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Original Research Article

DESIGN AND IMPLEMENTATION OF ARM BASED EMBEDDED WEB SERVER USING LINUX

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Abstract

This paper reveals the theory and methodologies of design and implementation of an embedded Web server, on ARM9 based AT91sam9260 board and Linux as its operating system. Usability of Linux is proved in terms of its flexibility and transplantable nature. The method used to transplant Web server Boa on the embedded Linux platform is also discussed in detail and working of Web server is explained. For the implementation of dynamic web pages use of CGI technology is proposed. Finally the implemented embedded web server is to be tested to indicate that it is responding rapidly and operates efficiently and steadily, which will achieve the expectant designing purpose

Introduction

With the rapid development of internet technology, the remote control is becoming increasingly common and the control system is in a trend that changing from field control to the remote internet control. Some of the existing remote control systems need the support of client-side program. That not only brings more difficulties to the development, but also increases maintenance of the client software. A web server is a system which hosts a web site and provides services for any requesting clients.

An embedded web server is a microcontroller that contains an Internet software suite as well as application code for monitoring and controlling the systems. Some of the main advantages of Embedded web server are, no additional software is necessary to install as browser can be used directly used also it is possible to develop cross-platform transplantation for Web server.

The main advantages of using embedded Web server mainly include: (1) the client can be freely set and the browser can be used directly without installing additional client software; (2) for the harmonization of Web standards, it is possible to develop cross-platform transplantation; (3) the operating system

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Linux, which can be reduced and transplanted, provides a convenient, fast and simple method for embedded systems and Internet access Arm9 is selected because of availability of MMU(memory management unit) and support of linux stack for it. Boa Web Server is selected among the number of web servers available and selection criterion is discussed below.

The Hardware Of Web Server

Picture 1:At91sam9260 board

AT91sam9260 microcontroller contains ARM926EJ-S ARM Thumb Processor which is used as core of the hardware platform in this paper. Picture1 shows the real picture of board Figure 1 is the block diagram of hardware system. It includes: serial port, Ethernet interface, USB port, storage systems and so on. AT91sam9260 microcontroller has ROM of 32 Kbyte, 2SRAM of 4k byte each. It has 3 to 20 MHz crystal support. The microcontroller externally has 2 SDRAM (32MB each), NAND flash (64 MB).

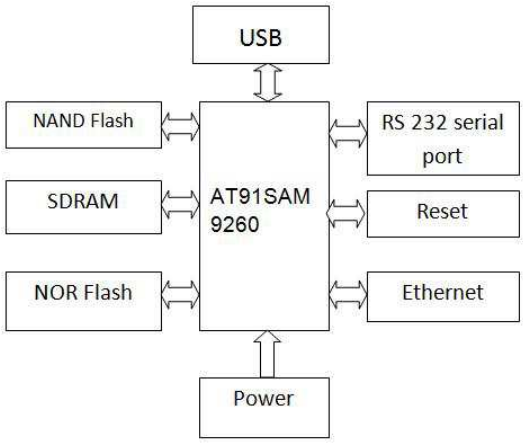


Fig.1

The images of boot loader, kernel and file system are stored in NAND flash. The board has a jumper which when connected NAND flash is selected, otherwise SDRAM is selected. For the Sam-Ba utility USB support is required. For transferring data to the board serial port is required. Fig.2 shows the connections.

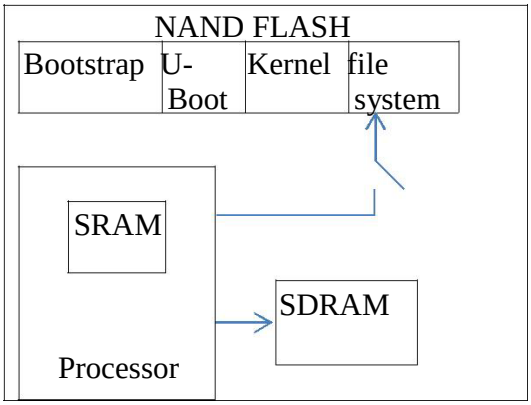


Fig 2

The Software Platform of The Web Server

A. *The choice of Embedded Web server*

The embedded devices have limited resources and don't need to handle the requests of many users simultaneously. Therefore they do not need to use the most commonly used Linux server Apache. Web server which is specifically designed for embedded devices are applied in such case .This kind of Web server requires relatively small storage space and less memory to run, which makes it quite suitable for embedded applications. The typical embedded Web server has three kinds, namely httpd, Boa and thttpd. The kind of web server to be select depends on the application. Their comparison is given in table 1.

