Analysis of Energy Saving Method for Multiple Relay Nodes in Wireless Volume Domain Network

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Abstract. In order to solve the problem that the transmission link of wireless volume domain network is likely to be interrupted and consume unnecessary energy, this paper introduces probability statistics and proposes a research on energy saving of wireless volume domain network multi-relay nodes based on probability statistics. The energy consumption of network is analyzed and the formula of total energy consumption per bit network is derived. The simulation results show that compared with the traditional multi-path multi-relay node forwarding method, this method can greatly reduce the overall energy consumption of the network. Consumption also plays a role. This method can reduce the overall energy consumption of the network and prolong the life cycle of the network. When the optimal relay node is used for transmission, the transmission power is greatly increased.

Keywords: Probability statistics · Wireless body area network · Multi-relay nodes · Energy saving

1 Introduction

Wireless body area network is a kind of wireless network based on RF technology, which is composed of micro nodes with sensor or actuator functions distributed on the surface of human body or implanted in human body. It is an application of wireless sensor network in biomedical field [1]. Wireless body area network can be used to monitor, collect and manage different vital signs (such as body temperature, blood pressure, heart rate, blood sample concentration, etc.) of human body. It has been widely used in disease monitoring, telemedicine diagnosis, home care and other aspects, and has gradually become a research hotspot. Aiming at the problem of signal attenuation in human body area transmission, a wireless body area network channel model based on path loss and power delay is proposed [2]; A UWB channel model of wireless body area network is proposed to solve the path loss problem in normal distributed small-scale fading environment; In this paper, a cooperative mechanism of network coding is proposed to explore the energy-saving way in lossy channel, and to give enlightenment to the energy-saving way in wireless body area network; A new network coding multicast routing algorithm based on link sharing degree is proposed to

S. Liu and L. Xia (Eds.): ADHIP 2020, LNICST 348, pp. 211–222, 2021.
https://doi.org/10.1007/978-3-030-67874-6_20

improve the performance of multicast transmission, which has certain guiding significance for multi-path and multi relay multicast transmission; The outage probability of direct transmission, single relay cooperation and multi relay cooperation, as well as the energy consumption and power consumption based on the outage probability are compared and analyzed in wireless body area network; The concept of cooperative communication between nodes is proposed, and the transmission link assisted by double relay is analyzed by using spatial diversity gain technology, but the energy efficiency of wireless body area network is not solved. Network coding is introduced to study the throughput of wireless body area network, but the energy consumption of network after network coding is not considered [3–5].

The traditional multi-path and multi relay forwarding method consumes too much network energy considering the transmission link interruption probability in wireless body area network. By introducing probability statistics into wireless body area network, this paper proposes a research on multi relay energy saving in wireless body area network based on probability statistics. Compared with multi-path multi relay forwarding method, this method can greatly reduce network energy consumption and improve the overall performance of the network.

2 Energy Saving Method for Multiple Relay Nodes in Wireless Volume Domain Network

2.1 Wireless Body Area Network

According to the various application forms of wireless sensor networks, researchers have designed different network structure forms. The most basic structure includes the following parts:

(1) Sensor network

The network is the core part of wireless sensor network. In the sensing area, a large number of sensor nodes monitor and perceive information, process the information and send it to the sink node; at the same time, receive the operation command from the sink node and execute [6].

(2) Sink node

The sink node has enough energy and transmitting power to process the information sent by the received sensor node and forward it to the transmission medium, or to transmit the user operation instructions to the sensor node [7].

(3) Transmission mode

The transmission mode includes satellite communication and network transmission, which realizes the information interaction between wireless sensor network and users, and is the communication medium [8].

(4) Network users

Network users are responsible for collecting the required data from the network, analyzing and processing the data, and monitoring the wireless sensor network [9].

The wireless body area network node consists of four modules. The network node module is mainly responsible for information collection and data conversion of the sensing object, such as measuring the physical properties of the surrounding light,

electromagnetic, acoustic and so on, so as to obtain the corresponding information; The processor module is mainly responsible for storing and processing the data collected by itself and the data sent by other nodes; the wireless communication module is mainly responsible for wireless communication with other sensor nodes, exchanging control information and receiving and transmitting the collected data; The energy module is mainly responsible for providing energy for network nodes [10–12].

