Transmission path optimization Based on Efficiency Communication System

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Abstract. Routing is the core of wireless sensor network deployment. This paper points out the research focus of the wireless sensor network transmission path and discusses the optimization problem of the transmission based on grid model. In this paper, routing attribute table that is maintained by the nodes, the density and relative distance of node distribution, is used to determine the clustering method. At the same time, the developed algorithm combines the relative position of the cluster and the base station to further improve the routing method of the sub-cluster head, Finally, the algorithm analyzes the influence of different parameters on the transmission path, and use the simulation experiments to evaluate the conclusions.

1. Introduction
With the rapid development of computer and communication technology, Wireless Sensor Network (WSN) is receiving unprecedented attention [1]. Composed of several nodes with sensing, computing and communication capabilities, WSN technology has now been widely used in various fields of life such as meteorological monitoring, environmental monitoring, deep-sea navigation and military surveillance [2,3]. Sensors in WSN is used to detect environmental conditions for the development of precise plant monitoring system [4,5]. For specific monitoring and data, dynamic tracking, the working time of WSN must be extended as much as possible to a certain extent. On the other hand, member nodes in WSN are limited in wireless data transmission communication, information analysis and processing, signal transmission bandwidth, battery power supply and storage space, etc. Traditional routing protocols cannot be directly applied to current wireless sensor networks because it is lacking of optimization process. Without optimization, power consumption in wireless sensor networks will increase when number of nodes in the network increases [6]. Hence, a good routing protocol should cover data transmission paths with low energy consumption, good scalability, strong robustness, good fault tolerance, good stability and low latency. Therefore, designing a specific routing protocol with high stability, strong robustness and low energy consumption is of great significance to the further development of WSN [7,8].

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2. The Principle of LEACH Algorithm

WSN works together through nodes to achieve common goals, so an energy-saving mechanism is needed to extend network life. Intelligent agriculture has the characteristics of wide coverage, long planting cycle and energy efficient data transmission. Throughout the years, there are a lot of researchers conducting study to improve energy efficiency of WSN using artificial intelligence such as Genetic Algorithm (GA) [9] and Low Energy Adaptive Clustering Hierarchy protocol. LEACH is a typical adaptive clustering routing protocol, which utilizes single-layer cluster routing [10] centered on data. Cluster head node is randomly selected in a round-robin manner, and evenly distribute the energy load of the entire network to each sensor node, so as to achieve the purpose of reducing energy consumption of the network and improving overall lifetime of the network [11]. Compared to the general planar multi-hop routing protocol and static hierarchical algorithm, LEACH can prolong the network lifecycle by 15% [12].

2.1. Algorithm topology

Fig. 1 shows the topology of the wireless sensor network LEACH algorithm. The nodes of the entire network are divided into three categories, namely cluster head nodes, sink nodes and common nodes. The network consists of multiple sub-regions. The sub-regions independently generate cluster head nodes. Other nodes in the region communicate with the cluster head nodes, and transmit data to the sink nodes through the cluster head nodes [13].

![Figure 1. Topological structure of LEACH algorithm](image)

2.2. Cluster formation process

After the common node is elected as cluster head, it starts to broadcast the message and position coordinates of the cluster head to the surrounding nodes. A node that is not elected as a cluster head receives multiple messages and selects the closest cluster head to join the cluster, and at the same time sends a request to join the cluster head. After the request command is received by the cluster head, a TDMA (time division multiple access) timetable will be established for each node, and the timetable will be transmitted to each member node at the same time. The specific process is shown in Fig. 2.

![Figure 2. Cluster formation process](image)

2.3. Data transmission process

The role of the TDMA [14,15] timetable is to maintain the stability of data during transmission. The transmission of data information mainly relies on internal timeslots. In order to ensure the use time of nodes, nodes in non-timeslots are generally in a dormant state. In order to ensure the accuracy of the received data, the cluster head is always in an active state. After the data is received, data fusion should be carried out, and the redundant part of the data information will be eliminated and sent to the sink node at the same time. The specific workflow is shown in Fig. 3.

The above-mentioned LEACH-based algorithm reduces network energy consumption to varying degrees, but there are still many obvious defects. For example, the distribution of cluster heads in the WSN network has great randomness; each node may or may not become a cluster head, but the process...
of repeating the election in each round will lead to waste of energy. The joining of cluster members only considers the distance between the member node and the cluster head, and does not consider the energy of the cluster head. In the process of electing the cluster head node, there are few constraints, so it is very difficult to select qualified cluster head nodes to complete the information exchange process between networks. In addition, there is only one cluster head in a cluster, and the cluster head needs to consume a large amount of energy because it needs to complete the information processing and routing. All these deficiencies lead to uneven energy consumption of WSN, which greatly affects the normal working time of the network [16,17].

