Embedded Web Server

Ms. Sonali V. Tarlekar
Electronics Department
K. C. College Of Engineering
Thane, India
sonutarlekar@gmail.com

ABSTRACT

As the World-Wide Web (WWW) continues to evolve, it is clear that its underlying technologies are useful for much more than just browsing the web. After the "everybody-in-the-Internet-wave" now obviously follows the "everything-in-the-Internet-wave".However the embedded Internet integration for remote maintenance and diagnostic as well as the so-called machine to machine communication is growing with a considerable speed.

In this system, a microcontroller system acts like web server that store the web pages in their memory. A client computer can access this web page using web browser to monitorand control the microcontroller where the microcontroller is used to control the various appliances like lamp,fan,potentiometer and LCD. This embedded web server can be used for remote monitoring, control and data acquisition systems etc.

Keywords

Embedded web server,ARM,Ethernet.

I. INTRODUCTION

Of all the semiconductor industries, the Embedded systems marketplace is the most conservative, leaning towards established, low-risk solutions. Because of this, the basic infrastructure of embedded systems has only evolved slowly over the past ten years.

Generally it is difficult for us to get information from remote equipments. From the very first we usually adopt RS232, RS485 or CAN, but these buses are too limited in distance nowadays. More and more devices are not only gaining embedded systems but are also being attached to a network. Internet is an astonishing technology because Internet created a new space from our physical world. This is propelled by the success of the World Wide Web (WWW) and its most common applications. More and more users want to access their equipment through Internet.

Embedded Web Server is a new technology extended from traditional embedded system. 'Embedded' reflects the fact that they are one part of the system and can be embedded into any equipment, machinery and consumer appliances. Functionally it can be a powerful web server or other Internet interface. Using embedded system along with server , user can visit their devices through Internet conveniently anywhere at any time. An embedded web server is a microcontroller that contains an Internet software suite as well as application code for monitoring and controlling systems.

The web server is the board that has the application and the RTOS. The operating system manages all the tasks such as sending the HTML pages, connecting to new usersetc.The RTOS manages all the required tasks in parallel, and in small amounts of time. Web-based management user interfaces using embedded web servers have many advantages:user-friendliness,low development cost and high maintainability. Embedded web servers have different requirements, such as low resource usage,high reliability, security and portability, for which general web server technologies are unsuitable. Embedded C language has been used for the software implementation of the embedded web server. The web pages which are required for the web server were developed using HTML.

1. SYSTEM DESIGN

The Fig.1 gives the overall system design. The main components of the system are Hardware, RTOS, HTML Pages, Transfer of Data.

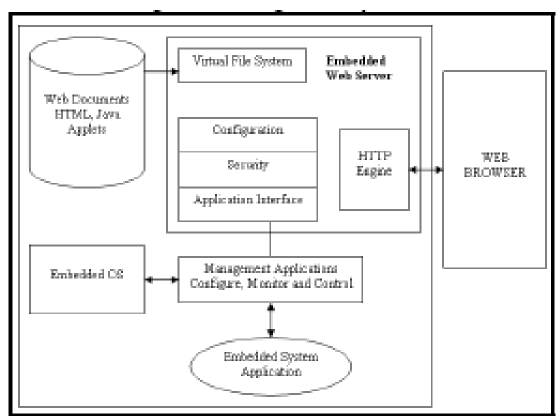

Fig 1: Overall System Design[1]

Hardware: The hardware used for embedded web server is ARM Cortex M3 based target board. The board has the html pages saved on it. Hardware of a web-enabled embedded system must have a powerful andlow-cost microcontroller, compact size, flash/EEPROM for accommodating the TCP/IP stack and an Ethernet controller.

The Cortex-M3 processor is the first ARM processor based on the ARMv7-M architecture and has been specifically designed to achieve high system performance in power and cost-sensitive embedded applications, suchas microcontrollers, automotive body systems, industrial control systems and wireless networking, while significantly simplifying programmability to make the ARM architecture an option for even the simplest applications.

The Cortex-M3 processor, based on the ARMv7-M architecture, has a hierarchical structure. It integrates the central processor core, called the CM3Core, with advanced system peripherals to enable integrated capabilities like interrupt control,memory protection and system debug and trace.

RTOS: The application runs in the form of tasks .Each user connecting to the server is treated as a task. To manage the users, connections, an operating system is required, that performs the operations in real time.

Including SAFERTOS in application allows to be structuredas a set of autonomous tasks. Each task executes within its own context with nocoincidental dependency on other tasks within the system or the scheduler itself .Only one task can be executing at a time. The scheduler is responsible for selectingthe task to execute in accordance with each tasks relative priority and state[2].

HTML Pages: To interact with the clients, the client has to send the data to them. In the embedded web server,web pages are selected as the media of interaction. The web pages are designed using HTML.

II. SYSTEM IMPLEMENTATION

The system implementation includes proposed system and software implementation.

1.1 PROPOSED SYSTEM

The Proposed System includes Embedded system, light, fan, LCD and potentiometer and server.The Embedded system consists of ARMLM3S9B96, Ethernet and UART. Various appliances are attached to Embedded system. The Server and Embedded system are connected by LAN(Local Area Network) as shown in figure 1.