The wireless body area network protocol framework mainly defines and describes the functions that the network and its components should complete. The wireless volume LAN protocol architecture is shown in Fig. 1.

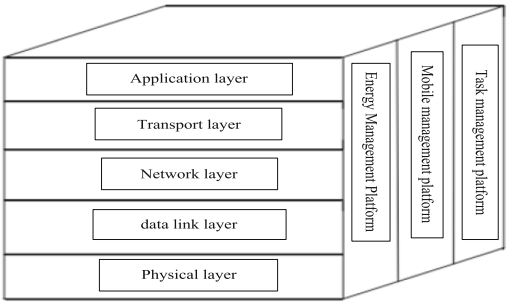

Fig. 1. Wireless body area network protocol architecture

The architecture of the protocol includes physical layer, data link layer, network layer, transmission layer and application layer, corresponding to the five layers of TCP/IP protocol. In addition, the protocol architecture also includes energy management platform, mobile management platform and task management platform [13].

(1) Physical layer

The main function of the physical layer is to evaluate the channel, select the better channel, detect the wireless signal, complete the transmission and reception of the signal and so on. The design goal is to obtain the larger link capacity and reduce the energy consumption as much as possible [14]. At present, the main problems in the physical layer of wireless sensor network are: how to design an integrated, digital and general circuit while reducing the cost of hardware; how to design a modulation algorithm with high data rate and low symbol rate while reducing the energy consumption.

(2) Data link layer

The main functions of data link layer are data framing, frame detection, media access and error control. This layer can be subdivided into media access control sublayer and logical link control sublayer. The main task of media access control sublayer is to share channel resources with users, and the main task of logical link control sublayer is to provide a standard and unified interface to the network [15].

(3) Network layer

The network layer is mainly responsible for route generation and route selection; its main functions include packet routing, network interconnection, congestion control,

etc. The main purpose of routing protocol is to establish the route between sensor node and sink node, and to transmit data reliably and safely.

(4) Transport layer

The main function of transmission layer is to complete the transmission control of data flow in wireless sensor network. The aggregation node collects data, and uses network, satellite and other ways to communicate with the external network. The operation of the transmission layer is an important part to ensure the quality of service.

(5) Application layer

The main function of the application layer is to acquire and process the transmitted data. The design of application layer is closely related to the actual application situation and environment, so the design of application layer needs to be completed according to the specific application requirements.

2.2 Model Building

As a branch of mathematics, probability and statistics generally includes probability of random events, statistical independence and deeper regularity. Probability is a quantitative indicator of the probability of occurrence of random events. In independent random events, if the frequency of an event in all the events, in a larger range, it is obviously stable near a fixed constant. We can think of the probability of this event as this constant. The probability value for any event must be between 0 and 1. The multi relay cooperation model of wireless body area network based on probability statistics is shown in Fig. 2.

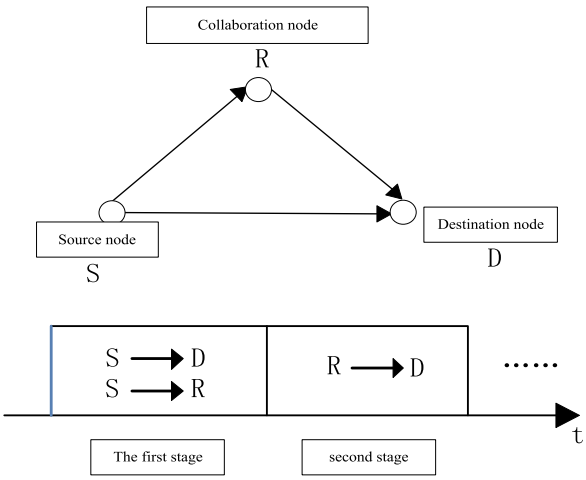

Fig. 2. Multi relay cooperation model of wireless body area network based on probability and statistics

