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LEACH Clustering Routing Protocol Based on Balanced Energy Consumption

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Abstract. Faced with the problems of unbalanced energy consumption (EC) and short lifetime of nodes in Wireless Sensor Networks (WSN), a Low Energy Adaptive Clustering Hierarchy (LEACH) clustering routing protocol based on energy balance, namely LEACH-EB (LEACH Based on Energy Balance) protocol was proposed. At the initial selection stage, the nodes which are close to the base station (BS) with great remaining energy and many neighbor nodes are selected as the cluster heads (CHs); then, the non-CH nodes enter the clusters which have the least costs based on the strength and remaining energy of the communication signals between themselves and different CHs. At the data transmission stage, if the CH which sends the information is one hop away from BS, the CH needs to select a neighbor CH with the largest forwarding probability as the next hop relay node based on the remaining energy of each neighbor CH, the number of nodes in the cluster, and the distance from BS. The selected neighbor CH continues to determine the next hop in the above manner until the data is successfully sent to BS. Simulation tests show that LEACH-EB protocol can receive more data and extend the network life cycle by 60%, 43.1%, and 13.36% compared with LEACH, LEACH-C, and FIGWO, respectively.

Keywords: WSN, LEACH, energy consumption, routing protocol

1 Introduction

Energy efficiency is the main problem in the development of WSN [1-2], and the clustering-based routing protocol is one of the effective methods to settle this problem. The classic clustering protocol LEACH [3] selects CHs according to a preset probability, and then keeps the EC balance through periodically rotating the CHs which cannot guarantee the remaining energy and position of the selected clusters. At the same time, the CH sends data to the BS using the single-hop approach, which increases the EC of the CH and shortens the WSN life cycle. Therefore, domestic and aboard scholars have intensely studied to settle this problem. Latif et al. [4] improved LEACH protocol and designed a centralized clustering protocol LEACH-C, which solved the problem of LEACH randomly selecting CHs, but the single-hop communication between the CHs and BS would accelerate the EC of the CHs, leading to their premature death, thereby shortening the network lifetime. Zhang [5] designed a K-means based uniform clustering routing algorithm, where the nodes could select the CHs according to their position and remaining energy. However, the K-Means clustering algorithm was sensitive to the initial point, which affected the clustering effect. In addition, the protocol failed to consider inter-cluster routing, and the single-hop mechanism accelerated the EC of the CH. Ari [6] designed the ABC-SD protocol, which used honeybees swarm to solve the clustering problem, and established inter-cluster routing based on comprehensive considerations of energy efficiency and hop count. Although this protocol improved network throughput, the protocol lacked consideration of load balancing among CHs, which reduced WSN performance. Sharma [7] proposed the EEE-LEACH algorithm, which improved the structure of LEACH to complete the target of balancing the EC of network nodes. Razaque et al. [8] proposed that in the choice of CHs, the average energy of the network and the remaining energy of the nodes need to be considered, and it needs to find a threshold according to the average energy to determine whether a node could become a CH. Gwavava et al. [9] proposed to provide a replacement node strategy for the CH, that is, when the CH energy was under a certain threshold, the replacement node replaced the original CH for data transmission. Ogundile et al. [10] proposed an energy-balanced and energy-efficient clustering routing protocol for WSN based on a selective path priority table which can improve network life cycle and throughput. Quoc et

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al. [11] proposed a Gaussian Network based energy efficiency clustering for WSN, which combines the shortest path routing protocol in Gaussian network with cluster protocol to increase the routing efficiency of WSN, and is simulated on NS2. Kumar et al. [12] proposed an energy-balanced hybrid depth-based routing protocol for underwater wireless sensor networks which uses the parameters such as sensor node depth, node residual energy and link reliability to select relay nodes to forward data packets, and then balances the sensor nodes' consumption participating in data transmission to prolong the network life. Liu et al. [13] proposed a distributed secure data acquisition scheme for wireless sensor networks based on chaotic compressed sensing which is applicable for long-term and large-scale wireless sensor networks, possessing characteristics of high energy efficiency and good security. M. Radhika et al. [14] proposed a routing protocol combining micro genetic algorithm and LEACH protocol for WSN which improved the network lifetime and EC by selecting the optimal channel. Zhou et al. [15] proposed a PSO optimization algorithm to select target nodes, so as to optimize energy efficiency and transmission distance, and alleviate the excessive EC of CHs.

