Design of the Quality Management System for Manufacturing Workshop Based on the Internet of Things

Qian-hong Yu, Hai-ping Zhu, Hong-cheng Yu, and Yun-jie Feng

Abstract The data collecting of the existing quality management systems (QMS) is generally not real-time, unintelligent and insufficient for quality analysis. A QMS based on the technology of Internet of Things (IOT) is proposed to make up for the drawbacks. We construct a wireless communication network using ZigBee technology for quality information transmission. The devices such as cc2530 chips are used to design the system hardware and .net platform is adopted in the software design. The QMS in this paper is more efficient and reliable, compared with the traditional system.

Keywords IoT • Quality management • ZigBee

1 Introduction

A high level of quality management system could greatly enhance the competitiveness of enterprises [1, 2]. Quality information collection is very important for quality management system of manufacturing enterprises. That is why we require real-time, automatic collection of the quality information in the manufacturing process and process-oriented dynamic online monitoring.

The wired data acquisition of quality existing management system is inefficient and inflexible on account of artificial collecting data [3]. In recent years, with the vigorous development of microelectronic technology, sensor technology, wireless sensor networks, radio frequency identification technology, the Internet of Things (IoT) emerges at a historic moment [4–6]. IoT has the characteristics of

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comprehensive sensing, reliable data transmission and intelligent data processing [7–10]. These characteristics make IoT very suitable for application in the quality management system of manufacturing enterprises.

Combining with the advantages of IoT and manufacturing enterprise's environment, this paper established a quality management system which is based on IoT for manufacturing enterprises, allowing quality engineers to monitor the quality of the products in real-time, and achieve more accurate control charts.

2 The Overall Design for the System

2.1 System Requirements

In an efficient and reliable quality management system, we need to perceive the relevant real-time information automatically, which is important for product quality monitoring. Therefore, it is necessary to achieve the materials' quality inspection results timely.

As drawing control charts need these basic data, it is essential for statistical process control (SPC) to realize the real-time monitoring for the quality of the products in the fabrication process.

2.2 System Structure

In order to meet the above requirements of an efficient and reliable quality management system, we design the structure shown in Fig. 1. The system consists of three layers: the perception layer, the network layer and the quality management layer.

As shown in Fig. 1, the perception layer is composed of numerous ZigBee sensor nodes. These nodes are distributed in the workshop, including the material warehouse, the production lines and the product inspection stations, to collect quality-related data and monitor the related statuses. The network layer is made up of some ZigBee route nodes, a ZigBee gateway and a web server. ZigBee route nodes maintain the routing table and transmit data in the ZigBee network. ZigBee gateway establishes the ZigBee network and manages the network. The ZigBee gateway communicates with the web server via Ethernet. The ZigBee gateway uploads the quality-related data collected by the ZigBee sensor nodes to the web server and receives commands from it. After receiving data from the ZigBee network, the web server converts the heterogeneous data into a standard format by data fusion and then stores them into database.

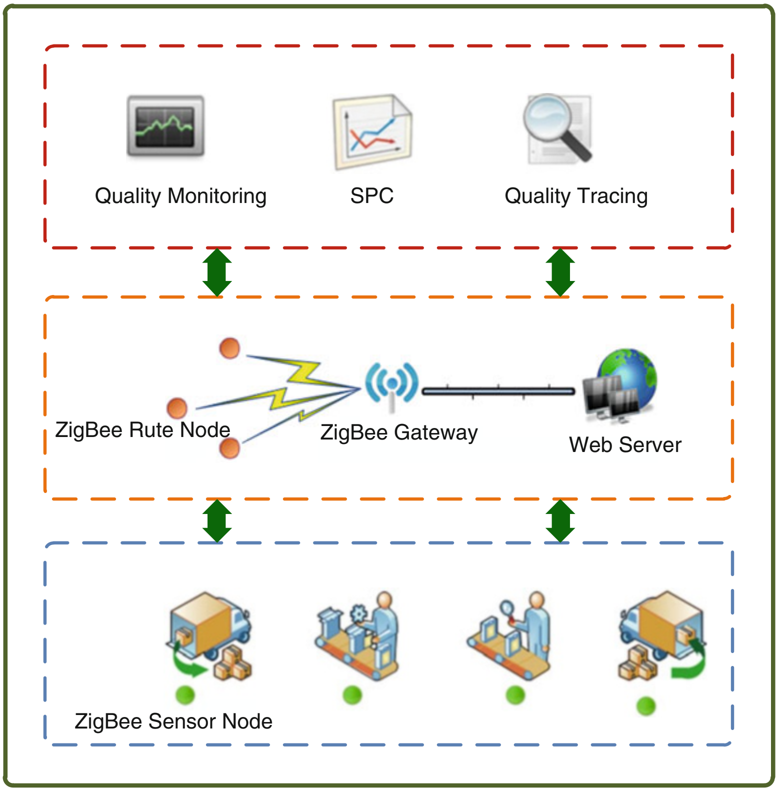

Fig. 1 Structure of the quality management system

3 Hardware Design

In order to satisfy the requirements of the quality management system, we choose CC2530 provided by Texas Instruments as the primary chip. CC2530 supports Z-Stack2007 and is able to establish various topology types of network, which is a real system on chip. CC2530 integrates an enhanced 8,051 μ control unit, AD converter, UART, etc. [11, 12]. With power consumption and industrial-grade anti-jamming capability, and the aid of some simple peripheral circuits CC2530 can meet many application requirements.

