Energy-Balanced Routing Algorithm For Wireless Sensor Networks

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***Abstract*—In wireless sensor networks, the wireless sensor networks node's energy is limited, so how to make the node's energy used with high effective has become the research focus of the routing algorithm. The paper proposes LEACH-EB algorithm that is belongs to clustering algorithm. In the selecting cluster head process that not only takes node's residual energy into considers but also node's neighbor degree, improves the probability that the center area node's becomes cluster head than boundary region, then to solve the total energy waste in the networks, and prolongs the lifetime of networks. Simulation experiments show that, compared with LEACH and LEACH-B, the proposed algorithm can effectively balance the network and prolong the lifetime of the networks.**

Keywords-Wireless Sensor Network; network lifetime; LEACH; node's degree; multi-hop

I. INTRODUCTION

The energy of Wireless Sensor Network's node is limited, so we cannot replenish their energy after deployment, and their own processing power is low. Therefore, how to efficiently use the energy of the sensor nodes and extend the network life cycle has become an important issues of wireless sensor network's design [1-2]. LEACH protocol [3] proposed by Heinzelman is a kind of classic distributed low-power adaptive hierarchical routing protocol's design for early wireless sensor networks. The protocol defines a concept of the round. Each round includes initialization and stability. Election cluster head randomly avoid excessive consumption of the cluster head in LEACH protocol, and data fusion reduce communication traffic. LEACH protocol assumes that all sensor nodes can communicate directly with the sink node, and this does not apply to detect wide range region of the application. Single hop communication routing algorithm is simple, but caused large energy overhead of node far from the sink node. LEACH-B [4] is the improved LEACH algorithm, clusters threshold T(n) considering the energy factor and cluster head number of factors, and improved LEACH protocol the total number of cluster selected from head randomly is uneven, but the algorithm is still cluster head far from the sink node energy fast failure..

In this paper, energy-balanced routing algorithm (LEACH-EB) in the cluster head election process, the residual energy of the reference node and node neighbors are considered, and as a reference standard of the cluster head election. Base station chooses the cluster. Data transmission use single hop communication model, and communication between the cluster head and the base station use single-hop mode.

II. NETWORK MODEL

The wireless sensor network model has the following basic properties:

1) The base station node is away from deployment area, and in static state.
2) Deployment of all nodes in the network, and all in static state.
3) The energy of the base station is not restricted, the initial energy of nodes in the network are equal.
4) The transmission power of the node is adjusted according to the distances of the receiving node.
5) Communication link in the network is symmetrical.
6) The data within the cluster have similarities and the cluster head have the function of data fusion within the cluster.
7) inter-cluster data is dissimilar, and cannot be fused.

III. RADIO COMMUNICATION MODEL

Wireless sensor network energy consumption is mainly from the radio transmission and the internal circuit. According to the literature [5], the sensor through the radio sending k bit energy consumption can be calculated according to (1).

$$E_{Tx}(\mathrm{k},\mathrm{d}) = \begin{cases} k*E_{elec} + \mathrm{k}*\varepsilon_{fs}*d^2, & d < d_0 \\ k*E_{elec} + k*\varepsilon_{mp}*d^4, & d \geq d_0 \end{cases} \quad (1)$$

Sensor receiving k bit data via radio can be calculated according to (2)

$$E_{Rx} = \mathrm{k}*E_{elec} \quad (2)$$

Wherein, E_{Tx} = the energy consumption of the node sending K bit data to distance d, E_{Rx} = the energy consumption of the node receiving K bit data. Usually, the magnification power of the amplifier is only limited to zoom into two models: free space model and multi-path fading

model. According to the distance d_0, these two models are distinguished. The energy consumption of the amplifier and the distance's quadratic is direct ratio in free space model, and distance to the fourth power is direct ratio in multi-path fading model. Distance threshold value $d_0 = \sqrt{\frac{\varepsilon_{fs}}{\varepsilon_{mp}}}$, ε_{fs} = the attenuation factor of the amplifier provided by free space model, ε_{mp} = the attenuation factor of the multi-path fading model.

IV. ENERGY-BALANCED ROUTING ALGORITHM (LEACH-EB)

The total number of cluster head in each round of network process in LEACH protocol cannot be guaranteed in a stable value. Especially when the network has the death node, fluctuations in the total number of cluster head is large, seriously affect network performance. LEACH-B has been optimized in terms of the total number of cluster head, and makes the total number of each round of cluster head stabilized. However, data transmission to the base station in the cluster head is transmitted directly, and energy consumption for cluster head away from the base station is larger. For lack of LEACH and LEACH-B protocol, in this paper, we present energy-balanced routing protocol LEACH-EB based on multi-hop. We draw on the experience of Leach-B protocol considering the remaining energy of the nodes in the cluster head election, in addition, considering the neighbors of the node, the node in the cluster head election weight residual energy, and neighbors. After the election of the cluster head, cluster members start to collect data and sent it to the cluster head, the cluster head collect data from intra-cluster directly transmit to the base station.

