Develop a data acquisition system for Geography accident warning, Environment monitoring in the North mountain areas of Vietnam.

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Abstract— Precipitation, soil moisture, temperature and humidity are the common parameters in monitoring systems. The data of those parameters can be used to study about landslide disaster, climate change, monitoring weather information, decision making assistant and give risk warning. In this paper, a data acquisition system developing for those purposes is depicted. The data acquisition system was designed to collect data from specific sensors (rain fall, soil moisture, temperature, and humidity) via RF communication. The system then gathered data and send to a cloud server for monitoring, warning, and decision assistant system by a GSM module. Hardware and software with suitable solutions for the North mountain areas of Vietnam are represented. System experiments and tests were implemented to check design targets. Results present measuring and data transmitting abilities of the system.

Keywords. Data acquisition, Geography accident, Environment monitoring, IoT

1 Introduction

Nowadays, data have a very importance role in modern world. Data can give huge amount of information to yield valuable insight about the fields, the things and phenomenon. Data can give information to human, technical machine system. It helps automation algorithm of the machines produce control signal; people handout decision or forecast.

Data collection is required before all other works on data. It is through data collection that business, management, or analysis systems have quality information they need to make informed decision. Furthermore, data collection provides resource for analysis, studies, or research. In order to collect data from real world such as in industrial control systems, IoT systems etc., the data acquisition systems must be used.

Result from rapid developments on data acquisition technology, such as sensor technology, wireless technology, GSM technology etc., data collection systems are used broadly in many areas which include Environment data collection and monitoring, Geography disaster early warning…

Research on warning system: Conducting research on deploying embedded equipment systems for warning models in the early warning systems. These include studies on implementation of early warning systems with predictive actions, dynamic alert alerts, communication [1][2]. The studies performed to build early warning and forecasting systems must include the works of Staehli, Calvello and colleagues [3], [4]; [5]. Researched warning systems can perform tasks to notify the authorities, scientists… in order to handle as [6], [7] or to notify the entire population community [8].

In landslide area, the studies to develop early warning systems have been implemented for long time ago. These systems have been developed with many different approaches, using one or more different methods of implementation to improve the accuracy and effectiveness of the alert. For the studies of monitoring and warning data collection, the alarm system can use sensors to collect data on rain gauge, displacement of rock, groundwater pressure, and display information on website [9]. The system can also collect information about groundwater levels, information on the movement of rock and soil in recorded space so that warnings can be given via website or phone message to the people [10] [11] [12]. Studies can also be conducted to find solutions that can collect the necessary data for alerting systems with ensured quality, low cost information sources such as sensor network applications in data collection or distance measurement as in [13] [3]. Along with the development of technologies in the field of electronics and communication, recently the trend of using independent measuring stations to collect information on the risk factors for landslides is rapidly increase. These stations will read the corresponding sensors, process collected data, and transmit it to the central station from which to transmit to the information processing center via wireless data transmission systems.

However, Vietnam does not have a shared database system, online software supports the early warning system and nature disaster forecast. That is the reason that the CT2019.01 program aims to build an early warning system for Geography accident forecast and warning; Environment monitoring; Climate changing study and Agroforestry decision assisting in the North mountain areas of Vietnam. In this paper, a data acquisition system development is presented. The paper will present the solutions for the system (system cost and ability of data transmission) which are suitable for the North mountainous areas of Vietnam. The experiment results in the laboratory depict the first step of success in our proposed system.

2 Proposed data acquisition system

Following the object of the CT2019.01 program to develop an acquisition system for environment data collection, the 4 stages of IoT architecture as in **Fig. 1**. a. is implemented with four stages.

- Stage 1. IoT devices layer (Sensor, Actuators, Devices etc.): In this stage, all things of the real world are converted into measurement signals to analysis by sensors, and actuators interfere with physical reality.

