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Design of Weather Monitoring System using Raspberry Pi and Arduino

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Abstract: In this paper, we designed and deployed a Weather Monitoring System (WMS). This system continuously monitors the weather status and updated in public cloud. This data can be used in various safety measure applications. This system concentrated particularly temperature and the carbon monoxide gas. Our WMS system contains two sensor nodes and one server node. In WMS, two nodes consist of temperature sensor and CO gas sensor, arduino microcontroller and zigbee communication modules and one server contains raspberry pi module to update the data on cloud. These sensor nodes deployed in locations where human interaction or maintenance is difficult and continuously measures the environmental temperature and CO level and same is packed and transmitted every 15 minutes to server through multi-hop manner. The environment data was measured and converted into the electrical signals by the sensors. This analog data is converted into the digital ADC in microcontroller, packed and transmitted to second node like multi-hop communication. Intermediate testing or step wise testing also verified using LCDs. this system was deployed and tested in thinkspeak cloud. We are able to access the cloud data through mobile phone or web from anywhere in the world.

Keywords: Raspberry Pi, ZIGBEE, Arduino UNO Board, Wi-Fi Module, and LCD.

I. INTRODUCTION

Wireless sensor network technology is a good solution to many innovative applications. Early works on sensor networks and cyber physical systems have been focused on the development of enabling technologies by addressing a myriad of technical challenges are multi hop routing, middleware and operating systems (OS), and abstractions and sharing of data. We have show a new wave of developments in open-source hardware/software, standardization, and of wireless sensor network technologies [5]. The zigbee standard specifies the physical and medium access control layers for low data-rate wireless personal area networks. ZigBee [6] is a low-cost, low-power, wireless mesh networking standard built upon 802.15.410. The 802.15.4 RF transceivers and ZigBee protocol stacks are now available as commercial-off-the-shelf (COTS) modules for rapid prototyping of and actuation systems [2]. The Digi XBee series OEM modules implementing the IEEE 802.15.4 radio and ZigBee networking protocol 11 and have become very popular in application system development. Sensor network systems, like most embedded systems, needs to be tightly coupled to their applications. However, the recent advances have helped to reduce the complexity of implementing wireless sensing and actuation systems and have made it fairly easy to implement a prototype system for demonstration purposes.

In this paper, we present a wireless sensor network system developed using open-source hardware platforms, Arduino [3] and Raspberry Pi [4], and the ZigBee module [8] . This design has the advantages of low cost, easy to build, and easy to maintain, as compared to some earlier designs. The major disadvantages for sensor network technology to become a transformational force in engineering, scientific, and commercial application domains of in its lack of reliability, flexibility, scalability, interoperability, and in its extreme difficulties in long-term deployment, operation, and maintenance. This paper overcomes the some challenges regarding the challenges. In this paper we are implementing the sensor network along with Wi-Fi module [1] to update the data into the thingspeak server [9]. Software implementation has been done in arduino compiler for node's side implementation [10]. For base station side we have to implement code in python language and interface the modules using connecting wires [11]. The organization of this paper is as . Section 2 reviews literature survey about WSN for Environmental applications. Section 3 describes our proposed-system architecture. Section 4 shows software implementation of this application. Section 5 shows the results and the last conclusion was elaborated in Section 6.

II. LITERATURE SURVEY

Most of the surveys are limited hardware level only that means result are display on local machine or device. Their experiment to and have a crucial worth within the contribution of the entire paper. It additionally provides some basic information or theoretical base and is employed as a foundation to with success deliver the goods the most objectives. Most of the literatures are from the connected articles, journals, books and former works of identical fields. These literatures then compiled and use as a steerage to the work of this paper.

A. Existing System

In the earlier days, the sensors' data from the remote areas were collected and those data was sent over to the

ZIGBEE communication module to the base station, but if you want to monitor the sensor data from anywhere, there is no chance to overcome this problem, in our proposed system, we are sending those sensor data to the web server, which can access from anywhere.

