Environment Monitoring With Smart Sensing Technology

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Declaration

We, hereby declare that this thesis is based on results we have found ourselves.

Materials of work from researchers conducted by others are mentioned in references.

Signature of Supervisor **Signature of Authors**

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Abstract

Environment pollution is a major concern in current development of civilization and many works are underway in order to tackle this issue by the science community. A Wireless Sensor Network using smart sensors to monitor environmental condition is just one example. Efficient aggregation of data collected by sensors is crucial for a successful application of wireless sensor networks (WSNs) [13]. These smart sensor networks consist of various sensory devices, which collect data from our surrounding and transmit them via wireless channels. All the sensors and components in this network are called nodes. Nodes are devices which are low cost self-possessed by a microprocessor, memory, sensors, radio frequency and power source (battery/solar). In developed system, data is sent from the transmitter node to the receiver node [14]. There is a base station or mother node which is the receiver node responsible for receiving and processing data. This network can be implemented in any kind of environmental scenario. Our project is developed for different environments like forest, greenhouse and any other place where areas are needed to be monitored. At present Internet of Things (IOT) is an emerging technology and we used the concept of IOT in this project. In this project Remote device management and data access are made simple with web interfaces, information such as hourly and daily averages is automatically computed [15]. This paper reveals an idea of environmental monitoring system by implementing a Wireless Sensor Network using sensors and wireless communication.

Acknowledgement

We would like to express our gratitude to the Almighty who gave us the opportunity, determination, strength and intelligence to complete our work. A very big and humble thank you goes to our supervisor Dr. Amitabha Chakrabarty who has constantly believed in us and has been there for us through thick and thins of the thesis and continuously pushed us to complete our work in time. We are fortunate and grateful to be able to work under his supervision.

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Chapter 1

INTRODUCTION

One of the greatest problems that the world is facing today is environmental pollution. It consists of soil, water and air pollution .The heavy industry that has grown around the world and the diversity of chemicals along with contamination resulting from humans‟ daily life, released into the environment have raised serious concerns on the effects of such materials on the ecosystem and human health [16]. The environmental monitoring system becomes a smart monitoring system when the environment itself becomes a self-monitoring and self-protecting environment that is aware of its current status with the possibility of an automatic alarm rising if some event occurred. So smart environmental monitoring not only includes environmental pollution monitoring, but also controls the effect of environmental changes on humans, animals, and plants. Accordingly, for providing innovative environmental monitoring methodologies and procedures, wireless sensor networks (WSNs) and internet of things (IOT) are the key that enables more flexible real-time environmental monitoring, diagnostics, and finally protection of further serious degradations [17]. Via integrating wireless sensor devices in the environment itself, the level of environmental protection could be substantially raised, giving the environment a lot of new intelligent features. These features are primarily self-monitoring and self-protecting with the possibility of not only reactive, but also proactive, reactions for different phenomena taking place in this environment. Through utilizing the self-configuration ability of the sensor nodes, they can then form a network that can provide access to information anytime and anywhere by collecting, processing, analyzing, and disseminating data. Thus, WSN actively participates in creating a smart environment. Currently, via having WSNs as the backbone for smart environments, there is a great and enormous challenge in the hierarchy of detecting certain phenomena, monitoring and collecting relevant data, assessing and evaluating the resulting information, conveying meaningful user displays, and carrying out decision-making. This chapter discusses the concept of smart environmental monitoring along with presenting its different architectures, applications, and related design issues. Also, it highlights how smart environments embody the trend toward increasingly connected and automated environmental monitoring through linking wireless sensing devices to environmental phenomena and events. The sensing nodes with multi sensors will be placed anywhere and everywhere within the desired coverage area. All the sensors then take data and send it simultaneously to the parent nodes which is a key feature of a dynamic wireless sensing network. It consists of features like analyzing of data before going to the server, Dynamic charge of another sub node when mother node fails, intercommunication between devices, compilation of data and probable solution to problems. Furthermore, the paper provides insights on the techniques and features researchers and system designers should consider for successful deployments and operation of real smart environmental monitoring systems.

1.1Objective

Wireless sensor networks (WSNs) enable new applications and require non-conventional paradigms for protocol design due to several constraints. Owing to the requirement for low device complexity together with low energy consumption (i.e. long network lifetime), a proper balance between communication and signal/data processing capabilities must be found [19].

The objective of this project is to build a system that monitors a specified area which in our case is a forest. The whole system is a low cost and self-powered device, which will upload the data collected from different nodes to a website. This makes our system more reliable as if one of the nodes is not working properly or been damaged somehow than the other one will begin to function or activate dynamically. Wireless communications are used to collect data and to communicate between the centralized control center and the actuators located at different locations within a specified area.

After getting those data from sensors gathering the data. Data collection is the process of gathering and measuring information on targeted variables in an established systematic fashion, which then enables one to answer relevant questions and evaluate outcomes. Data transmission, digital transmission or digital communications is the transfer of data over point to point or point to multipoint communication channel [20]. So here data passing from sensor to sensors and sensors data are received by sensor nodes.

Another point is data processing that means collection and manipulation of items of data to produce meaningful information and the data sending by sensors are meaningful that means we can assume any situation regarding sensor values. But we still need to remember that an essential aspect of creating the Industrial Internet of Things (IOT) is the growing prevalence of cheaper, more advanced sensors that can be installed easily through wireless connections to gather even more of that increasingly useful data. Besides from the data we can analysis it and predict a condition on that values.

Moreover, it is easy to relocate the measure points when needed just by moving sensors nodes from one location to another within a communication range of the coordinator device.

1.2 Motivation

Our main motivation throughout this thesis was to have a contribution in the emerging sector of Internet of Things (IoT). We wanted to implement a solution by thinking a few years ahead of us about the rising of technology and the increasingly amount of data that is to be processed in order to make the Internet of Things a reality. The topic of Internet of Things (IoT) rose in our minds after we saw the recent updates and innovations for making objects to sense and reply with the help of sensors and various IoT suites. We then realized the integration of these everyday objects into the Internet is a huge step and this will surely have a big impact on the network as there will soon be millions of these „Things" everywhere. Therefore, then and there we were convinced to do research and work for the distribution of data for the Internet of Things so that we could lessen the huge volumes of data traffic for the cloud to make a faster and reliable infrastructure.

1.3Thesis Outline

Chapter 1 is the introduction of thesis. We have discussed our motivation and objectives.

Chapter 2 is the background study that covers the literature review and all the research work we have done and projected the basic real life applications of Fog computing.

Chapter 3 is where we have talked about the different hardware used in our project.

Chapter 4 is the implementation section where we described all the algorithms and flowcharts we have built to prove the validity of our proposed infrastructure and compared our algorithms with the traditional infrastructure.

Chapter 5 is about the communication theory used to connects the nodes

Chapter 6 is the results of our algorithms projected through graphs and result comparison with the present cloud-computing model.

Chapter 7 contains conclusion and discussion about the future aspects of our thesis and research.

Chapter 2

LITERATURE REVIEW

Our underlying way to deal with this point was to fabricate gadget equipped for observing different condition parameters with the assistance of wireless sensing network(WSN).These are spatially dispersed independent sensors to screen physical or ecological conditions, for example, temperature, sound, pressure, and so forth and to cooperatively pass their data through the system to different areas. A WSN framework joins a door that gives wireless connectivity to the wired world and distributed nodes and we attempted to incorporate this to our postulation. To accomplish a reasonable vision of WSN we needed to research on previous work related to this subject, and shortlisted some of the important papers as references.

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2.1 Present Work and projects

The papers we have read has discussed various application of WSN, how to make WSN more efficient through algorithm and finished project where WSN is used. The first paper talks about how to enhance the efficiency of WSN in order to extend the network lifetime [3]. The second one is about data collecting with compressive sensing at sensor node [2]. Compressive sensing is the emerging theory in the field of wireless sensor networks, which works on a Sub-Nyquist sampling theorem. Sparse representation of a few non-zero samples of the original signal will significantly reduce the number of samples. In addition, reconstruction of the original signal is possible as per Sub-Nyquist sampling theorem. Another paper talks about the different topology of WSN connection and how it is used in different projects [7]. Some example projects that study oceanographic processes include the WAVCIS (wave–current information system) project [6], the "Monitoring Your Sound" (MYSound) project [6] and another is the Chesapeake Bay Observatory System (www.cbos.org). A more complex system is found in the SEACOS: Self-organizing Collegiate Sensor Networks Project which uses sea-bed sensors connected to buoys with long range wireless communication [6] . It records wave properties around an offshore wind farm and uses intelligent sensors capable of dynamic self-configuration [6].

2.2 System Topology

The system we have used is implemented using a star topology. In Star topology nodes are connected to a centralized communication hub (sink) and the nodes cannot communicate directly with each other [7]. The entire communication must be steered through the centralized hub. Every hub is then a " client" " while the central hub is the server. Codes with simplified serial message passing algorithms for star-WSN. The two algorithms are executed in light of variable hub refreshing [7]. One is the One is the modified sum-product algorithm (MSPA) [7] and the other is the improved input conviction engendering calculation (S-FBPA) [7], both of proposed calculations have fundamentally decreased complexity.

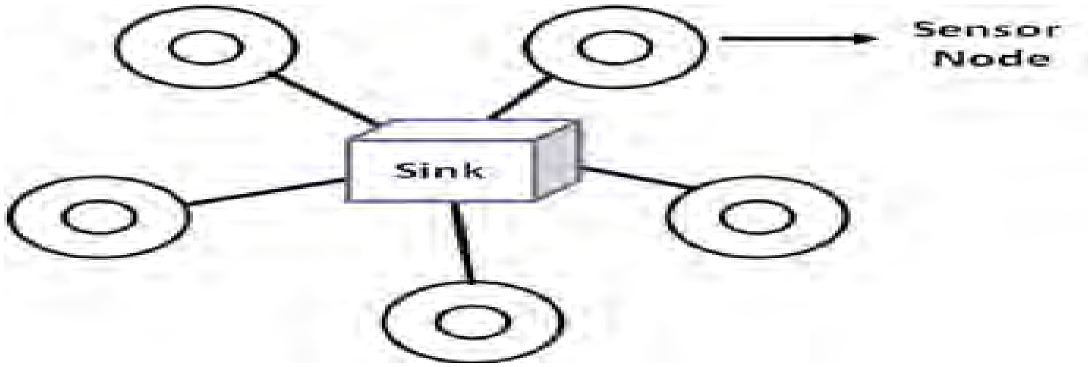


Fig-1 Star Topology

2.3Bio sensing Networks

This is an emerging set of systems, which are distinguished mainly by their use of biotechnology [7]. Biosensor comprises a biological sensing element attached to a physical transducer, which can be electrochemical, optical electronic, optical or acoustic. The transmitted information consists of physiological change or the presence of various chemical or biological materials in the environment.

2.4 Sensor web

Here, cheaper sensors are used with a presumed reduction in measurement fidelity [8]. Nevertheless, by correlating these measurements over space and time, it now becomes possible to extract spatio-temporal dynamics associated with a phenomenon [8]. As a result, these cheaper sensors, correctly configured, can provide a different type of information altogether. This is the essence of a Sensor Web.

