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## A New Approach to Sensor Energy Saving Algorithm

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### Abstract

*Wireless sensor network energy saving algorithm is a popular topic in recent researches. This paper proposes a new LEACH based energy saving algorithm to prolong the life of wireless sensor network. In this algorithm, sensors are divided into several static clustering. And each sensor takes turns to act as clustering head. Meanwhile, in order to reduce the network communication flow, the algorithm transports as little control signals as possible. Simulation results show that the algorithm proposed by this article is better than traditional fixed energy saving clustering algorithm in prolonging network's life cycle.*

**Keywords:** Energy Saving, Wireless Sensor Network, Clustering Head, Network Life Cycle.

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### 1. Introduction

Wireless sensor network contains sensor technology, embedded technology, modern networking, wireless communication technology and distributed information processing technology [1]. It is capable of real-time monitoring, sensing and gathering information of various environments and objects, distributing this information in the network, processing it and transmitting it to users. Wireless sensor network has broad application prospects in environmental science, space exploration and other commercial application areas [2].

Sensor network consists of sensor nodes. Sensor node is a tiny embedded system. It has low power, low cost feature, and can only carry limited battery energy. Moreover, sensor nodes work in various conditions. And under current situations, it is not feasible to improve the sensor nodes by increasing the battery capacity or replacing the battery by manually. How to conserve energy and prolong the life cycle of network is an important topic of recent researches.

### 2. Related Work

Prolonging the lifetime of a sensor node powered by battery in both homogeneous and heterogeneous wireless sensor networks is a massive challenging area of research nowadays. There are several solutions addressing the problem of energy saving. In general, some kind of duty cycle is involved, in which each node is shut down in turn for a period of time [3]. For example, Gong et al. have proposed naturally energy preserving way TDMA-based protocols, because they have a duty cycle built-in, and do not suffer from collisions [4]. However, maintaining a TDMA schedule in an ad-hoc network is not an easy task and requires much complexity in the nodes. Keeping a list of neighbor's schedules takes valuable memory capacity. Allocating TDMA slots is a complex problem that requires coordination. Furthermore, as TDMA divides time into very small slots, the effect of clock drift can be disastrous; exact timing is critical. So there are a few disadvantages in their method.

Another way of energy saving is to use an extra radio called wake-up radio, which operates on a different frequency than the radio used for communication [5]. As the wake-up radio is only for waking up other nodes, it needs no data processing and therefore uses much less energy. It does, however, require an extra component on the node and most wireless sensor nodes currently used in research only have a single radio that operates on a single frequency.

Introducing a duty cycle into a contention-based protocol that only uses a single frequency requires some kind of in-band signaling to save nodes' energy. The well-known IEEE

802.11 protocol, for example, has power-saving features, even when working in ad-hoc mode [6]. However, this protocol was designed with the presumption that all nodes are located in a single network cell, while wireless sensor networks will often be multi-hop. Adaptations for multi-hop networks have been proposed, but seem to require more complexity and dynamic state than would generally be available in wireless sensor networks.

Another protocol specifically designed for sensor networks to save energy is LEACH (Low Energy Adaptive Clustering Hierarchy) Protocol [7]. Many research works including LEACH and its variants use clustering techniques to reduce energy spent by keeping most of the nodes in sleeping mode whenever possible. LEACH cannot solve the problem of extending the networks life time due to losing huge energy of sensor nodes selected as cluster heads for communications. To save energy of cluster heads, relay node based schemes use independent relay nodes as cluster heads. These schemes, however, still suffer from the problems of relay node placement, blind spots and immature death of cluster heads [8].

Addressing the above mentioned problems, this paper proposes a new LEACH based sensor energy saving algorithm. Applications for these networks have some characteristics such as low message rate, insensitivity to latency, which can be exploited to reduce nodes' energy consumption by introducing an active/sleep duty cycle. This reduces the amount of energy wasted on idle listening, in which nodes wait for potentially incoming messages, while still maintaining a reasonable throughput.

