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IoT based Smart Environmental Monitoring using Wireless Sensor Networks and Raspberry Pi

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Abstract: In this paper we developed an IoT based environment monitoring system using the WSN technology. The main objective of the system is to provide environmental parameters at remote location using internet. This proposed system represents the environmental parameter monitoring using wireless sensors connected to the Internet. Raspberry pi is cheap, flexible and programmable small computer embedded linux board. Different sensors are connected to raspberry pi and it works as sensor node of the system. There are two different sensor nodes in the system.
The measured data can be monitored via the Web application by the user from anywhere on the Internet. If the sensor node data exceeds the configured value range in the Web Application, Web Application sends a warning message to users to improve environmental conditions.
Keywords: Internet of Things (IoT), Wireless Sensor Network, Raspberry pi, Energy Harvesting, IEEE 802.11.

I. INTRODUCTION

It is essential to track the variation of the environmental parameters to determine the quality of our environment. The most frequently monitored parameters include temperature, humidity, rainfall, atmospheric pressure, light intensity, air quality, and pollutants such as CO2, CO, SOx, volatile organic compounds and many others. One of the immediate benefits brought by the acquisition of such physical proprieties, like soil moisture, temperature, and salinity, can be seen in agriculture, where significant water resource savings can be achieved[9].The collected data encompass important details for a variety of organizations and agencies. With monitoring results, governments can make informed decisions about the impact of the environment on society and how society affects the environment.

Wireless sensor networks (WSNs) are becoming a global technology resulting from the development of low cost and low power wireless technology. WSNs are a group of spatially distributed sensing nodes with low maintenance requirements that can automatically monitor environmental parameters and transfer data to a main database via wireless networking through a gateway.

There are a number of applications for WSN. Most monitoring applications rely on WSNs, which have the unquestionable advantages: lower costs due to cable replacement, variable network topologies, scalability and lower maintenance. Wireless sensors and sensor networks have been used successfully in the implementation of solutions in various fields, including environmental monitoring, natural disaster prevention, and current consumption monitoring in large buildings, radiology monitoring systems for medical applications, location tracking [2].

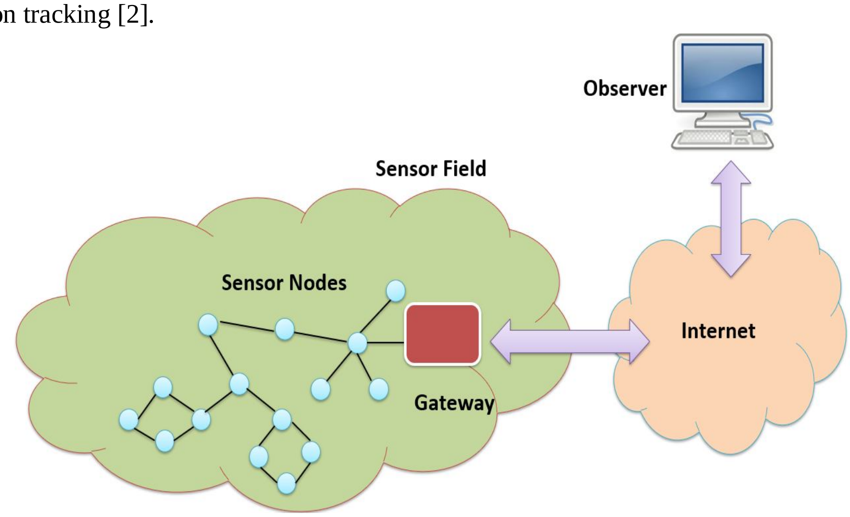

Fig.1. Wireless Sensor Networks

Minimizing energy consumption and prolonging network lifetime have become primal design goals of next-generation wireless networks, merely due to limited power resources of wireless devices [5]. From fig1, since the wireless sensor networks consist of tiny hungry energy sensor nodes, it is a difficult process to maintain the energy level of these nodes for a long period of time. The wireless sensor networks consist of small sensors used to monitor or detect data. Because of their small size, power supply is provided by a small battery, which, when deployed in a 'not-easily reachable' place, cannot be replaced or recharged frequently [2]. Energy efficiency is therefore one of the principal constraints of the wireless sensor network.

