Research on the ZigBee Network Protocol Intelligent Meter Reading System

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Abstract. Wireless Sensor Network, WSN to the exchange of data with each other must have the appropriate wireless network protocols, wireless protocols difficult to adapt to the traditional low-cost wireless sensors, low power, high fault tolerance requirements. In this case, ZigBee protocol came into being. ZigBee is an emerging short-range, low complexity, low-speed, low power, low-cost wireless networking technology, mainly for short-range wireless connection. It is based on IEEE 802.15.4/ZigBee protocol standards, in thousands of tiny sensors to achieve communication between the coordination. This background paper, based on ZigBee wireless meter reading system proposed routing algorithms and networking. In-depth analysis of several typical wireless sensor network routing protocols, through a network of some of the traditional routing algorithm feasibility, problems and improvement of, for the ZigBee standard in the meter reading system, designed for meter reading system Network routing algorithm, the test achieved the mesh point to point communication between modules[1].

Keywords: automatic meter reading, wireless sensor network, ZigBee, routing.

1 Introduction

With automation and the rapid development of measurement technology, people's lives, raising the level of intelligent home conditions, the indoor measurement instrument automatically Collecting data has gradually become the goal. Meanwhile, public utilities management also hopes that the new technology can solve the long plagued their meter reading difficult, difficult issues such as fees, in order to achieve savings in manpower, reduce corporate liquidity occupancy, user, and improve management purposes[2].

Existing wired meter reading system has many problems: to assume different functions of all kinds of cables, data lines on the one hand restrict the operator's hands and feet, on the other hand is a waste of electrical supplies. If installed in the indoor and outdoor long-term, likely to cause aging lines, there are short, the risk of disconnection, and the waste line, the cable will cause environmental pollution, in addition to improper due to aging and the layouts will be planted for the safety of no small risk.

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With the continuous development of wireless communication technology in recent years, low-cost equipment for the emergence of wireless networking requirements of the technical - ZigBee technology, it is a short distance, low complexity, low power, low data rate, low-cost Two-way wireless communications technology, mainly used in the field of automatic control and remote control. Although there are many successful development of the wireless meter reading system, but ZigBee's excellent performance, low power, high integration and low cost, has a very strong market competitiveness[3].

2 Backgrounds

2.1 ZigBee Protocol Architecture

As the wireless market and the high efficiency of the network growing demand for standardized, ZigBee protocol as to support low-rate, low power, secure and reliable wireless networking standards have emerged. A complete ZigBee protocol stack mainly application specifications component by the physical layer (PHY), media access control layer (MAC), network layer (NWK), security layer and high-level. Among them, the physical layer and MAC layers defined by the IEEE 802.15.4 protocol standard, the network layer and application layer developed by the ZigBee Alliance[4].

2.2 Network Layer

ZigBee network layer is the core protocol stack, which is responsible for the application layer to provide the right service interface, while on the IEEE 802.15.4 standard defines the MAC layer for proper operation. Including the network layer network layer data entity (NLDE) and network layer management entity (NLME) two service entities. Provide data transmission services which NLDE, NLME also responsible for providing management services and the network layer database - network information base, NIB[5].

Network layer will mainly consider technology-based Ad Hoc network protocols, is responsible for building and maintaining topology, naming and binding services, including the addressing, routing and security of these essential services, there are self-organizing, self-maintenance functions, to Minimize maintenance costs and consumer spending.

IEEE 802.15.4 network is the Personal Operating Space, POS use the same radio channel of mutual communication through the IEEE 802.15.4 standard set of a group of devices, also known as LR_WPAN (Low-Rate Wireless Personal Area Network) network, that is, low data rate Wireless personal area network. In this network, in accordance with the communication capabilities of the equipment can be divided into Full Function Device, FFD and Reduced Functions Device, RFD. And between the FFD and RFD FFD can communicate between; RFD cannot be communication between the only communication with the FFD, or forward the data out through a FFD.

