Chapter 20
LEACH Clustering Routing Protocol for WSN

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Abstract The node energy, storage space, and computation ability are limited, so energy saving is the primary goal in the design of wireless routing. The traditional wireless routing cannot be directly applied to the WSN, so WSN routing protocol research has important practical significance. The improved LEACH protocol means to make each nodes energy utilization more equalized to extend the total amount of data and network survival time. To improve the performance of the whole network is a crucial principle for the research of WSN according to a specific application in the future.

Keywords WSN · LEACH · NS2 · Simulation

20.1 Introduction

Wireless sensor network consists of a large number of nodes, which exchange data through wireless communication technology. Wireless sensor network collects information from plenty of nodes in sensors and has a data processing and integration to convey the final information to the observer. Routing protocol is so critical for network that it has a direct impact on network performance, efficiency, and safety [1]. Wireless sensor network has its own characteristics and is different from the traditional network, and its routing protocol presents difference from the letter. The routing protocol of traditional network cannot be directly applied to

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wireless sensor network [2]. As long as the differences between wireless sensor network and IP routing protocols as following: when designing routing protocols, node energy of wireless sensor network is limited and on the important position. In the transmission process, node energy is far away from the network center, while many-routing protocols mainly face much to one of the data current and one to much of the control current rather than point to point communication in the traditional network. During the data transmission, first, it is to do an integration of data processing. Mobility of wireless sensor network is poorer than the Ad Hoc networks [3].

20.2 A Wireless Sensor

20.2.1 Architecture of Wireless Sensor Network

Wireless sensor network is generally composed of the sensor nodes, cluster nodes, and management nodes, and sometimes it contains Internet, satellite links, and console. Aggregation has a received data processing and integration to convey the handled information to the management node through the Internet or satellite links. Furthermore, aggregation node has the function of data processing and transmission and designs enhanced sensor nodes in order to have much capacity and processing space [4]. While management nodes examine and manage the whole network, receive the information transmitted by aggregation nodes, and send the relevant control information.

20.2.2 Node Structure of Sensor

Node consists of the power service module, the radio traffic module, the processor module, and the sensor module. The node is the object in the wireless sensor network deployed studies fields to collect and the repeater information and complete cooperation assigns, each node is marked with different ID.

20.2.3 Layered Structure

According to the characteristics of the wireless sensor network design network system has two-dimensional structure, namely the lateral communication protocol layer and longitudinal management surface. Communication protocol layer is divided into five layers, respectively is physical layer, data link layer and network layer, the transport layer, the application layer. Network management surface is divided into mobility management, energy consumption management, and task management [5, 6].

20.2.4 Common Wireless Sensor Network Routing Protocol

Wireless sensor network routing protocol is divided into plane routing protocol and level of routing protocol in terms of the topological structure of viewpoint in routing protocol. Plane routing protocols include the flood agreement and chatting agreement, Sensor Protocols for Information via Negotiation (SPIN) agreement and directional diffusion, while level routing protocols include LEACH, TTDD agreement, SPEED agreement, and GEAR agreement.

20.3 Analyses and Improvement of LEACH Routing Protocol

20.3.1 LEACH Routing Protocol

The LEACH protocol is the first based on clustering hierarchical routing protocol. Compared with the plane routing protocol, LEACH has characteristics of low consumption and long survival of network. Selecting LEACH protocol as the research object and improvement can be understood more in-depth of the working process of hierarchical routing. The LEACH protocol makes use of self-organizing clustering, clustering with its strategy to select a node as the cluster head node, in the data transmission, all cluster member nodes first sending the data to the cluster and cluster head receiving all cluster members data, and then having the data fusion and sending to the remote base station.

(1) Selection in Cluster Head

The basic idea of LEACH protocol is that energy consumes a balance to each node so as to prolong the lifetime of network. The cluster head nodes receive other information within the cluster nodes, process the information, and sending to the base station. The LEACH protocol uses periodic selection cluster head nodes to solve the excessive consumption in cluster head node energy. In the LEACH algorithm, the node independently determines whether a cluster head or not. Periodic selection cluster head node is called round, each round consists of a cluster of the establishment stage and stable data transfer stage.