1. Wireless Sensor Network System Design using RaspberryPi and Arduino for Environmental Monitoring Applications

With over a decade of intensive research and development, wireless sensor network technology has been emerging as a viable solution to many innovative applications. In this paper, we describe a wireless sensor network system that we have developed using open-source hardware platforms, Arduino and Raspberry Pi. The system is low-cost and highly scalable both in terms of the type of sensors and the number of sensor nodes, which makes it well suited for a wide variety of applications related to environmental monitoring. Overall system architecture and the design of hardware and software components are presented in details in this paper. Some sample deployment and measurement results are also presented to demonstrate the usefulness of the system.

2. Design of Environmental Monitoring Applications System Using Temperature Sensor And Zigbee

Wireless sensor network technology has been emerging as a violable solution to many innovative applications like industry, science, transport, civil industry, agriculture and security. A wireless sensor network system that is developed using open source hardware platform called Raspberry pi. The system is low cost and highly scalable both in terms of type of sensors and number of sensor node, which makes it well suited for a wide variety of applications related to environmental monitoring. The design of ZigBee Protocol is investigated using XBee module to establish WSN.

3. IOT and Raspberry PI Based Environmental Monitoring Application

This paper presents the wireless sensor network system and Internet of things (IOT), by using WSN it develops an open source hardware platform, raspberry pi (2B model),zigbee and sensors. It is low cost, low power consuming device and highly scalable in a type of sensors and the number of sensor nodes. Sensor node is a combination of sensor, controller and XBee module, which makes it well suited for a wide variety of applications related to environmental monitoring. The Internet of Things (IoT) is an emerging key technology for future industries.

- Easily configure devices to send data to ThingSpeak using popular IoT protocols are easily configure.
- We have to Visualize the sensor data in real-time environment.
- Aggregate our data from third-party sources.
- By use of MATLAB we can sense of our IoT data.
- Run your IoT automatically based on events and schedules.
- Prototype and build IoT systems without setting up servers or developing web software.

III. IMPLEMENTATION OF WMS

The major hardware modules used in WMS are described below:

A. Raspberry Pi

The Raspberry Pi could be a credit-card sized pc that plugs into your TV and a keyboard. It's a capable of very little pc which might be utilized in physical science comes, and for several of the items that your desktop computer will, like spreadsheets, word-processing and games. It additionally plays high-definition video. The Raspberry Pi is a Broadcom BCM2836 system on a chip (SoC), which has an ARM1176JZF-S 700 MHz processor, Video Core IV GPU, and was originally shipped with 256 megabytes of RAM, later upgraded (Model B & Model B+) to 512 MB. However it uses SD card for booting and protracted storage, with the Model B+ employing a Micro SD.

B. Zigbee Module

Zigbee is a low-cost, low-power 802.15.4 standard. The low cost allows the technology helpful in wireless control and monitoring applications, the low power-usage allows longer life with smaller batteries and the mesh networking provides high reliability and larger range. its has been for capable wireless networking between numerous low power devices.

C. Arduino Microcontroller

Arduino Uno is a microcontroller board based on the ATmega328P. 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. It contains everything needed to support the microcontroller; we can connect it to a computer with a USB cable.

1. Thingspeak: Is an IoT platform service that allows us to aggregate, visualizations of data posted by your devices to ThingSpeak. Also we execute MATLAB® code in ThingSpeak we can perform processing of the data and online analysis as it comes in. These are the capabilities of ThingSpeak include:

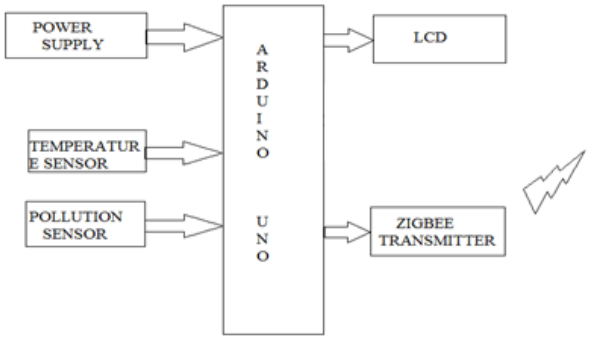
In this proposed System, we have a tendency to develop a new approach for environmental monitoring. In the proposed system, we are collecting the sensors' information from the different remote nodes and send those sensors' data to the base station via ZIGBEE communication protocol. At the base station side, we are using Raspberry Pi microprocessor, which will receive different remote area's sensor data and sent over the web server by using the internal Wi-Fi module. everyone can monitor those data by just login into the thingspeak account or by entering the URL in the browser. If the sensor value crosses the threshold limit, then the buzzer will give alert sound at remote station and the base station as well and the alert message will display at the both ends. The diagram of the planning is as shown in Fig.1. It consists of Raspberry pi processor,

Zigbee, Arduino controller. The temporary description of every unit is explained as follows.

