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# U-LEACH: A Routing Protocol for Prolonging Lifetime of Wireless Sensor Networks

**Nazia Majadi**
Department of Computer Science and Engineering,
Military Institute of Science and Technology (MIST), Dhaka, Bangladesh

## ABSTRACT

**A wireless sensor network is composed of a large number of sensor nodes that are densely deployed in a phenomenon or very close to it. The lifetime of sensor nodes shows a strong dependence on battery lifetime. Clustering provides an effective way for prolonging the lifetime of a wireless sensor network. Therefore, Clustering techniques are used to distribute the energy consumption among nodes in each cluster and extend the network lifetime. LEACH (Low-Energy Adaptive Clustering Hierarchy), a clustering-based protocol that utilizes randomized rotation of Cluster-Heads (CHs) to evenly distribute the energy among the sensors in the network. But LEACH cannot select CHs uniformly throughout the network. Therefore there is the possibility that the elected CHs will be concentrated in certain area of the network. Hence, some nodes will not have any CHs in their vicinity. The proposed approach U-LEACH is an approach to address this problem. It describes a uniform distribution technique that is Uniform Distribution Technique (UDT) for selecting CHs and their corresponding clusters. The goal of this paper is to build such a wireless sensor network in which each sensor node remains inside the transmission range of CHs and therefore, the lifetime of the network is prolonged.**

**Keywords- Base Station (BS), Cluster Head (CH) , Energy Efficient Unequal Clustering (EEUC) Mechanism, Low-Energy Adaptive Clustering Hierarchy (LEACH), Uniform Low-Energy Adaptive Clustering Hierarchy (U-LEACH), Uniform Distribution Technique (UDT), Wireless Sensor Network (WSN).**

## I. INTRODUCTION

Recent advances in wireless communications and electronics have enabled the development of low-cost, low-powered multifunctional sensor nodes that are small in size and jointly communicate in short distances. These tiny sensor nodes, which consist of sensing, data processing, and communicating components, leverage the idea of sensor networks [3]. A sensor network is consisting of a large number of sensor nodes and the position of sensor nodes need not be engineered or predetermined. This allows random Deployment in inaccessible terrains or disaster relief operations. On the other hand, this also means that sensor network protocols and algorithms must possess self-organizing capabilities. Another unique feature of sensor networks is the cooperative effort of sensor nodes. Sensor nodes are fitted with an onboard processor. Instead of sending the raw data to the nodes responsible for the fusion, they use their processing abilities to locally carry out simple computations and transmit only the required and partially processed data. Some of the application areas for WSNs are health, military, and home. In military, for example, the rapid deployment, self-organization, and fault tolerance characteristics of sensor networks make them a very promising sensing technique for military command, control, communications, computing, intelligence, surveillance, reconnaissance, and targeting systems [3].

Despite the innumerable applications of WSNs, these networks have several restrictions, such as limited energy supply, limited computing power, and limited bandwidth of the wireless links connecting sensor nodes. One of the main design goals of WSNs is to carry out data communication while trying to prolong the lifetime of the network and prevent connectivity degradation by employing aggressive energy management techniques. The design of routing protocols in WSNs is influenced by many challenging factors. These factors must be overcome before efficient communication can be achieved in WSNs [2].

In this paper, the proposed U-LEACH is described which consists of a technique for selecting cluster heads and their corresponding clusters that is *Uniform Distribution Technique* (*UDT*). The goal of this paper is to build a wireless sensor network in which CHs are uniformly selected base on the remaining energy of the sensor nodes, each sensor node remains inside the transmission range of CHs and therefore, the lifetime of the network is enlarged. The rest of the paper proceeds as follows. Section II describes some related work on routing protocol in WSN. The proposed routing protocol U-LEACH is discussed in Section III. The problem domain is described in Section IV. Finally, conclusion of this study is drawn in Section V.

## II.ROUTING PROTOCOL IN WSN

In general, routing in WSNs can be divided into flat-based routing, hierarchical-based routing, and location-based routing depending on the network structure. In flat-based routing, all nodes are typically assigned equal roles or functionality. In hierarchical-based routing, nodes will play different roles in the network. In location-based routing, sensor nodes' positions are exploited to route data in the network [2]. The objective of the Energy-Aware Routing protocol [1] is to increase the network lifetime [2]. LEACH (Low-Energy Adaptive Clustering Hierarchy), a clustering-based protocol that utilizes randomized rotation of local cluster base stations (cluster-heads) to evenly distribute the energy load among the sensors in the network. LEACH uses localized coordination to enable scalability and robustness for dynamic networks, and incorporates data fusion into the routing protocol to reduce the amount of information that must be transmitted to the base station [4].