In each round of clusters process, the goal is to form K clusters. Algorithm starts with a random value from 0 to 1 and gives it to each node, function in formula 20.1 showed as follows to select the cluster head node.

$$\begin{aligned} T(n) &= \frac{p}{1 - p[r \bmod (1/p)]} \cdots n \in G \\ T(n) &= 0 \cdots n \in other \end{aligned} \tag{20.1}$$

For an arbitrary node N, the node N generates a random number range 0–1, if this number is less than a given threshold value *T(n)*, the node N will become the

cluster head node, at the same time, the node N broadcasts itself as a cluster head information. P is cluster head node ratio, its value is generally 4–5 %, and the value will be changed with applications. R is currently circulating round number, such as the current is carried on the tenth round, $r = 10$; G is a set in recently 1/P wheel has not elected a cluster head node. In a cycle, a node can only become a cluster head. When $r = 0$, $T(n) = P$, whereby probability of each node as the cluster head node is the same, value of P, R will be larger. The $T(n)$ value is larger, the probability of cluster head nodes becoming cluster head is the greater.

(2) Phase in Cluster Building

The "wheel" (round) is defined as the unit circle in the LEACH protocol. Each round consists of two stages, namely the establishment phase and stable phase. Node uses the formula (1) to calculate. By setting a threshold $T(n)$ to judge whether itself becomes a cluster head node. Once a node becomes the cluster head node, we need to broadcast the news of being a cluster head in remaining nodes network.

When a node is a cluster head node, it will send broadcast message to other surrounding nodes to show that is the cluster node, during this period it has been waiting for other nodes respond and waiting for other nodes to join. A noncluster head node may receive information from a plurality of cluster head node; finally, it selects to join the cluster according to the energy which is determined by the size of.

(3) Stabilized Stage in Clusters

After completing cluster building stages into the stable stage, this stage is mainly to complete data transfer. If the sensor node always has data to send, when the time for their turn to transmit data, member node will send data to the cluster head node. In the transmission phase, each member node has been shut off its own wireless communication module until its own time slot come open module to save energy. But the cluster head nodes to accept other node information within the cluster, so the cluster head node transceiver needs opening, hence, the cluster head node energy consumes more quickly than others.

20.3.2 Shortcomings of LEACH Protocol

The LEACH protocol has many advantages, but it also has some shortcomings, mainly in the following aspects:

(1) Selection of cluster head is not ideal

The LEACH protocol uses random manner to become cluster head, which is lack of binding and does not use the residual energy of nodes as a reference coefficient to select the cluster head.

(2) Cluster head distribution is not balanced

The LEACH protocol uses completely random manner to produce cluster head nodes, so the distribution of the geographical position is not optimal and is more likely to produce the unreasonable distribution.

(3) Signal hop communication is not reasonable

LEACH protocol uses a single jump communication in the process of communication, which greatly limits the size of the network.

20.3.3 LEACH-Improved Protocol

Wireless sensor network node energy is so limited that routing protocols are designed to save energy in important position in order to prolong the survival time of the entire network. The LEACH protocol in the selection of cluster head nodes do not take the residual energy of nodes into consideration, it may choose the residual energy of less node as the cluster head node, where the cluster head nodes distribution is uneven and some regional cluster head distribution is much too small to reduce the network survival time. The way of single jump is used in communication, by the model of energy consumption; the distance from the base station node energy consumption is increasing dramatically. As for LEACH protocol existing problems, this paper puts forward an improvement of the LEACH protocol LEACH-improved.

The LEACH-improved protocol focus on problems of LEACH protocol, from the following two aspects of the LEACH protocol was improved:

(1) Selection of Head Cluster Node

The LEACH-improved protocol selects cluster heads to increase the residual energy of the nodes in the cluster detection, or selects those nodes with more energy as the cluster head node in order to prolong the network life time. Current node is current energy and origin is the initial energy of nodes. The LEACH-improved protocol increases the probability of higher energy node a cluster head to prolong the network lifetime. The improved formula for cluster head selection as shown in a formula 20.2.

$$\begin{aligned} T(n) &= \frac{p * Ecurrent}{1 - p * (r \bmod (1/p)) * Eorigin} \cdots n \in G \\ T(n) &= 0 \cdots n \in other \end{aligned} \tag{20.2}$$

