© 2018 IJSRST | Volume 4 | Issue 2 | Print ISSN: 2395-6011 | Online ISSN: 2395-602X
Themed Section: Science and Technology

Implementation of Internet of Thing of Geological Co2 Storage and Leakage Detection

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ABSTRACT

A remote online carbon dioxide (CO2) concentration monitoring system is developed, based on the technologies of wireless sensor networks, in allusion to the gas leakage monitoring requirement for CO2 capture and storage. The remote online CO2 monitoring system consists of monitoring equipment, a data center server, and the clients. The monitoring equipment is composed of a central processing unit (CPU), air environment sensors array, global positioning system (GPS) receiver module, secure digital memory card (SD) storage module, liquid crystal display (LCD) module, and general packet radio service (GPRS) wireless transmission module. The sensors array of CO2, temperature, humidity, and light intensity are used to collect data and the GPS receiver module is adopted to collect location and time information. The CPU automatically stores the collected data in the SD card data storage module and displays them on the LCD display module in real-time. Afterwards, the GPRS module continuously wirelessly transmits the collected information to the data center server. The online monitoring WebGIS clients are developed using a PHP programming language, which runs on the Apache web server. MySQL is utilized as the database because of its speed and reliability, and the stunning cross browser web maps are created, optimized, and deployed with the Open Layers JavaScript web-mapping library. Finally, an experiment executed in Xuzhou city, Jiangsu province, China is introduced to demonstrate the implementation and application.

Keywords: CO2 capture and storage (CSS), general packet radio service (GPRS), global positioning system (GPS), remote online leakage monitoring, wireless sensor networks (WSN)

I. INTRODUCTION

ATMOSPHERIC concentrations of the key greenhouse gas(GHG) carbon dioxide (CO2*)* well above pre-industrial levels constitute the main cause for the predicted rise at average surface temperature on Earth and the corresponding change of the global climate system [1]. CO2 Capture and Storage (CCS) is on the one hand an effective way to realize effective greenhouse gas storage, and on the other to improve oil and gas production [2]. Many countries such as the United States, Japan, and Canada are in search of effective approaches for CO2 storage in either geological formations or ocean. In China, the first demonstrative industrial project of CO2 storage has come into operation in Shenhua mine area. However, once CO2 leaks from the storage reservoir, all the efforts human beings have made to fight global warming would be go down the drain. Therefore, what is in needed after the geological CO2 storage is long-term terrain monitoring of the greenhouse gas leakage, which is absolutely crucial to help ensure that geologic sequestration of CO2 is safe. For this reason, the development of remote online monitoring system is of great significance to geological CO2 storage and leakage warning.

Recent advances in information and communication technologies have resulted in the development of more

efficient, low cost and multi-functional sensors. These micro-sensors can be deployed in wireless sensor networks (WSN) to monitor and collect air environmental information such asCO2 concentration, temperature, humidity, light intensity, air pressure, wind power, wind direction, etc. The information is then wirelessly transmitted to data centre server where they are integrated and analysed for evaluating of geologicalCO2 storage and leakage. Deploying sensor networks allows inaccessible areas to be covered by minimizing the sensing costs compared with the use of separate sensors to completely cover the same area.
The remainder of this paper is as follows. Section 2 presents the backgrounds of CCS leakage monitoring based on WSN and their related issues. Section 3 describes the hardware infrastructure of CO2 leakage monitoring equipment and different sensors and modules selected. Section 4 demonstrates the firmware flow of CO2 remote online monitoring system. In section 5, the implementation and application example is presented. Finally, section 6 is the conclusion of the paper and new avenues for the future works are put forward in this part.

II. LITERATURE REVIEW

Bob van der Zwaan, Reyer Gerlagh, Koen Smekens "Geological CO2 Storage and Leakage" Conference on the Economics of Climate Change and Sustainable Development Chia (Sardegna), Italy 27-28 September 2007

Observations from engineered and natural analogues as well as models suggest that the fraction retained in appropriately selected and managed geological reservoirs is very likely to exceed 99% over 100 years and is likely to exceed 99% over 1000 years." Today, our natural scientific understanding of geological CO2 migration and leakage processes is limited, and values of possible leakage rates only speculative. Cap rock integrity seems essential. MARKAL: A CO2 leakage rate of up to 0.5 %/yr is allowable from an overall energy system cost minimization point of view. DEMETER: CCS with CO2 leakage of even a few %/yr possesses non-negligible economic and climatic control value. In both cases, economically and climatically acceptable leakage rates are well above our current geo-scientific speculations. Hence, from a combined economic-climatic point of view at least, there seems today little urgency to increase our natural scientific understanding of possible leakage rates. But, of course, for other reasons increasing our understanding of geological CO2 leakage remains very important.

