Wireless sensor network node sleep scheduling algorithm

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Abstract. Wireless sensor network has been widely used in many fields, but in the application of the node battery can not be replaced, how to effectively save energy, prolong the lifetime of the network, is a very important and challenging work. In this paper, an algorithm is proposed to effectively prolong the network's life time by dividing the intermediate nodes into two types, which are only responsible for collecting data and only responsible for sending data, and making the redundant nodes go to sleep directly after the completion of network layout, and then scheduling the dormant nodes reasonably. Through the performance analysis, the algorithm can achieve a better effect of prolonging the network lifetime when there are a large number of redundant nodes in the network.

In recent years, along with the Internet of things was proposed and should be used more and more widely, in the wireless sensor network infrastructure has also been in the field of military and the people with more and more widely used, in deep space probe deep sea coupled with environmental monitoring and protection of wetland monitoring Rivers and lakes water city planning and construction aspects of a large number of deployment, the remote monitoring of intelligent city intelligent household intelligent office, and other fields is higher and higher practical value.

Due to the special application fields of wireless sensor network in many cases, sensor nodes deployed in one time, no longer recycling, energy cannot be added in the whole process, until all the section point in the network energy consumption of the light, the entire network failure Classic algorithms of cable network and some energy can not restricted or midway to supplement energy in wireless network algorithms cannot be directly applied to the limited energy in wireless sensor network For the energy limited network must do everything possible to save energy to prolong the life cycle. The study of energy saving has always been an important research branch of wireless sensor network.

1. Research status
With the progress of wireless sensor technology, the application of wireless sensor network (WSN) is more and more widely. But for deployment in the field or complex environment of the network, as the nodes in the network are mostly by the battery power, can quantity is limited, energy consumption situation determines the survival time of the network, because of how the current WSN node under the premise of limited electricity, effectively prolong the service life of WSN, is the important problem be solved. In the practical application of wireless sensor network node deployment Has a variety of forms, but the vast majority of wireless sensor network (WSN) are randomly deployed (such as a forest fire prevention water quality monitoring, etc.), a network topology for network topology, which should not only for the vast majority of the nodes Forward according to the acquisition and transfer data, for this
kind of node (routing), energy consumption than only for data acquisition node by node much larger. When the power of routing nodes runs out, even if the non-routing nodes still have sufficient power, the whole network can not work normally. Therefore, in order to effectively prolong the network life, it is necessary to balance the energy consumption between routing nodes and non-routing nodes.

There are many research results aimed at prolonging the life of wireless sensor networks. Up to now, the typical schemes include the following types:

1.1. Prolonging the life of wireless sensor networks through node sleep mode.

Literature [1] proposes a sleep mechanism based on unified time, whose principle is to set the sleep according to the unified clock in the network. Once the clock is timed to reach the time, all nodes enter a unified sleep state. For wireless sensor networks, it is difficult to have a unified clock. Literature [2] and [3] put forward an improved method, which unifies the clock through the packet exchange between the nodes in the network and the neighbors at regular time. Once the sleep state can be entered, the whole network will sleep uniformly. Packet switching increases the communication burden of nodes, but it may not guarantee the complete unity of node clock. Literature [4]-[6] proposes various node scheduling algorithms based on the amount of remaining energy of nodes. Literature [7] proposed that in the cluster structure, the ratio of the remaining energy of nodes and the remaining energy of the network was used as the criteria for selecting cluster head nodes. The nodes with more remaining energy had a higher probability of being selected as cluster head nodes, thus balancing the energy consumption of the whole network and prolonging the network's life time. Literature [8] proposes a dormant scheduling algorithm for redundant nodes, called RNSSA algorithm, for different scheduling of nodes in the inner and boundary of the network. Literature [9] makes the sensor nodes in the network work in turns and reduces the redundant coverage. Literature [10] proposed a method of dynamically adjusting sleep time, extending or shortening the sleep time of nodes according to the nodes and the remaining energy of nodes. Based on this, an energy saving algorithm (STDA) for dynamically adjusting the sleep time of nodes was designed.

Literature [11] proposed a broadcast based node hibernation mechanism and a network control strategy of broadcast hibernation method. Whether a node is dormant is judged by the server, which reduces the burden of the node, and the hibernation time can be adjusted dynamically, which can effectively prolong the life of WSN.

1.2. Prolong network life by adjusting node energy consumption

Literature [12] proposes an energy-saving routing and transmission (ECGR) algorithm based on node cooperation, which distributes energy consumption among many nodes in a balanced way and prolongs the network life. Literature [13] proposes an adaptive topological game algorithm for energy consumption equilibrium. The algorithm adjusts its own power according to the average life of nodes, helps the nodes with the shortest life to reduce power and prolongs the life time of the whole network. Literature [14] proposes a routing clustering algorithm to solve the problem of high energy consumption of cluster head nodes in heterogeneous wireless sensor network and low network life. With the goal of balancing the energy consumption of cluster head nodes, the gravity search algorithm is used to plan the communication chain of network cluster heads and reduce the negative load energy consumption of inter-node communication of cluster heads.

2. Improved algorithm

2.1. Algorithm description

Wireless sensor network is characterized by flexible networking. After the deployment and completion of networking, the end node at the boundary of the network is responsible for data collection, while the vast majority of nodes in the middle are not only responsible for data collection, but also responsible for data forwarding. Therefore, Easily than in the middle position of nodes in the boundary position of the section points ahead of running out of energy, and the faster the node energy
consumption, as near to the coordinator for this kind of situation, this paper proposes a aimed at intermediate nodes of dormancy algorithm, intermediate nodes can be divided into two categories, category section points only responsible for collecting the data, another kind of node is responsible for forwarding data, only to better balance the energy consumption between each node [15]. The algorithm flow chart of sleep node is shown in Fig.1. The algorithm steps are as follows.

