

The Improved Energy Efficient LEACH Protocol Technology of Wireless Sensor Networks

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Abstract

The most important factor within the wireless sensor network is to have effective network usage and increase the lifetime of the individual nodes in order to operate the wireless network more efficiently. Therefore, many routing protocols have been developed. The LEACH protocol presented by Wendi Heinzelman, especially well known as a simple and efficient clustering based routing protocol. However, because LEACH protocol in an irregular network is the total data throughput efficiency dropped, the stability of the cluster is declined. Therefore, to increase the stability of the cluster head, in this paper, it proposes a stochastic cluster head selection method for improving the LEACH protocol. To this end, it proposes a SH-LEACH (Stochastic Cluster Head Selection Method-LEACH) that it is combined to the HEED and LEACH protocol and the proposed algorithm is verified through the simulation.

Keywords: *Wireless Sensor Network, Cluster Head, LEACH protocol, HEED protocol, SH-LEACH protocol*

1. Introduction

Recent trends, the core technology of ubiquitous network is WSN(Wireless Sensor Network). And for the data collection and specific purposes, WSN is in general use a various fields-environment monitoring, tracking target, healthcare systems, hazardous materials, and fire, building internal surveillance, etc. [1] WSN is consisted of a lot of the sensor module, sensor nodes with a network module and the base station(BS) that receives data from the sensor node and can access by the user. In general, the sensor node is constraints such as the limited battery, the memory, the arithmetic processing and the communication space etc. [2]. The energy efficiency is very important for WSN and the routing protocol is extremely significant in WSN for transmitting efficiently the sensed data to the BS. The routing of clustering-based has a great advantage in the efficient energy sector and lifetime then the existing wired communication. [3] After the

cluster-based routing protocol is to form a local cluster, the sensed data in the cluster is transmitted to the cluster head(CH) and the routing protocol is able to efficient that the cluster head performs data collection. [4] The LEACH and HEED protocol is to have typical routing techniques. In this paper, it improved the decision method of cluster for the most important routing algorithm of clustering-based named LEACH. This paper is organized as follows: the related research is mentioned to the chapter 2, the proposed algorithm is presented in the chapter 3, the results of simulation for the proposed algorithms described in the chapter 4. And the conclusion is proposed in the Chapter 5.

2. Related research

In this chapter, it explained the LEACH, HEED algorithms for a typical routing protocols that have been proposed for sensor networks.

2.1 LEACH

LEACH is abbreviation for Low Energy Adaptive Clustering Hierarchy that the routing protocol proposed in the PhD thesis - "Application-Specific Protocol Architectures for Wireless Networks" of the professor Wendi Heinzelman of University of Rochester. [5]

LEACH is a method of cluster head that is collected data from member nodes of the cluster, to be process the data and to be transferred to the BS directly. The character of LEACH is that the form of cluster is continuously changed over each time the round and the selection of a cluster head is set itself among the sensor nodes in cluster. In addition, it improves the energy efficiency of the network by the reducing the number of transmitted data through the data fusion from the cluster head. Then, the cluster head carry out the data compression process and the data combination, it transmits the less data to the BS. Especially, in case the LEACH, the cluster head is selected in the ratio of the stochastic among sensor nodes, it is not central management system but distributed control system. The LEACH consists of the set-up and steady state phase.

In set-up stage, n times sensor node among of the all sensor nodes selects a random number between 0 and 1, then it ensures that all the nodes becomes the cluster head once by using the probability formula (1) below.

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

In the equation (1), T(n) is the threshold, and G is a set failed to cluster, r is the current round. If the random number is less than T(n), n times of the sensor node selected the cluster head in the next round. After the cluster head is selected, the cluster head sends a broadcasting message to sensor nodes and collects the cluster members. In steady-phase, the member nodes transmits the data to the cluster head according to the scheduling of forming clusters in the set-up phase. As usual, member node is in a sleep state. When the transmission time is approaching, member node is waked and transfer data to CH. At the end, member node go back to sleep state. Therefore it is possible to reduce energy consumption. However, thenode isdeterminedby the clusterhead onein theclusterheaddecisionprocess, the node do not have to be a cluster head again. Therefore, in the case ofthe irregularsensor network, the totalamount of data transferefficiency will drop. The below Figure 1 presents the LEACH algorithm.[6]

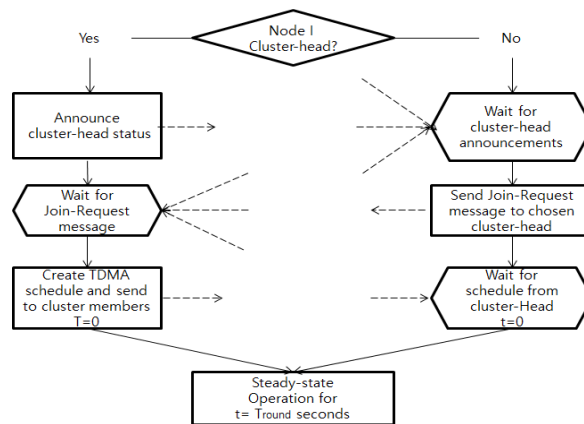


Figure 1. LEACH algorithm

2.2 HEAD

The HEED is abbreviation for Hybrid Energy-Efficient, Distributed clustering approach, is proposed by the Osama Younis and Sonia Fahmy of University of Urdue. Using the amount of remaining node energy, the HEED is selected the cluster head and is the cluster-based wireless sensor network routing protocols.[7] The cluster head selection of HEED is no need to know the energy of all the nodes, it is selected a cluster head using only the parameters of the node itself. The cluster head selection stochastic formula of the HEED is the equation (2) as follows.[8]

