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Wireless Multi-nodes Environment Monitoring System Based on Microcontroller, GPS/GPRS/GSM and Google Map

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Abstract: In this report, a wireless multi-nodes integrated system based on microcontroller, GPS/GPRS/GSM and Google map for wide-area environmental monitoring has been studied and implemented. The system enables us to view the historical and current data recorded of nodes on Google map through a designed website. The environmental data and location of each node are collected and sent to a web server through GPRS service. The web application is developed using PHP, JavaScript and MySQL in combination with embedded Google map service to retrieve and display the data in details. Besides, several commands are also designed for managing the nodes via SMS messages.

Keywords: Environmental Monitoring System, GPS/GPRS/GSM, IoT.

1. Introduction

The collection of environmental data plays an important role in environmental studies. From the data, not only the quality of habitat is evaluated but also many natural disasters can be predicted.

Normally, the environmental data can be collected using data loggers. This work usually takes up time and high cost. However, the device has been proved inefficient or it is difficult to use in different places, on wide areas and in a long period. Hence, building a system can collect and analyze the data automatically on a wide area is extremely necessary. This could save time and money. Recently, the problem has been attracting much attention by scientists all over the world [1-5].

Today, the development of information, communication and semiconductor technology brings to us an idea of a "wireless multi-nodes environment monitoring system", which could help us to measure and view data conveniently from anywhere and anytime. The system includes many microcontroller-based nodes for collecting environmental data in combination with a server for storing, analyzing and displaying the whole data. In this system, wireless communication is established using Global System for Mobile communication (GSM)/General Packet Radio Services (GPRS) network for transmitting data and operating the nodes via SMS built-in commands. For locating the position of each node, Global Position System (GPS) is used. Besides, a web application

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is developed using PHP, JavaScript and MySQL in combination with embedded Google map service to retrieve and display the data in details.

2. System design

2.1. Structure of the system

Our system is built as shown in Fig. 1. The system includes many nodes known as environmental data measurement stations which are deployed to different places on wide area. The position of nodes can be located using GPS. The measured data from the sensors integrated on stations is sent to a server through the GPRS service of mobile networks. On a hosting server, a Google map embedded website is developed for analyzing and displaying the measured data along with geolocation of each station in details.

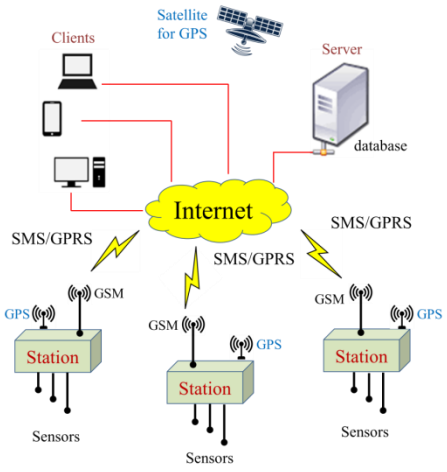

Figure 1. The structure of the system.

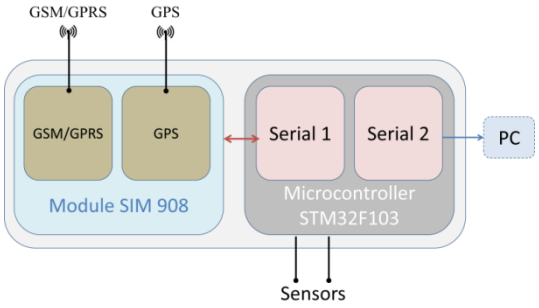

Figure 2. The hardware of a station.

The hardware structure of a station described in the Fig. 2 includes three parts. The most important part of the station is the microcontroller. It plays a role as a central controller unit for every activity of the station, especially for transmitting measured data from sensors to a server through a GPS/GSM/GPRS module. In this study, STM32F103C8T6 microcontroller by STelectronic [6] is selected due to its high-performance, low-cost and enough hardware resource for our project.

The second part is a GPS/GSM/GPRS integrated SIM908 module by SIMCOM company [7, 8]. The module supports both of TCP/IP and HTTP application protocols, this makes the recorded environment data from sensors are remotely sent to the server easily as expected. Due to GPS receiver unit integrated on this module, the geo-position of a station can be located. Besides, GSM is a basic part of the module, so that we can easily develop a set of Short Message Service (SMS) commands to manage the stations using smart phones.

For testing the system, we use Geiger tubes LND712 by LND Incorporated [9] along with our previous research [10] and digital temperature sensor DS18B20 by Dallas Semiconductor [11] on each station to detect environmental gamma radiation and measure temperature of environment, respectively. These sensors are good enough for our experiment.