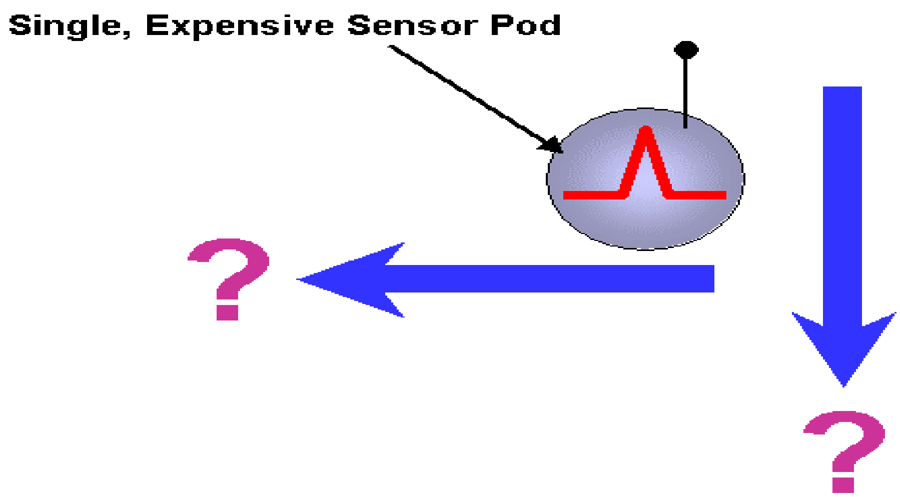


Fig- 2 Single, Expensive Sensor Pod

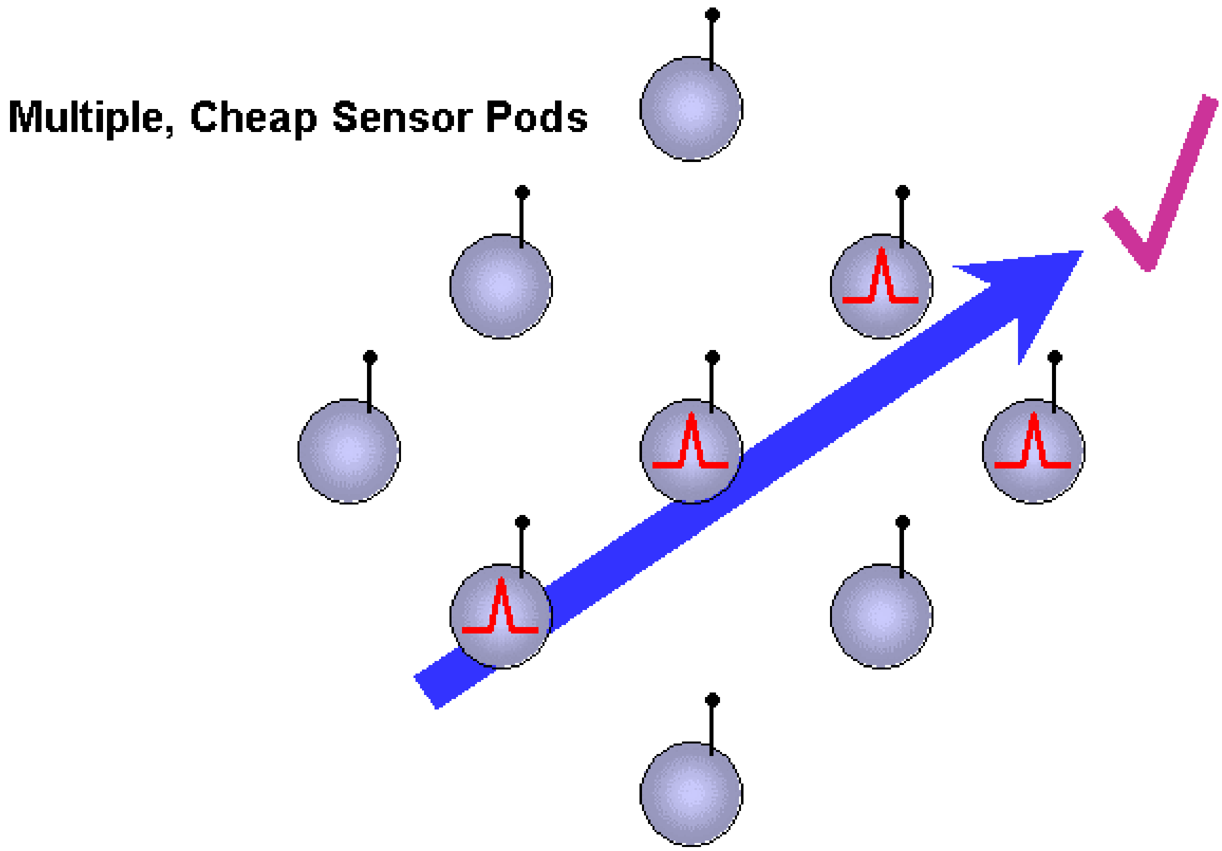


Fig- 3 Multiple Cheap Sensors Pods

Chapter-3

HARDWARE TOOLS

In our project we used the following hardware‟s like Arduino which acts as the sub nodes with multiple sensors integrated to it, Raspberry PI which is the central node of the system connecting the server and multiple senor whose configuration description and pin diagrams with figures are stated below.

3.1 Raspberry Pi B+

The Raspberry Pi Model B+ is a powerful, small and lightweight ARM based computer. It has better power consumption, increased connectivity and greater IO compared to other Pi models. Some of the internal specification are given below

- Broadcom BCM2835 SoC chip
- Has ARM11 core architecture.
- Uses a 700 MHz Low Power ARM1176JZFS Applications Processor and has a 512 MB of SDRAM.
- The GPU is Dual Core,
- VideoCore IV® Multimedia Co-Processor Provides Open GL ES 2.0,
- Hardware-accelerated OpenVG,
- A 1080p30 H.264 high profile decode Capable of 1Gpixel/s, 1.5Gtexel/s or 24GFLOPs with texture filtering and DMA infrastructure.
- Uses a microSD for its boot device and runs a version Linux.
- Dimension of 85 x 56 x 17mm.

- Powers up through a Micro USB socket 5V, 2A.
- It also has 10/100 BaseT Ethernet socket,
- HDMI (rev 1.3 & 1.4) Composite RCA (PAL and NTSC),
- 3.5mm jack, HDMI, 4 x USB 2.0 Connector,
- 40-pin 2.54 mm (100 mil) expansion header: 2x20 strip, Providing 27 GPIO pins
- +3.3 V, +5 V and GND supply lines,
- 15-pin MIPI Camera Serial Interface (CSI-2),
- Unpopulated JTAG,
- Display Serial Interface (DSI) 15 way flat flex cable connector with two data lanes and a clock lane and SDIO memory card slot,

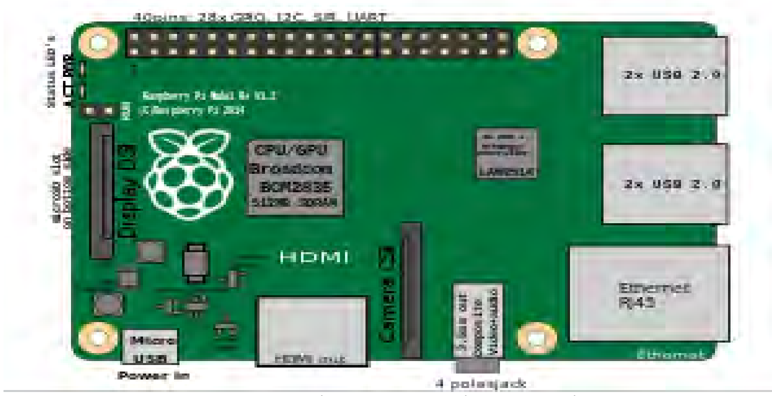
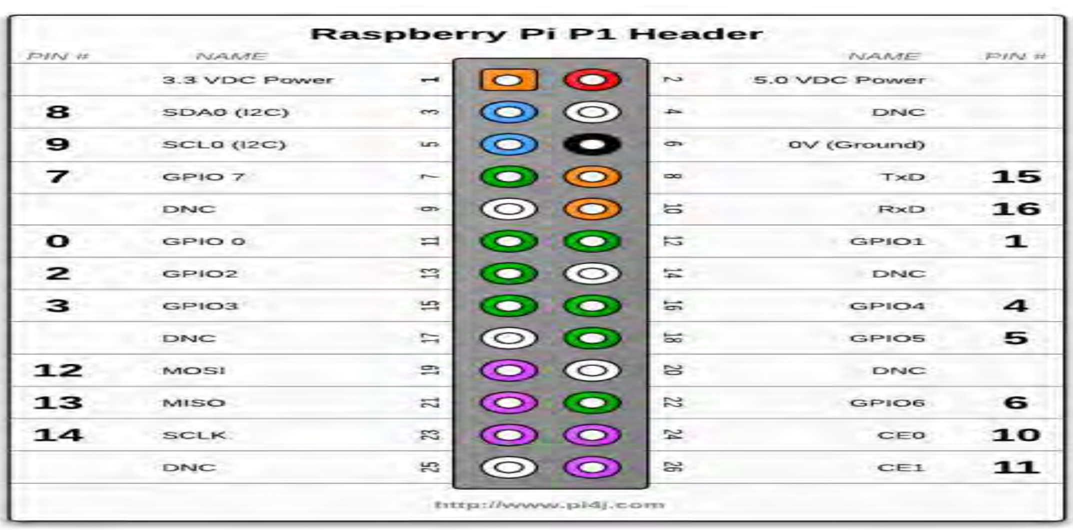


Fig-4 Raspberry Pi


Raspberry Pi P1 Header

PIN #	NAME			NAME	PIN #
	3.3 VDC Power	1	2	5.0 VDC Power	
8	SDA0 (I2C)	3	4	DNC	
9	SCL0 (I2C)	5	6	0V (Ground)	
7	GPIO 7	7	8	TxD	15
	DNC	9	10	RxD	16
0	GPIO 0	11	12	GPIO1	1
2	GPIO2	13	14	DNC	
3	GPIO3	15	16	GPIO4	4
	DNC	17	18	GPIO5	5
12	MOSI	19	20	DNC	
13	MISO	21	22	GPIO6	6
14	SCLK	23	24	CE0	10
	DNC	25	26	CE1	11

http://www.pi4j.com

Fig-5 Raspberry Pi P1 Header

3.2 Arduino Mega

Arduino Mega is a microcontroller board based on the ATmega 2560. It has 54 digital input/output pins. It has 16 analog input, 4 UARTs (Hardware Serial ports). It has 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. Its clock speed is 16MHz, length is 101.52 mm, and width is 53.33 mm and weight 37 g. The mega is compatible with most shields designed for Arduino.

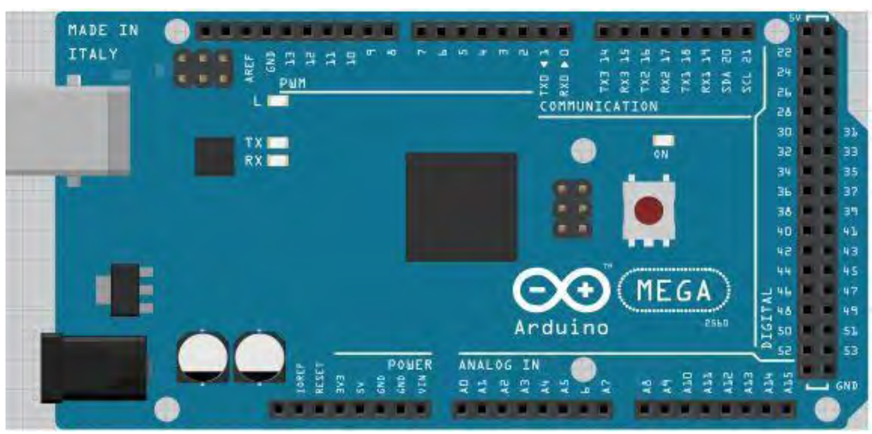


Fig- 6 Arduino Mega

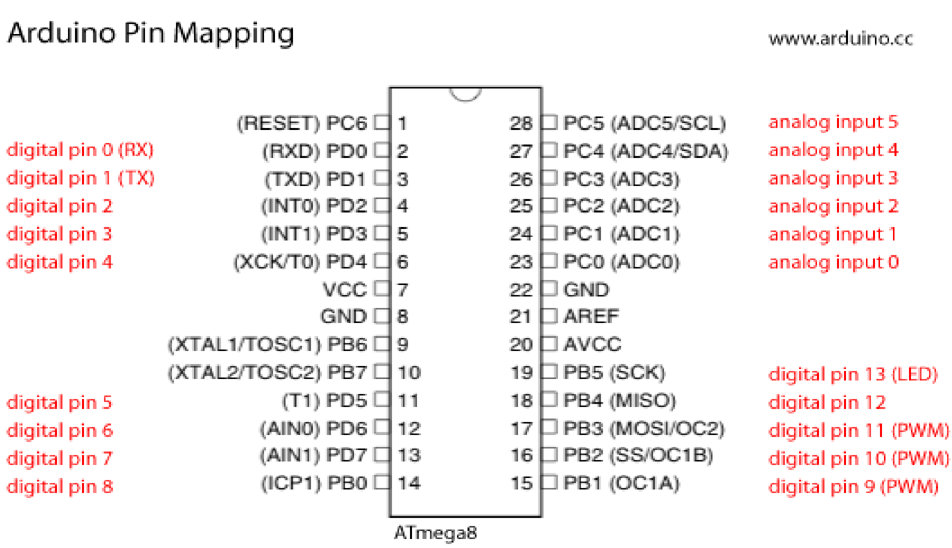


Fig- 7 Arduino Mega Pin Mapping

3.3 Soil Moisture sensor (SEN-005)

This moisture sensor can be used to detect the moisture of the soil, when the soil is dry the module outputs a high level otherwise the output low. It has an operating Voltage 3.3V-5V with adjustable sensitivity. It has a Module Dual Output mode, a simple digital output, analog output more accurate.

