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Energy efficient WSN Protocols: A Survey

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ABSTRACT- The wireless sensor networking mainly suffers from the fact that the nodes have low energy backup. Some issues in WSNs are that sensor nodes have constrained in terms of processing power, communication bandwidth, and storage space. Due to low energy backup several nodes may die out soon and there may be loss of data. Various routing algorithm have been developed to increase the lifetime of the network. Some of the types of routing protocol are cluster based routing protocol, chain based routing protocol, hierarchical routing protocol and hybrid routing protocol .In this paper we discuss the various protocols such as LEACH, PEGASIS, IEEPB, PDCH, TEEN, APTEEN, CCM, CCBRP, TSCP and see how they are simulated.

Keywords: LEACH, TEEN, APTEEN, CCM, PEGASIS, CCBRP, TSCP, IEEPB, PDCH,

1. INTRODUCTION

Wireless sensor networking is the latest technology for farming and lot of effort is put to find a low cost and energy efficient wireless sensor network. WSN connects information world with physical world. The sensor node senses the environment and sends the data to the base station. The data are received and analysed and based on those data farming can be improved. The challenges in WSNs are that sensor nodes have constrained in terms of processing power, communication bandwidth, and storage space which required very efficient resource utilization. Much research work is done finding the energy efficient routing protocol. Some of the categories of routing protocols in WSNs are cluster based routing protocol, chain based routing protocol, hierarchical routing protocol and hybrid routing protocol.

This paper is organized in following structure: section 2 LEACH, section 3 PEGASIS, section 4 IEEPB, ,section 5 PDCH, section 6 TEEN, section 7 APTEEN, section 8 CCM, section 9 CCBRP, section 10 TSCP and section 11 conclusion.

2. LEACH (LOW-ENERGY ADAPTIVE CLUSTERING HIERARCHY) [1]

In this paper the author have proposed hierarchical cluster based routing protocol called Low Energy Adaptive Hierarchy (LEACH) for wireless sensor network which partitions the nodes into cluster in each a dedicated node called cluster head (CH). Here the cluster formation is dynamic in each round and the cluster head is responsible for data collection from the other nodes of that cluster. It processes the data and sends the collected data to the base station. In LEACH cluster heads are selected randomly but the energy spent for each round is balanced as all the sensor nodes have a probability to be selected as a cluster head (CH).

This protocol is divided into rounds, each rounds is divided into two phases:-

i. Setup phase
ii. Steady phase

SETUP PHASE:-

In setup phase, a sensor node selects random number between 0 and 1. If the number is less than the threshold T (n) the node becomes a CH.T (n) is computed as;

T (n) = {p/1-p*(rmod1/p) , if n €G}

{0, otherwise}

Where,
r is the current round;
p is the desired percentage for becoming CH;
G is the collection nodes not elected as CH in the last 1/p rounds.

Each node decides independent of other nodes if it will become CH or not. This decision takes into account when the nodes that hasn't been a CH for a long time is more likely to elect itself than nodes that have CH recently. In the following phase the CH's informs the neighbourhood with an advertisement that they become CH's.

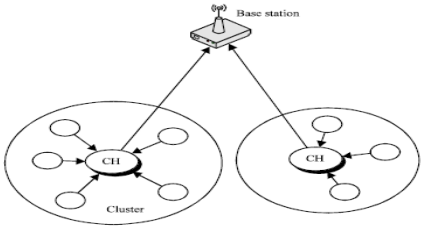

Fig: Structure of LEACH Protocol [1]

STEADY PHASE:-

In this phase the nodes send their data during their allocated TDMA slot to the CH. This transmission uses minimal amount of energy that is chosen based on the received strength of the CH advertisement. The radio of each nodes can be turned off until the nodes allocated TDMA slot thus minimizing energy dissipation in these nodes when all has been received the CH aggregates these and send it to the base station.

