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A Burglar Alarm System Based on ZigBee and GSM for Aquaculture

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Abstract: Recently fish are frequently stolen, which has seriously influenced agricultural production. On the basis of analyzing existing aquatic antitheft measures, in accordance with the advantage of ZigBee and GSM (Global System for Mobile communication), a burglar alarm system was developed. The system consisted of three parts: the anti-theft terminal, communication network and monitoring center. The anti-theft terminals communicated with monitoring center by communication network. Except that anti-theft terminals were installed at the fixed point on the banks of the river, they were also installed on mobile patrol boat, which invested in the fishpond according to the preset trajectory to patrol the fishpond. These anti-theft terminals made up wireless network based on ZigBee. The system discovered the cracksman by the human body infrared induction module, and user achieved the timely alarm message with GSM technology. This system can not only be used to guard theft in aquaculture, but can also be used in the on-line monitoring of other agricultural production. *Copyright © 2014 IFSA Publishing, S. L.*

Keywords: Aquaculture, Burglar alarm system, ZigBee, GSM, Mobile patrol boat.

1. Introduction

In order to remain the aquaculture production relatively stable, security is an important work of daily management in aquaculture. Farmers generally use the traditional purse-seining to stop outsiders from entering, or dog care and other security measures. They are somewhat effective in keeping a good lookout. But at night, farmers have to sleep, and night is the best period for burglars, who often poison the dog and destroy security facilities, resulting in damages to the farmers. Most of existing aquaculture anti-theft products use wiring and disconnection alarm principle to achieve the security goal. This method costs high, takes a lot of labor and is easy to expose. Therefore, farmers pay close attention to intelligence, practicability and costs of the burglar alarm system.

In the modern world, with the rapid development of science and technology, the integrate of digitize, networking and intelligence are the developing trend and characters of advanced burglar alarm system. Researchers have undertaken this work in vehicle [1] and home [2-3] security, but in aquaculture, more scholars pay attention to the monitoring of water quality [4]. A burglar alarm system for aquaculture is not reported.

It has to be updated with the rapidly changing technology to ensure vast coverage, remote control, reliability, and real time operation. Based on the ZigBee and GSM, this article proposed a simple wireless remote alarm system through the multi-

sensor detection. The proposed system consists of terminals interfaced with different sensors using ZigBee. Suspected activities are conveyed to remote user through GSM (Global System for Mobile communication) technology. This system offered a low cost, low power consumption and user friendly way of a reliable portable monitoring and control of the secured environment in aquaculture. The design has been implemented in the hardware using ZigBee CC2430 module, S3C2410 MCU (microcontroller unit) and Android mobile phone set. The property of the system was tested in order to provide a theoretical reference for the design of similar systems.

2. System Architecture

This burglar alarm system consisted of three parts: the anti-theft terminal, communication network and monitoring center. The operational principle of system architecture shows as Fig. 1.

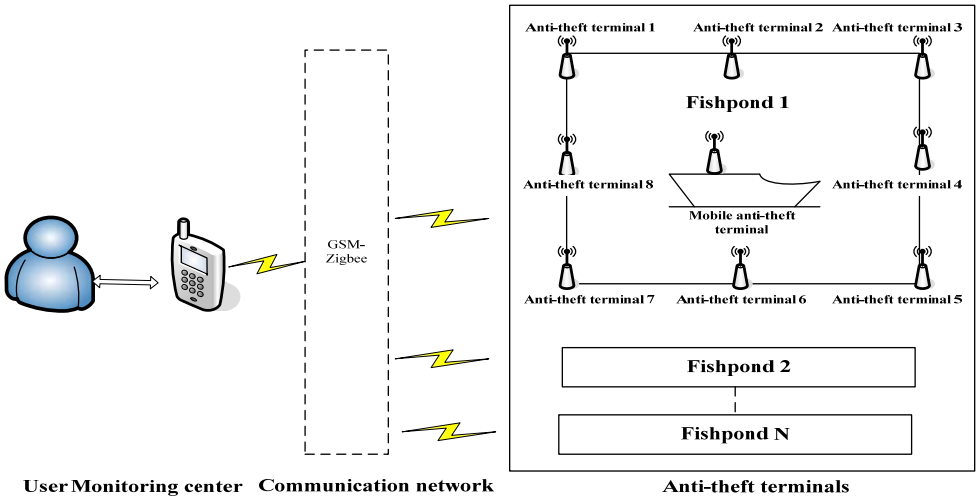

Fig. 1. System architecture.

