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An Improved LEACH Route Protocol based on SAX in WSN

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ABSTRACT

Recently, energy saving has become a hot issue in application of WSN. To solve this problem effectively, this paper proposes an improved LEACH route protocol based on Symbolic Aggregate Approximation (SAX). We firstly improve the selection method of cluster heads (CH) in LEACH so that the distribution of CH is more reasonable and the energy consumption is more balanced. Then we compress the sent data by using SAX in the stage of transmitting data so that the energy saving is reduced more. The simulation results show that, compared with other existing fusion algorithm, the proposed scheme saves energy effectively while ensuring the accuracy of reconstruction.

Keywords: WSN, Energy saving, LEACH, SAX.

INTRODUCTION

Wireless Sensor Network (WSN) consists of a large number of cheap, tiny, battery powered sensor nodes equipped with limited on-board processing, storage and radio capabilities. However, as the power of nodes is limited and the major power is used by wireless communication, saving energy has become a hot issue in the WSN.

SAX has been used to prolong the lifetime of WSN because the calculation of CS is simple and it can reduce the amount of data effectively [1]. However, it is unpractical that almost of data fusion methods in WSN assume that nodes directly send compressed data to base station [2,3]. As a routing protocol, LEACH which aims at balancing the network energy has been widely adopted in WSN [4,5]. Therefore, we propose an improved LEACH route treaty based on SAX to better prolong the lifetime of WSN. The Final experiment simulations show that our algorithm can save energy effectively while ensuring the precision of data reconstruction.

Our algorithm

To save energy effectively of WSN, we propose an improved LEACH route treaty combined with SAX. We firstly use an improved LEACH route to reasonably select the cluster-heads (CH) so that the energy consumption can be more balanced. Then all the compressed data is sent to base station by CH after every node compresses data with SAX algorithm. Finally, the original data is reconstructed in the base station.

Suppose that the number of sensors in a WSN is *n* and every sensor can communicate with its neighbor nodes. In addition, every sensor has a ROM to storage data, and we use the sliding window to implement the update of data. Now, we will introduce our algorithm in detail.

The stage of selecting CH. It is known that the randomly selection of CH is very important. The original solution of selecting CH is that every node selects a random number between 0 and 1, and the random number is compared with the threshold to determine whether the node will be selected as the cluster head. The threshold is defined as:

$$T(n)=\begin{cases}\dfrac{P}{1-P*(r \bmod \frac{1}{P})} & if\ n\in G \\ 0 & otherwise\end{cases} \quad (1)$$

Where P is the desired percentage of cluster heads (e.g. =0.05), *or* is the current round, and G is the set of nodes that have not been selected as the cluster heads in the last *1/P* rounds. After finishing the selection of CH, every node which is not selected as the cluster head should join the cluster where the distance between this node and the cluster head is minimal.

Related experiments have shown the original LEACH protocol can save the energy effectively, but there are still some problems. To better prolong the lifetime of network, we propose an improved selection algorithm of CH. The improved threshold is defined as:

$$T(n)=\begin{cases}\dfrac{P}{1-P*(r \bmod \frac{1}{P})}\cdot\dfrac{E_{re}}{E_{in}}\cdot\dfrac{D}{D_{\max}} & if\ n\in G \\ 0 & otherwise\end{cases} \quad (2)$$

Where E_{re} is the node residual energy, E_{in} is the node initial energy. D is the density of the current node, and the density is defined as the number of nodes located in the standard communication radius R of current node. D_{max} is the max node density in the entire network. As shown in the formula 2, the greater possibility of being selected as a cluster head the current node has, the bigger the density is. In addition, the more rest energy the node has, the greater possibility of being selected as the cluster head the node has. Therefore, our algorithm can better balance the network energy than the original LEACH. R can be calculated by:

$$R=\sqrt{\frac{S}{\pi\cdot N\cdot P}} \quad (3)$$

Where S is the area of this region where the current node is located, N is the number of nodes in this region.

After finishing the selection of CH with our algorithm, every node will be assigned to different clusters with the same way in original LEACH.

The stage of data transmission in improved LEACH protocol. Most of the existing algorithms about LEACH only consider prolonging the lifetime of network by improving the LEACH protocol itself. To better save the energy, we consider using data fusion algorithm to reduce the send data in the second stage of LEACH.

SAX which realizes the compression of data by using a symbol to approximatively replace a data sequence has been used in WSN, because it is a relatively computationally lightweight approach and has desirable properties such as dimensionality and tuberosity reduction. Therefore, we also propose SAX to compress the original data in this paper. Need to be paid attention, the data in current sliding window of every node will be compressed by SAX, and the detailed calculation process of SAX can be found in this paper [6]. The detailed steps of compressing data are shown below:

1. After clustering all nodes in last step, we will use SAX to compress data in every node. *Xi* represents the original data in the current sliding windows of the i^{tch} node, the compressed data *Yi* can be described as:

$$Y_i = SAX(X_i) \quad (4)$$

2. The base station adopts the mechanism in original LEACH to collect compressed data.

The phase of reconstructing original data. Once the base station accepts the data from one cluster, the original data of nodes in this cluster will be reconstructed. The detail process of reconstruction in our paper is the same with the process in the paper [1]. Therefore, we will not introduce this process in detail.