3. Improved LEACH Algorithm

3.1. Description of the improved algorithm
The main research idea of the algorithm in this paper is to study how to share the network energy consumption of WSN cluster heads, distribute the network cluster heads uniformly, optimize the network clustering, balance the global energy consumption, and prolong the effective working time of the system. In order to make up for the defects of the traditional LEACH protocol, such as the uneven
distribution of cluster heads in WSN and the excessively concentrated energy consumption of nodes, this paper adopts an improved LEACH routing algorithm, that is, the LEACH routing algorithm LEACH-C based on the cooperation of primary and secondary cluster heads. Improvements are mainly made in the following aspects:

1) Cluster head selection process: On the basis of LEACH cluster head selection, the sub-cluster head selection is further carried out according to distance and energy factors, that is, the selection of dual cluster heads for the same cluster (separation of collection processing and transmission) is effective. This alleviates the problems of uneven distribution of cluster heads and fast energy consumption in the LEACH algorithm.

2) Cluster creation process: In the traditional LEACH routing algorithm, determination of cluster members is based on the factor of the distance from the "quasi-cluster head" to determine the joining rule, but this is likely to cause uneven distribution of clusters in the entire monitoring area, which in turn leads to collection rules. Information is highly relevant and redundant. In the LEACH-C routing protocol proposed in this paper, the distance between the member nodes and the primary and secondary cluster heads (specifically the virtual coordinates between the primary and secondary cluster heads) is used to select different clusters, which can effectively overcome the excessive concentration of energy consumption. In order to avoid the redundancy of collected information and further reduce the energy consumption of the system, the sleep mechanism within the proximity distance is adopted.

3) Special node processing: The randomness of wireless sensor network node deployment may cause serious uneven distribution of nodes in individual areas. The existence of free nodes means that they do not belong to any cluster within the reference distance. The primary and secondary cooperative transmission or the rules of choosing to join the nearest cluster are used to collect and route information. The detailed flow of LEACH-C is shown in Fig. 4. In wireless sensor networks based on cluster routing, cluster head selection and determination play a crucial role in wireless tradition.

4. Simulation
The simulation is carried out on the MATLAB R2021a platform. This experiment simulates 100 sensor nodes that are placed in an area of 200m × 200m, and the base station is at the far right of the space by default. By adding a variety of control factors, the cluster head election, clustering and data transmission are optimized, and the remaining energy of the node and the number of running rounds are simulated through a variety of algorithms. In this experiment, LEACH algorithm and LEACH-C algorithm are analyzed and compared in terms of the number of nodes surviving and the ratio of remaining energy to improve the superiority of the algorithm. The WSN parameters are set as shown in Table I.

Intra-cluster transmission of nodes in WSN refers to the information exchange between common node members and the cluster head node in a single cluster. Inter-cluster transmission means that after the cluster head node completes the intra-cluster transmission, it finally transmits the data to the base station through multiple hops. Due to the different distances from the base station, the energy consumption is different. Therefore, in order to share the energy consumption pressure of the cluster head for data forwarding, 100 sensor nodes are randomly arranged in a space of 200 m × 200 m, and the nodes are simulated into clusters. The distribution of head nodes is shown in Fig. 5.
Figure 4. Flow of LEACH-C

Table 1. Parameter for WSN Setup

| Parameter name                  | Value     | Parameter |
|---------------------------------|-----------|-----------|
| Number of network nodes         | 100       | N         |
| Node initial energy             | 0.5J      | E0        |
| cluster head probability        | 0.05      | P         |
| Communication radius            | 80M       | R         |
| Data fusion energy              | 50 nJ/bit | EDA       |
| data transmission energy        | 500 nJ/bit| ETX       |
| data receiving energy           | 500 nJ/bit| ERX       |
Firstly, the relationship between the number of surviving nodes and the number of clustering rounds in WSN is analyzed. In order to compare the performance characteristics of the cooperative cluster-head routing algorithm proposed in this chapter, namely LEACH-C protocol, the curve corresponding to the traditional LEACH routing protocol is drawn in Fig. 6. The following conclusions can be drawn from Fig. 6:

1. The proposed LEACH-C cooperative cluster head routing algorithm significantly improves the survival rate of nodes in WSN, that is, under the condition of this parameter setting, the traditional LEACH routing protocol is in the 76th round. Around the time, the WSN system began to appear dead nodes, but the improved algorithm LEACH-C appeared dead nodes in about 451 rounds;

2. Before the number of clustering rounds was 750, the node survival rate of the traditional LEACH routing algorithm was about 50%. That is to say, about half of the nodes in the network cannot work normally, and the improved cooperative cluster head routing protocol LEACH-C routing protocol proposed in this paper has a node survival rate higher than 70%, and the normal working node survival rate in the overall network is increased by an average of 20% above. Based on the above analysis, it can be seen that when the base station is located in the center of the randomly distributed WSN network, the proposed improved algorithm LEACH-C routing protocol can greatly improve the survival rate of WSN network nodes, and effectively prolong the effective working time of the network.

In wireless sensor networks, the energy balance of nodes is an important criterion for judging how long the network maintains network data communication. Usually, after a certain number of rounds of operation, the remaining energy of nodes and the number of surviving nodes in the network can be used as network connectivity. The ratio of the minimum remaining energy and the average remaining energy of the node and the number of surviving nodes in the LEACH algorithm and the LEACH-C algorithm under the condition of a certain number of rounds is compared and shown in Fig. 7.
From the results shown in Fig. 7, it can be seen that the proposed new algorithm LEACH-C is lower than the traditional LEACH routing algorithm in the statistics of network energy consumption. In the set specific simulation environment scenario, the traditional LEACH routing protocol starts to consume energy when the number of rounds is about 300, and the network energy consumption of LEACH-C at this time is still close to 0. Further analysis shows that with the increase of the number of running rounds, the performance advantage of the proposed LEACH-C routing algorithm is more obvious, that is, with the increase of the number of rounds (lasting to about 1000 rounds), the energy consumption of LEACH-C is better than that of the traditional routing algorithm. The LEACH gap is wider, further illustrating the superiority of the algorithm. After 1500 rounds, compared with the LEACH algorithm, the improved LEACH-C algorithm saves about 5J in network energy consumption compared to the traditional LEACH routing algorithm. According to the analysis, the routing algorithm LEACH-C protocol based on cluster head cooperation can effectively balance the load.
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Figure 8. Comparison of Throughput distribution of the cluster head nodes by allocating the load of the cluster head, and further reduce the total energy consumption of the WSN network.

The throughput marks the amount of data that the network successfully transmits over a unit of time. According to literature [18], if throughput is defined as the sum of the packets sent, the throughput changes with the number of wheels during the stable data transfer phase are shown in Fig. 8. The throughput is an important measure of network performance. High throughput means the network can send and receive more packets, and the network performs well.

When the network runs to 1000 rounds, the node in the LEACH algorithm receives a $2.619 \times 10^4$ packet and the node in the LEACH-C algorithm receives a $7.277 \times 10^4$ packet. The longer the death time, the more packets the node transmits, and the greater the throughput. As can be seen from Fig. 8, the LEACH-C algorithm has more throughput than the LEACH algorithm because the cluster head needs to forward packets. The throughput of the improved algorithm has been greatly improved, with the highest throughput due to the extended life cycle. It can be seen that the LEACH-C algorithm effectively increases the number of packets received because it reduces the average energy consumption of the network and increases the average working time of nodes.

5. Conclusions
In the wireless sensor network node communication, balancing the node energy consumption and prolonging the network life cycle is the focus of the current research field. Summarize the shortcomings of the LEACH routing protocol: the energy consumption in the network is unbalanced, the local node load in the network is too large, the data collected in the network has high redundancy and correlation, the cluster head selection method is unreasonable, special nodes not fully considered etc. A LEACH-C optimization algorithm based on cooperative cluster heads is proposed. By setting the cluster head nodes to balance the energy consumption of nodes, considering the energy consumption of rounds while considering the remaining energy, the distance control factor and round energy consumption factor are set, and the data transmission process is added. The path weight factor selects the relay node to construct the optimal transmission path. Simulation experiments prove the superiority of the optimization algorithm. However, the calculation of the round energy consumption factor increases the complexity, and in the process of clustering, some nodes may not belong to any cluster, resulting in a waste of node resources. Optimizing and solving these problems is the next research direction.

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