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An Energy Balanced Algorithm of PEGASIS Protocol in WSN

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***Abstract*—Energy efficiency is the important work for wireless sensor network. Every node has limited energy .So to design Routing protocol in WSN ones should take care of less energy consumption. Already many routing algorithm has developed which result is less energy consumption. In this paper we have discussed all well-known PEGASIS routing algorithms based on grid which always focus on low energy consumption. Each algorithm is described in detail with their pros and cons along with their design issue .**

Keywords—Wireless Sensor Network, PEGASIS, PDCH, EEPB, IEEPB,MH-PEGASIS, PEGASIS-ANT.

I. INTRODUCTION

WSN is a network of wireless sensor nodes with each node having the sensing, computation and communication capabilities for monitoring and recording some of the parameters of the environment and organizing the gathered data at a central repository. The sensors, which are usually small, lightweight and portable, are specially designed for collecting a group of information at diverse location. For example the weather sensors have the ability to sense the factors like temperature, humidity, atmospheric pressure, and wind speed, direction etc. The soil sensors can sense the soil parameters such as temperature, moisture, conductivity, salinity, soil PH values etc. Similarly a plant sensor can sense temperature, moisture, carbon di oxide, hydrogen, photosynthesis etc. The major issues relating to WSNs are the energy efficiency. The sensors usually depend on batteries for power. While the data travels over the network, every node consumes some amount of energy in gathering data, fusing gathered data with its own data, and forward the packet to the next node in the network. Thus, the entire lifetime of a network depends on the energy consumed by the nodes in every phase of transmission. Various algorithms have been designed in this respect, whose aim is to provide more and more efficiency with respect to energy that increases the lifetime of a network. The protocols proposed for WSNs are classified into various classes. In this paper, we present an overview of some of the powerful grid based protocols [1-15].

2. GRID BASED PROTOCOLS

2.1 PEGASIS [1,2,3,4] : The authors in this paper states that PEGASIS is a greedy chain based protocol that forms a chain of the sensor nodes in such a way that they can communicate to the closer neighbor. The main working principle of PEGASIS is classified in the following two steps –

a) Formation of Chain: Using greedy algorithm it will construct a chain among the sensor nodes so that they can communicate with only their nearest neighbors and forward the data to the leader of all nodes . To construct the chain, the algorithm starts with the furthest node from BS.

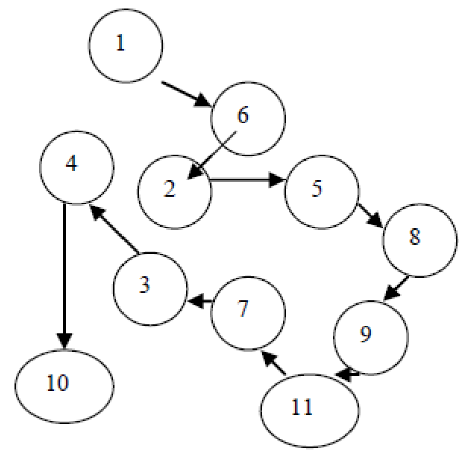

Fig 1: Chain Construction using Greedy Algorithm.

b) Data Gathering: In this step each node obtains data from one neighbor, fuses its own data with the obtained data and forwards the aggregated data to the other neighbor on the chain. The leader node is responsible for transmission of the accumulated data to the BS. The leader in each round of communication will be at a random location. In a particular round, the leader initiates a simple control token passing approach to begin the transmission from the end of the chain. This approach is illustrated in fig 2.

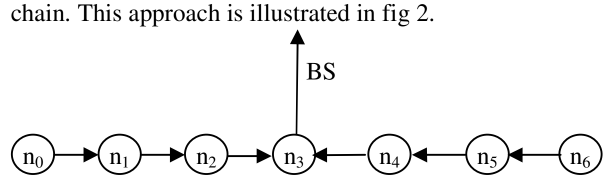

Fig 2: Token Passing procedure.

In the figure, node n_3 is leader and it will first pass the token along the chain to node n_0. Node n_0 will pass its data towards the leader node n_3. PEGASIS performs data fusion at every node except the end node in the chain. Data fusion produces a single packet by combining one or more data packets from different sensors. In our example, node n_0 will pass its data to node n_1. Node n_1 receives data from n_0, fuse this data with its own data and generate a packet. This packet will be received by node n_2, which fuses its own data with the received packet, generate another packet of same length, and then transmit to the leader. After receiving a packet from one side, the leader node passes the token to the furthest node of the other side. In our example, n_3 pass the token to n_6. Accordingly, n_6 passes its data to n_5. Node n_5 fuses the data received from n_6 with its own data, generate a packet, and transmit it to n_4. Node n_4 fuses this packet with its own data and transmit to the leader. The leader node fuses its own data with the data received from both neighbor, and finally forward one message to the BS.