$$CH_{prob} = C_{prob} * \frac{E_{residual}}{E_{max}} \quad (2)$$

In the formula (2), Cprob is the cluster head node ratio and Emax is the initial energy of node itself, residual energy of the node is Eresidual. These stochastic are calculated, HEED is multiplied by 2 to the probability calculated value, the CH is selected the node to be reached first to value "1". Depending on the time, because the energy of all the nodes will be to draw a line descent, the calculated value becomes smaller. The limitations that can't be most nodes to select a cluster head is present multiply by 2. However, if all of the energy is low similarly, increase during the multiple of 2, to the cluster head selection probability value disadvantages that may number of nodes the value arrives at 1 is too large, most nodes will be the cluster head exists.[8]

3. The proposed algorithms

3.1 LEACH problem

During the cluster head selection process in LEACH whereas once random node is selected to be a cluster head, this node never would be able to get selected again unless every node took turns for the cluster head. Additionally, a network with irregular transmission quantity data must have decrease in effectiveness. Consequently, the LEACH shows cluster instability. In order to develop this issue, we are suggesting to apply LEACH on a stochastic method of HEED.

3.2 Stochastic methods HEED

While HEED is selecting the cluster head, it uses a stochastic method called CHprob to determine the

cluster head. This is proved to be effective in irregular sensor network but it causes error in data flow and network composition process due to complicated routing technique

3.3 New stochastic cluster head selection method

The study introduces a new cluster head selection system within adapting a stochastic cluster head method based on LEACH. Unlike selecting each node in turns, the below stochastic formula (3) applies a random number of each node and select to be the cluster head.

$$CH_{prob} = C_{prob} * \frac{E_{residual}}{E_{max}} * \frac{C_{prob} * r}{1 + CH_{cho} \bmod \frac{1}{C_{prob}}} \tag{3}$$

The formula (3) is the improved cluster head stochastic function of HEED. As time flows, energy level decreases in every node which then, it may not be selected as cluster head. Therefore regarding to the increase of rounds, it multiplied a number of rounds to keep a certain level of stochastic. CHcho is a parameter stands for the number of nodes that are selected as cluster head till the present round. And add this to denominator for constant rate at the most. Moreover, mod function is used to reduce the stochastic when there are plenty selected nodes of cluster head until the present round. Nevertheless, if there are few selected nodes of cluster head, the stochastic increases.

4. Simulation and Discussion

4.1. Experimental environment

In this paper, a proposed stochastic cluster head selection method was performed by MathLab simulator. The parameter of used energy consumption is in table1 and table2 demonstrates the major variables that were addressed in this thesis. We proceeded the simulation under the circumstance of each node have equal amount of initial energy.

Table 1. Energy consumption model Table 2. Main parameters that are used in Parameters the simulation

Parameters	Set
n	100
C_{prob}	0.10
ϵ_{mp}	100pJ/bit/m2
E_{max}	0.5J
E_{TX}	50nJ/bit
E_{RX}	50nJ/bit

4.2.

Parameters	Description	Parameters	Description
E_{elec}	Circuit energy consumption	E_{DA}	Aggregation
ϵ_{fs}	Free space loss	ϵ_{mp}	Multi-path loss
n	Number of node	C_{prob}	Cluster head ratio
E_{TX}	Transfer energy	E_{RX}	Received energy

4.2. Simulation results

When the value of Cprob is 0.1 with 100X100 sensor field, the following figures and simulation result came out on the round of 2000.

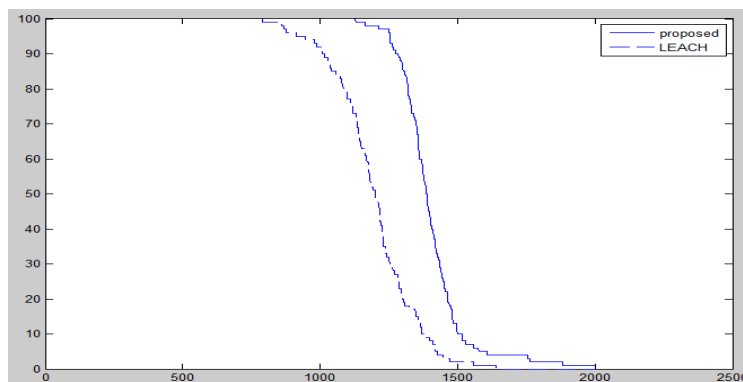


Figure 2. LEACH and proposed alive node compare

The lifetime, which is a common evaluation standard of routing technique illustrated similar or slight improvement to the existing LEACH, the suggested algorithm appeared to be more effective in the round of the first dead node.

5. Conclusion

The typical type of cluster based algorithm LEACH and HEED were investigated in this paper. Within the LEACH based and through adapting a stochastic cluster selection of HEED, we introduce a new stochastic method of selection on cluster head. The proposed algorithm has disadvantages that it does not ensure the number of cluster heads and produce more energy usage than LEACH although it has uniform energy consumption of node, the evaluation demonstrated better outcome when comparing to the lifetime with existing method. Besides, it also can slow down the speed of the first dead node occurrence.

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