### 3. Algorithm Description

#### 3.1. Analysis of LEACH Protocol

Routing protocol is the core protocol of wireless sensor network. Wireless sensor network has its own characteristics, which is different from traditional network. At present, many domestic and foreign researchers have proposed a variety of routing protocols, which are divided into flat and hierarchical routing protocols [9]. Flat routing protocols include Pan-Fa, SPIN, SAR, directed proliferation and what we mentioned above. Hierarchical routing protocols include LEACH (Low Energy Adaptive Clustering Hierarchy), TEEN and PEGASIS [10]. LEACH is the first protocol to propose hierarchical routing in wireless sensor network and the definition of "round" and "cycle". Each round was divided into two stages: clustering head election and stability work. In the clustering head election phase, RS (Receiving station) randomly selected some nodes as clustering head, the clustering head nodes sent broadcast messages to the surrounding, the other nodes determined which clustering region should join according to the strength of the received information and notified the information to the clustering head [11]. In the stability work phase, nodes collected required data and sent them to the clustering head. Clustering head mixed the required data and sent them to RS. When a work cycle was complete, the next round would repeat the former cycle, re-select the clustering head and divide clustering regions.

In order to improve LEACH protocol, people have proposed fixed clustering algorithm based on LEACH. Main objective is to reduce system energy consumption and extend the nodes' network life [12]. The basic idea of the fixed clustering algorithm is as follows: in the initial stage, according to the size of the target area and the total number of sensor nodes, we could use mathematical calculation to divide fixed clustering region, reduce the nodes' energy cost of the initialization phase. After fixed the clustering region, we could select the nodes which has the maximum residual energy as the clustering head, meantime, in order to avoid the rapid failure of a single node, we should dynamically select the clustering head in turn, so that each node within the clustering average commitment communication task. The communication between within clustering nodes and clustering head used single hop approach, which reduced system power consumption. For clustering heads, through the establishment of the routing tree, we formed hierarchical clustering structures to communicate with the RS, and reduced the number of nodes to communicate with the RS. Compared with the LEACH protocol, the fixed clustering algorithm based on LEACH extended the network life cycle to the maximum and balanced the energy consumption. However, the algorithm still has some problems. In this paper we will propose a new improved method.

### 3.2. Improved LEACH Based Energy Saving Algorithm

In the LEACH based fixed clustering energy saving algorithm, the selection of clustering head is dynamic rotation in each round. When chosen as clustering head, all nodes within the clustering must send their remaining energy value to the current clustering head, the current clustering head selects the node whose remaining energy value is the largest as the next clustering head, at the same time, the new clustering head should send a broadcast to every nodes within the clustering to inform this event, and the original clustering head turn into ordinary node. In this process, the comparison of the residual energy values in each round has increased the communication volume within the clustering region, and has increased the consumption of the nodes' energy. This paper argues that after the clustering regions have been fixed, the nodes within the region can hold a post as the clustering head alternately according to pre-set threshold, rather than compare with each other. This method reduces the communication volume between nodes, thus energy consumption is also reduced and the network's life cycle is extended.

In this article, the algorithm is a fixed clustering algorithm based on LEACH. The environment is an area with a known size, where sensor nodes are uniformly distributed. And there is a receiving station (RS) outside the sensor region.

- (1) All sensor nodes are equal and their initial energy values are the same.
- (2) The location of sensor nodes and the RS is fixed.
- (3) The power of every sensor nodes to send data to any direction is the same.
- (4) The algorithm only considers the energy consumption of data processing and data transmission.

The basic idea of the proposed algorithm in this article is: in the initialization phase, all nodes in the clustering are divided into a fixed clustering area, and the divided clustering area and all nodes within the clustering will not change since then; in the clustering head election phase, the clustering head is not the node whose residual energy is the maximum but is alternately held by every nodes within according to a certain order; the algorithm establishes routing tree between the clustering heads, and uses multi-hop way to communicate with the RS, so the energy consumption of communication between the clustering heads and RS is reduced. Algorithm steps are as follows.

Step 1: In a given target area  $m \times m$ , the total number of sensor nodes is  $n$ , the optimal clustering region  $Q$  is derived by related equation.

Step 2: RS uses  $Q$  nodes within the region to establish order array with the symbol. In all clustering regions, algorithm should select a nodes randomly as clustering head, and set the flag bits in the order array, and send this array, the current number of rounds  $R_i$  (Initial value is 1) and the threshold ratio  $x$  (set by the RS) to the current clustering head. The current clustering head sends broadcast to all the nodes within the region, to notice that it is the clustering head. In which  $R_i$  round threshold  $T_i = 2x^{R_i}$  ( $2$  is the initial energy of nodes).

