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Research and Implementation of Ad Hoc Network Protocol in Wireless Sensor Networks

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Abstract: In wireless sensor networks, the ability of the nodes to find themselves on the network is very important in Wireless Sensor Networks. In the light of research on ad hoc networks in Wireless Sensor Networks, a self organizing protocol for wireless sensor networks based on MSP430F149 and nRF905is proposed and a wireless network with low power consumption is realized in this paper.
Keywords: Ad Hoc Network, Wireless Sensor Networks, Network Protocol, Protocol Format.

1. Introduction

Wireless sensor network (WSN) is composed of a number of sensor nodes with low power consumption and small size. These distributed nodes can cooperate with each other to monitor, perceive and collect the information of various kinds of environment objects, which has a very broad application prospect [1]. In recent years, the research progress of wireless sensor networks is very rapid and has made a lot of research results. Self organization algorithm is one of the core technologies of wireless sensor network, and it can improve the efficiency of routing protocol and MAC protocol and establish the foundation for data fusion and time synchronization and target positioning and many other aspects through good network topology automatic self organizing algorithm, but also conducive to save node energy to prolong the network lifetime. Researchers at home and abroad have drawn on the valuable experience of ad hoc network, and put forward the self-organization algorithm with various forms and different emphases.

In the literature [2], a traditional flooding algorithm is proposed, which is also the earliest and simplest routing protocol. In the form of broadcast message sending node, the node receives the message to broadcast packets to all neighbor nodes and this process is repeated until the packet reaches the destination or the maximum hop preset number. The most representative hierarchical self organizing algorithm (LEACH, low energy adaptive clustering hierarchy) is proposed in literature [3]. LEACH is a low-power adaptive clustering routing algorithm designed by MIT et al. Heinzelman for wireless sensor networks. Mainly through the random selection of cluster leader, the average allocation of relay communication services to achieve. Literature [4] gives a data centric self-organizing algorithm SPIN (Sensor Protocols for Information Via Negotiation). Its main idea is to name the sensing data by means of high-level description metadata. Before sending the real data, the sensor node broadcasts the descriptive metadata of the collected data, and sends the data to the destination when there is a corresponding request. All of these researches have made progress in the self-organizing algorithm of wireless sensor networks. However, there are some defects in flooding algorithm. The dynamic clustering of LEACH brings the extra cost of topology transformation and mass broadcasting. There is no uniform form of metadata in SPIN, and the topology change of SPIN is local, so it is not suitable for high reliability applications. There are many other related algorithms in the theoretical stage. These studies have made progress on the self organization algorithm in wireless sensor network, but did not consider many factors in practical application, such as not easy to realize, the convergence of the algorithm, how to reduce the interference of external factors on communication, and node failure after supplementary etc..

According to the current research status of wireless sensor network self organizing algorithm, this paper proposes a self organization protocol is simple and easy to realize, using MSP430F149 MCU as the processor, the design of micro sensor nodes, and implements a low-power wireless network. Nodes can automatically generate multi-level mesh network by using the proposed protocol, and at the same time, according to the principle of energy priority, the transmission path of data can be determined. The software developed by the host computer can automatically display the topology of the network, reflect the change of the state of the sensor node, and display the path of network data transmission in real time. When the network topology changes, PC software will be reflected in time. The intelligent control strategy can greatly reduce the power consumption of the system.

2. Self-organizing Protocol

In the protocol, the self organization of nodes is realized by defining the format and key of the data packet. The data packet contains a key word and a plurality of bytes of data, so long as the corresponding information is filled in according to the format of the data packet, the self-organization function can be realized. More than one byte includes the node's own information, packet hops, data routing and other information; the key word to express the different nature of the packet, to distinguish between the various circumstances of the data, enhance the network communication capabilities. Only need to change the packet in the flag bit, you can encrypt the information.

2.1 Protocol format

The self-organizing protocol format is as follows.

Pre	Key	From	Final	Data	Check	Flag

Where *Pre*represents the preamble-code and the character clutter is not easy to generate. Through the test and the test it shows that the noise is not easy to generate regular signals like 0x55 and 0xAA.the *Key*represents keyword and distinguish between the various cases of data. The receiving node respectively get into different data processing unit according to these keywords. *From* represents the source address,which is its information node sending data; *Final* indicates the target address data.*Data* represents a valid data and these data can carry different information with the character of Key by adopting different formats. *Check*represents test bit, and it can avoid receiving packet errors. *Flag*represents packet end flag bit.