The core of this system is the anti-theft terminal in the right of Fig. 1. A decided difference in our burglar alarm system from every other is that our anti-theft terminals contained the fixed and mobile anti-theft terminals. The fixed were installed at the set points on the banks of the river, while the mobile was installed on mobile patrol boat as shown in the center of fishpond 1, which invested in the fishpond according to the preset trajectory to patrol the fishpond.

Several terminals made up a ZigBee network as shown in Fig. 2. Electronic devices of System-on-Chip (SoC) CC2430 based on the "ZigBee'' platform have been used to deploy the WSNs, which is composed of a ZigBee coordinator, ZigBee routers and many ZigBee end devices. These devices are responsible for acquiring the data from sensor module and transporting data or commands. The sampling time is 1 min. Meanwhile, monitoring center communicated with terminals based on GSM. As some burglars go through the terminals, the terminal would detect a steal by infrared detection principles and an audible and visible alarm would ring. Alarm sounded at the same time, monitoring center also received warning signs form the coordinator of the ZigBee by GSM module. GSM module [5] would send the alarm message wirelessly to mobile phones module would send the alarm message wirelessly to mobile phones.

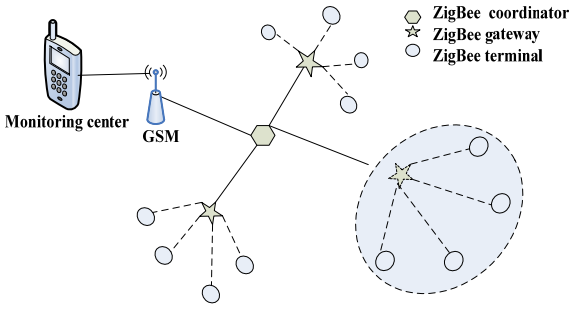

Fig. 2. System communication network.

3. Hardware Design of the System

3.1. ZigBee Wireless Communication Module

Considering the need of a microprocessor and a wireless RF, Samsung's S3C2410 and TI CC2430 as wireless module is a good option. The S3C2410 and CC2430 exchange data through the serial port. Samsung's S3C2410 as the control core, the chip is 32 bit RISC microprocessor based on an ARM920T kernel, which does the data processing and analysis. It is suit for usage fields of needing extremely low power consumption, and it has rich addressing methods, facilitate and efficient development methods and support simulation and programming

online. Its peripheral circuits include liquid crystal. CC2430 as the RF module control core, the chip combines a high-performance 2.4 GHz direct sequence RF transceiver (DSSS) and an industrial efficient Enhanced 8051 controller, and thus meets the requirements of low cost, low power based on ZigBee of 2.4 GHz ISM band application.

3.2. Sensor Module and Signal Processing Module

Pyroelectric infrared sensor HC-SR501, adopting Germany imported LHI778 probe design, detects whether someone is near. The microprocessor in pyroelectric infrared sensor adopts a microwave Doppler effect, spectral analysis and the photon detection technology, through intelligent analysis, quantitative calculation, accurately on the far infrared spectrum of human body and the Doppler frequency shift of human walking. The microwave and infrared and microprocessor, comprehensive detection analysis technology, could distinct between man's signal and animal's, so it could accurately make alarm on the movement of the human body. Further, signal processing module is composed of amplifier and filter circuit for amplifying and filtering the signal. The alarm information was sent effectively. The sensor is more stable, can more effectively prevent false alarm.

3.3. GSM Module and Alarm Module

The dual frequency 900/1800 MHz highly integrated TC35i module [6-9] of Germany Siemens company is as communication platform. The module was composed of GSM baseband processor, GSM RF module, power supply module, flash memory, ZIF connector and antenna interface. It was of small volume, convenient installation. It connected to application circuit through the ZIF connector. The input and output TTL positive level of TC35i module is not +5 V but +2.9 V, so port protection is necessary.

3.4. Mobile Patrol Boat Module

The design of mobile patrol boat requires two steps. The first is to design drawings of ship model, which is shown in Fig. 3. Another step is to cut plate, paste, polish, grind brush glue.

The ship using BTS7960 motor drive chip to drive motor. This chip has many functions of a current diagnosis, logic level input, over temperature protection, over-voltage protection, over-current protection and short circuit protection.