The research on cooperative transmission technology is based on this model. The model includes a source node s, a destination node D, and a collaboration section R. In

the process of data transmission, the source node s will forward the data relay to the destination node d with the assistance of the collaboration node R. The whole data transmission is divided into two stages. In the first stage, the source node s sends data signals in the form of broadcast. If the link sad exists, the cooperative node R and the destination node D can receive the data signals, otherwise only the cooperative node r receives the data signals; In the second stage, the source node s suspends the transmission of data signals, and the cooperative node r processes the received data information according to a certain cooperative transmission protocol and forwards it to the destination node D. At this time, the destination node D receives two identical data signals from different paths. It can decode the backup data comprehensively through certain criteria to obtain the spatial diversity gain.

In order to increase the reliability of network transmission, all relay nodes use a cluster based cooperative forwarding method to transmit data. At the same time, the relay node introduces random network coding to transmit data, which improves data throughput and reduces the overall energy consumption of the network.

In the network model shown in Fig. 3, a multi relay cooperative energy-saving algorithm based on probability statistics is proposed. The description process is as follows:

First, M source node sends its original packet $R_1, R_2, R_3, \cdots, R_M$ to all relay nodes in this cluster, and each relay node will receive the original packet $R_1, R_2, R_3, \cdots, R_M$ of M different source nodes at the same time.

Then, N relay node randomly encodes M original packets. The encoded packets are as follows:

$$Z_j = \sum_{i=1}^{M} \lambda_{\mathrm{ij}} R_i, \mathrm{j} = 1, 2, 3, \ldots, N \tag{1}$$

The coding coefficient λ_{ij} is randomly selected from the finite field g_{ij}, R_1 is the original data packet of the i-th source node, and Z_j is the j-th relay node coding packet.

In consideration of transmission interruption, no matter how many original packets of different source nodes are received by the a relay node, all received packets are encoded. The number of times the relay node encodes depends on how many packets of different source are received in j-th certain period of time.

Finally, the sink node decodes all the received encoding packets. When the sink node receives at least N encoding packets and the received encoding coefficients are linearly independent, the original data can be decoded. If the decoding is successful, the sink node will feed back the confirmation information to all relay nodes, and all relay nodes will lose the rest of the coding packets. If the decoding is not successful, the sink node will retain the first round of transmitted coding packets and feed back the denial information to all relay nodes. All relay nodes will send the second round of coding packets to the sink node until the sink node can successfully decode or send the second round of coding packets to the N round of sending.

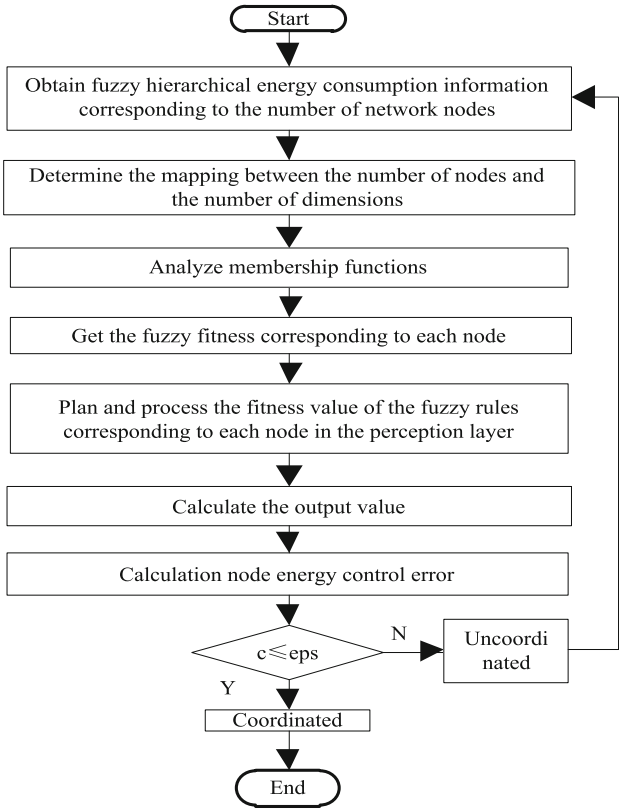

Fig. 3. Multi relay cooperative energy-saving process of wireless body area network based on probability and statistics

