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Cluster-head Election Algorithm for Wireless Sensor Networks based on LEACH Protocol

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Abstract. Nowadays, extending the service life of the WSN and reducing energy consumption are very important in the research of sensor networks. This paper proposes LEACH-ICE (LEACH Inner Cluster Election) algorithm based on LEACH algorithm. By adjusting the threshold function of the node selected to be cluster head and communicating with base station when node is closer to the base station, LEACH-ICE elects new cluster head inside the cluster when the resident energy of the former cluster head is lower than standard in order to improve the clustering mechanism. Simulation results show that the algorithm achieves saving energy and extending the service life of the WSN.

Introduction

Wireless sensor network (WSN) becomes more and more popular in the research of many fields [1]. WSN has many characteristics. For example, a large number of nodes are distributed, the energy of every node cannot be supplymentary, all the nodes are stationary and the distance to base station is fixed compared with the traditional network [2,3]. As so many routing protocol which affect energy consumption and node survival of the network has been put forward, we can divide them into planar routing protocol and cluster routing protocol [4,5]. However, people often use cluster routing protocol to manage the network communication because of its efficient and low consumption of energy [6]. So, this paper chose LEACH algorithm which is the typical protocol of cluster routing protocol to share something new.

The nature of LEACH algorithm is that all the nodes are divided into cluster head and common node to complete network communication using cluster [7]. The number and distribution of cluster heads have great drawbacks [8,9] which lead some cluster heads to premature death because of the random number when selecting the cluster head, although the LEACH algorithm achieves to use the energy effectively and prolong the time of network communication in some extent[10]. Besides, it also wastes some energy when common nodes choose to join in the cluster because the algorithm only chooses the nearest cluster head simply. What's more, the clustering time is too long because the whole network will regenerate the cluster once a cluster head dies. Thus, this paper put forwards LEACH-ICE (LEACH Inner Cluster Election) to solve these problems.

New cluster mechanism

Threshold of cluster head election. From the previous work, we know that the resident energy and the distance to the base station of node are very important factors in clustering. However, simulation results show that the more energy the node has, the longer the network alive. Thus, we choose the equation as given below [11].

$$T_{(n)} = \frac{p}{1 - p\left[\mathrm{r} \bmod (1/\mathrm{p})\right]} * \frac{E_{n\_resident}}{E_{n\_initial}}, \quad n \in G \tag{1}$$

where $E_{n\_resident}$ and $E_{n\_initial}$ are the resident energy and initial energy of node. In this way, cluster head election becomes much more reasonable. The cluster structure of whole network has better robustness because the algorithm increases the possibility of choosing node with high resident energy to be cluster head.

Cluster structure generation. Every common node chooses the nearest cluster head as LEACH algorithm regulates will lengthen communication distance and increase the energy consumption if the node is just closer to the base station. So, we can compare the distance to base station of node when we have judged which cluster head is closer. Once we find the best choice, we choose it to be the cluster head to join in the structure. The core pseudo code of this section is given below.

```
if(node .alive && node .is not cluster)
{
    for(all the cluster head)
    {
        direct= length .node to cluster;
        if(direct<min_distance) {min_distance=direct;}
    }
    if(min_distance >length .node to base station)
    {
      min_distance = length .node to base station;
      choose base station;
    }
    else {choose cluster head;}
}
```

Stable communication stage. To comprehensively consider the resident energy of node and time complexity of algorithm, LEACH-ICE protocol specifies that some cluster head should choose the nearest node insider the cluster to be the new cluster head when the resident energy of itself is lower than ∂E_{send} [12] which means this cluster head cannot send messages more than ∂ times. In this case, other cluster structure will continue to communicate and the structure of the whole network will not change until all the cluster members of some cluster structure are dead. If so, the network will restart to select cluster heads following the new cluster mechanism. The core pseudo code of this section is given as below.

```
if(node.resident_energy>=∂ E_send ){…}// continue to communicate
else if(node.resident_energy >= E_send && node.resident_energy <=∂ E_send )
{
    for(all the cluster member){ select the closest node[k] to luster-head;}
    for(all the cluster head){ change the number of cluster to the node[k];}
    node[k] becomes cluster head;
    for(all the cluster member){ chooses node[k] to join in the cluster;}
}
else { the node is dead};
```

The value of ∂ is very important in the algorithm because it decides when to hold a new cluster head election inside the cluster. If the ∂ is too small, the low resident energy of the former cluster head will let it die no longer when it becomes common node. But if ∂ is too big, the whole time of cluster head election will be to long and the algorithm is inefficient because this cluster will select their new cluster head frequently. Many simulation results show that this section play a great contribution in the whole algorithm because it improves the communication efficiency of WSN and prolongs the life span of the network.

Results and discussions

We generate 100 nodes randomly in the area of (100,100) and initialize the initial energy of every node is 2J and the node is dead when the resident energy is lower than 0.02J and the probability of becoming cluster head is 5% and the coordinate of base station is (50,175).

Simulation results show that the communication rounds along with the increase of ∂ trend to be a parabola function. Besides, the network has the longest time when the value of ∂ is 31.5. Thus, we regulate to select a new cluster head insider the cluster when the resident energy of the former cluster head is lower than 31.5* E_{send} in the following experiments.

