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Information Acquisition System Based on ZigBee and ARM

Junfang Tian*[a], Dianru Jia[a], Shuangyou Wang[b]

[a] School of Information Engineering, Handan College, Handan, Hebei, 056001, China,
[b] Software School, Handan College, Handan, Hebei, 056001, China.
tjfhdc@163.com

For the traditional wired radio frequency-identification (RFID) technology information acquisition system, is the drawbacks include its expensive cost, the complexity of connecting many nodes, deployment of the reader in advance, poor flexibility, inability to read and other issues on a mobile carrier and other related issues. Aimed at correcting these characteristics, the information acquisition system based on ZigBee is proposed in this paper. Using the flexibility of Zigbee wireless networking, and the powerful computing capability of ARM, a distributed Zigbee information acquisition can be realized. The design and implementation of the hardware and software of the system are introduced in detail. The feasibility and effectiveness of the system are verified by the experimental results.

1. Introduction

In the traditional cable monitoring network, data can only be transmitted along a fixed line, which has some disadvantages, such as being difficult to maintain and expand, and the high cost of maintaining it. Radio Frequency identification (RFID) is a non-contact automatic identification technology, which is based on a radio frequency method to realize automatic identification (J.R. Lu and L. Shan (2015)). The traditional information acquisition system of RFID needs a large number of readers with associated problems of wiring complexity, flexibility, and re-wiring when the reader is re-deployed. It is difficult to meet the needs of readers and at the same time provide a flexible configuration.

The information acquisition system of RFID based on Zigbee can effectively solve the problems above. RFID is the main realization for reading tag information; the ARM processor completes the data pre-processing of the reader, and ZigBee achieves the data transmission and reader through an ad hoc network. The system not only inherits the characteristics of the RFID technology to automatically identify, but also realizes the function of the pre-processing and the active sense and communication of the wireless sensor network (H.B. Yu and H.Q. Yu (2015)).

In this paper, a design is proposed whereby RFID automatic identification technology is combined with Zigbee wireless communication technology, with an embedded ARM processor and a wince operating system as a platform.

2. Analysis of the system structure

The system is composed of electronic tags, an RFID reader, an ARM microprocessor, a Zigbee module and a data server. In the front of the system is the RFID reader to collect tag information. In the middle is the ARM microprocessor to pre-process the collected label information, and to control the reader's working mode, and the number of the card reader. At the end is the ZigBee module, which completes the construction of the effective data wireless transmission and the dynamic ad hoc network. Data servers are used to store historical data. When the tag information is read by the reader, it is transmitted through the RS-485 bus to the ARM microprocessor. Which then carries out the filtration, collection and calculation of the tag information, which is ultimately converted into valid data and displayed in a user-friendly mode (M.H. Zhao et al. (2014)). The ARM microprocessor uses an embedded wince operating system, and the ZigBee module constructs a network of RFID readers through the structure of a tree network.

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3. The design of the system hardware

The system hardware is shown in Figure 1, including the main system parts (ARM controller, and memory), power module, ZigBee wireless communication module, reader module, serial communication module, USB module, man-machine interface module, etc.. The system hardware is divided into three parts: core board, ZigBee wireless communication board and expansion board (F. Jiang and W. Zhao (2013)). The core board includes the main controller and the memory, which constitute the ARM minimum system. The ZigBee wireless communication board is the smallest ZigBee system with the ability to communicate with the network. It is connected to the expansion board through the RS–232, and expands the power supply circuit, debug interface, communication interface, USB, man-machine interface and other circuits in the expansion board.

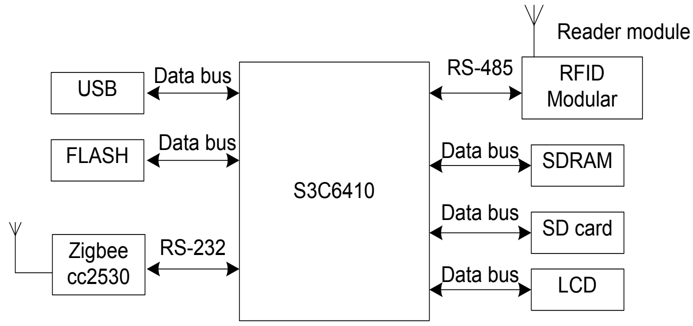

Figure 1: System hardware design

3.1 The selection of the ARM controller

The ARM controller has a complex function, and needs to achieve a variety of interface conversion and RFID data processing and task scheduling. The Micro-controller should have several interfaces with low power consumption. In this paper, a micro controller S3C6410 is used to build the whole system which is based on 32-bit ARM architecture (X.C. Liu and B. Lei (2015)). S3C6410 uses the ARM920T kernel, 0.13μm COMS standard macro cell and memory unit. The design is fully static which is particularly suitable for the application of cost and power sensitivity.

