RASPBERRY PI BASED REAL TIME ENVIRONMENT MONITORING SYSTEM

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ABSTRACT

Environment monitoring is becoming crucial with the severity of potential climate changes, environmental impact on health, supply chain of logistics in industries, surveillance and monitoring in agriculture and habitat monitoring. It is a domain where wireless sensor networks can have great impact. Conventional Data acquisition systems embed sensing & communication techniques which are unreliable, expensive or not easy to use. This paper describes a low cost, low power consuming, less complex, scalable & reliable wireless sensor network system. The designed system constitutes the several sensor nodes and the base station connected wirelessly via ZigBee, which will construct an effective and feasible hardware platform to complete the real-time monitoring of the environment. In addition, by adopting the C/S (Client/Server) architecture, users are able to grasp the current monitoring information at any time through a simple GUI. The realization of such real time environment monitoring system improve the system performance, provide a convenient and efficient method and can also fulfil functional requirements.

Keywords*: wireless sensor network; raspberry pi; environment monitoring;*

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1. INTRODUCTION

Environmental monitoring can be defined as the systematic sampling of air, water, soil, and biota in order to observe and study the environment, as well as to derive knowledge from this process. The derived knowledge can be used in plenty of applications such as air quality monitoring, water monitoring, habitat monitoring, monitoring of ware houses, cooling chains in logistics, server surveillance room, optimizing environment conditions in green houses etc. Formal Data Acquisition System includes analog data sensors which are reliable but expensive. Switching to digital signals reduce wiring by approximately 30% which in turn reduces cost. Digital sensors come with the ease to plug and unplug instantly from the system without affecting other components. Also the data transmission techniques used in conventional systems were either wired, radio, GPRS/GSM or optical media. Cable links or optical media increase the cost of the system abruptly whereas RF techniques such as Bluetooth, GSM are more power consuming and allows less number of nodes that can be connected.

1.1 WIRELESS SENSOR NETWORK

The WSN consists of low cost, low power consuming, wireless sensor nodes embedded into physical environment. A WSN is characterized as self- organizing, multi-hop communication, centralized data gathering and many-to-one traffic network. This means that sensor network protocols and algorithms used are capable of self-organization and also each node acts as router to another node hence able to cover large range. Fig. 1 shows a typical WSN.

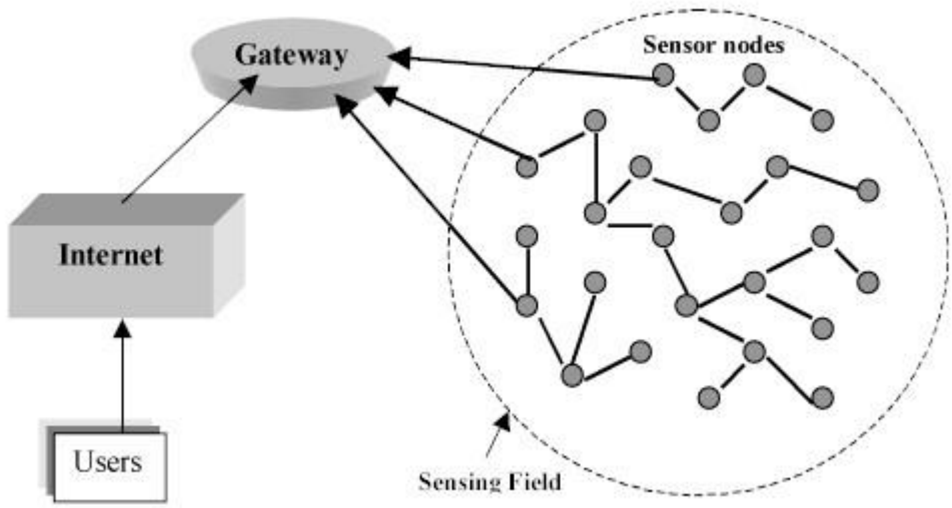

FIG 1: A TYPICAL WSN

2. SYSTEM ARCHITECTURE

The prototype proposed here comprises of three constituents, namely:

1) Sensor Nodes
2) The base station
3) The End User

Figure 2 shows the overall architecture of the system. The Sensor Network comprises of numerous spatially distributed sensor nodes. The Base station is a Raspberry Pi which manages all the nodes. The data acquired by the nodes is transferred in real time to the End User. The system composed of sensor board design, communication protocols & application software is capable of sensing, transmitting & displaying environment data.