According to the agreement in the form of Key communication nodes can be piggybacked data packets into ad hoc network information, information, environmental catastrophe control command, PC broadcast information etc.. For example, the format of the data packet is given when the node is in a state of change.

0x55	0xAA	0xFF	0x11	0x00	0x01	0x01	0x15	0x20	0x03	0x00…0x00	0x3A	0xBB

where *0x55* and *0xAA*represents data preamble.*0xFF* represents keyword sent out datafor sensor nodes in the sensor.*0x11* indicates the sending node address.*0x00*represents destination address packetto reach.*0x01* data represents data packet hops in the network transmission, then the *0x01* level nodes in the current network.*0x15*represents the temperature acquisition node.*0x20*represents the acquisition value of the supply voltage node at the time.*0x03*represents the state of node.*0x00... 0x00* is a valid data of 11 bytes, which can record the data packet through the address of the node.*0x3A* is the core data of the front and the low 8 bitsas the test code of the packet.*0xBB* is the end of the packet.

The receiving node needs to respond to the sending node, and the following table is the packet format when the response state is changed.

0x55	0xAA	0xFF	0x00	0x11	0x00	0x00	0x00	0x00	0x00	0x00⋯0x00	0x00	0xBB

0xFE represents the key character of the response state mutation followed by the address of the sending node and the receiving node.

2.2 Ad hoc network process

The network comprises a base station node and a plurality of sensor nodes connected with the host computer. Power on the base station is initialized to the low power mode. The sensor nodes are randomly placed on the sensor nodes, and then the nodes are sent to the base station node to send out the request level command, and then enter the low-power state and open the timer. At the time of setting, the level of the base station node is received, and the sensor node sends the data packet with self-organizing information to the base station node. If the level of the base station node allocation is not received within a set time, the node will wake up from a low power state, and then send a command to the request allocation level, such a loop. When the sensor node sends a request to the base station allocation level to reach the upper limit of the command, still do not determine their level in the network. The node sends a broadcast command to the whole network, and then enters a low-power state and opens the timer. When the time is up, the node returns to the broadcast command state. When the number of sensor nodes transmit radio reaches the preset value, the node will respond to information received, determine their levels in the network, and to determine the relevant information of superiors, peers and subordinates nodes. The node then sends a packet containing the information to the higher node, until the data packet is transmitted to the base station node, so that the topology of the whole network can be determined. The self-organization process of nodes is shown in figure 1.

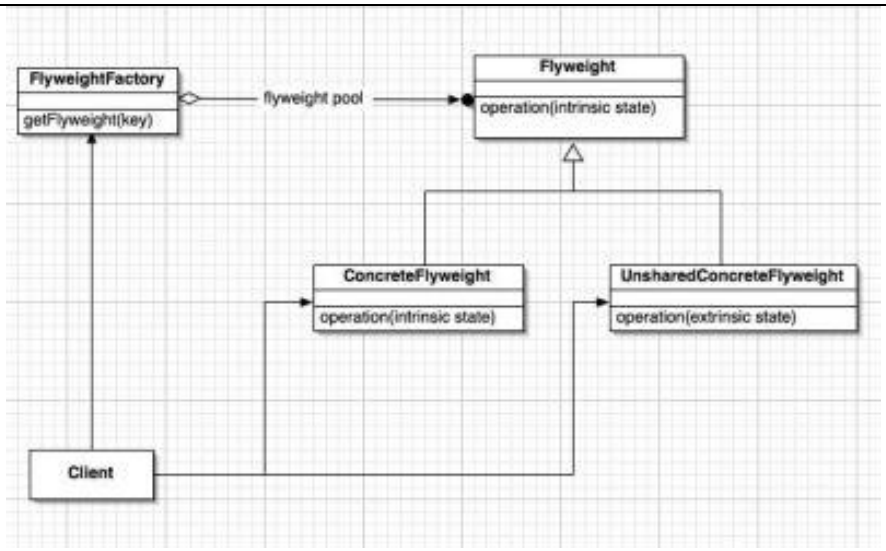

Figure 1: The self-organization process of nodes

3. Hardware Development

In order to verify the proposed self-organizing protocol, this paper selects the MSP430F149 chip with rich resources on chip as the processor, and develops a kind of micro sensor node.

