ETHERNET BASED HOME APPLIANCES CONTROL

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ABSTRACT

This paper presents the way to provide Ethernet internet connectivity to microcontroller based embedded systems. This system uses PIC microcontroller to store the main application source code, web pages and TCP/IP stack which is a vital element of the system software. An Ethernet controller chip, ENC28J60 is used to handle the Ethernet communications and it is interfaced with the microcontroller using SPI protocol. Configurations like IP address and other details are set using RS232 interface. The site can be viewed on any system with Internet/LAN connection by configuring the specific IP address and by giving User Login ID, password. There are several I/O pins available at the microcontrollers which are used to interface with sensors, LCD displays, Motors and relays for monitoring and controlling AC appliances. Nowadays, Internet has spread worldwide and most of the internet connections use Ethernet as media for data transfer. In industries or in home appliances, most of the time we need to monitor and control different parameters using microcontrollers. Once we enable Ethernet interface to such systems, we can communicate with them remotely over the internet. The popularity of home automation has been increasing greatly in recent years due to much higher affordability and simplicity through Smartphone and tablet connectivity. The concept of the "Internet of Things" has tied in closely with the popularization of home automation. Ethernet provides inexpensive, relatively high speed network access to individual users and low delay that can support many applications. This implementation is an attempt to connect an embedded device to an Ethernet. Using Ethernet based system we can control various home appliances from anywhere across the world. The existing system which uses the GSM,GPRS, Bluetooth, Zigbee Infrared and RFID technology which are having its own limitations.

Keywords: Home Automation, PIC microcontroller, Ethernet, TCP/IP, Web server
I. INTRODUCTION

The main aim of our project is to implement a Home automation console that can be easily accessible from distant places through a simple web server running inside the home. The basic functionalities in this proposed system includes automatic control of Lights and other electrical/electronic appliances. Internet-enabled hardware products are slowly becoming popular. A real web server can be implemented in a device in your own home connected to your pc via a local area network. This will allow you to do things like display temperature, control heater/geyser and switch light/fan remotely from any web browser in the house. This project comprises of two sub-parts. The front end involves designing a web page application using HTML language to communicate with remote microcontrollers over the Ethernet. The back end involves building a network of microcontroller based prototypes to emulate devices used at residential locations for the purpose of home automation such as TV ON/OFF control, speed control of fan, lighting control etc. Microcontrollers communicate with each other via Ethernet a wired communication. Because these systems use hard-wired Ethernet, communication between components is reliable and fast.

II. RELATED WORK

Ryan, J.L. [1] proposed “Home automation”. Home automation will be achieved not with the household robot but with embedded computing power and memory within dozens of pieces of domestic equipment, each of which will communicate with the user and with other equipments. Within the integrated home system the communication media will include infra-red, radio, mains wires, installed twisted wires and coaxial cable and later perhaps optical fiber. Applications will include security, lighting, heating, cooking, washing appliances, audio and video systems, energy management as well as a number of new applications such as health monitoring, home publishing etc.

Inoue, M. Uemura and K. et al. [2] proposed a system called Home Automation (HA) System based on this; Home Bus system has been developed. The system has a multi-layered hierarchical structure and is composed of four subsystems the Room Monitor Control Subsystem, the Telephone Subsystem, the Tele-control Subsystem and the In-house Video Control Subsystem.

Van Der Werff, and M. Gui, X. et al. [3] implemented, the rapidly advancing mobile communication technology and the decrease in costs make it possible to incorporate mobile technology into home automation systems. We propose a mobile-based home automation system that consists of a mobile phone with Java capabilities, a cellular modem, and a home server. This paper presents the design and implementation of AT modem driver, text based command processing software, and power failure resilient output for a microcontroller to facilitate in sending and receiving data via the cell module, together with the design of Java application to enable the cell phone to send commands and receive alerts through the cell module.

Gill, K; and Fang Yao et al. [4] presented a system, A zigbee-based home automation system, in this paper he identifies the reasons for this slow adoption and evaluates the potential of ZigBee for addressing problems through the design and implementation of flexible home automation architecture. A ZigBee based home automation system and Wi-Fi network are integrated through a common home gateway.

Nunes, R.J.C [5] implemented the problem of specifying a home automation system and behavior programming. He proposed a Web-based approach that offers a generic solution and is independent of the automation technology used. To achieve this degree of independence, our implementation describes an abstract model of the home automation device. We also present a simple model for describing the physical structure of a home. In this way, our approach can describe any system for any house.
Piyare, R. and Tazil, M. proposed technology is a never-ending process. To be able to design a product using the current technology that will be beneficial to the lives of others is a huge contribution to the community. He presents the design and implementation of a low cost but yet flexible and secure cell phone based home automation system. The design is based on a standalone Arduino BT board and the home appliances are connected to the input/output ports of this board via relays. The communication between the cell phone and the Arduino BT board is wireless. This system is designed to be low cost and scalable allowing variety of devices to be controlled with minimum changes to its core. Password protection is being used to only allow authorised users from accessing the appliances.

