**Chapter 3**

**LEACH (Low Energy adaptive Clustering Hierarchy )**

**3.1 Introduction**

W.R. Heinzeolman proposed LEACH protocol, which is based on cluster structure and hierarchical technology. Relative to the traditional protocol, LEACH could save a greater degree of energy. For most sensor nodes, the short-distance communication saved more energy, in LEACH, the more communication was limited within clusters, only a few Next Node, node communicated with base stations long distance. It used adaptive technology and Next Node, node rotation technology, the LEACH was more efficient than the original class network structure; the whole WSN was more balanced on load distribution, and could extend the WSN lifetime greatly. In addition, each cluster could calculate locally and remove redundant data, reduce the communication burden of Next Node, node. As the energy consumption of calculation was much less than the energy consumption of communication, so LEACH could save energy greatly. But there were still problems in LEACH: Firstly, the node used power control when sending data, the energy consumption of node was not same. When Next Node, node election, it was considered that the number of Next Node, node in the past, without the energy difference between the remained nodes, leading to uneven distribution of energy consumption. Secondly, LEACH selected Next Node, node randomly, the number of Next Node, node closed to the optimal value could not be guaranteed.

**3.1.1 Operation of the algorithm**

LEACH operation is broken into rounds, with each round having a set-up phase and a steady state phase. Set-up phase: each node decides whether or not to be a cluster-head based on its remaining energy and a globally known desired percentage of Next Nodes. Each node electing itself as a cluster-head broadcasts an advertisement message announcing its intention. Non-cluster-head nodes receive possibly several advertisements and pick one cluster to join based on the signal strength of the advertisement received from the corresponding cluster-head. Steady-state phase: each cluster-head waits to receive data from all nodes in its cluster and then sends the aggregated or compressed result back to a BS.

**3.1.2 Clustering :**

Clustering is a good approach which, if implemented properly, can lead to energy efficient networking in WSNs. LEACH assumes that all nodes can communicate with each other and are able to reach the sink (therefore, it is only suitable for small size networks), LEACH assumes that all nodes have data to send and so assign a time slot for a node even though some nodes might not have data to transmit, LEACH assumes that all nearby nodes have correlated data which is not always true, LEACH requires that all nodes are continuously listening (this is not realistic in a random distribution of the sensor nodes, for example, where cluster-heads would be located at the edge of the network), there is no mechanism to ensure that the elected cluster-heads will be uniformly distributed over the network (hence, there is the possibility that all Next Nodes will be concentrated in one part of the network), periodic dynamic clustering carries significant overhead which may off-set energy gains derived by the clustering option.

**3.2 LEACH-C**

An enhancement over the LEACH protocol, LEACH-centralized (LEACH-C), is proposed, LEACH-C uses a centralized clustering algorithm, where an attempt is made to distribute clusters throughout the entire sensor field. As a result of dispersing clusters throughout the network, LEACH-C protocol records better performance compared to LEACH. LEACH-C operation can be subdivided into two phases:

**Setup phase**: the base station receives information from each node about their current location and energy level. The nodes may get their current location by using a global positioning system (GPS) receiver that is activated at the beginning of each round. After that, the base station runs the centralized cluster formation algorithm to determine the clusters for that round. Before running the algorithm that determines and selects the clusters, the base station makes sure that only nodes with enough energy are participating in the Next Node selection.

**Steady phase:** Once the clusters are created, the base station broadcasts the information to all the nodes in the network. Each of the nodes, except the Next Node, determines its TDMA slot used for data transmission. Then, the node goes to sleep until it is time to transmit data to its Next Node. LEACH offers no guarantee about the placement and/or number of Next Nodes. An enhancement over the LEACH protocol was proposed. The protocol, called LEACH-C, uses a centralized clustering algorithm and the same steady-state phase as LEACH. LEACH-C protocol can produce better performance by dispersing the Next Nodes throughout the network. During the set-up phase of LEACH-C, each node sends information about its current location (possibly determined using GPS) and residual energy level to the sink. In addition to determining good clusters, the sink needs to ensure that the energy load is evenly distributed among all the nodes. To do this, sink computes the average node energy, and determines which nodes have energy below this average.

Once the Next Nodes and associated clusters are found, the sink broadcasts a message that obtains the Next Node ID for each node. If a Next Node ID matches its own ID, the node is a Next Node; otherwise the node determines its TDMA slot for data transmission and goes sleep until its time to transmit data. The steady-state phase of LEACH-C is identical to that of the LEACH protocol.

**3.3 LEACH-F**

LEACH with Fixed clusters (LEACH-F) is based on clusters that are formed once and then fixed. The Next Node position then rotates among the nodes within the cluster. The advantage with this is that, once the clusters are formed, there is no set-up overhead at the beginning of each round. To decide clusters, LEACH-F uses the same centralized cluster formation algorithm as LEACH-C. The fixed clusters in LEACH-F do not allow new nodes to be added to the system and do not adjust their behavior based on nodes dying. Furthermore, LEACH-F does not handle node mobility.

**3.4 E-LEACH**

Energy-LEACH protocol improves the CH selection procedure. It makes residual energy of node as the main metric which decides whether the nodes turn into CH or not after the first round. Same as LEACH protocol, E-LEACH is divided into rounds, in the first round, every node has the same probability to turn into CH, that mean nodes are randomly selected as CHs, in the next rounds, the residual energy of each node is different after one round communication and taken into account for the selection of the CHs. That mean nodes have more energy will become a CHs rather than nodes with less energy.