2.2 PDCH (PEGASIS with double cluster head) [5,6] : Instead of using a single cluster head in PEGASIS, the author proposed in PDCH that uses two (double) cluster heads which shares the loads of aggregating and transmitting data in order to increase the overall lifetime of the network. The working principle of PDCH are classified in the following four steps-

a) Cluster Formation : In a hierarchical structure, the BS is supposed to be at the center of the network. The network is divided into various levels by calculating the distance of nodes from BS using Euclidian distance formula. Every level has been assigned a unique ID with the first level ID 0, which belongs to BS. Next level is 1, nodes in this levels are most closest to the BS and so on. This hierarchy always runs at the start, and once it is done successfully, it will remain in force in the whole process. This helps in energy saving compare to forming new levels frequently in every round.

b) Chain Construction: In this step, the chain is built in every cluster level using the EEPB algorithm. Nodes belong to the same level (with same ID) can be built in the same chain. Nodes belongs to different level ID cannot put in one chain. Chain that includes all the cluster nodes in the same level ID is called branch chain and the head of this chain is called primary head. The chain formed among the all primary heads of all clusters is called main chain and the head belongs to the main chain is called secondary head.

c) Cluster Head Selection :

i) Selection of primary heads: The primary head is selected on the basis of residual energy of the nodes. At the beginning, all the nodes are having equal amount of energy. After each round, every node consumes some amount of energy which is certainly not equal for every node. The node which has the maximum residual energy will be the cluster head. Again, the nodes with a branch chain have more chance to be selected as cluster head than other nodes.

ii) Selection of secondary head:

Two factors are considered while selecting the secondary head-

1. If the primary chain head has exactly 3 neighbors, then there is only a single branch chain and we can select any one of the node as the secondary head.
2. If there are more than 3 neighbors, then there will be more than one branch chain, and the node that is more closer to BS will be selected as secondary head.

d) Data gathering and transmission :

The primary head is responsible for receiving the data from all the nodes in the same cluster, fuse all the data to a single packet. Once all the data have been aggregated, primary head transmits this data to secondary head through the same chain transmission.

The responsibility of the secondary head is to collect the gathered data from primary head and forward it to the BS. Secondary head collects all the data from primary heads and again aggregates these data received from all primary heads and then transmits this aggregated data to BS.

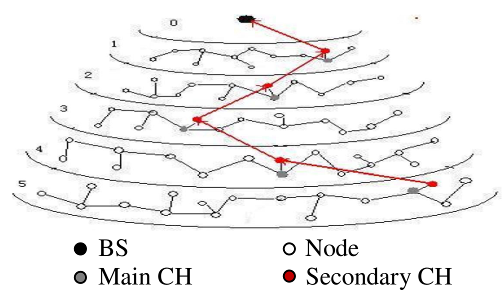

Fig 3 : Double CH method.

2.3 EEPB (Energy efficient PEGASIS) [3, 6, 7, 8] –

In PEGASIS, since we use greedy algorithm to construct a chain, it may results more distance in communication between two sensors. Therefore it consumes more energy in transmitting the data and as a result nodes die early. To avoid this, the EEPB algorithm computes the distance between each node from the formed chain adopting a distance threshold. It selects the leader by taking into account both the residual energy of nodes and distance between nodes and BS, and adjusts the reselection frequency of leader based on the remaining nodes in the network. The working principle of EEPB involves the following 3 steps -

a) Node Selection: A source node S broadcast a path request message to calculate and compare the distance from source node S to every other node. At the source node S, the neighbor with shortest path is selected for transmitting the data. These selected neighbors will be the source for other nodes which have not yet joined the chain.

b) Chain Construction: The chain is constructed based on two parameters, $D_{threshold}$ and $D_{average}$. When a node A receives a data packet form other node B to join the chain, node A first computes $D_{average}$. On the basis of $D_{average}$, node A will calculate the $D_{threshold}$. Then node A will send the chaining request to all other nodes that haven't joined the chain yet. Node A will then select a node whose distance is minimum from node A and compare this distance with $D_{threshold}$. If the distance is less than $D_{threshold}$, then this new node will join the chain and also this new node may take part in the formation of chain. If the distance is more than $D_{threshold}$, it indicates that the new node is far away from node A. This new node consumes more energy for data transmission; hence it will search for any other node who is nearest to node A than itself. If such a node is found, then node A will be the end node on that chain and this new node will join the chain through the nearest node and thus end the chain formation process. But if such a node is not found, then the new node will join the chain directly through node A and terminate the chain formation process.

c) Data Transmission: After the chain is formed, the end node starts the data transmission. Each node collects the data from the downstream node, fuse it with own data and forward it to the upstream node. This process continues until all nodes are visited. Finally, the leader node sends the data to BS.