2.3 Study on Energy Saving of Relay Cooperation

According to the optimal coverage model, the scheduling algorithm is improved, and the minimum transmission period of all nodes is T; The time between the sending periods of two adjacent adjusted nodes is, which represents the minimum common multiple of the sending time of all periodic information. In each adjustment period, the smaller the minimum common multiple of information transmission time is, the faster the adjustment speed of each communication data transmission period is.

In the research process of multi relay cooperative energy-saving in wireless body area network, taking the obtained transmission information of relay nodes as the input data of probability statistics, the optimal energy-saving solution of multi relay writing nodes is calculated, and the multi relay cooperative energy-saving flow based on probability statistics is designed, as shown in Fig. 3.

The specific collaborative energy saving process is as follows:

When there is at least one frame of information in the distributed network carrier communication network and no data is successfully transmitted in the longest

transmission time, the communication network can be considered to be in a non working state. At this time, the communication network idle time t_i shall meet the following requirements:

$$T < t_i \tag{2}$$

In formula (2): T represents the longest transmission time of a frame of information.

In this case, the minimum transmission period T can be expressed as:

$$T = T' - (t_i - t_j)/\alpha \tag{3}$$

In formula (3): T' represents the previous node regulation period; t_j represents the reference value of idle period.

When there are n nodes on the distributed network communication bus, the transmission cycle of each node is the same, and the change range of communication network utilization P is:

$$P \leq \frac{(2n+1)T''}{(2n+1)T'' + T} \tag{4}$$

Where T'' is the average transmission time of information frame, and $T'' < T$ is:

$$P < \frac{(2n+1)}{(2n+2)} \tag{5}$$

When T in formula (4) is idle, the inequality is an equation, which can be expressed as follows:

$$P = \frac{(2n+1)T''}{(2n+1)T'' + T} \tag{6}$$

Therefore, when the average transmission time of information frame is the minimum, the communication network utilization P is the highest.

When n value is 1, the minimum sending period is T, which can be expressed as:

$$T \geq (2n+1)T'' + T_k = 3T'' + T \tag{7}$$

Therefore, when the minimum transmission period is less than $3T'' + T$, the distributed network carrier communication will no longer work. Therefore, this period is the minimum period allowed for transmission.

In the distributed network, the transmission frequency in the same period increases with the number of information nodes, and the network delay becomes very serious. In order to improve the problem, the hybrid scheduling algorithm is improved.

Send in T minimum period. Only one time of data sent is sent through the network. Set in a certain transmission period, select any time as the transmission time, then the data to be sent will be sent successfully, and will not be sent in other time. After such optimization, the impact of network delay on data transmission can be reduced, and the real-time performance of distributed network carrier communication can be improved.

3 Experimental Results and Analysis

Under the environment of MATLAB 7.0, the Internet of things experimental simulation platform is built, and the experimental research is carried out under glomosim simulator. The network simulator is used as information transmission simulator, and C++ language is used as network protocol to verify the effectiveness of the research of multi relay energy saving based on probability statistics.

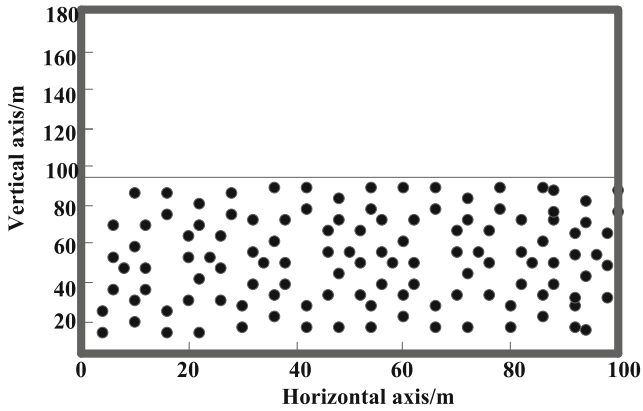

Fig. 4. Node distribution diagram

3.1 Initial Environment Setup and Parameter Setup

In the research experiment of the energy consumption control method of the nodes in the perception layer of the Internet of things, the node distribution diagram is shown in Fig. 4.