Some of its other features are:

- Fixed bolt hole for easy installation
- Small PCB board size: 3cm * 1.6cm
- Power indicator (red) and the digital switch output indicator (green)
- Using LM393 comparator chip
- Stable VCC external 3.3V-5V
- GND External
- DO small board digital output interfaces (0 and 1)
- AO small board analog output interface

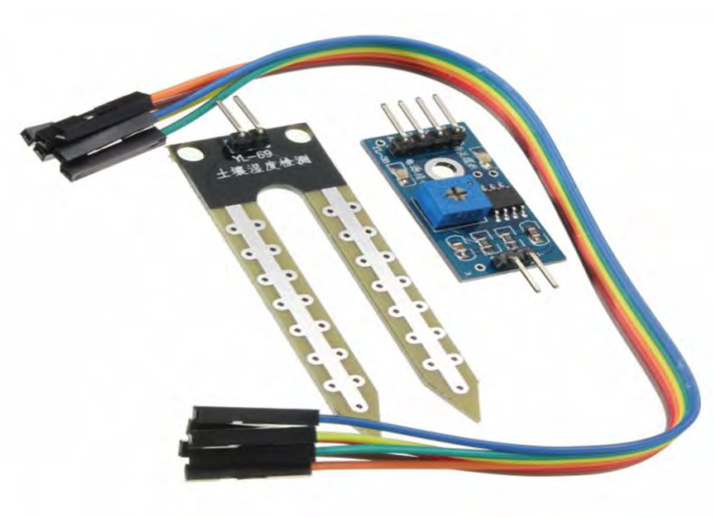


Fig-8 Soil Moisture sensor (SEN-005)

3.4 Flame sensor module (SEN-0018F)

This module is sensitive to the flame and radiation. It also can detect ordinary light source in the range of a wavelength 760nm-1100 nm. It can be used as a flame alarm. It can detect a flame or a light source of a wavelength in the range of 760nm-1100 nm within a range: up to 100 cm. which is also adjustable detection range. The detection angle about 60 degrees, it is sensitive to the flame spectrum. Its comparator chip LM393 makes module readings stable. Operating voltage is 3.3V-5V.Output is Digital and Analog. It has power indicator and digital switch output indicator.

Fig- 9 Flame sensor module (SEN-0018F)

3.6 Rain Sensor Module (SEN-2080)

The sensor USES the high quality FR - 04 double material, large area of 5.5 x 4.0 CM, treatment of nickel plating and surface, have fight oxidation, electrical conductivity, and life has more superior performance. With potentiometer sensitivity can be adjusted. The output format is Digital switch output (0 and 1) and analog AO voltage output. It has a fixed bolt hole, convenient installation. The comparator output, signal clean, good wave form, driving ability is strong, for more than 15 mA. The LM393 uses a wide voltage comparator. The working voltage is of 3.3 V to 5 V.

Fig- 10Rain Sensor Module (SEN-2080)

3.7 DHT22 Digital Temperature Humidity Sensor Module

DHT22 output calibrated digital signal. It utilizes exclusive digital-signal-collecting-technique and humidity sensing technology, assuring its reliability and stability. Its sensing elements is 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 (20m) enable DHT22 to be suited in all kinds of harsh application occasions. Single-row packaged with four pins, making the connection very convenient.

Technical Specification:

Model	DHT22
Power supply	3.3-6V DC
Output signal	digital signal via single-bus
Sensing element	Polymer capacitor
Operating range	humidity 0-100%RH; temperature -40~80Celsius
Accuracy	humidity +-2%RH(Max +-5%RH); temperature <+-0.5Celsius
Resolution or sensitivity	humidity 0.1%RH; temperature 0.1Celsius
Repeatability	humidity +-1%RH; temperature +-0.2Celsius
Humidity hysteresis	+-0.3%RH
Long-term Stability	+-0.5%RH/year
Sensing period	Average: 2s
Interchangeability	fully interchangeable
Dimensions	small size 14*18*5.5mm; big size 22*28*5mm

Fig- 11 Technical Specification of DHT22

Fig- 12 DHT22 Sensor

3.8 MQ-135 Gas Sensor

This module interfaces with the MQ135, They are used in air quality control equipment for buildings/offices, are suitable for detecting of NH3, NOx, alcohol, Benzene, smoke, CO2, etc.

Fig- 13 MQ-135 Gas Sensor

3.9 Nordic nRF24L01

The Nordic nRF24L01+ is a highly integrated, ultra-low power (ULP) 2Mbps RF transceiver IC for the 2.4GHz ISM (Industrial, Scientific and Medical) band. With peak RX/TX currents lower than 14mA, a sub µA power down mode, advanced power management, and a 1.9 to 3.6V supply range, the nRF24L01+ provides a true ULP solution enabling months to years of battery life from coin cell or AA/AAA batteries. The Enhanced Shock Burst™ hardware protocol accelerator offloads time critical protocol functions from the application microcontroller enabling the implementation of advanced and robust wireless connectivity with lowcost 3rd-party microcontrollers.The Nordic nRF24L01+ integrates a complete 2.4GHz RF transceiver, RF synthesizer, and baseband logic including the Enhanced Shock Burst™ hardware protocol accelerator supporting a high-speed SPI interface for the application controller. No external loop filter, resonators, or VCO reactor diodes are required, only a low cost ±60ppm crystal, matching circuitry, and antenna. The nRF24L01+ is available in a compact 20-pin 4 x 4mm QFN package.NRF24L01+ has 6 data pipes. This means that can receive data simultaneously from 5 nRF24L01+. My library uses only 1 data pipe, so 2 nRF24L01s can be connected together and communicate. Every of them has a unique 5bytes long address, which is software selectable.

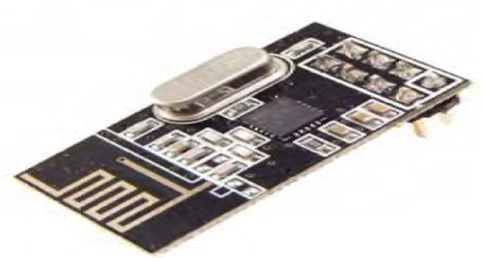


Fig- 14 nRF24L01

Pin	Name	Pin function	Description
1	CE	Digital Input	Chip Enable Activates RX or TX mode
2	CSN	Digital Input	SPI Chip Select
3	SCK	Digital Input	SPI Clock
4	MOSI	Digital Input	SPI Slave Data Input
5	MISO	Digital Output	SPI Slave Data Output, with tri-state option
6	IRQ	Digital Output	Maskable interrupt pin. Active low

Fig- 15 Pin Function of nRF24L01

3.10 Air Sensor

Works with 5V and 3.3V boards and can be used on the Sodaq Autonomo. The sensor is designed for indoor air quality testing. The main gas detected is carbon monoxide, alcohol, acetone, thinner, formaldehyde and other slightly toxic gasses. Evidently useful in many sensors or projects, whether it's for safety or for fun.

- Low power consumption
- High sensitivity
- Long life

- Automatic air ventilation
- Indoor air quality detector

Fig-16 Air Sensor

3.11 GSM

This is a GSM-compatible Quad-band cell phone, which works on a frequency of 850/900/1800/1900MHz and which can be used not only to access the Internet, but also for oral communication (provided that it is connected to a microphone and a small loud speaker) and for SMSs. Externally, it looks like a big package (0.94 inches x 0.94 inches x 0.12 inches) with L-shaped contacts on four sides so that they can be soldered both on the side and at the bottom. Internally, the module is managed by an AMR926EJ-S processor, which controls phone communication, data communication (through an integrated TCP/IP stack), and (through an UART and a TTL serial interface) the communication with the circuit interfaced with the Cell phone itself.

The processor is also in charge of a SIM card (3 or 1,8 V) which needs to be attached to the outer wall of the module. In addition, the GSM900 device integrates an analog interface, an A/D converter, an RTC, an SPI bus, an I²C, and a PWM module. The radio section is GSM phase 2/2+ compatible and is either class 4 (2

W) at 850/ 900 MHz or class 1 (1 W) at 1800/1900 MHz The TTL serial interface is in charge not only of communicating all the data relative to the SMS already received and those that come in during TCP/IP sessions in GPRS (the data-rate is determined by GPRS class 10: max. 85,6 kbps), but also of receiving the circuit commands (in our case, coming from the PIC governing the remote control) that can be either AT standard or AT-enhanced SIMCom type. =The module is supplied with continuous energy (between 3.4 and 4.5 V) and absorbs a maximum of 0.8 A during transmission.