A. Cluster Head Election

Nodes in the wireless sensor networks are generally provided by a portable battery, and battery power is limited. Considering the remaining energy of the nodes in the cluster head election process, we can avoid nodes with low residual energy elect cluster head, and saving low energy nodes' energy. This is one difference of LEACH-B from LEACH in cluster head election. In this paper, we consider the residual energy, at the same time; introduce the neighbors of the node as the cluster head election reference to one of the factors. Suppose node uniform deployments in the area of $M*M$, which contain K clusters head and uniform clustering. In terms of the size of the cluster size is equivalent to node neighbor radius of the radius of the circle, then, for each cluster head, the average radius of the degree of its neighbor is $R = \frac{M}{\sqrt{\pi * K}}$, shown in Fig. 1.

Can be seen in Fig. 1, in the neighbor radius R of the range, the node $S(1)$ has two neighbor nodes, node 3 and node 4, the node $S(2)$ has four neighbor nodes of node 5, node 6, node 7, and node 8. We define node neighbor: a node in its neighbor radius contain the number of other nodes in the case of determined the radius of the neighbor. In Fig. 1, the neighbor degree of the node $S(2)$'s is 4, the neighbor

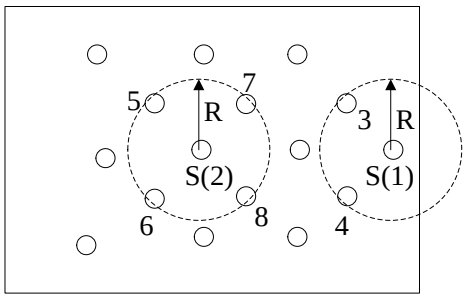

Figure 1. Compute node's neighbor nodes

degree of node $S(1)$'s is 2, node $S(2)$'s neighbor degree is higher than the neighbor degree of $S(1)$'s. With respect to $S(2)$, $S(1)$ is in the network node deployment location of the boundaries of the region and its neighbors within a radius include a detection area network. In order to reduce the probability of cluster head in boundary, the degree of the node neighbor method can be used in the case of the node not equipped with the GPS device within the deployment area of the network node. Each node neighbor radius as the radius of the broadcast messages, and the node receiving the information calculate cumulatively its neighbor degree, and then the neighbor value is sent to the base station. The base station are calculate after statistics of all the nodes from each node of the network neighbors average neighbor, then the average value of neighbor degrees is sent. After receiving the message, all nodes in the network compare the value of the own neighbors with their values. If their values are less than this value, nodes are boundary nodes.

TABLE I. THE PARAMETER OF EXPERIMENT

Parameters / attributes	***Value***
Deployment area	100 m*100 m
The number of nodes	100
Base station location	(50,175)
Cluster head probability (P)	0.05
Neighbor radius (Rs)	26m
Cluster head scale factor (a)	0.7

B. Algorithm Description

(1) // Node neighbor calculation
(2) Void COMPETE_NEIGHBOR()
(3) {
(4) For i = 1:N
(5) For j = 1:N
(6) If (i~=j && S(i) receive COMPETE_NEIGHBOR_NUM message from S(j))
(7) // If the node S(i) receives the node S(j) computation neighbor information
(8) S(i).Neighbor = S(i).Neighbor + 1; // Neighbor degree of node S(i) plus 1
(9) End
(10) End
(11) }
(1) // Node becoming a cluster head weight calculation
(2) Void compute_Cluster_val(int id)
(3) {
(4) If S(id).Eres <= 0
(5) S(id).pcluster = 0; // The esidual energy of the node is less than or equal to 0
(6) Else
(7) S(id).pcluster = a* $\frac{E_{res}}{E_{init}}$ + (1-a)* $\frac{S(\text{id}).\text{Neighbor}}{n}$; // The residual energy of the node is greater than 0
(8) End
(9) }

V. SIMULATION OF RESULTS AND ANALYSIS

A. Simulation Parameter Settings

Experimental simulation use MATLAB 7.0 software as an experimental simulation software in this paper, and the result compared with LEACH and LEACH-B algorithm. Parameters used in the course of the experiment are shown in Table 1.

Other parameters used in the course of the experiment and the corresponding data according to the literature [3]

B. Analysis Of Simulation Results

The core of this paper is a clustering algorithm, the introduction of the election of the cluster head neighbor degree is one of reference factors. To reduce the boundary region node cluster head probability can reduce the total energy consumption of the network, thus saving the total energy of the network in the cluster. Make ensure that the network each round of the total number of cluster head node is identical. Being cluster head or not is decided by the base station. Take any operation of the network 15, shown in Fig.2.

Can be seen in Fig. 2, the LEACH algorithm does not guarantee a constant number of the total cluster head in each round of network, but LEACH-B and LEACH-EB can guarantee in each round the total number of cluster head to maintain a constant value to avoid network number of cluster heads instability caused by the uneven distribution of the network node energy consumption.