3.1 ZigBee Gateway

The ZigBee gateway establishes the ZigBee network and controls the network. The ZigBee gateway uploads the quality-related data collected by the ZigBee sensor

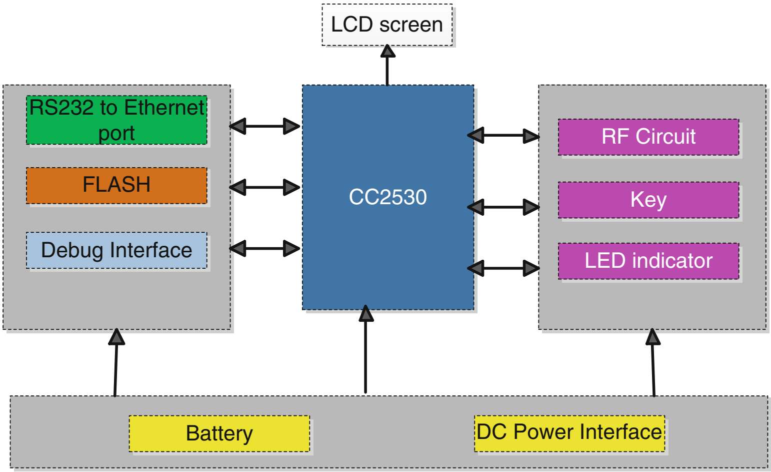

Fig. 2 Structure of the ZigBee gateway

nodes to the web server and receives commands from it. The ZigBee gateway is composed of CC2530, radio frequency circuit, RS232 to Ethernet module, power management circuit, etc. The hardware structure is shown in Fig. 2. The radio frequency circuit is used for transmitting and receiving wireless data packages. The only mechanism of communication with the web server is via the RS232 to Ethernet module.

3.2 ZigBee Route Node

The ZigBee route node's main task is to maintain the routing table and transmit data throughout the whole ZigBee network. The ZigBee route node's structure is simple, which is composed of CC2530, radio frequency circuit, power management circuit, etc.

3.3 ZigBee Sensor Node

The ZigBee sensor nodes are the nerve endings of the ZigBee network. The ZigBee sensor node is composed of CC2530, radio frequency circuit, the analog signal input circuit, the digital signal input circuit, the buzzer circuit, etc. The hardware structure is shown in Fig. 3. The ZigBee sensor nodes are connected with digital calipers via USB port to get the readings of the digital calipers. The ZigBee sensor nodes are connected with mechanical equipment via RS232 to monitor their running status.

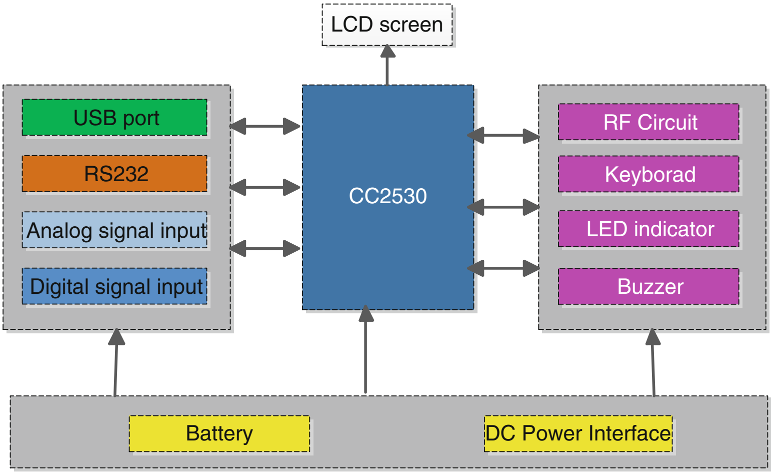

Fig. 3 Structure of the ZigBee sensor node

4 Firmware Design

Considering the characteristics of CC2530, we choose Z-Sack2007 as software platform to design firmware for the ZigBee nodes. Z-Sack supports star-type, tree-type, mesh-type topologies, and has many advantages such as: safe and reliability, low latency, large network capacity, etc. [13–15]. Therefore, it is quite satisfied with the requirements of the system.

