

# A Study on Energy Efficient Protocols in Wireless Sensor Networks

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**Abstract**— Wireless sensor networks consist of several nodes, where each node is used to detect an event and transmit the data to the base station. While transferring the data between the nodes they loss its energy level. There are many clustering and routing protocols which can be used to conserve the energy consumption. This paper focuses on homogeneous protocol LEACH and the heterogeneous protocols SEP and HEED based on energy consumption.

**Keywords**— Wireless sensor network, energy, LEACH, SEP, HEED

## I. INTRODUCTION

Wireless Sensor Network (WSN) plays a significant role in upcoming wireless communication domain due to its intelligence, small size and low cost. It have high density, self-organize, low energy capacity and an inaccessible environment [1]. Ensuring these three important tasks of sensor nodes such as capture, processing and sensing of data will extend the lifetime of a WSN [1]. Wireless sensor network is a collection of sensor nodes, which collects the information from environmental condition, pressure, temperature, sound and other things. Then it passes the sensed information to the certain main base station through some paths in a network. Fig 1 shows the wireless sensor network architecture [1].

Few characteristics of a wireless sensor networks:-

(1) There will be no availability of global unique identifier for the node and the sensor network will not be applicable for traditional Internet routing protocol.

(2) Each nodes used in the sensor network are of source nodes and sends information only to the destination node.

(3) Because of the large number of nodes they may situate in or near the target, so the collected data will be similar. This requires that the routing protocol has the ability of data fusion.

(4) The processing power and storage capacity of the nodes are very limited. The development of routing protocols for WSN has become a laborious problem in wireless sensor networks [3].

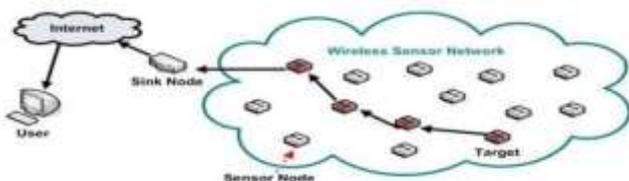


Fig 1: Structure of wireless sensor network

Sensor nodes usually have small batteries which are not feasible for replacing or recharging so there is a need for energy efficient consumption protocols. This paper studies about LEACH, HEED and SEP protocols. LEACH considers communication between sensor nodes randomly distributed in a fixed square area. SEP is an improvement version of LEACH. HEED is used to select cluster head from different clusters

## II. LOW ENERGY ADAPTIVE CLUSTERING HIERARCHY (LEACH)

LEACH is an adaptive cluster based wireless sensor network protocol [1]. In Wireless sensor network clustering approach, LEACH plays a major role in energy efficiency [2]. This algorithm has introduced with creative implementation of clustering, aggregation and dynamic scheduling [1]. LEACH protocol works with two different phases. They are initializing and stable [4]. The below Fig 2 shows the sequence diagram of leach protocol [3].

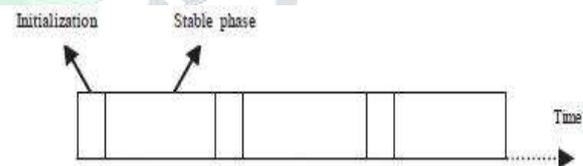
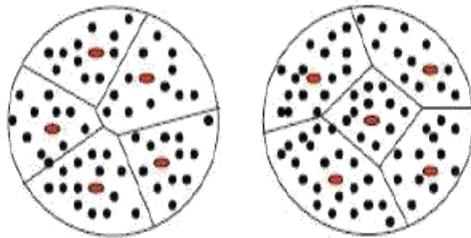


Fig 2: Sequence diagram of leach protocol

In initial phase, cluster head will be chosen which partitions the sensor nodes into clusters [4]. Cluster head will be choose based on their threshold value, in each round cluster head will change based on its energy level. Based on the random numbers the cluster head is been selected. The sensor nodes will automatically generates a random numbers such as 1 or 0. If the random number is getting less than the threshold value  $T(n)$ , then it choose as a cluster head for the current round. Fig 3 shows the different round for selecting CH's [5]. The following formula is used for calculating  $T(n)$ ,

$$T(n) = \begin{cases} p / (1 - p^{(r \bmod (1/p))}) & \text{if } n \in G \\ 0 & \text{otherwise} \end{cases} \quad (1)$$

Where  $n$  is the given node which is predetermined percentage of CHs ( $P=5\%$ ),  $r$  is the current round, and  $G$  is the set of nodes that have not selected as a cluster head in the last  $1/P$  rounds [5].



