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Implementation of Embedded Webserver on Beagle Bone Black for Industrial Controlling and Monitoring

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ABSTRACT: When networking technology is combined with embedded systems; the scope and applications of the system will be more useful for monitoring through internet. This paper gives design and implementation of embedded web server. The system we are implementing has Beagle Bone which can be used for Electrical Equipment monitoring.This work refers to internet of things with Beagle Bone. For measurement of Parameters like temperature, gas etc. Sensors are interfaced with Beagle Bone. We are presenting our work for sensing environmental parameters through beagle bone and uploading these values on internet via Ethernet cable. Our work will be beneficial for monitoring remotely. By typing IP address in web browser, client can monitor all devices in industry from any remote places via his/her own local browser.

KEYWORDS: Beagle Bone Black, Ethernet LAN, LinuxDebian OS, TCP/IP

I.INTRODUCTION

Internet of things have changed now a days technology drastically due to combination of embedded systems and arrival of Internet. Internet reduced the whole world communication boundary to that of a single village. After the “everybody in internet wave” now obliviously follows the “everything in the internet wave”.[1]

The communication is very important phenomenon in human life. It is vital for the progress of the human kind. So it is important to make available a platform for the efficient communication. The rapid development in wireless technologies made it possible to achieve the communication in very efficient way.[4].For efficient communication we are proposing wireless embedded system with internet access.

An embedded system is a computer system designed for specific control functions within a larger system, often with real-time computing constraints .When the embedded devices are provided with internet access, it is of no doubt that demand will rise due to the remote accessing capability of the devices. The paper includes complete implementation of an HTTP Web Server in Beagle Bone. Sensors are connected to ARM A8 Microcontroller. Temperature, Gas, Humidity, pressure, motion, and speed are must often measure parameters.

Some electronic circuits, chemical reactions, biological processes perform best with in limited temperature and also necessary to measure gas in environment. These parameters are mostly used in power plants, chemical industry, hospital, medicine Production Company.

In this paper embedded systems and Internet technology are combined to form a new technology –the Embedded Internet Technology, which developed with the popularization of computer network technology in recent years. The heart of communication is TCP/IP protocol. Network Communication is performed by the IEEE 802.3 Ethernet standard. It is the most modern technology of embedded systems

Since ARM embedded web server based on Beagle Bone has fast execution capability and Ethernet standard can provide internet access with reasonable speed, this system is suitable for enhancing security in industrial conditions by remotely monitoring various industrial applications.

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II. RELATED WORK

In [1] this same system is implemented on Raspberry Pi board using Xbee module for successful delivery of data between remote devices .In this system extra 89c51 microcontroller used for sensor modules along with external ADCs for each sensor and also Xbee module for transmitting sensed information to Raspberry Pi .Then with the help of Ethernet controller webpages are transmitted. So the extra microcontroller with extra ADCs along with Xbee module has increased the system cost and requires extra power. In [2] same system is proposed with the use of AT89c52 based S3C44B0X processor. It also made the use of external network controller chip RTL8019AS along with 24c02 as an EEPROM.Therefore this proposed system also increased the system cost and power as it required external network controller and EEPROM. So in our proposed system by using Beagle bone black board having in built Ethernet controller and ADCs we can reduce system cost and power requirement.

III.EMBEDDED WEBSERVER

The implementation of embedded Internet technology is achieved by means of the embedded web server. It runs on embedded system with limiting computing resources to serve web documents including static and dynamic information about embedded system to web browser. We can connect any electronic device/equipment to web server and can obtain the real-time status information and control remote equipment without time and space restriction through web page released by embedded web server. Embedded server is a single chip implementation of the Ethernet networking standard. It consists of two primary elements communicating with each other: i) a server consisting of an ARM processor with an Ethernet controller and ii) a client computer. The client computer sends/receives data to/from the arm microcontroller using TCP packets.