3.1 Overall scheme

The system consists of base station node and sensor node. The hardware of the node selects the MSP430F149 microcontroller and the nRF905 RF module, which supports low power consumption mode, and uses 32768 Hz low frequency crystal oscillator, which is powered by the power supply of the 2 section of the battery. In the process of designing the node, the design of the dial switch, the buzzer and the LCD indicator light is very convenient for the debugging of the experiment.

3.2 Node design

Figure 2 is a block diagram of the sensor node, the node using battery power, compact size, only the size of a lighter.

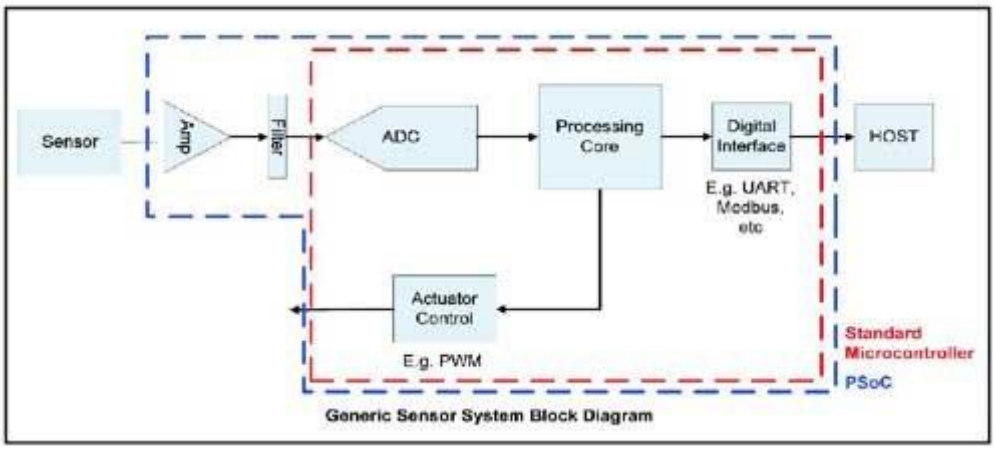

Figure 2: A block diagram of the sensor node

MSP430 Series MCU is a mixed signal controller produced by TI company, which has the advantages of low power supply voltage and low power consumption. It can be operated by batteries and has a long used time. NRF905 is a single-chip RF transceiver of Norway Nordic company launched VLSI, low voltage, power consumption is very low, working in the 433/868/915 MHz three ISM (industrial, scientific and medical) channel, channel between the conversion time of less than 650 μs.ShockBurstTM mode can automatically handle the prefix and CRC (cyclic redundancy check). Through the SPI serial communication with the microcontroller, the use is very convenient; built-in idle mode and shutdown mode, easy to achieve energy

saving. NRF905 is suitable for wireless data communication, wireless unlock and many other fields. Antenna design is a very important part of the whole system design. The power consumption of the system and the performance of the network are closely related to the design of the antenna. The antenna part is designed with integral PCB loop differential antenna. Compared with the traditional whip antenna, not only save space, reduce production cost, more stable and reliable mechanism.Because the ad hoc network and low power consumption, this paper mainly researches the technology of wireless sensor network, so only choose MSP430 MCU internal integrated thermal diode to measure the node temperature, but set aside a large external sensor interface, signal external sensor to fault mode wake up nodes.

3.3 System power

The sensor nodes are powered by batteries, and the power consumption directly affects the life cycle of the whole network. The power consumption of the system is not only related to the selected components, but also with the control strategy of the whole network. Using different control strategies, the working time of the system will be different. If you want to work for a year time node (365 * 24=8 for 760 hours), the theory requires an average working current is about 263 A (2300 / 8760). The working time of transmitting data to receive response is about 50 ms, which can be used to calculate the average sleep time. In practical application, we can choose the time of working and sleeping according to the response speed and the sampling rate.

4. Software Development

The design of low power consumption system is an integrated technology of hardware and software. It is necessary to use intelligent control strategy while using low-power chips. For example, allow the system to run at full speed when it is necessary to work; and when the entire system processes the event, it enters a low-power mode, waiting for an external event to wake up. The system software includes base station node software, sensor node software and PC processing software.

