Development of Linux Based Embedded System for Industrial Automation

Dr. R. Lakshmi Narayana[#1], Prof. K. Nagabhushan Raju[*2]

[#1] *Post Doctoral Fellow, Department of Instrumentation, Sri Krishnadevaraya University, Anantapur-515003, A.P. India*

[*2] *Professor, Department of Instrumentation, Sri Krishnadevaraya University, Anantapur-515003, A.P. India*

Abstract:

The growing popularity of Internet enabled system and development of embedded technology, web technology has been extended to the development embedded system. The embedded web server is designed by integrating embedded CGI scripts, HTML and Database. Here the proposed system consists of an ARM Cortex-A8 processor AM335x with 10/100/1G Ethernet can provide remote access with reasonable speed. This system is suitable for enhancing the security and control and status monitoring of industrial parameters where high safety and care is necessity. The Linux is dominating the embedded market with the many features like real-time control, open-source applications, easy upgradability, and compatibility with many processors. To create products that can endure rugged and extreme thermal industrial environments such as industrial automation and control, human machine interface etc.

Keywords: *ARM, Embedded web server, Linux, LwIP, CGI*

I. INTRODUCTION

In recent years, embedded Linux has been receiving a lot of attention as a viable, low cost and robust implementation platform for high performance embedded systems based on popular ARM microprocessors [1]. Royalty free licensing reliable IP stack and TCP/IP applications and source code for the OS kernel is also open source code for tool chains. It is very modular in nature, since all features of the system that are not needed for a specific embedded system can be removed from the kernel. In addition, Linux has been ported successfully to a large number of processor architectures, which allows it to run on many different types of CPUs. Many embedded devices have chosen to take when providing a GUI. Since network and Internet connectivity are so common these days, many systems choose to include a web server. Linux Processes their user interface via HTML. This allows the user to access the device remotely from any location with any platform that has a web browser. It also places fewer requirements on the size and shape of the device since it doesn't have to include a display. Embedded Linux [2] has a bright future. The ability to run on many different processors, lack of the requirement for an MMU and extremely low cost are huge factors. Also, its popularity seems to be rising rapidly and there is a large installed base of developers rapidly gaining experience. The area of remote control and monitoring using ARM processor with Ethernet technology for industry, Anwar presented the Human Machine Interface (HMI) System, OLE for Process Control (OPC) and their roles, coordination and functional in Industrial Automation Technology[3]. HMI is software that provides a front end to the industrial automation system. It basically consists of components that represent industrial devices e.g. motors, pumps, valves, and dampers etc. Miguel Domingues reported older technologies which play an important role in embedded systems [4]. Web server can be implemented with some restrictions and assumptions which is efficient for current industry demands. This communication makes an incursion into the hardware architecture as an embedded web server is based on simple 8051 processors. Mario Rodriguez presented a web based monitoring and control system, applied to an industrial rotational moulding plastic oven [5]. The developed system provides remote monitoring of several temperature sensors included in the oven as well as control of the operation cycle in which the oven works. Decotignie reported the use of Ethernet in the industrial context only recently it has attracted a lot of attention as a support for industrial communication. A number of vendors are offering industrial communication products based on Ethernet and TCP/IP as a means to interconnect field devices to the first level of automation [6].

Yanjun Fang reported a method using S3C4510B 32 bit RISC microprocessor and µC Linux embedded operating system to realize industrial communication. The traditional way of using a microcontroller (such as Rabbit 2000) in 8 bit mode, cannot meet the demands of industrial communication. In order to realize communication over industrial Ethernet in 32 bit mode, the hardware of network interface and software development under µC Linux was also present [7]. The results showed that the application has low cost but better performance in industrial field. The proposed system designed web access functionality is embedded in a device to enable low cost and enhanced user interface functions for the device. A web server can be embedded into any target device and connected to the Internet so the field

devices can be monitored and controlled from remote places through the any standard browser. This research article proposed a solution for field instruments/devices [8] access remotely using embedded Linux technology. The system is based on embedded web server running on ARM Cortex-A8 AM335x microprocessor.

