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A RASPBERRY-PI BASED IOT SYSTEM FOR MEASURING THE ENVIRONMENTAL PARAMETERS TO MONITOR THE POLLUTION LEVEL USING IBM BLUEMIX

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ABSTRACT

Environmental parameter monitoring using Internet of Things (IOT) provides a low cost and an effective system to monitor the weather condition and to take relevant steps to overcome it. The Internet of Things (IOT) refers to virtually representing a physical network. This work presents a functional design and implementation of a complete sensor system which can be used for monitoring the environmental parameters. The system fulfills all the requirements like high number of sensors, fast deployment, low maintenance, and high quality of service.

The system is based on acquiring data like carbon dioxide, temperature, humidity and carbon monoxide from various sensors and monitoring the sensor value. The measured parameters are thus uploaded to the cloud so that the users can track the present environmental condition and could identify the contribution of various elements towards it. A message is sent to the user notifying about the air index. The whole process is carried out on Raspberry-Pi. So, in short this is an integrated system which combines Internet of Things and Raspberry-Pi.

Index Terms: Raspberry Pi , Pollution , Sensor , IOT.

I. INTRODUCTION

The environmental problems are growing rapidly. There are many countries facing the environmental pollution problems. Different types of pollution have differrent effects on environment and living creatures. For example, air pollution which is caused due to release of harmful adulterant into the atmosphere pollutes our environment to a large extent . Global Warming is one of the adverse affect of air pollution which causes due to exemption of Green house gases in the atmosphere. Green house gases like nitrous oxide, methane, carbon dioxide results in increasing the earth's temperature which in turn is responsible for Global Warming. Global Warming also results in acid rain and ozone layer depletion. Transportation is responsible for more than about 50 percent of carbon monoxide in the atmosphere. Emission of polluting gases from vehicles contributes for more than 70 percent in air pollution. Air pollution leads to various diseases like lung cancer, skin cancer, respiratory disease, congestion, throat inflammation etc. Global Warming also results in death of aquatic animals which in turn causes water pollution. Defilement of water bodies by discharge of chemicals from the industries, mining activities, marine dumping, burning of fossil fuels, radioactive waste etc. causes water pollution. Thus both organic and non organic sources are accountable for causing water pollution. 70 percent of earth is surrounded by water, so it is counted as one of the greatest resource. Water Pollution results in many diseases like malaria, typhoid, cholera, diarrhea, jaundice, dysentery etc. Pollution is just not limited to the nature and resources. Extreme and unpleasant noise also disturbs the natural balance. Thus noise pollution is also considered as a kind of unbalance in nature which causes due to industrialization, social events, transporttation etc. Noise pollution affects the hearing capacity, it also causes stress and sleeping disorder. Moreover excessive noise also effects wild life. Thus environmental pollution causes an unbalance in nature which effects on living creatures. Thus, it is important to monitor the environmental condition so that relevant steps can be taken to reduce the hazards.

Environmental pollution is increasing day by day because of the increased population. According to the survey of World Health Organization (WHO) approx 1.2 million people are killed due to the pollution. Also air pollution results in increase of sugar level of pregnant women. It is also reducing IQ level of children thus effecting their ability to learn the things. The various surveys concluded that children grown up in more polluting areas have comparatively scored less marks in IQ test than those who lived in less polluted areas at the age of 5. This is due to the presence of Polycyclic Aromatic Hydrocarbons in the atmosphere. It has also been observed that children living in more polluting areas have symptoms of depression. As per the article published in "Proceedings of the National Academy of Sciences" it has been observed that electric cars produce 3.6 times more pollution than the gasoline fuelled vehicles because it causes more pollution in generating the electricity. Thus using an electric car is also a source of causing pollution since it produces electricity by burning coal which in turn contaminates the environment.