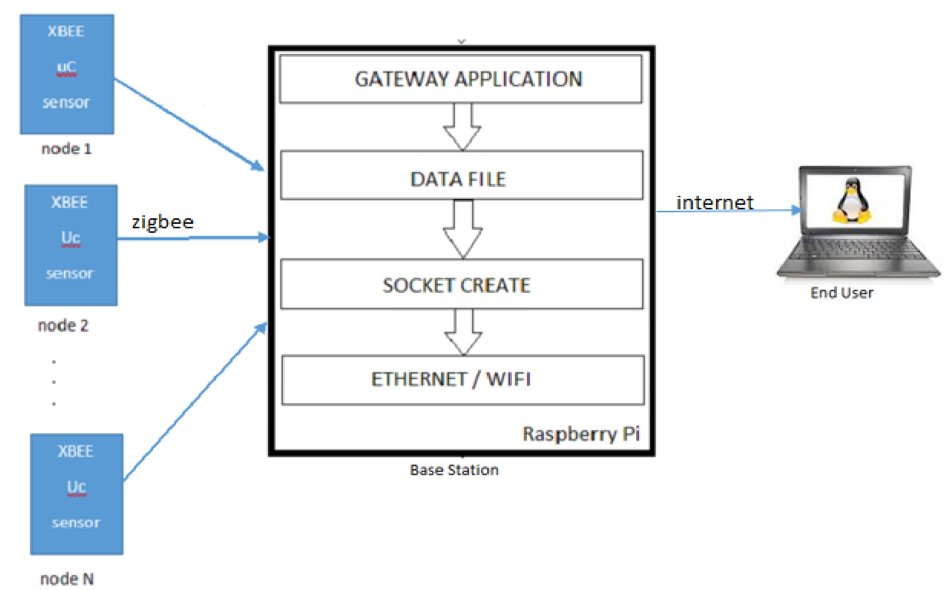

FIG 2: PROPOSED SYSTEM ARCHITECTURE

2.1 SENSOR NODE

Each sensor node is a combination of sensors, microcontroller (uC), and a ZigBee radio transceiver, i.e., the

XBee module. In addition, there is a user application program on each sensor node, which handles sampling data from sensors in a certain well defined manner and communication with the base station. Multiple sensor nodes combine to form the sensor field. The sensor node has four hardware subsystems: Power Unit, Sensing Unit, Processing Unit & transmission unit