II. SYSTEM ARCHITECTURE

The general hardware structure of the real time remote monitor and controller system based on ARM Cortex-A8 AM335x processor block diagram is show in Figure 1.

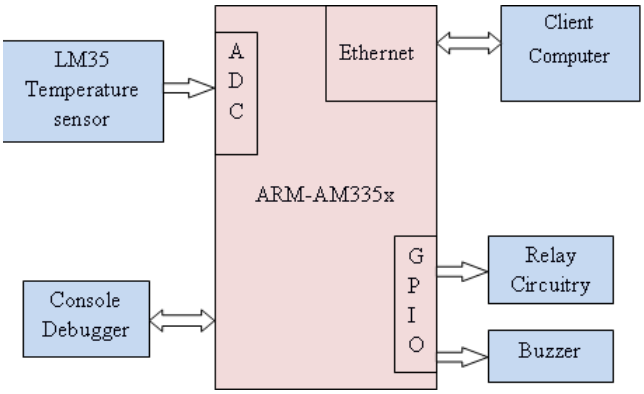

Fig. 1 Embedded Linux System Block Diagram

Texas Instruments ARM am335x microprocessor [9] is based on the ARM Cortex-A8 processor, are enhanced with image, graphics processing, peripherals and industrial interface options such as EtherCAT and PROFIBUS. The devices support high-level operating systems (HLOS). Linux and Android are available. The features of processor are up to 1-GHz ARM Cortex-A8 32-bit RISC [10] processor. The memory 32-kb of L1 Instruction and 32-kb of data cache with single error detection and 256-kb of L2 cache with error correcting code. 176-kb of On-Chip Boot ROM and 64-kb of dedicated RAM. The GPIOs, ADC and Ethernet peripherals are use for this proposed work. The four banks of 32 General-Purpose I/O pins per bank are multiplexed with other functional. GPIO pins can be used as Interrupt inputs are up to two Interrupt inputs per bank. The figure 2 shows the screenshot of proposed embedded Linux web server board.

A. Hardware Design:

The sensors and actuators are found in industrial applications it can be classified by analog, digital or serial communication signals are used for data receiving and transmitting. The proposed system used to control relay depending upon the temperature data. The relay circuitry is used for controlling the values depending upon the temperature. The below circuit diagram shown in figure 2, the components are BC-547 transistor, 1k resistors and 'HK jqc-3cf' relay are placed.

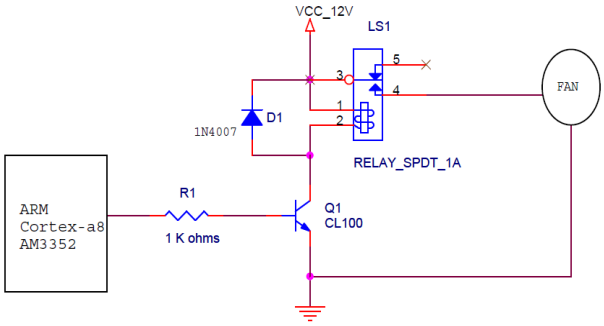

Fig. 2 Relay Driver Schematic Diagram

Temperature is the most-measured process variable in industrial automation. Most commonly, a temperature sensor is used to con-vert temperature value to an electrical value. Temperature sensors are the key to read temperatures correctly and to control temperature in industrials applications. A large distinction can be made between temperature sensor types. Sensors differ a lot in properties such as contact-way, temperature range, calibrating method and sensing element. The temperature sensors contain a sensing element enclosed in housings of plastic or metal. With the help of conditioning circuits, the sensor will reflect the change of environmental temperature. In the temperature functional module we developed, we use the LM35D temperature sensor circuitry is shown in figure 3. It is a precision integrated-circuit temperature sensor, whose output voltage is linearly proportional to the Centigrade temperature. LM35D [11] has an advantage over linear temperature sensors calibrated in degrees Kelvin, there is no requirement to subtract a large constant voltage from its output to obtain convenient Centigrade scaling. It can be used to detect ambient air temperature. The sensitivity of the sensor is 10mV per degree Centigrade; accuracy +2.0 Centigrade and functional range are 0 to 100 degree Centigrade. The complete hardware system setup is shown in figure 4.