Studies have shown that multi-hop can lessen EC in the data forwarding process of WSN, but the network energy is not balanced. N. Moussa et al. [16] proposed an energy aware cluster based routing protocol to avoid EC caused by frequent re-clustering, and introduced a multi-hop routing algorithm to minimize and balance EC. Cong et al. [17] realized the communication between the CHs and BS using the multi-hop communication method. Although the energy-saving performance looked good, it was easy to cause more EC of the CH close to BS on account of forwarding messages to other clusters, resulting in the imbalanced energy among the clusters of the entire network. Sun et al. [18] achieved clustering using non-uniform clustering based on the distance between the CHs and the nodes. The cluster closer to the BS has a small scale, and vice versa. Once received the member node data, the CH selects the closest CH with more remaining energy to transfer the data, to prolong the lifetime of the network.

Considering the above problems, a LEACH clustering routing protocol based on energy balance, namely LEACH-EB, is proposed in this paper. In the CH selection stage, the protocol comprehensively considers the remaining energy of the candidate CH nodes, node density, and the distance between the candidate CH nodes and BS, and optimizes the selection threshold to ensure that the generated CHs are reasonable; in the clustering stage, non-CHs enter the clusters with the least costs after calculation. Based on the comprehensive consideration of factors such as the residual energy of the CH, the number of members in the cluster, and the distance between the relay CH and the BS, inter-cluster communication can achieve multi-hop communication between the CHs and base stations, thereby balancing the EC of network nodes.

The main contributions of this paper are summarized as follows:

(1) A LEACH clustering routing protocol based on energy balance (LEACH-EB) is proposed, which can effectively balance the EC of WSN and prolong the network life.

(2) The strategy of multi-hop communication between the CHs and BS is designed which introduces CH as relay node to help forward data to BS.

(3) The simulation experiment is designed and fully compared with some main methods such as LEACH, LEACH-C and FIGWO, to verify the effectiveness of the method proposed in this paper.

2 LEACH Agreement

In WSN, LEACH works in rounds. Its working principle is as follows: after each running round, the CH will be chose again based on the following election principle: each candidate node randomly generates a random number between [0-1], and if the number is under the threshold $T(n)$, then this candidate node is selected as the CH. The threshold $T(n)$ is computed as formula (1).

$$T(n)=\begin{cases}\dfrac{p}{1-p[r\bmod(1/p)]} & ,n\in G,\\ 0 & ,\textit{otherwise}.\end{cases} \quad (1)$$

where r is the number of selection rounds, p is the proportion of CHs in all nodes, G is the set of CHs that have not been selected in this round, $r\ mod\ (1/p)$ is the number of nodes selected as the CHs in this round. The node selected as the CH in this round will no longer be the CH in the next round; on the other hand, the node that has not been selected as the CH will have an increasing probability of becoming the CH as the protocol runs more rounds.

The LEACH protocol has many problems in practical applications. For example, when determining the CH, it does not consider factors such as the distance between the CH and BS, its own residual energy, and the number of neighbor nodes, so that it is easy to have problems such as a non-uniform distribution of CHs, and uneven network load, which can result in the premature exhaustion of CH energy, ultimately resulting in problems such as reduced network coverage and shortened life cycles.

3 System Model

3.1 Network Model

If a WSN is distributed in a square area with N sensor nodes randomly scattered, it is assumed that: (1) All nodes in the WSN are homogeneous, and the communication and information processing capabilities, hardware configuration, and initial energy of the nodes are completely the same, each node corresponds to an ID. (2) The installation location of the sensor node is fixed, while BS can be moved. (3) Each node can sense its own remaining energy and position, as well as the neighbor nodes in the communication area, and the node can computed the distance to the signal sending node in term of the received signal strength RSSI. (4) All WSN nodes switch between CH and cluster member nodes. (5) As the EC of data processing is relatively small, WSN ignores it.