LEACH is a self-organizing, adaptive clustering protocol that uses randomization to distribute the energy load evenly among the sensors in the network. In LEACH, the nodes organize themselves into local clusters, with one node acting as the local base station or cluster-head. Sensors elect themselves to be local cluster-heads at any given time with a certain probability. These cluster head nodes broadcast their status to the other sensors in the network. Each sensor node determines to which cluster it wants to belong by choosing the cluster-head that requires the minimum communication energy. Once all the nodes are organized into clusters, each cluster-head creates LEACH outperforms static clustering algorithms by requiring nodes to volunteer to be high-energy cluster-heads and adapting the corresponding clusters based on the nodes that choose to be cluster-heads at a given time. Once the cluster-head has all the data from the nodes in its cluster, the cluster-head node aggregates the data and then transmits the compressed data to the base station.

## II. PROBLEM DOMAIN

According to the existing LEACH protocol, there are some drawbacks that need to be overcome:

(i) No uniform distribution techniques for predetermined CHs. It also assumes that nodes always have data to send, and nodes located close to each other have correlated data. It is not obvious how the number of predetermined CHs is going to be uniformly distributed through the network. Therefore, there is the possibility that the elected CHs will be concentrated in one part of the network; hence, some nodes will not have any CHs in their vicinity.

(ii) Failure of a CH causes fail to the whole cluster. As nodes in a cluster have the only way to transmit data to the base station through cluster-head, failure of the CH disappear the whole cluster. When cluster heads cooperate with each other to forward their data to the base station, the cluster heads closer to the base station are burdened with heavy relay traffic and tend to die early, leaving areas of the network uncovered and causing network partition.

(iii) There is no real time transmission. As the node senses ever changing real life data, sensed data can be changed during the transmission latency from nodes to base station through cluster-head.

## III. U-LEACH: A UNIFORM DISTRIBUTION TECHNIQUE OF CHS SELECTION

In this paper, a routing protocol U-LEACH is proposed which is a uniform distribution technique of CHs in LEACH Protocol in wireless sensor networks. It wisely organizes the network through consistent distribution of clustering. LEACH Protocol works in the following steps [4]:

**Step 1**: Decide CHs and broadcast advertisement.

**Step 2**: Nodes transmit membership.

**Step 3**: Heads broadcast schedule.

**Step 4**: Nodes transmit data.

**Step 5**: Heads compress data and send to base station.

**Step 6**: New turn begins go to **Step 1**.

If the coverage area of each CH can be predefined before Step 1, then the limitation of uniform distribution of CHs can be improved. The CHs will be efficiently allocated throughout the network. Initially all nodes are homogeneous. The node, which has the maximum remaining energy, advertises itself as the first CH. Then the first CH selects an area, no other node in that particular area can advertise itself as CH. After that another CH is selected from rest of the network. In this way the whole network is divided into some predefined areas. Each area contains one CH and all the nodes in that area constructs a cluster, not a single node will remain outside these areas. Thus the CHs are uniformly distributed throughout the network. The selection of coverage area for a certain CH can be determined by selecting a circle using an Energy-Efficient Unequal Clustering Mechanism [4]. EEUC is a distributed cluster heads competitive algorithm, where cluster head selection is primarily based on the residual energy of each node.

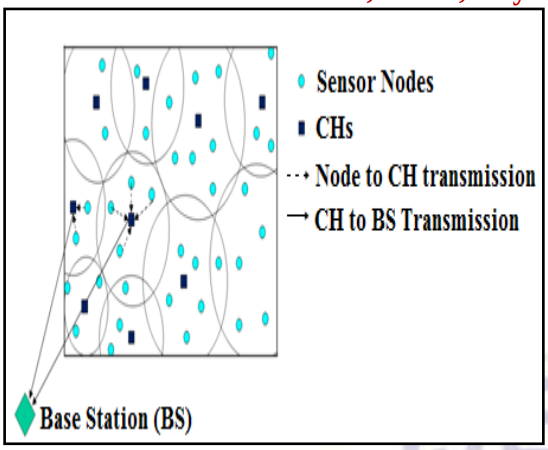


Fig. 1: An overview of U-LEACH

Fig. 1 gives an overview of U-LEACH protocol, where the circles of unequal size represent clusters. First, several tentative cluster heads are selected to compete for final cluster heads. Every node becomes a tentative cluster head with the same probability $T$ that is a predefined threshold. Other nodes keep sleeping until the cluster head selection stage ends. Suppose $S_i$ becomes a tentative cluster head. $S_i$ has a competition range $R_{comp}$, which is a function of its distance to the base station. If $S_i$ becomes a cluster head at the end of the competition, there will not be another cluster head $S_j$ within $S_i$'s competition diameter. Fig. 2 illustrates a topology of tentative cluster heads, where the circles represent different competition ranges of tentative cluster heads.