In the IEEE 802.15.4 network, the one called PAN (PAN Coordinator) of the FFD, is LR_WPAN network master controller. PAN Coordinator in addition to direct applications, but also complete membership management, and link state information management and packet forwarding tasks. IEEE 802.15.4 WPAN has the following characteristics:

1. Scalable: excellent network capabilities, up to 254 network devices on dynamic device addressing.
2. Adaptability: The seamless integration of existing control network standard. Coordinated through the network automatically establish a network, using CSMA / CA channel access way.
3. Reliability: For reliable transmission, provide full handshake protocol.

2.3 Network Topology Structure

Zigbee standard specifies the network topology structure: star, tree and mesh structure. and they may be summarized as point-to-point network. as shown in Figure 1.

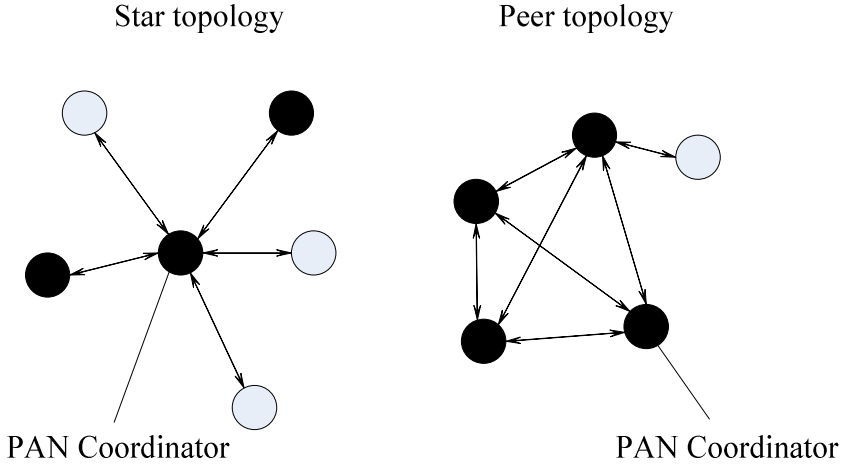

Fig. 1. Star and mesh topology graph

In a peer-to-peer network, there is a pan coordinator, which is initiated and organized by the network. a device on the other communications equipment, they can communicate. on the internet, the various devices to send a message when using a lot of dance and to build the network coverage. each separate pan has a unique identifier paid to the same network nodes to identify and communicate with each other. This used to wait for the topology as a network; coordinator of the first node has initiated a pan, the node in the organizations to join[6].

3 Network Routing Algorithm

Routing protocols will be responsible for the data are from the source through a network node to node forwards the purpose, it mainly include two aspects of search function: source and destination node to node between; the path of data grouped along the path to the right forward. Sensor in wireless network, sensors network node numbers, and the nodes usually by energy limited battery operated, the routing protocols for the local network information on the basis of the ability to choose the path and the efficient use of energy. Wireless network to meet the sensor: energy efficient, reducing redundancies, information, extensible, robustness, and they can outdo and security, etc. In order to save costs and reduce energy consumption, ZigBee in a network of the functions are simplified, these nodes can only a simple transceivers, and cannot act as routers. Following are introductions to some sort of typical routing, and to proceed to the improved technology, combined with ZigBee applied to the wireless network list system[4].

3.1 Flooding Routing Algorithm

Flooding is a data in the center plane of the route is the traditional network of communication routing protocols. Its design philosophy is: node generates or receives data broadcast to all neighboring nodes, the data packets reach their destination until it expires or stop transmission. The protocol has serious flaws:

1. Implosion. Nodes also received a number of neighbor nodes from the same data, shown in Figure 2.
2. Overlap. Node has received a number of nodes in the same area sent the same data.
3. Blind use of resources. Node does not take into account their resource constraints, in any case forward the data.

