# Efficient Modified-LEACH Protocol for Enhancing WSNs' Lifetime

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**ABSTRACT:**
Obviously, it is inefficient and pretty impossible to replace or recharge batteries of sensor nodes (SN) in a vast wireless sensor networks (WSN). Consequently, one of the major concerns in such networks is energy efficiency (EE) which helps to improve reliability and lifetime of these networks. Many researches have been conducted and some efficient methods have been introduced to increase the EE in WSNs. Low-energy adoptive clustering hierarchy (LAECH) is one of these methods, which can decrease energy consumption of each SN. This paper offers a novel technique of clustering and selecting cluster head (CH) which takes the energy level of SNs and distance between them into consideration. This algorithm improves EE and lifetime of each SN. Simulations prove this claim. Moreover, the proposed protocol has not significant complexity since there is no difficult equation to cause overload, then in term of simplicity this novel protocol is significantly efficient.

**KEYWORDS:** LEACH protocol, Energy Efficiency, Clustering, Sensor Node.

## 1. INTRODUCTION

A WSN includes a number of nodes, distributed randomly in a specific area, which perform with a low processing power. Since it is hard and not cost-effective to replace their batteries several researches has been conducted to tackle this problem by increasing EE in WSNs. Data transmission from SNs to base station (BS) is the main issue which is responsible for significant proportion of SNs' energy consumption. One simple method is that every individual SN transmits its data to BS directly. However, this technique causes intensive energy drop in SNs. In contrast, in hierarchical protocol, SNs can find the shortest and the most efficient direction to BS for transmission. As a result, energy consumption in WSNs remarkably drops. To save energy leach protocol select a SN as CH which receives data from other SNs and after processing send them to BS. This protocol includes two phases, clustering phase and steady state phase. In clustering phase SNs are distributed randomly in coverage of BS and in the following stage this coverage is divided into some specific areas that each of them hosts a number of SNs and a CH. In the latter phase each SN connect to its CH to transmit its data. Then, the received data is transmitted to BS by CHs. The proposed method for selecting CH in [1] is a way in which all SNs in a cluster have equal probability to be selected. This technique does not take energy level of SNs into account consequently, a SN with low energy may become CH which may run out of energy and the whole system's operation stops. To improve LEACH protocol's performance, centralized LEACH (C-LEACH) was introduced which selects the CH based on the energy level of CNs [2]. In this protocol information about location and energy level of SNs are sent to BS. Then, BS selects the CH based on this data. In [3] SNs may become CH repetitively whereas in LEACH protocol it is impossible. The authors in [4] selected two CHs, primary and secondary ones. The former connects to BS directly and the latter takes the responsibility of receiving data from SNs and transmitting them to the primary one. This helps SNs specially ones are located far from BS to save energy while transmission. FZ-LEACH protocol was designed for vast WSNs in which the SNs are located far from BS [5]. There are some standard levels of energy and the CH is selected based on them. Clustering phase in [6] MH-LEACH is similar to that of LEACH protocol, but in steady state phase a SN transmit its data to BS if distance between that and the BS be lower than this

distance between its CH and the BS. Due to the mentioned different clustering algorithms, we decided to optimize LEACH algorithm with a novel clustering technique. In this method BS's coverage is divided into some clusters and selecting the CHs is done according to location and energy level of SNs. In other words, the SN which has higher energy and also is closer to other ones and BS has more probability to become CH. The proposed algorithm provides an acceptable improvement in EE and lifetime of SNs.

## 2. MODEL SYSTEM

Since hierarchical systems include some standard levels, SNs from lower levels transmit their data to SNs from higher levels and this process continues till BS receives the data. This process is depicted in Fig. 1.

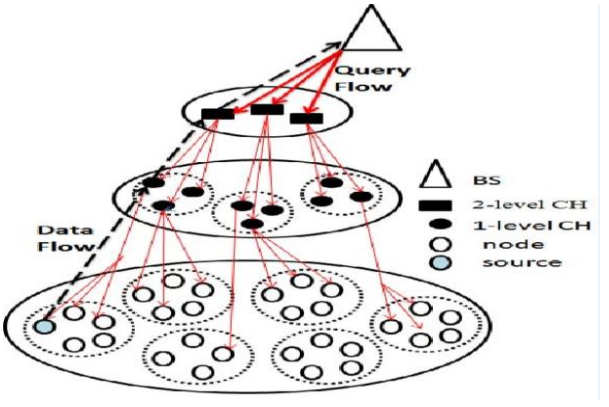


**Fig. 1.** Hierarchical system [7].

In the proposed LEACH protocol there are two standard levels, in which SNs from the first level are data collectors and the SNs from the second one (CHs) transmit the collected data to BS. The radio model in the steady state phase is the same we have in LEACH protocol as is shown in Fig. 2.