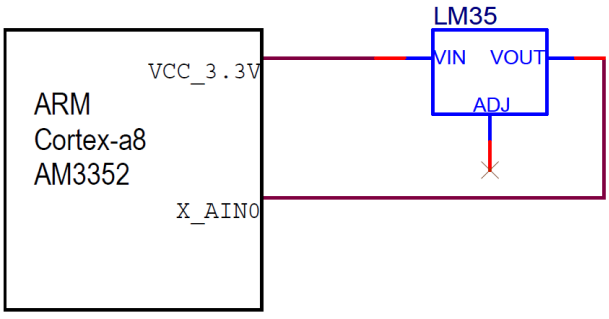

Fig. 3 LM53 Temperature Sensor Schematic Diagram

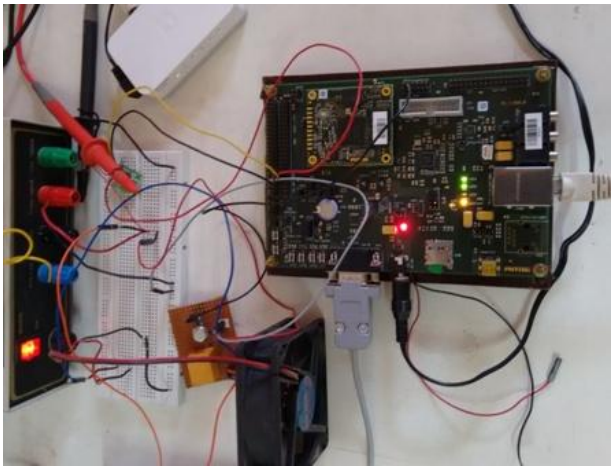

Fig. 4 Screenshot of Embedded Linux Development System Setup

B. Software Implementation:

The improvement of system reliability embedded Linux based system designed for industrial controlled parameters like sensor and actuators. The embedded Linux based web server [12] software designed on Linux kernel development platform. Remote monitor and control the field devices with help of web server. Light-weight Internet Protocol (LwIP) [13], Hyper Text Markup Language (HTML) and Common Gate Way Interface (CGI) programming languages are used for developing the system software. CGI is a protocol [14] for communication between a web page and a program executing on the web server. It allows the contents of HTML forms to be sent to the server, which runs a CGI script and passes this information to it via the standard input. The figure 4 shows the flow of CGI process. The CGI program can then process the data, and return its result usually in HTML form via the standard output to the client's web browser. CGI scripts can be written in virtually any language like C programming language.

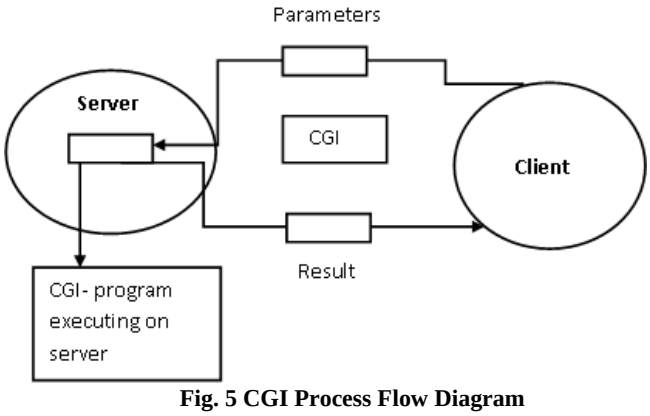

Fig. 5 CGI Process Flow Diagram

Hyper Text Transfer Protocol (HTTP) protocol is used for the communication between web server and web browser. The basic framework of the web server communications by handling requests and also by providing control information to be transferred between client side browser and web server. To obtain a web page, the client and server should establish a connection at port 80.

Building BSPs: ToolChain, BootLoader, RootFile System

PTXdist: Automatically generate all binaries..

Ptxdist is a build system for creating embedded linux distributions, with a focus on industrial applications. It is intended to be fully reproductible without external dependencies like toolchains and features.

The following steps are to compile RFS with PTX-dist.