According to the "Chicago Tribune" report, use of plastics can further increase the pollution. The tiny pieces of plastic are found in Great Lakes of North America. This particles are even difficult to filter out, thus there are more chances of it being present in drinking water. These particles are made from various petroleum- based products like polyester and nylon. These particles also absorb bacteria and chemicals which can affect human as well as wild life. According to a survey conducted by researchers from the "Royal Brompton and Harefield NHS Foundation Trust" in the United Kingdom it has been found that walking two hours in busy road can damage lungs and arteries. Nitrogen dioxide present in the diesel can reduce the functionality of lungs. Also it increases the asthma symptoms amongst children. Thus in order to combat the environmental pollution problem relevant steps should be taken.

Mostly use of advanced technologies is seen to be preferable solution to reduce the pollution but it is not

the case. Consumption should be reduced in order to overcome the environmental pollution problem. Petroleum and coal industries are the main source of pollution. Use of natural resources for generating of energy can really provide a clean atmosphere. For example, there has been many research work done in the field of solar and wind energy which is a natural source of energy reducing environmental pollution. Education system helps a lot for better understanding of clean environment. Many social sites really encourage people to keep surroundings clean. Use of eco-friendly raw materials and efficient technology can help to keep the surroundings clean. In day to day life, people use many synthetic materials that degrade the environment, for example wrappers used for packaging of food. Use of such synthetic materials should be reduced. Reforestation and recycling of products is another way to reduce pollution. Reforestation helps to balance the ecosystem. Recycling of paper, tin and other materials can help to prevent the potential damage to the environment.

Thus in order to control the pollution, frequent environment monitoring is required which can notify users about the various factors responsible for depleting the nature. Internet of things (IoT) plays a vital role as it simplifies the work and provides wide range of connectivity with the people that is also at low cost. IoT can be helpful in cities for monitoring air pollution from vehicles and from other resources also the data related to the amount of pollution on different roads of a city can be gathered and analyzed.

II. EXISTING WORK

There are various works done in the field of environmental pollution monitoring since it is one of the biggest problem faced by the country today. Basically, environmental monitoring system needs a wifi connectivity throughout to work, this can be considered as one of the limitation of monitoring system since the data can only be sent to the cloud when it is connected to the internet. But with the development of technologies many cities are wifi enabled. These small cities connect various resources to the wifi. Another solution for this problem can be obtained by using GSM modem so that a text message containing the sensor data can be sent to the user at a low sample period [1]. Earlier two technologies were considered as a key for the IoT: the radio-frequency identification (RFID) and the wireless sensor networks (WSN). RFID provides low-cost identification and tracking while WSNs bring IoT applications enhance capabilities for sensing [2]. Amongst all the IoT applications the environmental monitoring acquires a growing interest as environmental technology becomes a key field of sustainable growth worldwide. The open nature environmental monitoring is found to be challenging because of the harsh operating conditions and difficulty in the access to the field also the maintenance. Many IoT applications may have strict requirements like, low cost, ease of deployment, low maintenance, which in turn make these WSN platforms less suited.

In order to monitor the environment condition in a smaller area like home, office etc. zigbee module can be used which is considered as a low cost, flexible solution for monitoring the parameters. Use of zigbee module along with the Wireless Sensor network [WSN] provides a low power and effective system [3]. The system can further be used for automation of the electrical appliances at home, thus it provides the mechanism for monitoring as well as controlling the home equipments. For monitoring the data zigbee protocol format is translated to IPV6 format by gateway. For WSN network all the aspects of WSN platform should be considered like platform structure, flexibility, reusability, optimization of the sensor and gateway nodes etc. [2].

Industrial areas are mainly responsible for depleting the nature. Specially, the Green House Gases and chemicals form the industries which are discharged in the atmosphere result in increasing Global Warming effect. Thus these areas should be monitored because most of the harmful gases like methane, carbon dioxide, carbon monoxide emits from these areas [5]. Unbalance in the nature results in many natural calamities like droughts, acid rain, etc. Apart from weather monitoring, soil condition should also be monitored to predict future droughts [6]. Drought results from unbalance in the nature, for some areas there is shortage of rainfall while for other areas there is huge rainfall because of the unbalance in the temperature. Using GPS module along with the GSM module can provide a more effective and flexible system for monitoring the environmental conditions [7]. GPS module helps the user to differentiate between the environment conditions at different location so that possible solution can be opted. GSM module provides an extra feature to the user to analyze the weather condition through text messages.