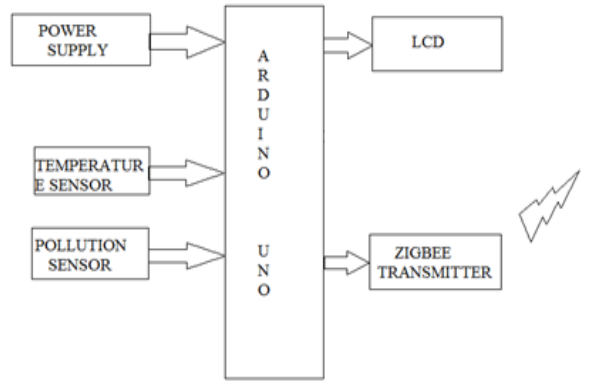
D. Block Diagram

1. Transmitter Side

- **Node 1**



Node 2:



Base station:

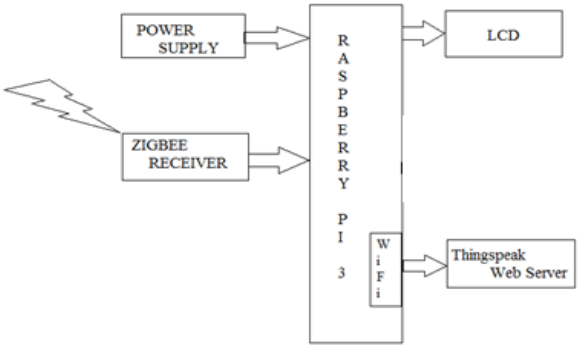


Fig.1. Functional Block Diagram of WMS

B. Function Implementation

The main aim of this paper is to send the sensor data from the remote node to the base station using wireless communication technology, ZIGBEE protocol. At the transmitter nodes, we have different sensors like temperature sensor and pollution sensor. These sensors will give us the analog output. The analog outputs are connected to the ADC channels of the Arduino UNO microcontroller. The microcontroller will send these sensors' information to the receiver side through the ZIGBEE wireless communication protocol. Here in this paper we are taking two nodes, each consists the same sensors. At the same time, the sensor information will also display on the LCD screen. The threshold values have been set to the sensors. If the sensor value crosses the set limit, then the buzzer will give alert sound. AT the base station side, we are using Raspberry Pi 3 board. The ZIGBEE receiver will receive the sensor data from the different nodes and sent those to the microcontroller through the UART port. The Raspberry Pi 3 board will receive those sensor nodes data and display those on the LCD screen. Here also if the sensor values cross the set limit, the buzzer will give you the sound alert. Here in this way we are collecting the different sensors data from different remote nodes using the ZIGBEE protocol. At the same time those different nodes sensor values are sent to the thingspeak free web server through Wi-Fi module. For this we should provide internet through Wi-Fi router or mobile hotspot to the internal Wi-Fi module. In the thingspeak web server, all the sensor values are displayed as in the form of graphs.

C. WMS Node Design

Here we designed two nodes for this application. First node is having temperature, gas sensor along with supply unit and communication module. Here the main aim is to send the sensor network data to the base station. Second node is also same as first node. The main functionality of designing of sensor node is to ability of multihop networking between the nodes

