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Design and Implementation of Embedded web Server Using Raspberry Pi for Monitoring Battery/ Solar System

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ABSTRACT: This paper presents monitoring solar system using a wireless sensor network (WSN) and embedded Linux board. The system provides a internet interface to the user so that the user can monitor the solar system remotely. Raspberry Pi is used as an embedded board which is designed based on the arm 11 microcontroller architecture and Linux as a real time operating system. Embedded Linux board communicates with all distributed sensor nodes placed at solar system through ZigBee protocol and itself act as a coordinated node within the wireless sensor network. The aim of coordinator node is to collect the parameters like temperature, humadity and intensity wirelessly. Each sensor node consists of temperature sensor, humadity sensor and light intensity sensor and one ZigBee RF antenna device for communication with the coordinator node. Raspberry Pi stores collected data in the database and analyzes the stored data. The board has an Ethernet interface and executes the data web server. Hence coordinator collects the data over ZigBee wireless communication protocol and permit user to monitor the information from an internet browser. User will build the solar system ON or OFF remotely.

KEYWORDS: Wireless sensor network, Raspberry Pi (Rpi), Zigbee, Embedded Linux.

I. INTRODUCTION

A web server can be embedded into a device which can be accessed remotely from an internet. This embedded system can serve the information on request by a user from other system. Such type of a web server is called as Embedded Web Server (EWS). It consist of ARM processor with Linux operating system which suite for monitoring parameters remotely. Web access functionality can be embedded in a low cost embedded Linux board which can be widely accessible from worldwide through the web browser in computer/mobiles/tab.

Advanced RISC Machine (ARM) andLinux as the operating system used for embedded Linux board. Embedded web server can build with low power consumption, low cost, high reliability, and high performance. InThis paper implementation of low cost embedded system using ARM11 processor and linux operating system which can be accessed remotely with convenient way. Web server will have to serve dynamic HTML pages provides two-way communication. In addition, it will be required to implement two different communication protocols one to establish the connection with the Internet and the other one to communicate with the wireless sensor nodes.

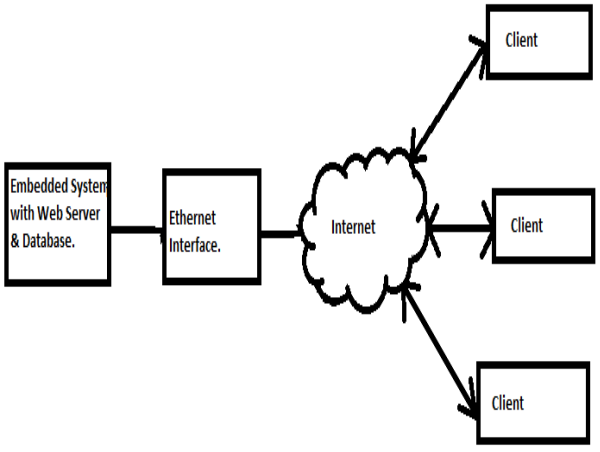

Figure 1:Embedded Web Server

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II. RELATED WORK

A. Solar Panel and Battery Street Light Monitoring System Using GSM Wireless Communication System.
The use of of single power solar system in generation of electricity for streetlights nowa day is widely used. Generally, many of this kind of streetlight is using one solar panel system to power its lamp. The problem that can be arise for this kind of streetlight is how to control and guarantee the optimal system [1]. The use of ACS712 current sensor and voltage sensor usingvoltage divider circuit with GSM communication system allows to monitor [2] both the battery and the solar panel. The information from the current sensor and voltage sensor then processed by a microcontroller. These microcontrollers then send the data through a GSM communication system to a server, via short message service (SMS). Thisserver then processed the data by parsing the information from the SMS, and send the data to a web server database. This information then can be accessed by internet. The expected outcome of this monitoring system is a system that can be used in monitoring small solar power plants system as the street lights.

