Distributed Environmental Monitoring Using Wireless Sensor Network

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***Abstract*—**Today environment monitoring becomes important for humans to ensure a safe and wealthy life. Monitoring requirements are extremely different depending on the environment, leading to specially appointed usage that needs adaptability. The proposed system describes an implementation of Wireless Sensor Network that can be adjusted to various applications. And it also inserts the adaptability required to be conveyed and updated without necessity of arranging complex infrastructures. The solution is based on small autonomous wireless sensor nodes, small wireless receivers connected to the Internet, and a cloud architecture which provides data storage and delivery to remote clients. The solution permits supervisors on-site not only to monitor the current situation by using their smart-phones but also to monitor remote sites through the Internet. The proposed system is useful in predicting environmental condition like rain, also, to measure the temperature, humidity, and presence of CO gas.

Keywords*—Wireless sensor network; environmental monitoring; android application ;cloud server*

I. INTRODUCTION

The environmental care has become one of the biggest concerns for almost every country in the last few years. Even though the industrialization level has been increasing without any control in the last decades, the current situation is clearly changing towards more environmentally friendly solutions. Water and air quality are essential to maintain the equilibrium between human development and a healthy environment. It is also important to notice that by means of looking for a more efficient production in factories both pollution and consumption of natural resources can be decreased. Processes, such as boiling, drying, binding, and so forth, are being carried out by almost every kind of the current factories. Those processes are responsible of a great amount of gas emissions and polluted water discharges. Although the majority of the factories have their own sewage plants, it is crucial to measure the quality of the waste water that is being poured into the public sewer.

In reality, clean air is a basic requirement for daily life. Air pollution affects human health and considered as a major serious problem globally, especially in countries where gas and oil industries are ubiquitous. According to the United States Environmental Protection Agency (USEPA), the air quality is characterized by measuring certain gases that affect the human health, which are: carbon monoxide (CO), ground-level ozone (O3), and hydrogen sulfide (H2S).

The main intention of environmental monitoring is not only to gather data from a number of locations, but also to provide the information required by scientists, planners, and policy-makers, to enable those making decisions on managing and improving the environment, in addition to presenting helpful information to end-users. There are huge efforts are carried out to improve the air quality in both environments: indoors and outdoors. Habitat and environmental monitoring represent an important class of sensor network applications. Recent advances in low-power wireless network technology have created the technical conditions to build multi-functional tiny sensor devices, which can be used to sense and observe physical phenomena. Wireless Sensor Networks (WSNs) are currently an active research area due to their wide range applications including military, medical, environmental monitoring, safety, and civilian. Many environmental monitoring examples of WSNs are already presented in the literature and developed for different purposes.

Environmental monitoring needs some technical requirements such as high level of system integration, performance, reliability, productivity, accuracy, robustness, flexibility etc. and WSN technology provides reliable solution. Since WSN technology introduced a low-cost, low-power featured hardware consisting of rich microcontrollers, storage memory, power supply, single chip radio transceivers, one or more sensors and in some cases an actuator.

II. PROBLEM STATEMENT

Existing ad hoc network implementations are complex, costlier and lack flexibility due to requirement of monitoring equipment that are different depending on the surrounding environment. Therefore, a system is proposed to design a low cost wireless sensor network to measure temperature and relative humidity, to detect rain and the presence of CO gas. Anyhow, the node hardware can be easily arranged to detect also many different environmental conditions, thus, making the system flexible.

III. OBJECTIVE AND SCOPE

- To design 3 wireless sensor nodes.
- To update the sensor value on the server in real time.

- To monitor environmental conditions like temperature, humidity, to detect rainfall.
- To alert authorized people about increasing level of carbon monoxide gas.
- To predict the weather condition based on the temperature and humidity values and update it on the server.
- To develop an android application.
- To add support of Google Assistant.

IV. PROPOSED SYSTEM

For determining temperature and humidity of atmosphere we are using DHT11 sensor which will help in predicting weather condition. MQ-7 sensor is used for detecting Carbon Monoxide in environment, whereas FC37 sensor is used for detection of rain. The system is placed in 3 different locations and data from each location is collected by the server as shown in figure. The server stores and displays the current values of all 4 parameters. A look up table is generated which contains the values of temperature and humidity and is used for predicting the current environmental conditions like if humidity is more and temperature is less then there is a chance of rain. Data from all 3 nodes is updated on servers as well as in Android App. User can access this data using authorized login ID and password. User can also access this data through Google Assistant.