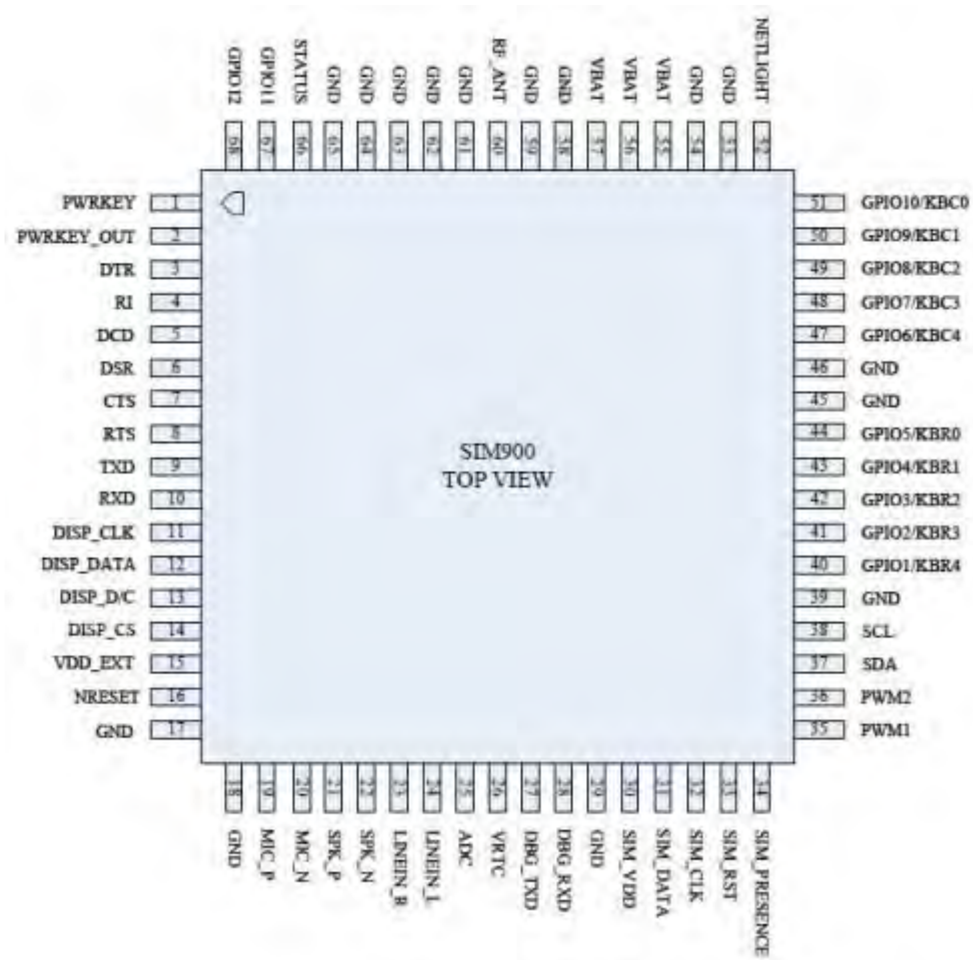
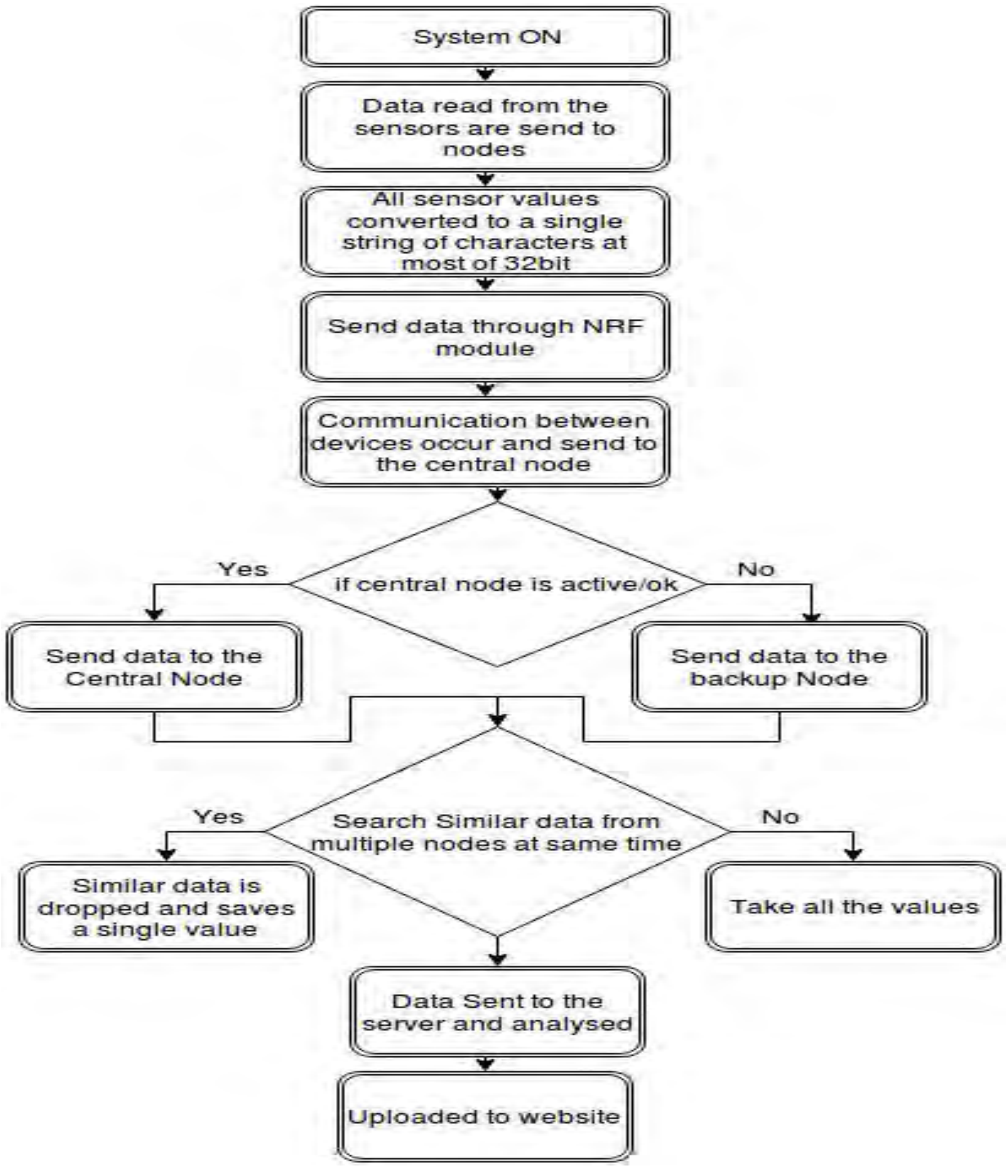


Fig -17 Pin out SIM900

Chapter 4

CIRCUIT SCHEMETICS &IMPLEMENTATION

4.1 Work Flow of the System



System ON
Data read from the sensors are send to nodes
All sensor values converted to a single string of characters at most of 32bit
Send data through NRF module
Communication between devices occur and send to the central node
Yes
if central node is active/ok
No
Send data to the Central Node
Send data to the backup Node
Yes
Search Similar data from multiple nodes at same time
No
Similar data is dropped and saves a single value
Take all the values
Data Sent to the server and analysed
Uploaded to website

Fig -18 Flow diagram of the total system

First of all the remote Arduino nodes reads the data with all the sensors and then forms a string consisting of the values. Then the string is converted into a character array, as NRF works with character protocols. It was also taken into consideration that the highest number of character that can be sent at once was 32 characters. Once converted to characters the string which was formed especially with some distinguishable characters is sent through the NRF with the default send method (write ()).the NRF on the other side, meaning the receiving Pi mother node, keeps listening for incoming data. Another Pi backup node also keeps listening for incoming data and also continuously checks if the other Pi mother node is active or not. If the main mother node is active then the backup mother node does nothing. But if it gets no response from the main mother node the backup node starts acting as the main mother node. When the main mother node receives the data it firstly checks for the similar valued data of similar time from different nodes. Then it drops that similar data by just keeping one to reduce the communication cost and save bandwidth. Then the data is sent through the server over the internet. There according to the intensity of the data a decision is generated and along with the data the generated decision is shown in the website.

4.1.1 Block Diagram

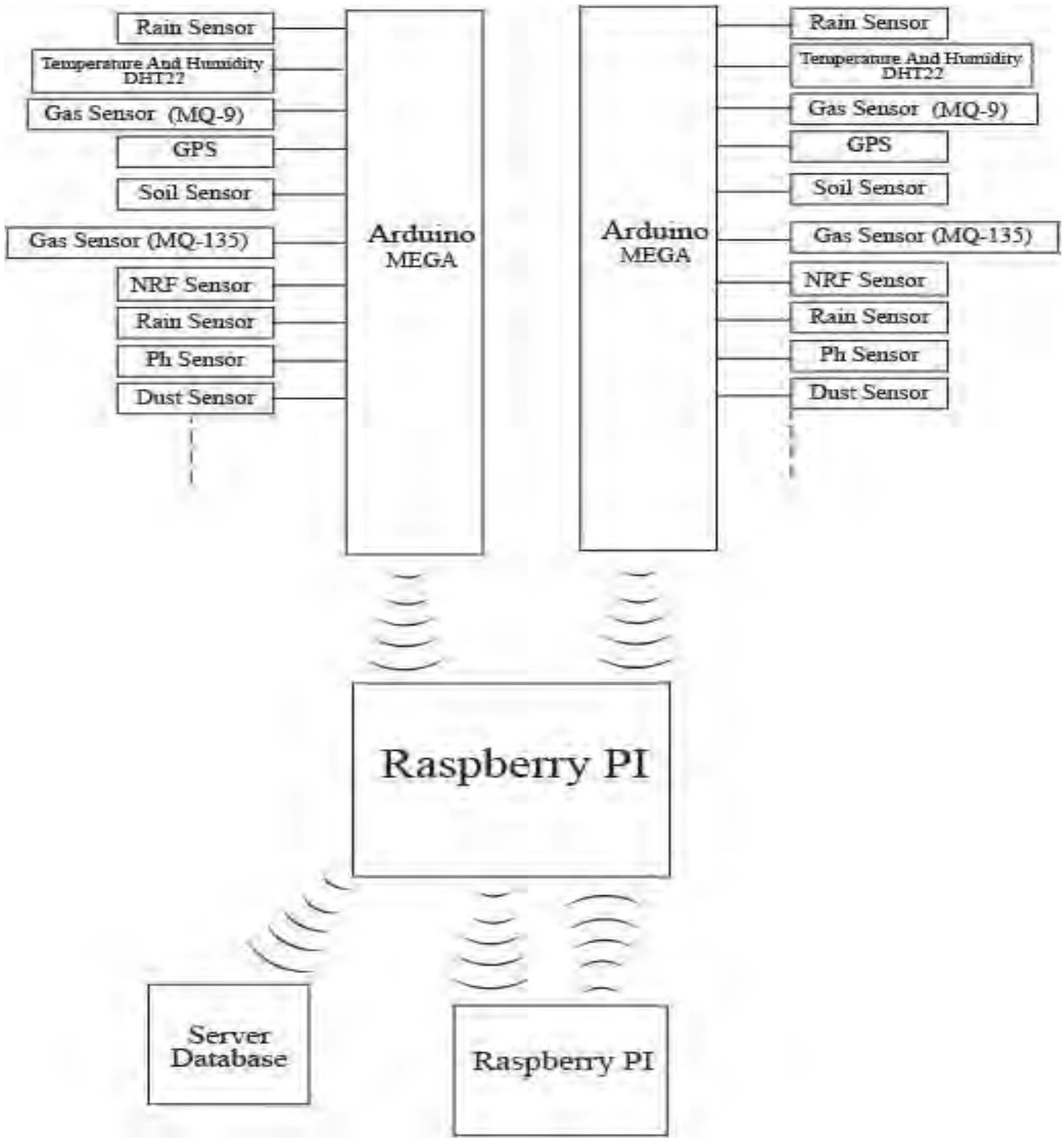


Fig -19 Block Diagram of the Sub node and Central Node

4.2 Work Flow of Gas Sensor (MQ-9)

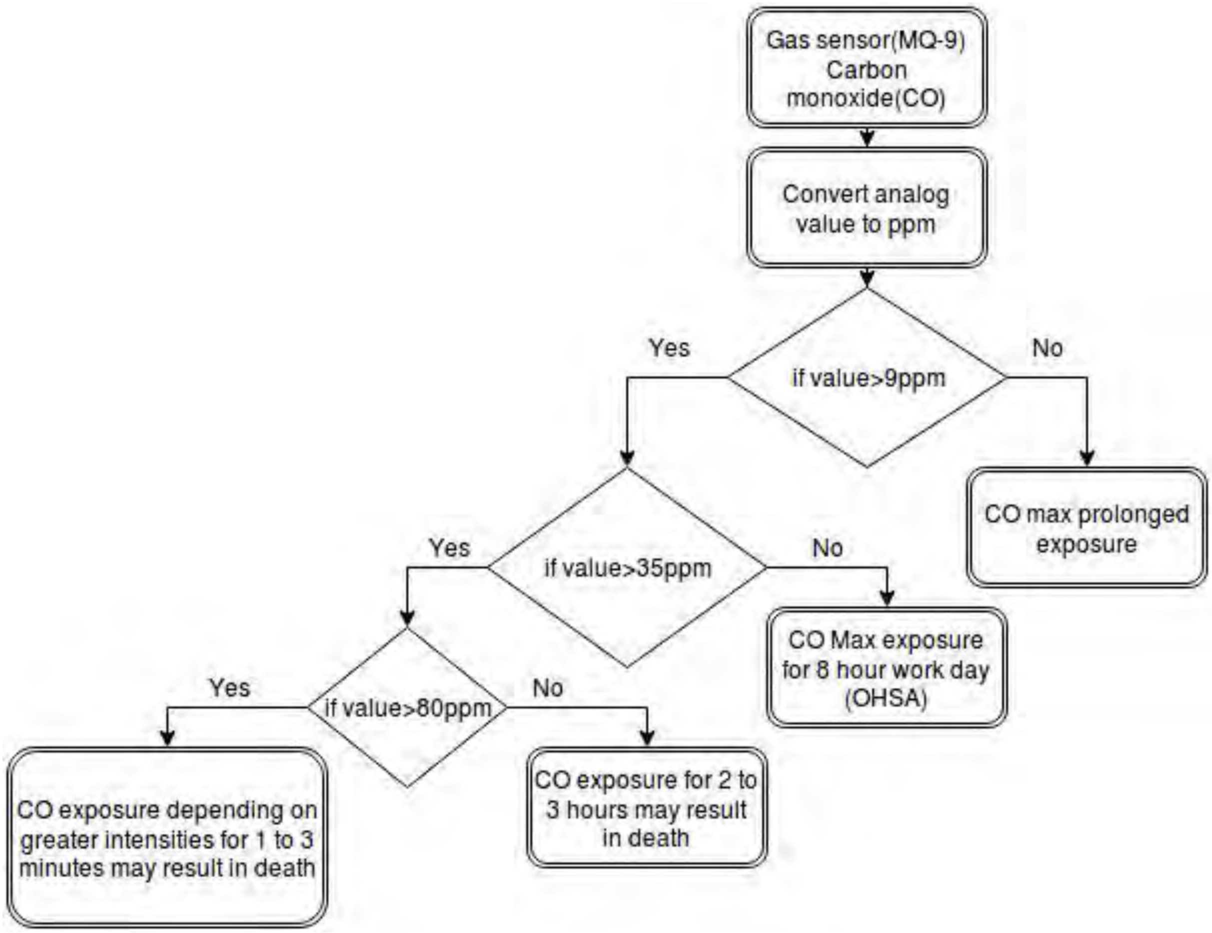


Fig -20 Flow diagram of MQ-9

To detect the level of CO we here used the mq-9 gas sensor. The sensor reads the data it receives as analog value. Then it converts it to PPM. To do that we first calculated the sensor voltage by the following equation.