B. Increase Efficiency of Solar Photovoltaic System by Data Acquisition Process.
In 2014 , Sunil Parashar and Sunil Dhankhar worked on data acquisition System. In current scenario, renewable energy sources helps to make the environment greener and better. Currently, solar energy is the most available resource of renewable energy. This paper mainly represents the working principle of solar photovoltaic system and way to increase efficiency of the solar system using a method known as the data acquisition system. Data acquisition is a process to monitor changes in system, collect corresponding data and analyze data to make a decision. The data acquisition system has two parts, data acquisition board that contains Microcontroller Kit, ADC, and RS-232 and Zigbee communication modules. Another part is running on a host computer that has a set of software tools as Keil, Proteus, and Visual Basic 6.0 help to analyze and store data. Zigbee communication helps in wireless data transfer without any communication cost. Complete experiment and the result show the data acquisition designed is simple and stable.

C. Design and Development of a Low Cost Solar Energy System for the Rural Area.
In 2013, Al-Mamun, K. Sundaraj, N. Ahmed, N. U. Ahamed, S.A.M. M. Rahman, R.B. Ahmad and Md. H. Kabir worked on low cost solar energy system for the rural area. Solar energy has turned into a popular alternative energy source to meet certain demands around the world due to the instability of oil and coal prices with global warming issues. The aim of this paper is to develop of a simple and cost-effective solar system for the rural areas where grid electricity is not available. To fulfil this objective, a 5-Watt PV (photovoltaic) stand-alone solar module was used as solar power source and a common type lead acid battery (12V, 7AH) applied for backup system. The solar panel was connected to the battery via a charge controller which was responsible to pass the correct voltage for charging the battery and also, ensure that the battery was not overcharged. In addition, the system was designed for 22W AC and 12W DC loads. An inverter was designed for the AC loads which could convert the fixed DC voltage from battery to an AC output voltage. Finally, the entire system was tested successfully and cost evaluation also presented in the paper. This developed system will be effective for the poor people in the rural area those are deprived from the electricity as well as the conventional fuels being save.

D. Analysis of TOI (Things of Internet) Industrial Monitoring System on Raspberry pi Platform.
In 2014, Mehta Karankumar D, Mehta Shreya B, Raviya Kapil S worked on An embedded system is a computer system design for specific control function within a large system often with real time computing system. This research paper was developed to produce web based temperature; humidity & pressure monitoring system that allows continuing monitor these parameters. This system allowed the data to be anytime & anywhere from the internet after we login into webpage. This research paper also concludes that user can set limit range of the above parameters & if these parameters go beyond that value, it will turn off devices. With Ethernet-based, internet-enabled instrumentation, remote access can be anywhere a smartphone has a signal. From the simplest application, viewing data through the web-browser on your iPhone, Blackberry device or laptop, to more sophisticated uses, such as sending a text or e-mail message when an alarm occurs, or transmitting a data log file over the internet from a remote location to a central office.

III. PROPOSED WORK

A. Raspberry Pi

In this proposed system we have used Raspberry Pi as the Controllerofco-ordinator node. Rpi is the small, inexpensiveminicomputer. It continuously collects the

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information send bysensor nodes via ZigBee, and processing large quantities ofdata timely and available for users to view. It is the core of thesystem.