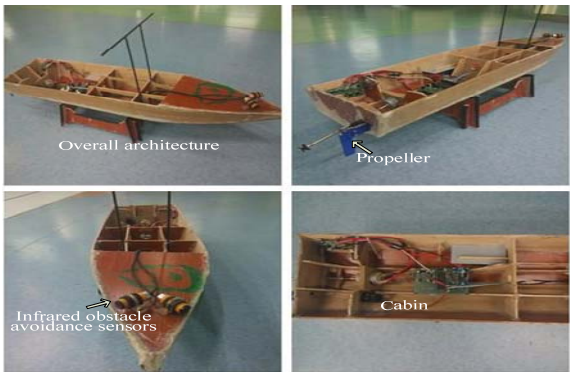

Fig. 3. Physical map of mobile patrol boat.

As shown in Fig. 4, we used two motor drive chips to control the motor positive inversion. VS is connected to the positive of the battery, while the EN is connected with the single chip microcomputer VCC. Make IN1 foot, IN2 foot of the chip to be input some PWM signal, and it could control the chip to output a corresponding voltage signal.

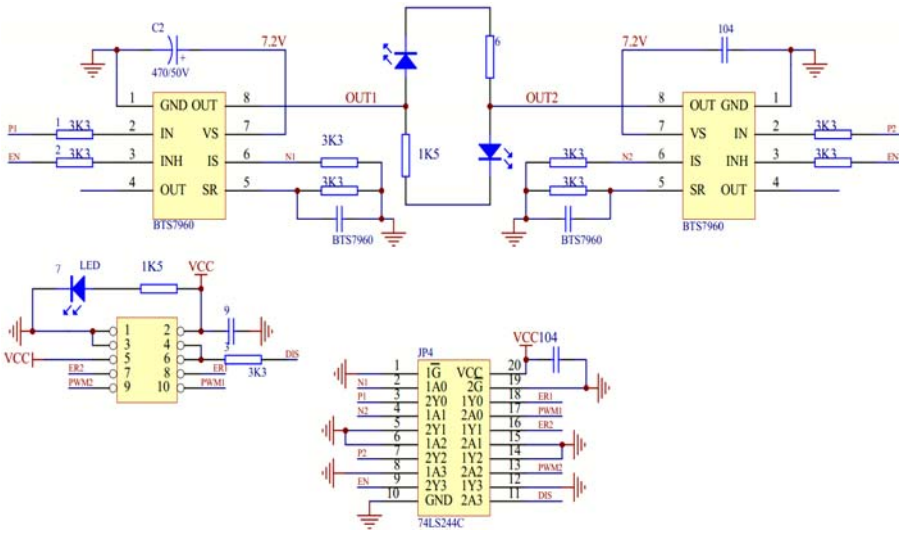

Fig. 4. Motor drive module circuit diagram.

E18-D50NK infrared obstacle avoidance sensors were applied to the obstacle avoidance module. Steering module used the PWM signal, a pulse width signaling. The obstacle avoidance module used E18-D50NK infrared obstacle avoidance sensors. The PWM signal of steering module is a pulse width modulated signal, whose characteristic lies in the time width between his rising and falling edges. It is a very effective technique using digital transmission of microprocessor to control analog circuits. In addition, mobile patrol boat contains GPS module [10], which would be able to find the target more accurately – to within 1.8 meter.

4. Software Design of the System

4.1. Software Design of Sensor Nodes

The task of the sensor node is sending the alarm to the coordinator device when it detected someone cheating. Sensor nodes in the ZigBee network also could detect the parameter information of different position. The sensor node, after electrify equipment, completed the initialization of the system, and then scanned channel, then joined to the appropriate network and sent its network address to the coordinator device. Sensor nodes periodically polled tasks to check whether there was the command of the parameter acquisition. If there is, then boot device of A/D conversion, the data is sent to the coordinator device. If not, then continue to listen on channel. Software flow chart of sensor node is shown in Fig. 5, and the monitoring and alarm codes of sensor nodes are as follows:

```
void SampleApp_SendPeriodicMessage(void) //Send periodic function
{if(P0_5 == 0) //The infrared sensor detects event when there is nobody.
 {//send data from the application layer to the network layer, and then to MAC, then to the physical layer through the AF_DataRequest; nobody event represented as zero
HalLedSet(HAL_LED_1, HAL_LED_MODE_OFF);//Set the LED1 light out
AF_DataRequest(&SampleApp_Periodic_DstAddr, &SampleApp_epDesc,SAMPLEAPP_PERIODIC_CLUSTERID,1,"0",&SampleApp_TransID,AF_DISCV_ROUTE, AF_DEFAULT_RADIUS )；
 }
 else //The infrared sensor detects event when there is somebody.
 {HalLedSet(HAL_LED_1, HAL_LED_MODE_ON);//Set the LED1 light on
AF_DataRequest(&SampleApp_Periodic_DstAddr, &SampleApp_epDesc,SAMPLEAPP_PERIODIC_CLUSTERID,1,"1",&SampleApp_TransID,AF_DISCV_ROUTE, AF_DEFAULT_RADIUS);//somebody event represented as one }
}
```