3.2 Data Transceiver Energy Model

In this paper, the first-order wireless communication model is used [19], and its structure is shown in Fig. 1. According to the distance between the sending end and the receiving end, the free space model or the multi-path attenuation model is adopted [20]. The consumed energy of a data packet with l bit sent from the sending end to a distance of d is calculated according to formula (2).

$$E_{TX}(l,d)=\begin{cases} lE_{\text{elec}}+l\varepsilon_{fs}d^2, d<d_0 \\ lE_{\text{elec}}+l\varepsilon_{mp}d^4, d..d_0 \end{cases} . \tag{2}$$

where, E_{elec} is the EC of the node receiving/sending 1 bit data, ε_{fs} and ε_{mp} are the amplified EC in the free space model and the multi-path attenuation model, respectively, d_0 is the distance threshold, and its calculation formula is as follows.

$$d_0=\sqrt{\frac{\varepsilon_{fs}}{\varepsilon_{mp}}} . \tag{3}$$

The EC E_{RX} of a node receiving a l bit data packet is calculated by formula (4):

$$E_{RX}(m)=lE_{\text{elec}} . \tag{4}$$

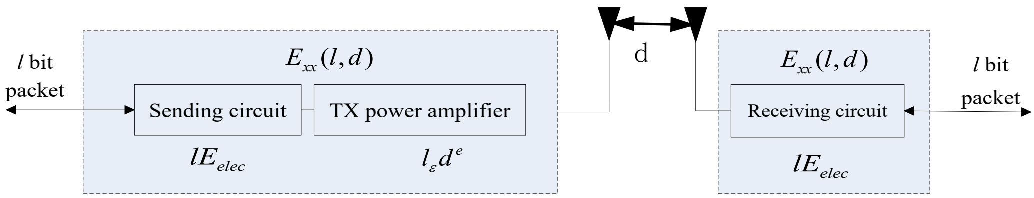

Fig. 1. EC model

4 LEACH-EB Clustering Routing Protocol

The LEACH-EB clustering routing protocol designed in this paper is composed of the cluster establishment stage and the stable data transmission stage. Two steps are contained in the cluster establishment stage: selecting the CH and node entering the cluster. At the cluster establishment stage, factors such as the residual energy of the node, the number of neighbor nodes, and its distance to BS are incorporated into the calculation formula for the probability of a node becoming a CH, to dynamically calculate the probability of each node becoming a CH in each round. Then, after calculating the entering costs, the non-CH nodes enter the clusters with the lowest cost. At the stable data transmission stage, the CH collects member information in the cluster and transmits the information to BS in a single-hop or multi-hop form.

4.1 Selecting CH

In a classical LEACH protocol, the proportion p of head clusters in all nodes are set in advance, and remains unchanged during the whole life of the WSN. The threshold $T(n)$ is determined by both p and the current round number r. Obviously, with the running of WSN, the EC of each node increases, and the number of dead nodes also increases. If the probability of a node changing into a CH is measured by a fixed p, it is unreasonable to ignore the remaining energy of the node. In the practical application of WSN, the position of the node is the influencing factor that affects the node to become the CH. If the node is far from the *BS*, the node needs to consume more transmission energy to transmit the information to the destination; if the source CH adopts multi-hop to send information, there will be more multiple relay nodes required to forward it, resulting in an increase in the overall EC of the WSN. Therefore, the selected CH should be close to *BS*. If the selected CH has a large number of neighbors, it will shorten the distance from the CH to the cluster members when providing services to cluster members, and thus the EC in the cluster is reduced.