3.2 The design of peripheral circuit

The serial communication interface design uses an RS-232 working power3.3V conversion chip SP3232E to carry on the level conversion. The level transmitter chip RS-485 uses SP3485 of working power supply 3.3 V. RS-485 circuit might introduce an Instantaneous surge of current into the system, so a DC-DC device isolates the main power supply from the RS-485 power circuit (R. Lv and C.H. Chen (2013)), and TLP521 — 4 isolates the signal part by a photo coupler.

The ZigBee wireless communication module chip uses CC2430 produced by the Chipcon Company. CC2430 integrates the front-end of Zigbee radio frequency (RF), 128kB flash, 8kB RAM and 8-bit kemel with 8051MCU on a single chip, In the design, the Zigbee coordinator and terminal node use the same hardware design; each Zigbee node is composed of a CC2430 (Y. Peng (2011)), power management, serial port module, JTAG debugging and reset circuit. The serial port module circuit is shown in Figure 2, using MAX232CSE uto converse RS-232 level and TTL level to achieve the connection with the ARM controller.

The RFID information acquisition module includes an antenna, RF transmission circuit and RF receiving circuit, demodulation circuit, DSP processing circuit, power supply, external communication interface and related items, and its external communication interface will enable the correct label information ID. In this design, a UHF RFID reader RFs-3611 is used produced by Jiangsu Ruifu Company, and the external communication interface uses an RS-485 communication mode. According to different applications and requirements, the reader can be replaced with an RS-232 communication mode.