The average energy consumption of node. In this section, we extract 11 rounds randomly to compare the average energy consumption of all the nodes in the network after two algorithms running as shown in Fig. 1. We can see that LEACH-ICE protocol saves about 20% energy more than LEACH protocol can. The reason is that we choose the node with high resident energy to be the cluster head and contribute to decreasing the energy consumption of whole cluster structure in the stage of cluster generation.

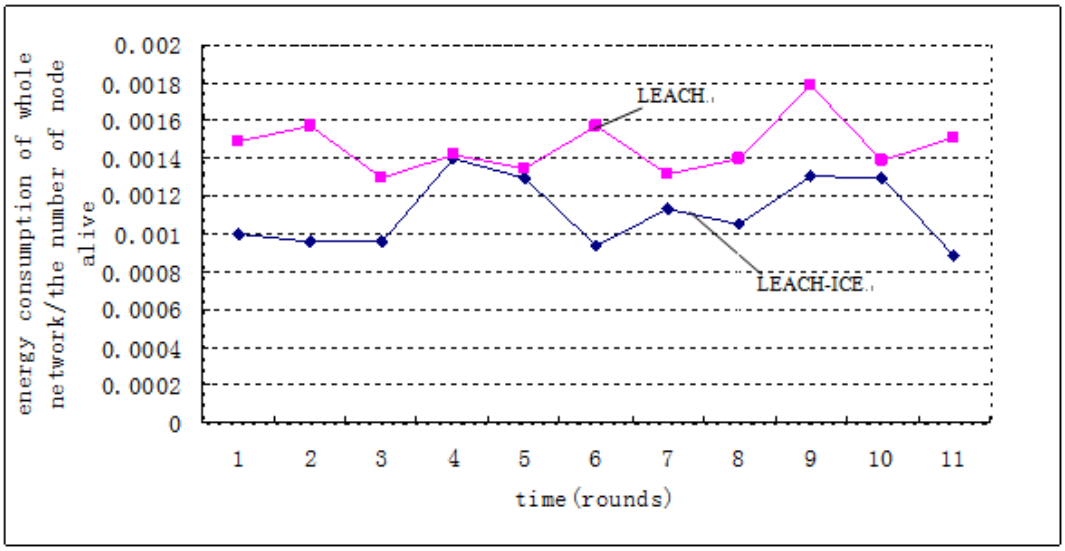

Fig. 1 Energy consumption

The life of nodes and network. We use the standards FND (First Node Dies) and HNA (Half Node Alive) and LND (Last Node Die) to measure the life of nodes and network [12]. Compared the number of nodes alive by statisticing all rounds as shown in Fig. 2. We can see that LEACH-ICE protocol can run 2191 rounds when LEACH protocol only can run 1877 rounds. That is due to the energy saved by inside cluster election. By the way, we record the time of FND and HNA and LND as shown in Fig. 3. Three parts of the life of nodes improved about 35%, 40% and 17% respectively.

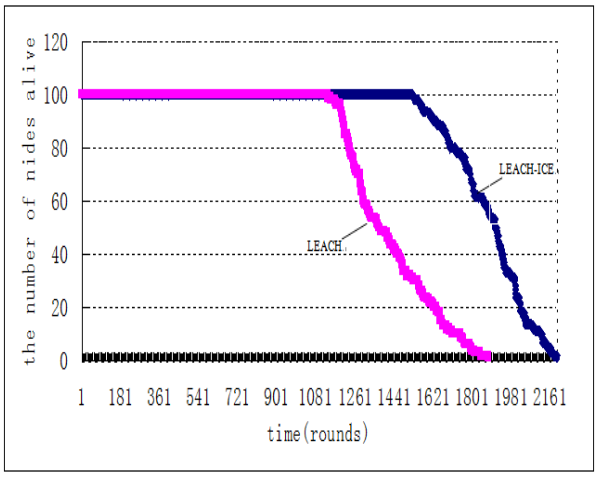

Fig. 2 The number of nodes alive in the same time

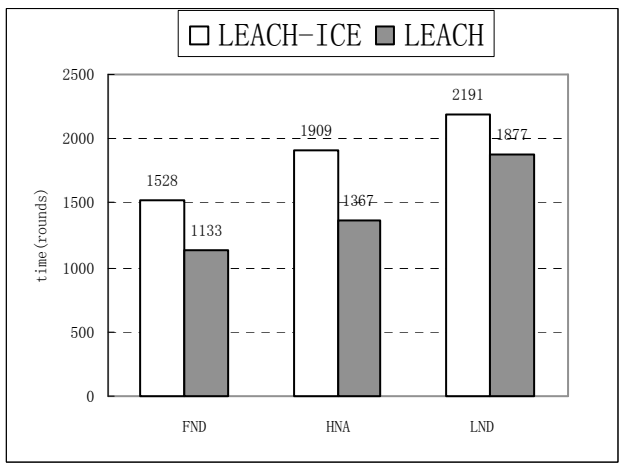

Fig. 3 FND, HNA, LND

Conclusions

In this paper, we proposed the LEACH-ICE algorithm which is used in wireless sensor network to improve the cluster head election process. Based on LEACH algorithm, by adjusting the threshold function of the node selected to be cluster head and communicating with base station when node is closer to the base station, LEACH-ICE elects new cluster head insider the cluster when the resident energy of the former cluster head is lower than standard in order to improve the clustering mechanism. Results show that LEACH-ICE protocol can decrease the average energy consumption and increase the time of stable communication and the life of network effectively.

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