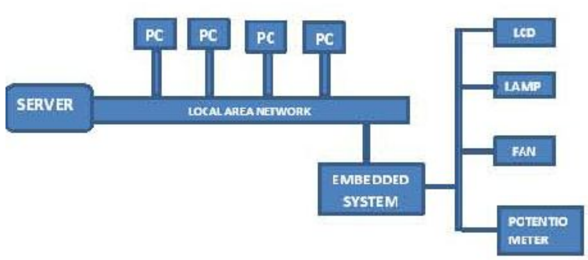

Fig 2: Proposed System

ARM LM3S9B96: The Stellaris family of microcontrollers, the first ARM Cortex-M3 based controllers brings high-performance 32-bit computing to cost-sensitive embedded microcontroller applications. These pioneering parts deliver customers 32-bit performance at a cost equivalent to legacy 8 and 16 bit devices, all in a package with a small footprint. The Stellaris family offers efficient performance and extensive integration, favourably positioning the device into cost-conscious applications requiring significant control processing and connectivity capabilities[3].

Ethernet: The LM3S9b96 include Ethernet Media Access Controller (MAC) and physical interface (PHY) on-chip. Two popular network stacks are μIP(micro Internet Protocol) and LwIP(Light weight Internet Protocol). LwIP is preferred because it is having more features than μIP like DHCP(Dynamic Host Configuration Protocol), PPP(Point to Point Protocol), Address Resolution Protocol (ARP) and Optional Berkeley-like socket API(Application Program Interface) etc. The controller confirms to IEEE 802.3 specifications and fully supports 10BASE-T and 100BASE-TX standards. The Lightweight IP (lwIP) stack is an open-source implementation of the TCP/IP stack developed specifically to reduce resource usage while maintaining a full-scale TCP/IP stack. For embedded systems,with lwIP it is possible to connect the system to a local intranet or the Internet. The lwIP stack has been ported to the Stellaris family of microcontrollers. LwIP can run with or without an underlying operating system.

Implementation:

The TCP/IP suite of protocols are defined in a layered fashion where each layer has a specific function. This layered protocol design has served as a guide for the implementation of the lwIPstack. Each protocol that is implemented has its own module with entry points into each protocol provided with function calls. The lwIP implementation uses a process model where all the protocols reside in a single process and are separated from the operating system kernel. Application programs can reside in the lwIP process, or be in separate processes .Having lwIP implemented outside of an operating system kernel allows the lwIP stack to be portable across operating systems or to be used without an operating system.

The memory and buffer management system in a communication system must be prepared to handle buffers of varying sizes. LwIP uses packet buffers called pbufs. The pbuf structure allows for allocating dynamic memory for packets as well as letting packets reside in static memory. The memory manager supporting the pbuf scheme handles allocations and deallocations of contiguous memory. The memory manager uses a dedicated portion of the total memory system, preventing the networking system from using all of the available memory. The lwIP stack provides a network interface data structure which allows the network interfaces to be saved in a linked list. The data structure provides a pointer to the next network interface structure, name of the interface, and the IP address information. There are also two function pointers provided in the data structure: one points to a function to process incoming data, and the other points to the device driver which is used to transmitdata on to the physical network.

Due to the process model of the lwIP stack, the implementation of the API is divided into two parts. The first part is a library linked into the application program, and the second part is implemented in the TCP/IP process. Interprocess communication(IPC) mechanisms are provided by the operating system emulation layer.

1.2 SOFTWARE IMPLEMENTATION

The software for this system can be generated by the TCP/IP Configuration Wizard. The only required application layer protocol is HTTP. An embedded web server should use the HTTP protocol to transmit Web pages from the embedded system to the web browser and to transmit form data back to the embedded system attached to the appliance. The embedded system requires a network interface, such as Ethernet, a TCP/IP

Protocol stack, embedded web server software and static and dynamic web pages that form the user interface for that specific device. Because the embedded systems have limited CPU and memory resources and these resources are mostly used by real-time applications, end users may have to wait up to few seconds for an HTTP response.

HTTP is based on a simple client/server concept. HTTP server and client communicate via a TCP connection. As default TCP port value the port number 80 will be used. The server works completely passive. He waits for a request (order) of a client. This request normally refers to the transmition of specific HTML documents. This HTML documents possibly have to be generated dynamically by CGI . As result of the requests, theserver will answer with a response that usually contains the desired HTML documents among others.

Creating AndStoring HTML Page:

The HTML page descriptions can be put into memory on the embedded system via high level language like 'C' data structures,compiled and linked into the on-chip flash. The makefsfile is used for converting html page to embedded c code.

2. RESULTS

Three web pages loaded into microcontroller.