To sum up, LEACH-EB calculates the probability of each node becoming the CH in each round based on the comprehensive consideration of the distance d_i, the remaining energy E_i, and the number of node neighbors N_i. The above influencing factors as well as the threshold $T(n)$ are calculated as formulas (5)-(9).

$$E_i = E(i) / E_{mean} \quad . \tag{5}$$

$$N_i = 1 - |N(i)| / (np) \quad . \tag{6}$$

$$d_i = \left(BS\max - d_{\mathrm{BS}}(i)\right) / BS\max \quad . \tag{7}$$

$$p(i) = \frac{E_i}{\alpha N_i + \beta d_i} \quad . \tag{8}$$

$$T(n) = \begin{cases} \dfrac{p(i)}{1 - p(i)[r \bmod (1/p(i))]} & , n \in G, \\ 0 & , otherwise. \end{cases} \quad . \tag{9}$$

where $E(i)$ and E_{mean} are the remaining energy of node i and the average energy of active nodes in WSN respectively, $|N(i)|$ is the number of active neighbors of node i in the communication area, $N(i)$ is the neighbor set of node i, $p(i)$ is the probability that node i becomes the CH, n and np are the total number of network nodes and the number of members in the standard cluster respectively, BS_{max} is the farthest distance from the WSN internal node to BS, $d_{BS(i)}$ is the distance between node i and BS; α and β are weighting factors, and $\alpha + \beta = 1$.

The derivation and analysis of formulas (5) to (9) shows that when the remaining energy of a node is larger with more neighbor nodes and closer distance to *BS*, the $p(i)$ and $T(n)$ values of the node are correspondingly larger. Then, the node is more possibly to generate a random number between [0-1] with the value of lower than $T(n)$, or in other words, the node is more likely to become the CH. Therefore, LEACH-EB is reasonable in the choice of CH.

4.2 Node Entering Cluster

The node will broadcast a message once it is selected as the CH indicating its becoming the CH. The message contains information such as the node's ID and remaining energy. Other non-CH nodes then calculate the costs of entering different clusters based on the received information and the distance from the CH, and finally enter the clusters with the least cost.

The cost between node *i* and CH *h* involves the remaining energy of CH *h*, the number of neighbors, and the distance from node *i*. If there are many CHs in the communication area of node *i*, the cost calculation formula for node *i* entering the nearest cluster is as shown in formula (10) when only the distance factor is considered in the communication cost.

$$\cos tF(i,h) \propto dis(i,h) \ . \tag{10}$$

where $costF(i,h)$ is the cost which node *i* entering the nearest cluster *h*.

Since the number of neighbor nodes of the CH will affect the scale and EC of the cluster, a CH with more neighbors needs to provide more data forwarding services, which accelerates the power consumption of the CH, resulting in the decrease of the overall performance of the network. Therefore, non-CH nodes should enter clusters with fewer members to balance the scale of each cluster, namely:

$$\cos tF(i,h) \propto \left|N(h)\right| \ . \tag{11}$$

When the WSN is running, the EC of general nodes is less than the cluster node, so the node should choose the CH with more remaining energy to enter [21], namely:

$$\cos t\,\mathrm{F}(i,h) \propto \frac{1}{E(h)} \ . \tag{12}$$

After integrating formulas (10)-(12), it can derive the following cost function:

$$\cos tF(i,h) = a_1 \frac{\mathrm{dis}(i,h)}{BS\max} + a_2 \frac{|N(h)|}{n} + a_3 \frac{E_0}{E(h)} \ . \tag{13}$$

where E_0 is the initial energy of all nodes, $|N(h)|$ is the number of neighbor nodes of CH *h*, $dis(i,h)$ is the distance between node *i* and CH *h*. a_1, a_2, and a_3 are weighting factors, and $a_1 + a_2 + a_3 = 1$. These weighting factors can adjust the influence of each factor in formula (13) on the cost function.

4.3 Communications between Clusters

In the actual application of LEACH-EB protocol, if the information sending the CH is far away from *BS*, it is necessary to construct a communication path with multiple relay nodes to *BS*. These relay nodes are CHs that are close to *BS*. The EC model formula (2) indicates that when the information sending CH selects the next hop relay node, it needs to consider the distance between the information sending CH and the relay node.