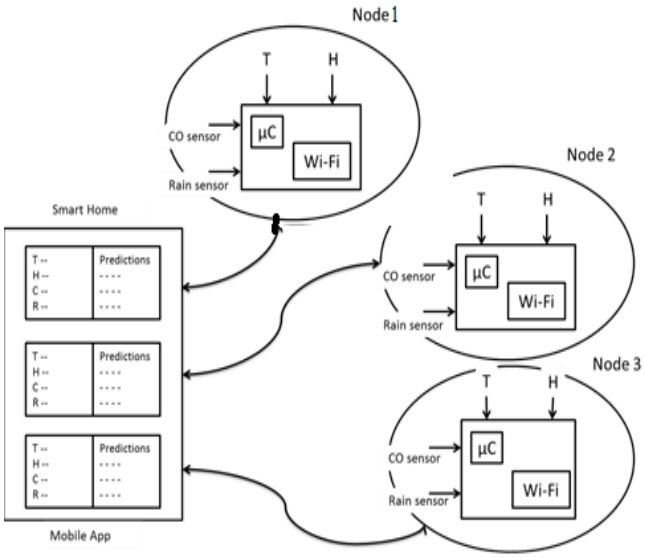

Fig. 1 Schematic of Proposed System

V. SYSTEM REQUIREMENTS

A. NodeMCU

There have been many different ESP modules over the years, each with their own advantages and drawbacks. There have been just two types of NodeMCU boards, however: versions 0.9 and 1.0. The 0.9 version is blue and comes loaded with the ESP-12 chip, while the 1.0 is black, and comes with the ESP-12E (which stands for 'enhanced'). There are several key differences between the two chips, the most notable being that the later version comes with 22 pins and the earlier one comes with just 16. Given that the ESP8266 is a more recent release than the Arduino, it's not surprising that it has stronger specs. There's a 32-bit RISC processor clocked at 80MHz, along with a generous RAM complement and support for up to 16mb of external flash storage. The device is especially useful for IoT applications, thanks to its tiny footprint and built-in WiFi support. In all other aspects, however, the ESP is pretty much similar to the Arduino. There's an on-board voltage regulator that ensures the cleanest possible power to the MCU itself, as well as a push-button reset and a USB connection for easy interface with your computer.

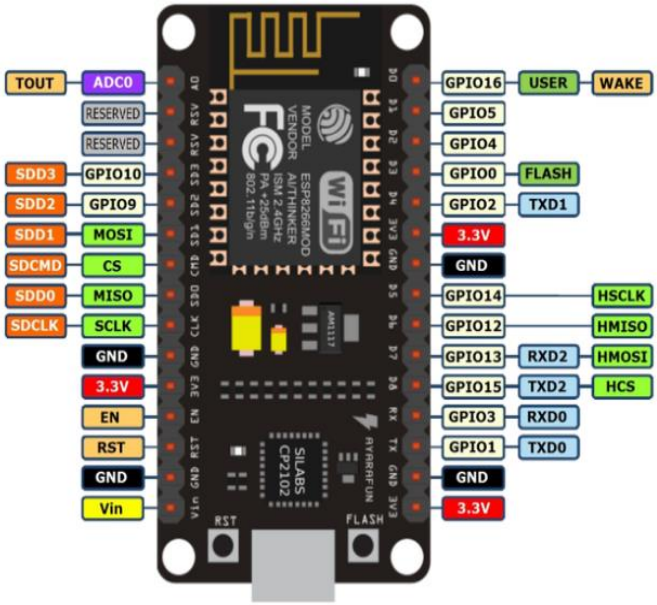

Fig. 2 NodeMCU Board

B. DHT11

The DHT11 humidity and temperature sensor makes it really easy to add humidity and temperature data to your DIY electronics projects. It's perfect for remote weather stations, home environmental control systems, and farm or garden monitoring systems. DHT11 Temperature and Humidity Sensor features a temperature and humidity sensor complex with a calibrated digital signal output. By using the exclusive digital-signal-acquisition technique and temperature and humidity sensing technology, it ensures high reliability and excellent long-term stability. This sensor includes a resistive-type humidity measurement component and an NTC temperature measurement component, and connects to a highperformance 8-bit microcontroller, offering excellent quality, fast response, anti-interference ability and cost-effectiveness.