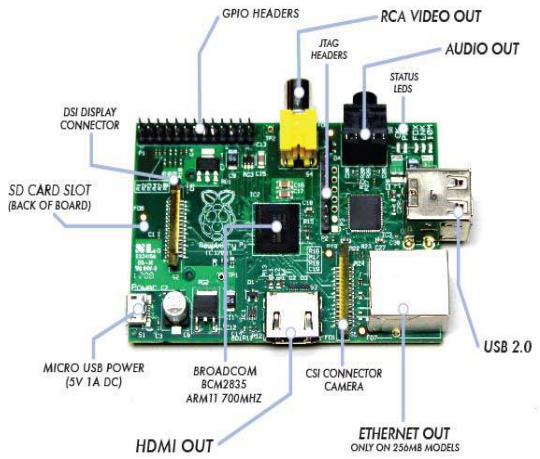

Figure 2:Raspberry Pi

B. **End device sensor node**

Sensor node used here to sense the parameters. It is designed using Arduino UNO microcontroller board based on Atmega 328. It consist of the ZigBee protocol based radio transceiver, power supply unit, humadity, light intensity and temperature (DS8B0) Sensors, and data logger for temporary storage. It will sense the parameter typically at one-minute intervals and send back to the coordinator node via the ZigBee wireless communication protocol..

Arduino UNO

The Arduino UNO is the microcontroller board based on ATmega328. It has 14 digital input/output pins, 6 analog inputs, 16MHz ceramic resonator, USB connection, a power jack. Arduino consists of a microcontroller and Integrated Development Environment (IDE). IDE is used to write and upload computer code to the microcontroller. It can be powered by USB cable or power jack of 5v. It contains everything needed to support the microcontroller.

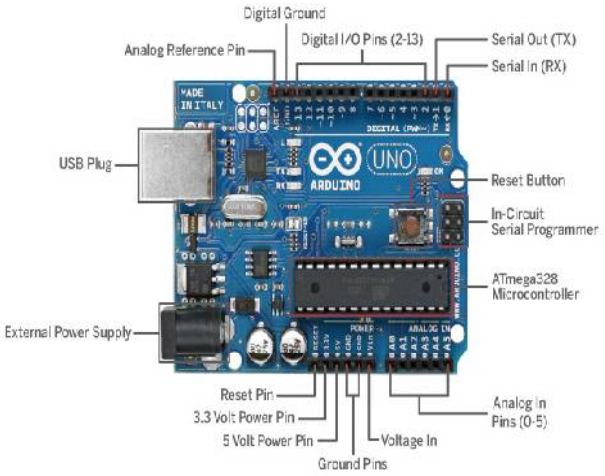

Figure 3:Arduino UNO

C. **ZigBee**

A ZigBee protocol for wireless communication which is based on the underlying protocol IEEE 802.15.4, which defines the network physical layer, and controlling layer for media access, while ZigBee protocol defines the network layer, application layer and specifications of the network security services.

IV. SYSTEM ARCHITECTURE

The designing part includes basically two sections as follows.

2.1 Hardware design

2.2 Software design

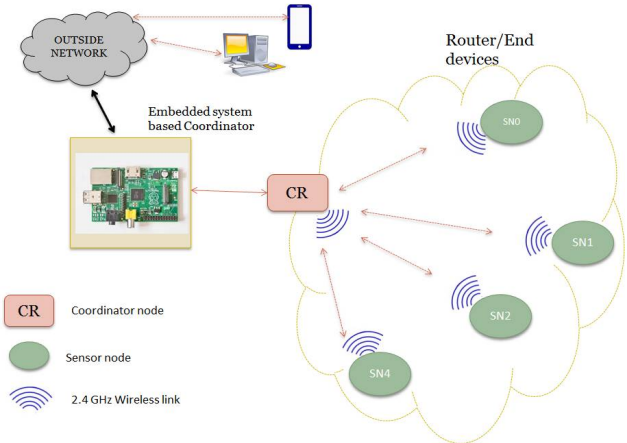

Figure4:System architecture

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The Raspberry Pi is a credit-card-sized single-board computer developed in the UK. It has a Broadcom BCM2835 system on a chip (SoC), which includes an ARM1176JZF-S 700 MHz processor, Video Core IV GPU. Its GPU provides Open GL ES 2.0, hardware-accelerated Open VG, and 1080p30 H.264 high- profile decode which is capable of 1Gpixel/s, 1.5Gtexel/s or 24GFLOPs with texture filtering with 512 Mb RAM. It does not have on chip built-in hard disk, but uses an SD card for booting and persistent storage. It has 10/100 Base T Ethernet socket. The Raspberry Foundation provides Debian and Arch Linux ARM distributions for download. Tools are available for Python as the main programming language, with support for C, C++, Java, Perl and Ruby. The video controller is capable of standard modern TV resolutions, such as HD and Full HD, and higher or lower monitor resolutions and older standard CRT TV resolutions.Features of Raspberry Pi shown below,

