A Review of Low Energy Adaptive Clustering Hierarchy (LEACH) Protocol for Effective Power Dissipation in Wireless Sensor Nodes

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Abstract

With the evolution of fourth generation wireless network and increased subscribers, power dissipation becomes the major concern for researchers. A wireless system with less power consumption is the need of the hour. With 5G technology, reduction in power dissipation will be the focus issue of all future researchers. The aim of this research is to design a wireless sensor network with modification in hardware and/or software algorithm, which works in a more energy efficient manner.

In this paper, we have reviewed the famous protocol called LEACH (Low Energy Adaptive Clustering Hierarchy) and its various versions proposed by researchers in recent times, to lower the power dissipation in Wireless Sensor Nodes like RED-LEACH and Hybrid LEACH.

Keywords: *LEACH, Power Dissipation, Wireless Sensor Nodes, Cluster.*

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1. Introduction

In the modern world of science and technology, Wireless Sensor Network (WSN) (Liu 2019, 40569-40580; Agrawal 2018, 60-64; Rasyid 2019, 394-399) is growing as one of the most impactful and useful technologies for sending and receiving information in the field of communication. In WSN, several mini sensor nodes are spread in the area to gather useful information. These sensor devices are equipped with sensing, processing and trans-receiver electronic units which make them capable of sensing and observing real world quantities like temperature, sound, pressure, light, humidity, etc. WSN is rapidly expanding its wings in almost every field like medical, military, healthcare, communication, etc.

Recent advancements in technologies of Wireless Sensor Networks (WSNs) enable to connect the real environment to the virtual environment. This advancement in WSNs gives greater benefits to many applications such as environmental monitoring, military surveillances, agricultural management, etc. There are many issues in WSNs, but the main issue of such networks is energy because in harsh conditions, it is difficult to replace batteries of sensor nodes. This is the reason why minimizing energy consumption when designing the routing protocol is very important to increase the lifespan of WSNs.

Wireless Sensor Networks (WSNs) have sensing nodes (SNs) with limited power, memory and computational capabilities. The applications of WSNs include local monitoring, fire-detection and health care information. WSNs are mainly used in remote areas where the replacement of dead nodes or recharging is nearly impossible.

2. Literature Review

Extensive work has been done on LEACH protocol and to reduce power consumption in wireless networks. Many researchers have done tremendous work in this area.

Fagui Liu and Yufei Chang (Liu 2019, 40569-40580), in their article, proposed a new unequal clustering algorithm EAKDE for WSNs. It aims to balance the workload among all sensor nodes. It consists of four main phases: cluster head selection, cluster radius calculation, cluster formation and routing process. In order to adapt to the dynamic change of node conditions, EAKDE is committed to assigning the appropriate cluster radius to the sensor nodes by utilizing adaptive kernel density estimation algorithm. From the perspective of CH selection and cluster radius calculation, EAKDE avoids the effects of random uncertainty and human experience. It is distributed in nature and has better performance compared to other tested algorithms (i.e., LEACH, EMAR, imp-K-means, EAUCF and DFCR) in terms of the network's lifespan and energy efficiency. These experimental results imply that EAKDE is a stable and energy-efficient unequal clustering algorithm for WSNs. In the future, we will consider using the adaptive kernel density estimation algorithm to elect the points-of-interest (POI) of the region. Let POI act as the active CH to further prolong the network lifetime.

In Agrawal (2018, 60-64), the working approach of LEACH protocol is simulated and analysed with the help of MATLAB. This protocol is studied in terms of various significant parameters of WSN like network lifetime, throughput, flow of packets to BS, etc. The outcomes show that the random selection of each node to become CH decreases the consumption of energy. The network lifetime varies significantly with the location of base station across the field. Centre position is the most optimal choice for enhancing the performance of the LEACH. In LEACH, the throughput of the operation depends on the value of CH probability (P). LEACH is a remarkable protocol in saving energy. Hence, it should be further analysed to make it a more energy-efficient protocol for WSN.