111. PROPOSED WORK

The system defines a cost effective solution for users to monitor the pollution level by using IoT as a platform. The existing system integrates Raspberry-pi, Sensors and IoT. The system consists of three sensors: Digital Humidity Temperature sensor (DHT11), MQ135 sensor and MQ7 sensor. These sensors are interfaced with Raspberry-Pi. After retrieving data from the sensors Raspberry-Pi uploads the data to the cloud so that the users can know about the presence of various contaminated elements in the environment. Whole process is carried out on Raspberry-Pi. Fig. 1 shows the block diagram of the system.

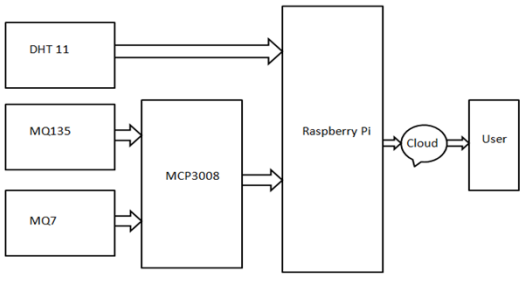

Fig. 1 Block Diagram

A. Raspberry-Pi

Raspberry-Pi is a small sized computer which has various applications in the field of education, gaming, medical, agriculture, home automation, Industries etc. It has many advantages like low cost, expansion capabilities, smaller size, less power consumption, noise free, HDMI capable graphics, etc. In other words, it is a small computer with external storage as SD card. It has 40 General Purpose Input Output (GPIO) Pins, audio port, in build ARM processor and 4 USB ports. Initially Raspberry-Pi was introduced to promote teaching in schools in various cities. Due to the rapid growth in the technology it became important for the people to have a computer system and thus there was no better option than Raspberry-Pi since it is portable and efficient. Fig. 2 shows Raspberry Pi B+ model.

Fig. 2(a) Raspberry Pi

Before starting with Raspberry Pi there are various configurations done on it:

- Install Raspbian OS image file, write the image file on SD card of 4GB or more using windows image writer.
- Set an ip address on Ethernet connection for Raspberry Pi.
- Share the internet with Raspberry Pi.
- Do the configuration settings on DHCP server to get the ip address of Raspberry Pi Fig. 2(b).
- Now open putty and give same ip address.
- Login to Raspberry Pi giving "pi" as username and "raspberry" as password.
- Open interfaces file and make the ip address static fig. 2(c).

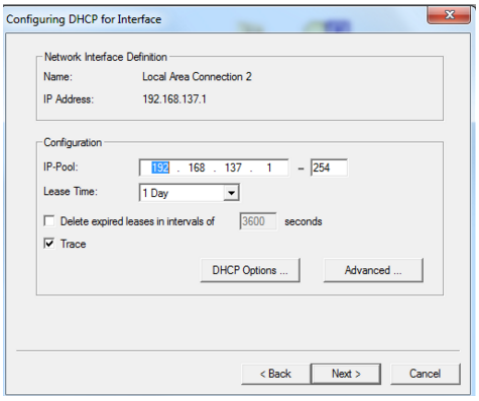

Fig. 2(b) DHCP Configuration

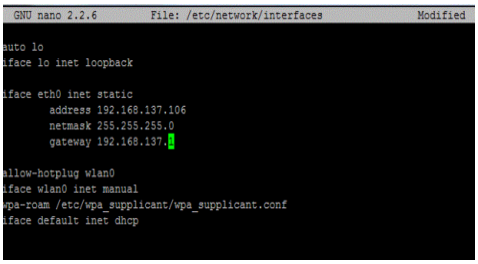

Fig. 2(c) Interfaces file

*B. **DHT 11 Sensor***

DHT 11 is a digital humidity temperature sensor which works on power supply of 3.3-5 volts. It provides high reliability and excellent long term stability. Fig. 3 shows DHT11 sensor with three pins that are: Power, Data, NC and Ground. This sensor has an NTC temperature measure component and a resistive type humidity measure component. It is smaller in size with low power consumption and has a range of 20 meters signal transmission. It provides humidity accuracy of ±5% RH and temperature accuracy of ±2ºC.