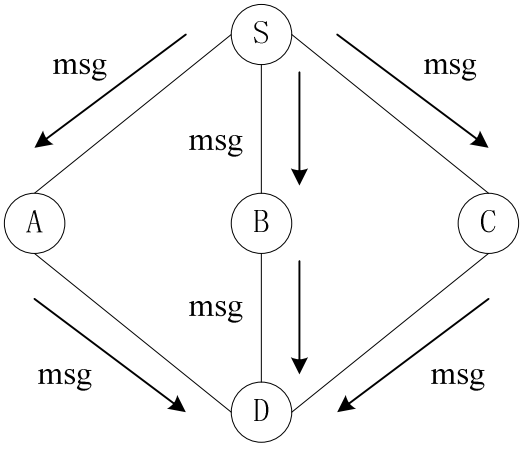

Fig. 2. Flooding implosion phenomenon

3.2 AODV Routing Algorithm and Its Improvement

AODV is on-demand routing algorithm, dynamic route discovery, maintenance mechanism and purpose of the sequence. AODV routing information obtained as follows: When a network node needs a route to reach another node, the source node broadcasts to all its neighbors a route request packet, the neighbor nodes in the network by way of Flooding in the dissemination of RREQ packets until the RREQ packet reaches the destination node or routing information can provide an intermediate node. In the dissemination process, the serial number is used to distinguish between the old and the new RREQ packet, to prevent routing loops. RREQ packet for each of the intermediate nodes forward it to create a temporary, to reach the source node routing, the route known as reverse route. When the RREQ packet reaches the destination node or a certain routing information to provide the intermediate nodes, a route reply packets at the path that RREQ packets sent back to the source node. When RREP transmit to the source node, for each of the intermediate nodes forward it to establish a route to the destination node, the route known as the forward routing. According to the source node receives the RREP packet to the destination node by its own route. When the source is moved, it will re-initiate route discovery algorithm; if the intermediate nodes move, then the adjacent nodes will find the link failure sends to its upstream node and link failure message has been spread to the source node, then the source node According to re-initiate route discovery process conditions[7].

Among the AODV algorithm, Flooding broadcast although improved, but the same node will repeat the broadcast packets redundant, so that power consumption greatly. And to receive intermediate nodes only handle the first RREQ, the RREQ packet received will be repeated regardless of how its performance, be discarded, which is equivalent to giving up the path later, then when the node failure on a route had to restart mechanism for routing the search request. This may lead to the efficiency of way finding and route efficiency not high.

For above, give a simplified version of the AODVgj. It has the main function of AODV, but taking into account cost, energy saving, ease of use and other factors, some of the features simplified AODV. This algorithm is characterized by the formation of the routing number after launch from the source node to destination node disjoint paths, when the path is interrupted for any reason, then the interrupt when the source node receives the report of the path, will first look for the results of the last route request whether there is a valid path, if it exists, the path to route data according to the new, if not a valid path, only to re-initiate route request command[8].

3.3 Cluster-Tree Algorithm and Its Improvement

Cluster tree algorithm is a typical cluster routing algorithm. In hierarchical routing, wireless sensor networks are usually divided into several clusters; each cluster consists of a number of cluster heads and cluster membership, the formation of multiple clusters of the first high-level network. In the high-level network, and can be divided into clusters, the formation of a higher level of network again until to the highest level of convergence node.

The core of the algorithm is to find whether the data to be transmitted is itself, if so, is no longer forwarded. If not, see if it came from a valid path, the so-called effective path is from the parent or the child came from, if the child node from the data, according to its destination to be reached, if it is a child of their own, then forwarded to the child node to the end, if not his own child, to reach the next address is the parent node, and thus a level, along the tree until you find the destination address.

Advantages of this algorithm is: clever use of the distribution of the various network nodes get the address properties of the tree was to select routes, equipment, do not keep in memory a routing table, nor take up the path to complete that operation, thus making the whole network traffic significantly reduced. Tree routing algorithm, but there are also many disadvantages, because according to an address on the routing tree structure, can not take the shortest path, the path to take longer than the actual.

The address allocation in improving the way is still assigned to the route for some address space to expand its child devices, and terminal equipment is assigned only a single address. Based on the above address assignment logic, by querying the destination address in the packet as long as a node to be able to easily move data packets transmitted to its destination. Way through this inquiry that is, the node simply decided to transfer its data packet to its child nodes, or terminal equipment of its routes to its parent node or child node.