4.1 Base station node software

The main program of the base station node is relatively simple, after the initialization into low-power mode, waiting for external events to wake up. External events include serial interrupt events, data events and timer interrupt events. In order to prevent the loss of data in the serial communication, the software design adds handshake protocol. When each node of the base station sends a packet to the host computer, the host sends an acknowledgement signal to the base station node, until the data packet is sent to the host computer. After receiving the data packet, the node will wake up from the low power mode, according to the different characters of the received data into different processing units.

When a number of sensor nodes communicate with a sensor node at the same time, the existence of the phenomenon of channel grab. In order to avoid data loss caused by multiple sensor nodes communicating with a sensor node at the same time, some back off mechanism is adopted in the software. On the one hand, the use of nRF905 RF chip CD (carrier sense) signal to generate a random delay, at the same time in order to avoid sending signals; on the other hand, when a sensor node and a sensor node has established a communication channel, the other node sends data will increase the number of transmitted data.

4.2 Sensor node software

When the sensor node is initialized, it first sends a request to the base station node to assign the command of the level, and simultaneously opens a timer for timing wake-up. If the number of nodes of the base station allocated by the sensor is set to the upper limit and the level of the node in the network has not been determined, the node will broadcast the information to the sensor nodes. When the number of broadcasting reaches the set value, the sensor node determines the level of the node according to the received information and the information of the node which is directly connected with the node, and sends the information to the base station node. The external interrupt events of sensor nodes include receiving data events, timer interrupt events, and state mutation events. When the sensor node detects the state change, it will wake up from the low power state, and timely collect the environmental parameters (including the state, the temperature value and the node voltage value), and send out the data. The data packet arrives at the base station node by single hop or multi hop and displays on the host computer software.

4.3 PC processing software

In order to monitor the whole network, it is necessary to establish a good man-machine interface on the host computer. Using Visual Basic (VB) to design man-machine interface. The use of VB MSComm control to achieve the upper and lower machine serial communication, the use of other controls to achieve wireless sensor network analysis, display and operation. Host computer main program to complete some variables and control

initialization, and then wait for serial data. Data reception and transmission are completed by the interrupt program, as shown in figure 3.

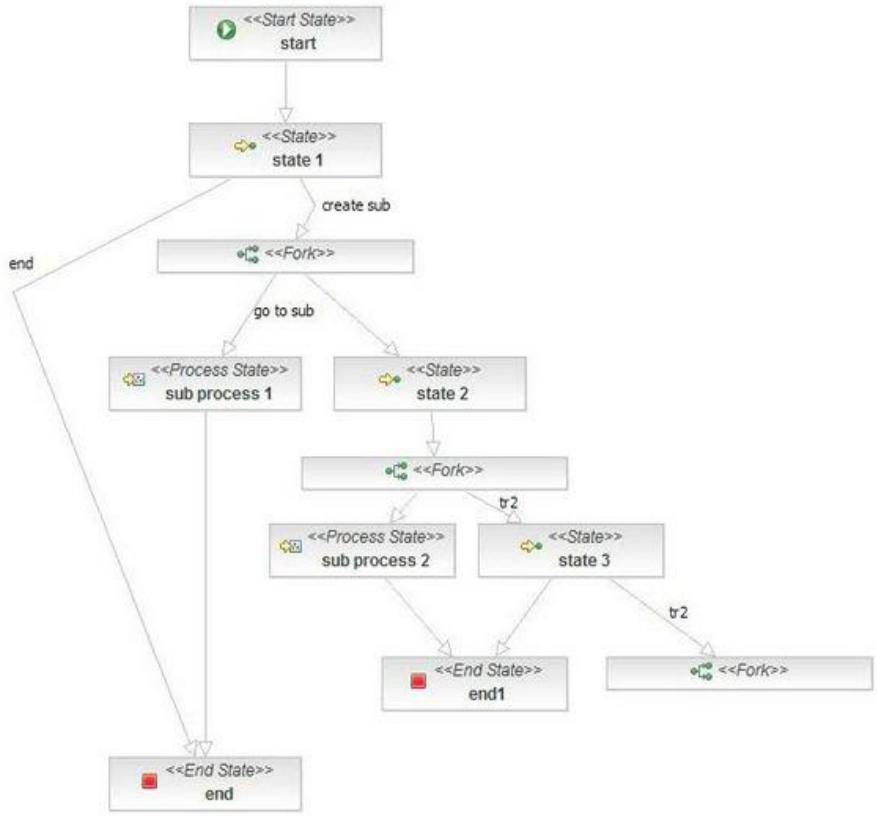

Figure 3: The interrupt program

After the host computer receives the complete data packet, it will carry on the different processing according to the key word in the data packet. When the data is transmitted, the path of the data is calculated according to the saved network data. In order to save the energy of the base station node, there are a lot of data processing in the network.