- Stage 2. Sensor data acquisition: Measurement signals are converted to digital signal at this stage, collected, processed, and transfer to the next stage.
- Stage 3. Pre-processing, edge analytics: This stage is also called edge IoT because here the data in stage 2 is process and transfer to the IT world.
- Stage 4. Cloud analytics (Analyzing, visualizing, and storing data): In the last stage, data is processed in depth to get higher valuable information which is used to provide monitoring, warning, forecasts, or decision support.

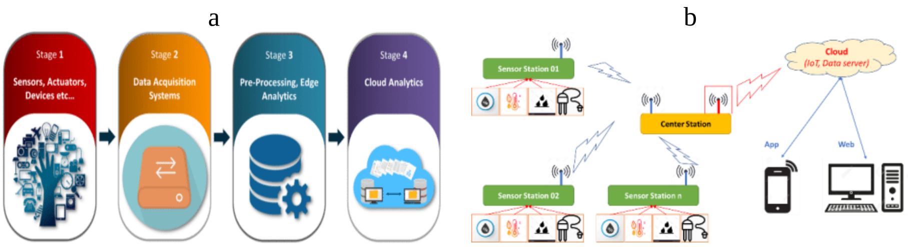


Fig. 1. a. The 4 stages of IoT architecture [14] b. Proposed system

In following sections, design of data collection system is presented. The challenges here are: the designed system must have acceptable price to widely used for data collecting purposes; the designed system can be easily installed and work well with the complicated areas of Vietnam North mountain region. To overcome these challenges, the proposed system, developed according to the 4 stages of IoT architecture, is depicted in **Error! Reference source not found.** b. The system analysis in four stages of IoT architecture in detail as following.

Stage 1 is expressed in sensor stations (SSs) where the sensors convert environment parameter into signals. The sensors used here, in the first phase of the project, are soil moisture sensor, air moisture sensor, temperature sensor, and rain gauge sensor.

The stage 2 take place in sensor stations to center station (CS). Sensor signals are converted to digital and arranged as SSs data to send to CS. Because in the Northern mountainous areas, there are many places where there is no GSM signal, the proposed structure uses CSs located in the area where GSM signal is strong, SSs are located in the surrounding areas and send data via RF signals. The proposed structure also can reduce operating cost of the system according to the telecommunication price.

In the CSs, data from SSs is gathered, locally stored, and transmitted to data server. Data in the CSs is added necessary information and changed into suitable structure for server sending. The data transmission is implemented by GSM (3G/4G) system. This period is called edge IoT as defined in stage 3 of IoT architecture.

On the server the collected data will be stored and processed. For the monitoring purpose, the data will be analyzed, and separated information related to the collection locations to be displayed on the map ArcGIS. These results can be seen by user in website or mobile application. For the depth information purpose, Artificial intelligence and Machine learning algorithms are implemented in the server. Implementing algorithms on the data system results in predictions, warnings, or decision support. All the results can be presented as analysis data tables, dash boards, trending graphs etc. That is the stage 4 of IoT architecture.

In following, Real SSs and CS with practical solutions are shown. The devices then are experimented in laboratory.

3 Design data collection system

3.1 Sensor stations (SSs)

Based on the objectives of the project, SSs are proposed to build with technical requirements as in following. Each SS is a system of measuring parameters: Air humidity; Air temperature; Rain gauge; And soil moisture. In addition to serving for future development purposes by increasing the amount of information collected (amount of sunshine, wind speed, amount of groundwater, etc.), the SSs are designed with some auxiliary IOs which can collect data from others standard sensors.

Normally, the SSs are in remote areas where are inconvenient in the electricity supply. Therefore, the proposed SSs are designed to be fed by a storage source (battery) combined with a generator (solar cell).

Communicating and exchanging data between SSs and CSs is implemented via wireless communication network system or GPRS mobile phone network (depending on the actual situation of station layout). Communication within an area between stations can use RF connections with distances from a few kilometers to less than 10 km (depending on space and obstructions).