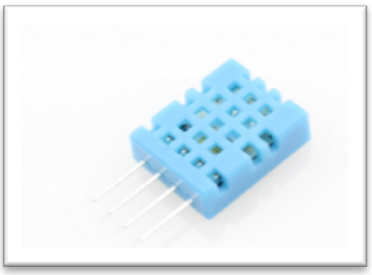

Fig. 3 DHT 11 Sensor

*C. **MQ135 Sensor***

MQ135 sensors are used to detect of NH3, NOx, alcohol, Benzene, smoke, CO2, etc. It operates on the voltage of 5volts and has heating voltage of 5 volts. It has adjustable load resistance and heating resistance of around 33Ω±5% . It has different concentration scope for different elements like 10ppm-300ppm for NH3, 10ppm-1000ppm for Benzene, 10ppm-300ppm for alcohol. This sensor has a layer of SnO2 which has less conductivity in clean air, its conductivity increases with the presence of alcohol, benzene, smoke and CO2. As shown in fig. 4 MQ135 has 4 pins: Ground, Power, Analog output, Digital Output. It has fast response and high sensitivity also it has stable and long life.

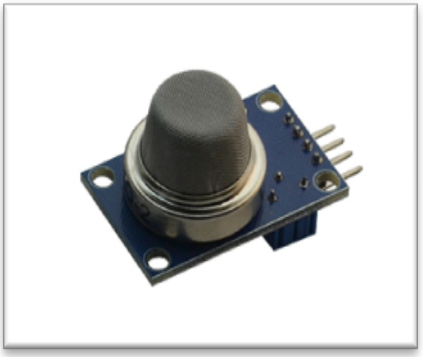

Fig. 4 MQ135 Sensor

D. *MQ7 Sensor*

MQ7 sensor is used to detect the carbon monoxide concentration in the atmosphere. It has high sensitivity towards carbon monoxide and has and stable and long life. It has operating and heating voltage of 5volts and an adjustable load resistance. It has heating resistance of 33Ω±5%. It has a detecting range of 20-2000ppm for carbon monoxide. It is an analog sensor. As shown in fig. 5 MQ7 sensor has 6 pins out of which 4 pins are used to fetch signal while 2 pins are used for providing current.

Fig. 5 MQ7 Sensor

E. *MCP3008*

The MCP3008 device is a successive approximation 10-bit analogue-to-digital converter. Communication with the devices is accomplished using a simple serial interface compatible with the SPI protocol. It is shown in Fig. 6.

MCP3008 has following features:

- 10-bit resolution
- ± 1 LSB max DNL
- ± 1 LSB max INL
- Analogue inputs programmable as single-ended or pseudo-differential pairs
- On-chip sample and hold
- Low power CMOS technology

It has following applications:

- Sensing & Instrumentation
- Signal Processing
- Automation & Process Control

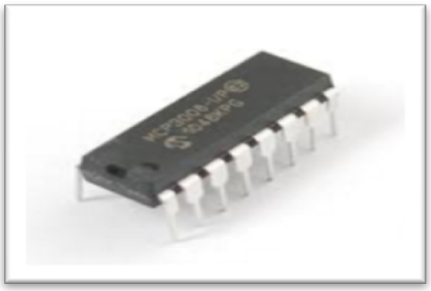

Fig. 6 MCP3008

F. *Internet Of Things*

The Internet of Things (loT) is implemented as a network of interconnected objects. Like vehicles, objects which are connected with sensors, electronics, software etc. IoT has various applications in the field of education, environment monitoring, home automation, security and emergencies, health care, automotive Industries, agriculture, etc. There are numbers of applications which can be developed with IoT. Cloud computing and network data-gathering of sensors are the main components of IoT. Through IoT various parameters can be monitored and controlled remotely.

IBM Bluemix is used as a platform to transmit sensor data to the cloud. IBM Bluemix is a cloud platform service developed by IBM which supports various programming languages like java, Node.js, Python, Ruby, PHP, etc. IBM Internet of Things Foundation use cloud services that allows the devices to transmit the data to the cloud. The devices send the data to the cloud using MQTT protocol.