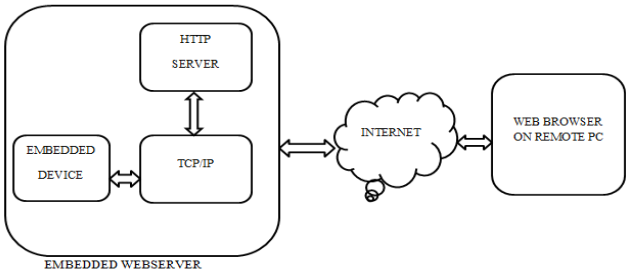

Fig. 1. Embedded Web Server Module

The client has to enter IP address to access this server. This request is taken by the operating system of the client and given to the LAN controller of the client system. The LAN controller sends the request to the router that processes and checks for the system connected to the network with the particular IP address. If the IP address entered is correct and matches to that of the server, a request is sent to the LAN controller of the server and a session is established and a TCP/IP connection is establishes and the server starts sending the web pages to the client through which we can remotely monitor and control the sensor and device status respectively.

A. TCP/IP Protocol

TCP/IP protocol describes the layered structure of embedded webserver. In TCP/IP suite different protocols for different layers are present. Each layer operates independently from other layers[2].TCP/IP allows communication between computers of different configuration, operating systems. The layered structure of TCP/IP is as shown in following figure,

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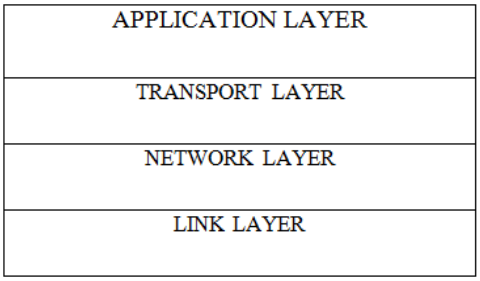

Fig.2. TCP/IP layered structure

Basically the link layer makes the interfacing of network interfaces and other devices easy in the computer. Networklayer makes and controls the communication between different hosts. There are different protocols operating in isolated manner in different layers like IP,ARP,ICMP,IGMP,UDP.So with the use of TCP/IP protocol we can access the webserver on remote PC over the internet. The server and web browser makes communication via the HTTP protocol.

IV.SYSTEM DESCRIPTION

The implementation of embedded Internet technology is achieved by means of the embedded web server. It runs on embedded system with limiting computing resources to serve web documents including static and dynamic information about embedded system to web browser.

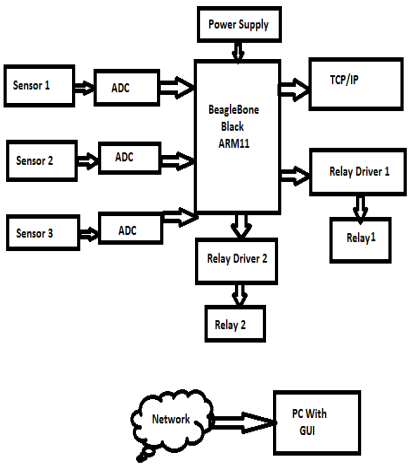

Fig. 3. Block Description of system

The architecture of industrial monitoring and controlling System consist of four modules. Sensor module consist of temperature and gas sensors with signal conditioning circuitry. The following diagram gives us the idea of how sensors are interfaced with beagle bone.

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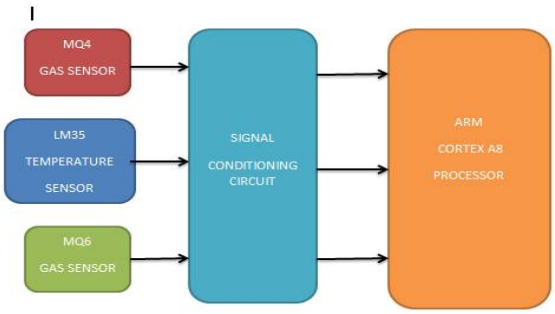

Fig. 4.Sensor Module

In sensor module, node of two sensors is developed i.e. Temperature and gas respectively which will measure physical quantities of the industrial devices. The AD0,AD1,AD2 channels of ARM cortex processor are used to connect sensors MQ2,LM35,MQ6 respectively. After embedded webserver next module is client pc with GUI(Graphical user Interface) for monitoring the industrial parameters on remote location.

The GUI on remote pc consists of following tabs for monitoring and controlling:

TABLE I.

SR.NO	TABS ON GUI
1	RELAY 1(ON/OFF)
2	RELAY 2(ON/OFF)
3	TEMPERATURE VALUE
4	CO2 GAS VALUE
5	METHANE GAS VALUE

After monitoring for controlling from remote place the relays are interfaced with ARM cortex A8 based processor of beagle bone.