The address allocation in improving the way, is still assigned to the router device to further a certain address space for its child devices assigned address, and terminal equipment is assigned only a single address, so it does not allow any child other equipment. Based on the above address assignment logic, as long as a node in the packet by querying the destination address to be able to easily move data packets transmitted to its destination. Way through this inquiry that is, the node can decide to pass its packet to its child nodes, or terminal equipment of its child nodes the router or its parent node. The data routing is to improve the cluster tree routing algorithm, the basic process algorithm shown in Figure 3, if the data transmitted from the FFD nodes (child nodes route), the first of the node to determine whether the data passed to itself, if it is received And by the upper handle, if not further to determine whether to pass to its child node that is to determine whether the packet destination address within its address space, and if it will forward the packet to its corresponding child nodes, if not in its address space Range, it will forward the packet to its parent node. When a packet is forwarded to its child nodes, and then determine whether the route of the child nodes of child nodes, if not the child node routing, that is the RFD node, packet processing directly by the upper node, if the child nodes for routing in accordance with the above Data processing to determine processing again.

3.4 Meter Reading System Routing Algorithm

Cluster tree-based routing algorithm, the device can be immediately passed to the first network packet to other devices without having to perform route discovery process. However, from the number of hops cost point of view, most of the cluster tree routing is not the best route. And the cluster tree routing can also lead to non-uniform flow distribution. Therefore, in the ZigBee wireless meter reading network, you can take the

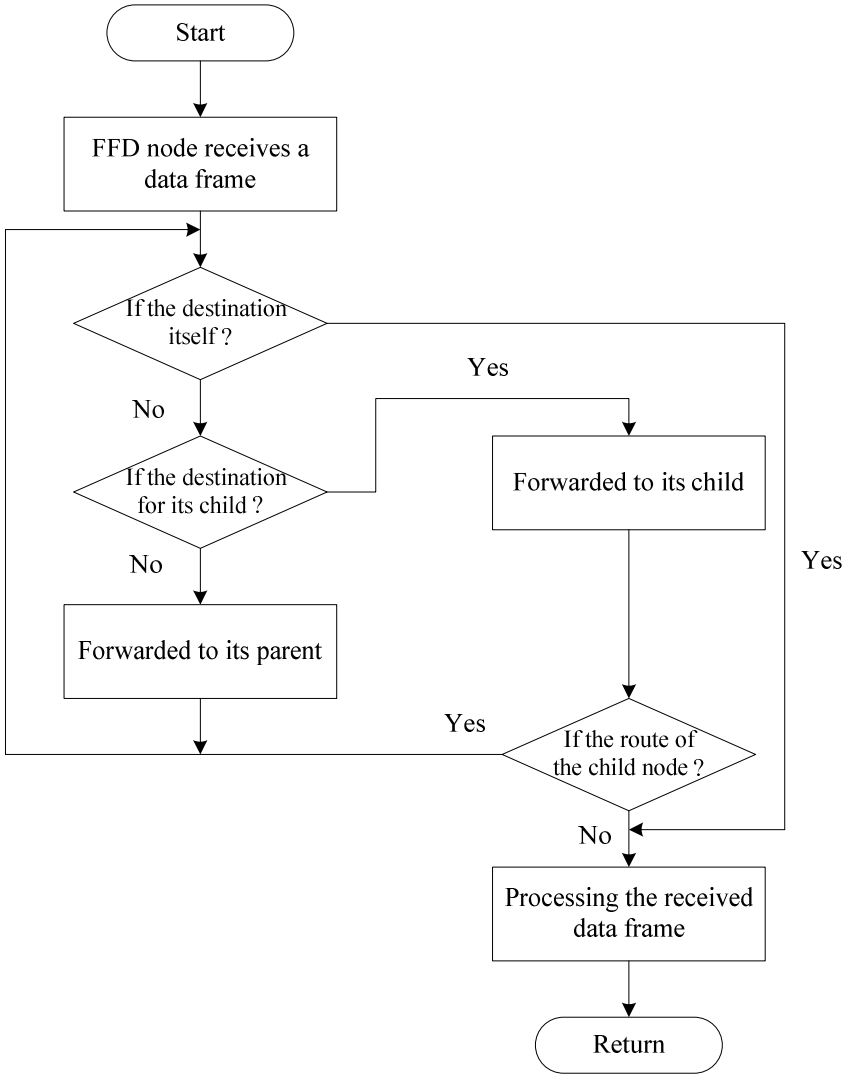

Fig. 3. Basic flow cluster tree routing algorithm

cluster tree routing table based on demand-driven routing algorithm for routing that AODVgj way to overcome the combination of the above-mentioned phenomenon.