For transmitting the data to the cloud following installation should be done on Raspberry Pi:

- Install Node.js on Raspberry Pi. Node.js platform is build on chrome JavaScript Runtime which is used to create fast and scalable network. It uses an event-driven, non-blocking input-output model which makes it suitable for real-time applications. It is an open-source, cross-platform runtime environment which is used for developing server-side and networking applications.
- Install Node-Red on Raspberry-Pi. Node-Red is a visual tool for wiring internet of things. It uses MQTT messaging protocol.
- Install Wiring-Pi on Raspberry.
- Install IoT cloud Dev application on Raspberry-Pi to enable cloud services.
- Get the MAC ID of Raspberry-Pi. Visualize graphical output on IBM Bluemix.

G. *Interfacing Sensors with Raspberry-Pi*

DHT 11 is a digital sensor, so it can be directly interfaced with Raspberry-Pi. As shown in fig. 7 power is connected to pin number 1 of Raspberry-Pi , Ground is connected to pin number 6 of Raspberry-Pi and Data is connected to pin number 7 of Raspberry-Pi which is a GPIO pin. A 10kohm resistor is connected between data pin and VCC of DHT 11 Sensor.

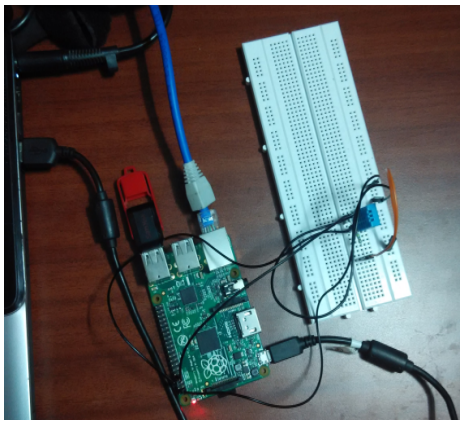

Fig. 7 Interfacing DHT 11 Sensor with Raspberry-Pi

MQ135 and MQ7 are analog sensors thus they are interfaced with MCP3008 ADC. As shown in fig. 8 MCP3008 ADC has 16 pins. VDD and VREF is interfaced with pin number 1 of Raspberry-Pi, Analog and Digital Ground is interfaced with pin number 6 of Raspberry-Pi. CLK, DOUT, DIN, CS is interfaced with pin number 23, 21, 19 and 24 respectively.

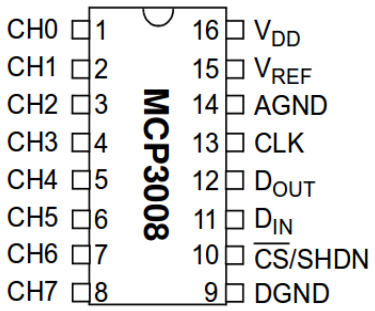

Fig. 8 MCP3008 Pin Diagram

MQ135 analog out pin is connected with channel 0 of ADC.

2 pins of MQ7 i.e. H are connected with ground and 5V of Raspberry-Pi for heating current. Pin B are connected to the channel 2 of ADC and 3.3 Volt of Raspberry-Pi via using a 10kohm resister. Pin A are connected to the ground of Raspberry-Pi. Fig. 9 shows the interfacing of Gas sensors with Raspberry-Pi.

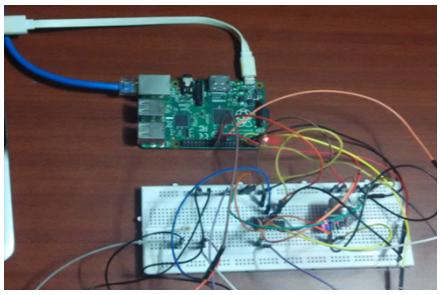

Fig. 9 Interfacing Gas Sensors with Raspberry-Pi

II. CONCLUSION

The proposed Environmental pollution Monitoring system is design in order to keep a track of environmental conditions so that solutions can be opted to minimize the hazards. The system is purely designed for the user's awareness about the surroundings. Fig. 10 shows the output of sensors on Raspberry Pi.

