ZigBee Implementation in Intelligent Agriculture Based on Internet of Things

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Abstract: The intelligent agriculture is one of the applications of Internet of Things (IOT),which has an extensive application and bright foreground. ZigBee Alliance formulated the ZigBee standards in the wireless sensor network technology,that are recognized widely as authoritative standard of the Internet of Things, but ZigBee nodes, as the important unit of an intelligent monitoring system for agricultural environment, are the basic unit to realize the monitoring function. The paper briefly presents the architecture of ZigBee technology, designs the hardware architecture of ZigBee nodes on CC2531 (ZigBee coordinator and end node) and the software architecture of ZigBee nodes, and implements on botanical garden in QiongZhou University. The actual test result demonstrates that the nodes can obtain the temperature, humidity and illumination information in real time, and then transferred to the remote monitoring center. It has better actual application value.

Introduction

As we all know, ZigBee Alliance is the standardization organization for the international important Internet of Things industry (Wireless Sensor Networks), formulated the ZigBee standards in the wireless sensor network technology are recognized widely as authoritative standard of the Internet of Things, a ZigBee is a low-cost, low-power, wireless mesh networking standard. The low cost allows the technology to be widely deployed in wireless control and monitoring applications, the low power-usage allows longer life with smaller batteries, and the mesh networking provides high reliability and larger range. As a brand-new information acquisition and the processing technology, the ZigBee has seeped gradually into the agricultural environmental monitoring domain [1-3].

The ZigBee technologies allow the identification of pests in the crops, drought or increased moisture. Having such information at a real-time interval, automated actuation devices can be used to control irrigation, fertilization and pest control in order to offset the adverse conditions. This technology can be applied for wireless applications in agriculture. The ZigBee nodes can obtain the temperature, humidity and illumination information in real time, and then transferred to the remote monitoring center.

ZigBee technology architecture

A. Device type and ZigBee network topology

To provide for low cost implementation options, the ZigBee physical device type distinguishes the type of hardware based on the IEEE 802.15.4 definition of reduced function device (RFD) and full function device (FFD). An IEEE 802.15.4 network requires at least one FFD to act as a network coordinator. ZigBee RFD is generally battery powered. RFD can search for available networks, transfer data from its application as necessary, determine whether data is pending, request data from the network coordinator, and sleep for extended periods of time to reduce battery consumption. RFD can only talk to an FFD, a device with sufficient system resources for network routing. The FFD can serve as a network coordinator, a link coordinator or as just another communications device. Any FFD can talk to other FFD and RFD. FFD discover other FFD and RFD to establish communications, and are typically line powered. The ZigBee logical device type distinguishes the physical device types (RFD or FFD) deployed in a specific ZigBee network. The logical device types are ZigBee coordinator, ZigBee router and ZigBee end device.

The ZigBee network layer (NWK) supports star, tree and mesh topology, depicted in Figure 1. In a star topology, the network is controlled by one single device called the ZigBee coordinator. The ZigBee coordinator is responsible for initiating and maintaining the devices on the network, and all other devices, known as end devices, directly communicate with the ZigBee coordinator. In mesh and tree topologies, the ZigBee coordinator is responsible for starting the network and for choosing certain key network parameters but the network may be extended through the use of ZigBee routers. In tree networks, routers move data and control messages through the network using a hierarchical routing strategy.

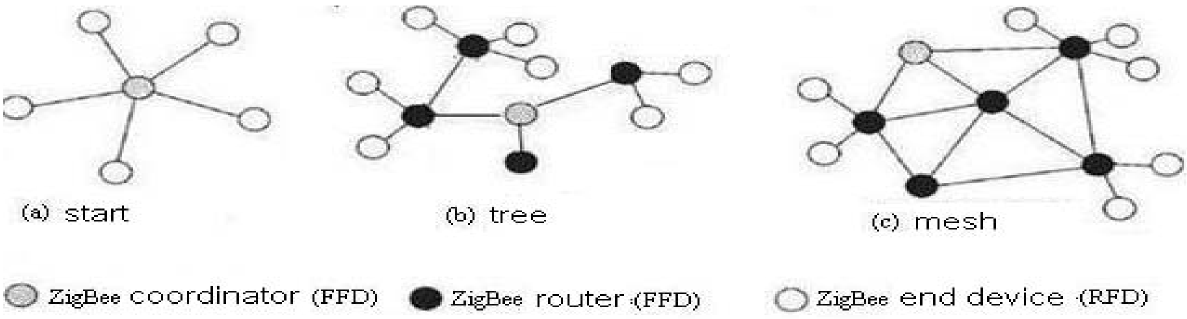

Fig.1. ZigBee network topology

B. ZigBee stack architecture

The ZigBee stack architecture, depicted in Figure 2, is based on the standard Open Systems