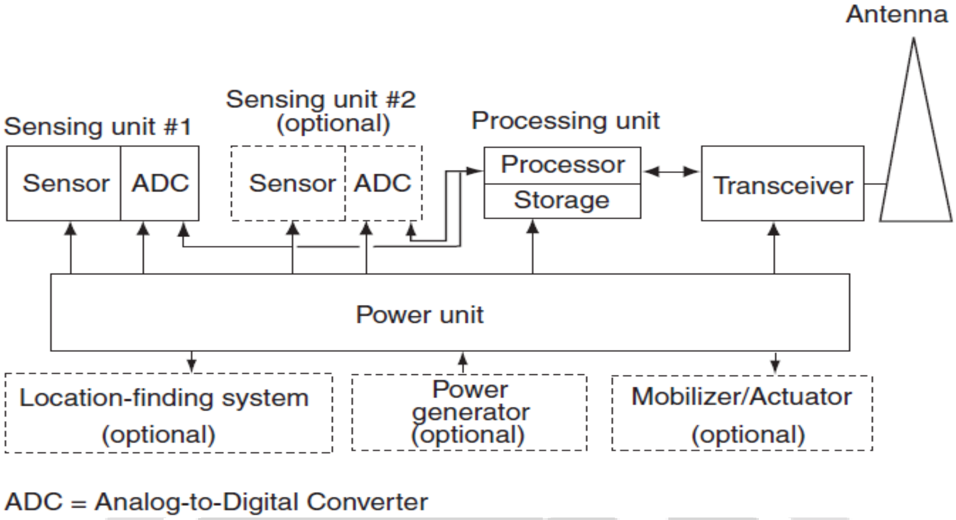

FIG 3: SENSOR NODE ARCHITECTURE

- The Power unit is responsible for appropriate energy supply & distribution necessary to support operation for required time period depending upon the application.
- Sensing Unit provides interface between the environment & the system through sensors. Some typically used sensors include temperature, humidity, pressure, light etc.
- The Processing Unit handles on board data processing, short-term storage, encryption, digital modulation & digital transmission
- The Transmission unit allows the system to communicate in point-to-point or multi-point-to-point arrangement. Protocols are developed keeping in mind the Transmission range, routing and transmission impairment.

1.2 THE BASE STATION

The base station is the gateway and is responsible for collecting data from different nodes and transmitting this at pre-defined period of time. This data is generally not sensitive hence infrequent packet losses or deadline miss are admissible.

1.3 END USERS

Accessing the acquired data through networks such as the internet requires an application layer management protocol. One such protocol is Sensor Management Protocol (SMP). This protocol allows the System administrator to interact with the sensor network through network such as the Internet.

3. DESIGN AND IMPLEMENTATION

On board monitoring systems face certain issues such as high power consumption, limited range, high deployment and operational cost etc. So our design goals are to achieve reliable, adaptable, scalable, easy to use, energy efficient system at low cost. The Monitoring system hereby depicted contains sensor nodes connected together wirelessly, transfer temperature, humidity & pressure sensor data using ZigBee protocol. The base station has a Gateway Application which collects data from all the nodes and transmits it to local server this data can be accessed at the client request through a Graphical User Interface.

3.1 HARDWARE

3.1.1 Microcontroller (Arduino Uno): The Arduino Uno board acts as the main control chip for each node. Arduino is an open-source electronics prototyping platform based on flexible, easy-to-use hardware and software. This chip is based on ATmega328P (by Atmel)which is an 8-bit Advanced

RISC Architecture with 32KB In System Self-Programmable Flash, 1KB EEPROM, 2KB SRAM. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. The Uno board can be powered via the USB connection or with an external power supply. The power source is selected automatically and can be programmed with the Arduino Software (IDE).

3.1.2 Sensors: To interface with the physical world we need sensors. Following are the sensors used in this system:

3.1.2.1 DHT22 (AM2302): Digital temperature & humidity sensor DHT22 is cheap, low power consuming easy to use. It is a four-wired sensor which uses a capacitive humidity sensor and a thermistor to measure the surrounding air, and spits out a digital signal on the data pin (no analog input pins needed).

3.1.2.2 Vegetronix VH400: Soil Moisture Sensor. For monitoring water status dielectric probes are used. These probes operate at 80 MHz and require a power supply with a voltage between 3.3 and 20 V DC. They provide a voltage reading between 0 and 3 V as a function of the water content of the medium surrounding the sensor with an average consumption of less than 7 mA. Other than the ease, the tests offer a few favorable circumstances: sensors are insensitive to water salinity, being small and rugged the probe does not corrode over time as conductivity-based probes usually do. Communication with the system is analog and occurs through the analog to digital converter at 10-bit resolution, which is included in the Arduino Uno board and converts voltage measurements in the range 0–1023 V. When a voltage of 5 V is provided to the probes, a resolution of about 0.005 V (5/1023) is obtained.

3.1.3 Transceivers (XBee S1 Module): This radio module runs on IEEE 802.15.4 ZigBee standard which is a specification for a suite of high-level communication protocols used to create wireless networks built from small, low-power digital radios. And support the unique needs of low-cost, low-power wireless sensor networks. It is a simple, efficient, reliable, and low cost, low-power standard of wireless technology.It provides Long Range Data Integrity Indoor/Urban: up to 100ft (30 m), Outdoor line-of-sight: up to 300ft (90 m). ZigBee devices can transmit data over long distances by passing data through a mesh network of intermediate devices to reach more distant ones. ZigBee is typically used in low data rate applications that require long battery life and secure networking (ZigBee networks are secured by 128 bit symmetric encryption keys.) ZigBee has a defined rate of 250 Kbit/s, best suited for intermittent data transmissions from a sensor or input device. Here we used XBee series module S2 from Digi international which fully implement ZigBee protocol. XBee series S2 module also covers more area than XBee S1 module.

