Research and Design of Energy Saving Strategy for Wireless Sensor Networks

Fan Yang[1,2], Zhi Liu[1, a]

[1]School of Electrical and Information Engineering, Wuhan University of Technology, Wuhan 430205, China

[2]Hubei Provincial Video Image and HD Projection Engineering Technology Research Center, Wuhan 430205, China

[a]524877477@qq.com

Keywords: wireless sensor network, mobile aggregation node, mobility strategy.

Abstract: The wireless sensor network is an important part of the Internet of Things system. It has many features, short life, and is not easy to replace. The aggregation node is experiencing more data transmission tasks and the energy is exhausted faster, which makes the system paralyzed. In response to this problem, this paper introduces a new mobile aggregation node, and specifically plans its mobile strategy, which can better complete the aggregation of the underlying static node data, so that the system not only has better computing and storage capabilities, but also It is not subject to energy loss, which effectively improves the service life of the system.

1. Introduction

How to effectively reduce the energy consumption and stability of wireless sensor network nodes is the main research direction. Most of the existing literatures focus on the optimization of routing algorithms. In order to reduce link interruption and obtain stable routing, Dr. Andraws Swidan (2019) proposed a new tree-based mobility-aware reactive routing protocol. The author brings communication to the mobile node due to high mobility. The problem that the link is easily interrupted proposes a distance vector routing protocol, which effectively improves the stability and energy consumption of the mobile node in mobile communication[1].Basma M. Mohammad El-Basioni (2011) designed the energy-efficient cluster-based routing protocol Qos and enhanced its routing efficiency for wireless sensor node energy consumption[2].Shirin Rahnamaei Yahiabadi (2019) proposed an enhanced intelligent hybrid routing protocol based on TIHOO for the problem of unstable routing in vehicle self-organizing networks. The improved fuzzy and cuckoo algorithm is used to find the most stable path between the source node and the target node, which effectively improves the security and stability of the network [3]. Catalina Aranzazu-Suescun and Mihaela Cardei (2019) are aimed at improving the stability and energy consumption of wireless sensor networks in the Internet of Things, mainly to propose new routing protocols, which effectively improve system stability and reduce energy consumption [4]. Mohamed Elhoseny (2019) proposed a new algorithm to manage routes. The FF-L algorithm based on multicast routing can effectively determine the best path of communication and ensure system stability [5].

2. Problem Description and Modeling

A mobile data sink node (MDSN) is added to the wireless sensor network. The aggregation node is responsible for collecting the data of the static node and uploading it to the gateway node and replenishing the energy, and adjusting according to the difference of the network environment. Thereby effectively adapt to different network environments. In order to cope with different scenarios, different routing policies are selected by judging whether the data information of the static node needs to be uploaded to the gateway node immediately. For example, the alarm information needs to be immediately fed back to the information of the gateway node. The static node completes the transmission of the emergency data by establishing a real-time route with the gateway node; for some periodic data information, it is uniformly collected by the MDSN and uploaded to the gateway node.

The paper will focus on the mobile data aggregation node mobility strategy (motion direction, distance and location) that is fully based on the system's energy consumption. As shown in Figure 1, (i = 1, 2, 3...) nodes are randomly distributed in a rectangular planar area network, and all are static data acquisition nodes, assuming that their initial energy is consistent. The gateway node is located around the area and has a fixed location. The static data collection node and the gateway node adopt multi-hop routing communication, which takes into account the requirements of real-time and energy saving.