The advantage of this protocol is that it avoids data redundancy at the sink/base station. The CH is generated by a random method so it cannot guarantee the even distribution of cluster heads, and the selection not considering the transmission distance leading the uneven energy consumption for different nodes. The communication between cluster head and base station uses the single hop model. Therefore the farthest node to the base station in the network area is dead earlier than other.

3. PEGASIS (Power-Efficient Gathering in Sensor Information Systems) [2]

In this paper the author have placed 100 nodes randomly in the play field (50m x 50m). Using PEGASIS he makes sure of the fact that each node receives from and transmits to close neighbours. A node is chosen to be the leader for transmission to the Base Station (BS) which is located at (25, 150) i.e., the BS is at least 100m from the closest sensor node.

To construct the chain, he uses greedy approach. He also assumes that all the nodes have a global knowledge of the network. He started the construction of the chain from the furthest nodes of the BS. It is done so to make sure that nodes farther from the BS have close neighbours as the neighbour distances will increase gradually since nodes already on the chain cannot be revisited. When a node dies, the chain is reconstructed using the same process.

In each round, each node receives data from the neighbouring node. The data is then fused and sent to the next neighbouring node till it reaches the leader (node). A simple control token passing approach is initiated by the leader to start the data transmission from the ends of the chain. The cost is very small owing to the small size of the token.

In Figure given below, node c2 is the leader, and it will pass the token along the chain to node c0. Node c0 will pass its data towards node c2. After node c2 receives data from node c1, it will pass the token to node c4, and node c4 will pass its data towards node c2.

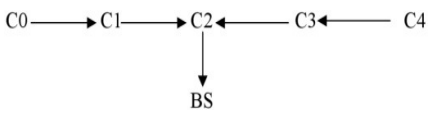

Figure: Token passing approach

The leader (node) changes once every 100 rounds. At times, the distance between a node and its neighbouring node might be more compared to other nodes. Dissipation of energy in such a case is more. Such nodes are not allowed to be leaders since it already has more consumption of energy. It is done by setting a neighbour distance threshold to be a leader (node).

4. IEEPB (Improvised Energy Efficient PEGASIS Based) [3]:-

IEEPB is a chain-based routing algorithm which is an improvised version of EEPB. It consists of 3 stages. They are:-

i. Chain construction stage,
ii. Leader selection stage and
iii. Data transmission stage

Long Links are avoided in IEEPB. When using IEEPB algorithm, at first the network parameters are initialized – determination of the total number of nodes, energy of nodes, BS location etc. The BS checks information like ID of nodes alive and distance from each node to BS by broadcasting a hello message to the network. The node which is farthest from BS is taken as end node (node 1) i.e., it joins the chain first.

Each node of the chain obtains the distance between itself and other nodes which are yet to join the chain. The nearest node is set as the node *i* waiting to join the chain; *i* show the ith node joined the chain. The process continues until the chain is complete.

Two elements – residual energy of nodes and distance between nodes and BS are used in a weighting method to determine the leader (node). The node with the minimum weight becomes the leader.

5. PDCH (PEGASIS with Double Cluster Head) [3]

In PDCH, the author use double cluster head (CH) in a single chain. He termed them as primary chain head and secondary chain head. It also gives a hierarchical structure so that long chaining is avoided.

The primary CH collects the data from cluster nodes and fuses that data. This data is sent to the secondary CH through the chain transmission. The secondary CH sends the data to the BS. To perform PDCH, the distance of the BS from each node is calculated using the Euclidean distance formula. The author divided the nodes in a hierarchical structure putting nodes in different levels. The nodes are divided in different levels on the basis of their distance from base station and each level is given an id. The nodes which are less than or equal to 100 meters comes under first cluster (level id=1). 100 to 150 come under second cluster (level id=2), 150 to 200 come under third cluster (level id=3) and 200 to 250 come under fourth cluster (level id=4). The head node is elected in each cluster based on the residual energy of the nodes. The node which has maximum residual energy is elected as a CH. In the first round of transmission a random node is elected as

CH since all the nodes will have the same energy at first. Chains are formed only by the nodes within a cluster.