Before the information sending CH selects an relay node, it is necessary to collect the information of the neighbor CHs. Since the CH has broadcast its own information in its communication area and received the message broadcast by the neighbor CHs at the same time, these messages include its ID, distance to *BS*, and remaining energy. After the broadcast ends, each CH will know the information of all neighbor CHs. Based on the residual energy of the neighbor CH, the number of nodes in the cluster, and the distance from the *BS* of the information sending CH, the forwarding probability of each neighbor CH can be calculated using formula (14), and then the neighbor CH with the greatest forwarding probability is selected as the relay node of the next hop. The same way is used for the selected neighbor CH to decide the next hop until the information can be successfully forwarded to the *BS*.

Assuming the information sending CH *i* and the neighbor CH node *h*, the calculation formula for the probability that *i* forwards the information to the *BS* through *h* is as shown in formula (14).

$$P(i,h)=\begin{cases}\tau_{ih}\dfrac{E(h)\ \ 1/|N(h)|}{\sum\limits_{k\in N(i)}E(k)\sum\limits_{k\in N(i)}1/|N(k)|}, h\in N(i)\\ 0,\quad otherwise\end{cases}. \quad (14)$$

$$\tau_{ih}=\frac{2BS\max-\text{dis}(i,h)-d_{BS}(h)}{2BS\max}. \quad (15)$$

where τ_{ih} is the distance between nodes i and h. It can be seen from formulas (14) and (15) that if the neighbor CH h has few neighbors, high remaining energy, and close distance to both the CH i and to BS, then the probability of CH h being selected as a relay point is high.

5 Simulation Test

To test and evaluate the performance of LEACH-EB protocol, the discrete event network simulator NS3 was used to build a simulation platform. The simulated hardware processor was Inter(R) Core(TM) i7-9700 CPU @ 3.00GHz with the memory of 16GB, the virtual machine was VMware Workstation 10.0.4, and the version number of Ubuntu was 16.4LTS.

5.1 Architecture of the Simulation System

NS3 was mainly used to construct a simulation network with multiple simulation nodes, and the simulation model structure is shown in Fig. 2. Each node has the function of receiving and sending. As is shown in Fig. 2, in the process of data packet transmission, NS3 has a clear layering. The upper sending function of the source node is called the lower sending function to transmit the data packet, and the lower receiving function of the destination node is called the upper receiving function to deliver the data packet to the peer layer.

The simulation operation of the network was the transmission of data at various layers. The NS3 network simulation architecture is composed of multiple network components, including nodes, applications, protocol stacks, network equipment and channels.

The Node in Fig. 2 is similar to a computer that can add various functions. Described by the Node class in C++, it managed various methods of network components in the simulator, including applications and protocol stacks; Application was the user program to generate a certain simulation activity, also described by the application class in C++; Channel was the object that connects the node to the data exchange channel, which was the medium through which the data flowed in the network; Net Device was equivalent to the network equipment installed on the node, including hardware equipment and software drivers, which enabled node to communicate with other nodes through the channel.

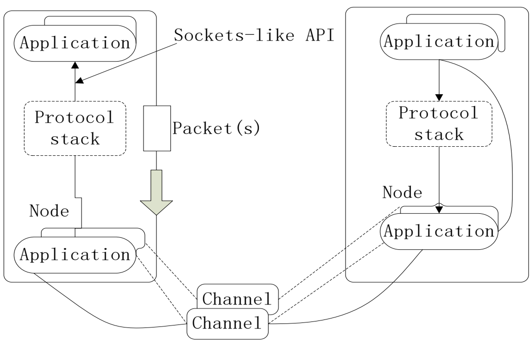

Fig. 2. Basic model of NS3

5.2 Simulation Analysis

After the simulation environment was set up, the four protocols of LEACH, LEACH-C, FIGWO, and LEACH-EB were analyzed and compared. Assuming that 100 nodes are randomly distributed in an area of 100 × 100 m^2

and all nodes have the same initial energy, the simulation parameters are shown in Table 1. BS was located outside the center of the network environment, and the distribution of network nodes is shown in Fig. 3.