The most widely used protocols in applications such as environmental monitoring, consist of ZigBee (IEEE 802.15.4) [3], Wi-Fi (based on IEEE 802.11) [2], and Bluetooth (IEEE 802.15.1) [2]. Being based on IEEE 802.15.4, a standard that offers low costs and low power at low data rates, ZigBee is extensively used in a wide range of monitoring and control application that require wireless connectivity. These solutions require additional hardware for packaging data and for transmitting them to the Internet. Wi-Fi is a popular networking technology based on the IEEE 802.11 set of standards that offers higher transmission range and throughput compared to IEEE 802.15.4, with the cost of higher energy consumption.

II. RELATED WORKS

The literature has reported a great number of research efforts to achieve monitoring applications using wireless sensors.

George Moise and Silviu Folea[2] This paper analyzes the significant differences and similarities between three different IoT-based wireless sen-sors for environmental and environmental monitoring: one using Wi - Fi communications based on the User Datagram Protocol (UDP), one via the Wi - Fi and Hypertext Transfer Protocol (HTTP) and one using Bluetooth Smart. The results show that Wi - Fi and BLE are two technologies which can compete with the widely used ZigBee protocol for monitoring applications.

Sudhir Nikhade[3] Proposes a wireless sensor network system that is developed with open source hardware platforms, Raspberry Pi and zigbee. This system is suitable for a wide range of environmental monitoring applications. Raspberry Pi as the base station, XBee as a networking protocol and a number of open source software packages are used for this system

Rohini Shet[4] Proposed paper mainly on a stand-alone system that provides a dynamic datasheet of the city environment parameters. The system uses a low - cost ARM - based mini-computer called Raspberry Pi. It can communicate via the Local Area Network (LAN) or through the external Wi - Fi.

Bassem Khalfi and Bechir Hamdaoui[5] The focus of this paper is on radio frequency (RF) energy harvesting for mobile wireless multiuser multicarrier networks. In particular, joint data and energy transfer optimization frameworks are developed to power mobile wireless devices through the use of RF energy. For each user, two types of harvesting capabilities are considered, one only harvests from dedicated RF signals. Another is hybrid retrieval from both dedicated and environmental RF signals.

Jalpa Shah[6] Presents a customized design of an environment monitoring system for the Internet of Things (IoT) for temperature, humidity and CO 2. Data is sent from the transmitter node to the receiver node in the developed system. The data received at the receiver node is monitored and recorded via a graphical user interface (GUI) in an excel sheet on a personal computer (PC) made in Lab VIEW. An Android application has also been developed to transfer data from Lab VIEW to a smartphone for remote data monitoring.

Raj Jain[7] Presents paper a case study of smart environment based on real time data collected by the city of Aarhus, Denmark. They analyzed the air pollution levels in order to detect unhealthy or anomalous locations based on the Air Quality Index (AQI). Machine learning framework for both binary and multi-class problems, namely neural network, neuro-fuzzy method and support vector machines, has been used to detect anomalous locations in the pollution database. MATLAB simulation results show that machine learning techniques are reliable in terms of accuracy and time-consuming for intelligent environments.

Ana Filipa and Octivian Postolache[8] This paper proposes an indoor or outdoor air quality monitoring web information system and a wireless sensor network. Two different smart coordinator architectures based on a Raspberry Pi, with and without a Jenni embedded computer and wireless network coordinator Ethernet border router, have been implemented.

III.OVERALL SYSTEM ARCHITECTURE

The wireless senor network system requires many hardware and software components to be developed and integrated. Figure 2 shows the overall system architecture of environmental monitoring WSN system. This system consists of raspberry pi as a sensor node controller [1]. Each sensor node is a combination of sensors, raspberry pi and Wi - Fi (based on IEEE 802.11). The sensor node is primarily responsible for the collection and distribution of information or sensor data. In this system architecture, we have combined the wireless sensor network gateway node into a single board computer (raspberry pi) hardware platform that reduces deployment costs and complexity.

