Wireless Sensor Networks Applied on Environmental Monitoring in Fowl Farm

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WIRELESS SENSOR NETWORKS APPLIED ON ENVIRONMENTAL MONITORING IN FOWL FARM

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Abstract: Aiming at the real time monitoring requirement of poultry farms on the environment, a online monitoring system is proposed for poultry farms on the environment based on ZigBee, its application of ZigBee wireless networks and sensor technology. supply a network structure of monitoring system, monitoring system node controller of data acquisition, data transmission and control node, which is TI's CC2430 based on ZigBee technology. CO_2 sensors use TGS4161, temperature and humidity sensors use SHT75 to detect environmental parameters. designed circuit diagram of parameter testing node and system master control node，CC2430 as a data processing chip. through the analysis of data transmission of system, simplifying the ZigBee protocol stack, designed data transmission protocols and communication formats of the system. given program flow chart of sensors nodes and main node. practical application shows that the performance ratio cable monitoring system is better, Especially in real-time systems and anti-jamming, it so superior on the current forms of environmental monitoring SCM cable system which cost lower than the SCM cable control system about 30%.Successfully achieved the Monitoring of fowlery's CO_2 concentration, temperature, humidity and other environmental parameters for large-scale poultry farming, and to provide a new monitoring environment technologie.

Keywords: ZigBee;CC2430, fowlery environment, Network protocol ,Monitoring system

1.   INTRODUCTION

With large-scale intensive poultry model increasingly promotion and popularization of farming , in order to improve the yield and quality, prevent poultry diseases, we need an monitoring system for the poultry house temperature, humidity, CO_2 concentration and illumination parameters[1]. At present, the domestic fowlery environmental parameters automatically monitor system ,generally use the single-chip or industrial computer systems, monitoring of signal transmission using Cable transmission[2], but this way exists many defects. Such ashighercosts, complicated system, poor anti-interference , limit the universal promotion in the poultry production. ZigBee[3] wireless sensor technology applied an IEEE802.15.4 standard[4] of a short-range wireless sensor network technology, is a combination of sensor and wireless network technology, is a new intelligent control technology, with low-cost, ad hoc network, small size, Strong real-time, low power consumption, anti-interference, good features such as embedded[5], can be widely used in industrial and agricultural production.

2.   MONITORING AND CONTROL SYSTEM DESIGN

2.1 Design of poultry house parameters monitoring and control system

The fowlery parameters of the principle of wireless monitoring system as shown in Fig.1, the system is composed of the sensor node, environmental parameter control node, data processing and the main nodes.pology Network using star-shaped structure, the main node is connected to control PC,set it as FFD (Full Functional Device) nodes or NC (network coordinator);and sensor or control of the implementing agencies are integrated from the node, the node is set as RFD(Reduced Functional Device). Node control chip use TI,(Chipcon) Corporation' chip which is based ZigBee technology with SOC (system-on-chip) features a small footprint wireless system-on-chip CC2430[6],it can according to consumer needs to be flexible and set to FFD, NC or RFD[7]. Sensor node regularly detect the poultry house environment parameters,when receive the master node's directions,will sent the monitored environmental parameters through wireless transmission to the master node; Host transceiver node after receiving data from the controller(or host) for the corresponding treatment, compared with setting datas and output corresponding action commands, transmitted to the various environmental

parameters control nodes, such as temperature control, ventilation control, humidity control, etc. the corresponding control equipment will make the stability of poultry house environment parameters in the set range. It can also input the environmental parameters detected into the computer storage system.
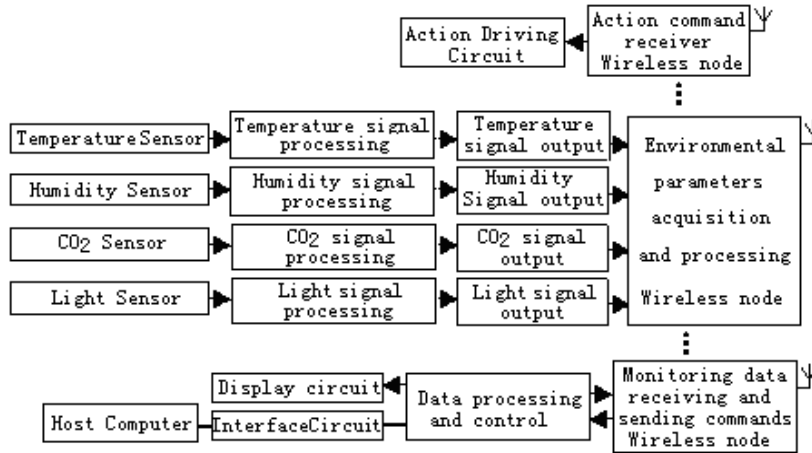