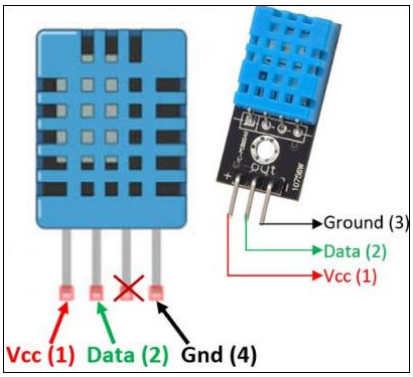

Fig. 3 DHT11 Sensor

C. FC-37

The rain sensor module (FC-37) is an easy tool for rain detection. It can be used as a switch when raindrop falls through the raining board and also for measuring rainfall intensity. The module features, a rain board and the control board that is separate for more convenience, power indicator LED and an adjustable sensitivity through a potentiometer. The analog output is used in detection of drops in the amount of rainfall. Connected to 5V power supply, the LED will turn on when induction board has no rain drop, and D0 output is high. When dropping a little amount water, D0 output is low, the switch indicator will turn on. Brush off the water droplets, and when restored to the initial state, outputs high level.

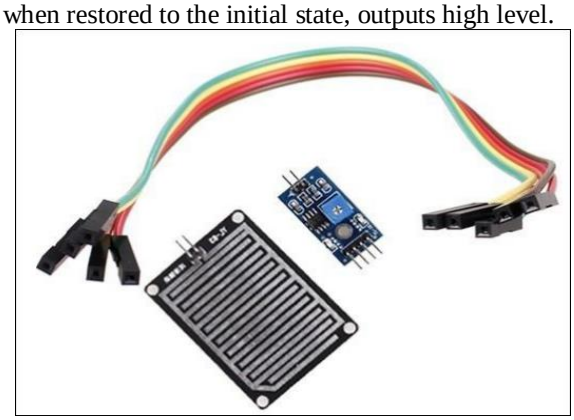

Fig. 4 FC-37 Sensor

D. MQ-7

The MQ-7 is a simple-to-use Carbon monoxide (CO) sensor suitable for sensing CO concentrations in the air. It can detect CO gas concentrations anywhere upto 2000ppm. This sensor has a high sensitivity and fast response time. The sensor's output is an analog resistance. The sensor's conductivity gets higher along with the CO gas concentration rising. At high temperature of the sensor, it cleans the other gases adsorbed at low temperature. The change of conductivity is converted to the corresponding output signal of gas concentration through a simple circuit.

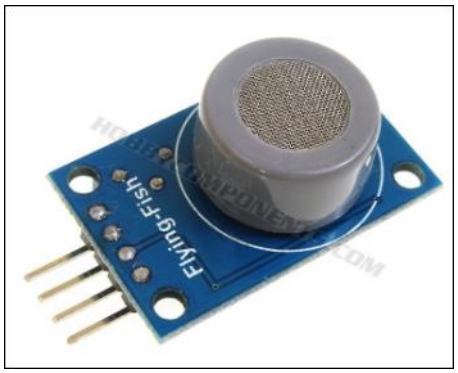

Fig. 5 MQ-7 Sensor

E. Battery

The nine-volt battery, or 9-volt battery, is a common size of battery that was introduced for the early transistor radios. It has a rectangular prism shape with rounded edges and a polarized snap connector at the top. This type is commonly used in walkie-talkies, clocks and smoke detectors. The nine-volt battery format is commonly available in primary carbon-zinc and alkaline chemistry, in primary lithium iron disulfide, and in rechargeable form in nickel-cadmium, nickel-metal hydride and lithium-ion.

F. Firebase and Ubidots

Firebase is a technology that allows you to make web applications with no server-side programming so that development turns out to be quicker and easier. It supports the web, iOS, OS X, and Android clients. Applications using Firebase can just utilize and control information, without thinking about how information would be put away, and synchronized crosswise over different examples of the application in real time.

Ubidots offers a platform for developers that enables them to easily capture sensor data and turn it into useful information. Use the Ubidots platform to send data to the cloud from any Internet-enabled device. You can then Configure actions and alerts based on your real-time data and unlock the value of your data through visual tools.

G. Arduino IDE

The Arduino integrated development environment (IDE) is a cross-platform application (for Windows, macOS, Linux) that is written in the programming language Java. It is used to write and upload programs to Arduino compatible boards, but also, with the help of 3rd party cores, other vendor development boards.

