AN IOT BASED WIRELESS SENSOR NETWORKS(WSN) FOR ENVIRONMENTAL MONITORING USING PI AND ARDUINO

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ABSTRACT: The project aims at designing a system which monitors the Environmental parameters and send the details through Wi-Fi module to the user data base. Wi-Fi (Short for **Wi**reless **Fi**delity) is a wireless technology that uses radio frequency to transmit data through the air. Wi-Fi has initial speeds of 1mbps to 2mbps. Wi-Fi transmits data in the frequency band of 2.4 GHz. It implements the concept of frequency division multiplexing technology. Range of Wi-Fi technology is 40-300 feet. The Raspberry Pi is a low cost, credit-card sized computer that can be used in electronics projects. It is a capable little device that enables people of all ages to explore computing, and to learn how to program in languages like Scratch and Python. It's capable of doing everything you'd expect a desktop computer to do, from browsing the internet and playing high-definition video, to making spreadsheets, word-processing, and playing games. The device which is able to perform the task is a Raspberry Pi processor. There are different sensors such as Such a sensor are temperature, vibration, pressure, moisture, light, and pollution. Temperature sensor measures temperature of a condition. All these parameters values are fed to the Raspberry Pi processor. All the parameter values are sent to the user mobile phone through Wi-Fi module and also constantly displayed on the LCD.

I. INTRODUCTION

The development in wireless sensor networks can be used in monitoring and con- trolling various parameters in the agriculture field, weather station field. The sensor network hardware platforms are basically low-power embedded systems with some different sensors such as onboard sensors and analog I/O ports to connect sensors. Like hardware, software should also be developed, including OS, sensor/hardware drivers, networking protocols and application-specific sensing and processing algorithms. The purpose or objective of environmental monitoring is different in different situations, but important aims to environmental monitoring to find risks to human and wildlife, scope to population migration from high density areas to low density areas and to restrict emission of gases. Wireless sensor network (WSN)[1]is a low cost, low power wireless network made up of thousands of smart sensor nodes which monitor physical or environmental conditions, such as temperature, pressure, moisture, etc. at different area or different location. The Internet of Things (IoT) is an emerging key technology for future industries, and environmental monitoring. The Internet of Things (IoTs) can be described as connecting everyday objects like smartphones, Internet TVs, sensors and actuators to the Internet where the devices are intelligently linked together enabling new forms of communication between things and people, and between things themselves. Building IoTs has advanced significantly in the last couple of years since it has added a new dimension to the world of information and communication technologies.

II. LITERATURE REVIEW

In this section, we briefly discuss the existing works about smart home systems based on the wireless communication technology. Han et al. [15] proposed a Home Energy Management System (HEMS) using the ZigBee technology to reduce the standby power. The suggested system consists of an automatic standby power cutoff outlet, a ZigBee hub and a server. The power outlet with a ZigBee module cuts off the ac power when the energy consumption of the device connected to the power outlet is below a fixed value. The central hub collects information from the power channels and controls these power channels through the ZigBee module. The central hub sends the present state information to a server and then a user can monitor or control the present energy usage using the HEMS user interface. This facility may create some uneasiness for the users. For example, if the users may want low intensity of light, for some situation but the system will cut the power off leading to darkness. Gill et al. [16] projected a ZigBee-based home automation system. This system consists of a home network unit and a gateway. The core part of the development is the interoperability of different networks in the home environment. Less importance is given to the home automation. Pan et al. [17] recommended a WSN-based intelligent light control system for indoor environments, such as a home for a reduction in energy consumption. In this paper, wireless sensors are responsible for measuring current illuminations and the lights are controlled by applying the model of user's actions and profiles. Song et al. [18] suggested a home monitoring system using hybrid sensor networks. The basic concept of this paper is a roaming sensor that moves the appropriate location and participates in the network when the network is disconnected. Suh and Ko [19] proposed an intelligent home control system based on a wireless sensor/actuator network with a link quality indicator based routing protocol to enhance network reliability.