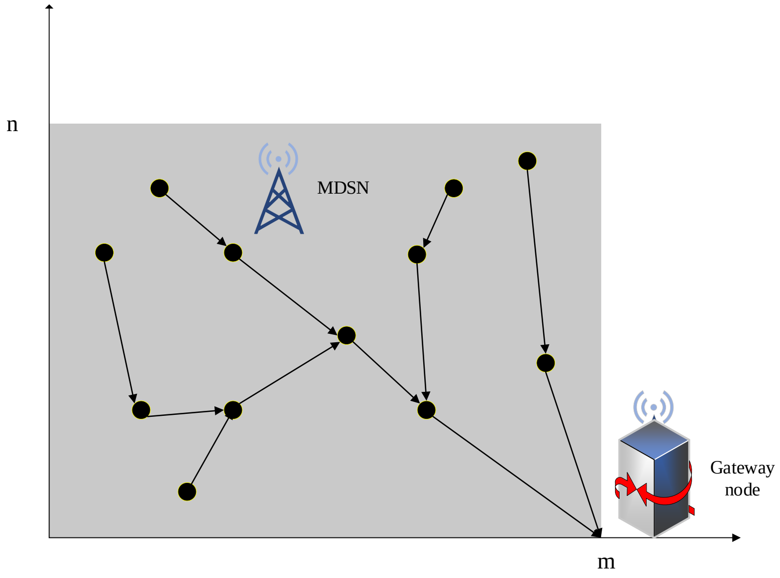

Figure 1. Data collection model added to MDSN

3. Mobile Strategy Design

3.1 Direction of Movement

The added MDSN works in the edge region of the wireless sensor network to help reduce energy loss. On the one hand, the added MDSN will effectively reduce the forwarding task of nodes near the gateway node, effectively reducing its energy loss; The farther away from the gateway node, the greater the energy consumed by its data backhaul, so the MDSN will have a greater probability of accessing static nodes farther away from the gateway node.

As shown in Figure 2, a plane rectangular coordinate system is constructed with the direction of the MDSN node pointing to the gateway node as the X-axis positive half-axis. The initial position of the MDXN node is recorded as the position after the motion is recorded as the gateway node. The distance from the distance is recorded as the distance between the two is recorded as the distance between the MDSN nodes and the circle whose radius is the center of the circle. The angle between and is recorded as:

$$\cos\phi = \frac{d_1^2 + d_2^2 - d_3^2}{2d_1d_2} \tag{1}$$

Therefore, at a certain time, at that time, proportional to the size, that is, the larger the MDSN node is farther away from the gateway node; at the time, the inverse of the size, that is, the smaller the MDSN is closer to the gateway node, the probability of selecting this motion direction Should be reduced. That is, when it is 0, the probability that the MDSN node moves to the gateway node is the largest, and it is assumed to be, and when it is, the probability that the MDSN node moves in the opposite direction to the gateway node is the largest, and it is assumed to be 1. Thus, at that time, it gradually moved away from the gateway node; at that time, it gradually moved closer to the gateway node. Therefore, the probability that the gateway node selects a direction and moves to it can be expressed as:

$$P = \begin{cases} p_0 + \frac{\varphi}{\pi}(1 - p_0) & \varphi \in [0, \pi) \\ 1 - \frac{\varphi - \pi}{\pi}(1 - p_0) & \varphi \in [\pi, 2\pi) \end{cases} \quad (2)$$