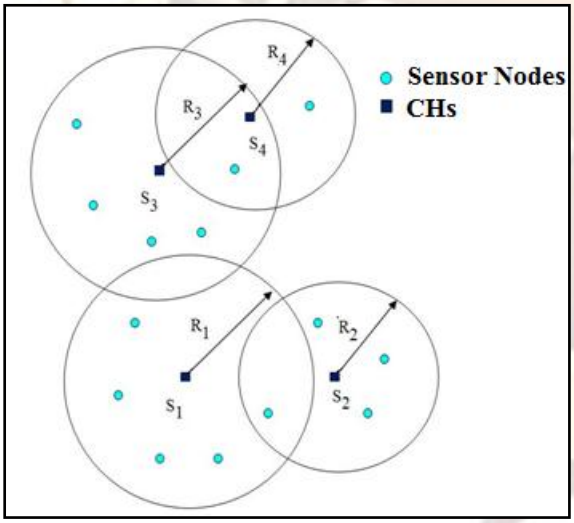


Fig. 2: The competition among tentative CHs

In Fig. 2, $S_1$ and $S_2$ can both be cluster heads, but $S_3$ and $S_4$ cannot. Therefore the distribution of cluster heads can be controlled over the network. And the cluster heads closer to the base station should support smaller cluster sizes because of higher energy consumption during the inter-cluster multihop forwarding communication. Thus more clusters should be produced closer to the base station. That is to say, the node's competition radius should decrease as its distance to the base station decreases. The range of competition radius in the network needs to be controlled [4]. Suppose $R^0_{comp}$ is the maximum competition radius which is predefined. Setting $R_{comp}$ of $S_i$ as a function of its distance to the base station [4]:

$$s_i.R_{comp} = \left(1 - c\frac{d_{\max} - d(s_i, BS)}{d_{\max} - d_{\min}}\right) R^0_{comp} \quad \text{.....} \quad (1)$$

where $d_{max}$ and $d_{min}$ denote the maximum and minimum distance between sensor nodes and the base station, $d(S_i, BS)$ is the distance between $S_i$ and the base station, $c$ is a constant coefficient between 0 and 1. According to the equation (1), the competition radius varies from $(1 - c)\ R^0_{comp}$ to $R^0_{comp}$.

Each tentative cluster head maintains a set $S_{CH}$ of its adjacent tentative cluster heads. Tentative head $S_j$ is an adjacent node of $S_i$ if $S_j$ is in $S_i$'s competition diameter or $S_i$ is in $S_j$'s competition diameter [4]. Whether a tentative cluster head $S_i$ will become a final cluster head depends on the nodes in $S_{CH}$. Therefore, the proposed approach to enhance the performance of LEACH protocol should pursue the following sequences:

**CHs Selection Algorithm of U-LEACH**

Initially all nodes are homogeneous and $CH_i = 0$ for all nodes where $i$ is the sensor node.

Let us suppose, number of nodes is $N$, queue $Q_N$ contains all nodes who will perform in the election and queue $Q_E$ contains those nodes that are not going to perform in the election, $E_{i=1}^{N}$ of node $i$, $t$ indicates time of rearrangement of CH selection. Initially all nodes are inserted into $Q_N$,

$Q_E$ = null

**Step 1:** The node, which has the maximum remaining energy, advertises itself as CH.

Then the CH selects an area, no other node in that particular area can advertise itself as CH.

After that another CH is selected from rest of the network. In this way the whole network is divided into some predefined areas.

Each area contains one CH and all the nodes in that area constructs a cluster. Thus the CHs are uniformly distributed throughout the network.

**Step 2:** Set $CH_i$ =1 for maximum $E_i$ of $Q_N$ - $Q_E$

**Step 3:** Push $Q_E$ all nodes inside $\pi R^2_{comp}$ where node $i$ is the center. Node $i$ advertises itself as CH.

Go to **Step 3** until $Q_N \neq$NULL.

**Step 4:** Each node starts data transmission to CHs and CHs transmit to BS.

**Step 5:** After $t$ time go to step 1.

## V. CONCLUSION

It is found that LEACH protocol fails in some conditions where the higher energetic nodes are concentrated, some nodes having highly probable to remain outside of any CH's vicinity will die within short period. Therefore the rotation of cluster heads and the metric of residual energy are not sufficient to balance the energy consumption across the network, CHs are required to be distributed uniformly throughout the network so that a single node should not be deducted by clusters. This paper has presented a routing protocol U-LEACH in WSN that can reduce the problems of LEACH. As well as, a uniform distribution technique of U-LEACH for selecting CHs can not only reduce energy consumption but also increase nodes life time. Therefore, the network lifetime is prolonged. As the future work, the proposed U-LEACH protocol will be applied to WSNs where sensor nodes are heterogeneous.

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