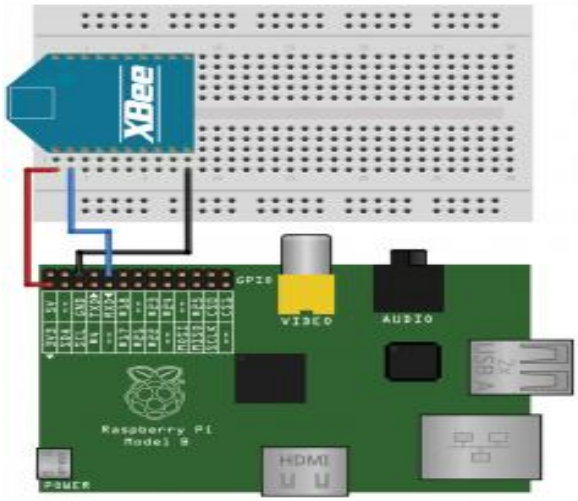


Fig.2. Interfacing Raspberry PI and Xbee Series

D. Hardware Interfacing

The two sensors like temperature sensor and gas sensors are connected with Arduino micro controller analog pins, temperature can be connect to A2 analog pin and gas sensor can be connected to A1 analog pin on the other side the zigbee transmitter pin connected to Arduino receiver pin and receiver pin connected to Arduino transmitter pin. zigbee and arduion pins vcc and the ground connected to PCB (printed circuit board),The data can be transimitted to base station based on the UART serial communication the mapping between Arduino and lcd: Digital pins D2,D3,D4,D5 are mapping with lcd DB4,DB5,DB6 And

DB7,LCD vcc and ground pin connected to Arduino vcc and ground. Digital pins D11 and D12 of Arduino is connected to LCD RS pin and enable pin. By this the interfacing of the components is over. after completing the designing of node,on the lcd welcome command displayed and it shows the temperature and gas values.

E. Software Interfacing:

In this phase we are using Arduino compiler to interface the code with the hardware at the node side. At the Base station side we are using Raspberry processor in python language. Let's now connect our Xbee to the RPI's GPIO. Note that on this schema, I only connected a wire from Xbee's DOUT to RPI's RXD as will only use it to receive data. However, you might also connect your Xbee's DIN to RPI's TX according to this RPI GPIO pin out. Your Raspberry PI should now receive it's first bytes via the Xbee; you can test this using Mini com (sudo aptitude install mini com, if not already installed).

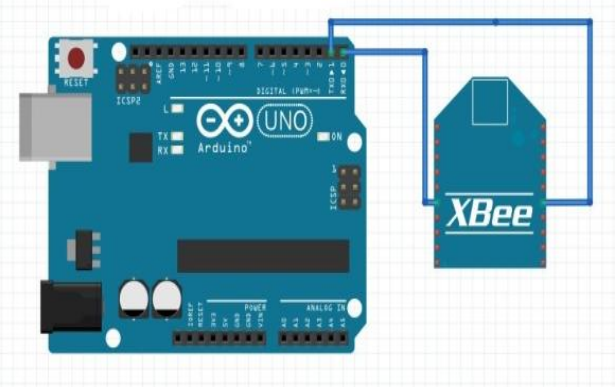


Fig.3. Zigbee Interfacing with Arduino

Figure above shows connection diagram of module with Arduino. Remember. Module should have regulated 5 volt and 3.3 volt. If you use Adafruit XBee Adapter it have both voltage level. Otherwise you have to use separate power supply. In above circuit. TX and RX pin of zigbee and Arduino are connected to each other. Arduino will send some instruction to zigbee and according to these instruction zigbee respond. Similarly zigbee receive instructions from other zigbee to which it have address. After receiving instructions or data from other zigbee. It send data to arduino through serial pins as shown in connection. Similarly other module can be connected with one more Arduino controller.

IV. SOFTWARE IMPLEMENTATION OF WEATHER MONITORING SYSTEM

A. Base Station Software Implementation

1. Python: Python was designed to be highly readable Python is a high-level, interpreted, interactive and object-oriented scripting language which uses English keywords frequently where as other languages use punctuation and it has fewer syntactical keywords than other languages.

- **Python is Interpreted:** and we do not need to compile our program before executing it this means that it is processed at runtime by the interpreter. This is similar to PERL and PHP.
- **Python is Interactive:** This means that we can actually sit at a Python prompt and interact with the interpreter directly to write our programs.
- **Python is Object-Oriented:** This means that Python supports Object-Oriented style or technique of programming that encapsulates code within objects.