III. DESIGN OF HARDWARE

This chapter briefly explains about the hardware implementation of environmental monitoring systems using iot and raspberry pi. It discusses the circuit diagram of each module in detail.

3.1. Temperature Sensor-LM35

It is an IC sensor that is used to measure temperature with an output voltage linearly proportional to the Centigrade temperature. The LM35 sensor has an advantage over linear temperature sensor, as the user has not to make the conversion of Kelvin to Centigrade. This is major significance of LM-35 that it calibrates directly in Celsius and it is also suitable for remote applications. It has better efficiency than thermistor.

Temperature is one of the most commonly measured parameter in the world. They are used in your daily household devices from Microwave,fridges, AC to all fields of engineering. Temperature sensor basically measures the heat/cold generated by an object to which it is connected. It then provides a proportional resistance, current or voltage output which is then measured or processed as per our application. Temperature sensor are basically classified into two types

- Non Contact Temperature Sensors: These temperature sensors use convection & radiation to monitor temperature
- Contact Temperature Sensors: Contact temperature sensors arethen further sub divided into three type
    1. Electro-Mechanical(Thermocouples).
    2. Resistive Resistance Temperature Detectors (RTD).
    3. Semiconductor based. (LM35, DS1820 etc).

In this project, we will be discussing about LM35 Temperature Sensor which is a semiconductor based sensor. LM35 is an integrated analog temperature sensor whose electrical output is proportional to Degree Centigrade. LM35 Sensor does not require any external calibration or trimming to provide typical accuracies. The LM35's low output impedance, linear output, and precise inherent calibration make interfacing to readout or control circuitry especially easy.

3.1.1 Features of LM35 Temperature Sensor

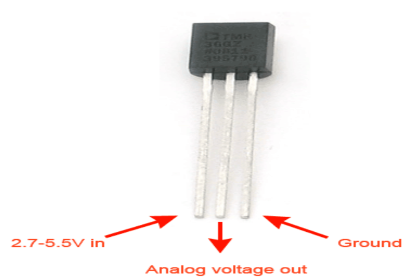

Fig 1: Pin diagram of LM35

- Calibrated directly in Degree Celsius (Centigrade)
- Linear at 10.0 mV/°C scale factor
- 0.5°C accuracy guarantee-able (at a25°C)
- Rated for full -55°C to a 150°C range
- Suitable for remote applications
- Low cost due to wafer-level trimming
- Operates from 4 to 30 volts

- Less than 60 mA current drain
- Low self-heating, 0.08°C instill air
- Non-linearity only 0.25°C typical
- Low impedance output, 0.1Ωfor 1 mA load

3.1.2 LM35 Interfacing Circuit

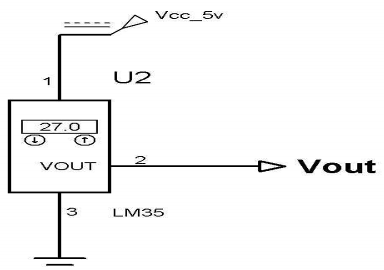

Fig 2 LM35 Interfacing Circuit

As such no extra components required to interface LM35 to ADC as the output of LM35 is linear with 10mv/degree scale. It can be directly interfaced to any 10 or 12 bit ADC. But if you are using an 8-bit ADC like ADC0808 or ADC0804 an amplifier section will be needed if you require to measure 1°C change.

LM35 can also be directly connected to Arduino. The output of LM35 temperature can also be given to comparator circuit and can be used for over temperature indication or by using a simple relay can be used as a temperature controller.

3.2 MQ2 Sensor:

Fig: 3.Mq2 arduino gas sensor

Sensitive material of MQ-2 gas sensor is SnO_2, which with lower conductivity in clean air. When the target combustible gas exists, the sensor's conductivity is higher along with the gas concentration rising. MQ-2 gas sensor has high sensitivity to LPG, Propane and Hydrogen, also could be used to Methane and other combustible steam, it is with low cost and suitable for different application.