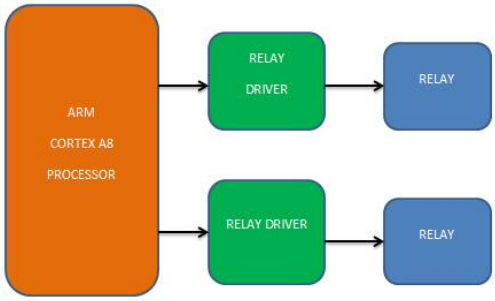

Fig. 6. Relay Module

V.SYSTEM DESIGN

The designing part includes basically two sections asFollows:

- Hardware design
- Software design

A. Hardware Design:

It includes Beagle Bone Black board, Temperature sensor, MQ2, MQ6 gas sensor, and LAN.

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1. Beagle Bone Black:

The Beagle Bone is the latest addition to the BeagleBoard.org family and like its' predecessors, is designed to address the Open Source Community, early adopters, and anyone interested in a low cost ARM Cortex A8 based processor. It has been equipped with a minimum set of features to allow the user to experience the power of the processor and is not intended as a full development platform as many of the features and interfaces supplied by the processor are not accessible from the Beagle Bone via onboard support of some interfaces.

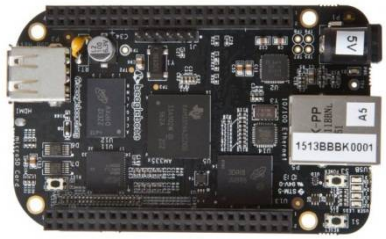

Fig. 7 Beagle bone Black Board

2. Gas Sensor-MQ2

MQ-2 is a Carbon Monoxide (CO) sensor, suitable for sensing Carbon Monoxide concentrations (PPM) in the air. The MQ-2 sensor can measure CO concentrations ranging from 20 to 2000ppm.This sensor has a high sensitivity and fast response time. The sensor's output is an Analog resistance. The drive circuit is very simple , just a voltage divider; all you need to do is power the heater coil with 5V DC or AC , add a load resistance, and connect the output to an ADC or a simple OPAMP comparator. They are used in gas detecting equipment for carbon monoxide (CO) in family and industry or car.

3. Temperature Sensor LM35

The LM35 series are precision integrated-circuit temperature devices with an output voltage linearly-proportional to the Centigrade temperature. The LM35 device has an advantage over linear temperature sensors calibrated in Kelvin, as the user is not required to subtract a large constant voltage from the output to obtain convenient Centigrade scaling. The LM35 device does not require any external calibration or trimming to provide typical accuracies of ±¼°C at room temperature and ±¾°C over a full −55°C to 150°C temperature range. Lower cost is assured by trimming and calibration at the wafer level. The low-output impedance, linear output, and precise inherent calibration of the LM35 device makes interfacing to readout or control circuitry especially easy.

B. Software Design

1. Debian Linux

A free Linux" Debian Linux Distribution" is utilized for software design.

VI. SOFTWARE LEVEL COMPILATION

The firmware development for the system operation is done in Python language. We have to create code for three modules. First is ADC module that code can convert sensor data into digital data. There are many different technologies to achieve dynamic Web page, commonly used CGI, ASP, PHP, JSP and so on. The PHP is implemented on web server which provides interface between webserver and program that generate the web content this server technology can be made to interact between the browser and server.

These modules coding is dumped into Beagle Bone development kit by using Putty. So by typing the IP address of Server we can access it.

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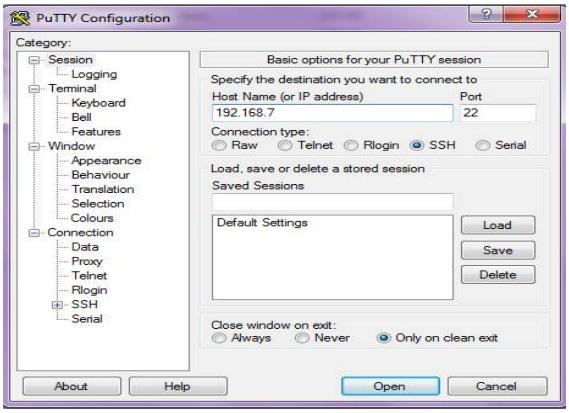

Fig. 9 Putty configuration window

The above putty configuration window shows that how to make all the necessary configuration settings along with IP .Therefore in this way with the help of Putty software we can make the interaction between operating system and hardware.The following flowchart will describe that how to do the software design of a system. It also shows that flow for how to make putty configuration.