B. Base Station Components Interfacing

In the raspberry pi we are already having the python source code in the sd card. Sensor nodes of node1 and node 2 data is received in the base station zigbee, The zigbee data is connected to the raspberry out pin pins. now the data is transferred using of the data cable with respect of the PCB to LCD. Simultaneously the zigbee vcc and ground pins are connected to PCB. By this interfacing is completed the data can be displayed on the LCD, When the power is on the zigbee antenna receives the data from the node1 and node2 and forward the data to raspberry pi using data cable after that the data is displayed on the screen

V. EXPERIMENTAL RESULTS

The implementation of realization of "Design of whether Monitoring Application using Raspberry Pi and Arduino" is done successfully based on multi hop communication. The communication is properly done without any interference between different modules in the design. Raspberry pi plays an important role in the paper as it is a platform. Proposed system output pictures are shown below.

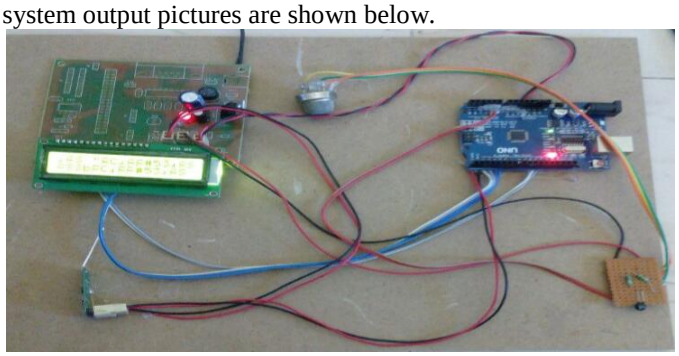


Fig.4. Transmitter at Node 1

Figure 4 and 5 shows the different sensors interfacing like temperature sensor and pollution sensor to the microcontroller. It will send these sensors' information to the receiver side through the ZIGBEE wireless communication protocol.

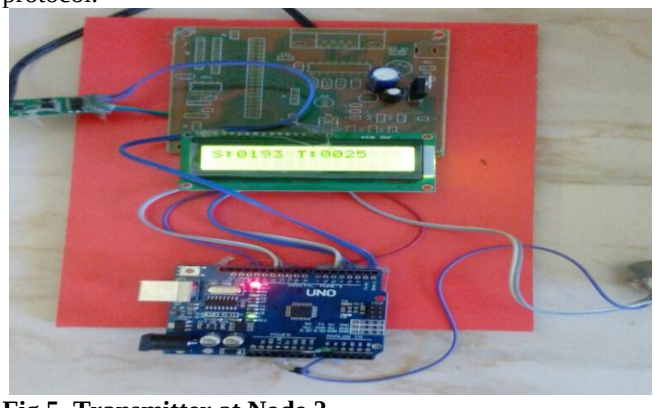


Fig.5. Transmitter at Node 2

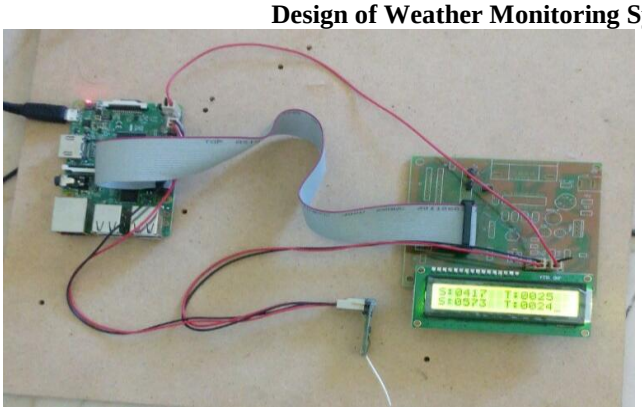


Fig.6. Base Station of WMS

At the base station side, we are using Raspberry Pi 3 board as shown in figure 6.

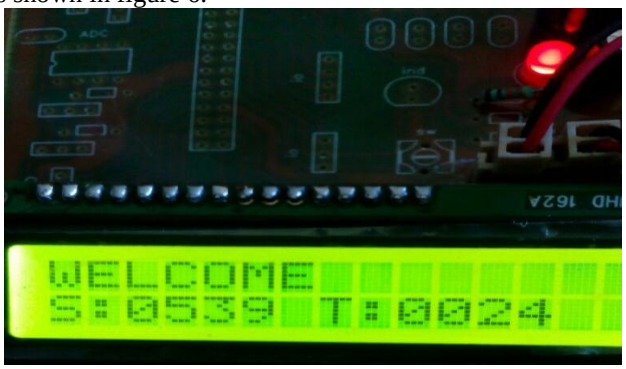


Fig.7. Node 1 Output Measured

Node 1 sensor data displayed on LCD as shown in figure 7.