3.3. Raspberry Pi

It is a powerful, low cost, and a small card sized device which is a perfect platform for interfacing with many devices. The board contains a processor, graphics chip, RAM memory, interfaces to other devices and connectors for external devices, of which some are necessary and some are optional. There are much versions of Raspberry Pi but the CPU (BCM2835) of all the models of Raspberry Pi remains same. The CPU is somewhat cheap, powerful and efficient and it does not consume a lot of power. It works in the same way as a standard PC requiring a keyboard for giving commands, a display unit and power supply.

Here, in Raspberry Pi, SD card is used in the same way as the hard disc in the computer. The connectivity of raspberry pi to the internet may be via a LAN (Local Area Network) cable / Ethernet or via a USB modem. The main advantage of Raspberry Pi is that it has a large number of applications. It also has 4 pole stereo output and composite video port. Video processing applications are also possible using raspberry pi like video compression.

Compressed video can successfully decrease the bandwidth required to transmit the video through terrestrial broadcast, cable TV, or satellite TV services [19]. The Raspberry-Pi runs on Linux based OS, an open source operating system. In this system we used Raspbian OS which is Linux based OS. The programming language for the Raspberry-Pi for the system implementation is Python.

3.3.1 Hardware

The Raspberry Pi hardware has evolved through several versions that feature variations in memory capacity and peripheral-device support.

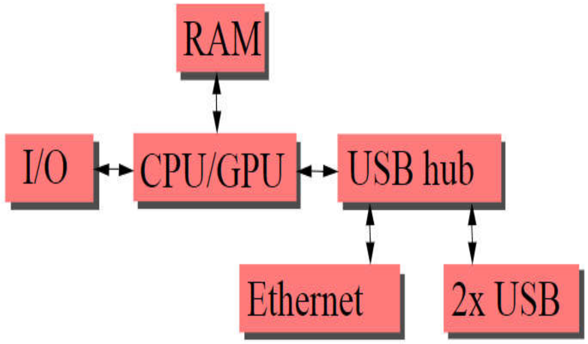

Fig 4. Raspberrypi block function

This block diagram depicts Models A, B, A+, and B+. Model A, A+, and the Pi Zero lack the Ethernet and USB hub components. The Ethernet adapter is internally connected to an additional USB port. In Model A, A+, and the Pi Zero, the USB port is connected directly to the system on a chip (SoC). On the Pi 1 Model B+ and later models the USB/Ethernet chip contains a five-point USB hub, of which four ports are available, while the Pi 1 Model B only provides two. On the Pi Zero, the USB port is also connected directly to the SoC, but it uses a micro USB (OTG) port.

3.3.1.1 Processor

The Raspberry Pi 2 uses a 32-bit 900 MHz quad-core ARM Cortex-A7 processor. The Broadcom BCM2835 SoC used in the first generation Raspberry Pi is somewhat equivalent to the chip used in first modern generation smartphones

(its CPU is an older ARMv6 architecture),[22] which includes a 700 MHz ARM1176JZF-S processor, VideoCore IV graphics processing unit (GPU),[23] and RAM. It has a level 1 (L1) cache of 16 KB and a level 2 (L2) cache of 128 KB. The level 2 cache is used primarily by the GPU. The SoC is stacked underneath the RAM chip, so only its edge is visible.The earlier models of Raspberry Pi 2 use a Broadcom BCM2836 SoC with a 900 MHz 32-bit quad-core ARM Cortex-A7 processor, with 256 KB shared L2 cache.[24] The Raspberry Pi 2 V1.2 was upgraded to a Broadcom BCM2837 SoC with a 1.2 GHz 64-bit quad-core ARM Cortex-A53 processor,[25] the same SoC which is used on the Raspberry Pi 3. The Raspberry Pi 3 uses a Broadcom BCM2837 SoC with a 1.2 GHz 64-bit quad-core ARM Cortex-A53 processor, with 512 KB shared L2 cache.[26]

Fig 5 The Model B boards incorporate four USB ports for connecting peripherals.

