Low Cost Hardware Design of a Web Server for Home Automation Systems

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Abstract

In the present scenario the world is moving towards automated systems. To design a hardware which is able to interact via internet is a challenging task in design of any automation system. A new term known as 'Internet of things' also faces the same kind challenge, of interfacing a dumb electronic terminal with the internet. As we know that Ethernet is the most preferred serial bus, and can be utilized for high speed data transmission system. In this paper a new kind of design is proposed which support's bi-directional data transmission. This approach require very low cost hardware units including 8 bit RISC processors, Ethernet controller, Ethernet adaptor, sensor's and actuating device like webcam or may be a motor, based on the type of application. The processor to be used can be AVR or PIC depending upon the availability. The main advantage of this design is that it does not require any pre-defined operating platform like Linux or Python. This design is able to receive and transmit data, and is able to respond accordingly. Automatic IP detection is a major advantage of this design. This design enables a user to communicate with the hardware via any web browser, Telnet, C- based client, or any other Java based client. There can be various applications of this kind of system specially related with automation and surveillance system. The investigated and developed design in this paper is based on home automation and Security system. Main advantage of this system is to interact and control all system or devices with Infrared signals (IR).

Keywords: Infrared (IR), Ethernet controller, web server, controller.

1. Introduction

In the present scenario the world is surrounded by various Electrical systems and Embedded systems such as home appliances viz. Television, Air-conditioner, music players etc. and even in the industries various electrical systems are present which require remote automation as well as surveillance. All these above mentioned devices or kind of these devices can be remotely operated controlled and can be monitored without any human intervention. The remote monitoring phenomenon is the most important capability in this Web server design. This phenomenon increases its application in field of "internet of things", which is based on the readings of various sensors attached to the server and the server unit can perform specific set of operations based on the present readings of the sensors. In this paper a new approach is investigated and developed which is able to measure, sense and respond according to various sensors attached to it and at the same time the data measured can be distributed in various geographic locations via Ethernet network before the system can only control the system but cannot get the state of system but in this system we can read the current state of the system. This Ethernet based web server module works over a "Real time operating system" specially designed for this type web server design, this RTOS doesn't require any pre-defined operating system viz. Linux or Python, to work on. The introduction of TELNET environment in this Operating system makes it easier to operate from a remote location. All the controls and the present readings of the attached sensors can be viewed in any geographic location with internet facility. There's no requirement of any kind of software installation in mobile or computer to control or monitor your automation system i.e. before system were dependent on the systems such as computer for connect to network or to get instructions . But this system is independent of all such system. This is self controlled system and is independent of all such dependencies.

2. Approach for the Design

The basic building blocks and the design approach is been shown in the Figure 1. In this scheme a remote client send some data packets to the server unit and server is able to display the data received as well as is able to respond accordingly. Remote Client can be any web browser, viz. Mozilla Firefox, Google Chrome or Windows Internet explorer etc., remote client can also be an Android, JAVA or C based API as shown in Figure 2 and Figure 3.Web Server access without any predefined software reduces the cost of the overall system design. The investigated approach for server unit is able to respond for all of the above mentioned client types. The server unit is so designed that it is able to display the received text in 16x2 LCD display as well as the server unit is able to respond for few of the specific text or commands.

The server unit consists of an Ethernet adaptor, Ethernet Controller with SPI (Microchip ENC28J60) [1], two processing units (can be any micro-controller depends on availability and memory requirement), LCD display, IR or radio frequency transmitter (depends upon the type of applications), with additional supporting devices such as switches, LED's, Oscillator's etc. Above mentioned Ethernet Controller (ENC28J60) [1]) fulfills all IEEE 802.3 specifications. It consists of a number of packet filtering schemes to limit incoming disturbed data packets. It also provides an internal DMA module for fast data throughput and hardware assisted checksum calculation, which is used in various network protocols.

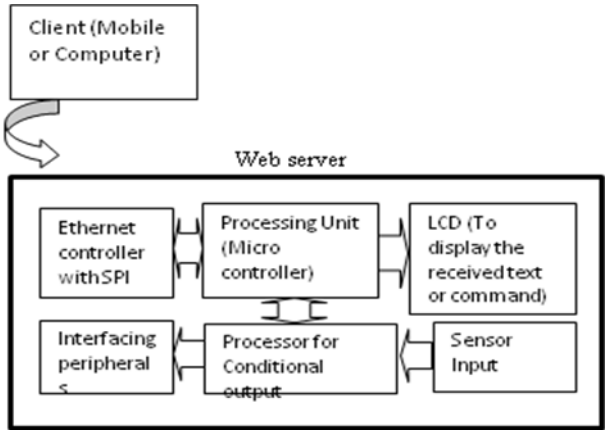

Figure1. Block Diagram representation of Automation and surveillance system

This integrated circuit requires an operating system or a driver to utilize its features for the maximum. So the investigated approach is based on real time operating system which does not require Linux, Python or windows as its platform but it is platform independent

and this platform independent operating environment of the device makes it much more cost effective and is one of the major features that we have developed and discovered in this design. The investigated operating environment can be easily dumped over any microcontroller and it reduces the system complexity and requirements of the design.

