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A Cyber-Physical System for Monitoring Geological Parameters: A Review

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Abstract: A remote real-time Carbon Dioxide (CO2) concentration monitoring system is developed, in such a way that it will utilize less memory and less processing configuration so as to have better results as compared with the others work on high memory with high processing power. The remote real-time CO2 monitoring system consist of monitoring equipment and clients PC and concern system based on technology of wireless sensor network. The monitoring equipment collects air environmental information. The CPU automatically stores the collected data and displays on the LCD display module in real-time. The GPRS module continuously transmits the collected information to the clients PC.

The resulted solution provides the possibility of logging measurements from locations all over the world and of visualizing and analyzing the gathered data from any device connected to the Internet. This work encompasses the complete solution, a cyber physical system, starting from the physical level, consisting of sensors and the communication protocol, and reaching data management and storage at the cyber level. The experimental results show that the proposed system represents a viable and straightforward solution for environmental and ambient monitoring applications.

Keywords: CO2 Capture and Storage (CCS), Wireless Sensor Networks (WSN), Liquid Crystal Display (LCD).

1. INTRODUCTION

Atmospheric concentrations of the 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. CO2 Capture and Storage (CCS) is an effective way to realize effective greenhouse gas storage, and to improve oil and gas production. 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. 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, after the geological CO2 storage, long-term terrain monitoring of the greenhouse gas leakage is needed. 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 as CO2 concentration, temperature, humidity, light intensity etc. The information is then wirelessly transmitted to clients PC where they are integrated and analyzed for evaluating of geological CO2 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 remote online CO2 monitoring system consists of monitoring equipment and the clients PC. The monitoring equipment is composed of a Central Processing Unit (CPU), air environment sensors array, Global System for Mobile Communication (GSM) module, memory for storage purpose and Liquid Crystal Display (LCD). The sensors array of CO2, temperature, humidity, and light intensity are used to collect data. The CPU automatically stores the collected data in memory and displays them on the LCD display module in real-time. Afterwards, the GPRS module continuously wirelessly transmits the collected information to the data centre server. 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 as CO2 concentration, temperature, humidity, light intensity etc. The information is then wirelessly transmitted to data centre server where they are integrated and analyzed for evaluating of geological CO2 storage and leakage.

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2. LITERATURE REVIEW

From the rigorous review of related work and published literature, it is observed that many researchers have defined a cyber-physical system for monitoring geological parameters,

I. J. Wan, M. Chen, F. Xia, D. Li, and K. Zhou[1], M. Broy, M. V. Cengarle, and E. Geisberger[2] founds, the constant attempts of social and economic bodies for the development of technologies for improving energy efficiency and reducing pollution and for the more efficient use of national infrastructure along with the needs of decreasing the cost of computation, networking, and sensing had lead to the emergence of a new generation of digital systems, called cyber-physical systems (CPSs). These include embedded systems, sensor networks, actuators, coordination and management processes, and services to capture physical data and to act on the physical environment, all integrated under an intelligent decision system.

II. A. Zaslavsky, newly appeared systems have a lot of similarities with the Internet of Things (IoT)[3] introduces, an enabler of ubiquitous sensing, that envisions a world in which many billions of Internet-connected objects or things, with sensing, communication, computing, and potentially actuating capabilities, will coexist, allowing an uninterrupted connection between people and things.

III. Z. Guo, P. Chen, H. Zhang, M. Jiang, and C. Li[4] presents, a system for environmental and ambient parameter monitoring using low-power wireless sensors connected to the Internet, which send their measurements to a central server using the IEEE 802.11 b/g standards. Finally, data from all over the world, stored on the base station, can be remotely visualized from every device connected to the Internet. This overcomes the problem of system integration and interoperability, providing a well-defined architecture that simplifies the transmission of data from sensors with different measurement capabilities and increases supervisory efficiency.

IV. S. Tozlu, M. Senel, W. Mao, and A. Keshavarzian[5] founds that Until, Wi-Fi technology has not been considered for implementing wireless sensing solutions because of its inability to meet the challenges in these types of systems, with the major drawback consisting in the unsatisfactory energy consumption. However, this has changed, since new power-efficient Wi-Fi devices have been developed and new solutions can benefit from several advantages offered by this technology, namely, the reduction of infrastructure costs while improving total ownership costs, native IP-network compatibility, and the existence of familiar protocols and management tools.

3. PROBLEM DEFINITION

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.

1. The traditional embedded systems, a full-fledged CPS is typically designed as a network of interacting elements with physical input and output instead of as standalone devices.