III. THE PROPOSED SYSTEM

The goal of this project is to develop a home automation system that gives the user complete control over all remotely controllable aspects of his or her home. The automation system will have the ability to be controlled from a central host PC, and the Internet. Habitat shall be able to take decisions on its own based on its learning from its user behaviour. The functional block diagram is shown in figure 1, employed with the PIC Microcontroller (PIC18F4620), with built in required components such as MAX-232, Ethernet phy, SPI, I²C protocols. The external component involves the memory and Ethernet Controller-ENC28J68 (LAN) which is interfaced to the PIC Microcontroller with the help of SPI bus.

![Basic Functional Block Diagram](image)

**Fig. 1 Basic Functional Block Diagram**

IV. HARDWARE IMPLEMENTATION

**A. System Architecture**

The proposed Ethernet Based Home Appliances Control system architecture consists of PIC Microcontroller, Ethernet Controller-ENC28J68, Relay Board, and DC motor and 16x2 LCD Display.
B. Operation

This section explains the operation and interfacing of each module present in the Ethernet Based Home Appliances Control system architecture. The whole circuit can be divided into following sections:

1) **Power supply modules**: This module is basically designed to achieve 12V, 1A and 5V, 500mA and 3.3V. The design consists of a transformer which is used to step down the AC voltage, IN4007 diodes used to form a bridge rectifier to convert AC to DC, capacitor 1000uF which used as a filter circuit, 7812 regulator to obtain a 12V DC and followed by 7805 regulator to obtain a 5V DC, at the output of the regulator a 330 ohm resistance and LED is connected as Power ON indicator. LT1086CT (3.3V) regulator is used to generate 3.3V which is required for Ethernet Controller as shown in figure 2.

![Fig. 2 Diagram of Power Supply section](image)

2) **PIC Microcontroller**: Controller is the heart of the design. It implements TCP/IP stack and communicates with Ethernet controller and serves clients requests. It reads requested web page from serial EEPROM and transfers to client. It controls I/O devices connected to controller. It provides interactive text based menu using HyperTerminal to configure board IP, MAC addresses. It controls an LCD display which is used to display purpose. PIC microcontroller is RISC architecture. The PIC microcontroller was originally designed around 1980 by General Instrument as a small, fast, inexpensive embedded microcontroller with strong I/O capabilities. PIC stands for "Peripheral Interface Controller". A microcontroller is an integrated chip that is often part of an embedded system. The microcontroller includes a CPU, RAM, ROM, I/O ports, and timers also supports serial protocols SPI, USART, USB and I2C. They are much smaller and simplified so that they can include all the functions required on a single chip, PIC18F4620 is one of the most advanced microcontroller from Microchip.

3) **Ethernet Controller**: The ENC28J60 is Microchip's first incursion into the Ethernet controller arena, this new device includes all MAC & PHY IEEE 802.3 10BaseT functions, 8KB of dual access RAM packet buffer and a SPI serial interface, all in a convenient 28-pin package SPDIP. It takes just few components to get the ENC28J60 up and running and connected to a host microprocessor or microcontroller with support for the industry standard SPI interface. The interface is as shown in figure 3. Ethernet controller is interfaced with PIC Microcontroller with the help SPI serial bus protocol.IO Pins 23, 24, 18 of the microcontroller are connected to Ethernet controller Pins 7-DATA IN (SDI), 6-DATA OUT (SD0), and 8-CLOCK (SCK) using the SPI protocol.
The Serial Peripheral Interface Bus or SPI bus is a synchronous serial data link standard that operates in full duplex mode. Devices communicate in master/slave mode where the master device initiates the data frame. Multiple slave devices are allowed with individual slave select (chip select) lines. SPI is often referred to as SSI (Synchronous Serial Interface). To begin a communication, the bus master first configures the clock, using a frequency less than or equal to the maximum frequency the slave device supports. Such frequencies are commonly in the range of 1–100 MHz, the master then transmits the logic 0 for the desired chip over chip select line. Logic 0 is transmitted because the chip select line is active low, meaning its off state is logic 1; 

4) LCD Display: LCD is a type of display used in digital watches and many portable computers. LCD displays utilize sheets of polarizing material with a liquid crystal solution between them. An electric current passed through the liquid causes the crystals to align so that light cannot pass through them. LCD technology has advanced very rapidly since its initial inception over a decade ago for use in lap top computers. Technical achievements has resulted in brighter displace, higher resolutions, reduce response times and cheaper manufacturing process.

This LCD can be used to display 16 characters in 2 rows. It has the ability to display numbers, characters and graphics. It has an inbuilt refreshing circuit, thereby relieving the CPU from the task of refreshing. The figure 5 shows the interface of PIC microcontroller with LCD using a
SIPO shift register. Data is sent serially into shift register at a very faster rate whereas the register transmits the same data to the LCD using parallel data lines D0 to D7.

