REAL-TIME EMBEDDED WEB SERVER FOR REMOTE ACCESS AND INDUSTRIAL MECHANIZATION USING ARM PROCESSOR

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ABSTRACT

Industrial automation is one of the mounting fields that forge many technologies for its growth that makes the mechanization simple and user friendly. Embedded system based design made many applications user friendly and surmounts all the disadvantages that subsist in the erstwhile design like CPU Utilization, Memory and power supply. Industrial automation engrosses data acquisition and Control System units for a meticulous application. Now days electrical power is a major problem and this interrupt the unremitting working of the industrial appliances. Hence the electrical power must be hard in some ways, so that it can be utilized for other operations. The data acquisition system was realized first to obtain the data from the working system and then manage the system based on the acquired data. The proposed system was developed using the ARM processor that performs like a general purpose computer which collects the data and take the obligatory action depending on the data collected. The Central Processing Unit of the system is S3C2440 16/32-bit microprocessor based target board which contains all the peripherals like RAM, ROM, secondary memory, Ethernet controller with high performance ratio. This system overcomes the disadvantages that exist in other design and uses underlying protocols for data communication over the computer networks since the target board itself act as an embedded Web server. The main advantage of the system is lesser computational memory and larger storage memory for the real time control of the industrial appliances. Overall the system is a single stand alone multitasking system that performs various tasks like data acquisition, supervise and control.

Keywords—: *Embedded Linux, ARM, Data acquisition (DAQ), DC motors, Digital Control, Graphical User Interface (GUI), and TCP/IP.*

I. INTRODUCTION

Real-time distributed industrial control systems are flattering one of the vital areas in embedded control applications. Web based control systems are employed for many applications like home automation, industrial automation and medical field, etc. As they can afford a GUI interface [1] to various client server applications which increases the performance and reduces the human errors occur in the monitored system. Remote access is performed by using the different communication protocols that are used either on the sides of the communicating device. Microcontroller and Microprocessor based systems have been developed for the

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industrial automation but most of the system developed needs a secondary storage device that stores the acquired data and publish it as a web page on the internet via Web server [2]. Due to the progression of semiconductor techniques a whole system is developed in a single board that can produce the identical results as though the application is developed for the general purpose system [3]. In the proposed system, the target board is programmed to be acting as a general purpose computer that work in a multitasking environment to do the various tasks like data acquisition and Web server for remote access of the peripherals and respond to the clients independent of the location [4]. A data-acquisition system is connected to web clients via the Internet through the web browser. The data acquisition system needs to relay on the acquired information to send the data to the requesting clients. Digitally acquired data are stored in a Web server's database and they are updated every particular time period [5]. Whenever the client wants to access data, it sends the request to the server; this request is taken from the router, then connected to the internet. The web processes the request made and finally connects to the desired Web server [5], access the requested data and sends the data to the client.

In this proposed work, we depict the design and implementation of an embedded system with an onboard ethernet interface allowing remote device control and data acquisition through internet. The embedded device of the system can be an important element for building systems that shows a very promising prospect for building manufacturing systems and for industrial applications. The main advantage of the system is memory and power management as the whole system is developed by a single target board.

II. Embedded Linux

The real time operating system is embedded in the processor for its working in the multitasking environment. Some of the real time OS that is mostly used in the embedded system are µCOS, Embedded Linux, PSOS [8], [14]. The most widely used operating systems for any embedded development is the Embedded Linux. The programmers prefer this operating system for their development because it is open source and it needs small memory for running on a processor. The main advantage of the Linux kernel is it can be configured according to our application. The embedded Linux OS is developed for the networked embedded systems that have the TCP/IP protocol stack for data communication over the network. The number of tasks is loaded in the memory and they are given priority depending upon the importance of the task. The interrupts are used to stop the lower priority task and run the higher priority tasks. The user can define the task's importance with the help of the registers in the memory. The OS schedules these tasks for the execution in the processor. The different task required for the application are created and they are scheduled according to the priority. The linux kernel is used to schedule all the tasks. The RTLinux is a real time OS that communicates the user with the hardware. The operation of a real time Linux is depicted as in the following Figure 1.