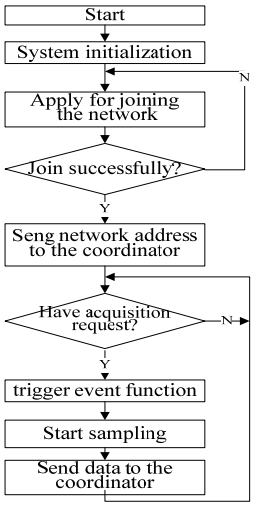

Fig. 5. Software flow chart of sensor node.

4.2. Software Design of Coordinator

Software flow chart of coordinator node is shown in Fig. 6. The coordinator node firstly establish network, and then monitor sensor node's data. If somebody approaches the sensor, then the coordinator sends the alarm by GSM module.

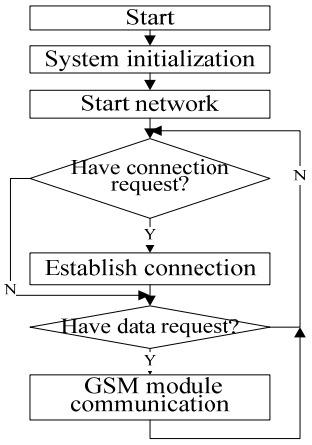

Fig. 6. Software flow chart of coordinator node.

The GSM module is connected directly with the coordinator node through the UART serial port, which achieves real-time alarm function. This requires that the configuration section of the GSM module should be written in the coordinator node program, which is information processing function SampleApp_MessageMSGCB handling the information from sensor nodes. In this function, the information is converted to from ASCII code to hexadecimal. Only by adding 0x0A, 0x0D at the end of each message could we configure the configuration GSM module successfully. For the convenience of viewing and avoiding mistakes, the code conversion was eventually chosen.

After the coordinator node received the alarm information, it directly used HalUARTWrite function within ZigBee protocol for serial output, since the function does not need to use redundant. Similarly, the HalLedSet function can set Led1 light on and off simply.

This design mainly includes three parts, one is the GSM configuration information. The main is to set the target mobile phone number and convert information into mobile phone SMS text messages and so on. The code is as follows.

```
uint8 TC_ZZZXH[13]=
{0x41,0x54,0x2B,0x41,0x55,0x54,0x4F,0x3D,0x4E,0x4F,0x0D,0x0A,0x0D};
// set local mobile center number
uint8 TC_ZXH[12]=
{0x41,0x54,0x2B,0x43,0x4D,0x47,0x46,0x3D,0x31,0x0D,0x0A,0x0D};
//set the text message format as text{"AT+CMGF=1\r\n"};
uint8 TC_MDSJ[27]={0x41,0x54,0x2B,0x43,0x4D,0x47,0x53,0x3D,0x22,0x2B,0x38,0x36,0x31,0x35,0x31,0x36,0x31,0x31,0x31,0x36,0x31,0x37,0x37,0x22,0x0D,0x0A,0x0D};
{"AT+CMGS=\"+8615161116177\"\r\n"};  //set target mobile phone number
uint8 TC_FSNRa[10]={0x61,0x6E,0x6F,0x72,0x74,0x68,0x0D,0x0A,0x1A};//set Location 1as "anorth!\r\n"
uint8 TC_FSNRb[8]={0x62,0x65,0x61,0x73,0x74,0x0D,0x0A,0x1A};//set Location 2 as "beast!\r\n"
```

The two is to increase the delay procedure, which prevents the ZigBee procedure sending information too frequent to the GSM module, resulting in a waste of resources and hardware breakdown. The code is as follows.

```
void send(uint8*tab)//the delay procedure
{unsigned long x,y,z;
  for(x = 60000000; x> 0; x--)
    for(y = 60000000; y > 0; y--);
      for(z = 60000000; z > 0; z--);
  HalUARTWrite(0,tab,sizeof(tab));
}
```

