

Design of Indoor Temperature Monitoring and Energy Saving Control Technology Based on Wireless Sensor

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Abstract—Considering the indoor temperature monitoring and energy saving control technology, based on the traditional low energy adaptive clustering hierarchy (LEACH), a multi-hop clustering routing algorithm is proposed. By adding a threshold in LEACH, the algorithm makes the nodes with high residual energy and high nodes become cluster heads. The results show that the improved algorithm can effectively prolong the life cycle of wireless sensor networks. Based on above findings, it is concluded that the proposed algorithm can save the system energy and improve the network energy efficiency.

Keywords—wireless sensors, temperature parameter monitoring, sink node, cluster head

1 Introduction

Wireless sensor network (WSN) is a new type of network, it came into existence with the development of computer network, sensor technology, microelectronics technology and wireless communication [1]. Wireless sensor networks use various types of sensors to sense the external environment parameters, and convert the physical signals of the objective world into electrical signals, so that the state of the objective physical world can be known. It satisfied subscribers' demands for the network. The wireless sensor network is introduced into the temperature monitoring system, which will shift the monitoring system from a wired network and labor-centric measurement model to an information and software-centric measurement model, so as to realize the automatic deployment, self-organization transmission and intelligent control of the information collection system such as in the greenhouse, the engine room and home environment, and it improves work efficiency and quality of life [2-3].

2 Materials and Methods

Aiming at the shortcoming of LEACH algorithm, this paper proposes a multi-hop clustering routing protocol based on residual energy and node degree.

2.1 Wireless communication model

A threshold d_0 is set in the model. When the distance $d < d_0$ between the sender and the receiver, the energy consumption of the sender is proportional to the square of the distance d . Otherwise, it is proportional to the fourth power of the distance d . These two different energy attenuation models are called the free space model and the multi-path attenuation model. The different energy consumption models are determined according to the distance between the sending node and the receiving node. The energy consumed by a node to send k bits of data to a distance d is:

$$E_{Tx} = \begin{cases} kE_{elec} + k\epsilon_{fs}d^2 & d < d_0 \\ kE_{elec} + k\epsilon_{amp}d^4 & d \geq d_0 \end{cases} \quad (1)$$

Among them, ϵ_{fs} , ϵ_{amp} are the energy required for power amplification in these two models, and the threshold d_0 is defined as follows:

$$d_0 = \sqrt{\epsilon_{fs} / \epsilon_{amp}} \quad (2)$$

The energy consumed by the node to accept k bits of data is:

$$E_{Rx} = kE_{elec} \quad (3)$$

In wireless sensor networks, the computing power consumption of nodes is far less than the energy consumption of communication. For example, in the case of a quadratic multipath fading model, the energy consumed to transmit 1 KB of data at 100 M distances is roughly equivalent to 3 million instructions executing on a 100 MIPS processor. Therefore, only the communication energy consumption of nodes is considered in this paper.

2.2 Network model

In this paper, N wireless sensor nodes are randomly distributed in the region, and the network model has the following properties [7]:

After the sensor nodes are arranged, they are fixed there and have their own unique node numbers.

The convergence nodes are arranged in a fixed position outside the region, and the energy is not exhausted and unique.

All the nodes in wireless sensor networks are isomorphic, and the node energy is limited.

2.3 Improved clustering algorithm

As with LEACH, the execution of the BRENDA algorithm is periodic. Each round can be divided into three stages: cluster selection, cluster formation, and data transmission stabilization [8].

Improved cluster head election:

In the cluster head election, the residual energy of every node and the number of nodes (the number of neighbors of the node) can be used as the basis for selecting the cluster head, which makes the cluster head load balance and the energy consumption of the whole network equalization. The greater the residual energy, the greater the probability that the node with larger node degree becomes the cluster head.

The new cluster-head election algorithm takes into account the conditions of the elected nodes, and introduces the energy regulation parameters and density adjustment parameters. Through the energy adjustment parameter, it can make the nodes with larger residual energy and smaller average energy consumption per round has more opportunities to become cluster heads. Through the density adjustment parameter, it can make the nodes located in the dense distribution area of nodes have more chance to become cluster heads.