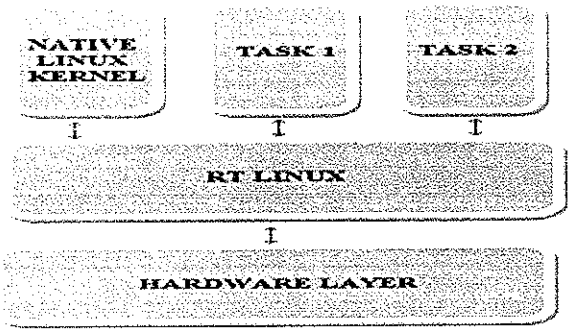

Figure 1 : Real-time Linux Architecture

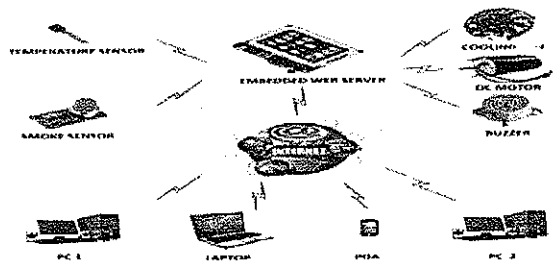

Figure 2 : System Architecture

III. System Overview

The overall system consists of the three major units. One is the data acquisition unit, control unit and other is the data communication unit that is similar to an industrial environment. The analogue data are acquired by the sensors that convert the external physical parameters to a voltage level that can be processed by the control unit. The control or central processing unit is an ARM processor [6] which controls all other units. The peripherals components like DC motor and cooling fan status can be viewed in the browser and it can be ON/ OFF manually. In the automated mode, DC motor is in ON condition but when the temperature rises beyond the particular limit, DC motor stops and cooling fan starts running. The security of the system is enhanced by providing the smoke detection using the smoke detector. Using the standard web browsers the client can log in and view the status as well as control all the peripherals connected to the system via the browser [7]. Data communication is carried using the Ethernet controller resent in the target board. The overall system architecture is shown in the following Figure 2.

A. Embedded Web server

Embedded Web server acts as an intermediate between the user and the application for accessing and controlling data. The target board is configured as the embedded Web server using the programming code written in C and HTML. This code is very useful in the interaction of the client with the server. Application running on the embedded target board is updated and the information about the updated data is sent to the requesting clients through the standard communication protocols through the browser. The server allows the client to access the data acquisition system through the username and password. The server code developed matches the user name and password and if it is equal to the typed content at the client side, the server allows the user to access the data acquired by the ARM target board. The well known commands in the HTTP protocol are GET and POST. When a client request for a particular information GET command is used by the protocol and to put any data in the server POST command is used by the HTTP protocol. For a system to be act as a Web server we need to configure the IP address and the protocol stack for networking is available in the embedded Linux which is used for our application.

The HTML web page is generated by the server that is shown at the client side. The embedded Web server that uses the HTTP protocol is explained as in Figure 3.

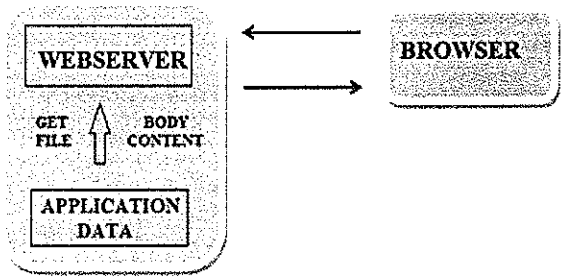

Figure 3 : Embedded Web server Architecture

Many numbers of tasks like data acquisition, process, and data communication are carried out over the network [8]. Data acquisition is implemented with the help of both hardware and software. Most of the embedded systems [9] employ sensors to convert the physical parameters to voltage and make the process by ADC that is available in the central processing unit. Data acquisition Unit [10] consists of sensors like temperature sensor LM35, smoke sensor and the information about the peripherals is monitored data is collected in the ARM based embedded board. MINI2440 target board which is a single board computer based on Samsung S3C2440 microprocessor has inbuilt ADC, Web server, Ethernet controller [2]. We make use of ADC for analogue data processing by connecting the sensor at the analogue input on the board and Web server updates the web page at stipulated time which is to be shown at the client side. The board has inbuilt DM 9000 network chip [8], an Ethernet controller performs the communication of packets over the network that send and receive the data for client-server interaction.

B. MINI2440 Target Board

For the proposed system, the system should act as a standalone system that acquire data and transmit the data to the client side via the Web server [11]. The Target board contains the Samsung S3C2440A processor that operates at frequency 400 MHz up to highest 533 MHz. 64 MB SDRAM is used for faster memory access. 64 MB NAND flash is used to store the boot loader of the application OS which is Qtopia, 2 MB NOR flash is used for execution of the application code which is stored in the SD card. It has one 100 Mbps Fast Ethernet RJ-45 interface (used network chips DM9000). It consists of Serial ports which include RS 232, two USB interface and 4 user LEDs. The LCD is used is on-board integrated 4-wire resistive touch screen. The graphical user interface for the board is Qtopia 2.2.0 which contains the Linux kernel 2.6.29 but the board can support other OS like WINCE, etc [12] [15]. The application is developed for Linux based system as the development is easy and OS is free of cost.