3.4 Arduino

The Mega 2560 is a microcontroller board based on the ATmega2560. It has 54 digital input/output pins (of which 15 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. The Mega 2560 board is compatible with most shields designed for the Uno and the former boards Duemilanove or Diecimila. Arduino Mega, etc. I used Arduino Uno in this development. Arduino is based on ATmega328. The package contains a 16 MHz ceramic resonator, a USB connection, a power jack and ICSP header and a reset button. Instead of using the FTDI USB-to-serial driver chip our Arduino features the Atmega16U2 chip programmed as a USB-to-serial converter.

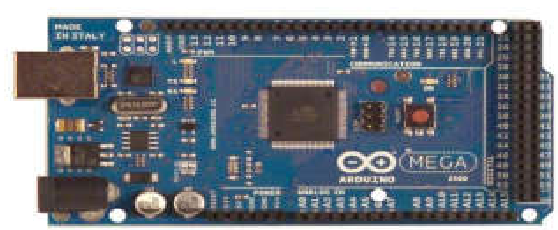

FIG: 6.Arduino Mega

3.5 XBee Module

Zigbee is a high-level communication protocols used to create wireless networks. Transmission distances to 10–100 meters depending on power output and environmental characteristics, ZigBee devices can transmit data over long distances by passing data through a mesh network topology. The Zigbee transmission data rate is 250 Kbit/s [6]. Zigbee is an established set of specifications for wireless personal area networking (WPAN), i.e. digital radio connections between computers and related devices. For the wireless communication between sensor nodes and the gateway node ZigBee RF modules were used. All the ZigBee devices are based on ZigBee standard which has adopted IEEE 802.15.4 for its physical layer and MAC protocols. The wireless devices based on this standard operate in 868 MHz, 915 MHz and 2.4 GHz frequency bands having a maximum data rate 250Kbps. ZigBee protocol layers are based on OSI model. When the pan is to use ZigBee, it is necessary to mention IEEE 802.15.4 standard. One of the finest characteristics about this standard is it allows user to use PHY and MAC layer defined by IEEE 802.15.4 and lets user to define the upper layers of the OSI model. Similarly, ZigBee also use the MAC and PHY layer of IEEE 802.15.14 standard.

FIG: 7.XBee Module

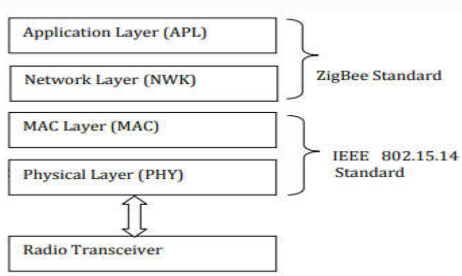

FIG:8. ZigBee Protocol Stack

3.6. POWER SUPPLY:

The power supplies are designed to convert high voltage AC mains electricity to a suitable low voltage supply for electronic circuits and other devices. A power supply can by broken down into a series of blocks, each of which performs a particular function. A d.c power supply which maintains the output voltage constant irrespective of a.c mains fluctuations or load variations is known as "Regulated D.C Power Supply".

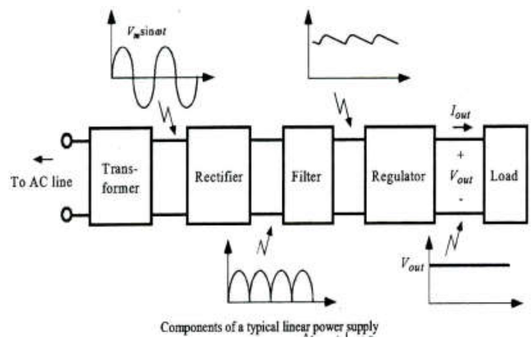

Fig:9. Block Diagram of Power Supply

IV. PROJECT DESCRIPTION

This chapter deals with working and circuits of "**ENVIRONMENTAL MONITORING SYSTEMS USING IOT AND RASPBERRY PI**". It can be simply understood by its block diagram &circuit diagram.