3. Hardware Design Approach

As shown in Figure 1. Hardware part consists of two processing units. One of which is utilized as the driving unit of the Ethernet interfacing circuit, while other processing unit is utilized to generate the output. In our application of home automation system, another processing unit is utilized for the generation of REMOTE IR signals based on various IR REMOTE Protocols viz. RC5, NEC, SONY, SHARP etc.

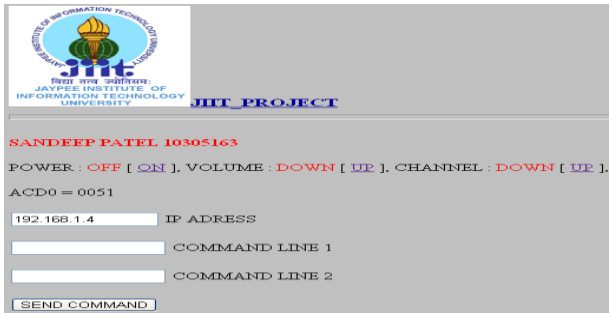

Figure 2.Graphical user interface (HTML Web Page) for the remote automation

The use of processing unit or code's to generate the various IR protocols makes it compatible with appliances of the all the companies, or we can say our IR transmitter unit is Universal IR remote transmitter which is able to transmit the IR bit pattern of any IR Remote Protocol. This second processing unit increases the application of our web server design; it enables us to use radio frequency communication with the compatible devices. The core of the whole hardware design is the Ethernet controller (EN28J60) along with its operating environment written in the processing unit. The operating environment or the RTOS is written in the embedded C language and hence with slight modification in the code it can be utilized with any processing core available viz. AVR, PIC etc. write now, in the investigated approach the processor in use is ATmega32 with open source AVR-GCC compiler. This system is also attached with a device at the receiver end of the home appliances to detect the state of device and respond it back to the controller. This helps us to take the correct decision and to alarm the user if required.

Figure 3. Graphical user interface (Android Mobile application) for the remote automation

The stand alone Ethernet controller IC ENC28J60 [1] requires 25 MHz parallel cut crystal oscillator and it requires 7500 number OSC1 clock cycles (300usec) to initialize its operation, this is called as Oscillator Start-up Timer(OST). After OST, based on the state of ESTAT (Ethernet Status) register the software can begin its operation. Step wise software operation is explained in section IV. Rest of the physical inter connection's are made as per Figure 4.

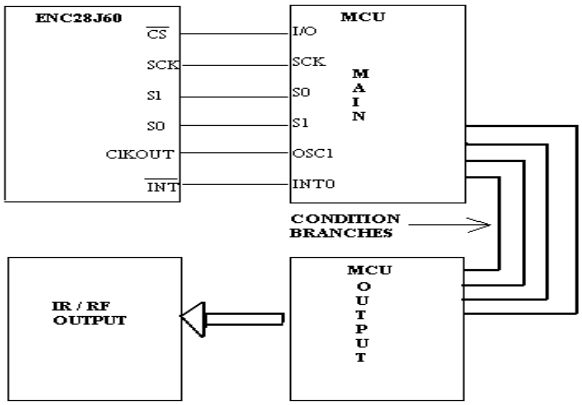

Figure4. Physical connection's to be made in between various entities of the design

4. Software Design Approach

The system software in the "Main Processing Unit (MPU)" is written in Embedded C language and is designed to ensure the proper communication of data packets in between the client and the server

unit. The number of Sub-processes involved in this Web server based automation system is explained with help of state machine diagram in Figure 5.

State P1: INITIALIZATION: Hardware initialization.
State P2: OST (required time for software operation).
State P3: Peripherals initialization (LED's, LCD etc)
State P4: Server Process:

1. Break the packet received.
2. Check packet is valid or not.
3. Put data to buffer of Rx, Tx.
4. Get MAC and IP address of client.
5. Packet Validation: whether the received data packet is of UDP, TCP or ICMP.
6. Start web server at 8080 port number.
7. Check the request type and get the value from request variables.
8. Based on the request type function is been performed at the output port. Example blinking or led.
9. And at the end response is been generated in the form of web page and is send to the buffer.

State P5: Client Process:

1. Read the buffer data to be send.
2. Create packet header .Insert client IP and MAC address.
3. Insert data into TCP packet and send it to client IP.

State P6: jump to step 4.
State P7: RESET State.