Fig.1: block diagram of the fowlery environment monitoring system

2.2 Sensor and data acquisition node design

Parameters of the fowlery environment monitoring system sensor node circuit as shown in Fig.2. the detection of CO_2 concentration is useing sensors TGS4161. The sensor has a small size, long life, selectivity and good stability characteristic, and also with low temperature and humidity-resistant properties, can be widely used in automatic ventilation system for CO_2 gas or long-term monitoring applications[8]. CO_2 Sensor output weak voltage thourgh the amplification of amplifier U2, and then output to the U5 amplifier P0_3 to A/D conversion. PR1 adjust amplifier gain so that the concentration of the output signal voltage change between $0 \sim 3$ V . U5 conducted by A/D conversion, stored in designated memorizer cell CC2430. In order to enable the sensor maintain the temperature in the most sensitive State, the general need to provide heat heater heating voltage.

Temperature and humidity testing apply digital temperature/humidity sensor SHT75[9]. The sensor has a small size, simple and reliable, low cost, digital output, the avoidance of debugging, and calibration-free interchange ability of strong features, integrated A/D converter and memorizer, in the measurement process can be automated calibration of relative humidity. U4's DATA and SCK pin , respectively connected with the U5's P0_0, P0_1 pin, U5's P0_1 pin controlled the SCK pin of U4, from U4 memorizer to read the temperature or humidity data. And then make temperature/humidity parameters stored the

memorizer cell designated in CC2430. Testing the use of light for illumination photodiode detection, Photosensitive components D1's signal Amplified through the U3, the input to U5's P0_2 to A/D conversion.
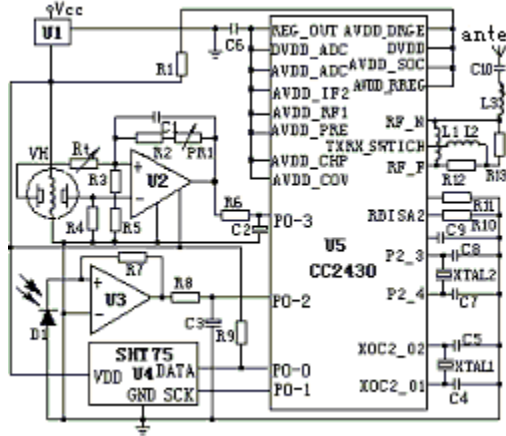

Fig.2: basic circuit of the fowlery environment sensor node

2.3 System control and transceiver node design

   System control and wireless transceiver node of the basic circuit shown in fig.3. Mainly are formed of the power supply, controller, RS232 interfacer, display circuit and the wireless transceiver circuit. through the connection of RS232 serial port chip MAX232 with other devices , U1 provide 3V power for u3, LCD display for TBG128064F type with Chinese font display module. When Receiveing data ,the sensor node received send data stored in the transceiver circuit in the FIFO, and then entered into the data storage area designated unit of CC2430 with DMA mode. CPU received data of various sensor node, and then according to a certain algorithm to derive the average, compare with the setting datas, If it exceeds setting range, will send control commands to the appropriate control node. Data transmission with DMA mode to the RF of the FIFO, then sent through a wireless circuit sent.
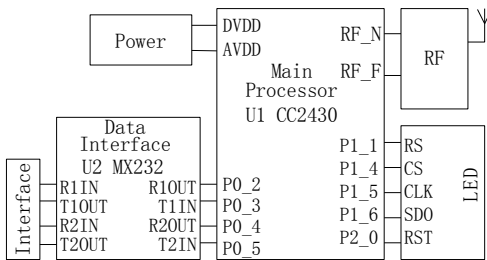

