Design and Implementation of a Real-Time Web Service for Monitoring Soil Moisture and Landslide in Lai Chau Province, Viet Nam

Hong Anh Le, Bao Ngoc Dinh, and Dung Nguyen(✉)

Hanoi University of Mining and Geology, 18 Pho Vien, Bac Tu Liem, Hanoi, Vietnam
{lehonganh,baongocdinh}@humg.edu.vn

Abstract. Web service technology has been recognized as one of key factors for developing natural hazards monitoring systems. This study proposes an open source web service solution for monitoring soil moisture in Lai Chau, a northern province of Vietnam. The system supports a real-time mechanism for data communication with gateway and mobile applications via http-based protocol. It receives structured data packets from the gateway, then makes the visualization on map and immediately alerts users if data is in warning range. Mobile applications are also capable to retrieve web map services by using provided RESTful APIs. The system has made a great contribution to the local government for natural disasters monitoring and management in Lai Chau province.

Keywords: Real-time · Monitoring · Landslide · Web service

1 Introduction

Environmental and natural resources monitoring systems collect, measure, and analyze the data to evaluate changes and predict the up coming events. These systems play an important role in protecting environment and preventing natural hazards. In Feb 2020, Vietnamese government approved a national master plan to build nationwide systems for monitoring environmental and natural resources including land, water, air,.. This plan also consists of many tasks such as developing laboratories, implementing frameworks and platforms for analyzing and sharing data from localities. Lai Chau is a mountainous province in Northwest region of Viet Nam with population is around 403,200 and approximately 9068 km2 in square. This region has high risk of landslide and flooding which cause many damages in both economy and human death every year. Developing a system which monitors landslide and soil moisture in Lai Chau is essential. It is even more important if such system supports local government for monitoring natural resources at real-time, therefore they can give better decisions that reduce potential damages. Web services are well-known technologies which allow to reuse software's resources and functionalities over the Internet using XML-based

P. C. Vinh and A. Rakib (Eds.): ICCASA 2020/ICTCC 2020, LNICST 343, pp. 131–140, 2021.
https://doi.org/10.1007/978-3-030-67101-3_11

protocol. Based on this technology, many software systems developed in various languages and platforms can communicate and transfer data easily over the networks. Web services contribute significantly to developing systems which act as management center and share resources for the other systems [9,11]. Zhou *et al.* [10] applied web service technology to develop a personal digital assistant (PDA) forest fire monitoring system. The system showed the advantages of using web services for sharing and realizing the forest fire data. S. Lee *et al.* [4,5] implemented a project which collects sensor data about soil, atmosphere, ecology, etc. and makes them sharable using a common platform. This study presents a soil moisture and landslide real-time monitoring web service system which is designed and deployed for Lai Chau Province. Based on open source technologies, this system has several advantages such as reducing the deployment cost, supporting various communication protocols with hardware devices and mobile-based applications which are specifically designed for Lai Chau's observation stations.

The structure of this paper is organized as follows. Section 2 presents the technologies used for developing the platform and the study area. Followed by Sect. 3, we present methodologies of the platform development including system design and functionalities. In Sect. 4, the system implementation and results are described. Section 5 summarizes and compares our work with related ones. Finally, Sect. 6 concludes the paper and discusses the future work.

2 Technologies and Study Area

In this section, we present the open source technologies which are used for developing the system and brief information of Lai Chau province.

2.1 Node.Js

Node.js [1] is a open source, cross platform which provides a lot of modules in for developing server-side and network applications. Node.js application are written in JavaScript, a light weight, interpreted, and most well-known script language for web pages, and can be run in various operating systems such as OS X, MS Windows, or Linux. Node.js has a bunches of built-in modules which users can use such as events to handle events of applications, net to create servers and clients, https to make it available as a HTTPS server. In order to use a built-in module, users just need to specify module name using statement require.

2.2 Data Technologies

In order to store data received from monitoring stations, the proposed platform use PostgreSQL [2] which is a powerful, open source object- relational database with reliability, security, and high robustness. The applications connect to PostgreSQL over TCP/UP network connection to perform database operations. PostgreSQL has many advanced features such as user-defined types, table inheritance, asynchronous replication, etc. JSON and GeoJSON which are data interchange formats used in the proposed system. JSON consists of an unordered set of name/value pairs. A JSON text is sequence of tokens.