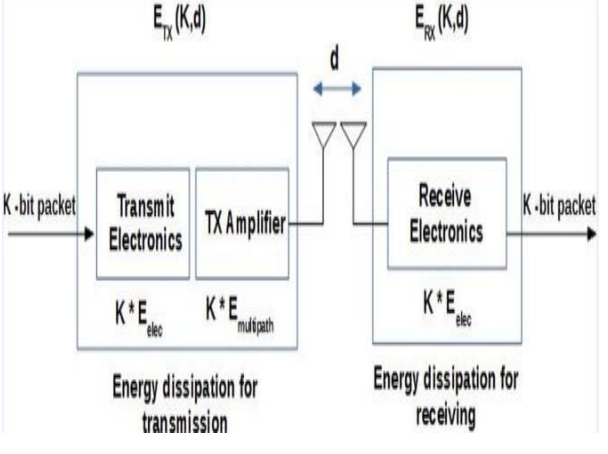


**Fig. 2.** Radio model in LEACH protocol [8].

Where we have [8] :

$$\begin{gathered} E_{Tx}(k.d) = E_{Tx-elec}(k) + E_{Tx-amp}(k.d) \\ E_{Tx}(k.d) = kE_{elec} + \varepsilon_{amp} k d^{\alpha} \\ E_{Rx}(k.d) = E_{Rx-elec}(k) \\ E_{Rx}(k) = kE_{elec} \end{gathered} \quad (1)$$

## 3. PROPOSED SCHEME

The stag of SNs Distribution is followed by dividing the whole BS's coverage into several equal square areas which are called cluster. The number of needed cluster is M that is calculated as equation 2.

$$M = \begin{cases} 4 & 0.03K \le 6 \\ 9 & 6 < 0.03K \le 12 \\ 16 & 12 < 0.03K \le 20 \\ \dots & \dots \end{cases} \quad (2)$$

Where $K$ is the number of SNs.

In the next step CH of each cluster is selected. To select that, SN's energy level and the distances between SNs and those between them and the BS are taken into account as fallow:

$$Q = \alpha \frac{E(k)}{E0} - \beta \frac{d(k)}{D(k)} - \gamma \frac{\sum\left(\left(dis(k)\right)\right)^2}{(L)^2} \quad (3)$$

Where $E(k)$ is the energy of $k_{th}$ SN and $E_0$ is primary energy of each SN. Also, $d(k)$ is the distance between $k_{th}$ SN and the center point of its cluster. Distance between $k_{th}$ SN and the BS is $D(k)$, $L$ is the length of each cluster and $\sum\left((dis(k))\right)^2$ is the distance between $K_{th}$ SN and other SNs from its cluster. The factors, $\alpha$ , $\beta$ and $\gamma$ are related to the number of SNs, length and width of WSN, and the number of clusters respectively. According to equation (3) the SNs which has most $Q$ deserves to be a CH.

The system which has been created based on above equations is in Fig. 3.

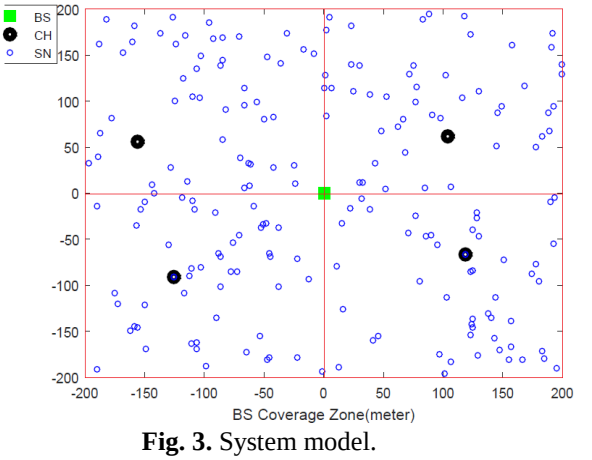


**Fig. 3.** System model.

## 4. SIMULATION

In this section we compare LEACH protocols' performance and that of the proposed scheme. The used parameters are in Table 1.