Table 1. Experimental parameter configuration

Parameters	Value
Target area $(M \times M)/m^2$	100×100
Initial node energy E_0 / J	0.5
Number of nodes *n*	100
Base station location//m	(50, 50)
Cluster head optimizing proportion *p*	0.05
Data packet size *m*//bit	4000
Control packet size//bit	20
Communication radius *R*//m	40
Multi-path channel attenuation coefficient: $\varepsilon_{mp} / pJ / (bit \cdot m^4)$	0.0013
Free space attenuation coefficient: $\varepsilon_{fs} / pJ / (bit \cdot m^2)$	10
Energy consumption for sending or receiving data: $E_{elec} / (nJ / bit)$	50
Energy consumption for data aggregation: $E_{DA} / (nJ / bit)$	5
α, β	0.6, 0.4
a_1, a_2, a_3	0.5, 0.3, 0.2

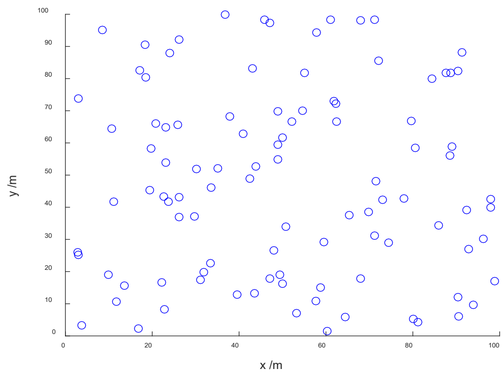

Fig. 3. Diagram of network node distribution

WSN Life Cycle Assessment.

Fig. 4 shows the changes of the number of dead nodes in WSN overtime when the four network protocols LEACH, LEACH-C, FIGWO and LEACH-EB were used. If the round of the first node death in WSN was defined as the WSN life cycle, then as is shown in Fig. 3, no matter what protocol was used, WSN was in an unstable state since the death of the first node. Meanwhile, the figure indicates that with the extension of the WSN running time, the number of dead nodes would also increase. However, the network life cycle using LEACH-EB was the longest, and the node death rate was the lowest. The reason was that the LEACH-EB protocol selected the CH after comprehensively considering the residual energy of the node, the number of adjacent nodes, as well as the distance from BS, and when the non-CH nodes entered the cluster, the cost was considered, making the distribution of the cluster more scientific and reasonable. In addition, the CH node communicated with BS in a multi-hop manner, which reduced the EC of the CH and prolonged the WSN life cycle.

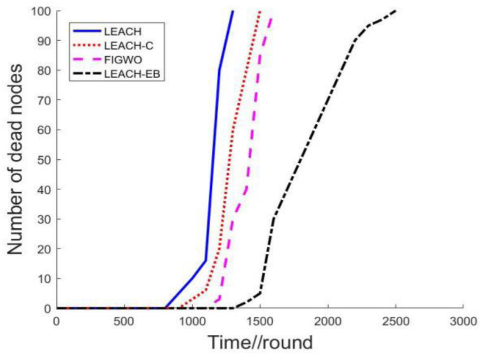

Fig. 4. The network life cycle of different protocols

Fig. 5 shows the comparison on the death time of the first network node, 10% of nodes and all nodes when using these four protocols. As is shown in the figure, the death time of the first node using these four protocols was at rounds 875, 978, 1235, and 1400, respectively; the death time for 10% of the nodes was rounds 966, 1070, 1354, and 1539, respectively; the death time of all nodes was at rounds 1269, 1301, 1639, and 2496 respectively. The network life cycle using LEACH-EB protocol was 60%, 43.1%, and 13.36% longer than that of LEACH, LEACH-C, and FIGWO, separately. Therefore, LEACH-EB protocol effectively extended the network life cycle.