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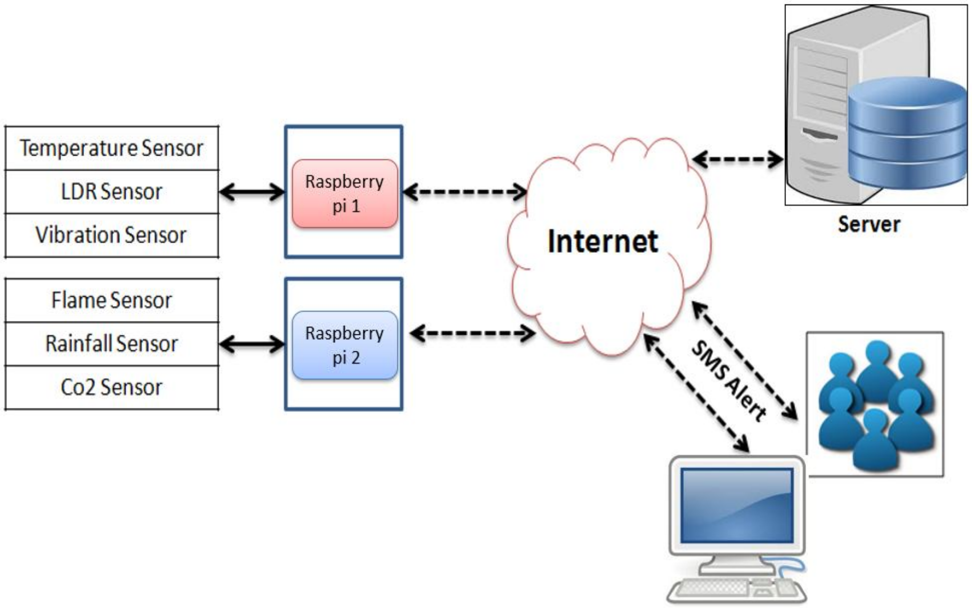

Fig.2. Overall System Architecture

A. System hardware design

1) *Raspberry Pi:* The raspberry pi is a low cost, low power credit size single board computer which has recently become very popular[1]. Raspberry pi is the cheapest Linux operating system powered by ARM11 capable of a single board computer. This board runs an ARM11 @ 700 MHz microcontrollers and has 1 GB RAM memory. Raspberry pi3 model B is used in this paper as shown in figure 3, because this model has better specifications than other raspberry pi models. It supports a number of operating systems including a Raspbian that is recommended for use in our design by the raspberry pi foundation. Raspberry Pi can be connected to the internet via Wi-Fi connected to the raspberry pi 3 system. It also includes 4 USB ports and an Ethernet port. An external SD or micro SD card boots the raspberry pi.

Fig.3. Raspberry pi 3 model B

2) *WI-FI Standard:* Wi-Fi is the name given to the IEEE 802.11 standard suite by the Wi-Fi Alliance. 802.11 defined the initial Wireless Local Area Networks (WLAN) standard. Basically, Wi-Fi means the transmission of radio signals. Wi-Fi, like Ethernet, is a physical link layer interface.

3) *Sensors:* To monitor temperature, daylight, earthquake and environmental changes in real time, the system uses six sensors such as temperature, light intensity, rain, earthquake, CO2 and fire. These sensors monitor the parameters of the environment and pass to raspberry pi. If the parameter value exceeds the threshold, the system sends a warning to the rand to treat it appropriately.

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IV. EXPERIMENTAL SET UP AND RESULTS

A. Web Application

For monitoring the environment parameters by the user via internet a web application has been developed. The application is developed with JAVA programming language and its database has developed with MySQL. It is simple and easy to use application. The first page of application is for user login as shown in fig 4.

