Design of Wireless Sensor Network Routing for Renewable Energy Microgrid

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Abstract. Wireless sensor network (WSN) is a self-organizing network composed of a large number of energy limited sensor nodes. As the wireless sensor network in new energy microgrid environment may be close to the node receiving station due to the amount of traffic and the first run out of energy, resulting in shorter life cycle, part of the micro network environment for many sensor nodes, working environment and other factors can not be timely replacement of batteries, the reliability of sensor network is difficult to guarantee. Therefore, this paper optimizes the design of LEACH routing algorithm. The simulation results show that the improved routing algorithm has obvious advantages in prolonging the lifetime of sensor networks.

Key words. renewable energy microgrid; sensor network; clustering; mobile node

1. Introduction

With the increasing penetration of renewable energy, renewable energy is becoming more and more difficult to deal with the challenges of network consolidation, energy consumption, the existence of grid-connected, low energy efficiency of long-distance transmission, high loss, low utilization of equipment, poor system capacity investment marginal efficiency and so on. Under normal circumstances, renewable energy microgrid run with large power grid. When a large grid failure is detected, it will separate from the big power grid timely and began to run independently[1]. Whether the renewable energy microgrid is running with large power grid or running independently. It is important to control the distributed power and energy storage equipment to ensure system stability. Therefore, we need real-time monitoring of photovoltaic arrays, wind turbines, batteries, inverters, controllers and other equipment timely to ensure timely, accurate, all-round reflect the operation of independent power supply network.[2]

Wireless sensor network combine sensor technology, embedded computing technology, distributed information processing technology and communication technology. It can perceive and collect the information of the monitored object collaboratively, and then And then transmit within the area and upload to the background management system. Therefore, wireless sensor network is widely used in national defense and military, environmental monitoring, urban management, health care, industrial control, anti-terrorism and many other areas. As the wireless sensor network has the characteristics of no center self-organization, dynamic network topology, multi-hop routing, limited energy and bandwidth, large network size and the nodes use the same transmit power, multi-hop relay communication and many-to-one traffic, so that the traffic distribution in the whole network is seriously
uneven. The nodes close to the receiving station is the first to run out of energy due to excessive traffic, resulting in network partition and disruption of network connectivity, then the service life of network will be a serious decline[3]. And the micro network environment for many sensor nodes, working environment and other factors can not supplement the power of battery timely, limited node energy will severely restrict the working life of wireless sensor network and increase the cost of network maintenance. It is necessary to extend the life of the sensor network to ensure reliable monitoring of renewable energy microgrid to maintain its stable operation[4]. Therefore, based on the routing algorithm of a variety of wireless sensor network, this paper optimizes the design of LEACH routing algorithm, extend the life cycle of the wireless sensor network, and realize real-time monitoring, optimize scheduling, rapid maintenance and integrated management in microgrid.

2. Analysis of Typical Routing Protocols in Wireless Sensor Network

At present, the design of wireless sensor network routing algorithm is divided into two types according to its networking and routing: plane type and hierarchical type. Among them, the planar routing algorithms are flooding, SPIN (sensor protocol for information elder negotiation), SAR (sequential assignment routing), GEAR algorithm and Direct Diffusion algorithm. Typical hierarchical routing algorithms include low power adaptive clustering routing algorithm (TEACH), TEEN (threshold sensitive energy efficient sensor network protocol) and multi-layer clustering algorithm[5-8]. The following is a brief introduction of flooding algorithm, GEAR algorithm, directional diffusion algorithm and low power adaptive clustering routing algorithm.