In each cluster, data is sent from one node to another till it reaches the primary CH. Now all the CHs are considered to form a separate cluster. From this cluster of primary CHs, the node nearer to the base station is elected as head which is known as secondary cluster. A chain is formed among these nodes and data is transmitted to secondary CH. This secondary CH will transmit that data to the BS. After each round, the author check for the dead nodes by finding the nodes with residual energy less than or equal to zero. The dead nodes are removed from the corresponding cluster. A count is kept of the number of nodes which are dead in each round and is saved in an array. The sum of residual energies of all the alive nodes in every round is stored in another array. Now the plot is made for the number of alive nodes in each round and residual energy of the network in each round.

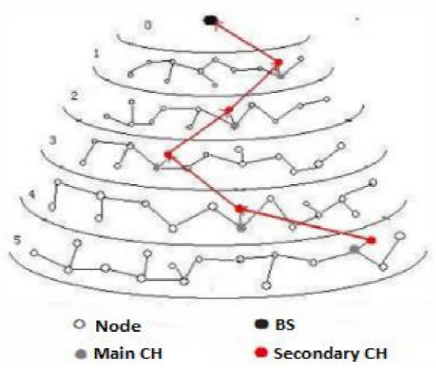

Figure : Double CH method

6. Threshold Sensitive Energy Efficient Sensor Network Protocol (TEEN) [4]

In this paper the author describes that TEEN is a hierarchical clustering based protocol in which nodes react immediately to drastic and sudden changes in the environment. The formation of cluster and the data transmission are same as in the LEACH protocol. After cluster formation, the cluster head broadcasts two thresholds to the sensor nodes namely

i.Hard threshold
ii.Soft threshold

i.Hard threshold (H_T):

It is a threshold value for the sensed attribute. It is the absolute value of the attribute beyond which, the node sensing this value must report to its cluster head.

ii.Soft threshold (S_T):

This is a small change in the value of the sensed attribute which triggers the node to switch on its transmitter and transmit.

The nodes sense their environment continuously. The first time a parameter from the attribute set reaches its hard threshold value, the node switches on its transmitter and sends its sensed data. The sensed value is stored in an internal variable in the node, called sensed value (sv).

If the following conditions are satisfied the node will next transmit data in the current cluster period.

i. The current value of the sensed attribute is greater than the hard threshold.
ii. The current value of the sensed attribute differs from sensed value by amount equal or greater than transmission soft threshold.

In TEEN the hard threshold tries to reduce the number of transmission by allowing the nodes to transmit only when sensed attribute is in the range of interest, whereas the soft threshold further reduces the number of transmission which might have otherwise occurred.

7. Adaptive Threshold Sensitive Energy Efficient Sensor Network Protocol (APTEEN) [5]:-

In this paper the author described that APTEEN is a hierarchical clustering based protocol in which nodes react immediately to drastic and sudden changes in the environment. The formation of cluster and the data transmission are same as in the LEACH protocol. . After cluster formation, the cluster heads broadcast the threshold values, attributes and transmission schedule to all sensor nodes. In order to save energy, cluster heads also aggregate data before sending to base station.

A. Parameters in APTEEN:-

i.Attribute (A):
It is a set of physical parameters about which the user is interested in obtaining information.
ii.Hard threshold (H_T):
It is a threshold value for the sensed attribute. It is the absolute value of the attribute beyond which, the node sensing this value must report to its cluster head.
iii.Soft threshold (S_T):
This is a small change in the value of the sensed attribute which triggers the node to switch on its transmitter and transmit.
iv.Schedule:
It is a time division multiple access schedule that assigns a slot to each node for transmission.
v.Count Time (Tc):

It is the maximum time period between successive reports sent by a node.

B. Some important features:-

- Energy saving as the node senses the environment continuously and only transmits if hard threshold condition meets.

- Energy consumption can be controlled by changing the count time as well as the threshold values.