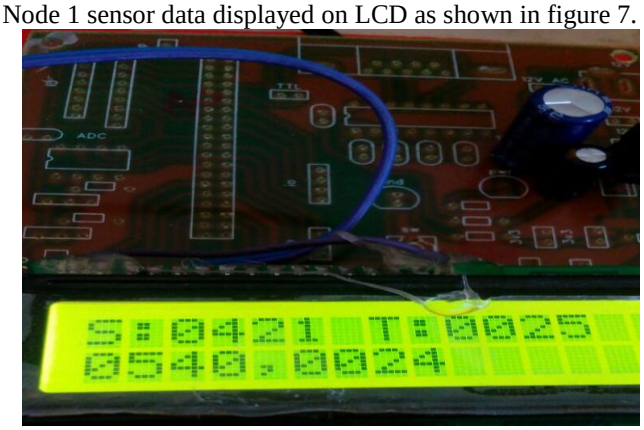


Fig.8. Node 1 and Node 2 Output

Node 2 sensor data displayed on LCD as shown in figure 8.

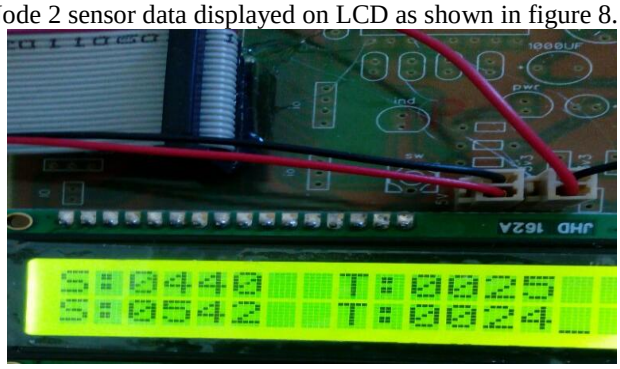


Fig.9. Result At Base Station

This figure shows the sensors data from node 1 and node 2 respectively.

Fig.10. Node 1 Temperature Graph in Cloud

This figure shows the daily Node 1 Temperature report in the thingspeak channel.

Fig.11. Node 1 CO Gas Graph in Cloud

This figure shows the Node 1 gas sensor report in the thingspeak channel.

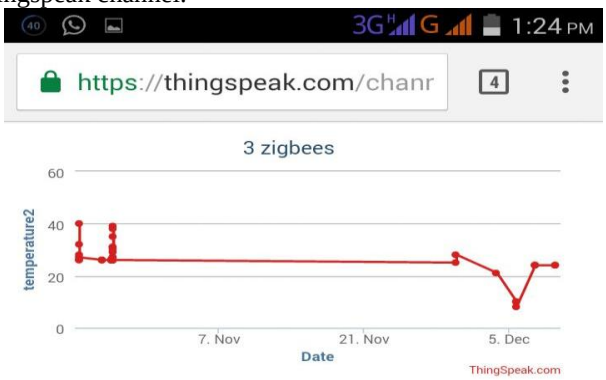


Fig.12. Node2 Temperature Graph in Cloud

This figure shows the Node 2 Temperature report in the thingspeak channel in cloud

Fig.13. Node 2 CO Gas Graph in Cloud

This figure shows the Node 2 gas sensor report in the thing speak channel.

VI. CONCLUSION & FUTURE SCOPE

As we have gone through the literature and reviewed most of the recent developments in environment monitoring. Although this paper designs a new 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. Comparing with collection and forwarding information or data of traditional base station (gateway), this system has low-cost, low power consumption, and easy to One major advantage of the system lies in the maintain. Integration of the gateway node of wireless sensor network, sensor network into one single compact, low-power, credit-card-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. In future, we can receive data from more number of remote stations with accurate and fast measurement and we can even add more sensors to the present proposed one.web interfaces can be developed to implement the new applications like data visualizing and data management

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