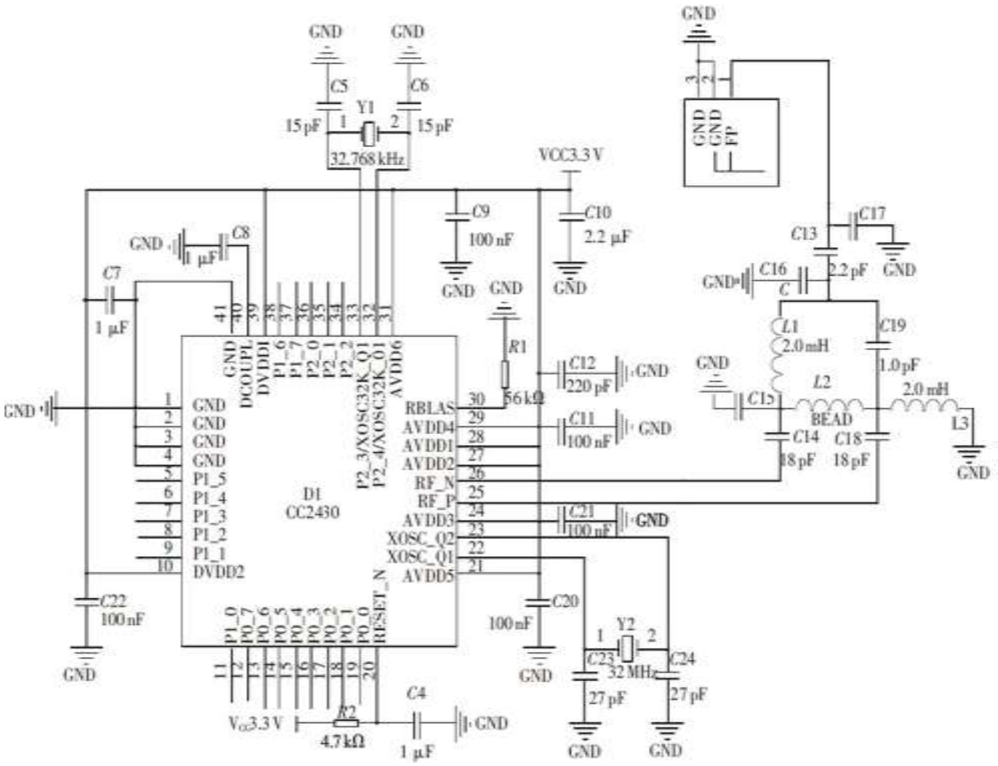

Figure 2: Typical application Circuit of CC2430

4. The strategy of the Zigbee Ad Hoc network

The Zigbee ad hoc network is composed of three kinds of network: a star structure, a tree structure and a net structure. In the distributed RFID information acquisition system, the RFID reader and tag are likely to move in several regions. Because the wireless communication range of its nodes is very small (tens of meters) and the network coverage is limited, the star network is not conducive to the expansion of the network function (X.F. Feng and S.F. Lv (2014)). Although the network is robust, the equipment in the network needs to be fully functional with high energy consumption, and the routing nodes of the net in the network increase its delay. The tree structure network has the advantages of the star structure and the network structure, and also the structure has fewer structure nodes; coverage expansion and the network are scalable to increase the routing nodes. Therefore, this design uses the tree structure network topology, which is shown in Figure 3.

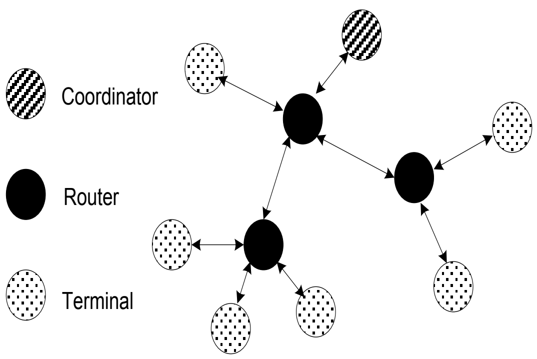

Figure 3: The graph of tree network topology

5. The design of the software system

5.1 The design of RFID data acquisition and processing

First of all, the RFID reader initializes many parameters, including its working mode, the output power, speed, and so on. When receiving a tag command issued by the ARM microprocessor, the reader scans whether the tag has entered the active region, and detects whether it is valid. After the successful acquisition of the tag card information, the process provides the card information (including card number, card status, label data and the current time) to the user through the display screen. The communication protocol of the RFID reader and ARM processor use the character-oriented serial communication protocol, and protocol analysis is carried by the RFID interface driver module, which fills each domain according to the format of the protocol frame, divides them into the command frame and response frame, and packages them into the interface function. The upper application program achieves a variety of RFID reader operations through the function interface. The specific process is shown in figure 4.

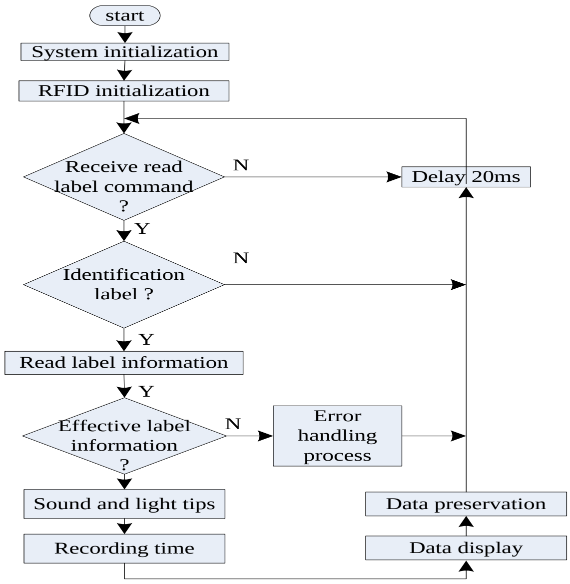

Figure 4: The flow chart of RFID data acquisition and processing

5.2 The design of the Zigbee interface program

MAC CC2430 and PHY layer protocol of Zigbee are implemented by RF chip CC2430, which is controlled by the RF communication module MCU. The working status of the RF communication module is divided into communication state and sleep mode. The module is usually in sleep mode. When the RFID Reader collects the tag information, the ARM processing platform transmits the tag information to the Zigbee module via the serial port and the sleep mode is activated into the communication state. The specific process is shown in figure 5.