Cluster-Tree AODVgj improved routing algorithm brings together the Cluster-Tree and the advantages of AODV. Each node in the network is divided into four types: Coordinator, RN, RN-and RFD, routing node; where RN is sufficient storage space and capacity to implement AODVgj node routing protocol, RN-is its storage space by limited agreement that does not have the ability to perform AODVgj node, RN-After

receiving a packet with the Cluster-Tree algorithm can handle. Coordinator of the routing algorithm in which the same with the RN, Coordinator, RN and RN-are the FFD nodes, give the other nodes act as a routing node; RFD can only act as Cluster-Tree terminal child nodes. If the target node to send data to be their own neighbors, direct communication can be; the other hand, if not their neighbors, the three types of nodes to process the packet differently: RN to start AODVgj find the best route to the destination node , and it can play the role of the routing agent to help find other nodes route; RN-only use Cluster-Tree algorithm, which can be calculated to determine the packet is its own parent or a child node and forwarding; and RFD only the data to the parent node, please forward it.

Figure 4 for the Cluster-Tree + AODVgj diagram of the network layer data transmission. Nodes send packets to node N3 N4, figures represent the time sequence of all packets. It can be seen from the figure, the type of the node N3 is the RFD, it can only send packets to its parent node DATA N1. N1 is the type of RN +, so it first data into the cache, and then through the multicast request packet RREQ AODVgj find the routing node N2, node N4 and then through the shortest uncast path along the N4-N2-N1 to the node N1 Reply AODVgj reply packet RREP. Node N1 to find routes, the cache data along the N1-N2-N4 sent to the node N4, node N4 and then along the N4-N2-N1-N3 send a confirmation packet ACK to node N3, node N4 receive a confirmation packet, the entire communication process end.

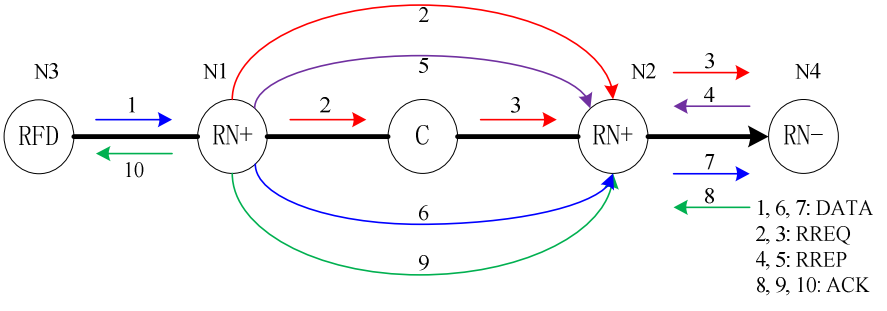

Fig. 4. Schematic diagram of network layer data transmission

4 Route Establishments

ZigBee routing protocols, RN-node needs to send packets to the network using a node in the Cluster-Tree routing to send packets.

RN + node sends a packet to the network but no access to the destination node in the routing table entry, it will initiate route discovery process:

1. Create node broadcasts a RREQ to the group around the node, the node if the received RREQ is a RN-node, it forwards by Cluster-Tree Routing in this group; If you receive a RREQ the node is a RN, is based on the information in the RREQ establish the appropriate routing table entries and routing table that entry and continue to broadcast this group.

2. Nodes will be calculated before forwarding the RREQ RREQ to its neighbor nodes send with the link cost between nodes and add it to the link stored in RREQ overhead, and then the link will be updated into the route discovery overhead table entry.
3. Once the RREQ reaches the destination node or destination node of the parent node, the node replies to the RREQ source node, a RREP packet, RREP should be established along the reverse path transmission to the source node, the node receives RREP to the destination node to establish forward path and update the corresponding routing information.
4. RREP before forwarding node will be calculated in the reverse path with the next hop link cost between nodes and add it to the link stored in RREP overhead. When the RREP reaches the corresponding RREQ initiator node, the route establishment process is complete.