Hence due to support of Authentication, CGI technology and dynamic web technology, Boa Web Server is used.

B. *The system diagram of Embedded Web server*

The system structure of embedded Web server is shown in Fig.3. The client PC is connected to the Internet through a browser and then gets access to the embedded Web server. Through this way, remote login and operation are realized Compared with the traditional mode, this mode is simple to use, convenient to maintain, and easy to extend.

Table -1

Server / Parameter	Httpd	Thttpd	Boa
Development Language	C	C	C, Perl
CGI Support	No	Yes	Yes
Platform	Windows	Linux , Mac OS,BSD	Linux, BSD
Authentication	Not Supported	Supported	Supported
Resources	Need more resources	Need more resources	Need less resources
Dynamic Web Technology	Not supported	Supported	Supported
Kernel Space/ User Space	Not Defined	User Space	User Space
Open Source	Yes	Yes	Yes
Cost	Free	Free	Free

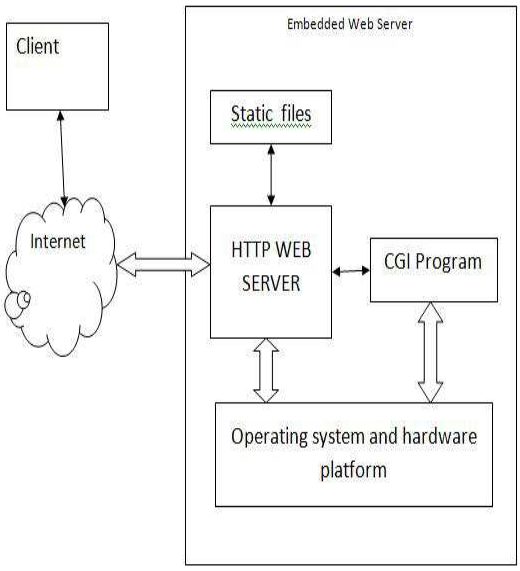


Fig.3

The system structure of embedded Web server is shown in Fig.3. The client PC is connected to the Internet through a browser and then gets access to the embedded Web server. Through this way, remote login and operation are realized Compared with the traditional mode, this mode is simple to use, convenient to maintain, and easy to extend.

C**.** *Principle of Embedded web server*

Boa is a single task Web server. Boa does not create a separate process for each connection like other servers, nor handle multiple connections by copying itself. Instead, Boa handles multiple connections by establishing a list of HTTP requests, but it only forks new process for CGI program.

The algorithm of Boa web server is as follows:

1. Initialization of web server which includes creating socket, binding a port, continuously listening to port for the connection requests.

2. After a connection request, it accept the request, analyzes request, URL target, information list. Then it saves the information and simultaneously processes the request.

3. After it is finished, the Web server sends responses to the client browser and then closes the TCP connection with the client. For different request methods, the embedded Web server Boa makes different responses. If the request method is HEAD, the response header will be sent to the browser; If the request method is GET, in addition to sending the response header, it will also read out from the server the

URL target file of the client. If request method is POST, the information of the list will be sent to corresponding CGI program and then take the information as a CGI parameter to execute CGI program. Finally, the results will be sent to client browser.

Linux Transplantation

Fedora, a distribution of Linux is used as operating system. Operating system consists of 3 main components i.e. boot -loader, kernel, filesystem which is discussed further.

Before actual transplantation, Referring to the boa.conf file in /etc directory, html pages to be displayed are created in /var/www directory.

For the transplantation of Linux onto board following steps are done.

2. Creation of Bootloader image

Bootloader is the first piece of code after power on.It performs power on self-test, initializes the hardware, boot-

medias and load kernel to RAM from bootable media.

Initially a shared folder between host and guest OS named ‘winxp_shared’ is created. In directory:

/home/workspace/uboot/include/configs

Header file at91sam9260ek.h is explored with text editor and with the command: #make at91sam9260ek_nandflash

a binary file of u-boot is generated which is to be loaded while porting Linux on ARM9 For copying this binary file to windows shared folder:

#cp u-boot.bin /mnt/winxp_shared.