The impact of residual energy and distance to base station on LEACH is proposed in Chit (2018, 186-190). The main objective in this paper is to prolong the network life by reducing energy utilization. To fulfil this goal, the proposed protocol focuses on cluster heads (CH) selection by choosing the node with high energy and minimum distance to BS as cluster head (CH). Thus, the proposed RED_LEACH reduces energy utilization to one-third of the original LEACH and the network life doubles. From simulation results, it can be concluded that RED_LEACH notably lessens the dead node numbers and it can reduce energy usage by a greater degree than LEACH protocol. In this paper, the proposed work considers only cluster heads (CH) selection with the node's remaining energy and remoteness to base station (BS). In future work, cluster formation using fuzzy logic will be considered and optimized energy efficient clustering algorithm will be developed.

Another paper (Ali 2018, 1999-2006) presents the simulation results obtained using the proposed algorithm. It is clearly seen from the simulation results that our proposed scheme BFPSO LEACH-C shows better performance compared to the classical schemes. Performance improvement is seen in terms of energy efficiency. Furthermore, it enhances the network's lifespan and coverage as was expected.

M. Udin Harun Al Rasyid, Nur Rosyid Mubtadai & Jeni Abdulrokhim (2019, 394-399) present an analysis of LEACH-GA and LEACH performance in terms of throughput, network lifetime and energy efficiency in several scenarios with different network areas and three different BS placements (centre, corner, and outside position from the network area). The simulation results show that the LEACH-GA can improve network performance in the form of energy efficiency, higher network lifespan, and energy consumption used in each round compared to the LEACH algorithm. In addition to these, the other factor that affects network performance is the location of the BS; if the BS is close to the network area (the BS is in the centre of the network area), then the performance of the network will be good, but if it is too far, then the performance will be reduced because the communication between the node and BS will require more energy. The area that must be covered by the nodes also affects the performance; if a wider area (200x200) has to be covered with the same number of nodes used for a narrower area (100x100), the performance will be poorer. In a wider area (200x200) with the same number of nodes, the performance of the LEACH-GA has advantages compared to LEACH.

Protocols proposed in Kumar (2019) aim to keep sensor nodes alive to meet scalability issues. Transceiver energy-based approach for optimization of energy consumption with a number of sensor nodes, sink node, initial energy, transmitter & receiver energy and cluster head is proposed to operate the sensor network for a long period. The energy conservation issue exists in the sensor ad-hoc network due to research gap in work performed by different researchers.

Tan (2019) proposes an improved LEACH-M protocol in a three-dimensional dynamic sensor network. This protocol solves the problem of communication failure caused by mobile nodes patrolling and then deviating from the cluster communication range. The protocol is improved based on the existing LEACH-M protocol and MCR protocol. An efficient solution for outlier nodes is proposed to ensure that they can re-home quickly and efficiently. Simulation analysis shows that the improved LEACH-M protocol effectively extends network lifetime and optimizes information transmission efficiency.

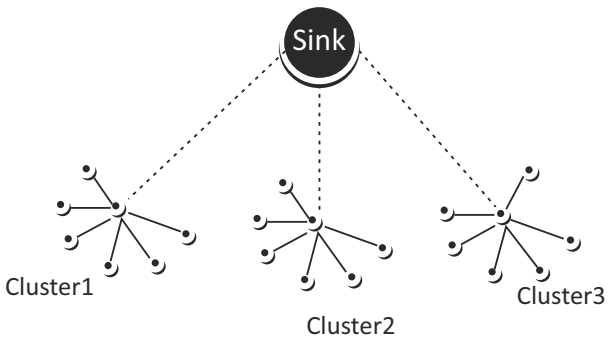
3. LEACH Protocol

In the modern world of science and technology, Wireless Sensor Network (WSN) is growing as one of the most impactful and useful technologies for sending and receiving information. WSN is rapidly expanding its wings in almost every field like medical, industries, environment tracking, etc. In WSN, numerous mini sensor nodes are distributed in the area to gather relevant information. These nodes are capable of sensing and observing the surrounding events like temperature, sound, pressure, motion, humidity, etc. The sensor node performs different data operations like sensing, processing, reception and transmission using energy from its battery. Due to the tiny size of node, mini battery has very less power. Hence, it is very important to use this scarce resource efficiently to enhance the life period of the network. In this direction, Low Energy Adaptive Clustering Hierarchy (LEACH) routing protocol has been developed. In this protocol, every node becomes a cluster head (CH). This random selection of CHs makes it energy saving protocol.