Temperature Sensor – DS8B20
The DS18B20 digital thermometer provides 9-bit to 12-bit Celsius temperature measurements and has an alarm function with nonvolatile user- programmable upper and lower trigger points. The sensor communicates over a 1-Wire bus that by definition requires only one data line for communication with central microprocessor. It is operating temperature range of -55°C to +125°C and is accurate to ±0.5°Cover the range of -10°C to +85°C. In addition, the sensor can derive power directly from the data line, no need of an external power supply.

Humidity Sensor-DHT22.
This sensor applies exclusive digital-signal-collecting-technique and humidity sensing technology, assuring its reliability and stability. Its sensing elements are connected with 8-bit single-chip computer. Every sensor of this model is temperature compensated and calibrated in accurate calibration chamber and the calibration-coefficient is saved in type of program in OTP memory, when the sensor is detecting, it will cite coefficient from memory. Small size & low consumption & long transmission distance (100m) enable DHT22 to be suited in all kinds of harsh application.

LDR Sensor:
An LDR (Light dependent resistor), as its name suggests, offers resistance in response to the ambient light. The resistance decreases as the intensity of incident light increases, and vice versa. In the absence of light, LDR exhibits a resistance of the order of mega-ohms which decreases to few hundred ohms in the presence of light. It can act as a sensor, since a varying voltage drop can be obtained in accordance with the varying light. It is made up of cadmium sulphide (CdS).
An LDR has a zigzag cadmium sulphide track. It is a bilateral device, i.e., conducts in both directions in same fashion

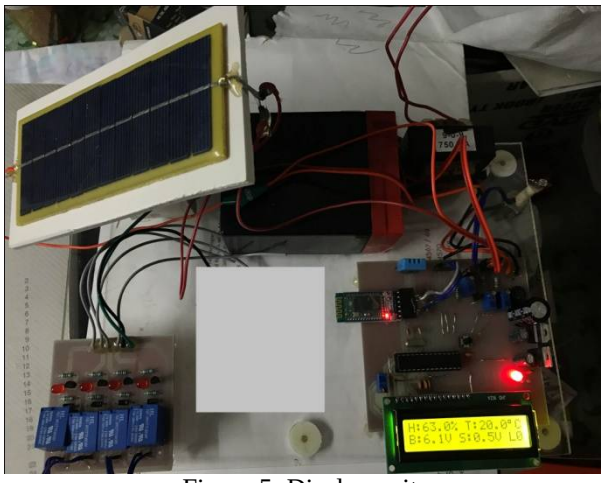

Figure 5: Display unit

I2C (Inter Integrated Circuit)
I2C (Inter-Integrated Circuit, pronounced "I squared C") is also a synchronous protocol, and it's the first we see which has some "intelligence" in it; the other ones dumbly shifted bits in and out, and that was that. I2C uses only 2 wires, one for the clock (SCL) and one for the data (SDA). That means that master and slave send data over the same wire, again controlled by the master who creates the clock signal. I2C doesn't use separate Slave Selects to select a particular device, but has addressing. The first byte sent by the master holds a 7 bit address (so that you can use 127 devices on the bus) and a read/write bit, indicating whether the next byte(s) will also come from the master of should come from the slave. After each byte receiver must send a "0" to acknowledge the reception of the byte, which the master latches with a 9th clock pulse. If the master wants to write a byte the same process repeats: the master puts bit after bit on the bus and each time gives a clock pulse to signal that the data is ready to be read. If the master wants to receive data it only generates the clock pulses. The slave has to take care that the next bit is ready when the clock pulse is given.