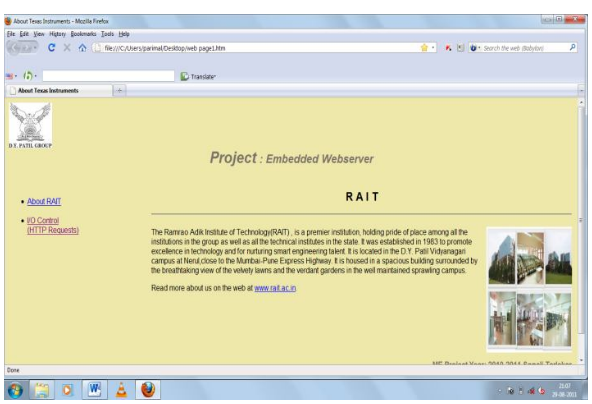

Fig.3 First web page

In this,when we click on Toggle Light, lamp will be ON if it is previously off and OFF if it is previously ON.

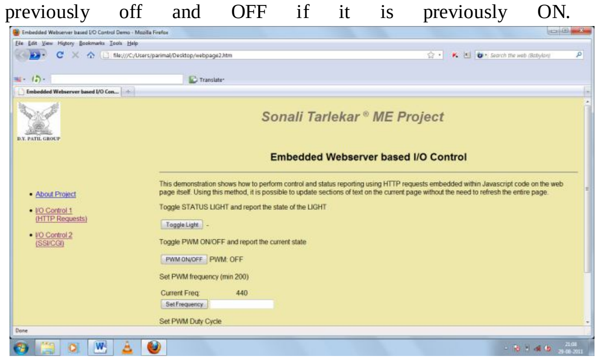

Fig.4 Second web page

The potentiometer is of 5K,so the voltage drop across it will be 0-3V,which will be read by ADC and displayed on LCD as shown in fig.5.

Fig.5 Graphical LCD Display

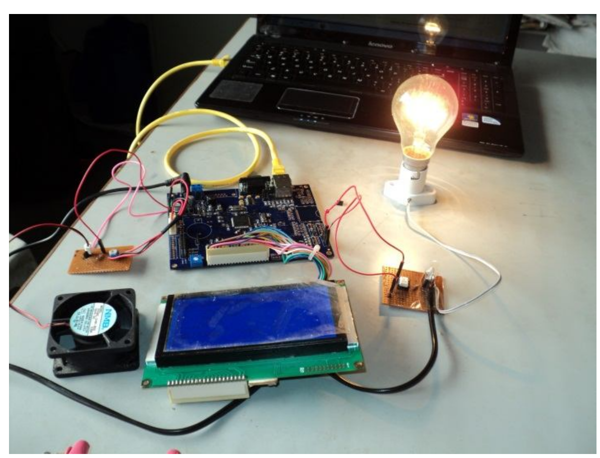

Fig.6 When Lamp is ON and Fan is ON

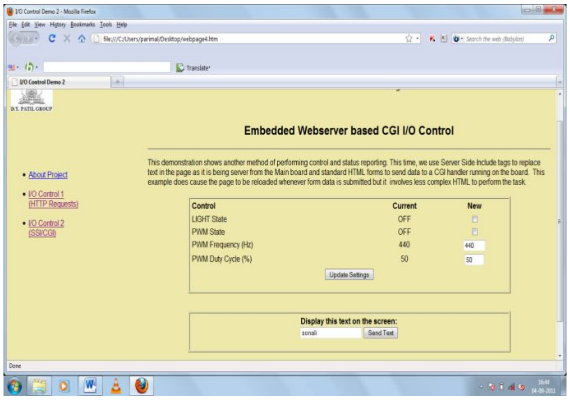

Fig.7 Third web page

When we click on LIGHT State and click on update setting,it will show the status of Light. The PWM state is used for fan On-Off. We can send the string from the web page to the LCD.With duty cycle and frequency,we can change the speed of fan.

3. CONCLUSION

Web servers are already being built into many network devices today. In the near future,we can expect this trend to grow even further to home appliances, medical instrumentsand industrial equipments. Embedded Web servers for Web based network element management provides an administrator with a simple but enhanced and more powerful userinterface without additional hardware.

With the web server embedded, we will begin to see the application of computingtechnologies in settings where they are unusual today device and appliance networkingin the home; faithful capture of scientific experiments in the laboratory; and automatedfull-time monitoring of patient. Today, embedded system with Ethernet connectivity hasbecome popular choice for the system design. The advantage of the Ethernet communication in the embedded system has improved remote monitoring, control, diagnostics, anddata collection application to the next level. With this Embedded Web Server, we can control various appliances like lamp, fan, potentiometer and LCD and home appliancesalso.

REFERENCES

[1] V.BillyRakesh Roy, SanketDessai, and S. G. Shiva Prasad Yadav. Design andDevelopment of ARM Processor Based Web Server.*International Journal of RecentTrends in Engineering*.

[2]SarikaChhatwani and Dr. K. B. Khanchandani. Embedded Web Server.*InternationalJournal of Engineering Science and Technology*.

[3]Texas Instruments. *SAFERTOS Users Manual*.

[4] Texas Instruments. *Stellaris LM3S8962 Microcontroller Datasheet.*

[5] Texas Instruments. *Using the Stellaris Ethernet Controller with Lightweight IP (lwIP)*