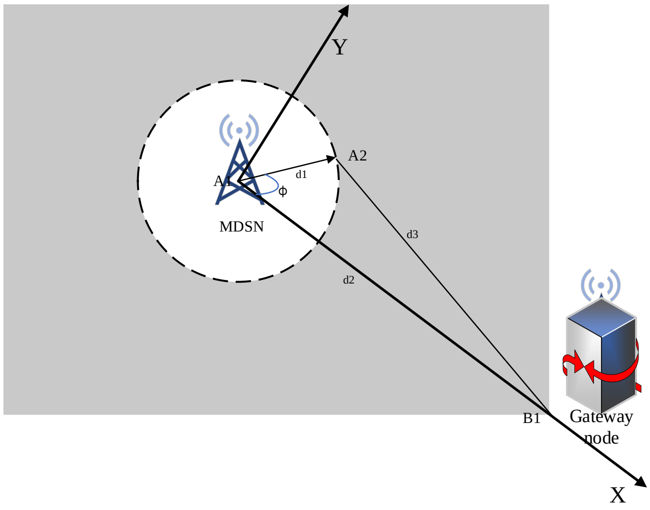

Figure 2. MDSN motion direction analysis

3.2 Movement Distance

Although the MDSN node collects data in a polling manner, it is the most energy efficient, but it will greatly reduce the real-time performance of the system. The newly added MDSN nodes in this paper will summarize the data by establishing a routing tree [1]. After each move to a location, the broadcast information will be published, and the data collection tree will be established centered on itself. This can not only improve the data collection efficiency, but also Reduces the energy loss caused by data layer transfer.

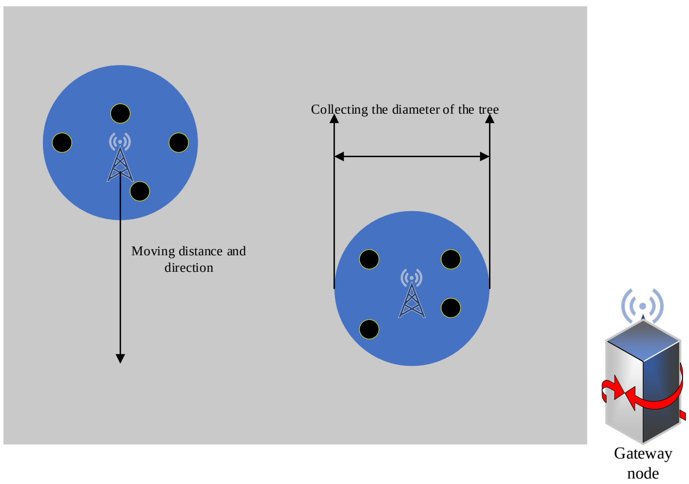

Figure 3. Motion Distance Model

To confirm the moving distance of the MDSN node, you must first confirm the size of the data collection tree. Assume that the coverage area of the collection tree is a circle centered on the MDSN node, so the optimal moving distance of the MDSN should be the diameter of the collection tree. To determine the radius of the collection tree, you must first determine the number of layers in the tree and the length of each layer. Assuming that the number of nodes in each data collection tree is k, the sum of the distances between the MDSN and the K nodes is s, and the average distance S/k between the MDSN node and the static nodes in the tree is approximately considered to be the length of each layer.

Next confirm the number of layers in the collection tree:

$$E_T = a \bullet e_0 + a \bullet \varepsilon_{fs} \bullet l^2 \tag{3}$$

$$E_R = ae_0 \tag{4}$$

Wherein, the energy consumed by the node for transmitting data; the energy required for the node to receive the data, the energy change generated by transmitting or receiving 1 bit of data for each node; the power amplification factor; the distance for data transmission.

Suppose any node has the following relationship in the reception and transmission of data:

$$k_{Ri} = k_{Ti} + Q \tag{5}$$

That is, the amount of data received by each static node is equal to the sum of the amount of data sent by the node and the amount of acquisition.

$$\sum_{i=1}^{k} k_{Ri} = \sum_{i=1}^{k} c_i \bullet Q \tag{6}$$

$$\sum_{i=1}^{k} k_{Ti} = \sum_{i=1}^{k} (c_i + 1)Q \tag{7}$$

Among them, the shortest hop count from the node to the MDSN, and k is the total number of static nodes in the area. The total energy required for the data tree to collect data is:

$$\begin{aligned} E &= \sum_{i=1}^{k} E_{Ri} + \sum_{i=1}^{k} E_{Ti} \\ &= \sum_{i=1}^{k} e_0 \cdot c_i \cdot Q + \sum_{i=1}^{k} e_0 \cdot Q \cdot (c_i + 1) + \sum_{i=1}^{k} (c_i + 1) \cdot Q \cdot \varepsilon_{fs} \cdot l^2 \end{aligned} \tag{8}$$

It can be seen from formula 8 that the energy required for the MDSN data tree to collect data is determined by the sum, that is, the required energy is only related to the total hop count and transmission distance. At the same time, considering that the static nodes in the network can communicate with the MDSN node normally, the main hop count is mainly affecting the size of E. For the design of the collection tree, the density of the static nodes in the data collection area is mainly considered. When the density of the nodes is small, the number of layers of the collection tree is increased; otherwise, the number of layers of the collection tree is reduced, and the system energy consumption is reduced as much as possible.