Therefore, equation (1) of LEACH algorithm can be improved as shown in equation (5):

$$T(n) = \begin{cases} \left[\frac{p}{1 - p \left(r \bmod \frac{1}{p} \right)} \right] \left[a \times \frac{E_{\text{current}}}{E_{\text{average}}} + (1 - a) \times \frac{N(n)}{\pi R_0^2} \right] & n \in G \\ 0 & \text{otherwise} \end{cases} \quad (4)$$

In the equation, E_{current} is the residual energy of the current node; E_{average} is the average energy of all surviving nodes in this round; $T(n)$ is the total number of neighbor nodes of node n ; R_0 is the basic communication radius; a is the adjustment factor of energy and node degree.

The flow chart of cluster formation:

The cluster formation process is shown in Figure (1).

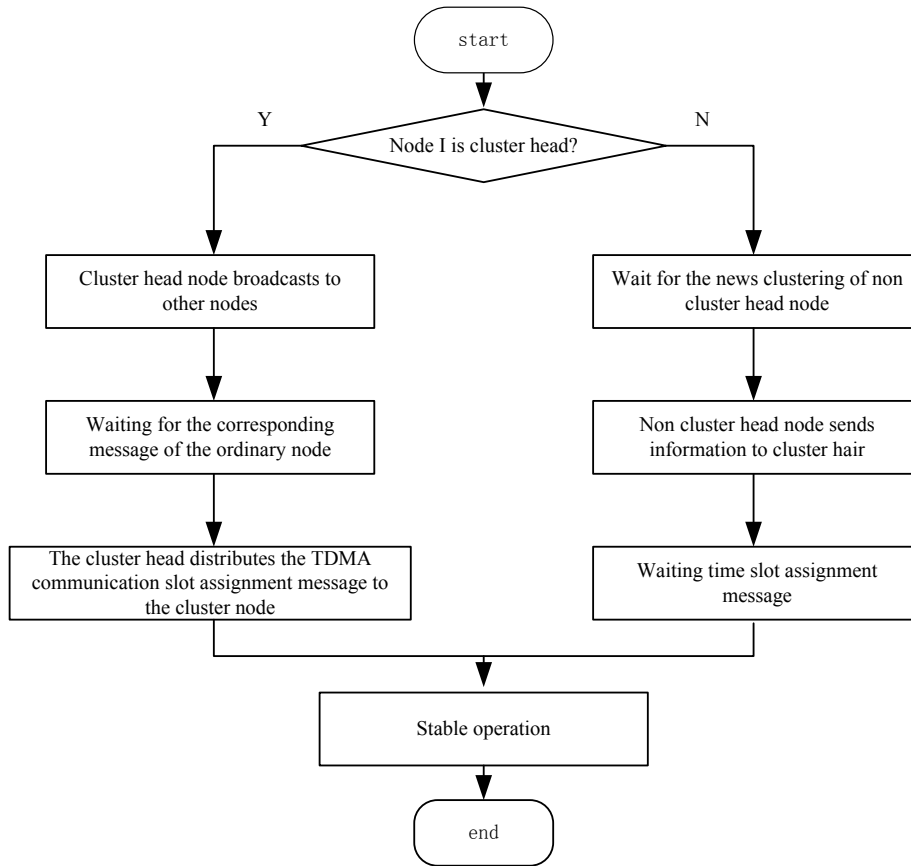


Fig. 1. Flow chart of cluster formation

After initialization, if the node is a cluster head, it broadcasts the selected message to other nodes within its communication radius. If it is not a cluster head, it receives the message sent by the cluster head, and chooses the strongest cluster according to the strength of the received signal and reports it to the cluster head.

Improved communication between cluster heads and sink nodes:

Aiming at the defect of LEACH algorithm, we can use multi-hop communication between clusters, here consider using Floyd algorithm. Floyd algorithm is a typical dynamic programming algorithm for finding the shortest path between vertices in a given weighted graph, where the path length is the sum of the weights carried by the edges on the path. The basic idea is as follows: The shortest path from any node A (cluster head or sink node) to any node B (cluster head or sink node) is no more than two possibilities, the first is directly from A to B, the second is from the A through a number of nodes X (cluster head) to B. Therefore, suppose that $Dis(AB)$ is the shortest path distance from node A to node B, for each node X, check whether $Dis(AX) + Dis(XB) < Dis(AB)$ is set up. If it is proved that the path from A to

X to B is shorter than the path from A to B, then set $Dis(AB) = Dis(AX) + Dis(XB)$. As a result, when traversing all nodes X, the shortest path distance from A to B is recorded in Dis (AB).

