

A Wireless Control Platform Based on Browser/Server Mode

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Abstract

This paper builds a wireless control platform based on browser/server mode. The platform uses the ARM9-series S3C2440A to build embedded Web server, sets up a wireless local area network with ZigBee technology and designs responsive web as user interface which allow users to remote control devices in ZigBee network through the browser.

Keywords: S3C2440A, Embedded Web Server, ZigBee, Responsive Web

0. Introduction

With the popularity and development of the Internet, the network has become a trend in today's society. Nowadays, the realization of the network has two ways: wired and wireless [1]. Due to the wired network has the drawback of wiring complexity and poor scalability. So the wireless network will be the hot spot of the network application. Internet has a large coverage and fast transmission rate [2]. And ZigBee network has the advantages of low-power, low-cost. In our lives, control which appears in many areas is an essential adjustment way. Therefore, this paper puts forward a wireless control platform based on browser/server mode. This system combines two types of network, uses Internet as external network, and uses ZigBee as internal network, which is widely used and also can be redeveloped according to the application.

1. System Overview

This system mainly builds a wireless control platform based on browser/server mode. Users can use the browser of phones, IPAD or PC to control the ZigBee devices through the web page. This platform consists of three parts: web page which is front-end and operated by users, web server which is middle-end and based on ARM9, used to respond to the request from the web page and

sends commands to control devices through ZigBee network, and ZigBee devices which is terminal node and can be extend a variety of functions according to the needs. ARM 9 is connected to the Internet via Wifi or DM9000 network card. System diagram is shown in Figure 1.

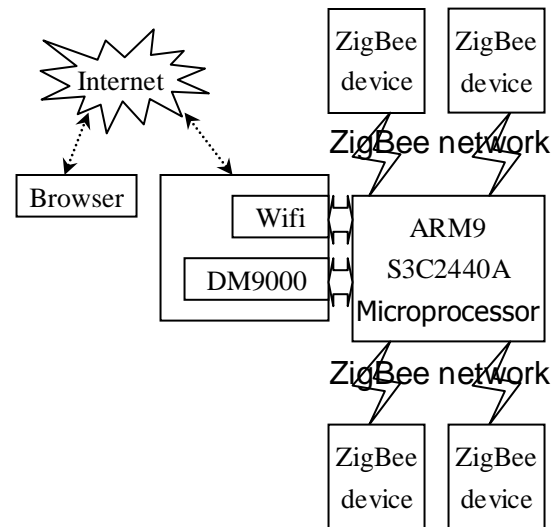


Fig. 1: System diagram

2. System Implementation

2.1. Building System Environment

The Samsung S3C2440A microprocessor (ARM 9) is used in this system, which has rich on-chip resources. The platform uses the Linux operating system. Operating system transplantation requires three steps [3]: 1) transplant bootloader 2) transplant Linux kernel 3) transplant file system. U-boot is used as bootloader; Linux 2.6.30 is used as kernel; Yaffs is used as file system in this system. Kernel transplantation requires configuring the peripheral hardware support. In this system, Wifi module with USB interface and DM9000 network card are used. Hence, USB and DM9000 hardware drivers need to be added while configuring kernel, which makes ARM9 can access the Internet through wired or

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wireless network connection. And the file system is built by BusyBox before Yaffs file system transplantation.

2.2. Embedded Web Server

2.2.1. Introduction of Boa and CGI

The Embedded Web Server is a key part of the system, its function is to analyze and process the web page from users' submission, and send control signals to the ZigBee devices. The server is built by Boa and CGI program.

Boa is a tiny web server which only has about 60 KB executable codes. It is a single-task HTTP server that runs under UNIX or Linux and is suitable for embedded systems. As a single task web server, Boa can only complete the users' request one by one, and will not fork a new process to handle concurrent connection requests. However, Boa which supports CGI can fork a process to execute CGI program [4]. The design goal of boa is speed and security, and its source is open and has high performance.

CGI (Common Gateway Interface) is one of the most important technologies in WWW technology, which plays an irreplaceable position. CGI is a standard interface and rule for information transfer between CGI programs and web server. It offers client interface with HTML web pages which physically is a program that runs on the server. The function of CGI program is to analyze and process the input information from the form on the HTML web pages [5], and to produce the corresponding operation on the server or feed back the corresponding information to the browser. This function makes web pages dynamic and makes the server interact with users. The specific processing step of CGI is a、send users' request to the server through the Internet; b、the server receives users' request and hands it to the CGI program to process; CGI program transmits the processed result to the server; d、the server sent back result to the user.

2.2.1. Implementation of Boa and CGI

The specific steps of building Embedded Web Server is: 1) transplant boa software, configure makefile, use the command "make" and "arm-linux-strip" respectively to compile and optimize; 2)transplant CGIC library used to support CGI program, the steps of transplantation is the same as boa. It also need to configure makefile and use the command "make" and "arm-linux-strip" to compile

and optimize; 3)configure boa, CGIC library, namely the executable files of boa and CGIC are compiled into file system.

2.2.3. Responsive web design

Web server uses web page as user interface, thus the design of web page is more important. This system uses HTML and JavaScript to design web. The idea of this platform is which allow the user to access with the browser of different devices. And different devices mean the size of screen is not the same. So making web page adapted to different size of screen is a problem to be solved. In 2010, Ethan Marcotte proposed the term "Responsive Web Design" and indicated that web can automatically identify the width of screen and make appropriate adjustment [6].The point of responsive web design is as follows [7]:1) Allow the width of web to adjust automatically and the initial size of web is accounted for 100% of the area of the screen and uses the "viewport". 2) Do not use absolute width, but use a percentage of the width or automatic width. 3) Use relative size font (e.g. em). 4) Use fluid grid, namely each module is floating, and not fixed. 5) Use Media Queries of CSS3,which can load CSS selectively [8], that is to say, load different CSS according to the size of screen which detected by web page and CSS is designed according to different sizes of screen.