- Download the PTX-dist packet from the following link
  ftp://ftp.phytec.de/pub/Products/India/OpenBoard-AM335x/Linux/latest/buildsystems/ptxdist/ptxdist-2012.03.0.tar.bz2
- Extract the PTX-dist downloaded source
  $ tar –xvf ptxdist-2012.03.0.tar.bz2
- Go to extracted folder
  $ cd ptxdist-2012.03
- Configure the ptxdist source
  $ ./configure
- When the configure script is finished successfully, to compile and run
  $ make
  $ sudo make install
- Download the toolchain from the public ftp of PHYTEC from the link below.
  ftp://ftp.phytec.de/pub/Products/India/OpenBoard-AM335x/Linux/latest/tools/toolchain/OSELAS.Toolchain-2012.12.1.tar.gz
- Extract the toolchain that has been downloaded, issue the following command.
  $ tar –xvf OSELAS.Toolchain-2012.12.1.tar.gz
  $ cp OSELAS.Toolchain-2012.12.1 /opt/
- Download the PTX-dist board support package source from the following link
  ftp://ftp.phytec.de/pub/Products/India/OpenBoard-AM335x/Linux/latest/buildsystems/ptxdist/OpenBoard-AM335x.PD13.0.0.tar.gz
- Extract the downloaded source
  $ tar –xvf OpenBoard-AM335x.PD13.0.0.tar.gz
  Go to extracted folder
  $ cd OpenBoard-AM335x.PD13.0.0
- Generating board support binaries
  Select the toolchain
  $ ptxdist toolchain <path_of_toolchain_bin>
  Start the build
  $ ptxdist go
  Check the images at directory of platform-phyCORE-AM335x/images/ to issuing the below command.
  $ ls of platform-phyCORE-AM335x/images/

- Boot partition required MLO,barebox.img,uImage, Linuximage
- Rootfs partition required root.tgz (extract before sending to Rootfs partition)

Note: We can also build system using Yocto or Buildroot.

III. RESULT

The webpage displayed when embedded target board configured IP address (example IP: 172.16.1.47) entered on web browser URL is shown in Figure 6. Here the first task of the application program is to receive analog data from temperature sensor and converted into digital form then send data packet to web server for monitoring on remote location. The second task is to control the fan and valve in the plant depending upon the temperature in the field area. This proposed work is to easily integrate other field devices like flow meters, valve positioners, drivers and motor controls.

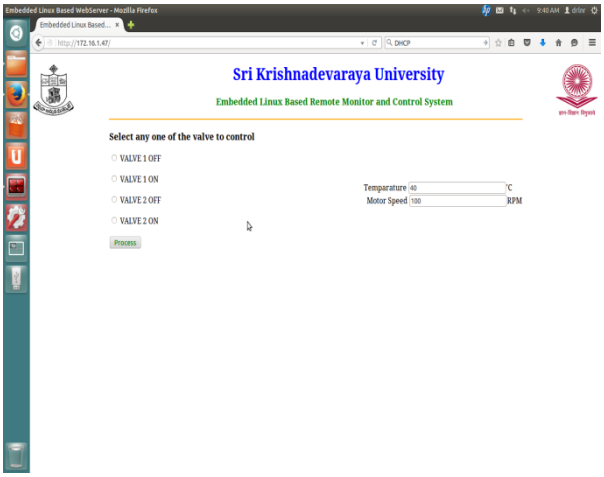

Fig. 6 Screenshot of Webpage Output to Monitor and Control

IV. CONCLUSION

The remote monitoring and controller system designed based on embedded web server using ARM cortex-a8 am335x processor. It deals with various industrial parameters control and monitor by means of integrating network technology to embedded technology. Embedded Web server also used for building automation applications, from monitoring human safety and security, controlling the environment and periodic or continuous data logging of environmental and system data to detect irregular system conditions. By using this reduce the cost and size of the system and make it available to various external devices for further development of system. It is portable and highly resistant to disturbance. The methodology of the proposed system is to improve the performance in terms of remote monitor and control, reducing hardware complexity, reduce man power and browsers are universal its availability and familiarity. A web-interface is the cheapest interface as it is only software (and a network connection).

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