In order to reduce the price, a shared hosting is considered to use for storing measured data, developed website, database of authorized phone number and the International Mobile Equipment Identity (IMEI) of SIM908 modules integrated in stations. On the hosting, the collected data is stored in files. Each file is for each station and the name of a file is the IMEI of a module in the station. This could help us recognize and manage the files more conveniently and effectively. MySQL database contains authorized phone number and IMEIs for managing the whole system via SMS messages and identifying which station is connected to or removed out of the system, respectively.

2.2. Data logging flowchart

The data logging operation of a station is described as below.

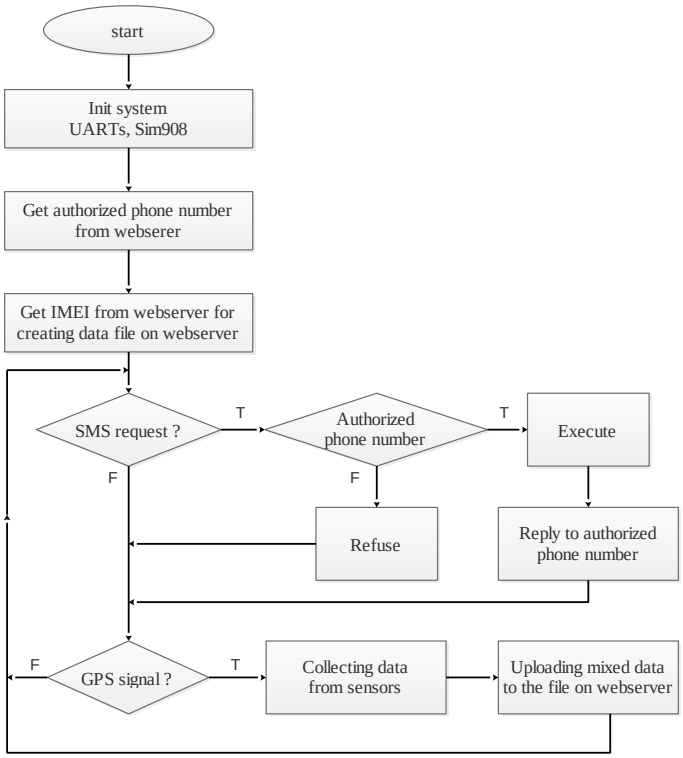

Figure 3. The flowchart of the operating of a station.

Firstly, the microcontroller initializes a counter for counting the gamma rays detected by Geiger tube, the serial communication and toggle on the SIM908 module. This module is also configured for getting authorized phone number from database on the webserver. The IMEI of SIM 908 is used for naming the data file and recognizing each station.

Next, the SMS checking process is to execute external commands from authorized phone number. Then, the system begins to seek for the GPS signal. After that, gamma rays per minute are counted and environmental temperature are collected by the microcontroller.

Finally, the whole data including date, time, geo-location, number of gamma rays per minute (counts per minute - CPM) and environmental temperature are combined under a string form (see Fig.5) and ready to upload to a file on the hosting server.

The above process repeats at the checking point SMS request.

3. Experimental results

As a result of studying of a wireless multi-nodes environment monitoring system, it shows that the system could log the measured data to a webserver in files (see Fig. 4 and Fig. 5), display the data of each station along with its geo-location on a Google map embedded website in details (Fig. 6a). The website is also designed to help us manage the number of stations (Fig. 6b) on the system and authorized phone number (Fig. 6c) for interacting to the stations via SMS messages (Fig. 7a, 7b and 7c).

The Fig. 5 describes the structure of collected data from a station stored in a file. Each line presents the measured data after every two minutes and includes date (day, month, year), time (hour, minute, second), geo-location (latitude, longitude), number of gamma rays per minute (counts per minute - CPM) and environmental temperature from left to right.

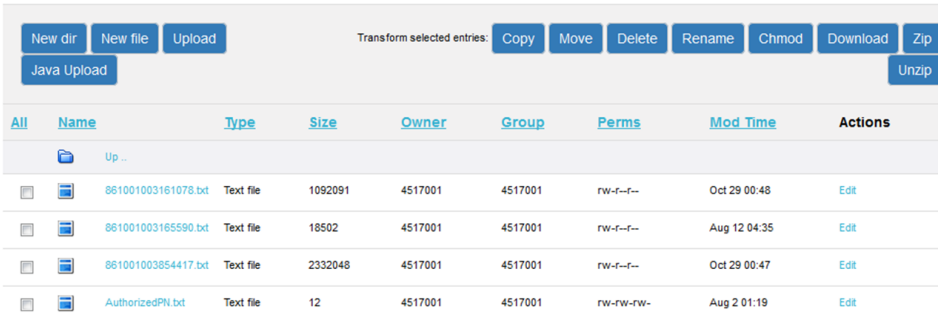

Figure 4. The files for storing measured data from stations.