8. CCM (CHAIN CLUSTER BASED MIXED ROUTING PROTOCOL) [6]

In this paper author describes that CCM algorithm combines the advantages of both PEGASIS and LEACH algorithm. The author's main motive was to improve routing performance that was very important for many time-critical applications by Energy x Delay metrics. Author distributed N sensor nodes in a 2-Dimensional area with a size of L(m) x L(m) and divided that area as a set of strips. Each strips having a height of h(m) and the total number of strips k=L/h in that network.

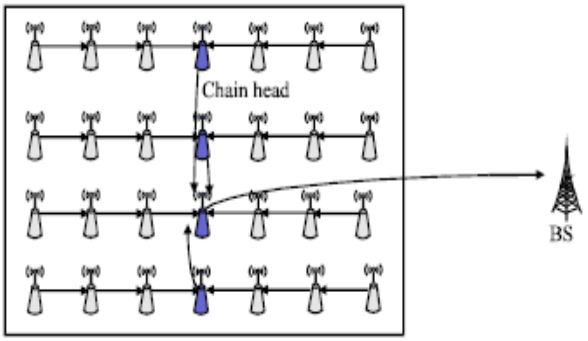

Figure: Scenario of CCM

The CCM algorithm consists of following phases: creating cluster head, creating chain and data transmission

At first each node within the radio range R sends their position to all neighbours. Then each nodes start computing their weights (that is inverse distance to the node in its neighbourhood) and residual energy. And the node having highest residual energy and lowest distance among other neighbouring node is elected as the cluster head. And if in the case two nodes having same conflicting values then the node that was issued firstly will be elected as cluster head.

After the formation of cluster head . The chain is formed in each cluster. The node which has the highest distance from the cluster head is elected as the first node in the chain. Then all other nodes join to each other based on their distance.

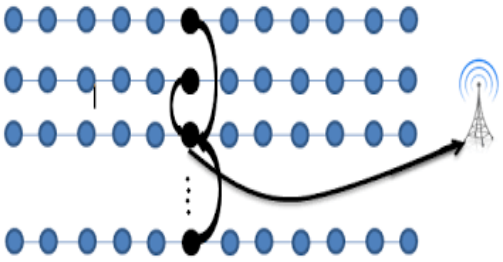

Figure: Data transmission in CCM.

And lastly the data transmission is done. The cluster head assign individual TDMS time slot for each member node so that the member can transmit their sensed data to cluster head in their own time slot. The cluster head fuses all the received data and send them to the sink station.

9. CCBRP (Chain Chain Based Routing Protocol) [7]

In this paper the author divided the WSN in a number of chains and runs it into two phases. CCBRP uses Greedy algorithm. In first phase the sensor nodes transmit their data to the chain head nodes. In the second phase the chain head forms a chain and all the head nodes transmit their data to a randomly selected head node. The chain head in first phase is selected randomly and the selected chain head sends a token message to all the nodes in the chain to notify them. The neighbouring nodes receive data from the nearest nodes and fuse the data and send to the next node in the chain and so on. This process is repeated until the data reaches to the chain head. In the second phase starts when all the chain head nodes have received data from all the other nodes of their chain. These chain leaders form a chain and select a chain head for the newly formed chain. The chain head in this phase is selected randomly and the selected chain head sends a token message to all the nodes in the newly formed chain to notify them. The neighbouring nodes receive data from the nearest nodes and fuse the data and send to the next node in the chain and so on. This process is repeated until the data reaches to the chain head. The chain head after receiving the data fuses with its data and sends to the base station (BS).