3.3 Algorithm Working Process

As shown in Figure 4, the system first needs to determine the number and location of nodes in the wireless network area, determine the number of layers in the data collection tree, and establish a collection tree to complete the collection of data in the area. After completing the data collection of one cycle, the returning gateway node uploads the data; if the data collection period is not completed, it determines the direction and distance to be moved, completes the collection of the node data in the new area, and returns to the gateway node after the acquisition is completed.

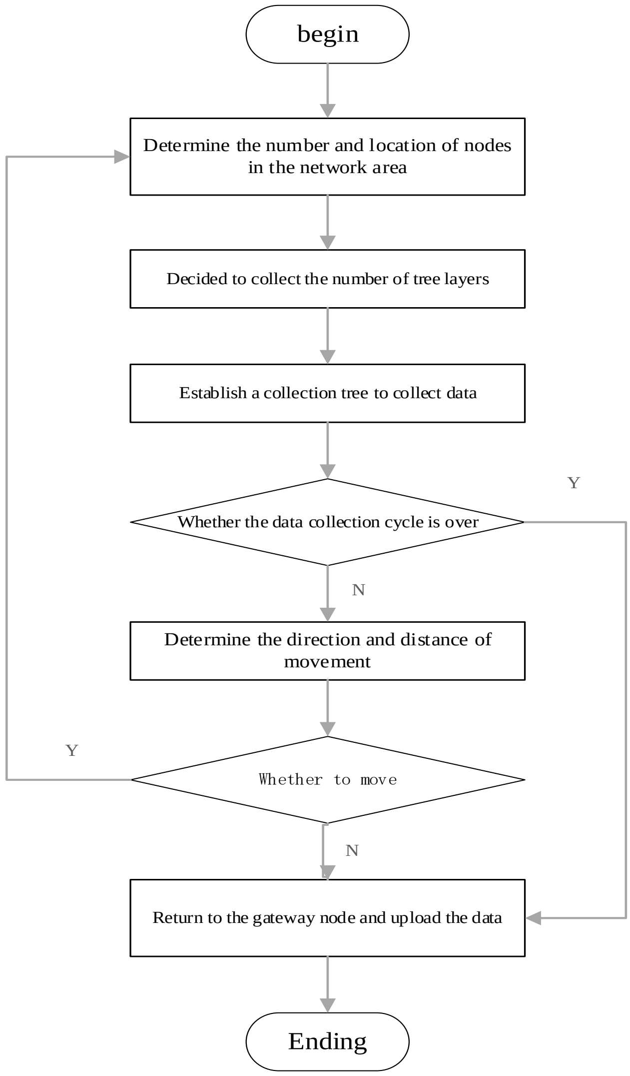

Figure 4. Algorithm flow of MDSN

4. Analysis of Experimental Results

The new MDSN motion algorithm is combined with the traditional routing protocol DSDV to form a new mobile data collection algorithm MDSNV. Through the NS2 platform to complete the experimental test, in the rectangular network area of 400 * 300, 100 static nodes are randomly generated, and the initial energy of each node is consistent.