Sensor Voltage = Analog Reading * 3.3V / 4095

Then we used exponential fit and go got the PPM from the following equation

CO sensor: PPM = 3.027*e^(1.0698*V_RL)

After converting the data, are send to mother node. In mother node similar data is being dropped to reduce processing time. Now selected data is sent to server where it is analyzed and according to the intensity of the data a message is generated and shown in the website.

4.3Work Flow of Gas Sensor (MQ-135)

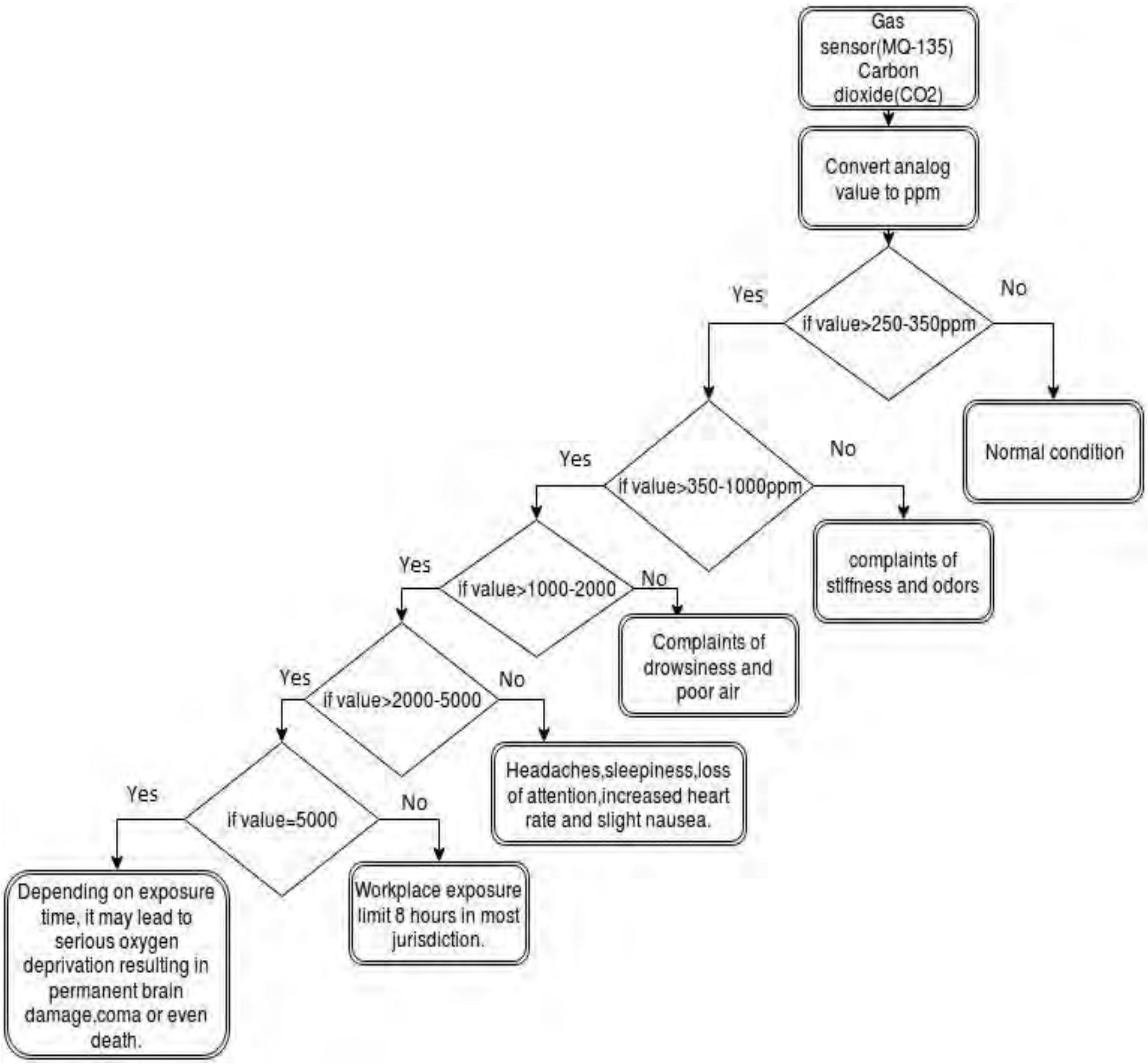


Fig -21 Flow diagram of MQ-135

To detect the intensity of the carbon-di-oxide we used the MQ-135 gas sensor here. Similar to the MQ-9 sensor this sensor also detects data as analog data then converts it into PPM and sends it to the mother node. The mother node after receiving the data checks for duplicate data at the same time then drops the data if not necessary or if necessary sends it to the server. There in the server the data is analyzed and according to the intensity a decision is generated and shown in the server.

4.4 Work Flow of Soil Sensor

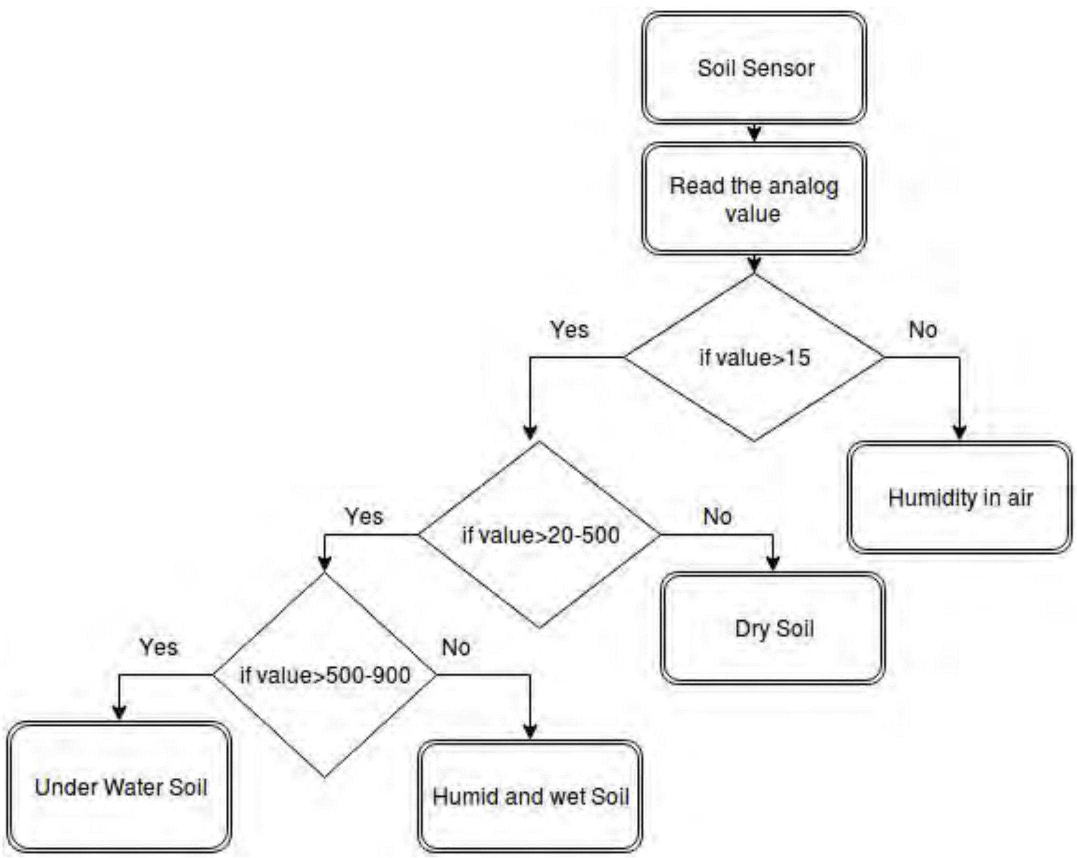


Fig -22 Flow diagram of Soil Sensor

This part is about soil and the sensor detects the whether it is humid and wet soil or under water soil. We are using SEN-005 sensor to detect the characteristics of soil. Moreover, this one follow the same equation like as Carbon Di Oxide, detect the data as analog, then convert it as PPM, and send to the mother node. As always-duplicate data is dropped and if the data is necessary then send it to the server. At the server, the data is analyzed and according to the intensity, decision is selected and published in the server.

4.5 Work Flow of Rain Sensor

For rain detection, we are using SEN-2080. Mainly the sensor is used for detecting water droplets. The sensor gives output in the following ways. If the sensor board detects any water droplets or the panel is flooded, it gives an output or else return null.

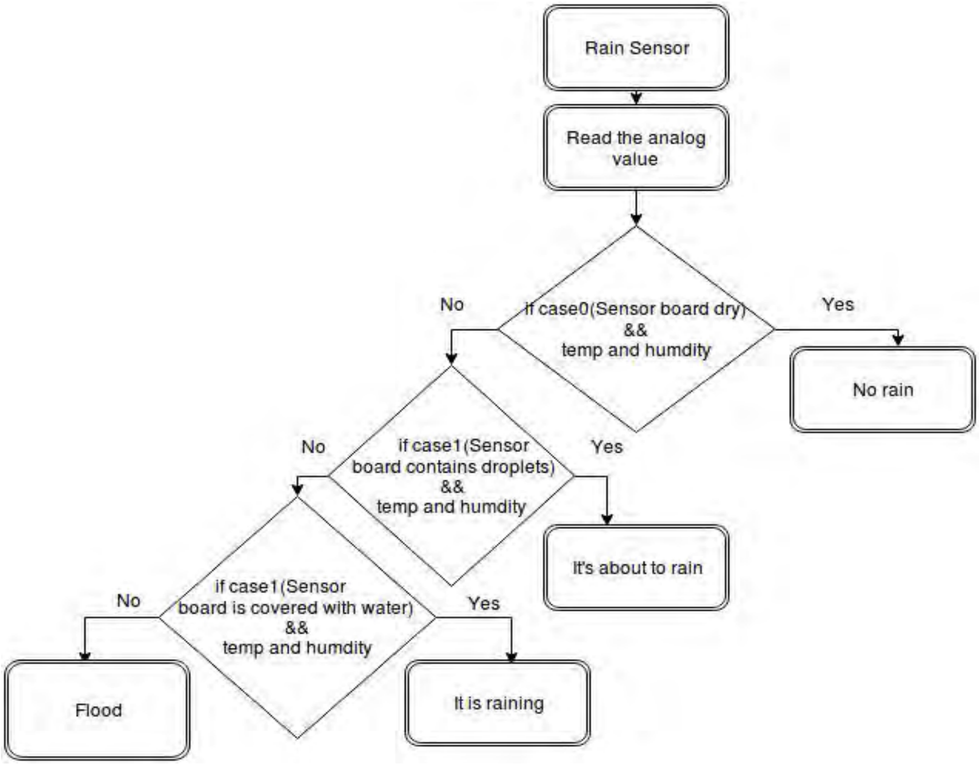


Fig -23 Flow diagram of Rain Sensor

4.6 Heat and Humidity Index Danger Zones

Heat Index												
Dry Temperature		**Relative Humidity (%)**										
(°F)	**(°C)**	**0**	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
70	21.1	64	65	66	67	68	69	70	70	71	71	72
75	23.9	69	70	72	73	74	75	76	77	78	79	80
80	26.7	73	75	77	78	79	81	82	85	86	88	91
85	29.4	78	80	82	84	86	88	90	93	97	102	108
90	32.2	83	85	87	90	93	96	100	106	113	122	
95	35	87	90	93	96	101	107	114	124	136		
100	37.8	91	95	99	104	110	120	132	144			
105	40.6	95	100	105	113	123	135	149				
110	43.3	99	105	112	123	137	150					
115	46.1	103	111	120	135	151						
120	48.9	107	116	130	148							

Fig -24 Temperature vs. Humidity

- 90-104 : Heat cramps or heat exhaustion possible
- 105-130 : Heat cramps or heat exhaustion lightly, heatstroke possible
- 130 and more : Heatstroke highly likely

4.6 Motion Detection

This proposal method will detect motioned objects using live feeding from our system. Firstly, a PI-cam need to be set up in the raspberry pi. After activating the camera, we need to capture the still image that is the first frame with no motion. This will be consider as the background, with that we‟ll compare our further process.