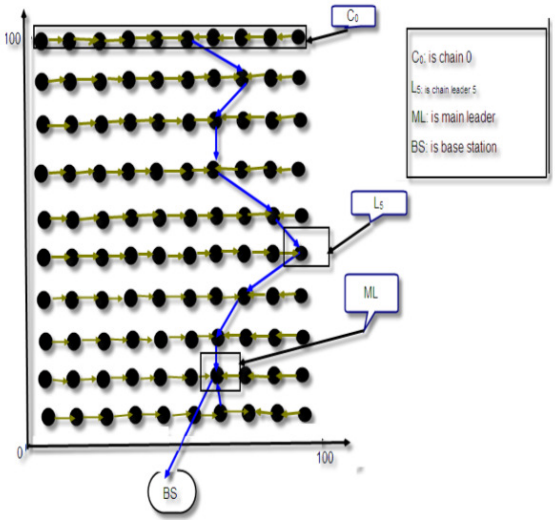

Figure : Data transmission in CCBRP [7]

Advantages:-

a. CCBRP consumes less energy than LEACH and CCM but same energy compared to PEGASIS.
b. CCBRP has better energy*delay metrics compared to CCM, LEACH and PEGASIS.
c. The transmission delay of CCBRP is same as LEACH and CCM but less than PEGASIS.

10. TSCP (Two Stage Chain Routing Protocol) [8]

In this paper the author consider the nodes in a grid form and consider each row as a chain. This protocol works in two phases. In first phase all the chain nodes sends their data to their nearest neighbours until the data reaches the chain head. In second phase the chain heads forms a vertical chain and select a main head (head of the heads) randomly and all the nodes sends their data to the chain head and the chain head then send the aggregated data to the base station. The author has taken a model of 100 nodes forming a 10*10 grid. . In first phase the chain head is selected in a sequential manner and all the head nodes will be in the same column. Each node is chain head one time within 10 sensing round. The nodes will sense the area and send their data to the chain head using greedy algorithm. At some stage when some nodes will consume large amount of energy it will not be easy to select chain head sequentially so at that stage the chain head is selected based on the residual energy.

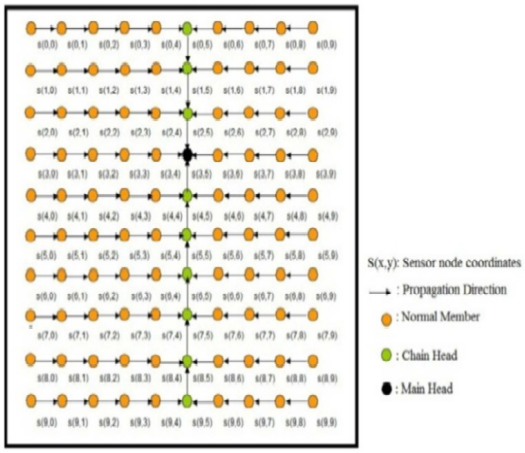

Figure2: Common Case Scenario of TSCP [8]

Advantages

i. TSCP consumes less energy than LEACH, CCBRP and CCM.

ii. TSCP has better performance than CCBRP and CCM in terms of Network lifetime.

11. Conclusion

Some of the challenges faced by wireless sensor networks are low energy backup, limited processing power, communication bandwidth, and storage space. Various routing algorithms like LEACH, TEEN, APTEEN, CCM, PEGASIS, CCBRP, TSCP, IEEPB and PDCH are described. Data redundancy is avoided in LEACH at the base station. PEGASIS uses Greedy approach to create chains and has low energy consumption. IEEPB shows a positive increase in energy efficiency and network lifetime by avoiding long links.

In PDCH, double cluster head (CH) is used in a single chain to decrease energy consumption. TEEN reacts to sudden changes in the environment to decrease energy dissipation while in APTEEN energy consumption is controlled by changing the count time as well as the threshold values. CCM combines chain based routing and cluster based routing to achieve low energy consumption and short transmission delay. CCBRP divides the WSN into many and has less energy consumption than LEACH and CCM and a decreased transmission delay compared to PEGASIS. In TSCP, each row is taken as a chain. It is more energy efficient than LEACH, CCBRP and CCM and performs better in terms of network lifetime than CCBRP and CCM. Thus, these algorithms aim to achieve maximum utilization of resources available.

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