EXPERIMENTAL SECTION

Our simulation is conducted in OMNeT++4.1. We assume that one hundred sensor nodes with initial energy = 0.5J are arranged randomly in the field of 100m×100m square meters, and the base station is located at the coordinates (0,0). All nodes are no longer mobile as long as they are placed. In addition, the length of sliding window is defined as 20.

In order to analysis the effectiveness of our algorithm, we use the energy consumption model proposed in papers [4, 5]. In addition, we use the classical sensor data of the temperature diffusion from fire sources in our experiment [7].

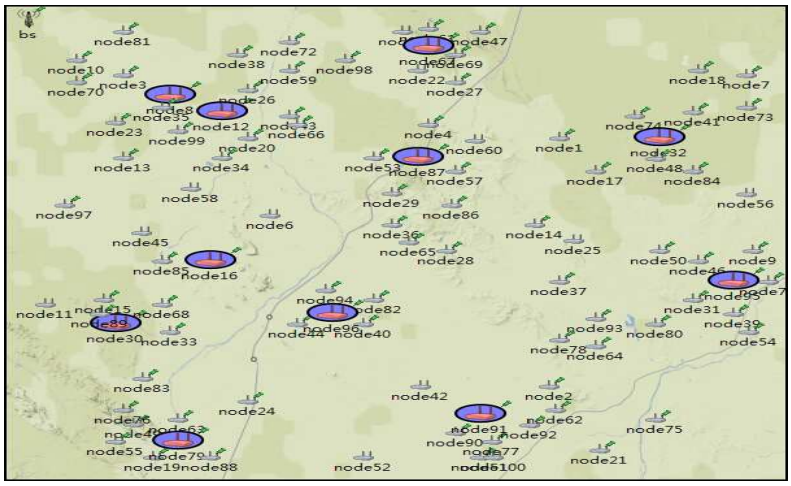

Fig.1 The distribution of CH

The distribution of CH in one round with our algorithm is shown in Fig.1 where all cluster heads have been marked by ellipses. As shown in Fig.1, the more the number of nodes in a region is, the more the number of cluster heads is. Therefore, the distribution of CH is more reasonable in our algorithm, because we consider the influence of node density on selection of CH.

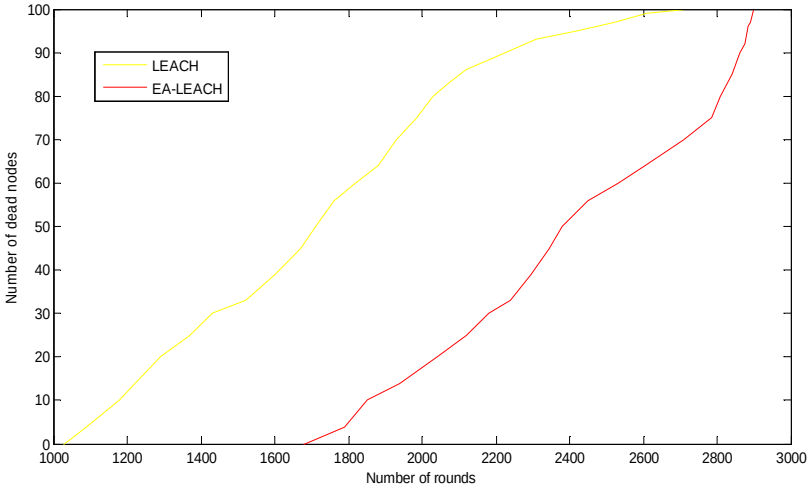

Fig.2 The change of dead nodes

To verify the improved algorithm we proposed, we will compare the results with LEACH's. Fig.2 shows the change of the number of dead nodes, and EA-LEACH is the abbreviation of our algorithm. It can be seen from the figure that the first dead node in original LEACH appears at about the 1029th round, while the first dead node in our algorithm appears at the 1679th round. The appearance time of first dead node delays by 63%. In addition, the time of nodes death is more concentrated after the 2400th round, because the energy consumption in our algorithm is more balanced. Though the time of nodes death in LEACH is decentralized, the function of remaining nodes is limited because the death of some key nodes will affect the work of entire network.

It is important to ensure the precision of reconstructed data, because there may be subsequent process on the reconstructed data. The mean construction precision of our algorithm is 82.4% when the length of sliding window is 20, and the precision will reduce when the length is bigger. Therefore, our algorithm can ensure a high accuracy of reconstruction.

Conclusion

In this paper, in order to save energy in WSN as much as possible, we propose an improved LEACH protocol based on SAX. The experiment result shows that our method effectively prolong the lifetime of network and balance the energy consumption while having a relatively high accuracy of reconstruction. However, how to improve the construction precision is our future work.

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