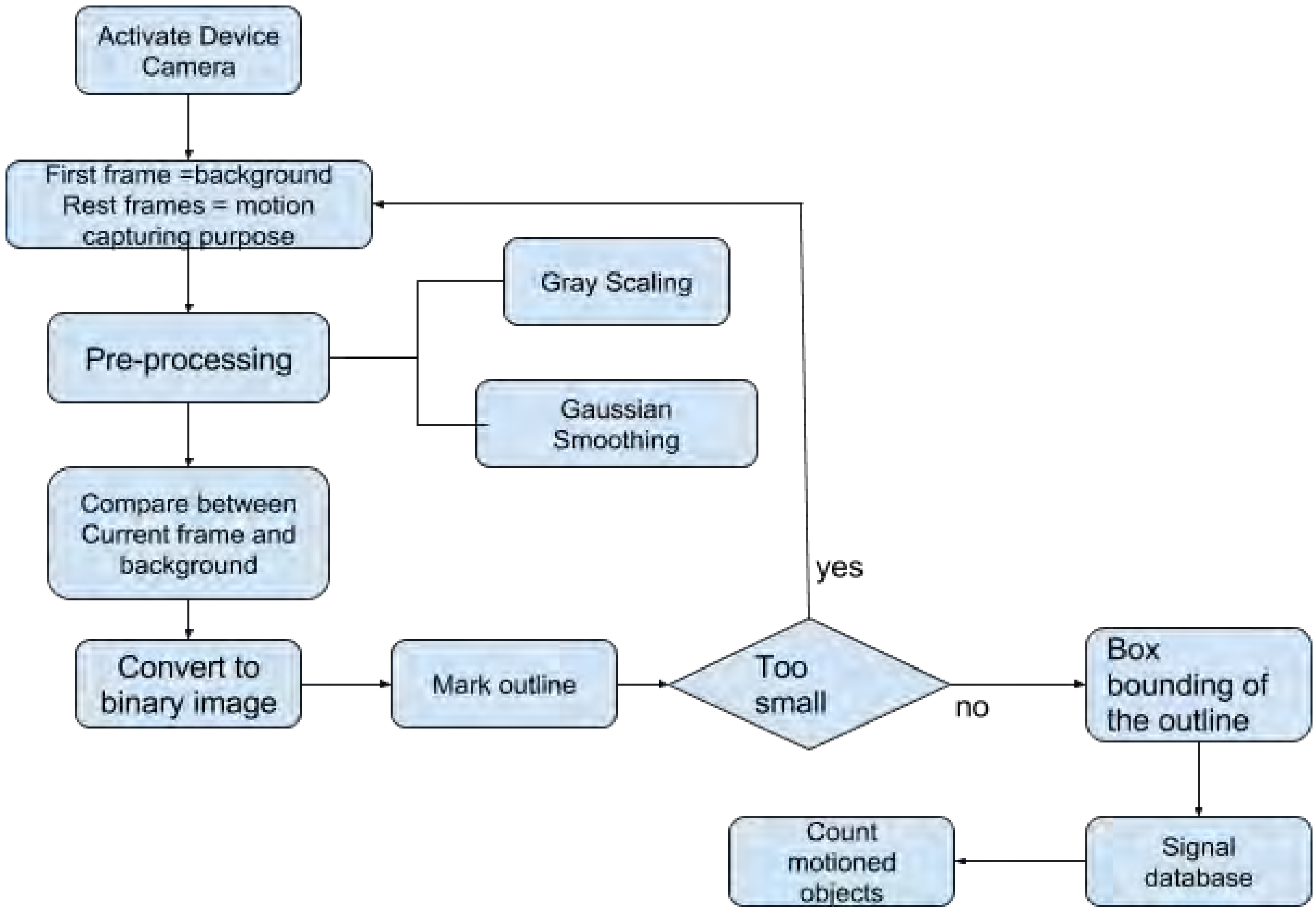


Fig -25 Flow Diagram of Motion Detection

Now, with every frame, getting from the camper will go to the pre-processing sector where we will reduce the color complexity to process our frame and preparing it for motion analysis .There is no need to process the large, raw images straight from the video stream. We will also convert the image to grayscale since color has no bearing on our motion detection algorithm. Finally, we will apply Gaussian blurring to smooth our images. Due to tiny variations in the digital camera sensors, no two frames will be 100% the same, some pixels will most certainly have different intensity values. We need to account for this and apply

Gaussian smoothing to average pixel intensities across a*21 x 21* region. This helps smooth out high frequency noise that could throw our motion detection algorithm off. Computing the difference between two frames is a simple subtraction, where we take the absolute value of their corresponding pixel intensity differences

Frame difference = (background model – current frame)

By applying binarilizing methods to convert the image into binary image. The background of the image is clearly black. However, regions that contain motion is much lighter. This implies that larger frame deltas indicate that motion is taking place in the image. Now by threshold value, we mark and detect the outlines of this white area.

Finally bounded the boundary of the detected motioned image using open-CV‟s bounding Rectfunction. Then, mark it as occur the motioned image and sent 1 to the database. A1 output will indicate a motioned object is detected.

4.7 System Architecture

4.7.1 Motes/Wireless Sub Nodes

The schematics of the sub wireless node contains all the sensors, Arduino mega, GPS and NRF communication module. The sensors are connected to the digital pins as shown in the circuit diagram. All are connected with VCC of 5V and GRND. But the NRF module cannot be connected to a 5V source. So it gives 3V with resistors connected to it. The sensor that are shown in the diagram are DHT22, Soil Sensor, Rain Sensor, and Fire Sensor.

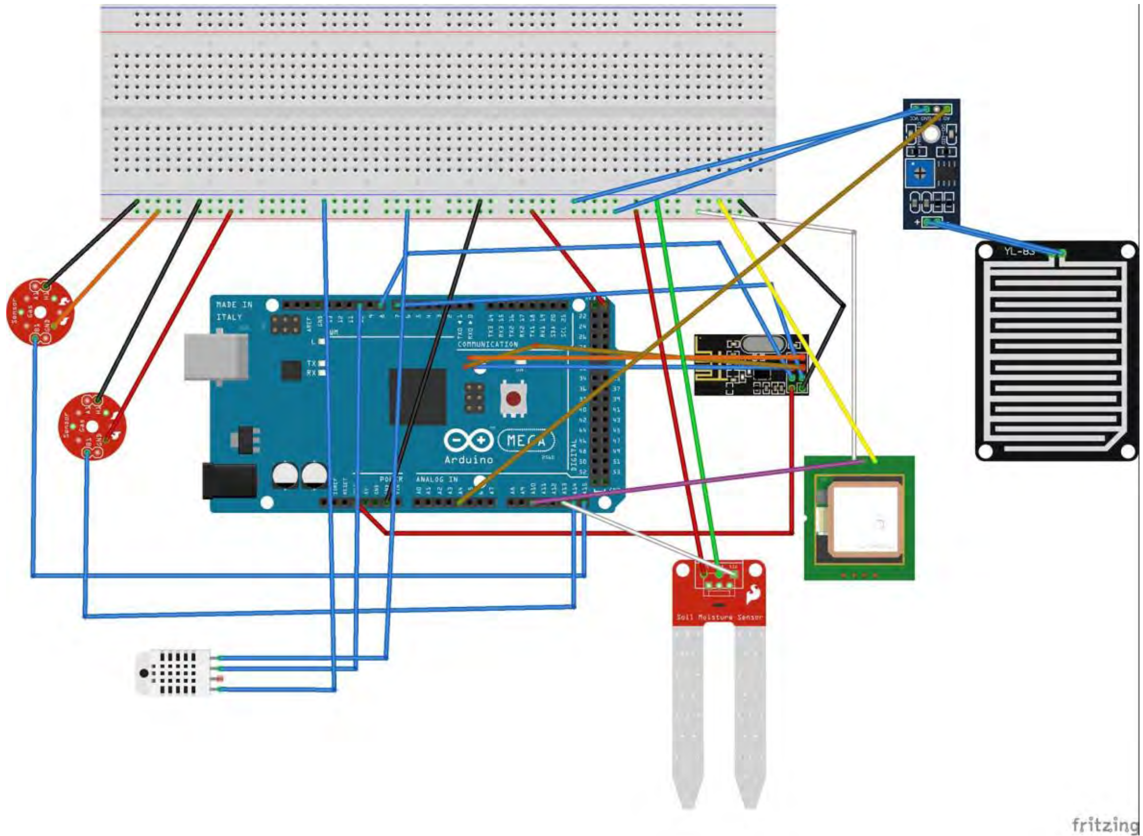


Fig- 26 Sensors and other components connect with Arduino Mega.

4.7.2 Raspberry PI-Raspberry PI communication

The Raspberry PI are connected together wirelessly through connection under the same router or connected wiredly. The receiving PI has a nrf with acts as a receiving nodes for all the sub nodes that sends data to it. The PI is connected to the server which acts as a uploading medium for all the nodes that sends the sensor values. The root node has the capability to look for similar data‟s in the same time for the nodes that sends data. The data‟s are processed according to time and send to the server as a single value for the nodes if the values are same.