(2) The Multi-hop Path Transmission

The LEACH-improved protocol joins intercluster routing strategy. Cluster head is responsible for the data collection of cluster member cluster head node, data fusion calculation, and sends the fusion data through the multihop routing to the

base station. This chapter assumes that the data redundancy is limited and data from different clusters can not further data fusion, so it relays cluster head node simply forwarded from other formal cluster header data. In the network a cluster head node is denoted as Ci, Ci and the distance between the base stations recorded as D (Ci, BS), jump process is as follows: the cluster head nodes with radius d to broadcast their own news around, message contains the node ID Ei, energy, distance between cluster heads and base station (Ci D, BS). This cluster head node Ci is adjacent to the cluster head node set to SCi = {Cj, Ck},…, where the cluster head relays cluster head set for SCv = {Cv|Cv in SCi&d (Cv, BS) = D (Ci, Bs)}, if SCv is empty, then the cluster head transmits data directly to the base station, or selects the largest cluster head node of energy value in the collection SCv. If the maximum residual energy node is the only, then the node as the next hop routing node or in a plurality of energy values in the largest cluster head node selects the distance from the base station to recent cluster head node as the next hop routing node.

20.4 Simulations

20.4.1 Comparison of Protocol Stimulation

The comparison of LEACH-improved protocol and LEACH protocol is mainly from two aspects contrast analysis-the node data transmission amount and node of the survival time.

(1) Data transmission quantity simulation analysis

Data transmission quantity is node of the total amount of data that is transmitted to the base station. Figure 20.1 shows the improved LEACH-improved protocol and the original agreement in the test of energy consumption and the base station receives the total data quantity of the curve. From the chart shown, protocol LEACH-improved in consuming the same energy, the base station receives the great total amount of data. This shows the LEACH-improved has a promotion space than the original protocol, as you can see from Fig. 20.1, when consumed the same energy 80, LEACH-improved protocol accepts 6,000 of the amount of data, when consumption is 100, LEACH-improved protocol accepts the amount of data 7,000 than the LEACH protocol, which describes that the LEACH-improved protocol improves the total data receiving volume, this is mainly because the improved protocol in energy consumption is compared to the average, so the lifetime of the whole network is improved and the data transmission is more efficient.

(2) Simulation Analysis of Node Survival Time

Node of the survival time of wireless sensor network is one of the important parameters, survival time directly determine the performance of networks and the life time of the whole network. Figure 20.2 shows the number of nodes in the

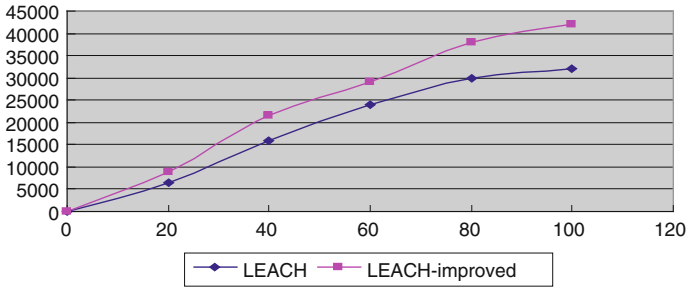

Fig. 20.1 The amount of data sent

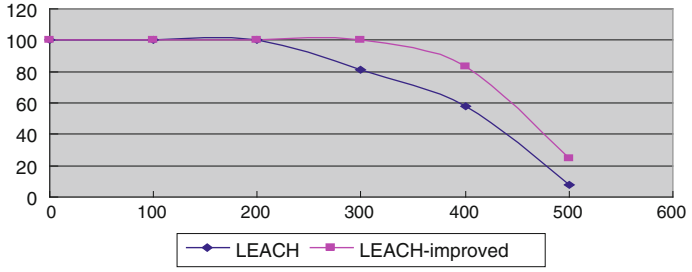

Fig. 20.2 Node survival time

network survival curves varying with time. The coordinates stand the time, and the ordinates stand node survival number. As can be seen from the graph, LEACH protocol has node death in 215 s, while LEACH-improve emergences the phenomenon of death node until in 275 s, and node death time postpones too much. This description of the LEACH-improve Protocol extends node survival time, at the same time, the energy consumption of the node is lower and the LEACH-improved protocol indeed reduces the energy consumption of the node, making the node energy consumption is more balanced to prolong the survival time of a single node, so that the performance of the whole network is in promotion.

20.5 Summary

After the detailed analysis of the first choice of LEACH agreement and the stability of the family of transmission stage, and the instructions of LEACH agreement during operation of the energy consumption model, it points out the shortcomings of LEACH agreement: in the process of selection of cluster head without considering the residual node energy, in the process of transferring, the way of communication is the single jump and proposed the improved protocol LEACH-improved agreement in this foundation. Through the simulation

experiments, it can be concluded that the improved LEACH-improved agreement can increase the overall data transmission and extend the node of survival time, which improves the network environment and makes the network performance improved.

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