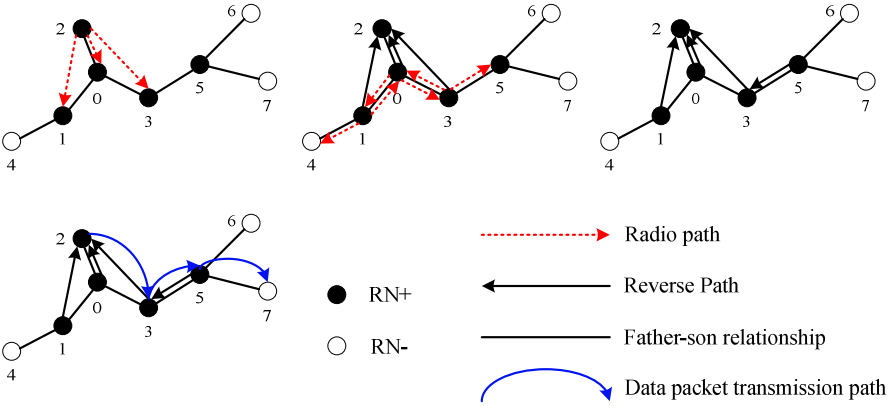

Fig. 5. ZigBee routing set up process

Figure 5 is an example of route establishment. Where node 0 is the focal point for ZigBee, if node 2 sends data packets to the node 7, but did not reach the node routing table 7 of the route, the node 2 is the RN nodes, so it will initiate route discovery process. Around node 2 to node broadcasts RREQ created (Figure a), nodes 0,1,3 established after receipt of RREQ reverse route to Node 2, and continue broadcasting RREQ (Fig. b), but not to the parent node broadcast sent, only the route to be broadcast the same level. Figure 3 c node has been forwarded RREQ, so it is no longer forward the packet; the node RN-4 is a node, does not have routing functions, it was found that they are not receiving RREQ the destination node, it will stop broadcasting; node 5 found RREQ the destination node is a child node of its own, it will replace the destination node along the reverse path to the newly created RREQ source node (Node 2) return a RREP, the establishment received RREP to the destination node node (node 7) positive route. RREP reaches the source node 2, the route establishment process is complete, the data packet along the path 2-3-5-7 just found transmission (Figure d). If the node 7 wants to send data packets to node 2, since node 7 is the RN-node, it only sends the packet to its parent node (node 5), initiated by the parent routing node, the process of building.

Network layer to achieve the following functions: power on any one node can work automatically join the network, automatically find their own parent; any one node of the power of information transmitted through a limited jump to reach the coordinator; any one node because leave the network for some reason, when the network does not affect other nodes, the network can automatically heal, that is, the original node to forward data through the nodes to find a new parent as a way to forward the data.

5 Comparison of Simulation Performance

Experiments using OMNet + + simulation tool, based on discrete event OMNeT + +, is a free, open source multi-protocol network simulation software, in the field of network simulation plays a very important position. OMNeT + + English name is Objective Modular Network Testbed in C + +, in recent years in the field of science and industry, an increasingly popular component-based open modular network simulation platform. In the simulation, defines the following scenario: A total of eight nodes 0, 1, 2, 3, 4, 5, 6, 7, parameter is set to: data rate = 1Mbps, delay = uniform (0.1ms, 1ms), packet length = uniform (128byte, 1024byte). However, the definition of routing protocols, respectively, using different protocols: AODV and AODVgj.

5.1 Figure 6 is Obtained Using Different Protocols with Different Data Plans

The experiment can be clearly seen that makes use of AODVgj overall network traffic routing protocol AODV routing protocol than with many stable and AODVgj routing protocols make the network link is more smooth, can send and receive large amounts of data packets.