Aldo Annunziatellis, Stefano Graziani, Salvatore Lombardi, Chiara Petrioli, Roberto Petroccia "CO2Net: A marine monitoring system for CO2 leakage detection" ©2011 IEEE

Underwater oil and gas extraction and distribution, as well as the investigation of solutions for CO2 storage underwater, demand for new technologies to perform pervasive real life monitoring and control of underwater critical infrastructures. In this paper we present a system, named CO2Net, we have developed to perform accurate real-life monitoring of underwater CO2 storage infrastructures. The basic component of our system is the CO2Probe, a new underwater monitoring node which combines sensing, acoustic communications and networking capabilities. CO2Probes are connected via acoustic links in an underwater sensor network which provides robust, real-life communications of the monitored data both in single-hop and multi-hop deployments. The user has a real-time control on the monitoring system, being able to change alarm threshold values and sampling rates. The proposed CO2Net approach overcomes the major limitations of system currently available on the market, and provides a first easy to use, flexible and easy to extend, complete monitoring system for underwater infrastructures, based on the emerging underwater sensor networking paradigm. A first prototype of CO2Net has been tested during summer-fall 2011 at the NATO Undersea Research Centre (NURC) in La Spezia. Results of these experiments confirm system reliability, and its adaptability: all requested data where provided in real-time, the system was remotely accessible and end user could change monitoring parameters.

We have investigated the design of a new underwater monitoring node which combines different sensors (temperature and concentration of methane and CO2 dissolved in water) with communications and networking capabilities. Acoustic communications are used for remote control of the system and real-time data gathering without the need of cables, thus overcoming some of the major limitations of monitoring systems currently available on the market. Underwater nodes can organize themselves into a network and interact using

acoustic links (in a single-hop or multi-hop way) with the onshore control station. A complete protocol stack has been implemented allowing the nodes to acquire the underwater channel and to route data and control information to the network sink(s). The proposed system has been tested and evaluated in summer-fall 2011 at NURC presenting good results and performance in terms of accuracy and reliability of both data acquisition and system operations. CO2Net builds on a flexible powerful framework which can be applied to several monitoring scenarios, and can be easily extended with additional sensors or be ported to different platforms. To exploit at best this flexibility current work is addressing integration of additional sensors and porting of our solution on underwater mobile vehicles.

Suganya.R, Suseendhar.P "Online Monitoring of Green House Gas Leakage in Industries" IJREAT International Journal of Research in Engineering & Advanced Technology, Volume 1, Issue 6, Dec-Jan,2014

In recent years, there are so many industries emitting the green house gases (GHG) which affect the human beings. The most harmful gases among all of them are CO2, methane gas, NO2, etc. So it is necessary to monitor these gases that leaks from industries through online. This system is developed to monitor the green house gas leakage such as CO2, NO2, humidity and temperature from industries by its corresponding sensors interfaced with the ARM7 controller. LM35 temperature sensor is used. LED is used to indicate the emission level. LCD is used to display the constituents of gases and temperature. Relay is used to shut down the power supply for industries. GSM is used to communicate with the server to convey the emission level. Virtual terminal is connected with the controller in the simulation output. The system is user friendly. The proposed system which is designed shows the simulation output of sensing the CO2 gas, NO2 gas, temperature and humidity in the industry environment. LED is used instead of buzzer. When the criterion level exceeds the controller will induce the LED to glow. If it glows, the motor will be stopped. Later if the emission gets reduced the LED will gets off and the motor starts. By using Proteus and Keil software we saw the simulation output. Embedded C language is used for programming the concept. In future, hardware implementation can be done. By having criteria for the level of gases emitted from the industries, the ARM controller will indicate an alarm through buzzer to reduce the emission.

Huan Hui Yan, Yusnita Rahayu "Design and Development of Gas Leakage Monitoring System using Arduino and ZigBee" Proceeding of International Conference on Electrical Engineering, Computer Science and Informatics (EECSI 2014), Yogyakarta, Indonesia, 20-21 August 2014

Gas leakage in industrial area causes many health issues. Thus, to prevent such disasters happen, the atmosphere of a workplace should be regularly monitored and controlled, in order to maintain the clean air environment. However, efforts in industrial air quality control have been impeded by the lack of science-based approaches to identify and assess atmosphere air quality and level of dangerous gas. Therefore, a monitoring system for gas leakage detection needs to be developed. For the development of this system, the combustible gas sensor (MQ9) was used in order to detect the present of methane (CH4) and carbon monoxide gas (CO). This sensor will detect the concentration of the gas according to the voltage output of sensor and operated in the alarm system, autonomous control system and monitoring system by using Arduino uno as the microcontroller for the whole system. Whereas the Zigbee will send the data reading from the gas sensor to monitoring system that display on Lab VIEW Graphical User Interface (GUI). Besides, user can take immediate action upon the leakage occurs, else the gas supply and the system will shut down automatically within 10 minutes to prevent the condition becoming worst.