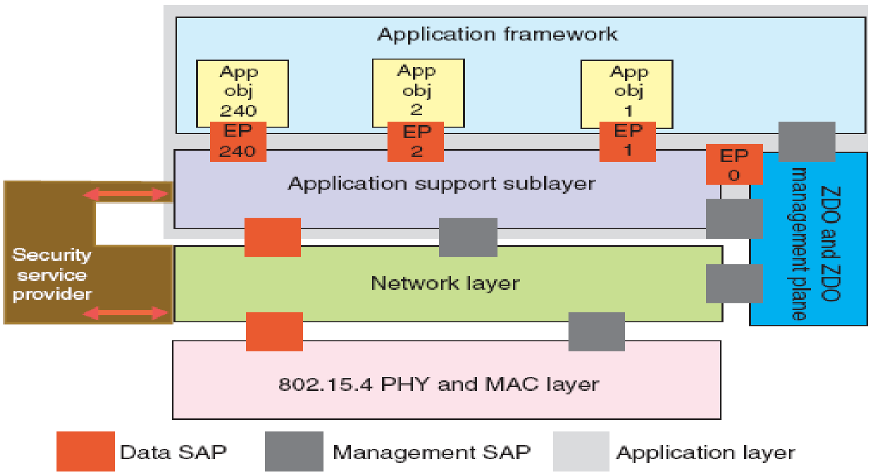

Fig.2 outline of the ZigBee stack architecture

Interconnection (OSI) seven-layer model [4], but defines only those layers relevant to achieving functionality in the intended market space. The IEEE 802.15.4-2003 standard defines the two lower layers: the physical (PHY) layer and the medium access control (MAC) sub-layer. The ZigBee Alliance builds on this foundation by providing the network (NWK) layer and the framework for the application layer. The application layer framework is comprised of the application support sub-layer (APS), the ZigBee device objects (ZDO) and the manufacturer-defined application objects.

Design of ZigBee node

A. Design of hardware for ZigBee node

ZigBee node, as the important unit of an intelligent monitoring system for agricultural environment, is the basic unit to realize the monitoring function .Which has traditional network terminal and routing dual function: on the one hand, realizing data collection and processing; on the other hand also forwarding, storage and management data. Although its design is different, but the basic structure is the same. It generally consists of the sensor module, the processor module, the wireless communication module and the energy supply module, depicted in Figure 3 [5].

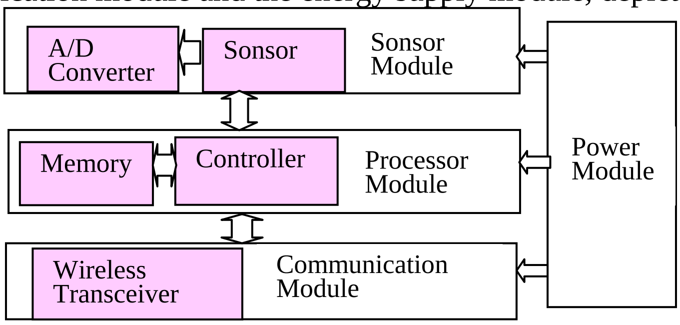

Fig.3 hardware structure of the ZigBee node

In the research, ZigBee coordinator and end node adopted CC2531.The CC2531 [6] is a USB enabled true system-on-chip (SoC) solution for IEEE 802.15.4, ZigBee and RF4CE applications. It enables USB dongles or USB upgradeable network nodes to be built with low total bill-of-material costs. The CC2531 combines the performance of a leading RF transceiver with an industry-standard enhanced 8051 MCU, in-system programmable flash memory、8-KB RAM and many other powerful features. The CC2531 has various operating modes, making it suited for systems where ultra low power consumption is required. Short transition times between operating modes further ensure low energy consumption. Designed ZigBee coordinator node depicted in Figure 4 and ZigBee end node depicted in Figure5.

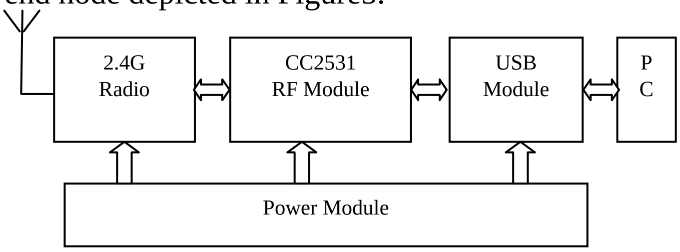

Fig.4 hardware structure of ZigBee coordinator

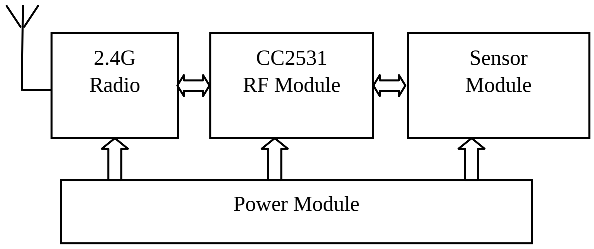

Fig.5 hardware structure of ZigBee end node

B. Design of software for the ZigBee nodes

System software design is based on the hardware design; software design is an important part of the system functions, and also the key to improve the system performance. Considering node design based on the versatility and simpleness of development, the software design is based on TI's Z-Stack 2007 protocol stack.