The multiple parameters of several typical routing algorithms are compared, as shown in Table 1.

| Table 1 Typical Routing Algorithm Performance Comparison |
|---------------------------------------------------------|
| parameter                  | Flooding | LEACH | Direct Diffusion | GEAR |
| Route optimization capabilities | no       | no    | yes             | no   |
| Network life cycle          | Short    | Long  | Long            | Long |
| Route robustness            | Good     | Better| Good            | Better |
| Resource availability       | Bad      | Good  | Better          | Good |
| Data aggregation            | No       | Yes   | Yes             | No   |
| Data / query cache          | No       | Yes   | Yes             | No   |
| Metadata description        | No       | No    | Yes             | Yes  |
| Data transmission mode      | Continuous | Continuous | Query driver | Query driver |
| Path Selection              | Multi-hop | single hop | Multi-hop | Multi-hop |

The flood routing protocol directly forwards the packets of the message to all neighboring nodes in the form of broadcasts. The Flooding protocol is the oldest and classic flood routing protocol. Its research goal is how to effectively solve the message "implosion" and "overlap" and "resource blind spot" problem; Hierarchical routing protocol efficiently transports sensor data by dividing the sensor nodes into different subnets, LEACH is the first hierarchical routing protocol proposed in a wireless sensor network; The factors that influence the formation of subnets and the communication of sub-network nodes are the hotspots of future research; Data-centric routing protocols are based on data queries and rely on data naming. Directed Diffusion is a milestone in the development of data-centric routing protocols. Efficient standard data naming mechanism and the efficient transmission of query information is the direction of future research; The location-based routing protocol utilizes the location information of the nodes for data transmission. GEAR is a location-based routing protocol that takes full account of energy efficiency[9]. The key to the study is how to intelligently utilize the location information of the nodes to achieve the goal of energy efficiency.
3. Wireless Sensor Network Mobile Node Routing Optimization Scheme

In view of the environment and business characteristics of the new energy micronetwork, this paper designs the improvement scheme of wireless sensor network mobile node cluster routing. The wireless sensor network of design includes five stages, namely cluster heads, cluster heads, node cluster, stable communication and cluster head rotation.

3.1 Clustering

Clustering is accomplished on the basis of the following assumptions: First, all the nodes in the monitoring area are known for the location information of the nodes themselves. Second, all the nodes in the monitoring area are known to the location information of the monitored range. According to the location information of each node in the monitoring range and the communication radius of the node, the monitoring range can be divided into several clusters. The monitoring nodes in each cluster decide the cluster head according to the rules mentioned below. The cluster head is responsible for collecting the cluster The data collected by the node is transmitted directly after data fusion or transmitted to the Sink node via other cluster head nodes. As shown in the figure 1, the wireless sensor play distribution area is divided into several virtual clusters. The following figure shows a schematic representation of the virtual clusters in the area.

where the wireless sensor network is located. In the monitoring area, there are 16 square areas with a length of a, and the sensor nodes in each square area form a virtual The nodes in the cluster are responsible for collecting the data and sending them to the cluster head. In order to ensure that any node in the cluster can send data to the cluster head node, the relationship between the length of the virtual cluster and the communication radius R of the sensor node is: \[ a = \frac{2}{\sqrt{2}} R \]. This setting ensures that common node data can be sent to cluster heads. The node cluster flow chart is shown in Figure2.

![Figure 1 Node clustering diagram](image-url)
Figure 2 Node clustering flow chart

3.2 cluster head

In order to select the node with the highest stability in the cluster as the cluster head, we give the concept of the stability of the node. The stability of the node is related to the residual energy of the node and the relative velocity of the node. We introduce the weight index to represent the contribution of the residual energy of the node and the relative velocity of the node to the stability of the node. Node stability is defined as:

\[ S = w_1 \times E + w_2 \times R \]  \hspace{1cm} (1)

In formula (1), \( w_1 > w_2 \), \( w_1 + w_2 = 1 \).