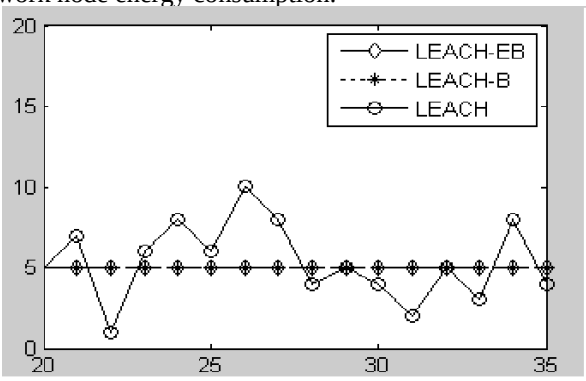

Figure 2. The number of cluster heads in network

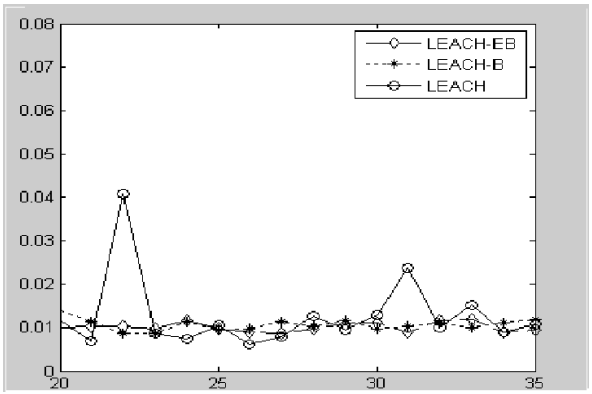

Figure 3. The average energy consumption of the cluster head

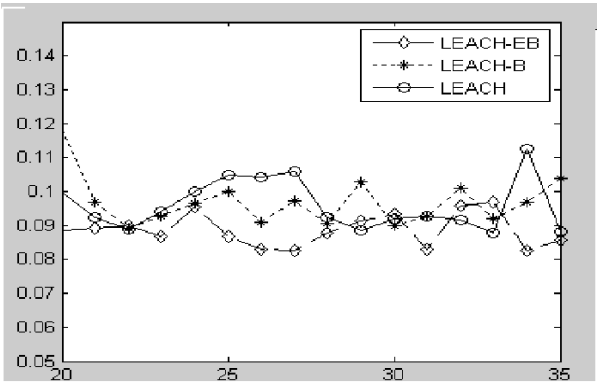

Figure 4. The total energy consumption of the network nodes

The simulation result of the energy consumption of the cluster head and the total energy consumption of network nodes in the network shown in Fig. 3 and Fig. 4.

From Fig. 3, it can be seen that the LEACH algorithm cluster head average energy is not balanced, 2 rounds of energy consumption is relatively large in rounds of 20-35.

Corresponding to Fig. 1, it can be seen that the total number of network cluster head is smaller at the time, while the average energy consumption of cluster head is large. Seen from Fig. 4, the algorithm leach-EB proposed in this paper compared with LEACH and LEACH-B, the total energy consumption of the network nodes is small, due to introduction of the neighbors degree of the node in the cluster head election. The node near the center becoming a cluster head probability is greater than the node in the boundary area of the region, thus saving network running total energy network. Running life of network is shown in Fig. 5.

In Fig. 5, the network using LEACH algorithm appear the first death node is in round 403, the Leach-B algorithm appear the first death node is in round 454, LEACH-EB algorithm proposed in this paper appear the first death node is in round 495. Based on first node of death in network as the lifetime of the network indicator, LEACH-EB algorithm of network lifetime is longer than LEACH algorithm by 22% and the lifetime of LEACH-B by 10%.

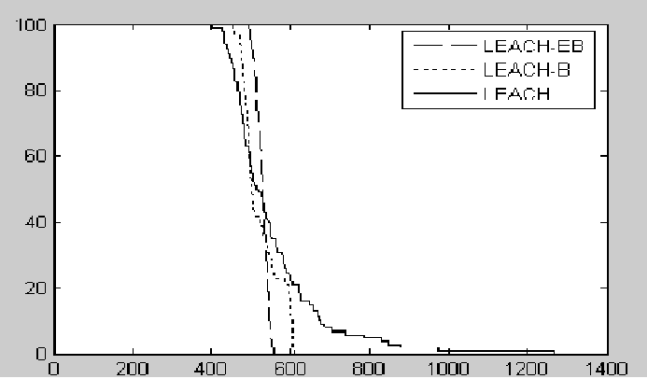

Figure5. The lifetime of network.

VI. CONCLUSION

In LEACH algorithm, the total number of cluster head is not balanced in the network, and cluster head election do not take into account the residual energy, as well as LEACH-B algorithm in the process of cluster head election possible of boundary region node cluster head becoming a cluster head. A new energy-balanced routing protocol (LEACH-EB)is on the base of analysis and research of the algorithm. Processing of cluster head selection, we consider the residual energy of nodes and node neighbors degree to improve the residual energy and central regional location of the node becoming a cluster head probability, thus extending the time of occurrence of the first death node in the network, saving the total energy of each round. Simulation results show that compared with LEACH and LEACH-B algorithm, LEACH-EB effect balance the total network energy consumption and prolong the lifetime of the network.

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