2.4 IEEPB [3, 7]-

IEEPB is an improved energy efficient PEGASIS based routing protocol, which overcomes the deficiencies of EEPB. At the time of development of a chain in EEPB, the threshold adopted is uncertain and complex to determine, leads to formation of Long Link (LL). Again at the time of selecting the leader, it ignores the ratio of nodes energy and distance between node and BS that optimizes the leader selection. The IEEPB algorithm compares the distance between nodes twice, and get the shortest path to link the two adjacent nodes. The working principle of IEEPB involves 3 steps –

a) Chain Construction : The following steps are involved in the formation of a chain –
   1. Initialize the network parameters. Calculate the number of nodes, initial energy of each nodes, BS location information etc. Then the construction of the chain starts.
   2. BS broadcasts a HELLO message to the whole network to acquire network information such as the live node's ID, distance from each node to BS.
   3. The node at the farthest from BS is set as an end node, it joins the chain first and is labeled as node 1.
   4. Each node of the chain obtains the distance between itself and other nodes which are yet to join the chain , finds the nearest node and set it as node i waiting to join the chain, i represents the i^{th} node joined.
   5. Node i gets the distance between itself and i-1 nodes, find the nearest node j where ($1 \leq j \leq i-1$) and directly connects with it to join the chain, now node i becomes the new end node of the chain.
   6. Repeat steps 4) and 5) to connect node i+1, i+2,i+3… till all the nodes have joined the chain, the same process continues , and finally the branching chain is formed.

b) Leader Selection: In this step, IEEPB chooses the leader by using a combined weighting method that considers both the residual energy of nodes and the distance from the node to BS. The steps are-
   1. Estimate distance d_{toBS} between sensor node and BS.

$$D_{bs} = d^4_{toBS} / d^4_{ave}$$

   2. Compute the energy portion E_p as follows

$$E_p = E_{init} / E_i$$

   Where E_i represents the residual energy of node i for round n and E_{init} represents the initial energy of node i.
   3. Calculate the combined weight W_i for each node using the equation-

$$W_i = w_1 E_p + W_2 D_{bs}$$

   Where W_1 and W_2 are the coefficient of weight factors and satisfies the formula W1 + $W_2 = 1$.
   4. Compare the different weights of each node and the minimum weight node is selected as the leader in this round.

c) Data Transmission: In this step, the leader initiates a token passing strategy to begin the data transmission from the end node of the chain. The chain has more than two end nodes. Every node submits its own data to its neighbor node. The neighbor nodes fuse this data with their own data and forward this aggregated data to their neighbor node and so on. Finally the leader receives all this aggregated data and transmits it to the BS.

2.5 MH-PEGASIS: [3, 8]

According to the author, the disadvantage with the hierarchical protocols PEGASIS that follows an approach based on cluster and chains is that, the routing in a single hop within the cluster heads where CHs located far away from the BS requires strong signals to communicate with BS and that increases their energy consumption.

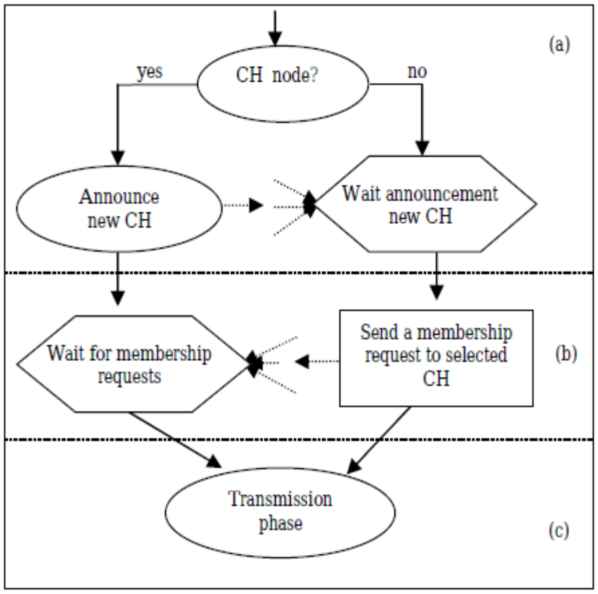

Fig 4: Hierarchical PEGASIS protocol

The three phases involved are a) Announcement phase, b) Cluster formation phase, and c) Data communication phase.