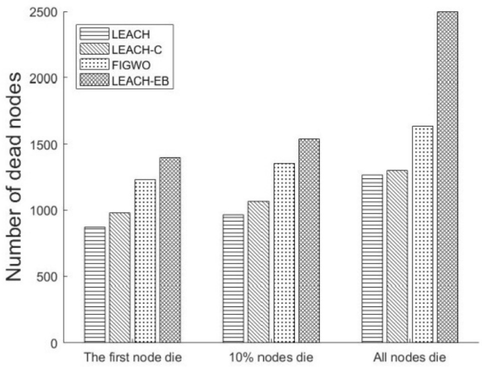

Fig. 5. Node death time

EC Performance Analysis.

With the running of WSN, no matter which protocol was used, the remaining energy of the network showed a downward trend. As is shown in Fig. 6, the remaining energy curve of the network using LEACH-EB protocol had a gentle decline, and its network EC was significantly lower than that of the other three. At round 1500, the network energy using LEACH, LEACH-C, and FIGWO protocols had been completely exhausted, while the remaining energy of the network using LEACH-EB protocol was still 12J left, which was finally exhausted at round 2350. Therefore, compared with the other three protocols, LEACH-EB had much higher energy utilization efficiency and energy-saving effects. The reason was that it gave comprehensive consideration to the number of neighbor nodes of CHs, the distance to BS, and the residual energy of nodes during CH selection, node entering clusters, and inter-cluster communication, which balanced the EC of each CH node. Therefore, under the same network environment, WSN has more surviving nodes and more remaining energy during the same running time.

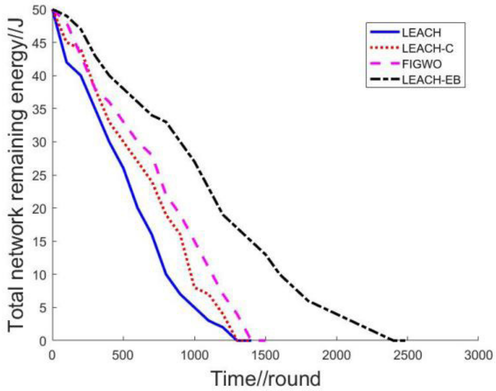

Fig. 6. The remaining energy of the network under different protocol conditions

BS Receiving Data Packet Analysis.

When WSN used these four protocols to run, changes of the data packet received by BS with time is as shown in Fig. 7. It can be indicated from this figure that when WSN used LEACH-EB protocol, the number of data packets received by BS was always more than that used by the other 3 protocols. When the WSN used LEACH and LEACH-C protocols, the number of data packets received by the BS no longer increased at round 1300, and the received data packet of BS reached saturation after 1500 rounds when using the FIGWO protocol. However, with LEACH-EB, the data packet that BS received increased until 2000 rounds. Thus, the network data transmission capability using LEACH-EB protocol is significantly better.

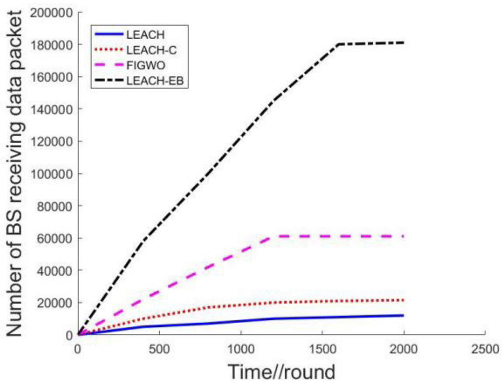

Fig. 7. BS receiving data packet comparison

Fig. 8 indicates the total amount of data packets received by the BS at the end of its life cycle when using the 4 protocols. As is shown in Fig. 7, when the network used LEACH-EB protocol, the number of data packets received by BS was 26.22 times, 10.71 times, and 2.88 times that of LEACH, LEACH-C, and FIGWO, separately. The reason was that when WSN used LEACH-EB, the EC of the node was reduced, especially in the later period of the WSN running, there were still many live CHs, which were sent to BS after integrating the data of the nodes in the cluster, thus extending the life cycle.