Fig.3: basic circuit of system control and transceiver node

3.   THE DESIGN OF SYSTEM NETWORK PROTOCOL AND SOFTWARE

3.1 the design of network Protocol and data frames

Through the application analysis of the system, we simplify the ZigBee protocol for saving the program storage space of the nodes. The beaconing and security mechanisms have been omitted in system protocol, the device type of the FFD node is set to FFDNBNS and the device type of the RFD node is set to RFDNBNS[10]. The primitive that has nothing to do with this application of the system node is omitted in order to improve the efficiency of the protocol. The protocol and the realization primitive of the sensor and control node are shown in Fig.4.
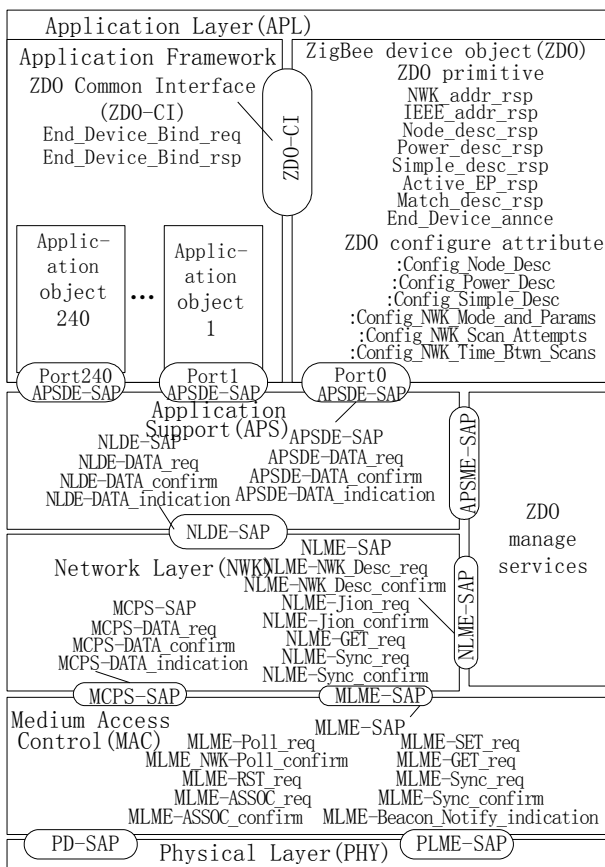

Fig.4: Protocol stack of sensor and control node

In the system, data transmission path used for routing cost metric of comparison, the path cost show with formula (1):

$$C\{P\} = \sum_{i=1}^{L-1} C\{[D_i, D_{i+1}]\} \qquad (1)$$

The $C\{[D_i, D_{i+1}]\}$ is the link costs, link L of the cost of C (L) is the value in $[0 \cdots 7]$ within the scope of functions that can be used formula (2). Formula p_l is transmission probability in the link packet . Through the MAC layer of each frame the LQI average to estimate p value.

$$C\{L\} = \left\{ \begin{array}{l} 7 \\ \min\left(7, round\left(\dfrac{1}{p_l^4}\right)\right) \end{array} \right. \qquad (2)$$

In the data transmission process，routing algorithm used in classification of data frames transmitted along the tree. if a router's address is A, depth is d, when the target device is currently receiving equipment or its sub-equipment, next skip address N is available to the formula(3):

$$N = A + 1 + \left[\frac{D - (A+1)}{Cskip(d)} \right] \times Cskip(d) \qquad (3)$$

If the NWK layer of routing node to receive data frame of the MAC layer non-broadcast frame, NWK layer to determine data frame the purpose of this address is for the current device the logic address, If it is, data frame will processing be transmitted to the upper layer of node, otherwise, data frame will be transmitted to other node.

MAC layer of ZigBee data packet format is used in data frame format of system data transmission[11]. The structure is shown in Fig.5. The definition of frame load of data packet is node ID which is binding with sensor nodes port ID plus port parameters.
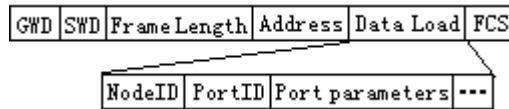
| GWD | SWD | Frame Length | Address | Data Load | FCS |

| NodeID | PortID | Port parameters | ... |

Fig.5: Data Frame structure.