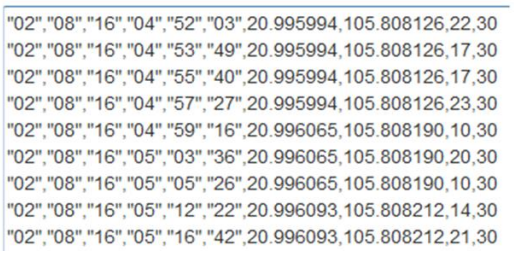

Figure 5. Structure of measured data in a file.

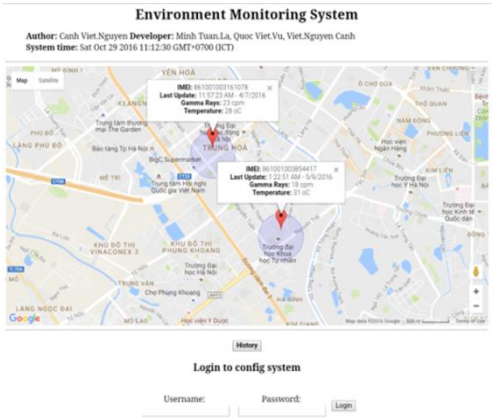

Figure 6a. The monitoring home page.

Figure 6b. Managing authorized phone number.

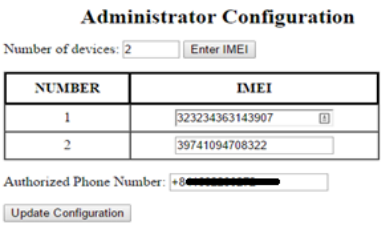

Figure 6c. Managing stations via IMEIs.

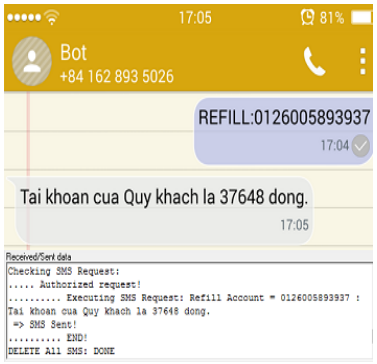

Figure 7a. Refilling account.

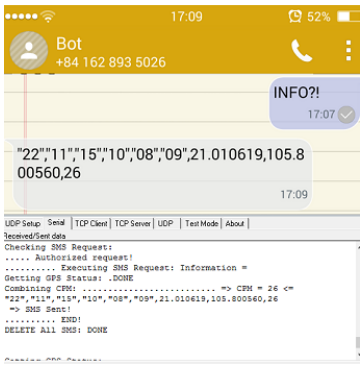

Figure 7b. Checking data.

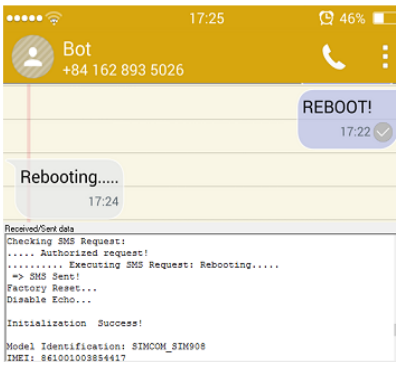

Figure 7c. Remotely reboot.

The Fig. 8 and Fig. 9 shows the temperature and the number of gamma rays collected from environment in a 24-hour period from 29th to 30th October 2016 at two stations in Hanoi. On the Fig. 8, the number of gamma rays per minute changes from N_{min} = 10cpm to N_{max} = 36cpm with N_{mean} = 22.4cpm and temperature varies from 22.5°C to 29°C at station 1. Whereas, at station 2, the gamma rays per minute changes from N_{min} = 9cpm to N_{max} = 37cpm with N_{mean}= 22.1cpm and temperature varies from 22.7°C to 29.2°C as shown in Fig. 9. The results indicate that the system works stable.