(1) First judge whether the node breaking point is redundant. If yes, go to (2); otherwise, go to (4);
(2) Entering dormancy;

**Figure 1.** Sleeping node algorithm
(3) When this round of hibernation is over, check the message queue. If you receive a hibernation message from a neighboring node, go to (4), otherwise go to (2);
(4) Transfer to the pre-working state;
(5) Process messages. If a node is found to need to be replaced, go to (6); otherwise, clear the message list, then go to (2);
(6) Select a target node and reply the replacement message;
(7) Check whether the confirmation message of the node to be replaced has been received. If so, replace the corresponding node and enter the working state; otherwise, empty the message list and then go to (2).

The algorithm flow diagram of the working node is shown in Fig.2.

The steps are as follows:
(1) The node works normally.
(2) After a certain interval, the node judges its own remaining electricity once, if the remaining electric quantity is lower than the set value K1, then go to (3), no Then go to the (1);
(3) It still works normally and sends the sleep message, while emptying message queue;
(4) Monitor whether replacement messages are received in the message queue, if upon receipt of the replacement message, a confirmation sleep message is sent and then processed. After finishing the current data, enter the sleep, otherwise wait time T1, turn (3).

![Algorithm Flow Diagram](image-url)

**Figure 2.** Work node algorithm.
2.2. Detailed explanation of some steps in the algorithm
In the step (5) of the algorithm of the sleeping node, the link of message processing is more complex, and it is necessary to determine whether there are pre-sleep and confirmed sleep messages from the same node in the message list. If so, the node has found a replacement node. If not, the message is divided into routing node and normal node based on its source. Routing nodes should be selected first when the nodes to be replaced, and the node with the lowest remaining power should be selected first among each class of nodes. However, if the power of the replaced node is close to or significantly higher than that of the current node, no node is considered to need to be replaced [16].

In work node in the step (2) algorithm for normal work of routing nodes, the judge set when soc K1 can appropriate a few bigger, can be set to 30% ~ 40%, for example, when we should by the node dormancy awakening, can continue to replace other nodes need to be dormant, it also can guarantee the early entering the dormant period Point as far as possible, be used to replace the routing node, to better balance the energy consumption of the whole network;

For normal work of ordinary nodes, sentenced to break set when soc K1 less as far as possible, such as can be set to about 5%, when the ordinary node dormancy, stop work directly, no longer used to replace any node, the advantage is to reduce the number of state transitions node, significantly reduced due to communicate that the transformation of times, and for the common node saves energy effectively. In the algorithm step (4) of the worker node, if only one replacement message is received, the confirmation sleep message is sent directly. If more messages are received, a node with the highest power needs to be selected and sent to confirm the sleep message. When the remaining electric quantity of the normal working ordinary node is lower than K1, the pre-sleep message will be sent. If only one replacement cancellation is received, the confirmation sleep message will be sent directly. If more messages are received, the node with the lowest power quantity should be selected and sent to confirm the sleep message [17]. This can ensure that the whole network in the control of the balance of energy consumption, better guarantee of network coverage.

2.3. The protocol shall be adjusted accordingly according to this algorithm
Increase the message queue for each node, used to receive and save the adjacent sink point send pre dormancy messages and confirm dormancy. Dormant in the message, there should be a field tag the current node number, there is a field is used to mark the node routing nodes or ordinary nodes, there is a field tag node current remaining power. Replace the message, there should be a field tag the current node number, there is a field tag is replaced node number. Confirm dormancy in the message, there should be a field tag current quarter point number, there should be a field is used to mark the node routing nodes [18]. Again, a normal node, with a field marker instead of the node number.

3. Algorithm analysis
3.1. Innovation points of this algorithm
(1) the energy consumption of the node routing process than data acquisition, especially near the Sink node routing nodes, energy consumption faster, as a result, this algorithm can satisfy the requirement of network coverage of the case, after the net in the middle position of the node is divided into two categories, category node only responsible for data collection, data only responsible for another type of node forwarding, redundant nodes directly enter a dormant state.

(2) In order to maintain effective coverage of the entire network and reduce communication between neighboring nodes, routing nodes send pre-sleep messages when the electric quantity is lower than a higher value, and select a sleep node with higher electric quantity for replacement; For ordinary nodes, when its battery is running low, only send a pre-sleep message to find a node to replace.

3.2. Scope of application of this algorithm
This algorithm is used in the scheduling process of redundant nodes in the network. In the case of a large number of redundant nodes in the network, compared with the network without sleep strategy, it
can undoubtedly prolong the network's life time. For the algorithm that applies sleep strategy but frequently changes work nodes, this algorithm can effectively reduce the overhead caused by communication between nodes and routing adjustment by setting K1 value reasonably, so as to achieve the purpose of prolonging network life time.

3.3. Further questions to be further studied
Message queue is set in this algorithm to collect messages sent by neighbor nodes when nodes are in hibernation state. The implementation mechanism of message queue still needs further research.

4. Summarizes
In this paper, an algorithm is proposed. Firstly, the intermediate nodes are divided into two types, one is only responsible for collecting data and the other is only responsible for sending data, and the redundant nodes enter the sleep state directly after the completion of network layout. Then, the sleep nodes are effectively scheduled by setting the K1 value reasonably. Through the performance analysis, this algorithm can achieve the effect of better prolonging the network life time under the condition that there are a large number of redundant nodes in the network. However, the implementation mechanism of message queue needs to be further studied.

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