H. MIT App Inventor 2

MIT App Inventor 2 for Android is an open-source web application originally provided by Google, and now maintained by the Massachusetts Institute of Technology (MIT), which allows newcomers to computer programming to create software applications for the Android operating system (OS). It uses a graphical interface very similar to Scratch and the StarLogo TNG user interface, which allows users to drag-and-drop visual objects to create an application that can run on

Android devices. In creating App Inventor, Google drew upon significant prior research in educational computing, as well as work done within Google on online development environments.

I. *Dialogflow*

Dialogflow (formerly Api.ai, Speaktoit) is a Google-owned developer of human–computer interaction technologies based on natural language conversations. It gives users new ways to interact with their product by building engaging voice and text-based conversational interfaces, such as voice apps and chatbots, powered by AI. Connect with users on your website, mobile app, the Google Assistant, Amazon Alexa, Facebook Messenger, and other popular platforms and devices. It is a Google service that runs on Google Cloud Platform, letting you scale to hundreds of millions of users. It incorporates Google's machine learning expertise and products such as Google Cloud Speech-to-Text. It is user-friendly, intuitive, and just makes sense.

VI. FLOW CHART

The below flow chart shows the graphical representation of the workflow of the proposed system. The proposed system uses 3 nodes which are identical to one another. The below flow chart shows the workflow for any one node and the workflow for other 2 nodes will be the same.

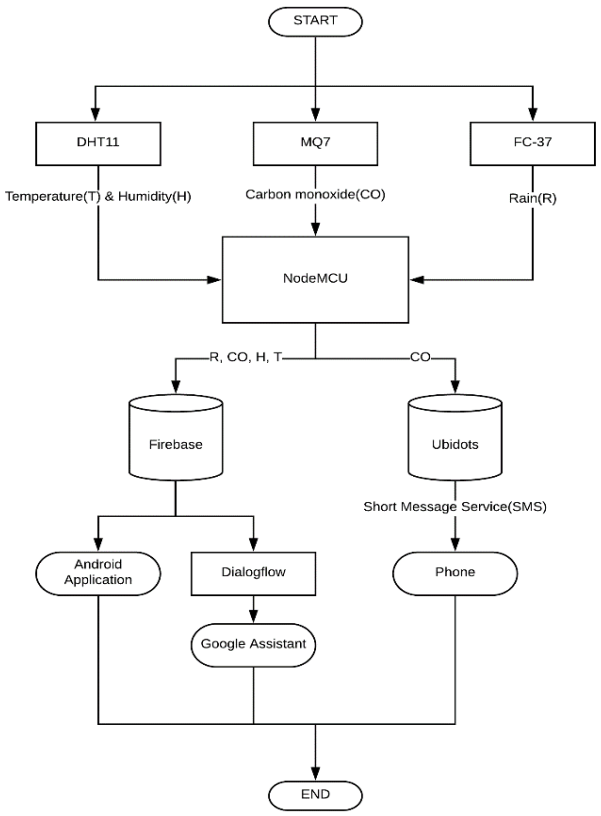

Fig. 6 Flow Chart

VII. RESULTS

A. *Designed 3 WSN nodes*

Successfully designed 3 WSN nodes. Each node comprises of a NodeMCU, a DHT11 sensor, a MQ-7 sensor, a FC-37 sensor and a battery.

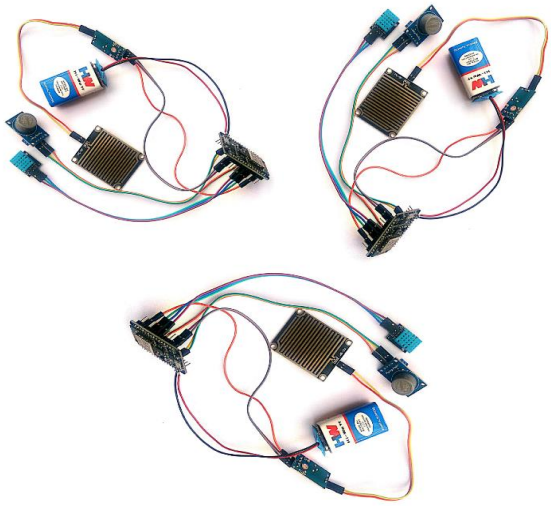

Fig. 7 3 WSN Nodes

B. *Developed an Android Application*

Successfully developed an android application named "eWeather" which is integrated to the firebase server. When user opens this app, the very first thing he sees is a login screen. To monitor the environmental conditions of the 3 nodes, the user must have to login with authorized email ID and password. To be able to login successfully, the entered email ID and password should match with the email ID and password stored on the firebase server. If it is not matched, the app shows an error. Once successfully logged in, the home screen is appeared showing the environmental conditions.