IV. Software Implementation

The application code for the proposed system is developed using the embedded C language and Hypertext Markup Language (HTML). The ADC conversion process[3] is carried out in the target board that runs the C code for the conversion process. HTML language is used for client-server interaction between the target board and the client via the browser. The OS [14] used for the implementation is Embedded Linux which is widely used OS in the embedded applications. This section explains about the porting of Linux into the target board and application development in the Linux environment.

A. LINUX Porting

The boot loader and Qtopia [15] are provided along with the target board. It is loaded using the memory card or the NAND flash. The compiler for the development is installed in the Linux environment like Ubuntu and the application code is compiled with the help of the GCC compiler based on Linux environment. The compiler produces the bin file and this is to be copied in the memory card which can be executed on the target board. The steps for RTLINUX porting is explained below

1) USB driver has to be installed and connect cable to system for copying.

2) RUN DNW. exe in tools. Configure to 11500 baud rate. We use 2 kinds of serial communications.

3) This helps PC information & board information to be seen in the PC itself. For PC we use CMD window using USB. For board we use Hyper Terminal RS232.

4) Using DNW download elements in the NAND Flash and Format NAND flash by pressing F

5) Transfer .Bin file for having information about what how to read file Linux kernel V.

6) Uboot NAND RAM .Bin by pressing K and Downloaded rootfs_qtopia_qt4. Image.

The following Figure 4 shows the Hyper Terminal window which is generated by the board

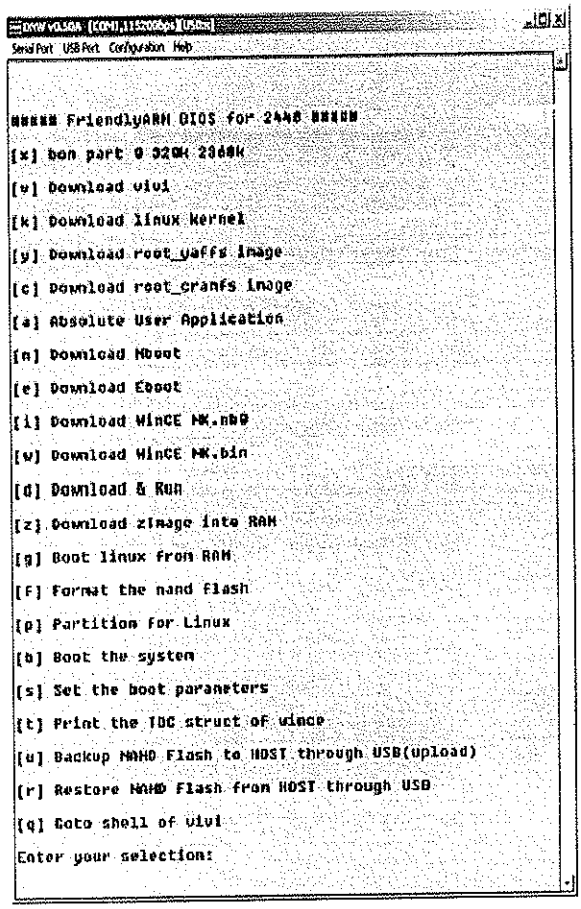

Figure 4 : DNW terminal window

V. Application Development

Board Support Package (BSP) is provided along with the board that contains the device driver package for all the peripheral devices in the board. These device drivers are used in the application code as functions so that the particular device can be used by the user. For example if the ADC is needed for the application, driver for ADC is to be used by the user for connecting the peripherals at the analogue input of the target board. Hence the programmer should be familiar with the driver code provided by the board. The application code is compiled in the Linux environment and the .Bin file

which is obtained as the output of the compiled file is stored in the SD card/NAND flash to be executed in the target board [15]. The procedure for the application developer in the Linux environment is discussed as follows.

1) The code is written for the application in embedded C and compiled through the GCC compiler in the Linux platform. But the compiler must be installed in the Linux before the application development.

2) The compiled code generates the object file in the source.

3) The SD flasher is the tool used for flashing the SD card. This tool is provided along with the target board.

4) On the Linux platform the DNW Hyper Terminal is used to show the target board, booting options to be seen in the terminal. Here we can view the target board terminal on the PC.

5) Then the application code is executed from the SD card.

VI . Results and Discussions

The implemented system works in two modes, manual mode and auto mode. In case of manual mode the peripherals connected on the target board are controlled by the client through the browser. The client has to login through the username and password. The web page is shown at the client side by embedded Web server where the client has to send commands for controlling the peripherals. The login session shown at the client side is shown in Fig 5. Using proper authentication, the user can login. Fig 6 shows the overall system set up on the client. It also shows the overall hardware setup for this industrial mechanization system. Information monitored on the PC also shown in the same Figure.