The cluster head node is responsible for collecting the data sent by the ordinary node in the cluster, and the data is fused to the sink node (Sink Node). Therefore, the energy consumption of the cluster head node is faster. In order to ensure the energy balance between nodes and maximize the survival time of the extension of the network, the cluster head node need to be replaced regularly. In the process of cluster head replacement, we consider two factors: first, the residual energy \( E \) of the nodes, the more the remaining energy of the node, the greater the probability that it is selected; and the second, the node in the wireless sensor network, the nodes are moving. When the cluster head node is running, it is possible to enter the range of other virtual clusters, resulting in the distance between the nodes in the cluster and the increase of the energy consumption. The worse the situation caused by the loss of data, so we consider the node movement speed as a factor, \( R \) take a negative value, the greater the node movement speed \( R \), the lower the probability of being selected as the cluster head node.

The node residual energy \( E \) is defined as:

\[ E = \frac{\text{Energy}_{\text{residual}}}{\text{Energy}_{\text{average}}} \]  \hspace{1cm} (2)
In the formula (2), the \textit{Energy\_residual} is residual energy of the node \textit{Energy\_average} is the average energy of the nodes in the cluster.

The node motion velocity \( R \) is defined as:

\[
R = - \frac{V_c}{V_{MAX}}
\]

In equation (3), \( V_c \) is the current velocity of the sensor node, \( V_{MAX} \) is the maximum velocity of the sensor node.

In the above figure 2, the overlapping of the signals is generated in the adjacent clusters. The nodes in the overlapping area can receive the broadcast information sent by the cluster heads. After receiving the broadcast message sent by the first cluster head, If the node is able to receive broadcast messages from other cluster heads, it will compare the distance between the node and the cluster head. If the new cluster head is closer to the node, the node will join the new cluster. Otherwise, the cluster will be ignored. Head broadcast message.

4. Simulation analysis

In this paper, we use matlab to compare the performance of the proposed routing protocol with LEACH routing protocol. Firstly, the network lifetime of the two algorithms is simulated and analyzed. The lifetime of a wireless sensor network is defined as the time from the beginning of the simulation to the failure of the first node in the network. If the remaining energy of the node is less than 5%, the node is considered to be exhausted.

Simulation parameter setting, such as table 2. The monitoring area of the wireless sensor network is set to 200m × 200m square area. 400 wireless sensor nodes are randomly arranged in the monitoring area, and the Sink node of the network is set in the upper right position, that is (200,0). The initialized energy of all nodes in the simulated wireless sensor network is the same, set to 1J. All nodes in the wireless sensor network can move, the maximum speed \( V_{MAX} \) is 2m/s, the actual movement of the node \( V_s \) takes a random value between 0 ~ \( V_{MAX} \).

| Parameter                      | Setting parameters       |
|-------------------------------|--------------------------|
| The size of the sensing area  | 200×200                  |
| Number of sensing nodes       | 400                      |
| Send energy consumption       | \( \delta \times \text{Dist3} \) |
| The initial energy of a sink node | 5J                       |
| The initial energy of an ordinary node | 1J             |
| Broadcast energy consumption  | 0.0001                   |
| \( \delta \)                  | 0.0001*(1/(25^3))        |

Figure 3 Continuation of the relationship between the death time of the first node and the number of network nodes
Figure 3 shows the relationship between the death time of the first node and the number of nodes in the network. The figure shows the time corresponding to the energy consumption of the wireless sensor network at the first node. The size of the network is different, and the time at which the first node is exhausted is different. Figure 2 shows the time at which the network's first node dies when the network size is from 200 to 600 nodes. As can be seen from the figure, the larger the network size, the earlier the death of the first node. By using the algorithm proposed in this paper, we can delay the death time of the first node of the network to a certain extent and improve the life cycle of the network.

5. Conclusion
Based on the analysis of the routing algorithm of traditional wireless sensor networks, this paper proposes an improved mobile node clustering based on clustering, cluster node selection cluster head, node into cluster, stable communication and cluster head rotation based on Leach algorithm algorithm. The simulation results show that this algorithm has obvious advantages in prolonging the life cycle of wireless sensor network and provide a favorable foundation for the reliable operation of wireless sensor network.

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