From Fig. 4, we can see the node distribution. Use the energy consumption equalization protocol to set the experimental parameters, as shown in Table 1.

Table 1. Experimental parameter settings

Parametric	Value	Parametric	Value
Number of communication network nodes	100 nodes	Initial energy	10 J
Monitoring range	100 m × 100 m	Communication energy consumption	40 bit
Initial power	0.40 J	Data fusion energy consumption	10 bit
Receiving power	0.30 J	Multipath model magnification	0.010
Control layer protocol	MAC-SENSOR	Experimental time	1000 s
Data packet	550 B	Baotou size	25 B

According to the experimental environment and parameters, the experimental results are analyzed.

3.2 Comparison of Experimental Results

The traditional method is compared with the probabilistic method, and the results are as follows:

(1) Scheduling time

Scheduling time is an important indicator to judge the scheduling speed of the two methods. In this experiment, the number of communication tasks was taken as an independent variable. During the experiment, the set communication task was increased from 0 to 80. The more communication tasks, the more scheduling time is required. The simulators used in the process are ready to sleep and ready on duty. With the support of glomosim simulator, the scheduling time of the two methods is compared and analyzed. The results are shown in Fig. 5.

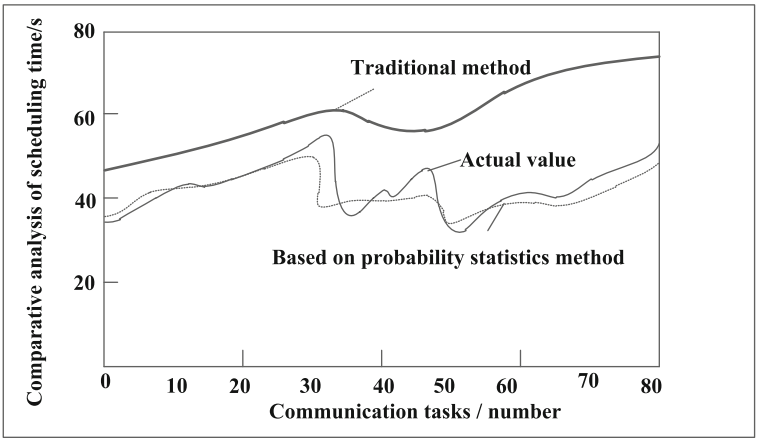

Fig. 5. Comparative analysis of scheduling time of two methods

It can be known from Fig. 5 that the curve based on probability statistics method is closer to the actual value curve, while the curve of the traditional method is far from the actual value curve. When the number of communication tasks is 35, the actual value and the scheduling time based on the probability statistics method both reach the maximum, which are 53 s and 49 s in order. The traditional method is that when the number of communication tasks is 80, the maximum scheduling time is 73 s. It can be seen that the scheduling time based on the probability statistics method is closer to the actual value, and compared with the traditional method, the scheduling time of the method is shorter.

The analysis of the traditional node cooperation method and the network survival time based on the probability statistics method, the results are shown below.

It can be known from Fig. 6 that with the increase of time, the number of surviving nodes of both methods decreases. When the time is 600 s, the number of surviving nodes under the traditional method is 0, and the number of nodes surviving based on the probability statistics method is 40. The experimental results show that the number of viable nodes in the proposed method decreases less and more slowly. Therefore, for a node with a research period of 400 to 600, under this condition, a comparative analysis of its energy consumption situation is shown below.

