Research of Routing Protocol for Wireless Meter Reading System

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Abstract. To improve the data transmission reliability of wireless meter reading system, a bidirectional routing algorithm is proposed. The routing algorithm is developed to make all nodes in the network establish optimal routing and register a complete neighbor table for routing maintenance. The neighbor exchange mechanism based on Hello Packet can timely detect changes in network topology and solve the problem of nodes flexibly coming in or out of the network. Simulation and system testing have all verified the reliability and usefulness of the algorithm which can satisfy the need of wireless meter reading application.

Introduction

According to the ministry of construction proposed a well residential district planning requirements[1], measures will be put forward to implement the unified management of water, electricity and gas meter, realize computer automatic monitoring, measuring and charging, suitable for the requirement of the social overall development.

At present, China's automatic meter reading technology mainly include the IC card, electric power carrier meter reading and RS485 bus meter reading, but these techniques each have a lot of disadvantages[2]. IC card meter can't realize online real-time monitoring because table with direct contact with the user is easy to damage. Power carrier meter reading is susceptible to electromagnetic interference, seriously affect the quality of communication. RS485 bus meter reading technology, the data transmission reliability is higher, but the wiring is difficult and the late maintenance is complex. Wireless meter reading technology is easy to implement, high transmission rate, low cost and easy to popularize, will become the inevitable trend of the future development of Chinese public utilities.

System organization

The wireless meter reading system mainly consists of three parts[3].

(1) intelligent wireless gas meter, which is installed on the user home, is responsible for data acquisition, compute and wireless transmission;

(2) the center node, installed between the many buildings, its computation and storage abilities are stronger than ordinary nodes, it is mainly responsible for forwarding data come from wireless nodes and server;

(3) server management system, general installed in the energy management company.
The system adopts passive meter reading method, center node receives commands sent from the server management system, then inform wireless node to upload data. The node finds the optimal path by querying the routing table to upload data to the center node, and finally by GSM, GPRS and 3G wireless technology center node forwards packets to server management center. The communication reliability is an important index of performance measure of wireless meter reading system[4]. This Paper make a study of the downward communication network between user meter and center node, proposes a bidirectional routing algorithm for wireless meter reading application, through routing build and maintain mechanism to guarantee the reliability of the communication link. Finally, software simulation and system testing are carried out to verify the reliability.

Routing Algorithm

Routing establishment algorithm. Each node in the network have a neighbor list[5], on which information of the node within the scope of one-jump has registered for the routing maintenance. neighbor table structure as shown in Table 1.

| Name          | Attribute                                      |
|---------------|------------------------------------------------|
| Node_Address  | The address of the neighbor node.              |
| Node_length   | The depth of the node, the distance indicators between node and center node. |
| Rssi          | Link quality, the sum of each jump link Rssi. |
| Relation      | The relationship with neighbor node.          |
| State         | State of the node: online or offline.         |
| Fail_time     | Failure times of the exchange of Hello message.|

1. At first, the center node builds Route Request Packet, which contains distance message 
   Node_length. Node_length is initialized as 0, the destination address for the entire network broadcast address is initialized as 0xFFFFFFFF, then put Route Request Packet into the network;

2. Each node in the network maintains its own depth property iNode_length, namely the distance between current node and center node, power on initialization for 0xFF. When receiving Route Request Packet relayed by different neighbor node, the node compare Node_length value with their own depth value iNode_length. If Node_length + 1 < = iNode_length, modify its depth attribute value iNode_length = Node_length + 1, add the information of upper hop node to the neighbor table, set Relation=Parent, modify the value in Route Request Packet,such as current node address replace as upper hop address, Node_length+1, and continue to broadcast the Route Request Packet. If Node_length > = iNode_length, only registered the upper hop node to its neighbor table, no longer to forward the packet.

3. After forwarding Route Request Packet, node access to its neighbor table to choose the optimal parent node and register it to the routing table, then package and send routing table information to the parent node. The optimal parent node selection algorithm is as follows[6]: 1) the minimum value of Node_length, 2) the optimal node link quality.

4. After the node receiving routing information from child node, register routing information of child node in its routing table and continue to upload it to the center node. Routing establishment algorithm flow chart is shown in Fig. 2.

