these networks and need to be addressed properly [3] [4]. When the nodes are deployed,they cannot work unless there is sufficient power supply. When the sensor nodes deplete their battery power, the network does not achieve its desired results of sensing. As a result, there is a need of highly adaptive and resource-aware routing techniques. There are many routing algorithms such as, LEACH, HEED, PEGASIS and TBC. These networks produces large amount of data when require data fusion techniquesto reduce the redundancy and improves throughput. Data fusion techniques are applied by almost all of the aforementioned algorithms and other chain-based protocols such as PEGASIS [6], PEDAP [7] and TBC [8]. All these protocolsassume that the length of message transmitted by each node must be constant. It means that the same amount of data is transmitted by each node regardless of the amount of data a node receives from respective child node. The energy of a network is consumed by transmitting and receiving data. For data overhearing,more energy is required. Therefore, the route constructions consume unnecessary a considerable amount of energy. In this paper, we also discuss about GSTEB which assumes that all nodes senses the environment periodically and transmits the information from nodes to a base station. The network lifetime can be defined in two ways:

- The time from the start of network till the death of first node.
- The time from the start of the network till the death of last node.

In this paper, the focus is on the first objective. The remainder of the paper is organized as follows. In, Section II, literature survey is presented. In Section

III, GSTEB is discussed followed by conclusion in Section IV.

II. LITERATURE SURVEY

WSNs are a collection of multiple low-power small sized devices known as nodes, which are used in various application domains such as, agriculture, industrial automation, healthcare, military surveillance and habitat monitoring. In these networks, operation of the nodes is restricted by resource-limitations imposed on these miniature devices. In Figure 1, the basic architecture of WSN is shown. In WSN, a significant amount of power is consumed in communication. Therefore, highly efficient and performance-oriented routing techniques are required. In literature, routing techniques are divided into three main categories: flat routing, location-based, and cluster-based hierarchal routing. Researchers has proposed various protocol under these three categories such as Flooding, direct diffusion, Gossiping, LEACH, HEED, PEGASIS, TBC, TREEPSI etc. Of the proposed protocols hierarchical protocols achieves satisfactory result and are discussed below.

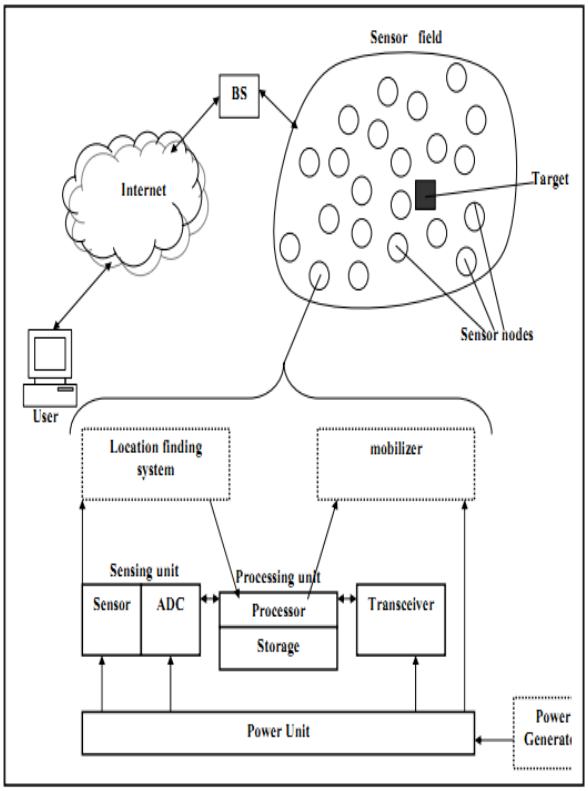

Figure 1: architecture of WSN

I. LEACH and HEED

LEACH is a pioneer hierarchical routing protocol which uses data fusion technique. Many routing protocols use the same underlying cluster-based hierarchy of LEACH. In LEACH protocol, the nodes are partition into cluster and in eachcluster,a single node isselected as cluster head(CH). Each CH collects data from its member nodes and forward to a base station, also known as sink. LEACH uses a randomized rotation of cluster heads to evenly distribute the energy load among the sensor nodes [5] [9]. When a CH is selected,it assignsTDMA slots to its member nodes for data transmission. Every member node has its own time slot for sending its data. When a CH collects data from all member nodes, it aggregates the data, fusion it and transmits to a base station. Again for next round, cluster heads will be elected in order to homogeneously distribute the power load which increases the network life time. The same process will be repeated in each round till the network run out of its residual energy.