**Table 1.** Used parameters in simulations.

| Parameter | Value |
|---|---|
| $\alpha$ | 0.9 |
| $\beta$ | 0.4 |
| $\gamma$ | 0.3 |
| L | 400 meters |
| K | 200 |
| $E_0$ | 0.5 J |
| $E_{amp}$ | 100 $pJ/bit/m^2$ |
| $E_{elec}$ | 60 $nJ/bit$ |
| Broadcast Packet size | 25 bytes |
| Packet header size | 25 bytes |

This comparison is done in the same condition. The simulations show that the proposed scheme optimizes LEACH protocol and creates a great improvement in LEACH protocol's performance. Fig. 4 illustrates that the number of alive SNs in rounds. In round 200 the number of alive SNs begins to decrease while this figure of proposed scheme remains in maximum till round 300.

In term of saved energy, as Fig. 5 shows, the proposed protocol has performs better than LEACH protocol, and increases the lifetime of WSNs. It is clear that considering energy level of SNs helps to select the SN which has higher energy as cluster head and keeps the SNs alive for longer time.

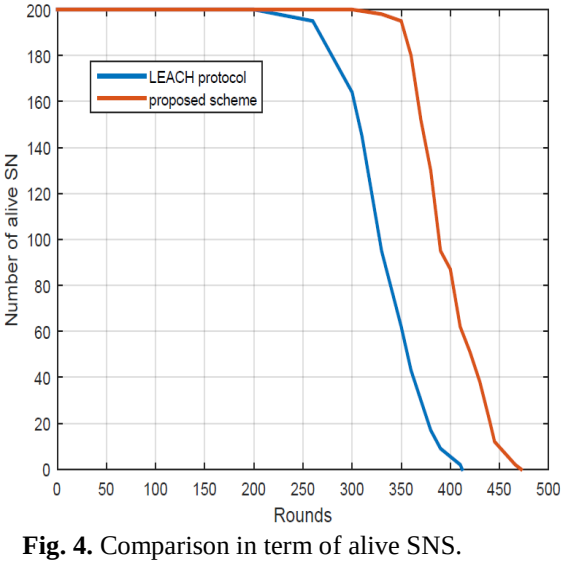


**Fig. 4.** Comparison in term of alive SNS.

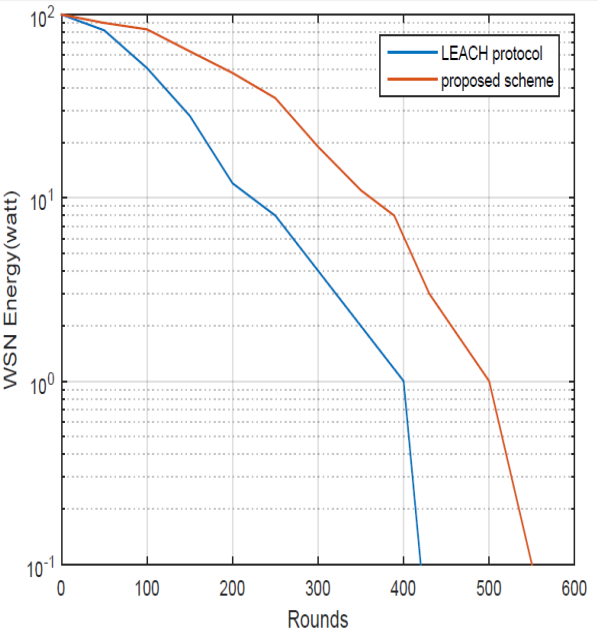


**Fig. 5.** Comparison in term of saved energy.

## 5. CONCLUSION

The modified LEACH protocol offers a novel method of clustering which is done according to the number of SNs and assigns cluster heads based on energy level of SNs and distances between them and BS. In comparison with LEACH protocol the proposed protocol maintains the SNs alive for longer period because the SNs with less energy have less probability to become CH which helps them to send their data with less energy. Simplicity is another upside of this scheme because there is no difficult calculation to perform. Simulations prove in figures 4 and 5 prove these claims.

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