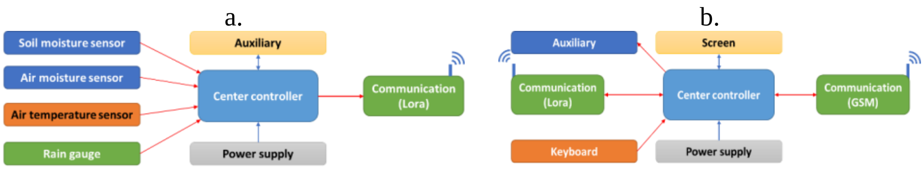


Fig. 2. a. SS block diagram, b. CS block diagram

From the technical requirements for SSs above, the proposed structure presented in block diagram is shown in **Fig. 2** a. To manager and regulate entire the SS, a central control unit based on microcontroller is used. The control unit has duty to collect information from the sensors and auxiliary IOs then communicate with the center to send result data.

3.2 Center Station (CS)

CS plays the role of a central station collecting data from regional measurement stations and transmitting it to a data collection server. In addition, the station also has the task of sending status settings and synchronous information to the measuring stations.

With such functions above, the CS must have the following technical requirements: Ability to communicate and exchange data, status information, information synchronized with measurement stations through wireless communication systems (RF); Ability to communicate and exchange data with the server system providing measurement data; Ability to process, encode and store data from measurement stations in certain time periods to ensure data continuity in some cases of disconnection; Ability to display measurement information, operating status or set working mode for measuring stations; Ability to set up on-site warning thresholds when the measured data reaches the limit value; Can use electricity from civil electricity (in case it can be arranged at points with grid sources) or use stored sources in combination with solar cells.

From the above requirements, a CS block diagram was proposed in **Fig. 2** b. The CS is also controlled by a central microprocessor. The control unit collects data from SSs via Lora wireless connection. The collected data will be processed to: Screen monitoring; Store locally in CS; Communicating to server through mobile phone network (GPRS); Warning when the value exceeds the threshold. In addition, the Station also needs a keyboard to be able to perform setting parameters, working status for stations.

4 Implement data collection stations

4.1 Sensor stations (SSs)

From the above-mentioned challenges and proposed block diagram **Fig. 3**, the SSs are implemented. They include major sensor components: Soil moisture sensor; air moisture sensor; air temperature sensor; and rain gauge. These components were selected with suitable price and quality. In the center controller block a PIC16F886 from Microchip is implemented to receive and process sensors signals. Collected data from sensors will be transmitted to CS by a 1W LoRa module from Ebyte.

Power supply for each SS is a solar power system, which consist of a solar cell panel, a 12V battery, and a charger control module.

a. b.

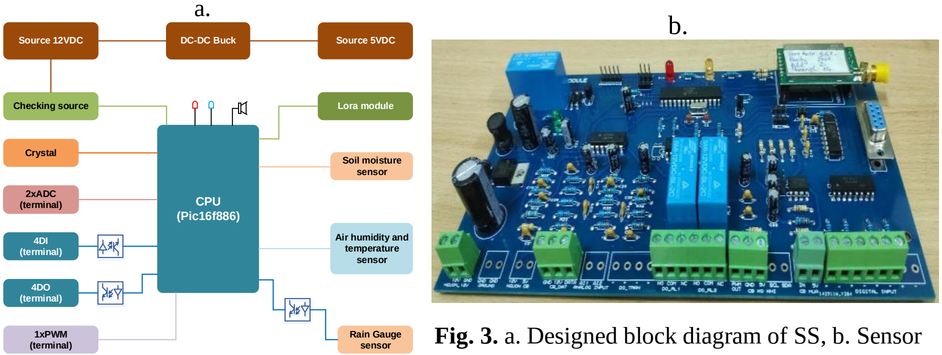
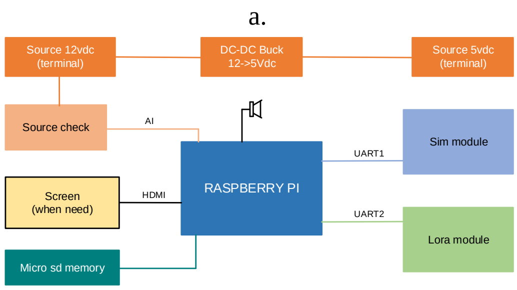


Fig. 3. a. Designed block diagram of SS, b. Sensor station (SS)

With the selected devices and equipment, the integrated block diagram of SS is presented in detail in **Fig. 3** a. The SS circuit was designed, and the real implemented board is in **Fig. 3** b.