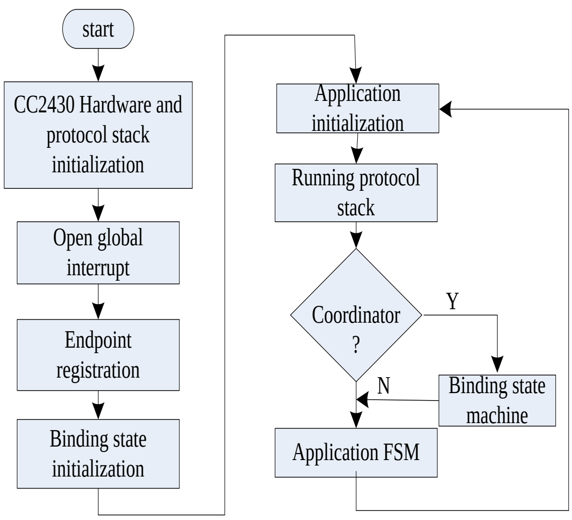

Figure 5: The chart of the Zigbee interface program

6. Test of the system performance

The test of the node receiver sensitivity tests the effect of the communication distance between two nodes on data acceptance and packet loss rate, in order to determine the effective communication distance between 2 nodes. The test used two S3C6410 as the controllers which were connected with two Zigbee terminal nodes. The software of the test used Smart Studio of Chipcon Company. There was an indoor test and an outdoor test. The indoor test was carried on in the experimental building of the corridor at both ends, with the middle barrier free. Some electromagnetic interference existed in the room. The outdoor test was carried out in an open area, without any obstacles or electromagnetic interference. In the test, the two nodes were of a fixed size (36 byte), the communication channel was 0x04, and the transmission power 0 dB. The test results are as shown in Table 1; from the test results it can be seen that as long as the effective distance between the nodes is within 60 m, the communication of nodes can operate normally.

Table 1: Experimental results of RSSI

Experiment number	Test environment	Test distance(m)	Packet loss rate(%)	RSSI(dBm)
IS1022	Workshop	58	0	-75.26
OS1030	Outdoor	82	0.82	-80.04
OS1036	Outdoor	100	1.25	-88.47
OS1042	Outdoor	130	7.53	-90.59
OS1051	Outdoor	150	40.02	-98.05

The test of the transmission efficiency of the network data was used to test the data transmission efficiency of the distribution point of the RFID. The test used four ARM control boards as the RFID information processing platform to connect four 3611RFID-RFS readers and four Zigbee terminal nodes, which constituted four distributed RFID information collection points. One coordinator node was connected with the server, and two router nodes were used to expand the network coverage. The test in the laboratory needed two adjacent rooms with about 20 cm wall. One coordinator, one server, one routing node and two RFID information collection points were arranged in the first room, and one routing node and two RFID were arranged in the second room. The distribution of each node was about 5~10 m. Each room contained about 6 to 10 computers in the operation, with consequent electromagnetic interference. When the RFID reader read the tag, the coordinator node and the terminal nodes periodically sent a fixed load (64 byte) of the data packets. The test results are shown in table 2.

Table 2: Experimental results of network data transmission efficiency

Data sending cycle (ms)	Test time (s)	Total amount of sending data(bytes)	Total amount of receiving data(bytes)	Total failure data(bytes)	Sending packet Success rate(%)	Packet loss rate(%)
12	500	5726451	5335382	391069	93.17	6.82
15	500	6394366	6311241	83125	98.70	1.29
14	450	6123240	5924979	198261	96.76	3.23
16	550	6726451	6624065	102386	98.47	1.52
20	500	6538276	6217945	320331	95.10	4.89
30	3500	793268	793268	0	100	0
40	320	782056	782056	0	100	0
50	300	682541	682541	0	100	0

From the test, it can be seen that, because of the delay of the node processing data and the interference of the electromagnetic environment, the node data transmission cycle should be higher than 20 ms to reduce the packet error and loss. During the process of the test, some nodes were powered, and they could detect the network interruption and add to the existing network automatically. The test verifies the feasibility and effectiveness.

7. Conclusions

In this paper, Zigbee wireless communication technology is combined with RFID automatic identification technology. It uses the effective radius of Zigbee wireless communication technology as high as 60 m to build a distributed RFID information acquisition system. The system can be deployed in non-fixed network infrastructure, can reduce the cost of cable network deployment, improve the flexibility of the RFID system, can make up the shortage of the original RFID information acquisition system, and broaden the application range of the system.

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