Z-Stack 2007 is designed specifically for CC2531 chip by TI. It is managed by a simple single thread operation system, which based on task scheduling mechanism. The event handling function of each task according to the priority of task is placed into a function pointer array tasksArr [idx], events using the 16-bit variable form are stored up the array tasksEvents [idx], so each task may be defined at most 16 events.

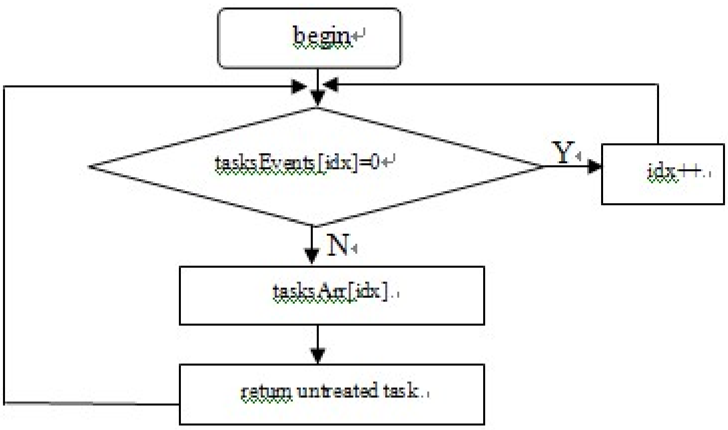

Fig. 6 the running process of the operating system

The running process of the operating system is depicted in Figure 6. Main function completing the node initialization goes into the operating system, which is an infinite circulation. The operating system has been detected the event each task tasksEvents [idx], when it is not zero, it will call the appropriate event handler tasksArr [idx]. If finishing an event, this array tasksEvents[idx] representing the event will reset, at the same time to return unhandled events, until all the event handling of the task finished (that all events reset), the operating system will jump down the next task.

Experiment

In order to test the monitoring nodes had been designed, from September to October; five nodes were deployed on botanical garden in QiongZhou University [2]. The values measured at 7:30 am to 8:30 in July 18 when the sun was shining by five nodes, depicted in Figure 7.

The five node collection of temperature, humidity, illumination data, in its turn, woke up to send the data, then went back to sleep for 5 min, continuous monitoring for 20 days. At a time, only one node was reading data from the sensors which embed in it, and waiting data request from the gateway. The gateway dealt with data requesting, and the other nodes were only able to answer the request. The fickle weather on the measurement day affected the results.

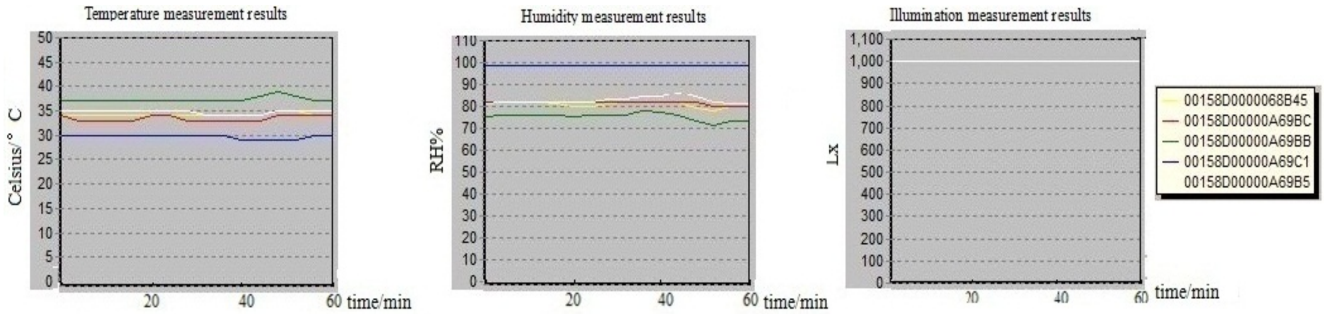

Fig.7 the measurement results

Conclusion

ZigBee with low power consumption, high reliability has a place in the short distance wireless transmission technology; this technology is the most suitable wireless technology for agriculture applications. That allows the administrator to instrument, observe and react to events and phenomena in an agriculture environment. This paper introduces ZigBee technology architecture and design ZigBee nodes finally implements experimental test in the Qiongzhou University, Sanya Campus Botanical Garden. Although today is not enough mature, but in the future the role of ZigBee in the Internet of Things will become greater and greater.

Acknowledgments

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