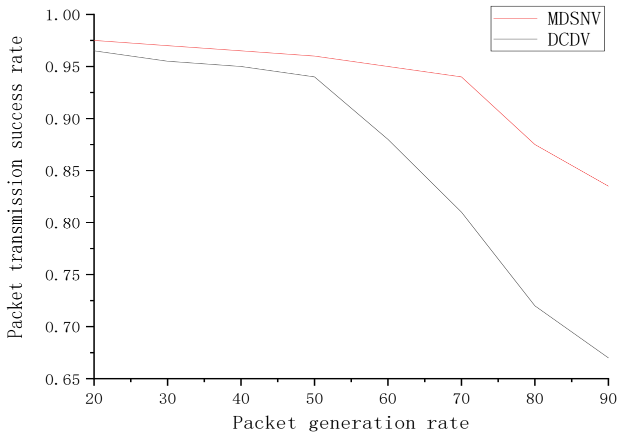

Figure 5. Success Rate of Outsourcing

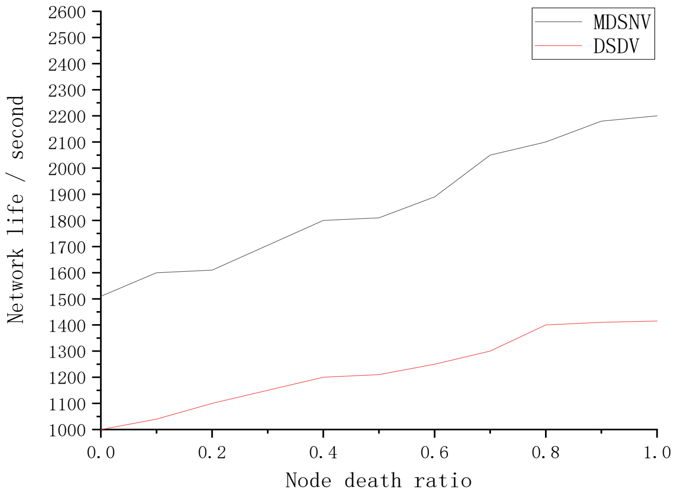

Figure 6. System life

As shown in the figure 5 and figure 6, the success rate of packet transmission under different data generation rates is revealed. After adding the MDSN, the hop count and distance of the data are effectively reduced, and the data transmission efficiency and benefit are effectively improved compared with the traditional routing algorithm DSDV. On the other hand, as shown in the figure, by comparing the network lifetimes of the two algorithms, it can be seen that after the introduction of the DSDV, the energy loss caused by multiple forwarding is avoided, and the lifetime of each static node is significantly improved.

5. Summary

In order to extend the service life of the wireless sensor network and reduce the network energy consumption, a new mobile aggregation node is added to complete the data collection in the network area. At the same time, in order to better reduce the system energy consumption, the MDSN's moving direction and distance are studied in detail, and the MDSN mobile strategy is improved. Compared with the traditional DSDV routing protocol, MDSN can not only effectively improve the data transmission efficiency of the system, but also significantly improve the network life.

References

[1] Andraws Swidan, Haytham Bani Abdelghany, Ramzi Saifan, Zeljko Zilic. Mobility and Direction Aware Ad-hoc on-Demand Distance Vector Routing Protocol[J]. Procedia Computer Science, 2016, 49 -56.

[2] Basma M. Mohammad El-Basioni, Sherine M. Abd El-kader, Hussein S. Eissa, Mohammed M. Zahra. An Optimized Energy-aware Routing Protocol for Wireless Sensor Network[J]. Egyptian Informatics Journal,2011,12(2).61-72.

[3] Shirin Rahnamaei Yahiabadi, Behrang Barekatain, Kaamran Raahemifar. TIHOO: An Enhanced Hybrid Routing Protocol in Vehicular Ad-hoc Networks[J]. EURASIP Journal on Wireless Communications and Networking, 2019(1).192.

[4] Catalina Aranzazu-Suescun, Mihaela Cardei. Anchor-based routing protocol with dynamic clustering for Internet of Things WSNs[J]. EURASIP Journal on Wireless Communications and Networking, 2019(1).130.

[5] Mohamed Elhoseny. Intelligent firefly-based algorithm with Levy distribution (FF-L) for multicast routing in vehicular communications[J]. Expert Systems with Applications,2020,140.