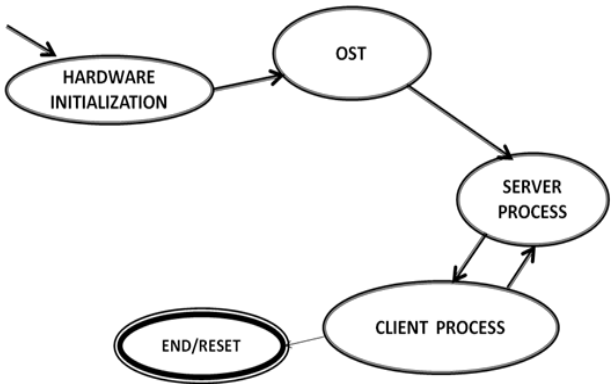

Figure5. Various states involved in software flow

Step P1 include hardware initialization which means the initial time taken by Ethernet controller to establish a connection to the network. The above mentioned steps are executed in the controller sequentially .And this controller is capable of capturing the request of different types and can identify the request type and can perform the operation accordingly like displaying the string in the led display.

This system is different from previous system .The difference is that previous proposed system require Linux as the operating system and python based server .But the use such developed and configured platforms requires costly hardware and software's and hence it will increase overall system cost. The investigated approach is cost effective because it utilizes open source AVR-GCC compiler and a very low cost micro-controller.

The software in MPU deals with network interconnection and the exchange of data between client and the server unit. Based on commands (Specific text) or binary data MPU generate certain bit conditions in its I/O port, Depending upon these bit positions at the I/O port of MPU, "OUTPUT" processing unit performs certain functions like 'transmitting IR remote control codes of various protocols' or 'transmitting RF signals to another device to perform accordingly'. The investigated approach utilizes embedded C language to generate output from the OUTPUT processing unit. The C code written for OUTPUT processing unit is a very simple IF-ELSE based code. For every specific input it has to call certain IR or RF functions. However developing IR protocols is not an easy task, it requires good understanding various IR protocols.

5. Comments

The investigated approach has lots of benefits in terms of cost and its functionality. The required memory in the MPU is about 32 Kb and if we want increase its functionality in terms of increasing peripheral units like sensors or a digital camera then the memory and processing requirement of the MPU will increase up to a certain level. The investigated approach is able to support LCD, 1 sensor, few switches for input and TELNET environment in the MPU.

6. Future Work

This approach will provide many opportunities for the improvement in the field of automation and monitoring systems. Few of them are mentioned below –

(a) Utilization of image or edge detection techniques with this web server for the vehicle monitoring system in Toll offices. This system can take the snap shot of vehicle number plate and due to its connectivity with internet or with the main server unit, it can easily identify the details of the vehicle or if there is some kind of security hurdle in toll office, this web server design can identify the vehicle and its owner by extracting data from main server and can alert related authorities about

it. This existing hardware design can support this type of application.

(b) Interfacing a digital camera and the utilization of few image detection techniques can increase the applications of this web server design. The investigated web server design helps us to monitor the environment in the real time scenario. For example- This can be utilized in high alert areas. The digital camera attached to it, can detect every face in the crowd and can match it with the images already available in main server. If somebody found relevant it can automatically alert the related authorities.

(c) This approach can provide accurate data in various surveys like- traffic load in a particular road or a particular place, water pressure in tunnels, Railway or roads salinity etc. It can bundle up the data or readings from various remote areas in a centralized server. This technique of survey reduces human effort and increase survey accuracy. The collected data can be monitored by the authorities without any kind of manipulation by the people involved in the work place.

References

1. Wei-Chen Wang ,Li-Chen Fu A," Mobile agent based integrated control architecture for home automation system", In Intelligent Robots and Systems, 2004. (IROS 2004), pp: 3668- 3673 vol.4.
2. Kayalar, A.A., Tosun, M.B.,Ozcan, M.K., Alkar, A.Z.," A GSM, internet and speech controlled wireless interactive home automation system ",Consumer Electronics, IEEE Transactions on,2006 ,pp. 837- 843.
3. Azwai, F ," Friendly home automation system using cell phone and J2ME with feedback instant voice messages" In Computer Systems and Applications, 2009. AICCSA 2009pp: 531- 538.
4. Al-Ali, A.R.," Java-based home automation system ", Consumer Electronics, IEEE Transactions 2004, pp. 498-504.
5. Kwang Yeol Lee," Remote-controlled home automation system via Bluetooth home network", SICE 2003 Annual Conference , 2003, pp. 2824 - 2829 Vol.3.
6. Gui, X. ; Xu, W.L.," A mobile-based home automation system" ,In Mobile Technology, Applications and Systems, 2005 2nd, pp. 5.
7. Maiti, A.," Cloud controlled intrusion detection and burglary prevention stratagems in home automation systems", Future Internet Communications (BCFIC), 2012 2nd Baltic Congress on: 25-27 April 2012, pp. 182 – 186.
8. Alkar, A.Z." IP based home automation system", Consumer Electronics, IEEE Transactions on: November 2010,pp. 2201- 2207,vol.56.
9. Golzar, Manouchehr Ghahramanian Tajozzakerin, HamidReza," A New Intelligent Remote Control System for Home Automation and Reduce Energy Consumption", Mathematical/Analytical Modelling and Computer Simulation (AMS), 2010 Fourth Asia International Conference on: 26-28 May 2010, pp. 174-180.