4.2 Center Station (CS)



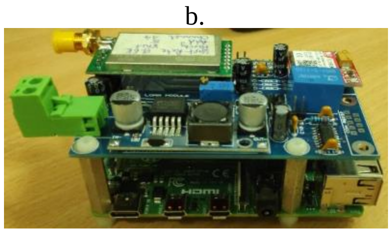


Fig. 4. a. Designed block diagram of CS, b. Actual product of CS

The CS block diagram in **Fig. 2** b. was analysis and the suitable components for CS were selected. The CS consists of two communication modules: A LoRa module as in SS; A GSM module SIM800L. The CS's central controller acts as a gateway to collect data from SSs which are managed by itself (maximum 30 stations). Therefore, the Raspberry Pi 4 module was selected for the center controller of CS. In addition, CS also has accessories such as keyboard, screen, solar power, etc. Final designed block diagram of CS is depicted in **Fig. 4** a. and actual product of CS module is shown in the **Fig. 4** b.

5 Communication and data management

5.1 CS-SSs communication

As mentioned above, communication between CS and SSs is implemented through the LoRa physical protocol which is low-power wide-area network. To establish a communication link between CS and SSs, Data link layer in OCI model, the master - slave communication protocol was designed using Modbus standards. In there, CS plays the role of the master station that sends requests for measuring results from SSs. Otherwise, SSs play the role of slave relays in Modbus network, respond to the requirements from master. According to Modbus regulations, the data on the SSs are divided into four categories as follows:

- Digital outputs are designed as relay coils with pre-address 0x. The outputs of SSs include: Status led; Output relay for sensors power supply, alarm buzz, and auxiliary.
- Digital inputs are the discreate inputs of SSs and they are allocated in addresses with 1x prefix. They are rain gauge input and other reserve inputs.

- Input registers are specified at 3x addresses. They are used to store data from sensors and others working data. Sensors signals are converted and processed into suitable digital data. The data is stored in these registers. The working data, such as time or station status, are generated during station operation.
- Holding registers can be used as the output registers of the SSs. The configuration, address, ID…etc. of the SSs are stored in these registers. They are defined with 4x prefix.

In this data collection system, CS will read and write data of SSs at predetermined intervals (default is 30 minutes).

5.2 CS-Server communication

Designed for use in mountainous areas, CSs use GSM connectivity to communicate with the data center (cloud server). Data collected from SSs are processed and standardized in JSON format. This JSON data will then be sent to the server via GSM network according to AT&T protocol. The data structure of the JSON file is shown in following.


```
[{“station_id”: “mã trạm trung tâm”,“device_id”: “mã trạm
đo”,“gps_lati”: “vĩ độ”, “gps_long”: “kinh độ”, “time_stamp”:
“thời gian ghi dữ liệu”,“soil_moiture”: “thông số độ ẩm đất”,
“air_moiture”: “thông số độ ẩm không khí”, “air_temp”: “thông số
nhiệt độ không khí”,“rain_gauge”: “thông số lượng mưa”
,“battery_state”: “trạng thái ắc - quy”
“station_state”: “trạng thái output của trạm”}]
```


6 Results and discussion

A system with one CS and two SSs was implemented in order to verify the proposed system. The CS was placed in the Laboratory in the ground. The two SSs are place in fourth and fifth floor of other building about 100m far away the Laboratory. The SSs collected the temperature and moisture of the two placed rooms. Soil moisture of these SSs are place in potted plants. The system was tested, and the results of 7 days are presented in **Fig. 5** to **Fig. 7**.