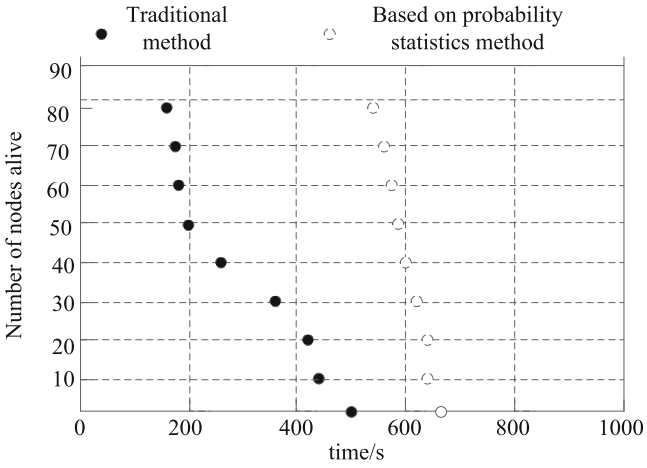

Fig. 6. Network survival time analysis results of two methods

As shown in Fig. 7:When the time is 10 s, the energy consumption of the traditional method is 0.92 mw, while the energy consumption of the probability based method is 0.66 mw, and the energy consumption of the actual node is 0.65 mw; When the time is 20 s, the energy consumption of the traditional method is 0.85 mw, while the energy consumption of the probabilistic method is the same as that of the actual node, both of which are 0.56 mw; When the time is 30 s, the energy consumption of the traditional method is 0.88 mw, while the energy consumption of the probability based method is 0.51 mw, and the energy consumption of the actual node is 0.53 mw;

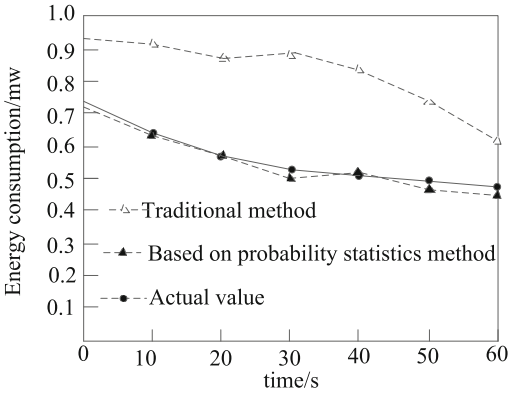

Fig. 7. Comparison of node energy consumption in two methods

When the time is 40 s, the energy consumption of the traditional method is 0.86 mw, while the energy consumption of the probabilistic method is the same as that of the actual node, both of which are 0.54 mw; When the time is 50 s, the energy consumption of traditional method is 0.76 mw, while that of probability based method is 0.52 mw, and the actual energy consumption of node is 0.49 mw; When the time is 60 s, the energy consumption of traditional method is 0.68 mw, while that of probability based method is 0.47 mw, and the actual energy consumption of nodes is 0.48 mw. Therefore, the method based on probability and statistics is basically consistent with the actual node energy consumption.

4 Summary

Wireless body area network is one of the focuses in the field of science and technology. It penetrates into every link of our life and every corner of the society. It is conducive to broaden human's understanding of the depth, breadth, accuracy and timeliness of the physical world, strengthen and close the relationship between human and the whole physical world, and to a large extent enhance human's remote monitoring of the physical world environment It has a wide application prospect. Energy limitation is one of the key problems in wireless body area network. How to control the energy consumption of multi relay cooperation in wireless body area network is very important for the application of wireless body area network.

The energy-saving scheme of multi relay cooperation in wireless body area network based on probability and statistics is studied. In the case of multi-source and multi relay, considering the influence of network environment fading, the transmission link is interrupted. The energy consumption formula under the corresponding network model is derived by using the link interruption probability. The experimental results show that, in the case of path loss, the energy-saving scheme of multi relay cooperation based on network coding can reduce the overall energy consumption of the network to a certain extent. At the same time, to meet the requirements of interrupt value, increasing

the number of network source nodes and reducing the number of relay nodes also play a role in reducing the energy consumption of the network. The future research direction is how to apply network coding mechanism to improve the overall performance of the network when considering the change of human posture.

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