LEACH protocol is split into several rounds. A round has the following two phases:

A. Set-up phase

B. Steady-state phase.



- Cluster Head
- Member Node

Figure 1 : LEACH Protocol

Flow chart of LEACH protocol

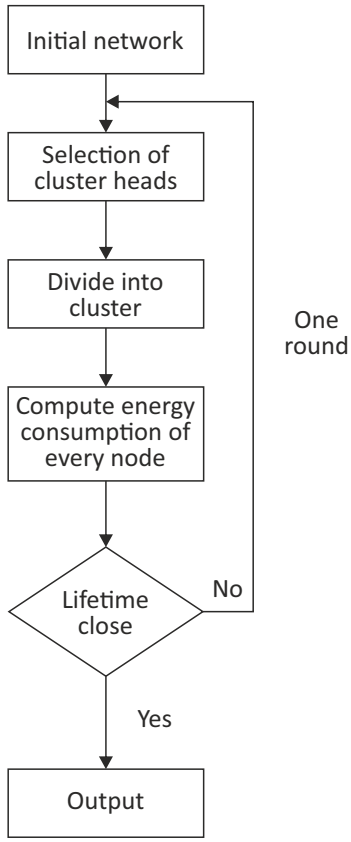


Figure 2: Flow Chart of LEACH Protocol

4. RED_LEACH Protocol

LEACH suffers from early dead nodes problem because it chooses cluster heads (CHs) without considering the remaining energy of each node and remoteness to base station (BS). Therefore, Chit (2018, 186-190) proposes the lifetime improvement of Wireless Sensor Network (WSN) using residual energy and distance to the Base Station (BS) parameters on LEACH protocol and the proposed protocol is termed as RED_LEACH. To prolong the network life in WSNs, RED_LEACH uses two parameters: remaining energy in each node and remoteness to base station in heads of clusters selection and its results are compared with the results of original LEACH in terms of sum of energy of nodes against round and the number of dead nodes against round.

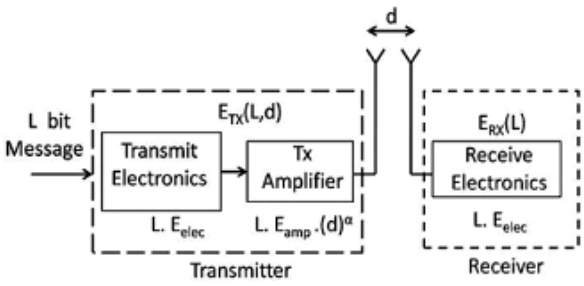


Figure 3: Radio Energy Dissipation (RED) Model

The proposed RED_LEACH reduces energy utilization to one-third the original LEACH and the network life doubles**. From simulation results, it can be concluded that RED_LEACH notably lessens** the dead node numbers and it can reduce more energy usage than LEACH protocol.

5. Hybrid LEACH Protocol

The energy efficiency of sensor nodes is an important issue to handle in distributed Wireless Sensor Network (WSN) for gathering massive information. In WSN, the sensor node has drawn back of limited energy and has a shorter lifespan. Therefore, efficient network routing protocol should be developed to minimize the energy dissipation while maximizing its coverage. In the proposed algorithm, the main focus is to efficiently utilize energy while communicating to the Base Station (BS). Since the location of most BSs varies from node to node in the sensing area, energy dissipation in sending data also varies. Low-Energy Adaptive Clustering Hierarchy (LEACH) protocol is no doubt a good alternative, but its performance is not consistently good. In Ali (2018, 1999-2006), a hybrid protocol is proposed, which optimizes the energy and enhances the coverage of nodes. A hybrid LEACH protocol is a combination of Bacteria Foraging (BF) and Particle Swarm Optimization (PSO). It enhances the network's lifespan by making it energy efficient.

This paper concludes with the simulation results that our proposed scheme BFPSO LEACH-C shows better performance compared to the classical schemes. The performance improvement is seen in terms of energy efficiency. Furthermore, it enhances the network's lifespan and the coverage of the network, as was expected.

6. Conclusion

The famous protocol called LEACH (Low Energy Adaptive Clustering Hierarchy) proves energy efficiency by using the clustering method. In clustering, there are two main phases: heads of clusters choosing phase and clusters making phase. Among them, Cluster Heads (CHs) selection is the most important. LEACH protocol suffers with the early dead nodes problem, which can be overcome by RED_LEACH protocol. Further improvement in energy efficiency can be achieved by using hybrid further optimizing LEACH-C protocol by using hybrid LEACH protocol like BF-LEACH and BFPSO LEACH Protocol.

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