U-boot.bin file is generated after compilation of at91sam9260ek_nandflash file. This .bin file is the image to be loaded onto the board for boot loader.

3. Creation of Kernel image

Kernel is computer program that manages the tasks and the hardware most notably memory and CPU time. While

compiling kernel things such as networking support, kernel features etc. are to be taken into account. In directory: /home/workspace/uboot/include/configs/

at91sam9260ek.h

Initially addresses of images are to be written

#define CONFIG_BOOTCOMMAND "nand read 0x21000000 0x80000 0x200000; bootm 21000000 " Also user defined delay is set by:

2#define CONFIG_BOOTDELAY 12

7. In uboot directory: #./make.sh

directory: /home/workspace/linux-3.3.7

#make ARCH=arm menuconfig

This displays a GUI. Requirements are configured corresponding to arm9 board. The OS will support only the selected configurations.

In same directory: /home/workspace/linux-3.3.7

Make.sh file is explored. After configuring kernel, uImage file is generated to be transfer on the board.

A. Creation of File system image

File system is data structure or a collection of files. Linux has single parent directory known as root directory. It has tree structure of other basic directories under root directory. Filesystem is used to control how data is stored and retrieved.

In directory: /usr/local/buildroot-2012.05

#make ARCH=arm menuconfig

Using GUI configuration is to be made according to ARM9 board. At the same time, Boa is also included within it.

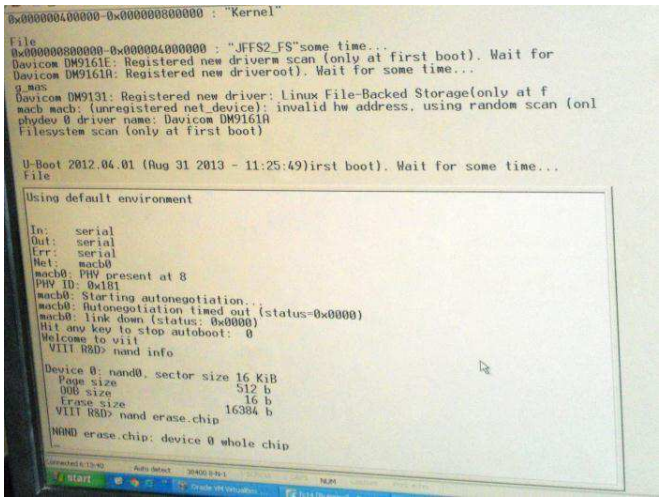
B. In the same directory

#make ARCH=arm

This will generate rootfs.jffs2 (journaling file system2) is created in /output/images. All 3 images are collected to the shared folder 'win_x shared' created initially.

Implementation

ARM9 board is connected to the host PC using serial cable, Ethernet cable, USB cable. IP address of PC is set as 192.168.0.2



Picture 2: command prompt while booting the board.

On hyper terminal a connection with baud rate 38400 is selected. A prompt will display on hyper Terminal. Now IP address of Board is to be fixed as ifconfig eth0 192.168.0.3.After setting the IP address the board will get boot up. Ethernet connection is checked by 'ping' command on host PC.

Now, SAM-BA utility allows us to transfer the configured images to corresponding addresses of microcontroller. With the the command 'boa' on the command prompt of board, webserver will get initialized and the HTML pages which were created are supposed to get displayed.

For preparing dynamic web pages use of CGI (common gateway interface)technology is proposed. CGI is a common interface standard which is applied to interact between

the application of external expansion application and Web Server. CGI provides the Web server with channel to implement external program. This service technology makes browser and server interactive.

Conclusion

This embedded Web server removes PC as gateway and is a separate module which can provide a standard interface. It can be applied easily to embedded fields such as on-site servo system, industrial control, and intelligent appliances. Therefore, it has a wide range of applications.

In this paper, ARM and embedded Linux OS are used as hardware and software platform, Boa is used as a Web server. Boa Web server occupies less system resources, Boa can stably run on the target board, easy to use and maintain. In addition, the solution based on "embedded Web server" is also easy to expand, conform to small client side requirements, good openness and portability, and is easy to maintain and upgrade. It also has more functions and supports CGI. This method improves system security, and makes it possible to interact with users and create dynamic Web pages.

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