As a conclusion, this gas leakage monitoring system by using Arduino and Zigbee was successfully developed and works well. There are various type of project using the same wireless concept in different field of application but in this system consists of many features compared to other projects, such as the monitoring system developed by using LabVIEW GUI, Zigbee transceiver used to monitor the gas concentration, gas detector with LCD display, alarm system built by using buzzer to alert the workers, and in the autonomous control system used to trigger the exhaust fan automatically in order to ventilate the dangerous gases in the room as well as auto shut down the main power and the gas supply within 10 minutes upon the leakage occurs to prevent the condition getting serious. Last but

not least, this system was built for the purpose of lifesaving that many people in a wide range of industries rely on to alert them to an explosive or hazardous atmosphere and prevent any disaster happen.

Priti P. Chavan, Surpiya S. Kadam "Zigbee Based Wireless A Remote Carbon Dioxide (CO2) Monitoring System" International Advanced Research Journal in Science, Engineering and Technology National Conference on Emerging trends in Electronics & Telecommunication Engineering (NCETETE 2017) Vol. 4, Special Issue 2, January 2017.

The increasing quantity of CO2 is a big problem leading to global warming. Therefore it is necessary to properly design a system to monitor the amount of CO2 in the atmosphere to prevent the debacles of future. This paper gives us details about how to develop CO2 monitoring system based on the ZigBee protocol. Graphical user interface is helpful to display monitoring data on screen. This is another important advantage present in this paper. By using this system we will be able to monitor the amount of CO2 in the working conditions. As today's demand of the workers motivation is proper working conditions. The quality of life of people will improve to a greater extent. According to the requirement of the industries, this system works at real time. This system measure theCO2 gas in working area to check whether gas cross the safety limit or not. When the amount of gas cross the safety limit then system indicates danger signal with real time and date.

III. PROPOSED WORK

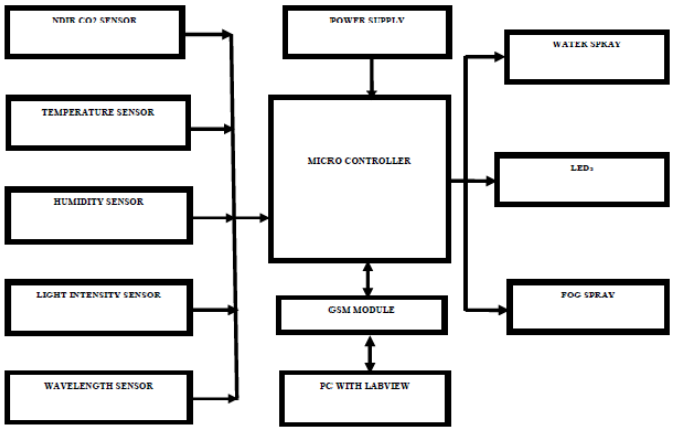

Figure 1. Block diagram of Geological system storage and leakage

There are a number of systems existing for the monitoring of environmental parameters inside the greenhouses. Some of them are not having the controlling action. Some other systems don't have the Carbon dioxide monitoring. The proposed system is having a preset value range for all the parameters. These values are user defined based on the crop requirements. When the parameter value goes beyond this range, the controller will switch the control actions on. The control actions include water spray, fog spray, LEDs, shadow pads, natural ventilation etc. The sensing unit contains five sensors. These sensors monitor the changes in the parameters such as temperature, humidity, light intensity, wavelength of the light, and Carbon dioxide concentration. The sensors send their data to the micro controller. The micro controller is connected to a PC via a GSM module. The PC is equipped with the support of Lab VIEW. In the Lab VIEW GUI, the user can adjust the minimum and the maximum range of each parameter. The PC will compare the preset value and the real time value. If the value is not in range, the PC will command the controller to adjust the change through proper action. The wavelength sensor senses the wavelength of the light present in the greenhouse. The photosynthesis rate depends on the wavelength of the light. The photosynthesis rate is maximum in the wavelength range of 650-700nm. This wavelength is near the red light region. With the wave length value, the rate of photosynthesis can be determined. From this rate, we can get the consumption of Carbon dioxide at a time. By measuring the Carbon dioxide concentration, we can get the amount of additional Carbon dioxide to be supplied. The increase in the consumption rate also indicates a leakage.

IV. CONCLUSION

This experiment adopts self made portable co2 monitoring equipment, which obtains localization and time service information through GPS, and it can cache dynamic change of real-time monitoring data into sd card. GPRS is employed to wirelessly transmit them to the server, which ensures the continuity of data acquisition and monitoring.

Based on sensor which have used for co2, temperature, humidity, and light intensity, the equipment which are suitable for the surface co2 concentration monitoring was developed in order to realize remote real-time

acquisition of multivariate information in the monitoring of co2 geological storage.

As because of co2 leakage there are many hazardous things can happen with human beings. So it is important to detect leakage from storage. Apart from this, the monitoring system is simple in structure, easy to operate, convenient to carry, remote monitoring, automatic storage, it gives continuously wireless information and real-time display, which provide remote real-time monitoring means for further study of quantitative analysis and dynamic simulation of the process of co2 geological storage, leakage, diffusion and migration under complex air environment.

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