4.1. BLOCK DIAGRAM:

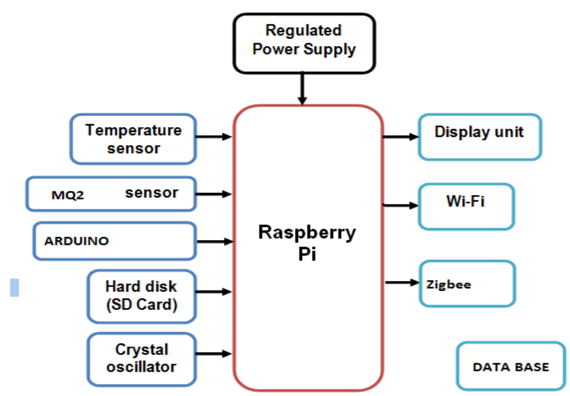

Fig 10: block diagram

4.2. SOFTWARE REQUIREMENTS:

- MATLAB
- Flash Magic
-

4.3. HARDWARE REQUIREMENTS:

- Power supply
- PI
- LM35
- LCD
- SD CARD
- MQ2

4.4. WORKING:

FLOW CHART:

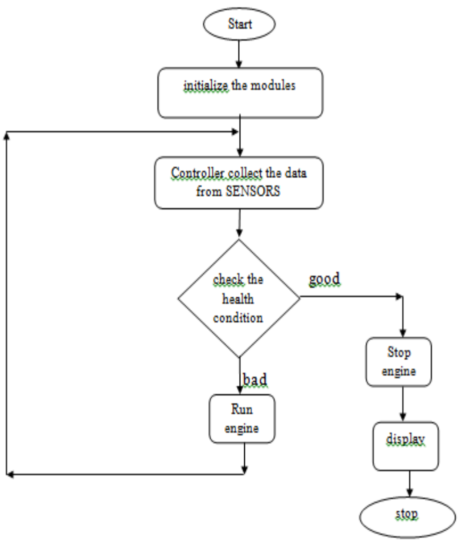

Fig 11. Flow chart

XBee module is configured as coordinator on the raspberry pi. Raspberry pi can be connected to XBee module directly through USB cable and by UART serial communication interface [3]. The base station also acts as a gateway in this application. The data collected or detected by sensor node sends to the base station and inserts the data received from sensor nodes into database of raspberry pi. Raspberry pi acts as a base station which connects to sensor nodes by zigbee communication protocol and clients by external network (internet etc.). Python is a widely used general-purpose, high-level programming language, its syntax allows programmers to express concepts in fewer lines of code than would be possible in languages such as C++ or Java. For wireless communication and multi-hop networking protocol, we used XBee series module S2 from Digi international. Multiple users can access the raspberry pi through Ethernet or Wi-Fi connection within local area network or from anywhere on the internet [11].

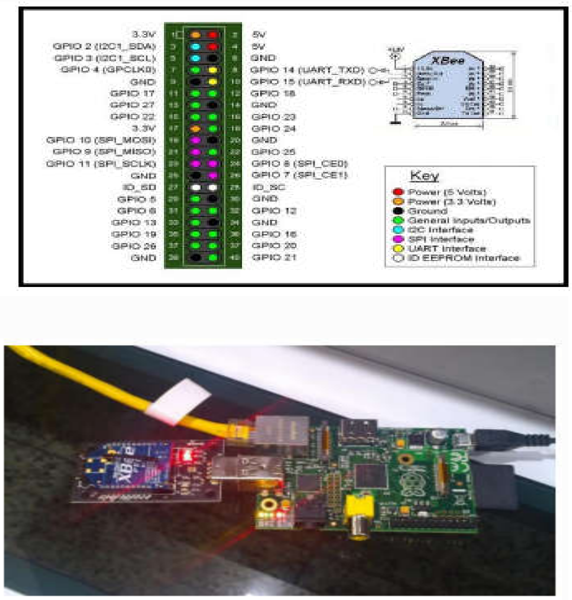

Fig: 12.Interfacing between raspberry pi

V. RESULTS

In wireless sensor network, there are three types of devices: coordinator, router and end tags shows in figure 8. Open source data platform for the Internet of Things provides access to a broad range of embedded devices and web services. So, here one XBee is configured as a coordinator, which is connected with the raspberry pi using UART protocol shows in figure 9,10. Here sensor node is configured as router (R1and R2) and end tag(E52), it will send its real-time data to the nearest router. There is only one coordinator in the network, which communicates with the base station (raspberry pi).