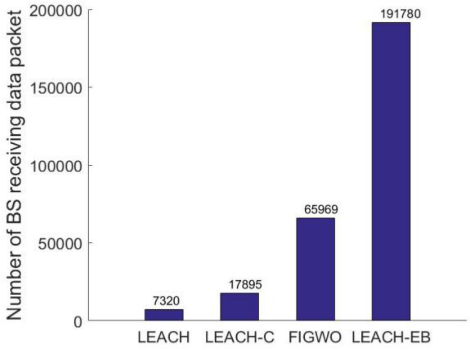

Fig. 8. Total data packets received by BS

WSN Life Cycle and EC Analysis under BS Dynamic Conditions.

In the process of WSN application, the topological structure of WSN changed due to the movement of BS. If the WSN and experimental parameters are configured as shown in Table 1, then Fig. 9 and Fig. 10 show the simulation results of the network life cycle and remaining energy when the WSN uses four different protocols and the BS moves from coordinates (50, 0) to (50, 130). As is shown in Fig. 9, the node using LEACH-EB protocol died first in round 830, while the first node using LEACH, LEACH-C, and FIGWO protocol clusters died in rounds 870, 975, and 1121, respectively. The reason was that when LEACH-EB selected the CH, it considered the distance between the candidate node and BS, so that nodes close to the BS had more chances to become CHs in each round of CH selection. At the same time, it also makes some CHs near BS frequently become the relay nodes, making them die early due to high EC. However, in general, the network that used LEACH-EB protocol had the longest survival time, and the death rate of nodes was lower than that of nodes that adopted the other three protocols. This was because LEACH-EB ensured the rationality of CH selection, reduced the EC of communication between nodes, and increased the survival time of nodes.

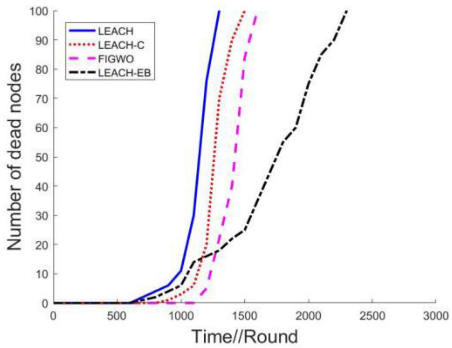

Fig. 9. Comparison on network life cycles under BS dynamic conditions

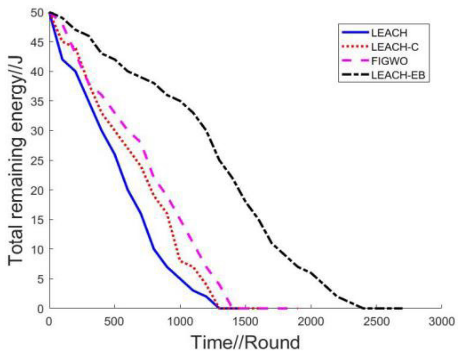

Fig. 10. Network remaining energy under BS dynamic conditions

Although the first dead node appears in the network using LEACH-EB, the total remaining energy was always higher than the energy of the other three protocol networks during the entire network running time. As shown in Fig. 10, the comparison shows that the designed LEACH-EB protocol in this paper can prolong the life and save the energy of the network with its comprehensive consideration of distance, energy and neighbor nodes in clustering.

6 Conclusion

Considering the problems of unbalanced EC in WSN and short network lifetime, the LEACH-EB clustering routing protocol is proposed. This protocol considers the residual energy of the node and the distance to BS when selecting the CH; when clustering, it also considers the cluster scale, energy, and distance between the CH and BS; finally, when the communication distance between the CH is greater than one hop, the CH is introduced as a relay node to assist data forwarding to BS. The simulation test results indicate that compared with LEACH, LEACH-C and FIGWO protocols, LEACH-EB clustering can balance energy, prolong life cycle and send more data packets to BS.

7 Acknowledgement

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