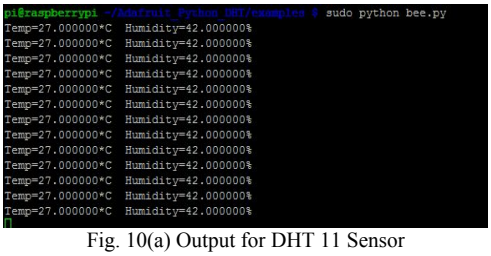

Fig. 10(a) Output for DHT 11 Sensor

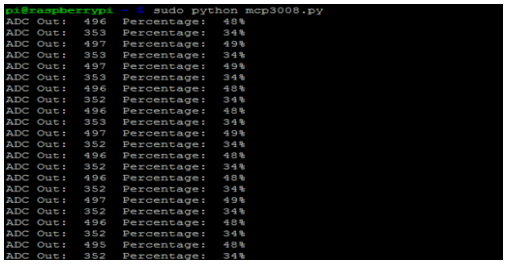

Fig. 10(b) Output for Gas Sensors

These sensors output is send to the cloud for the users to monitor the weather condition. Fig. 11 shows the graphical output on IBM Bluemix.

Fig. 11(a) DHT 11 Sensor Output on Cloud

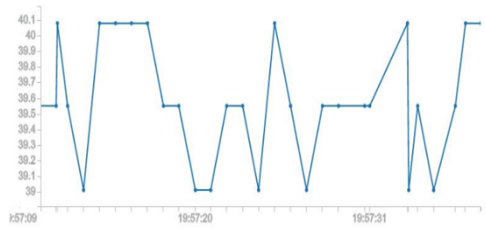

Fig. 11(b) Gas Sensors Output on Cloud

The proposed system uploads the live sensor values to the cloud i.e. it does not stores the value. The cloud service enables users to just view the sensor data not to store it. The system needs continuous wifi connectivity for its processing. If the wifi disconnects than the system will not work and the observed data will be lost, thus the data can be stored in the SD card so even if the internet gets disconnect the data will be saved and can be transmitted once the wifi works. Another extension to this system can be provided by adding GPS module to the system so that users may track the location of the sensors and can differentiate between the areas with different pollution level. The system has a limited coverage area i.e. it may not work beyond a distance. So, the area may be increased by using network of sensors.

The proposed system provides an easy solution for the users to monitor the environmental conditions.

REFERENCES

[1] Kuruvadi Praveen, Ankhit Bala Venkata, Rithesh M Nanda and Harshini H Kadakol; Modular Weather and Environment Monitoring Systems using Raspberry Pi. International Journal of Engineering Research & Technology (IJERT) **3**(9): 686-689 (2014)

[2] Mihai T. Lazarescu, Design of a WSN Platform for long term Environmental Monitoring for IoT Applications. IEEE Journal on Emerging And Selected Topics in Circuits and Systems **3**(1): 45-54 (2013).

[3] Sean Dieter Tebje Kelly, Nagender Kumar Suryadevara and Subhas Chandra Mukhopadhyay, Towards the implementation of IoT for Environmental Condition Monitoring in Homes. IEEE Sensors Journal **13**(10): 3846-3853 (2013).

[4] www.raspberrypi.org.

[5] Tharun Kumar Reddy, K., N. Kiran Kumar and G.N Kodanda Ramaiah, Design & Implementation of Remote Monitoring System for Measuring Green House Gas Emissions at Landfill sites and Industries using Raspberry Pi2. IOSR Journal of Electronics and Communication Engineering (IOSR-JECE) **10** (3): 92-96 (2015).

[6] Gaddam, A., M Al-Hrooby and W F Esmael, Designing a Wireless Sensors Network for Monitoring and Predicting Droughts. International Conference on Sensing Technology, September (2014).

[7] Aruljothi, R, Air Pollution Measuring System with Mobile Sensor Arrays. International Journal of Scientific & Engineering Research **4**(5): 911- 914 (2013).