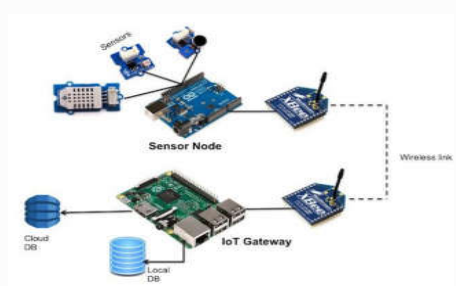

Fig:13. Overall system design

Step1: In WSN system the sensor node sense the data from the sensor. Step2: Sense data receives the end tags and end tag search the nearest router. Step3: If router it in range than end tag sends the data to the router. Step4: router to coordinator and coordinator directly communicate with base station Step5: In base station stored the all data, the client can visit directly to the base station. Step6: Base station sends all data to the cloud or Ethernet (Database server) shows in figure 11, end Users or clients can interact with the web application within the local area network. Step7: In wireless sensor network, there are three types of devices, each device sending and receiving data display on the screen.

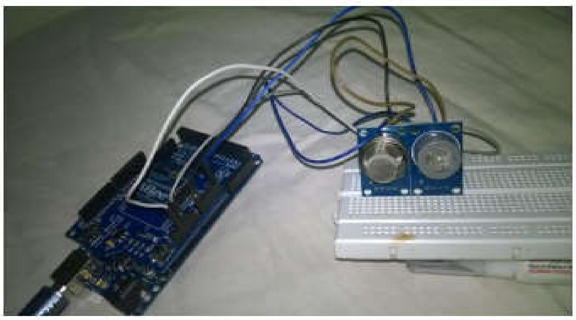

Fig:14. Interfacing sensors with arduino

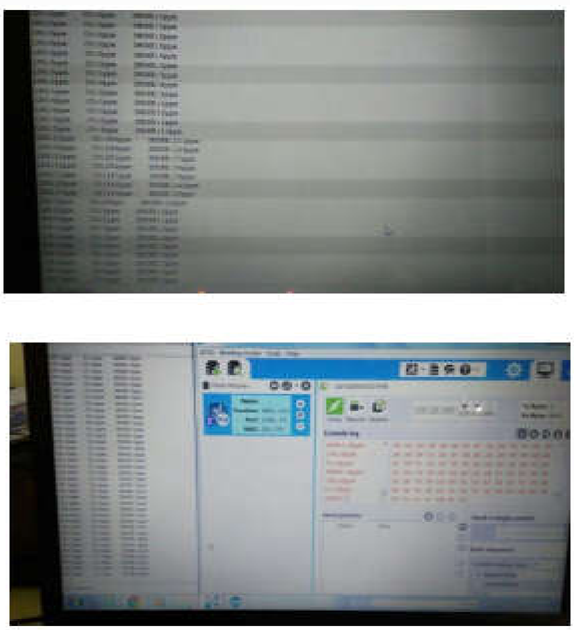

Fig:15. Received output

VI. CONCLUSION

Comparing with collection and forwarding information or data of traditional base station (gateway), this system has low-cost, low power consumption, and easy to maintain. This paper designs a wireless sensor network system using Raspberry Pi as a base station, XBee as a networking protocol, sensor node as combination of sensors, controller and zigbee. Hence, we can create sensor-logging application, location-tracking applications, and a social network of things with status updates, so that you could have your location parameter control itself based on your current location. One major advantage of the system lies in the integration of the gateway node of wireless sensor network, database server, and web server into one single compact, low-power, creditcard-sized computer Raspberry Pi, which can be easily configured to run without monitor, keyboard, and mouse. Such a system is very useful in many environmental monitoring and data collection

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