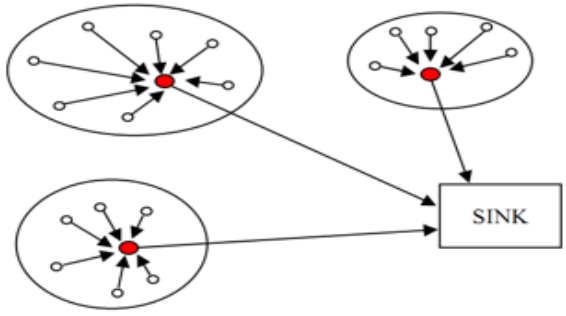

Figure 2: architecture of WSN

HEED (Hybrid Energy Efficient Distributed Clustering) protocol is an energy efficient clustering protocol. It extends the basic operational mechanism of LEACH protocol. It uses the residual energy as a primary parameter andnetwork topology features (e.g. node degree, distances to neighbors) are only used as secondary parameters to establish relationshipamong candidate cluster heads. This feature is useful for cluster selection to achieve load balancing. All nodes in the network are assumed to be homogenous, i.e. all sensor nodes with thesame initial energy. The clustering process is divided into a number of iterations and in each iteration, the nodes that are not covered by any cluster head doubles the probability of becoming a cluster head. HEED does not guarantee optimal elected set of cluster heads [6] [7]. LEACH and HEED protocols effectively increase the network lifetime but greatly reduce the total energy consumption since they consume more

energy in cluster head node due to which node dies early. Once head nodes die, all other nodes associated with it becomes isolated.

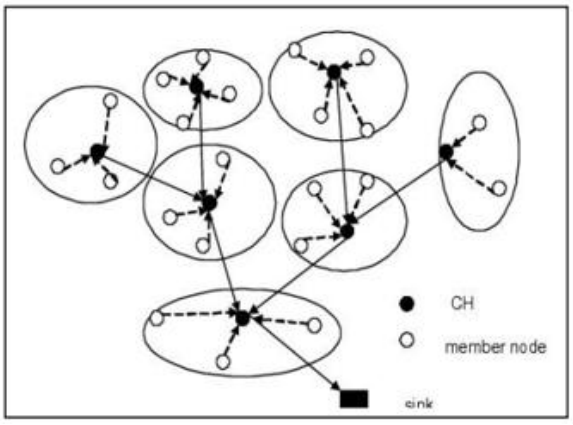

Figure 3: Clustering in WSNs

II. PEGASIS

PEGASIS (Power Efficient Gathering in Sensor Information System) is a chain-based power-efficient protocol that is an improvement over LEACH [8]. In PEGASIS, greedy algorithm is used for chain construction. Each node communicates only with a nearest neighbor and transmitting data to the base station, thus reducing the amount of energy spent per round. Each sensor node in the network has control over its power. All nodes have location information about all other nodes in the network. Some extra energy is consumed in findingthe close neighboring nodes by sending a power signal to nodes, and then gradually reduce its power to find which neighbor is closest to it. The sensor network model has the following properties.

- The BS is fixed at a far distance location from the sensor nodes.
- The sensor nodes are homogeneous and energy-constrained with uniform energy.
- Sensor nodes are static.

The key idea in PEGASIS is the formation of chain among the sensor nodes that every node will send and receive data from closest neighboring nodes, gather all data to one sensor node called chain leader node and then the data transmits to BS. 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 [2]. Nodes take turns in transmitting to the BS so that the average energy spent by each node per round is reduced [7]. This protocol may not be suitable for event-based applications where, information is captured only when certain events occur.

III. TBRP

TBRP (Tree Based Routing Protocol in wireless sensor network) increases the network lifetime by balancing the energy load among all the nodes. TBRP introduces a new algorithm for cluster head election, which can better handle the heterogeneous energy capacities which elects CH by considering the distance to neighbors and residue energy of node. Base station is a central cluster and it will not change because all nodes are static but in each round the selected CH in the same cluster may be different. After the cluster formation phase, TBRP constructs a fuzzy spanning tree for over all of the CH. Only the root node of this tree can communicate with the sink node by single-hop communication. Because the energy consumed for all communications in network can be computed by the free space model, the energy will be extremely saved and thus sensor network have long-life [8]. In TBRP protocol each node stores all information about its neighbor nodes in neighborhood table. In each round, ECH_MSG message containing residue energy, all node broadcast by each node within the radio range r.That nodes are situated in this radio range they are neighbors with each other. ECH_MSG is received by all nodes and update its neighborhood table and generate a fuzzy number (FEN). In TBRP, the CH always rotating in whole life span there is uniform energy consumption among all nodes. In TBRP, after clustering base station broadcasts the criteria message to all cluster heads, and all CH generates a fuzzy number for itself. In next stage CH broadcast CRT_MSG message, it containing node ID and FEN within range R, then this two FEN, one received from neighboring cluster head, All cluster head own FEN are compare with others CH FEN if cluster head's FEN is small then it will select another 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 slot assign to their active member nodes to be ready for data collecting. It compared other schema TBRP outperforms in optimizing cluster heads energy consumption, amount of data gathered and improves system lifetime [10].