3.1.4 Raspberry Pi: The raspberry pi is a low cost, low power credit card size single board computer which has recently become very popular [4] [5]. The raspberry pi is the cheapest ARM11 powered Linux operating system capable single board computer board. This board runs @700MHz and comes with a 512 MB of RAM memory. In this paper, raspberry pi B+ model [5] is used as this model has better specifications as compared to other raspberry pi models. It supports a number of operating systems including a Debian-based Linux distro, Raspbian which is recommended by raspberry pi foundation, which is used in our design [4] [5]. Raspberry Pi can be connected to a local area network through Ethernet cable or USB Wi-Fi adapter, and then it can be accessed by more than one client from anywhere in the world through SSH remote login or by putty software by just putting raspberry pi ip address in it. The raspberry pi is booted by external SD or micro SD card.

3.2 SOFTWARE

In this paper we used open source raspberry pi embedded Linux board which works on open source Linux operating platforms [4] [5]. And for Arduino we used Arduino Integrated Development Environment - or Arduino Software (IDE). The Arduino integrated development environment (IDE), is a cross-platform application written in Java. Arduino IDE supports the C and C++ programming languages using special rules of code organization. For the End User application QT application framework is used QT is a cross-platform application framework that is widely used for developing application software that can be run on various software and hardware platforms with little or no change in the underlying codebase, while still being a native application with the capabilities and speed thereof.

4. EXPERIMENTAL SETUP

For actualizing the above configuration we have made two sensor hubs. Every hub includes a microcontroller Arduino Uno, interfaced with the multi-sensors: DHT22, Vegetronix VH400 and the XBee S1 (Digi International, Eden Prairie, MN) through its serial port. The microcontroller controls the radio modem and procedures data from the temperature sensor DHT22 and soil moisture sensor. These parts are powered by rechargeable AA 2000-mAh Ni-MH Cycle Energy batteries (SONY, Australia). These parts were chosen to minimize the power utilization for the proposed framework. Figure 4 is the image of setup.

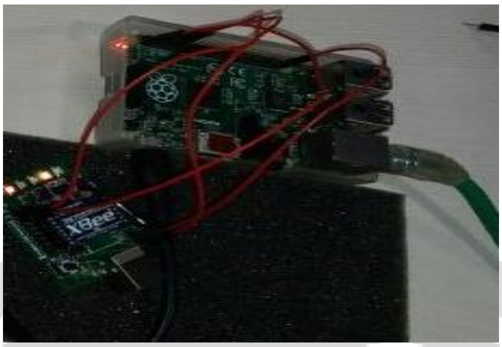

FIG 4: SETUP OF THE BASE STATION

The microcontroller was programmed in GCC compiler for monitoring the temperature probe through an analog-to-digital port and the humidity probe through another digital port, implemented in 1-Wire communication protocol. A battery voltage monitor is coupled to an analog-to-digital port. The data are packed with the respective identifier, date, and time to be transmitted by means of XBee radio modem utilizing using a RS-232 protocol through the digital ports transmitter (TX) and receiver (RX). In order to keep the power consumption low, the microcontroller is set in sleep mode for certain period, after sending data. When the sensor node is launched for first time, the system inquires the base station the date and time. First task of the base station is to set date & time through ntp server; ntpdate will run when an Ethernet interface is brought up, and time is set. The base station is now ready to transmit via XBee the date and time for each sensor node once powered. Then, the microcontroller receives the information package transmitted by each sensor node that conform the WSN.

The base station that first identifies the least significant byte of a unique 64-bit address encapsulated in the package received. Second, the soil moisture and temperature data are recorded.
The sensor ID, the date and time. When the server receives a request for the web page, it inserts each data to the data file. Graphical user interface software was developed for real time monitoring of agriculture field based on soil moisture and temperature data. The software application permits the user to visualize graphically the data from each sensor node online using any device with Internet. The application for monitoring and programming was designed in QT application creator.