2. The notion is closely tied to the concept of robotics and sensor networks with intelligence mechanism proper of computational intelligence leading the pathway. Ongoing advances in science and engineering will improve the link between computational and physical elements by means of intelligent mechanisms, dramatically increasing the adaptability, autonomy, efficiency, functionality, reliability, safety and usability of cyber physical systems.

3. This will broaden the potential of cyber physical systems in several dimensions including interventions (e.g. collision avoidance) precision (e.g. robotic surgery and nano-level manufacturing), operation in dangerous or inaccessible environments (e.g. search and rescue, firefighting and deep sea exploration), co-ordination, and efficiency.

4. The proposed system which is designed shows the simulation output of sensing the CO2 gas, NO2 gas, temperature and humidity in the industry environment.

5. The constant attempts of social and economic bodies for the development of technologies for improving energy efficiency and reducing pollution and for the more efficient use of national infrastructure along with the needs of decreasing the cost of computation, networking, and sensing had lead to the emergence of a new generation of digital systems, called cyber-physical systems (CPSs).

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6. The resulted solution provides the possibility of logging measurements from locations all over the world and of visualizing and analyzing the gathered data from any device connected to the Internet.

7. This work encompasses the complete solution, a cyber-physical system, starting from the physical level, consisting of sensors and the communication protocol, and reaching data management and storage at the cyber level.

4. PROPOSED WORK

Proposed system flowchart: Monitoring process includes two main parts, real-time collecting and wireless transmission. First, the sensors array of CO2, temperature, humidity and light intensity are used to collect data; with GSM continuous wireless transmission is conducted. Specific procedure are as below:

1) Power the equipment on, then is to initialize the entire CO2 remote real-time monitoring system, including the circuit initialization of air environment sensors array, central processing unit and all modules. Display the control signal in a fixed time and monitor the operational status of each module real-timely.

2) After the initialization of TCP protocol stack and the success of dial-up of GPRS wireless transmission module, the central processing unit achieves the connection to remote mobile network and then the point to point communication will be established.

3) Wait for the data of air environmental sensors including CO2 concentration, temperature, humidity, light intensity and timing from converters of UART and A/D.

4) If data collection is completed, the central processing unit will automatically store the collected data into memory if required or directly on IP address of clients PC, otherwise go to Step three.

5) Central processing unit displays the collected data and power supply information on the LCD display module real-timely.

6) When the transmission time interval is reached. The AT commands is applied to control GPRS wireless transmission module to connect to remote wireless communication network and the data packet will be sent wirelessly to clients PC.

Hardware infrastructure: Geological CO2 leakage monitoring equipment based on WSN are mobile devices used by humans. The equipment is composed of the air environment sensors array, GSM module, central processing unit, memory for data storage purpose, LCD display module as shown in the figure given below,

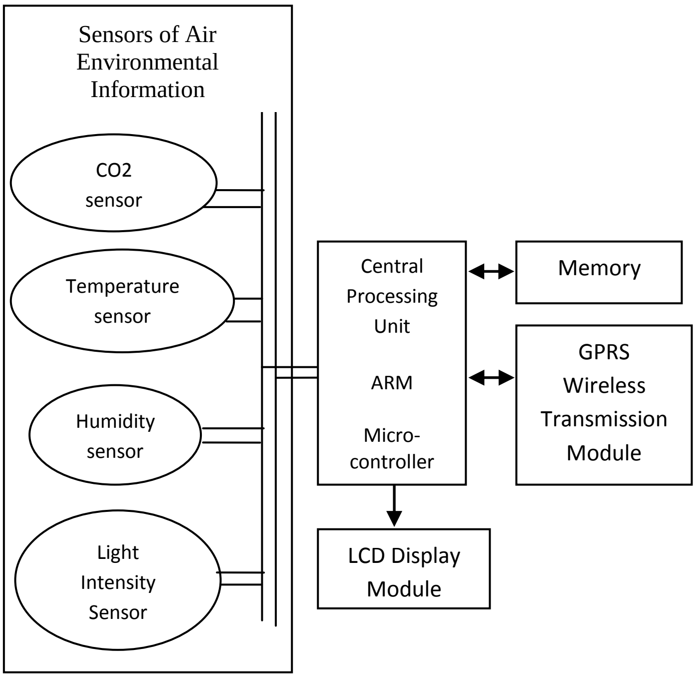

Figure : Hardware infrastructure diagram of geological CO2 leakage monitor

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5. CONCLUSION

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 microcontroller. In this system 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.

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