V. SOFTWARE IMPLEMENTATION

1) Front End Design: HTML is a format that tells a computer how to display a web page. The documents themselves are plain text files with special "tags" or codes that a web browser uses to interpret and display information on your computer screen. HTML stands for Hyper Text Markup Language; an HTML file is a text file containing small markup tags. The markup tags tell the Web browser how to display the page. An HTML files must have an htm or html file extension.

Example of HTML program:
```html
<html>
<head>
<title> WEB ENABLED SMART HOUSE </title>
</head>
<body bgcolor=lightblue text=black>
<form name=f1 method=get action="4">
<center> Enter username(MAX 16 char's): </center>
</form>
</body>
</html>
```
<br>
Enter Password: (MAX 8 char's):
<br>
<input type=password name=1>
<br>
<input type=submit value=Login>
</form>
</body>
</html>

Fig. 6 Home Page using HTML

2) **Microcontroller Programming with Embedded C**: MPLAB IDE is a software program that runs on a PC to develop applications for Microchip microcontrollers. It is called an Integrated Development Environment or IDE, because it provides a single integrated “environment” to develop code for embedded system. The MPLAB C18 compiler is a full-featured ANSI-compliant C compiler for the Microchip Technology PIC18 family of PIC microcontrollers. MPLAB C18 is fully compatible with Microchip’s MPLAB Integrated Development Environment, allowing source level debugging with both the MPLAB ICE 2000 In-Circuit Emulator and the MPLAB SIM simulator. The PICkit 2 Development Programmer/Debugger is a low-cost development tool with an easy to use interface for programming and debugging Microchip’s Flash families of microcontrollers.

3) **LwIP Stack**: LwIP protocol is a set of open source TCP/IP protocol stack for embedded systems. LwIP is a few lines of code to implement the TCP/IP protocol stack developed by Adam Dunkels at the Computer and Networks Architectures (CNA) lab at the Swedish Institute of Computer Science (SICS). LwIP consists of several modules to implementing the TCP/IP protocols such as IP, ICMP, UDP, and TCP and a number of additional support modules. The support modules consists of the operating system emulation layer, network interface functions, the buffer and memory management subsystems and functions for computing the Internet checksum. The objective of the LwIP stack is to reduce memory requirement and code size, making it suitable to use in small foot prints. It requires 10KB of RAM and 40KB of ROM. LwIP uses Application Program Interface (API) in order to reduce processing and memory demands [12].

VI. EXPERIMENTAL RESULTS

In this section, the results of the proposed system to control the devices over internet through Ethernet connectivity using PIC controller is presented. Figure 6 shows the login page which we designed using HTML language as a home page, after entering the embedded web server IP address (192.168.1.101). Once the home page is loaded, the user need to provide username and password to facilitate the further access to control home appliances. This ensures the security feature to user
access. In the proposed system four devices are considered for demo purpose Light, Geyser, TV and the speed of the DC motor control. After login, the next control webpage as shown in figure 7, on this page we can control 4 devices just by clicking the menus on the web page, initially all devices Light, Geyser, TV and the speed of the DC will be in off State i.e., ‘0’ state is as shown in figure 7.

![Control Web Page using HTML](image)

**Fig. 7** Control Web Page using HTML

The complete hardware setup is as shown in figure 8,

![Hardware System Design](image)

**Fig. 8** Hardware System Design
1) Light Control:
Here, on this web page we are controlling Light, just by clicking the light menu on the web page as shown in the figure 9, initially Light State = ‘0’ now the state changed to ‘1’ and also we can see the light ON state on the hardware design module.

![Fig. 9 Light Control]

2) Geyser Control:
Here, on this web page we are controlling Geyser, just by clicking the Geyser menu on the web page as shown in the figure 10, initially Geyser State = ‘0’, now the state changed to ‘1’ and also we can see the light ON state on the hardware design, here we using Red light instead of geyser just for demo purpose because we can control any AC appliance through relay.

![Fig. 10 Geyser Control]

3) DC Motor Control:
Here, on this web page we are controlling DC motor speed, by giving suitable speed between 10 to 100 percent on the web page as shown in the figure 11 we can control the speed, initially Speed State = ‘0’ now as we enter 50, the state changed to ‘50’.
VII. CONCLUSION

In this paper we presented concepts and a prototype system for home automation which can fit into a home appliance using Ethernet. Internet-enabled hardware products are slowly becoming common place. Ethernet’s potential as a network for distributed measurement and control is virtually unlimited. As Ethernet provides inexpensive, relatively high speed network access to individual users and low delay that can support many applications. Ethernet continues to be enhanced with greater performance, higher determinism, and lower cost implementations and even consolidate control network applications. A real web server is implemented in a device in your own home, which is connected to your pc via a local area network. If we compared Ethernet Technology with other technologies like Bluetooth, Zigbee, IR, RF-ID and GSM, it is having low response time, having very high speed, secured and also reliable. In future the separate embedded web server can be designed with Wi-Fi and Ethernet, which is co-existence technology on a single-chip. So the home appliances can also control from Wi-Fi enabled smart device such as smart phones with high graphical interface.

REFERENCES