Node	Distance from neighbors	Residual Energy of	Residual Energy

Figure 4: Information stored in neighborhood table.

IV. TREEPSI

TREEPSI (Tree Based Energy Efficient Protocol for Sensor Information) is a tree based protocol. In this protocol have one root node which is collect data from other sensor nodes and leaf nodes that is capture data and send to our parent node. 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 the WSNs will elect a root node for whole network then root creates the data gathering process to their child nodes. The next step is data gathering after forming a tree. All leaf nodes sense the data and they will start sending data towards their parent nodes. The parent node will collect the received data from our leaf nodes and attach 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 tree path will not change until the root node dead. TREEPSI and PEGASIS are using the same way to transmit data from leaf node to chain/root head. 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]

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

GSTEB is increase the network life time. In each round GSTEB elect a root node and send the root 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. The operation of GSTEB is divided into [11].

- Initial Phase
- Tree Constructing Phase,
- Self-Organized Data Collecting and Transmitting Phase, and
- Information Exchanging Phase.

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) = ┌residue energy (I)/α┐** [11]

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. In first step the beginning of the phase the base station is broadcast a packet to all nodes it contain information about the time start, time slot length. Energy level is a load balancing parameter and it's an estimated value rather than true one [11].

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 ith time slot node ID i will send out its packet to his neighboring nodes. All other node will monitor the network at that time and the nodes who are neighbors of I will receive this packet and save in memory all information transferred by i. All nodes which are not in radius Rc range will turn off and switch to sleep mode in order to save their energy. Like that all other node will transfer this packet and each node will have a table containing information about neighbor's node in their memory.

Step3: After Step2, every node of the network has a table containing its neighbor's node information and in their time slot they broadcast this table. 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

After initial phase the Tree Constructing Phase, 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 [11] can change the root and reconstruct the routing tree with short delay and low energy consumption.

iii. Self-Organized Data Collecting and Transmitting Phase

After the routing tree is constructed, each sensor node collects information to generate a DATA_PKT which needs to be transmitted to BS. The TDMA time slot is also used for collecting the information from each and every node. In Information Exchanging Phase, the collected data is transmitted to the base station.

The GSTEB protocol is compared with the other existing protocols LEACH, PEGASIS and HEED. The author showed that the performance of GSTEB is better than the others and it achieves the energy consumption. Although GSTEB protocol achieves it has some problems such as difficult to distribute the load evenly on all nodes in tree structure. Even though GSTEB needs BS to compute the topography [12-48], which leads to an increase in energy waste and a longer delay. Distribute the load evenly on all nodes in tree structure. Even though GSTEB needs BS to compute the topography, which leads to an increase in energy waste and a longer delay.

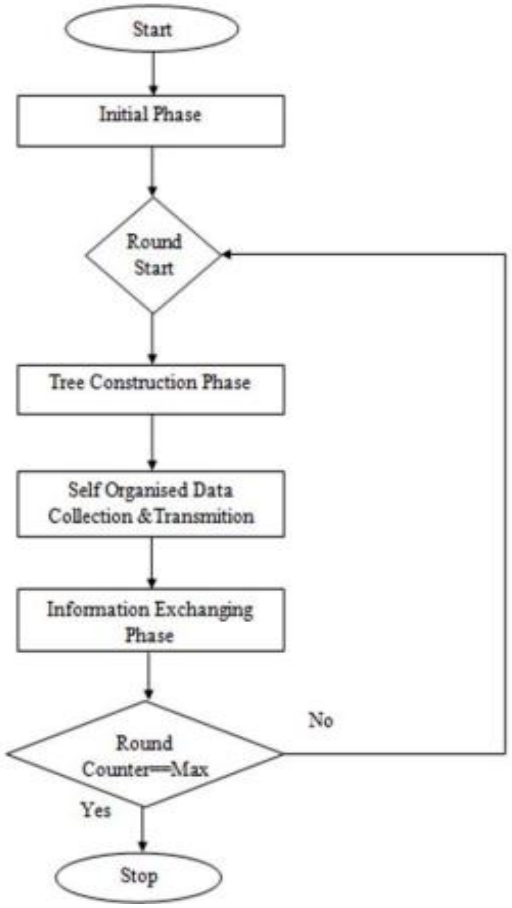

Figure:5 GSTEB flow chart

4. 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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