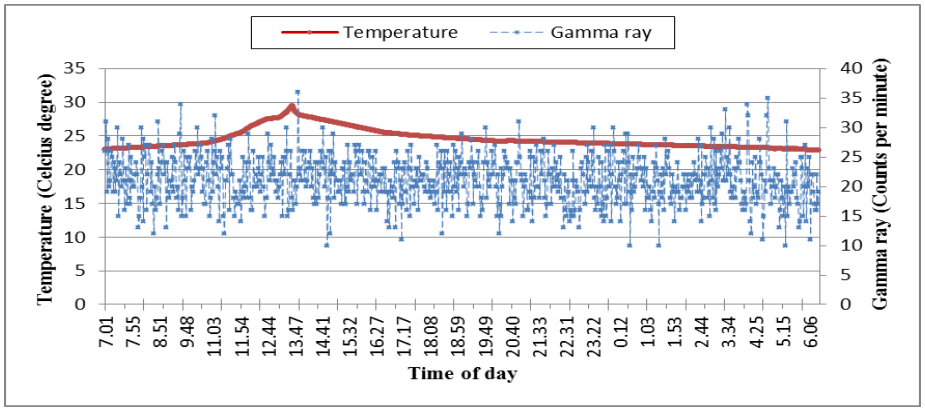

Figure 8. Temperature and Gamma rays collected in a 24-hour period at station 1.

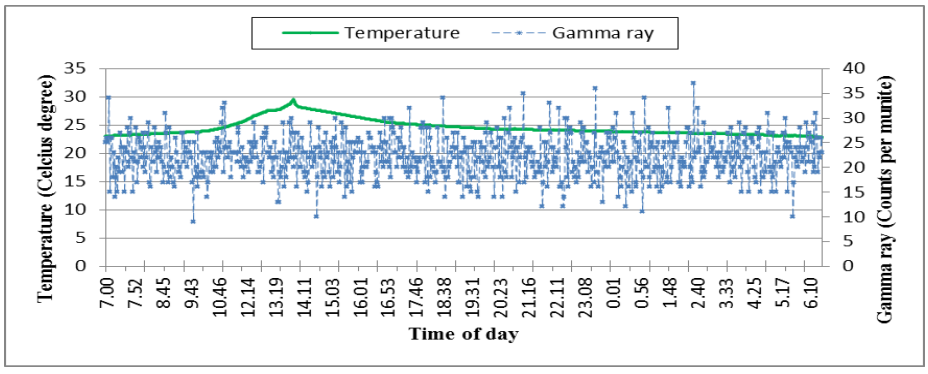

Figure 9. Temperature and Gamma rays collected in a 24-hour period at station 2.

4. Conclusion

In this study, we have successfully developed a wireless multi-nodes environment monitoring system. This system could not only log measured data to files contained on a webserver but also display the data and geo-location of stations on a Google map embedded website in details. This helps us have a visual look about the data and location of stations on the map. Besides, many commands under SMS form are created for interacting to stations via an authorized phone.

We have experimentally tested the two node system with Geiger-tube detector and digital temperature sensor on each node. Through the experimental results, it has shown that the system works flawlessly as expected. Based on this system, we can measure other environmental parameters by integrating different types of sensors.

The system can be applied in practice and could bring to scientists in many fields relating to meteorology and environmental studies more advantages in cost and time when many stations of the system are deployed on wide areas. This system is especially useful for researchers in developing countries.

Acknowledgments

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References

[1] A. Peulic, S. Dragicevic, Z. Jovanovic, R. Krneta, Flexible GPS/GPRS based System for Parameters Monitoring in the District Heating System, International Journal of Computers, Communications & Control (IJCCC) 8(1):105-110, 2013.

[2] H.S.Yu, S. H. Zhang, X. J. Liu&X. K. Ji, The design of the automatic monitoring system of water regimen based on GPRS, International Conference on Frontiers of Energy and Environmental Engineering(ICFEEE), pp. 607-609, 2012.

[3] Rafael Marin-Perez, Javier García-Pintado, Antonio Skarmeta Gómez, A Real-Time Measurement System for Long-Life Flood Monitoring and Warning Applications, Sensors, *12*(4), 4213-4236, 2012.

[4] Wei Dehua, Liu Pan, LU Bo, Gou Zeng, Water Quality Automatic Monitoring System Based on GPRS Data Communications, International Conference on Modern Hydraulic Engineering, Vol. 28, pp. 840-843, 2012.

[5] Xiuhong Li, Xiao Cheng, Peng Gong, Ke Yan, Design and Implementation of a Wireless Sensor Network-Based Remote Water-Level Monitoring System, Sensors, 11(2), 1706-1720, 2011.

[6] STMicroelectronic, STM32F103x8 datasheet, 2015.

[7] SIMCom, SIM908_Hardware Design_V2.00, 2012.

[8] SIMCom, SIM908_Reference Design Guide_Application Note_V1.00, 2011.

[9] LND, Incorporated, LND712 Gamma Detector.

[10] Nguyen Canh Viet and La Minh Tuan, Design and Fabrication of a Dosimeter for Measuring Ionizing Radiation, VNU Journal of Science: Math - Phys, Vol.31 No.1, pp. 63-70, 2015.

[11] Maxim, Programmable Resolution 1-wire Digital thermometer, 2015.