2.3. ZigBee network

ZigBee which is characterized by short distance, low complexity, self-organizing, low-power, low-data-rate, low-cost is low-power local area network protocol based on IEEE802.15.4 standard and suitable for application in the field of automatic control and remote control[9].There are three types of device: coordinators, routers, end devices and three network topologies: star, tree, mesh in ZigBee network[10].This platform builds the ZigBee network by star topology network that is shown as in the Figure 2.The star topology network is composed by a coordinator and one or more end devices. The coordinator is the core of the entire network, which is responsible for starting the network, managing the other endpoint and assigning different network address for all endpoints [11].In star topology network, endpoints only perform wireless communication with the coordinator and can't

send information between each other. As shown in the Figure 2 above, the coordinator communicates with S3C2440A via the serial port. The S3C2440A transmits information with end devices and sends control signal to end devices by the coordinator. End devices also return the processed result by ZigBee network.

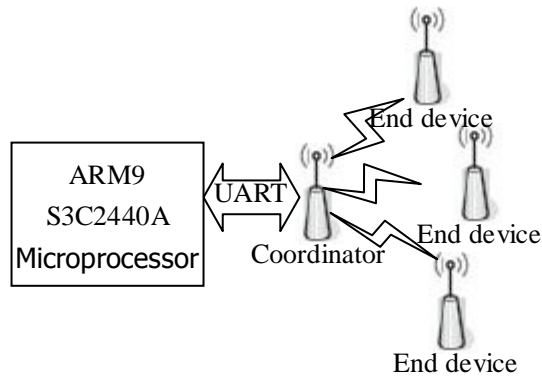


Fig. 2: ZigBee network topology

The coordinator and end devices both use CC2530 which the chip of Texas Instruments. The CC2530 combines 2.4GHz IEEE 802.15.4 RF transceiver and enhanced 8051 core which has programmable flash memory, 8 KB RAM, 5 channel DMA, 2 powerful USART that support a variety of serial communication protocol, 21 digital I/O pins that can be configured as general-purpose digital I/O or as peripheral I/O signals, a watchdog timer, 8 individually configurable channels and 12 bits ENOB ADC, 18 interrupt sources. Rich on-chip resources make CC2530 to have great extensibility [12].

CC2530 is developed by Z-stack in this system. ZigBee protocol is divided into two parts: the IEEE 802.15.4 defines PHY (physical layer) and MAC (medium access control layer); the ZigBee standard defines NWK (network layer), APL (application layer) [13-14]. The Z-stack is an API interface for users which realizes define of the protocol in each layer in form of functions.

Developing specific applications only need to call its functions directly without caring about Z-stack implementation details, which greatly reduces the development time. ZigBee-pro/2007(Z-stack) is used in this system. The Z-stack is a mini operating system and the work mode is task polling, as shown in Figure 3. As the communication between the coordinator and end

devices is a point-to-point communication and is bidirectional, the communication mode of each nodes(including the coordinator) are set to peer-to-peer mode of transmission.

The steps of implementing the coordinator:

- 1) Build networking: call the function of building network and the function of joining the network in the Z-stack to achieve the establishment of network and the joining of endpoint.
- 2) Send data: call the function of wireless data sending to wireless send data.
- 3) Receive data: call the function of wireless data receiving to wireless receive data.

As end devices only has the function of sending and receiving, so they should simply call corresponding functions.

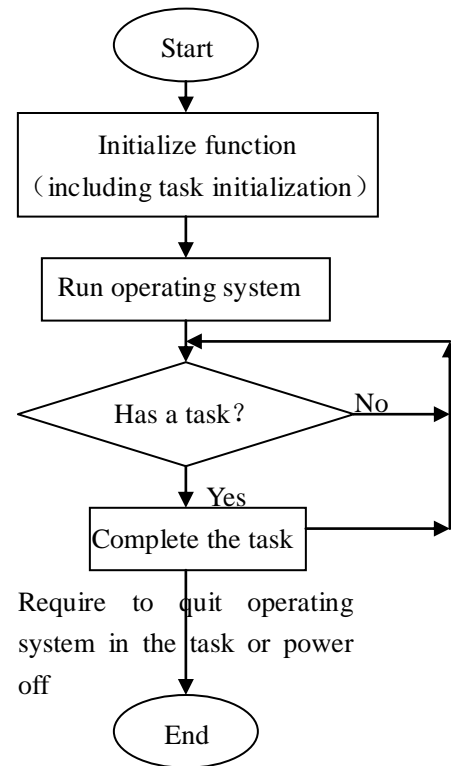


Fig. 3: Task polling workflow in Z-stack

Each endpoint which is with 8051CPU that has the function of control can be equipped with various sensors, LED lights, stepper machines and other devices. One specific application of the present system is the monitoring of the laboratory environment. The end devices are equipped with temperature and humidity sensors, light sensors, smoke sensors, gas sensors and

other sensors and placed in every corner of laboratory. Designing a responsive web provides users with an interface for inquiring, controlling, setting. As long as visiting the web page, the user can remotely monitor laboratory environment.

3. Summary

The research builds a wireless control platform based on browser/server mode with designing responsive web, building embedded web server and setting up ZigBee network. Used in this system, the S3c2440A and CC2530 chip both have a wealth of on-chip resources and has good scalability, which is convenient for secondary development. ZigBee network can increase or decrease the endpoints according to the application which has great flexibility. This system with the merit of convenient, reliable, low-cost, low-power has a large application space and is suitable for the smart home, smart lab, remote data collection system and so on, which combines the characteristic of Internet and ZigBee network.

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