The MH-PEGASIS has been proposed as a remedy to this problem which is an improvement to hierarchical PEGASIS protocol that uses multi hop routing between the cluster heads so that the BS can be reached efficiently.

This protocol takes place in rounds of which the duration is determined in advance. Like the hierarchical PEGASIS protocol, each round consists of two main phases: an invitation phase and a data transmission phase. The first three sub phases in the initialization phase are similar to hierarchical PEGASIS. The last sub phase, known as phase of research of neighbors at the level of CHs, is as follows-

The level of a CH is determined as a function of its distance with respect to BS. For this, it has three circles whose center is at the BS. Level 1 is the first circle with radius x which is closest to the BS than the circle level 2, whose radius is y and (y>x). Similarly circle level 2 is closer than circle level 3 with radius z (z>y). Hence, node with a distance less than or equal to x from the BS will be in level 1, node with a distance d , such that x≤d≤y, will be in level 2 and rest will be in level 3.

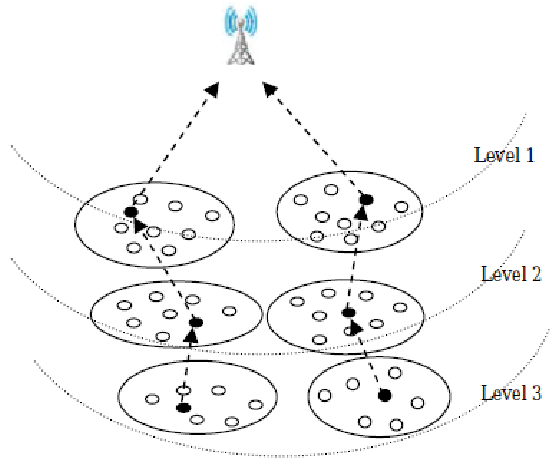

Fig 5: Multi –hops inter clusters routing.

2.6 PEGASIS ANT [3,9] :

Inspired by the actual behavior of ants that communicate with each other by pheromone, the author suggested an Ant colony algorithm which achieves global optimization. In this algorithm, the energy factor is taken into account so that the lifetime of WSN can be maximized in the process of chain building and leader selection. The working of PEGASIS ANT algorithm is described in the following steps-

a) Chain Building : In the chian building process, to choose a next node on the chain, we consider all the neighbors of the current node as candidates and take factors such as the remained energy of the candidate. It is assumed that , the BS has infinite energy, and all other nodes initiated by the equal amount of energy are located in fixed positions. Each node's current condition such as the position and the remained energy of the node is iformed time to time to the controller, i.e the BS. In data transmission, the amount of energy consumed is in proportion to the total square of distance. To judge whether it is an optimisation, the fact whether the square sum of neighbor's distance along the chain is the minimum is considered as a standard.

b) Leader Selection : The node whose current energy is the maximum is selected as the leader in each round of communication. Then, starting from the end nodes, each node fuses its own data with the received data and form a packet, and forward to the other neighbor in the direction of leader. Finally, the leader fuses all the received data with its own data and transmits to the BS.

3. CONCLUSION

In this paper, we present a no of grid based protocols. We have seen that PEGASIS, which uses greedy algorithm, outperforms LEACH (LEACH is a cluster based WSN hierarchical protocol) by removing the overhead of dynamic cluster formation, reducing the distance that data of each node (non leader) travel, and confines to only one transmission from the leader to the BS every round. PDCH uses double cluster heads in comparison of a single cluster head in PEGASIS , avoids the formation of long chain, which shares the loads of aggregating and transmitting data in order to increase the overall lifetime of the network. The EEPB protocol overcomes some of the drawbacks of PEGASIS by adapting a threshold value. It selects the leader by taking into account both the residual energy of nodes and distance between nodes and BS. IEEPB is an improved over EEPB which computes the distance between nodes twice. The method used to construct the chain simplifies the chain construction process and avoids the formation of LL. Next, we study the MH-PEGASIS protocol which extends the network lifetime duration and this is due to multihop communication between CHs and BS as well as data aggregation at the CHs that allows decreasing the amount of packets travel in the network. We further study the PEGASIS ANT protocol, which is inspired by the real ant's behavior that is searching for food.

This protocol consider the distance to minimize the square sum of transmission distance, and also take into account the energy factor in both chain building and leader selection to extend the lifetime of WSN.

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