Step 3: Each clustering head with the others in the con-text of one hop to establish the routing table and form a routing tree. Node sends the collected data to clustering head. After calculates and mixes data, the clustering head transmits the data back to RS by the route.

Step 4: When energy consumption of the current clustering head reaches its threshold value  $T_i$ , it will no longer serve as clustering head. It will first query the nodes to be the next clustering head according to the order within the array. Then, set the flag bits, inform the node, and send the order array, rounds  $R_i$  and threshold ratio  $x$  to the next clustering head. Since then, the current clustering head will become ordinary node.

Step 5: When a node receives the notice of to be the clustering head, it will first judge whether its energy is lower than the threshold  $T_i$  of this round or not. If its energy value below the threshold, the node will select the next node as clustering head. Otherwise, the node will send a broadcast to the clustering region, to inform itself as the new clustering head.

Step 6: Repeat Step 3 to Step 5, when all nodes' flag bits are set, reset all the flag bits, and to start a new round of rotation. When start a new round, number of the round  $R_i$  added one automatically. When the energy of all nodes is exhausted and the nodes unable to work, the fixed clustering region will be failure.

#### 4. Results and Analysis

In this paper, we have done simulate experiment to the proposed algorithm and have analyzed the results. In the simulate experiment, the number of sensor nodes is 500, and the nodes were evenly distributed in the 500\*500 area. RS was located in coordinate (130, 360). All nodes had the same initial energy, initial energy value was 2J, the data packet length was 500B, the energy consumption of data sending and receiving was 50nJ/bit, and the amplifier power was 100 pJ/(bit·m<sup>2</sup>).

Figure 1 shows relationship between node mortality and time round.

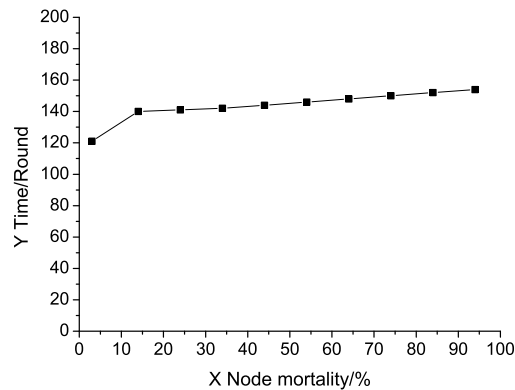


Figure 1. Relationship between node mortality and time round.

As can be seen from figure 1, the node mortality of the algorithm in this paper is delayed compared to the former fixed algorithm. This shows the algorithm of this paper is effective. This algorithm delays the death time of nodes through reducing the communication traffic between nodes to save the energy consumption.

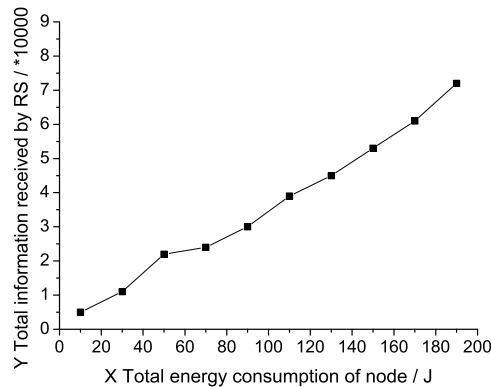


Figure 2. Relationship between total energy consumption of nodes and total information received by RS.

Figure 2 shows the relationship between total energy consumption of nodes and total information received by RS. As can be seen from figure 2, we know that the total information received by RS in this improved algorithm is more than in the former fixed clustering algorithm. It shows that the saved energy has transmitted more efficient data, and the algorithm uses the node energy more rationally and efficiently.

## 5. Conclusion

To solve the problem of nodes' energy efficiency in a wireless sensor network, we have proposed an improved LEACH based energy saving algorithm. The algorithm reduced the control communication flow between nodes in clustering area so that the nodes' unnecessary energy consumption can be reduced and the useful data can be transmitted more efficiently among nodes. Many wireless sensor network applications depend on nodes being able to accurately determine their locations. In our algorithm the nodes in the clustering area hold a post as clustering head alternately, which balanced the network load and greatly extended the limit of the network life cycle. Simulation results show that the algorithm in this paper saves nodes' energy and prolongs network life cycle. It's a more effective algorithm compared to fixed clustering algorithm.

## Acknowledgements

This work was supported by Ministry of Education of the People's Republic of China, Humanities and Social Sciences project (No. 12YJC870036).

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