Cluster heads at time t1 Clusterheads at time t2=t1+d

Fig 3: The Cluster head changes after n time travel “d”

After the cluster head selection, in the stable phase, the formation of clusters will be done. The selected CH will construct Time Division Multiple Access tables based on the number of clusters, then the sensor nodes sense the data and broadcast the data to the cluster head based on the Time Division Multiple Access (TDMA). The duration of stable phase will longer than that the initial phase in order to minimize the overhead. Fig 4 shows about the cluster organization, data transferring from each node to CH and then CH to base station [11]. LEACH is a hierarchical protocol so in which each node sends the data to the cluster head and then compresses and aggregate the relevant data and moves it to the base station. Cluster head will first senses the target base station and then sends it to the base station.

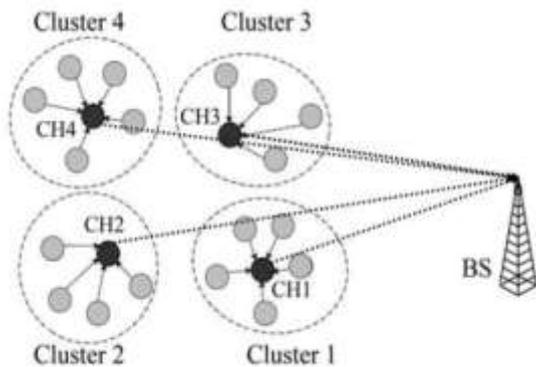


Fig4: Cluster organization for sensor networks

Advantages:-

- The cluster heads aggregate the whole data which lead to reduce the traffic in the entire network.
- As there is a single hop routing nodes from nodes to cluster head it results in saving energy
- It increases the lifetime of the sensor network
- It is fully distributed so it doesn't need control information from the base station as well as no global knowledge of the network is required.

### III. STABLE ELECTION PROTOCOL (SEP)

SEP is a heterogeneous protocol which is a refinement of LEACH. It introduces two types of nodes, named advanced and normal node. These nodes collect data from a network and send those collected data to the desired cluster head, and finally cluster head sends the data to the base station. The energy of the advanced node is more as

compared to the normal node. Advanced node has more probability to become cluster head iteration. So the SEP protocol increases lifetime of the network as compared to the LEACH protocol in terms of delay, packet loss and throughput but the first CH node of the LEACH node is faster than the SEP CH node, which is more stable [4] [3].

Threshold formula for selecting CH in Common node:-

$$T(S_{nrm}) = \frac{P_{nrm}}{1 - P_{nrm}[r \bmod (1/P_{nrm})]} \quad (2)$$

Threshold formula for selecting CH in Advanced node:-

$$T(S_{adv}) = \frac{P_{adv}}{1 - P_{adv}[r \bmod (1/P_{adv})]} \quad (3)$$

Where r is the number of rounds,  $P_{adv}$  is probability of weighted voting for advanced nodes.  $P_{nrm}$  probability of weighted voting for common nodes, [7]

$$P_{nrm} = \frac{P_{opt}}{1 + am} \quad (4)$$

$$P_{adv} = \frac{P_{opt}}{1 - am} (1+a) \quad (5)$$

The parameter of distance is selected because maximum energy consumption in a sensor node occurs in transmission of data, which is primarily determining the remaining energy level of sensor node.

### IV. HYBRID ENERGY EFFICIENT DISTRIBUTED CLUSTERING PROTOCOL (HEED):-

HEED is the clustering protocol designed to select different cluster heads in a field as per amount of energy distributed [2]. CH selection is based on the residual energy and node density each node [1].

Goals of HEED:-

- Prolonging network life-time by allocating energy consumption [1].
- By ceasing the clustering process within a constant number of iterations/steps -Minimizing control overhead
- Producing well-distributed cluster heads and compact clusters.

Residual energy is used primarily for selecting the cluster head and can be estimated by the energy consumed in sensing, processing and communication. For becoming the cluster head, each node sets its probability  $CH_{prob}$  as follows:

$$CH_{\text{prob}} = \max \left( C_{\text{prob}} * \left[ \frac{E_{\text{residual}}}{E_{\text{max}}} \right]^{p_{\text{min}}} \right) \quad (6)$$

Where,

$C_{\text{prob}}$  the initial percentage of cluster head among  $n$  nodes (it was set to 0.05),  $E_{\text{residual}}$  is the residual energy,  $E_{\text{max}}$  the maximum energy

The value of  $CH_{\text{prob}}$  not allowed to fall below the threshold  $p_{\text{min}}$  [2].

If a node is selected as a cluster head it sends an announcement message. i.e. cluster\_head\_msg (Node\_Id, selection status, cost). If its  $CH_{\text{prob}}$  value is less than 1, the selection status set to tentative\_CH or it is to final\_CH if  $CH_{\text{prob}}$  reached to 1 [2].

Advantages:-

- Creates well distributed clusters
- Terminates in constant time
- Requires only local communication
- Reduces energy load
- Extends network lifetime

## V. CONCLUSION

Wireless sensor networks are expanding and being more prevalent. In this paper different protocols has been discussed which includes LEACH, SEP, and HEED. The election of cluster head and the importance of residual energy in the selection of cluster head for LEACH, SEP and HEED has been discussed.

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