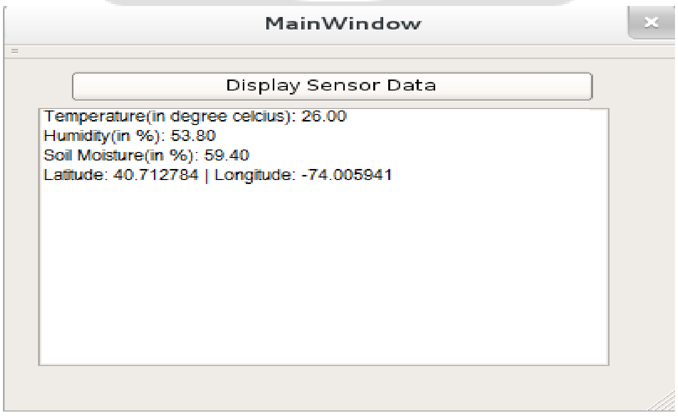

FIG 5: SCREENSHOT OF QT APPLICATION RUNNING ON LINUX MACHINE

5. CONCLUSION AND FUTURE WORK

This paper designs a remote sensor system framework employing sensor node, Raspberry Pi as a base station, XBee as a systems administration convention, and various open-source programming software. Contrasting and gathering and sending data or information of conventional base station (portal), this framework has ease, low power utilization, conservative, adaptable, simple to convey, and simple to keep up. One noteworthy point of interest of the framework lies in the reconciliation of the gateway node of remote sensor system, database server, and web server into one single reduced, low-control, Raspberry Pi, which can be effortlessly arranged to keep running without screen, console, and mouse. Also, this framework permits us to utilize it with actualized sensor systems utilizing distinctive equipment stages. Such a framework is exceptionally valuable in numerous natural checking and information gathering.

6. REFERENCES

1. Sudhir G. Nikhade, "Wireless Sensor Network System using Raspberry Pi and Zigbee for Environmental Monitoring Applications", International Conference on Smart Technologies and Management for Computing, Communication, Controls, Energy and Materials (ICSTM), 2015, pp.376-381
2. Jin-Shyan Lee, Yu-Wei Su, and Chung-Chou Shen "A Comparative Study of Wireless Protocols: Bluetooth, UWB, ZigBee, and Wi-Fi" The 33rd Annual Conference of the IEEE Industrial Electronics Society (IECON) Nov. 5-8, 2007, Taipei, Taiwan
3. LIU Yong-Min, WU Shu-Ci , NIAN Xiao-Hong , "The Architecture and Characteristics of Wireless Sensor network" International Conference on Computer Technology and Development, 2009.
4. G.Werner-Allen, P. Swieskowski, and M.Welsh. "MoteLab: A wireless sensor network testbed" Fourth International Symposium on Information Processing in Sensor Networks, pp. 483-488, Boise, ID, USA, April 2005,
5. Akyildiz, I., Su, W., Sankarasubramaniam, Y., Cayirci, E., "A Survey on Sensor Networks",IEEECommunications Magazine, Aug. 2002,pp. 102- 109.
6. Sheikh Ferdoush, Xinrong Li "Wireless Sensor Network System Design using Raspberry Pi and Arduino for Environmental Monitoring Applications",The 9th International Conference on Future Networks and Communications
7. Byungrak Son, Yong-Sork Her, Kyuwon Shim, and Jung-Gyu Kim "Development of an Automatic People-Counting and Environment Monitoring System Based on Wireless Sensor Network in Real Time; To realize in Korea Mountains" International Conference on Multimedia and Ubiquitous Engineering IEEE.
8. RaspberryPi,webpage:http://en.wikipedia.org/ wiki/Raspberry_Pi [Sept20, 2015]
9. ZigBee Specification. ZigBee Alliance 2006.http:// www.zigbee.org/.
10. IEEE 802.15 WPAN Task Group 4 (TG4), available at http://www.ieee802.org/15/pub/TG4.html
11. https://www.mems-exchange.org/MEMS/challenges.html