4.1 ZigBee Gateway

The ZigBee gateway establishes the ZigBee network and controls the network. The ZigBee gateway uploads the quality-related data collected by the ZigBee sensor nodes to the web server and receives commands from it. The workflow of the ZigBee gateway is shown in Fig. 4. When the ZigBee gateway has successfully established the network, it will get into circulation mode. The ZigBee gateway assigns addresses for other nodes to join the network and manages these addresses.

4.2 ZigBee Route Node

The main task of the ZigBee route node is to maintain the routing table and transmit data throughout the whole ZigBee network. The workflow of the ZigBee route

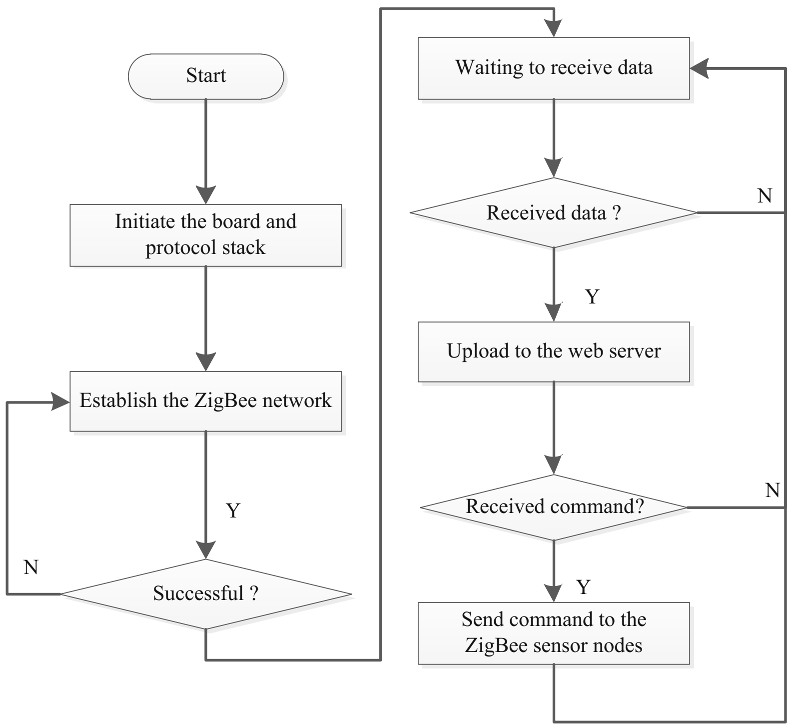

Fig. 4 Flow chart of the ZigBee gateway

node is shown in Fig. 5. After power on, the ZigBee route node first initializes the hardware and the protocol stack, and then begins to search the ZigBee network that can be joined.

4.3 ZigBee Sensor Node

The ZigBee sensor nodes are the nerve endings of the ZigBee network. As the nerve endings of the IoT, the primary assignment of ZigBee sensor nodes is to collect relevant data in real-time and automatically. The workflow of the ZigBee route node is shown in Fig. 6. After the initiation of the board and protocol stack, the ZigBee sensor nodes search Zigbee network to join. Once it has joined the network, it will pack data and upload to the web server.

The sensing targets of the ZigBee sensor nodes are various. The ZigBee sensor node connected to the RFID reader is used to collect the quality inspection data of materials in the warehouse district. In the mechanical processing zone, the ZigBee sensor node connected to the numerical control machine reads machine status. In the quality inspection area, the ZigBee sensor node connected to the digital measurement tools collects their readings.

