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Review of LEACH Variants

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Abstract: Wireless sensor networks (WSNs) consist of sensor nodes. These sensor nodes are powered by battery to communicate with each other. Energy efficiency is the vital issue in wireless sensor networks. Various Routing techniques have been evolved to maximize network lifetime, throughput and scalability. LEACH is one of the hierarchical clustering protocols widely used in WSNs. The goal of this paper is to provide brief overview of some LEACH variants.

Keywords: Wireless Sensor Network, LEACH, Hierarchical routing, cluster based routing.

I. INTRODUCTION

Various routing techniques for wireless sensor networks have been developed. The Wireless Sensor network has mainly two parts, one is base station and others are sensor nodes. One of the routing techniques is hierarchical routing, which uses the model of cluster head (CH). Hierarchical routing is an energy efficient technique because it uses data aggregation and fusion to reduce the number of data transmission from sensor nodes to base stations. LEACH is an example of hierarchical routing. Various protocols have been created by modifying in LEACH protocol. Our aim is that survey variants of LEACH protocol.

II. CLUSTER

Clusters are formed in hierarchical routing for data aggregation. Each cluster has one cluster head and sensor nodes. Cluster head is responsible to aggregate the data received from sensor nodes within the cluster. Cluster head fuses the data and transmit this data directly or indirectly through intermediate Cluster heads to the Base Station (BS). Cluster heads act as the controller of the cluster. Cluster head consumes more energy as compared to other sensor nodes in the cluster. LEACH protocol proposed that role of cluster head should rotate periodically among all the nodes within the cluster. Base station is generally far away from sensor nodes. Base station processes the data received from cluster heads (CHs).Cluster heads (CHs) works as entrance between cluster and Base Station (BS).

III.LEACH PROTOCOL

LEACH is acronym stands for Low Energy Adaptive Clustering Hierarchy. This was introduced by Wendi Rabiner Heinzelman, Hari Balakrishnan and Anantha Chandrakasan, in 2000 [1]. LEACH protocol has following features:

- A LEACH is one of the clustering algorithms for WSN.
- It forms clusters as per the received signal strength and cluster head nodes act as routers to the base-station.
- Data fusion and aggregation are local to the cluster.
- LEACH uses autonomous decisions to form the cluster.
- The job CH is rotated periodically.
- Each node chooses a random number T (n) between 0 and 1.
- A node becomes a cluster head for the current rotation round if the number is less than the following threshold

$$T(n) = \frac{p}{1 - p * \left(r \bmod \frac{1}{p} \right)} : \text{if } n \in G \qquad (1)$$

$$T(n) = 0 \qquad : \text{Otherwise}$$

Where p is the desired percentage of CH nodes in the sensor population, r is the current round number, and G is the set of nodes that have not been cluster heads in the last 1/p rounds.

- Due to probabilistic decision of selection of cluster head, there is a possibility that a node with lowest energy gets selected as a cluster head and after this node dies, the cell becomes useless.
- LEACH uses one-hop intra and inter- cluster topology.
- LEACH does not support selection of cluster head depends upon energy consumption of the nodes.
- LEACH can be used in small-scale wireless sensor networks.
- All nodes in the network must be motionless.

IV.DESCENDANTS OF LEACH PROTOCOL

Over the period of the times various descendants of LEACH protocols have been proposed. They are as follows:

1. LEACH-C:

- Predetermined approach is used for cluster head selection.
- Energy consumption of nodes is considered at the time of cluster head selection.
- It uses location information of nodes using global positioning system or other location tracking system.
- It is not robust because it needs location information of the node in the cluster.

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- This does not support energy balancing of the network. [2, 3, 10, 14, 15, 16]

2. Multi-hop LEACH :

- LEACH protocol uses single hop communication from cluster head to Base station. But, Multihop LEACH protocol uses multihop communication for inter-cluster and intra-cluster communication.
- Multihop LEACH consumes less energy for data transmission from cluster head to BS.
- In Multihop LEACH, throughput is 8 times greater than LEACH- C.
- It uses optimal path for the communication between cluster head to Base Station.
- Multihop leach protocol also performs well even if as network diameter increases. [3, 10, 14, 15, 16]

3. Vice LEACH (VLEACH):

- There are two cluster heads in each round, one cluster head is responsible to send data from cluster to base station and another one is vice cluster head.
- Cluster head has responsibility to collect data from the nodes in the cluster and send this data to the base station. Therefore Cluster head consumes more energy than the other nodes in the cluster.
- In LEACH, cluster head selects randomly. Due to this, there is possibility that node which has less energy can be selected as cluster head. But if cluster head fails due to loss of energy, then there is no alternative to send data collected from nodes in the cluster to the base station.
- Vice LEACH overcome this problem by introducing one more cluster head called as Vice Cluster head. If one cluster head fails due to loss of energy then vice cluster head will become new cluster head.
- Due to this improvement in LEACH throughput and network lifetime increases.[11, 3, 10, 14, 15, 16]

4. RECHS (Redundant and Energy-Efficient Cluster head Selection Protocol):

- There are two cluster heads in each round, one cluster head is initial cluster head and another one is initial redundant cluster head.
- Base station decides the cluster head out of these two cluster heads depend upon remaining energy of the nodes and average hops from ordinary nodes to these cluster heads.
- RECHS protocol uses multihop routing within cluster.
- RECHS protocol improves the security and reliability of the network.
- RECHS protocol balances the network load as well as improves the network lifetime [9].