The bidirectional routing algorithm makes all nodes in the network establish optimal routing, register a complete neighbor table. Through the registration of routing information, the nodes establish a downlink routing to child node. In this process, the node registers a complete neighbor table and increases redundant route, at the same time, updates the neighbor nodes’ state timely and improves the reliability of the algorithm.
Routing maintenance algorithm. Low power consumption, external disturbance or man-made factors will make node offline. In addition, the node’s replacement and new node into the net will also bring some changes to the network. According to this, routing maintenance algorithm based on bidirectional Hello Packet is proposed to keep reliable routing to server.

Fig. 2 Routing algorithm flow chart

Nodes in the net periodically broadcast the Hello Packet to the neighbor node, the destination address of Hello Packet is one hop broadcast address 0xFFFFFFF1. When neighbor nodes receiving the Hello Packet, add its depth value of iNode_length into packet, modify the value of destination address for the current node address, then single-route broadcast to the source node. Once the source node receives the Hello Reply Packet, check its neighbor table:

1) If the node is already in the neighbor table, update the corresponding node attribute values in the neighbor table. For example, update the depth value of iNode_length and reset the value of Fail_time to zero.

2) If the node didn't receive the neighbor node’s Hello Reply Packet in a certain period of time, change the neighbor node’s State value to offline and check the Fail_time value of neighbor node in the table. If Fail_time < MAX_FailTimes, Fail_time value plus 1. If Fail_time = MAX_FailTimes, indicated that the neighbor node has left the network, then clear the node information in the neighbor table. If the neighbor node is a parent node in the routing table, indicate that the routing to server is failure, then select the optimal node from the neighbor table to update the routing table, and through the new parent node sending Routing Update Packet to center node. If the neighbor node is a child
node in the routing table, then delete this neighbor node’s information, send Routing Update Packet to center node.

3) if the node do not exist in the neighbor table, indicate that the node is a new node, then make the node’s information registered in the neighbor table, through its parent node uploading Routing Update Packet to center node.

Once a new node is power on, it will regularly send the Hello Packet, according to the Hello Reply Packet received from its neighbor node, the new node will join their neighbor node into its neighbor table and select a optimal parent node to register it to the routing table. At the same time, the new node sends Routing Update Packet through the parent node to the center node.

Routing Algorithm Simulation
The wireless network model is established through the network simulation software OMNeT++[8] to verify the reliability of the routing algorithm. The network coverage area is 500 m x 400 m, the wireless channel bandwidth is 1 m, network node number is nine, node’s maximum transmission distance is 100 m. Network topology is shown in Fig. 3. Assume that node distribution is relatively uniform, sink node in the system regularly send Route Request Packet to every intelligent wireless node. Nodes in the net reply response to center node through their parent node.

As data transmission diagram shown in Fig. 4, each node in the network maintains its optimal route to the central node, along the optimal route data was transferred to the center node. For example, the 3 node uploads its data to the sink via 2_0 and 1_0 node. Fig. 5 is data transmission diagram after the 1_0 node become invalid, it can be seen that 2_0 node choose the 1_1 node as a new parent node to update its routing table, ensure reliable route to the center node.
System Testing

A wireless monitoring software is developed to test the wireless meter reading system, mainly includes networking testing, the node parameter configuration testing. As shown in Fig. 6, monitoring software sends Route Request Packet to 40 nodes, terminal nodes complete routing registration and return routing information to server. Fig. 7 is the parameters configuration response picture. System testing further verifies the stability and reliability of the routing algorithm in wireless meter reading applications.

![Fig. 6 The networking response of 40 nodes](image)

![Fig. 7 The parameters configuration response](image)

Summary

This paper proposes a bidirectional routing algorithm oriented for wireless meter reading application, this algorithm makes each node in the net establishes its optimal routing to the center node, reduces the network load. Neighbors exchange mechanism based on the Hello Packet can be effective for routing maintenance. The routing algorithm has low complexity and high reliability. Simulation and system testing all prove the feasibility and effectiveness of the algorithm. But the problem of the conflict in packet transmission remains further research.

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