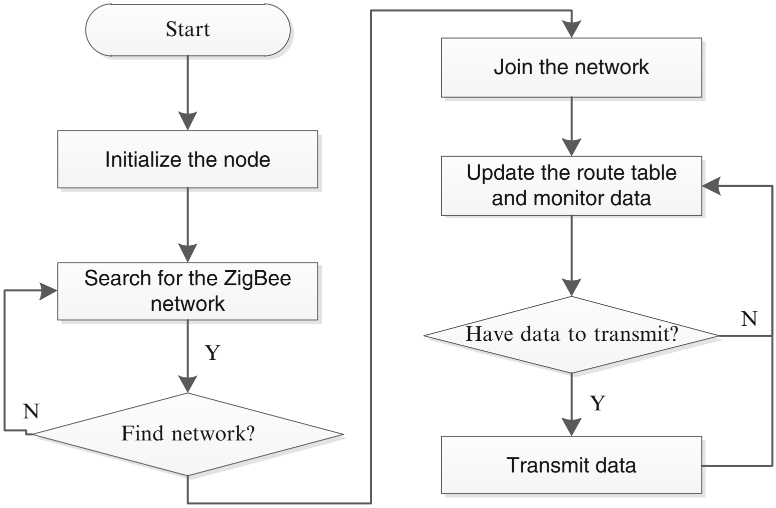

Fig. 5 Flow chart of the ZigBee route node

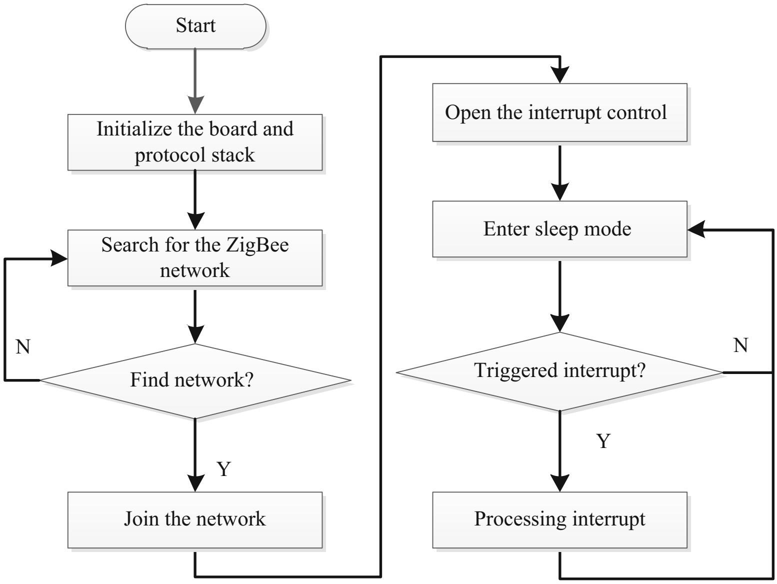

Fig. 6 Flow chart of the ZigBee sensor node

5 Quality Management System Based on the Internet of Things

Consideration of web service, we develop the quality management system on the .net platform, installed on the web server. The service platform has two functional modules.

1. Data processing module. The sensing targets of the ZigBee sensor nodes are various, which results in the complex structures of the original data. We exploit huge numbers of ZigBee sensor nodes to collect data, which leads to serious data redundancy. The primary task of the data processing module is to eliminate the above problems. The data processing module using data fusion techniques is used to eliminate redundant data, using data transformation to obtain the data with uniform data format.
2. Quality management module. With the aid of further data analysis and processing, quality management module provides quality monitoring, quality tracing, and SPC for quality engineers. The interface of the system is shown in Fig. 7. The system interface consists of three areas, the area of the raw data, the area of the information tree associated with quality, the area of SPC chart.

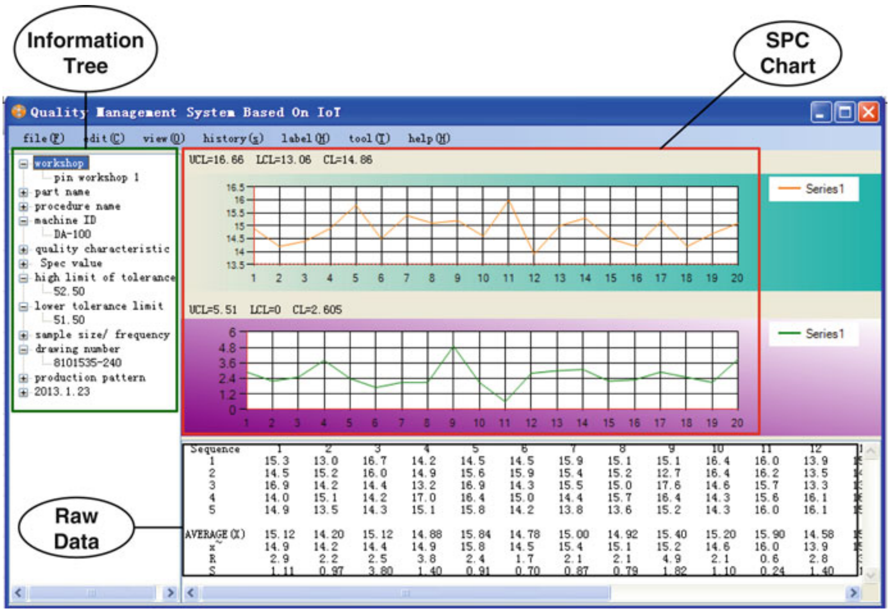

Fig. 7 Interface of the system

6 Conclusion

In order to improve the efficiency and reliability of the quality management system, this paper introduces IoT technology especially ZigBee into monitoring procedures and designs the quality management system based on IoT adapting to the manufacturing environment. The system has following advantages.

Using intelligent sensing technology of WSN and automatic identification technology of RFID, the quality management system could be more efficient and accurate.

Compared with conventional systems, it costs less and is easier to deploy.

These essential functions have been accomplished. Some other expected functions would be the future research emphasis.

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