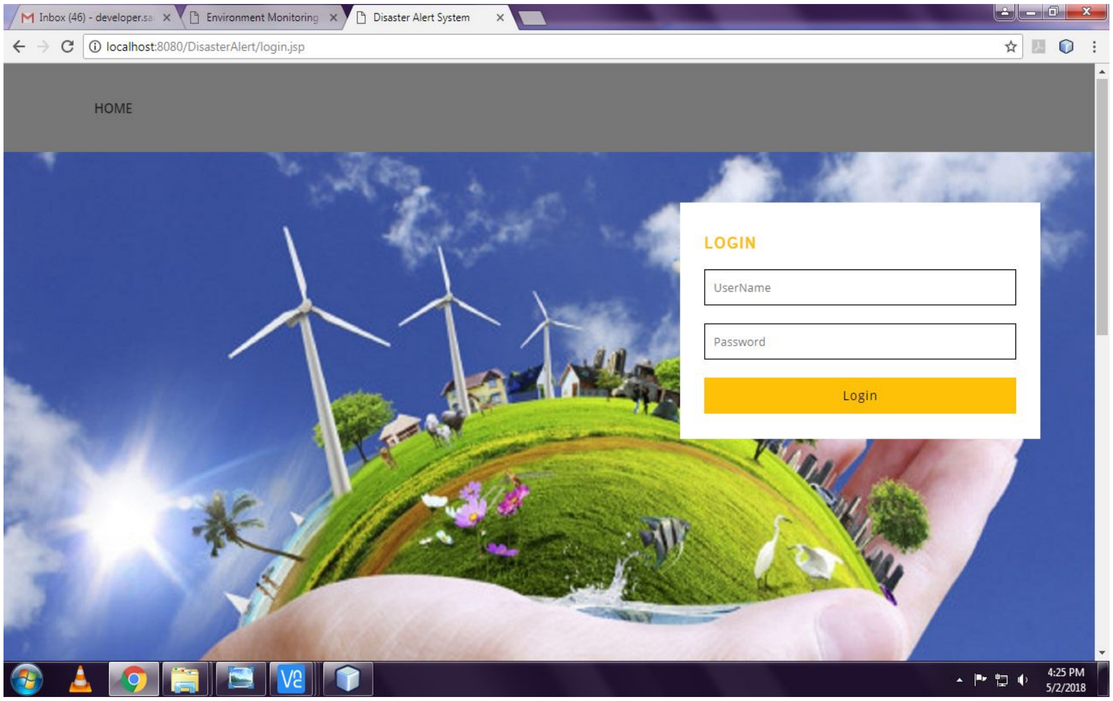

Fig.4. First page of WEB Application

B. Experimental Set up and Results

There are two sensor nodes each with connected three sensors. First raspberry pi has temperature, fire and CO_2 sensor. And the second raspberry pi has rain, earthquake and LDR sensor. These two wireless sensor nodes transmit their data from remote location to the end user. These two sensor nodes are shown in fig 5.