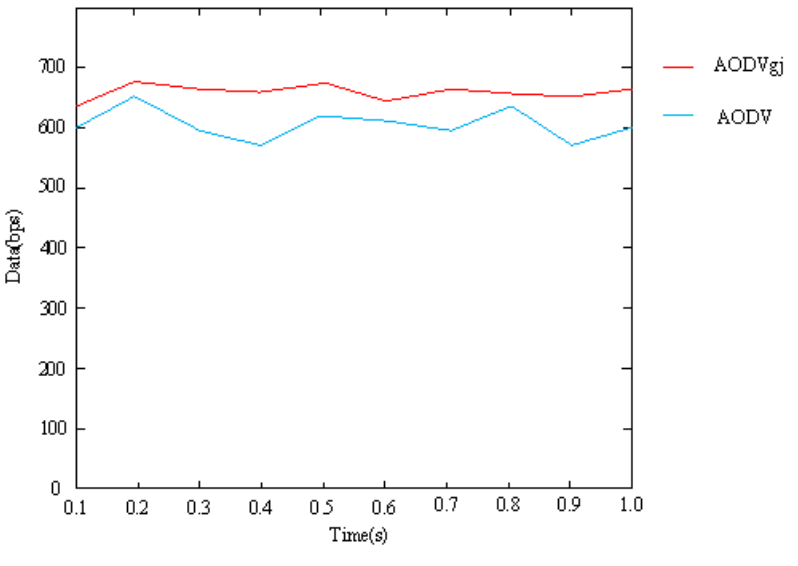

Fig. 6. Routing data

5.2 Figure 7 AODV Routing Overhead and AODVgj

Routing overhead: Every packet needs to send a data packet number of routing control. It reflects the degree of network congestion and node power efficiency, cost, the probability of a large great deal of congestion, and will delay sending the packet interface queue. Routing overhead for route discovery and route maintenance for the control group received the number and ratio of the number of data packets.

The experiment can be clearly seen that the routing protocol makes use of AODVgj overall network congestion is much smaller than that of AODV, routing protocol and makes the node AODVgj power efficient.

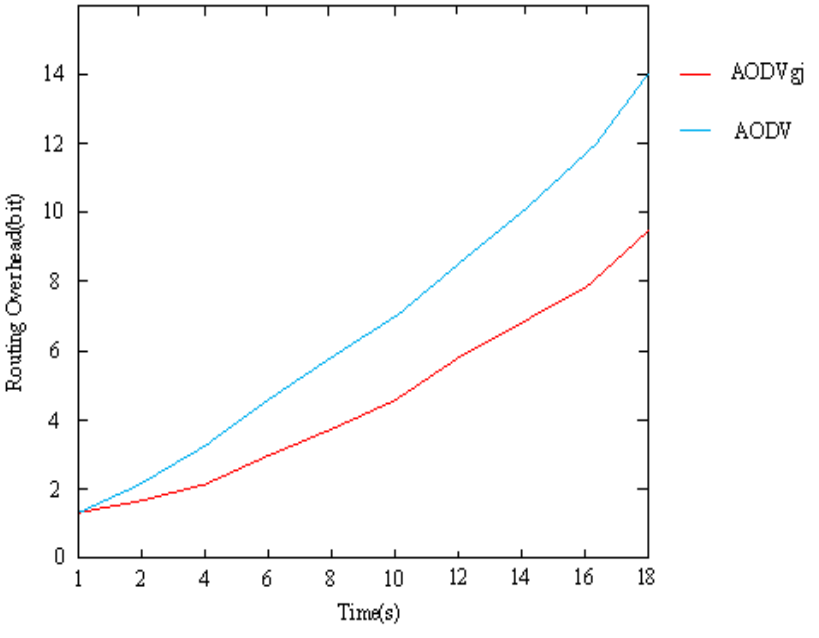

Fig. 7. Routing overhead

6 Conclusion

This study compared the traditional for wireless sensor network routing algorithm, in the ZigBee network layer protocol analysis, based on the characteristics of wireless sensor networks to improve it, make meter reading system for the routing algorithm. This article ZigBee standard implementation of the new wireless meter reading, and widen the scope of application of the ZigBee standard to solve the traditional manual meter reading and other drawbacks of the model. Experiments show that the performance indices in different embody AODVgj excellent than AODV, but not as

good as the experience, there are many research and operational needs further. This paper is supported by " The 211 Project Central Special Fund of Hainan University " .

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