We can apply this idea to the communication between cluster heads and sink nodes. In the mesh network of cluster heads and sink nodes, the cluster heads and sink nodes can communicate with each other in their communication range. Therefore, we can regard the network as a graph, and consider all the cluster heads and sink nodes as a set of points in a directed graph. Each edge weights can be determined by the energy consumption of the starting node to the end node data transmission, if there is no edge connection between the two points, the weight is infinite, so as to find the shortest path from the cluster head transmitted to the sink node, reduce energy consumption, and prolong the life cycle of the project.

3 Results

3.1 Simulation parameters

In this paper, the BRENDA algorithm and LEACH algorithm are simulated and compared by MATLAB. The experimental parameters are shown in Table 1, and the simulation results are shown in Figure 2~4:

Table 1. Simulation parameter settings

Parameter name	Value
The total number of nodes	500
Network monitoring area	200m*200m
Sink node location	[100,300]
Sensing radius R_0	15m
The initial energy of the node	0.2J
E_{elec}	$50/nJ(bit)^{-1}$
ϵ_{fs}	$10pJ/bit/m^4$
E_{amp}	$0.0013nJ/bit/m^2$

3.2 Simulation results

Determination of regulatory factor. As shown in Figure (2), when the value of the adjustment factor a is different, it affects the life cycle. When a = 0.6, the best result is obtained.

System life comparison. The number of surviving nodes in BRENDA and LEACH is compared with that of the network lifetime as shown in Figure 3.