3.2 System software design

System Program design applying the modular system design approach, is composed of the host node and transceiver modules，sensors and control node module. the main program and the transceiver node process of System, shown in Fig.6(a). Sensor node flow chart shown in Fig.6(b).
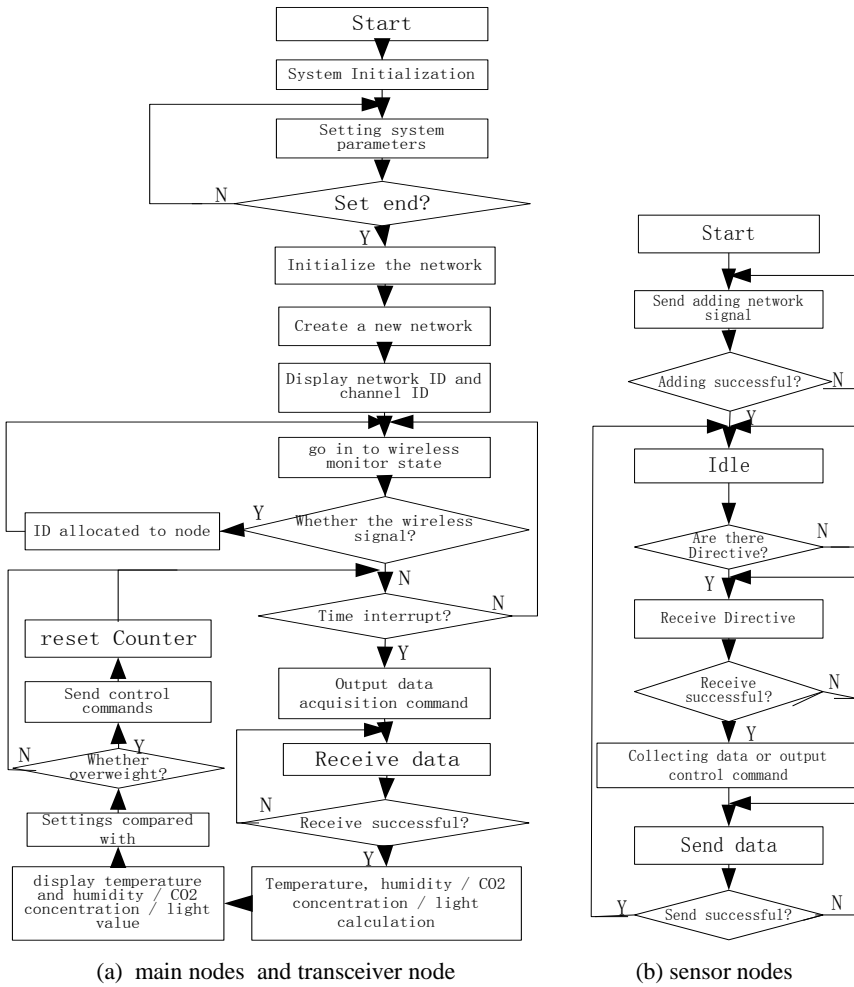
(a) main nodes and transceiver node   (b) sensor nodes

Fig.6: Flow chart of main nodes and sensor nodes

4.   SYSTEM PERFORMANCE TEST RESULTS AND DISCUSSION

After the completion of the design of the system, the application of test. choose two 500m^2 fowlery area, placed 10 sensor node, the distance between each other for about 20m, routing node location relatively fixed, the successful implementation of the environmental monitoring birdhouse. Table 1 for the system with a SCM (single-chip microcomputer) cable control system using the comparison test parameters and test results show that this system in single node in data transmission distance less than SCM cable

monitoring system, and other parameters are higher than using SCM cable monitoring system.

Table 1: System test parameters and comparison of SCM monitoring system

Test items of the detection	CO_2 concentration measurement	CO_2 concentration accuracy	Temperature measurement accuracy	Temperature detection range	Humidity measurement accuracy	Humidity detection range	Light detection range	Data transmission distance	Response time	Distortion rate(%)	Node power consumption	Node cost
Cable mode	0~5000PPM	±5%	±0.3℃	−10~+40℃	±2%HR	0~100%HR	0.01~20000LX	50~100m	>1S	2.5%~5%	>5W	1
wireless mode	0~5000PPM	±5%	±0.1℃	−15~+45℃	±1%HR	0~100%HR	0.01~30000LX	20~40m	>0.5S	<1.5%	>3W	0.7

Data transmission distance for the CC2430 the supply voltage of 3V,the data distortion rate <1.5% distance CO_2 concentration measurement accuracy is the CO_2 conventration of 1000ppm accuracy

About data transmission distance, it can increase distance by set up network routing method node transmission. Since the wireless transmission of the frequency of 2.4GHz, at all nodes need to take the appropriate anti-jamming measures. In order to improve the detection sensitivity, Heating voltage must be stable in the range of 5.0±0.2VDC。

5.   CONCLUSION

In this paper, the design based on the ZigBee wireless sensor parameter of the fowlery monitoring systems, with low-cost, reliable operation, widely area of application characteristics, it can improve the production and quality of Poultry farms, improve the degree of automation, lower production costs, reduce labor intensity. and has a certain significance, The technology in poultry production has a good promotional value.

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