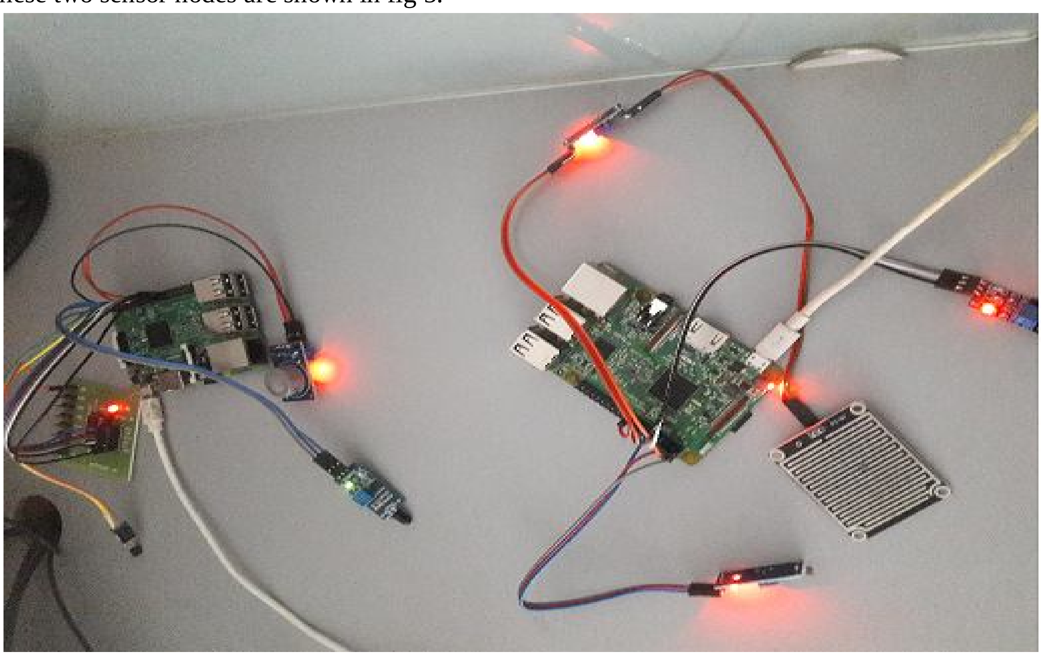

Fig.5. Two Wireless Sensor Nodes

The sensors results are displayed on web application. The application first must be configured therefore it has to be given the message to improve environmental conditions if the sensor sends data out of range. The results of two sensor nodes are displayed on separate web page as shown in fig 6.

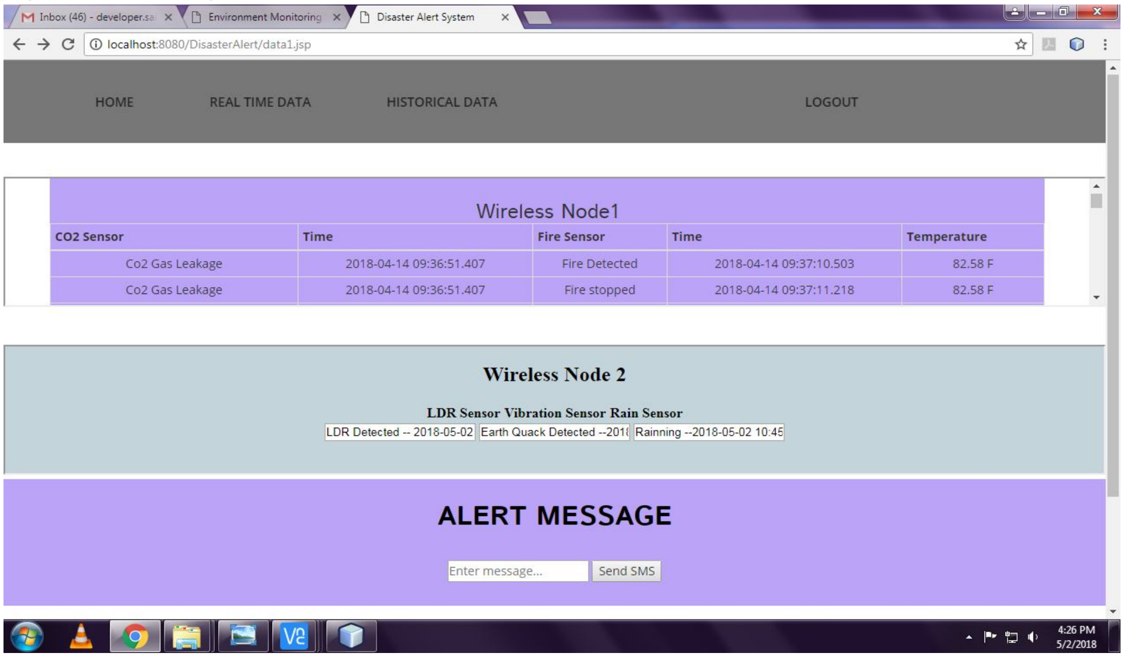

Fig.5. Results of Two Wireless Sensor Nodes

V. CONCLUSIONS

This paper designs a wireless sensor system that uses raspberry pi as a sensor node and Wi-Fi as a networking protocol. The IoT system can be used for remote monitoring of weather parameters such as daylight, temperature, earthquake, rain, etc. The data can be stored online, which can be used for weather forecasting and analysis of climate patterns and other meteorological purposes. All aspects of the WSN Platform are considered and discussed are Platform structure, flexibility and reusability, optimization of the sensor and gateway nodes. However, it is increasingly difficult to define common requirements for the WSN nodes and platforms due to the wider range of applications.

This basic design can be extended and modified suitably to realize other IoT applications as well.

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