5. Energy Aware Centralized LEACH (EA-LEACH):

- Cluster heads are not selected randomly. In EA-LEACH, Base station decides the cluster heads depend upon available energies of each and every node at each round.
- The node which has higher energy will have high priority to become cluster head.
- Cluster heads are separated by the favourable distance so that there is no possibility that no cluster heads lies close to each other. Thus the network load is balanced.
- Optimum number of cluster heads is selected in each round.
- Due to balanced network load and optimum number of cluster heads selection, network lifetime and throughput increases [6].

6. Energy-Efficient Adaptive Protocol for Clustered Wireless Sensor Networks (EEAP):

- Multi-hop approach is followed inside the cluster and outside the cluster.
- All the sensor nodes are stationary.
- The elector nodes are used to gather the energy information of the adjacent sensor nodes and select the clusterheads.
- The elector node selects the cluster head based on the residual energy of each sensor node within the cluster.
- EEAP prolongs the lifetime of the sensor networks by balancing the energy consumption of the nodes.
- Network lifetime is almost same regardless with the increase of network size [4].

7. EDRLEACH:

- Base station decides the cluster heads at each round.
- In EDRLEACH, Decision of cluster head selection in first round is different than the other rounds.
- In first round, Base station uses table to store information of nodes such as number of neighbours, residual energy and distance.
- This supports direct communication between node and Base station.
- EDRLEACH improves LEACH by using a very equally distributed cluster and decreasing the imbalanced topology of the clusters.
- Network lifetime increases considerably by balancing network load.[12]

8. Two level Low Energy Adaptive Clustering Hierarchy (LEACH-TLCH):

- In LEACH protocol, the cluster head sends the aggregated data to the sink directly.
- Due to this process clusterheads would die very early compared to the other sensor nodes due to energy loss for transmission of information to the sink where sink node may be located too far away from the clusterheads.
- To overcome from this TL-LEACH was been proposed. In this cluster head collects information as LEACH protocol, but for transmission to the sink it uses one of the cluster head that present between cluster head and sink.
- Cluster head works as a relay station [8, 14, 15 and 16].

9. Quadrature-LEACH (QLEACH):

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- QLEACH can be used for homogenous as well as heterogeneous network.
- Network is partitioned into four quadrants to achieve better clustering.
- In Q-LEACH network is partitioned into sub-sectors and hence, clusters formed within these sub-sectors are more deterministic in nature.
- Portioning of network into quadrants yields in efficient energy utilization of sensor nodes.
- Nodes are well distributed within a specific cluster and results in efficient energy drainage.
- Efficient clustering mechanism yields significantly better coverage of whole network.
- Exact distribution of nodes in field is also well distinct.
- QLEACH enhances stability period, network life-time and throughput quiet significantly [7].

10. Energy Efficient LEACH Protocol (EELP):

- EELP is especially proposed for critical applications such as sensing of poisonous and explosive gases.
- Each node has specific identity information.
- The node with the highest energy is selected as the cluster head to decrease the probability of the selection of a node with low energy and to balance the total energy load distribution of the network.
- In the cluster head selection process, all cluster head candidate nodes send their current energy information with their identity information as a message to the base station.
- The base station determines the node with the highest energy as cluster head and sends the identity of the node selected as cluster head to the other nodes in the cluster. Thus, the nodes in the cluster which receive this information send their data to the cluster head.
- This process is repeated to determine the new cluster head after a certain time.
- An XOR operation is performed on the data sensed by close-by nodes to prevent the sending of duplicated data to the base station by the cluster head.
- Selecting the node with less energy as cluster head, ignoring the data below certain values and decreasing the number of transmissions by not sending the duplicated data to the sink node prolongs the lifetime of the network.
- Upper and lower threshold are used to decide the path of data transmission. Depending upon these thresholds, data can directly send to base station or it can send via cluster head to the base station.
- EELP consumes less energy for data transmission as compared to LEACH protocol, thus it is more energy efficient than LEACH protocol [5].

11. LEACH-FL:

- LEACH-FL uses Fuzzy logic which considers battery level and distance of a node, node- density.
- It uses coordinates of all the nodes in the network.
- Clusterheads are determined from fuzzy sets which have three inputs such as distance, node density and battery level.
- As increase of the battery level and node density, the probability of a node to be selected as a cluster head is increased.
- Whereas, increase of the distance between the node and the base station, the probability of a node to be selected as a cluster head is decreased.
- A node of low battery level will have a low probability to become cluster head.
- The battery level is the key for the probability of cluster heads selection.
- As compare to LEACH protocol, Energy Efficiency and Network lifetime are more in LEACH-FL [13].

V. CONCLUSION

In this paper, LEACH protocol is described first. LEACH protocol used clustering hierarchical method for energy efficient communication in the wireless sensor network. LEACH protocol has advantages as well as disadvantages. Disadvantages of LEACH are rectified in the descendants of LEACH. This paper reviewed descendants of LEACH such as LEACH-C, Multi-hop LEACH, VLEACH, RECHS, EALEACH, EEAP, EDRLEACH, LEACH-TLCH, QLEACH, EELP, and LEACH-FL. These descendants show improved performance of wireless sensor networks in terms of network stability, network scalability, network security, energy efficiency and network lifetime.

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