5. Experimental Results

After the development of the system, it is necessary to design the experiment to evaluate the effect of the network and the network performance. In the experiment, the first concern is the random distribution of sensor nodes in the network under the definition of the organization protocol. In order to assess the effect of self-organization, first of all, we let the base station node connected to the host computer through the serial port and open the PC processing software. Then we turn on the power supply of the sensor node, and the sensor nodes are arranged in the way of manual or random seeding.

With the help of the processing software of the host computer, we can clearly see the topology of the whole network and the environmental parameters of the network nodes. When the host computer processing software detects the sensor nodes in the network, it will display on the host computer and save the data of the sensor nodes. Figure 4 shows the interface of the system when the sensor nodes of the system are free to set up. Network time is about 3 min.

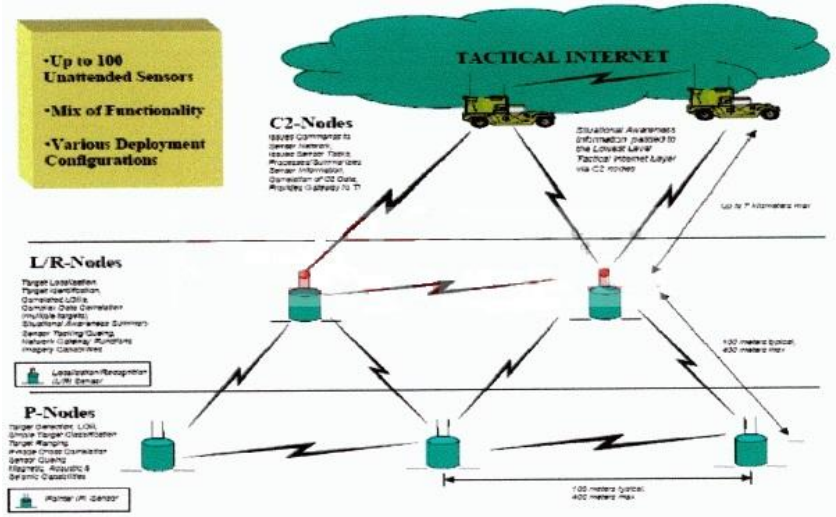

Figure 4: The network performance of the system

When the mouse click on a node, the node will be the information collection card. The information acquisition card reflects the state of temperature, node value, voltage value and residual energy, through the acquisition card directly to remote control the node. In the experiment of network performance, the sensor nodes are distributed at the first level. Through the host computer software, we can clearly see the network topology of the maximum number of hops that the sensor nodes can be divided into. When the network is formed, remote control of each node in the network by the host computer interface; when each node state mutation, will wake up nodes in the form of interruption, to the principle of giving priority to energy gradually transferred to the base station node, and the corresponding display in the host computer interface.

When the new sensor node is added to the network, the system will reflect the new node. When the system detects sensor nodes because the supply voltage is lower than the working voltage, or damage caused by failure, the topology will delete the node from the network and related information, detection method and timing sampling two manual refresh. The data transmitted in the network are stored in the network database, easy to search. Through the host computer software can also reset the network, so that all the sensor nodes to re networking.

6. Conclusions

In this paper, we use the information carried by the wireless communication to automatically generate the multi-level mesh network, and automatically generate the data transmission path according to the principle of energy priority. In wireless sensor networks, the answer and back off mechanism is used to avoid the data loss caused by the transmission of data from one node to another. The bidirectional nature of ad hoc wireless communication can not only display the information of each sensor node, but also take the initiative to carry out remote control for each sensor node. The use of low power consumption mode of the network hardware, with the software of intelligent control strategies to achieve low power consumption, as far as possible to extend the network life.

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