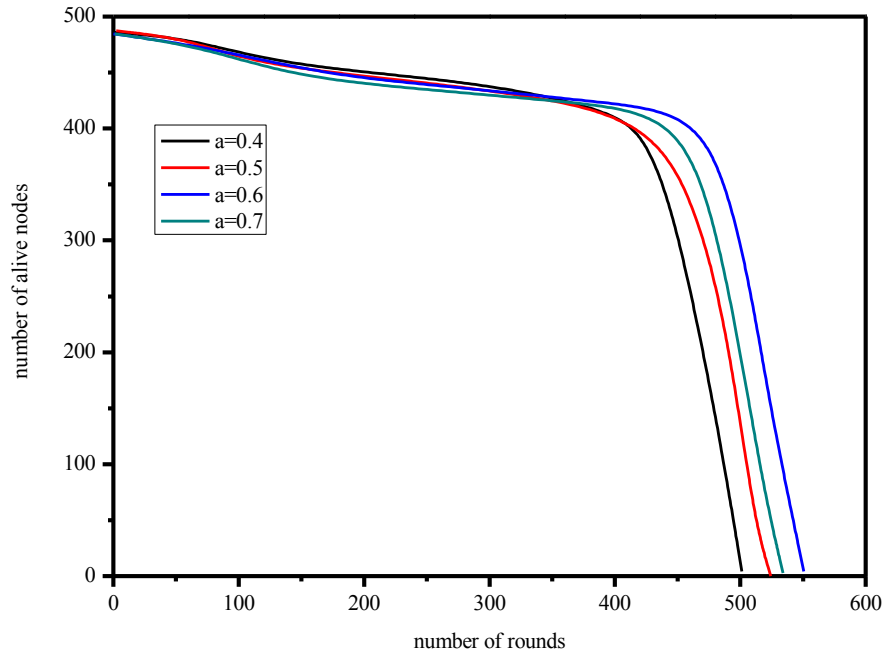


Fig. 2. Statistics of survival nodes when a takes different values

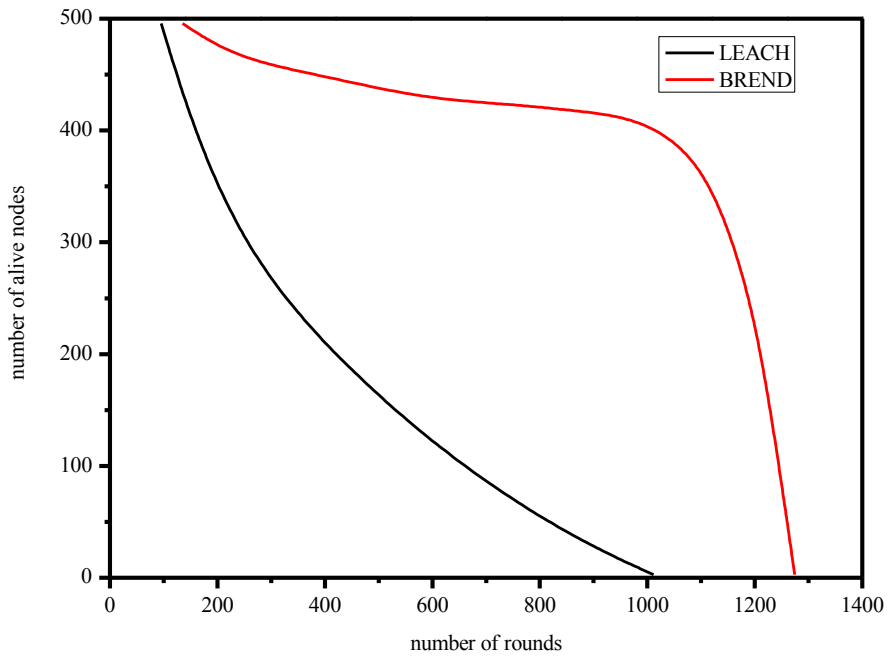


Fig. 3. System life comparison (survival node)

From the Figure 3, it can be clearly seen that with the increase of the number of rounds, when the improved algorithm BREND is increased to 1100 rounds, the 500 sensor nodes also survived by 420, but the nodes of LEACH have all died. We can also say that BREND in the 80% node death by LEACH than the number of rounds is increased by 90.35%, that is, it extends the system life cycle. This is because in the distribution of nodes in a wider environment, the communication distance between LEACH cluster heads and convergence points is increased. LEACH is a single hop, cluster head of the first round of communication energy loss is increased. In this paper, the communication between the cluster head and the sink node is a multi-hop forwarding to find the nearest path. Therefore, the energy loss of a single cluster head will not increase significantly with the increase of the area.

Comparison of total energy consumption. The total energy consumption of BREND and LEACH algorithm is shown in Figure 4.

The improved algorithm has lower energy consumption than LEACH at any time, which shows the energy saving advantage. This is because the improved protocol adopts a more reasonable mechanism of cluster head election and inter-cluster communication, thus effectively reducing the overall consumption of the network.

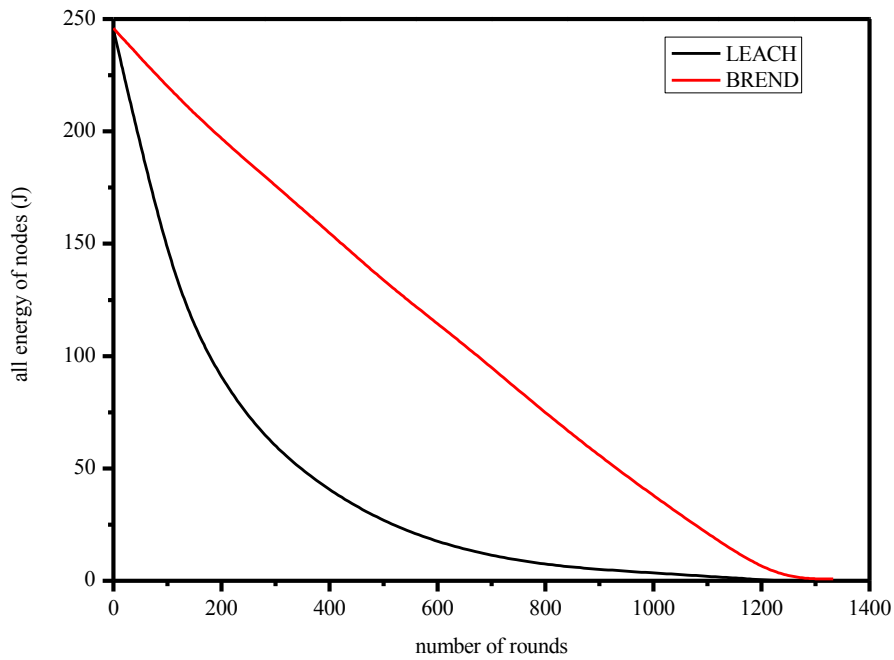


Fig. 4. Energy consumption statistics

4 Conclusions

Through the analysis of the wireless sensor network communication protocol, the routing protocol in the communication protocol is studied to improve the shortcoming of the existing LEACH algorithm. The simulation results show that the BREND in the 80% node death by LEACH than the number of rounds is increased by 90.35%. Thus, it is concluded that the improved BREND algorithm can effectively prolong the life cycle of wireless sensor networks, and can complete the monitoring tasks better.

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