The Fig 7 shows the auto mode where the DC motor is ON and cooling fan is OFF. The Fig 8 shows the manual mode where the clients can ON/OFF the DC motor and cooling fan. At the time of any smoke or fire emission, smoke sensor alert message is displayed on the client side making the DC motor to OFF and cooling fan and buzzer to ON as shown in Fig 9. ON state condition of the cooling fan and the buzzer is based on exceeding the reference level of heat and smoke.

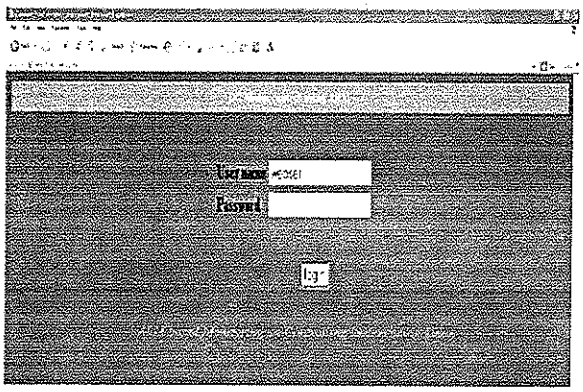

Figure 5 : Login page

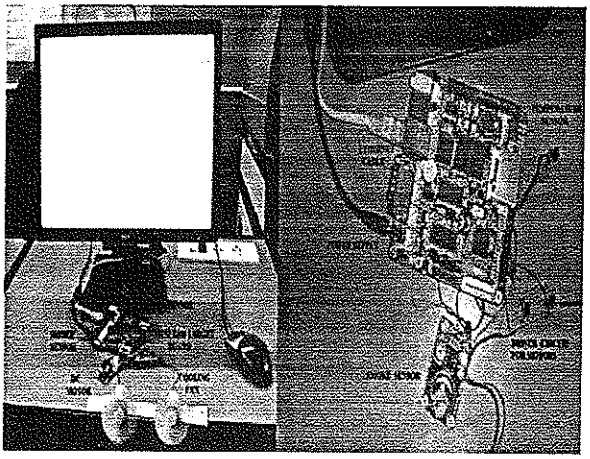

Figure 6 : Overall System

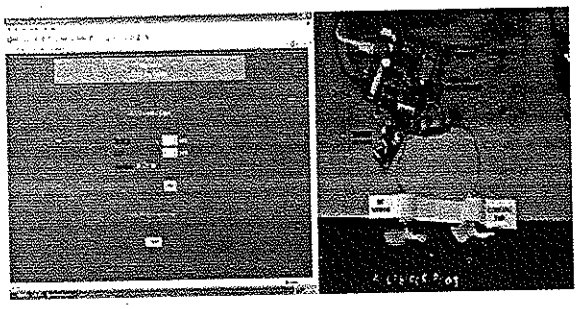

Figure 7 : Auto mode and DC motor is in ON condition

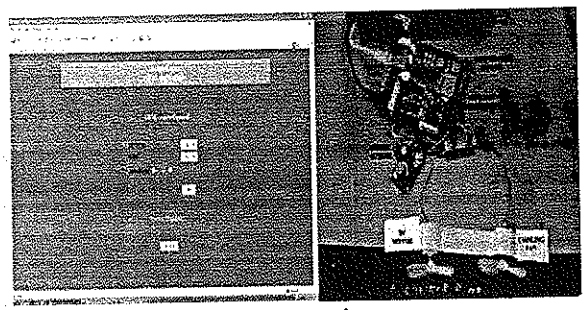

Figure 8 : Manual Mode DC motor and cooling fan ON condition

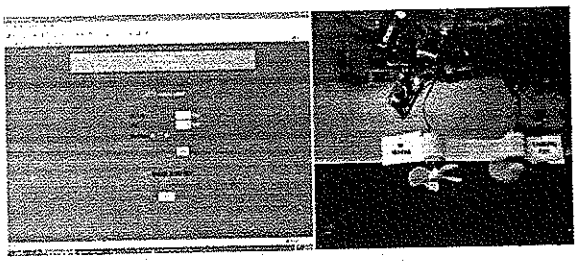

Figure 9 : Smoke Detection Alert and Cooling Fan ON

VII. Conclusion

This application creates a primary data acquisition through low power high end processor. Since low power processor ARM9-S3C2440A is being used, power consumption will be reduced. ARM9-S3C2440A consists of 8 ADC channel of 10 bit, as a result this processor has been used to design low power hardware interface. Even those can be modified according to application with ARM11, RABBIT processors etc, as a future work. This application is designed with high secured access of web server through USER AUTHENTICATION. This system can be enhanced by the online database system that displays the information about the acquired data during the specified periods of the user at the browser side. The information can be stored in the SD card, for which the slot is provided on the target board. Implementing wireless sensor network improves the data communication and avoids complexity in circuits for the industrial automation.

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