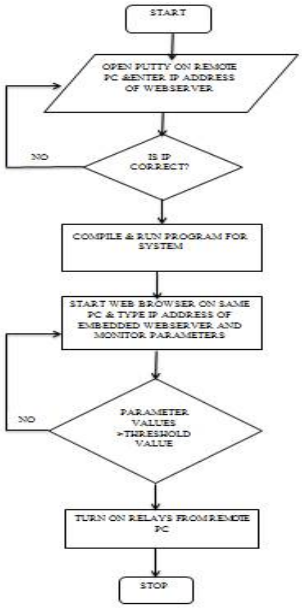

Fig. 10 Flowchart for Accessing Embedded Webserver on remote PC

The above flowchart also shown that how to access webpages from remote embedded webserver on local remote pc . In this way whole system works in above manner.

VII. RESULT

The individual testing of different modules are developed and the final setup was made arranging all devices in proper manner. After this final arrangement the whole system was tested.

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This hardware setup is shown in the figure:

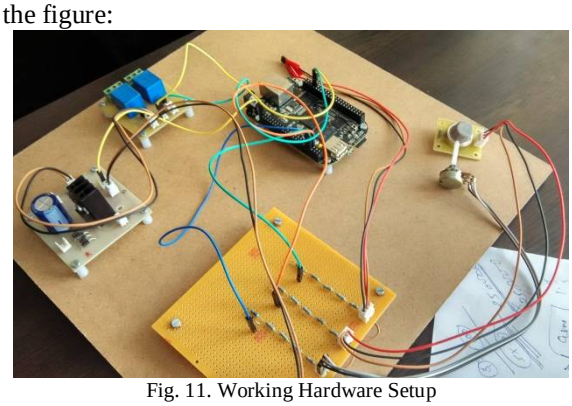

Fig. 11. Working Hardware Setup

The LM 35 temperature sensor is the transducer that sense temperature of the industrial environment, which we want to measure and converts the temperature into corresponding electrical signal. This analog signal from sensor is amplified by signal conditioning circuit and then the analog value is converted into digital by means of analog to digital converter in order to read microcontroller. Microcontroller is programmed to read this digital value corresponding to temperature and gas it is stored in the microcontroller. The final arrangement was made and the system was run, the data from internet (TCP/IP) receive by remote computer which shows data on designed HTML webpage and controlling of industrial parameters from remote computer is also done.

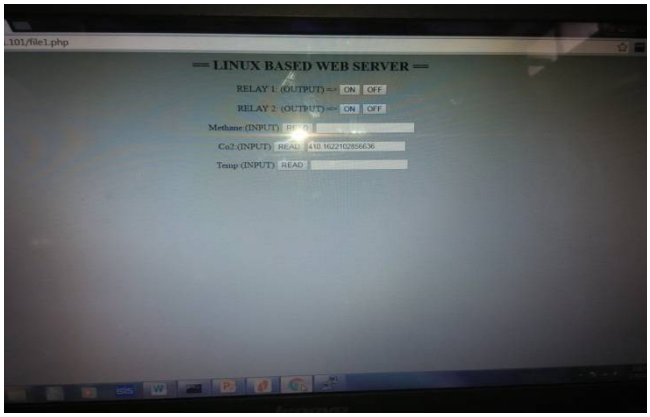

Fig. 12 Output monitoring window on client PC

The HTML web page displayed when the configured IP address of embedded webserver wasentered on the web browser is shown. Here the first data gives information about the concentration of Methane gas sensed in the remote location. The second data displays the concentration of CO in the location of monitoring and the third location displays the sensed temperature. Depending on threshold values decided for each sensed value controlling of respective quantities was done from remote place on real time.

VIII .CONCLUSION

Implementation of web server using Beagle bone black for intelligent monitoring and controlling of industrial parameters is a new method to monitor and control an environment which designed here for the real time implementation. The system can directly transmits sensed information in the form of webpages without need of PC. It also supports online supervision and control not only within Private Network(LAN) but also in Public Network (Internet).The whole system has low-cost and is easy to maintain and upgrade. So it can monitor and control the operation of different industrial sections through Internet from remote location. This work on beagle bone black board

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can further be extended with usage of high end embedded servers with use of wireless sensors with increase in industrial parameters and sensor nodes.

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