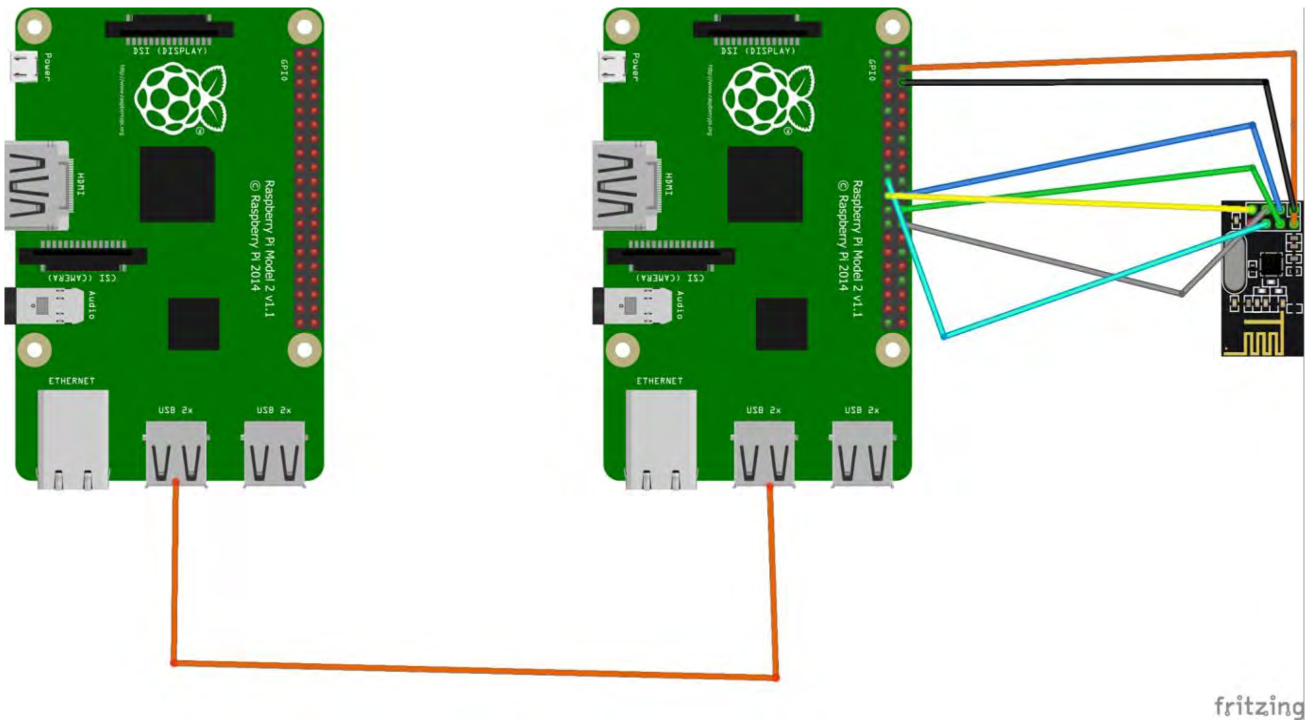


Fig- 27 Raspberry Pi Duos

Chapter 5
Communication

5.1 Wireless sensing network:

The availability of micro-sensors and low-power wireless communications will enable the deployment of densely distributed sensor/actuator networks for a wide range of applications [1]. Application areas are different and can incorporate an assortment of information sorts including acoustic, picture, and different concoction and physical properties. These sensor hubs will perform significant signal processing, calculation, and system self-setup to accomplish adaptable, vigorous and long-lived networks. All the more particularly, sensor hubs will do nearby handling to decrease correspondences, and subsequently energy costs. Above all else, the remote hub arduino reads the data from every one of the sensors and afterward shapes a string comprising of the values. At that point, it changes over them into character cluster since NRF works with character protocols. It was also taken into consideration that the most noteworthy number of character that can be sent without a moment's delay was 32 characters. Once converted to characters the string which was formed especially with some distinguishable characters is sent through the NRF with the default send method (.write ()). The NRF on the other side, meaning the receiving node, keeps listening for incoming data. When it reads the data, it separates the long string in a pre-defined way and separates the various values. The once again another string is formed from these values in order to send to the server. Once the new string is formed, it is sent to the server. The Raspberry Pi does the sending.

5.2 Functionality

The raspberry continuously receives data through the serial port from the connected arduino. While the active Pi sends data to the server, the backup Pi continuously checks if the main pi s up. If the main pi fail the backup pi immediately, takes over by sending the data though the other Raspberry pi (self).
The main characteristics of a WSN include:

- Power consumption constraints for nodes using batteries or energy harvesting
- Ability to cope with node failures (resilience)
- Some mobility of nodes (for highly mobile nodes see MWSNs)
- Heterogeneity of nodes
- Scalability to large scale of deployment
- Scalability is the capability of a system, network, or process to handle a growing amount of work, or its potential to be enlarged to accommodate that growth.[1] For example, a system is considered scalable if it is capable of increasing its total output under an increased load when resources (typically hardware) are added.
- Ability to withstand harsh environmental conditions
- Ease of use

- Cross-layer design[2]

Cross-layer is becoming an important studying area for wireless communications [2].In addition, the traditional layered approach presents three main problems:

1. Traditional layered approach cannot share different information among different layers, which leads to each layer not having complete information. The traditional layered approach cannot guarantee the optimization of the entire network.
2. The traditional layered approach does not have the ability to adapt to the environmental change.
3. Because of the interference between the different users, access conflicts, fading, and the change of environment in the wireless sensor networks, traditional layered approach for wired networks is not applicable to wireless networks.

So the cross-layer can be used to make the optimal modulation to improve the transmission performance, such as data rate, energy efficiency, QoS (Quality of Service), etc. [2].Sensor nodes can be envisioned as little PCs which are to extremely basic in terms of their interfaces and their components. They comprise of a processing unit with constrained computational power and restricted memory, sensors or MEMS (counting particular conditioning circuitry), a communication device (generally radio handsets or on the other hand optical), and a power source for the most part as a battery. Other conceivable incorporations are energy harvesting modules,[3] auxiliary ASICs, and potentially optional correspondence interface (e.g. RS-232 or USB).The base stations are one or more components of the WSN with much more computational, energy and communication resources.

They act as a gateway between sensor nodes and the end user as they typically forward data from the WSN on to a server [4]. Other special components in routing based networks are routers, designed to compute, calculate and distribute the routing tables.

5.3 Distributed sensor network

If a centralized architecture is used in a sensor network and the central node fails, at that point the whole system will fall, however the reliability of the sensor system can be expanded by utilizing a distributed control architecture. Distributed control is used in WSNs for the following reasons:

1. Sensor nodes are prone to failure [4].
2. For better collection of data,
3. To provide nodes with backup in case of failure of the central node.

There is also no centralized body to allocate the resources and they have to be self-organized

5.4 In-network processing

To reduce communication costs some algorithms remove or reduce nodes' redundant sensor information and avoid forwarding data that is of no use. As nodes can inspect the data they forward, they can measure averages or directionality for example of readings from other nodes. For example, in sensing and monitoring applications, it is generally the case that neighboring sensor nodes monitoring an environmental feature typically register similar values. This kind of data redundancy due to the spatial correlation between sensor observations inspires techniques for in-network data aggregation and mining. Aggregation reduces the amount of network traffic, which helps to reduce energy consumption on sensor nodes [5]. Recently, it has been found that network gateways also play an important role in improving energy efficiency of sensor nodes by scheduling more resources for the nodes with more critical energy efficiency need and advanced energy efficient scheduling algorithms need to be implemented at network gateways for the improvement of the overall network energy efficiency [5].

5.5 Data integration and sensor web

The information accumulated from remote sensor systems is typically saved as numerical data in a central base station. Also, the Open Geospatial Consortium (OGC) is determining standards for interoperability interfaces and metadata encodings that empower real time integration of heterogeneous sensor networks into the Internet, enabling any person to screen or control remote sensor networks through a web program

5.6 Stability

The capability of a system, network, or process to handle a growing amount of work, or its potential to be enlarged to accommodate that growth. For example, a system is considered scalable if it is capable of increasing its total output under an increased load when resources (typically hardware) are added. Here our system is built in such a way that additional sensing devices and be added with no issues and hence meets the criteria of scalability.

5.7 Withstanding harsh conditions:

This sensing device is used for environment monitoring like fire detection, soil detection, temperature and humidity, gas detection(MQ-9,MQ-135 etc.) and rain. Therefore, the system is built in such a way that it can sense these readings and at the same time survive the harsh environment.

5.8 Power Source:

Due to its small size, these nodes consume less power. Instead of using small batteries, our nodes are powered by small solar panel. This increases the longevity of the nodes.

5.9 Limitations

In our device, we used Arduino, which has a low computation power; therefore, we were not able to add the detection feature at the child node end. For our central node, we used Raspberry Pi, we used Pi camera at the central node for motion detection. The Pi cam only can detect something if there is motion but cannot take pictures of the objects in front of it because of limited processing power. Our sensing network do not have a mobile app or mobile site, we only have an website to show our detected data.

The communication device we used in our project is a NRF. But the NRF module cannot handle large data's properly and hence gives a big disadvantage of data loss. Then the sensors in our project are experimental sensors and cannot gather readings efficiently and hence accuracy is low. It does not perform on all environmental conditions. Each sensors work on different conditions and parameters. The sensors and the base node are prone to external environmental factors; like rain, fire etc. As the concept of data collection is widely implemented on the field on analysis and prediction, we were not able to gather that huge amount of data that is required.

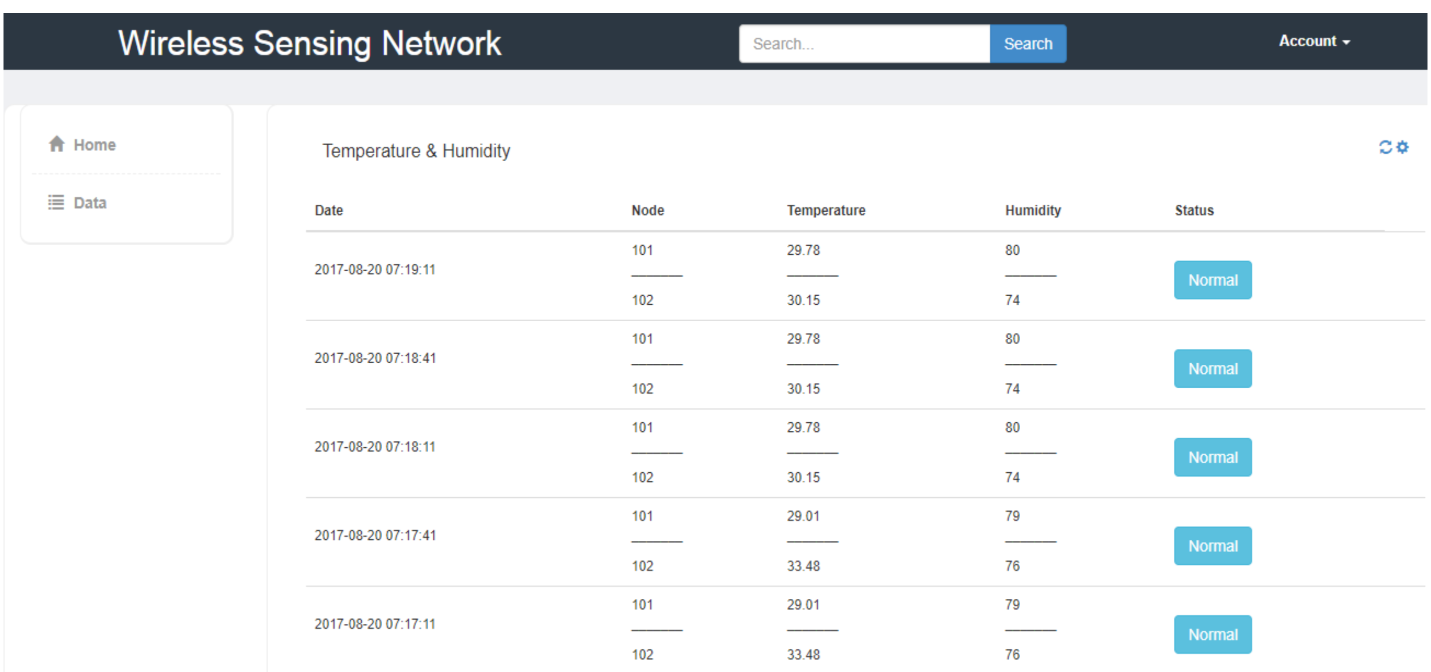
Chapter 6

RESULT AND ANALYSIS

The data's that were read from the sensors are saved to the database and displayed by a website that we created. This website contains all the readings of the sensor and backhand calculation that will be given as output. The following screen shots and details will be you have a idea about what the outputs will be along will status and graphs.

6.1 Result and Analysis of Temperature and Humidity Readings

From the figure, we can see that we got the temperature and humidity values. The temperature value is shown in degree Celsius and the humidity reading is shown in



Date	Node	Temperature	Humidity	Status
2017-08-20 07:19:11	101 102	29.78 30.15	80 74	Normal
2017-08-20 07:18:41	101 102	29.78 30.15	80 74	Normal
2017-08-20 07:18:11	101 102	29.78 30.15	80 74	Normal
2017-08-20 07:17:41	101 102	29.01 33.48	79 76	Normal
2017-08-20 07:17:11	101 102	29.01 33.48	79 76	Normal

percentage . All these readings contains status which will indicate whether the shown reading are dangerous or not. These status are displayed according to the ranges as mentioned above and we set and can be changed as any particular requirement.

Fig -28 Temperature and Humidity Readings

6.2 Result and Analysis of different Gas Readings

From the figure, we can see that we got the readings of different gas sensors like CO2,CH4,CO,NH3 and LPG. These gas readings are shown in ppm. All these readings contains status which will indicate whether the shown reading are dangerous or not. And according to the status and some preset conditions in the code the probable outcomes will be displayed as shown in the below figure tabulation. We can change the status and readings depending on the environment and requirement.