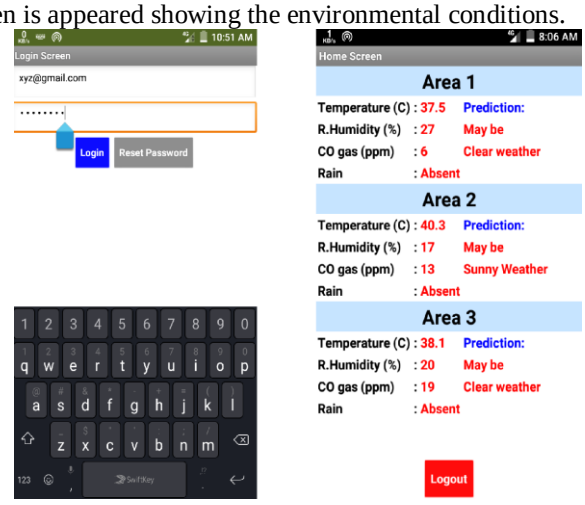

Fig. 8 Login Screen and Home Screen of Android Application

C. *Added support of Google Assistant*

Successfully added the support of Google Assistant. Once the user opens Google Assistant, he has to speak "I want to talk to my test app" or just "talk to my test app" to open the Google Assistant test app. From here, the Google Assitant responses to the user queries. I have created 3 user queries. For a query by the phrase "get me the details of surrounding 2", for which the Google Assistant responses with the data collected by node 2. Similarly, for other 2 queries, the Google Assistant responses with the data collected by the respective nodes.

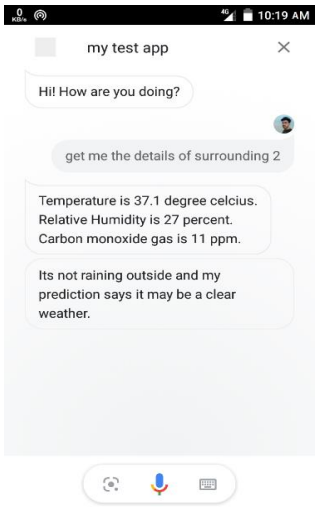

Fig. 9 Support of Google Assistant

D. *Sending SMS as an alert to the user*

If the level of CO gas is increased, a SMS is sent to the user's mobile number alerting him that there is an increase in CO gas level. This is done by using the Ubidots server. There are 3 different messages for 3 different nodes mentioning the increase in CO gas level in that particular area where the respective nodes are placed.

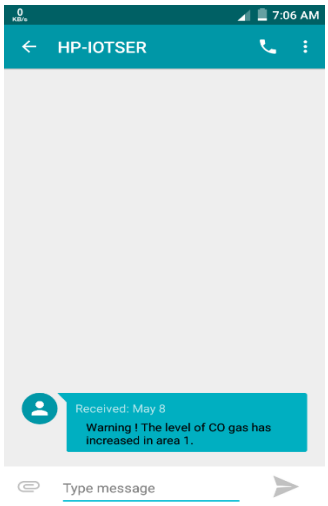

Fig. 10 SMS sent to user's mobile number

VIII. CONCLUSION

Environmental monitoring is a tricky activity as the environmental conditions can easily change from point to point even at small distances. This is especially true inside buildings where temperature, humidity, and pollutants can be different not only in different rooms but also within the same room especially when showcases and closed furniture are used. While several architectures have been proposed that can manage many sensing nodes, often there is low attention given to its flexibility and also they are quite costly. Therefore, the components developed within the framework described in this work is designed flexible enough to adapt to the change in different environmental parameters. It is a simpler system with minimal cost which uses battery-operated sensors equipped with a wireless transmission protocol, which ensures realtime monitoring. The system is user-friendly as it has support of Google Assitant and an android application is developed which acts as a Graphical User Interface (GUI) which is able to prevent unauthorized access.

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