Ethernet: Ethernet is the computer networking technology which allows computers to communicate and share resources over the internet. Ethernet was standardized as IEEE 802.3. it is one of the most widely implemented LAN standard originally developed by

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Xerox. Different Ethernet networks also connect to a router that provides.Access to the internet.

Software Used:
Linux Operating System:
Linux is the best known and most used open source operating system. It is Linux kernel based operating system which uses on the light weight ARMv6 instruction set that a typical Broadcom processor understand.

Apache2: It is also known as "Apache HTTP Server"which allows the online distribution of website service using Hyper Text Transfer Protocol (HTTP). It is widely popular web server for different operating systems such as Linux, Unix, Windows, Solaris, Mac OS X, Novell NetWare, OS/2 etc. Apache2 version was used in this project for creating
web server.

PHP5: The PHP hypertext preprocessor (PHP) is a server- side scripting language designed for web development. PHP code is integrated by a web server with a PHP processor module which generates the resulting web page. PHP is basically used for developing web based software applications and also to manage database, dynamic content, session tracking, even build entire e-commerce sites. PHP5 version was used in this project.

MySQL: MySQL is database management system which runs on a server. It support standard SQL and compiles on a number of platform. MySQL is open source, free to download and use.

Proftpd: Proftpd is a File Transfer Protocol(FTP) server which is used to transfer website from computer to raspberry pi. It is free and open source software, compatible to number of platforms such as Linux, Mac OS X, Solaris, Sun OS, Windows(via cygwin) etc. It is a secure and configurable FTP server with more number of option's.

IMPLEMENTATION:
For implementation of this project we need to install the software and then copy website on raspberry pi.
Now, the website will be available on the localnetwork. To make website available outside the localnetwork too use a WAN IP, by using which we can accesshosted website from outside local network.

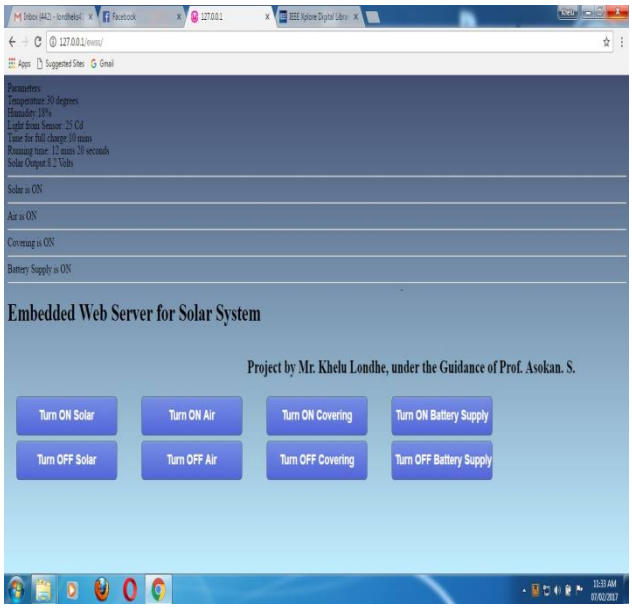

Figure 6: implementation

V. CONCLUSION AND FUTURE WORK

This paper Design and Implementation of Embedded web server using Raspberry Pi for Monitoring battery/ solar system. In this we have usedraspberry Pi as an embedded Linux board which allowscollecting the sensor information from sensor nodecontinuously, store it in a database and providing the webinterface to the userThe system provides a internet interface to the user so that the user can monitor the solar system remotely. By providing the web interfaceand automation user can easily monitor the system and it willminimize the human intervention. The ZigBee protocol is usedhere for wireless communication it will create network easilyand combination of Arduino, Xbee and sensor create a lowpower inexpensive sensor node. The Apache web server cratedon Raspberry Pi easily displaying the contents of sensor data.

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