Gas Reading

Date	Node	Co2	Co	NH3	LPG	Status	Probable Outcome
2017-08-20 07:19:11	101	400.35	23.44	23.08	24.26	Normal	Normal background concentration in outdoor ambient air
	102	490.14	24.73	23.08	22.48	Acceptable	
2017-08-20 07:18:41	101	400.35	23.44	23.08	24.26	Normal	Normal background concentration in outdoor ambient air
	102	490.14	24.73	23.08	22.48	Acceptable	
2017-08-20 07:18:11	101	400.35	23.44	23.08	24.26	Normal	Normal background concentration in outdoor ambient air
	102	490.14	24.73	23.08	22.48	Acceptable	
2017-08-20 07:17:41	101	377.39	24.17	23.08	24.26	Normal	Normal background concentration in outdoor ambient air
	102	417.4	24.93	23.08	22.48	Normal	
2017-08-20 07:17:11	101	377.39	24.17	23.08	24.26	Normal	Normal background concentration in outdoor ambient air
	102	417.4	24.93	23.08	22.48	Normal	

Fig -29 Gas Readings in Different Environment

6.3 Result and Analysis of soil sensor readings with characteristics

As we can see in the below tabulation, there are readings of temperature, humidity and moisture. We compared these three readings together because by only taking the value of the moisture sensor, we will have many faulty readings and thus the conditions will display wrong outcomes. So with that vision we set these three conditions together were the outcome will be displayed depending on these parameters. After satisfying the conditions, the outcome is shown which is preset in the database and it can be changed depending on the environmental condition.

Soil Charactarestics

Date	Node	TEMPERATURE	HUMIDITY	Moisture	Condition
2017-08-20 07:19:11	101	29.78	80	79	Too Much
	102	30.15	74	81	Normal
2017-08-20 07:18:41	101	29.78	80	79	Too Much
	102	30.15	74	81	Normal
2017-08-20 07:18:11	101	29.78	80	79	Too Much
	102	30.15	74	81	Normal
2017-08-20 07:17:41	101	29.01	79	79	Too Much
	102	33.48	76	81	Normal
2017-08-20 07:17:11	101	29.01	79	79	Too Much
	102	33.48	76	81	Normal

Fig -30 Soil Characteristics

6.4 Result and Analysis of rain sensor readings

As we can see in the below tabulation, there are readings of temperature, humidity and rain sensor. We compared these three readings together because by only taking the value of the rain sensor, we will have many faulty readings and thus the conditions will display wrong outcomes. Rain sensor can give three possible outcomes like if droplets of water fall on the sensor panel it gives rain is about to rain, if the sensor panel is drowned with water it gives output that it's raining else no rain. Taking this reading will give us faulty outputs frequently. So with that vision we set these three conditions together were the outcome will be displayed depending on these parameters. After satisfying the conditions, the outcome is shown which is preset in the database and it can be changed depending on the environmental condition.

Raining Probability

Date	Node	Temperature	Humidity	Raining Condition
2017-08-20 07:19:11	101 102	29.78 30.15	80 ↑	RAIN WARNING!! RAIN WARNING!!
2017-08-20 07:18:41	101 102	29.78 30.15	80 ↑	RAIN WARNING!! RAIN WARNING!!
2017-08-20 07:18:11	101 102	29.78 30.15	80 ↑	RAIN WARNING!! RAIN WARNING!!
2017-08-20 07:17:41	101 102	29.01 33.48	79 ↑	RAIN WARNING!! RAIN WARNING!!
2017-08-20 07:17:11	101 102	29.01 33.48	79 ↑	RAIN WARNING!! RAIN WARNING!!

Figure -31 Rain Status

6.5 Result and Analysis of fire sensor readings

As shown in the below tabulation, it displays the readings of the fire sensor. The output is shown depending on intensity. So if there is any presence of fire, the fire sensor would give a feedback as quick as possible. Like there is fire, depending upon intensity of the fire it will give a particular outcome which in here is given as "Danger". If no fire then it will display "No Danger". After satisfying the conditions, the outcome is shown which is preset in the database and it can be changed depending on the environmental condition.

Fire Status

Date	Node 1	Node 2	Status	Probable Outcome
2017-08-20 07:19:11	39.8 %	44.3%	Danger	Fire in Range Detected
2017-08-20 07:18:41	39.8 %	44.3%	Danger	Fire in Range Detected
2017-08-20 07:18:11	39.8 %	44.3%	Danger	Fire in Range Detected
2017-08-20 07:17:41	39.8 %	44.3%	Danger	Fire in Range Detected
2017-08-20 07:17:11	39.8 %	44.3%	Danger	Fire in Range Detected

Fig -32 Fire Status

6.6 Total Tabulation with all the readings

The total tabulation of the website is shown along with all the values of all the sensors that are stored into the database along with the date and location of each and individual node. There as you can see in the tabulation, there are two nodes 101 and 102. These two nodes are collecting data at a given time with their longitude and latitude. The main concept of WSN will have multiple nodes that can be of any number. So the purpose of giving the location is that we can trace the particular location where the nodes are or where the following occurrences that we are detecting will take place. Along with that, the point of impact can be determined through it. There is option through the search bar for searching data within a given time.

All Data

10 records per page

Search:

Date	Node	CO2	CO	CH4	NH3	FLAME	TEMPERATURE	HUMIDITY	Rain Probability	MOISTURE	LONG	LAT
2017-08-20 07:12:11	101	370.39	24.17	23.08	24.26	3.98	29.01	79	NO RAIN	79	23.77992	90.423399
	102	417.4	24.93	23.08	22.48	4.43	33.48	76		81	23.7798	90.42335
2017-08-20 07:12:41	101	370.39	24.17	23.08	24.26	3.98	29.01	79	NO RAIN	79	23.77992	90.423399
	102	417.4	24.93	23.08	22.48	4.43	33.48	76		81	23.7798	90.42335
2017-08-20 07:13:11	101	370.39	24.17	23.08	24.26	3.98	29.01	79	NO RAIN	79	23.77992	90.423399
	102	417.4	24.93	23.08	22.48	4.43	33.48	76		81	23.7798	90.42335
2017-08-20 07:13:41	101	377.39	24.17	23.08	24.26	3.98	29.01	79	NO RAIN	79	23.77992	90.423399
	102	417.4	24.93	23.08	22.48	4.43	33.48	76		81	23.7798	90.42335
2017-08-20 07:14:11	101	377.39	24.17	23.08	24.26	3.98	29.01	79	NO RAIN	79	23.77992	90.423399
	102	417.4	24.93	23.08	22.48	4.43	33.48	76		81	23.7798	90.42335
2017-08-20 07:14:41	101	377.39	24.17	23.08	24.26	3.98	29.01	79	NO RAIN	79	23.77992	90.423399
	102	417.4	24.93	23.08	22.48	4.43	33.48	76		81	23.7798	90.42335

Fig -33 All Data Readings

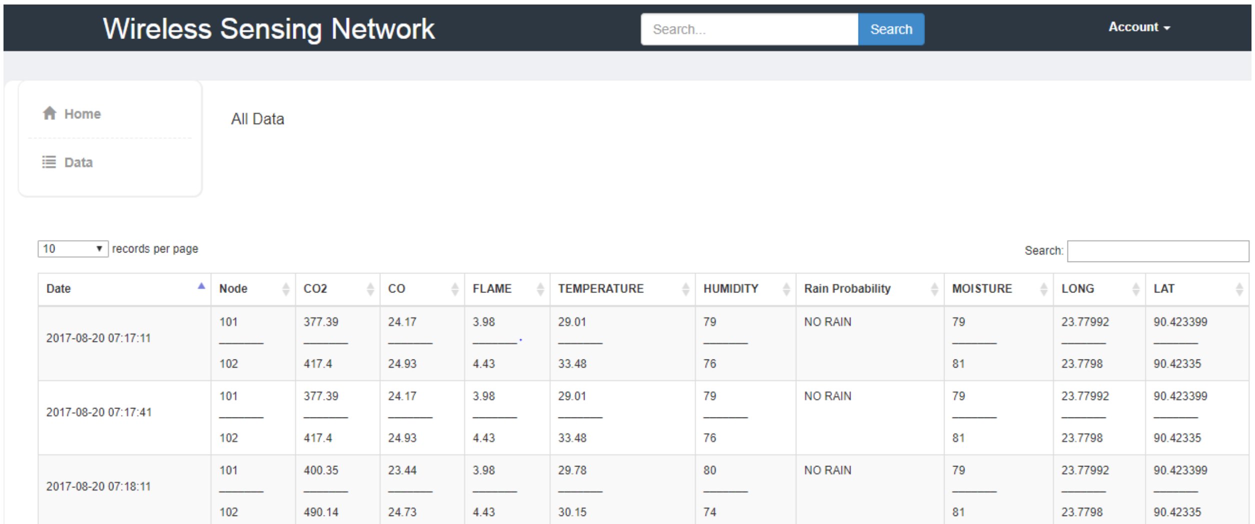
6.7 Graph of CO2

There will be graphical representation for each and every sensors along with multiple characteristics graph will shown the output of the readings with respect to time. The main purpose for this graph is that we can see the overall change the is going on. We have given the output of CO2 gas as a sample. As you can see the blue line represents the margin that is the normality. The red line represents the change that is going on which we are getting through our sensors reading. The Y-axis represents the ppm and the X-axis presents with respect to time.

Fig- 34 CO2 PPM VS Time Graph

6.8 Total Tabulation with all the readings

As you can see in the stated table, there are two selecting options which are HOME and DATA. The home will contain the graphs along with most updated 5 entries that will be read by the sensors. The purpose of this is transparency and user friendly. It is sometimes difficult to trace to keep track of all the values. So whenever someone wants to check the most recent data's, they do not have to scroll through logs of data. It will simply be displayed on the HOME panel.



Date	Node	CO2	CO	FLAME	TEMPERATURE	HUMIDITY	Rain Probability	MOISTURE	LONG	LAT
2017-08-20 07:17:11	101 102	377.39 417.4	24.17 24.93	3.98 4.43	29.01 33.48	79 76	NO RAIN	79 81	23.77992 23.7798	90.423399 90.42335
2017-08-20 07:17:41	101 102	377.39 417.4	24.17 24.93	3.98 4.43	29.01 33.48	79 76	NO RAIN	79 81	23.77992 23.7798	90.423399 90.42335
2017-08-20 07:18:11	101 102	400.35 490.14	23.44 24.73	3.98 4.43	29.78 30.15	80 74	NO RAIN	79 81	23.77992 23.7798	90.423399 90.42335

Fig -35 Preview of the latest received data's

Chapter 7

CONCLUTION& FUTURE WORK

7.1 Conclusion

Wireless Sensor Networks are one of the significant topics in the literature. Real world implementations of WSN and sensor motes are discussed compared in this paper. However, there are many sensors nodes, which can be commercially sold in the internet most of them, have high prices and there is a need for low cost and easy to build up sensor nodes. Low cost WSN network design and implementation is presented for environment monitoring applications. For this aim, a low-cost alternative sensor mote is developed by using Arduino and Raspberry pi platform for environment monitoring system using four different sensor parameters. In order to enlarge sensing filed of the WSN, multi-hop based sensor network application are implemented. Moreover, environment-monitoring application with our sensor motes are implemented and a windows application is developed to monitor sensor"s data collected from the WSN. The cost of the sensor mote is suitable for small budgets and prototype studies. In order to enlarge sensing filed of the WSN, multi-hop based sensor network application are implemented. Energy efficiency is one of the most important tasks for WSN.

7.2 Future work

By evolution of technology, devices are getting smaller day by day. Therefore, our sensor nodes may minimize to the size of a dust node and we may be able to spread these dust like sensor nodes throughout the world. These smart dust motes will sense not only the air quality, detect fire or rain but also everything that surrounds it. The authorities to take necessary action such as emergency warning messages and evacuation of people to safe places could use the information that are collected by the sensors. Further implementing pollution monitoring systems will help to assess how bad air pollution is from day to day and save the environment from further pollution. Currently the Pi cam only detects motion. However, in future we plan to detect objects or animals and track their moving position. We also tend to add face detection feature to the system. We will try to develop a mobile application and data would be exported to external programs to perform more sophisticated statistical analysis.

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