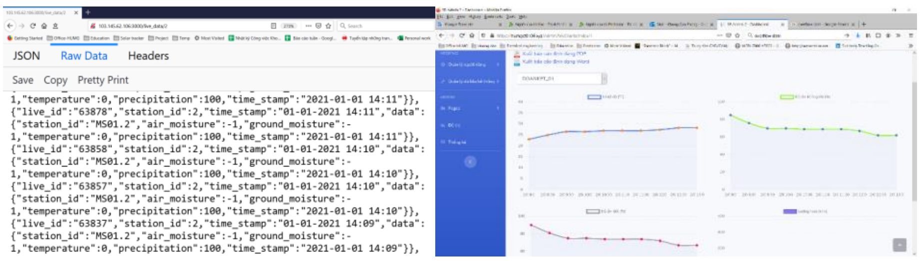


Fig. 5. Data from the Monitoring system

In **Fig. 5**, webpages with APIs to receive POST data from CS was designed and installed at http://humgct0106.xyz and http://103.145.62.106:3000/live_data/2. The pages show the data and GUI dashboard of the two tested rooms. They present that the designed system can collect and monitor environment data.

The collected data is used to plot temperature and moisture graphs as in **Fig. 6** and **Fig. 7**. These graphs present characteristic of the two tested room. The fist room (SS01) has a 24/24 running air condition that keep the temperature and moisture of the room quite stable. The air condition of the second room (SS02) just turn on in the day and turn off in the night. That makes the temperature and the moisture of the second room vary in day cycle. The date 16-17/08 was the day off (Sunday), the air condition of the second room was not working that make the graph seem to be changed un-normal. The graphs also depict that the moisture of the soil (red) is more stable than the moisture of the air (blue).

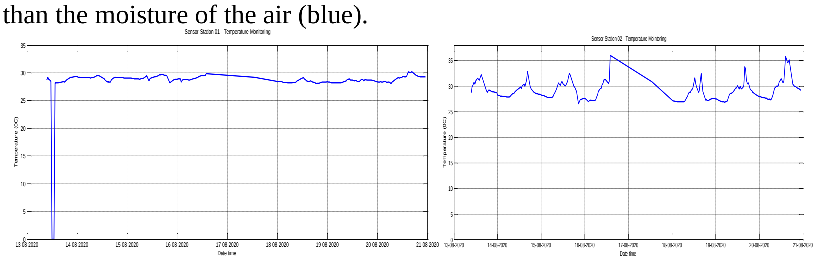


Fig. 6. Temperature of the two rooms in 7 days

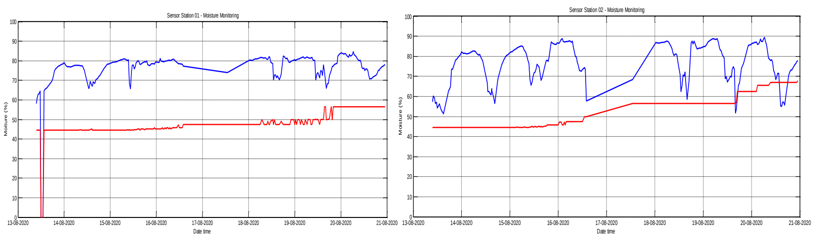


Fig. 7. Air moisture and soil moisture in the two rooms in 7 days

The experimental stations were also tested in the distance of 3km in the city (with building obstructions) and transmitted data well.

Experimental results show that the proposed system can collect data of surround environment and send to server continuously. With the data, the analysis can be implemented to get more information where the SSs are placed.

7 Conclusions

The paper described the implementation of a data collection system for monitoring, warning of geography disasters with suitable cost (about 200USD for one SS and 400USD for one CS). The system was designed to overcome the challenges of working in the North mountain areas of Vietnam. Test results show the ability to collect data and transmit to the center of the system and displayed in webpage. The monitoring data can be used to analysis characteristic of supervised objects. In order to be able to deploy into the real early warning system, it is necessary to continue to be tested in field with real conditions. The system must be tested with the condition of supplying electricity from solar power system, the transmission of data in conditions of obstacles.

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