The third is the coordinator node processing the alarm information from the sensor nodes. The code is as follows.

```
void SampleApp_MessageMSGCB( afIncomingMSGPacket_t *pkt )//information processing function
{ .....
  switch ( pkt->clusterId )
  {case SAMPLEAPP_PERIODIC_CLUSTERID:
      osal_memcpy(hongwai,pkt->cmd.Data,1);//pkt->cmd.data is the application layer data
      if(hongwai[0] == '1')// Location 1
      {   flag = 1;
       HalLedSet (HAL_LED_1, HAL_LED_MODE_ON);//set LED_1on
       P1_3=1;
       }
      else if(hongwai[0] == '0')
      {  .....
       }
      if((flag == 1) && (flag1 == 0) )//somebody approaches the Location 1,light on.
      {  //The serial output configuration information, directly transmitted to the GSM module through UART of the coordination. The GSM module completes the configuration and the SMS short message sending.
       HalUARTWrite(0,TC_ZZZXH,13);
       HalUARTWrite(0,TC_ZXH,12);
       HalUARTWrite(0,TC_MDSJ,27);
       HalUARTWrite(0,TC_FSNRa,10);
        flag1 = 1;
       }
      if((flag == 2) && (flag1 == 0) )//somebody approaches the Location 2,light on.
  .....
      case SAMPLEAPP_FLASH_CLUSTERID:
      flashTime = BUILD_UINT16(pkt->cmd.Data[1], pkt->cmd.Data[2] );
      HalLedBlink( HAL_LED_4, 4, 50, (flashTime / 4) );
      break;
    }
  }
```

5. Experiment

In the situation of completed debugging in the software and hardware, for simplicity, this system has two sensor nodes, two routers and one coordinator, and a router works as a sensor node at the some time.

The coordinator automatically establishes wireless sensor network, and then sensor nodes join the network, the lights of sensor's LED4 and LED3 come on. When the infrared sensor detects interlopers, LED2 of the router lights, and then LED1 of the coordinator lights, mobile phone received alarm information. The pictorial diagram is shown in Fig. 7.

Some alarm information in the Android mobile phone could be seen from Fig. 8. The information "anorth" means that node 1 detects that people appeared in the north of the fish ponds, which "beast" means that node 2 detects that people appeared in the east of the fish ponds. Farm staff should timely process alarm information. At the same time, we also tested animal, such as a cat through the sensor node. The sensor did not alarm, which shows that the infrared pyroelectric sensor is working properly. The system can distinguish human beings from animals.

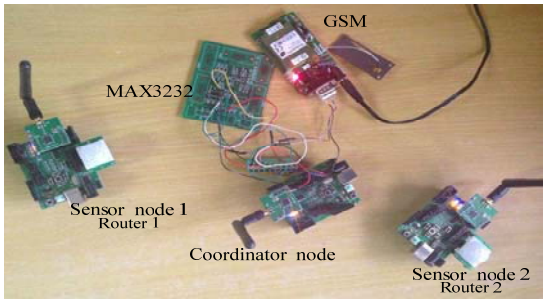

Fig. 7. Physical map of ZigBee and GSM.

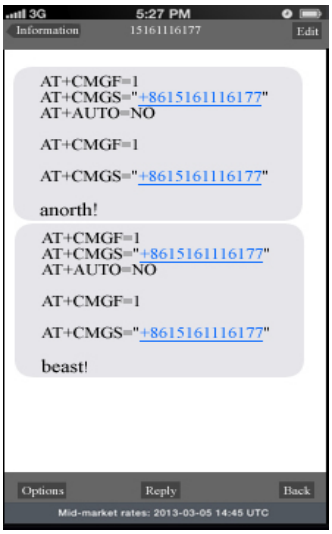

Fig. 8. Test results on the mobile phone.

6. Conclusions

This paper proposed the overall design of a burglar alarm system based on ZigBee and GSM for Aquaculture. Then briefly introduced how the related software and hardware are designed, and finally the entire system functionality testing is performed. The experimental results show that: the anti-theft system could accurately alarm when someone is near the pond. It is high in reliability, low in the false alarm probability.

Although the system basically realized anti-theft function based on ZigBee and GSM for aquaculture, to achieve complete intelligent monitoring, the system still needs to be improved in many aspects. This work could be extended for future work in many directions. For example, research on energy optimization in wireless sensor networks to lengthen using time, data transmission between the coordinator, server and Android with GPRS network.

Acknowledgments

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