2.3 Socket.io

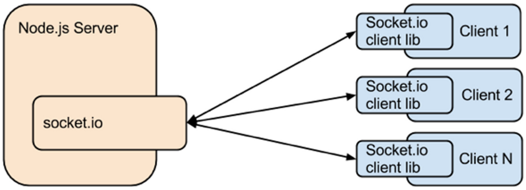


Fig. 1. Communication between server and clients with Socket.io

Socket.io [3], built on top of WebSocket and Node.js, has two components which are a Node.js server and a Javascript client library (web browser or Node.js client). It provides real-time directional event-based communication mechanism between client and server that means whenever an event occurs the server will be notified and can push messages to the client. The communication between server and clients is illustrated in Fig. 1.

2.4 Study Area

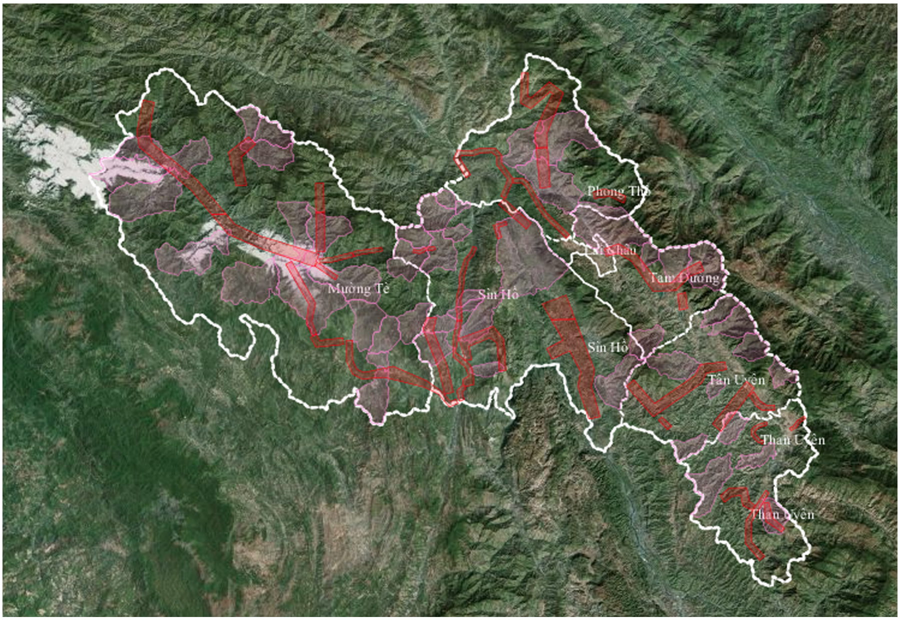


Fig. 2. Lai Chau areas with high risk of landslide

Lai Chau is a poor province situated at approximately 1,5 km latitude above the sea where floods and landslides cause many damages every year. Lai Chau has eight districts with population density is 53 people/km2 that is the sparest province in Vietnam. According to statistics of Vietnam Disaster Management Authority, in recent 17 years, there are nearly 600 floods and 850 landslide sites causing around 673 deaths and 41.436 houses devastated. There were around 905 sites at which landslides possibly happen while have been occurred at nearly 970 locations. Among these, authorities defined 28 areas had wide scale of landslides (Fig. 2). The hazard in Lai Chau usually accompanies heavy rains or volcanic eruptions. Table 1 shows the number of landslide, flash flooding, and eroding bank sites in Lai Chau in 2013.

Table 1. Lai Chau landslides statistics in 2013

No	District	Landslide sites	Flash flood	Eroding bank
1	Muong Te	203	5	7
2	Nam Nhum	106	5	6
3	Phong Tho	80	5	10
4	Sin Ho	334	1	12
5	Tam Duong	24	1	1
6	Tan Uyen	101	0	2
7	Lai Chau City	7	0	0
8	Than Uyen	115	18	42

3 Methodologies

3.1 The System Design

Figure 3 shows the architecture of the proposed platform. It consists of four main components including Communication, Core, and GUI services.

- **Communication**: Monitoring stations use sensors getting soil moisture, soil temperature then push data to the Communication module in the format of JSON or GEOJSON via HTTP RESTful. This component also handles queries from other external systems then forward the query content to the **Core** component.
- **GUI services**: It allows end users (e.g., local government or residents in Lai Chau) to access monitoring and administrative features such as viewing maps of landslide sites, real-time data and charts from stations, updating warning from the decision support system.

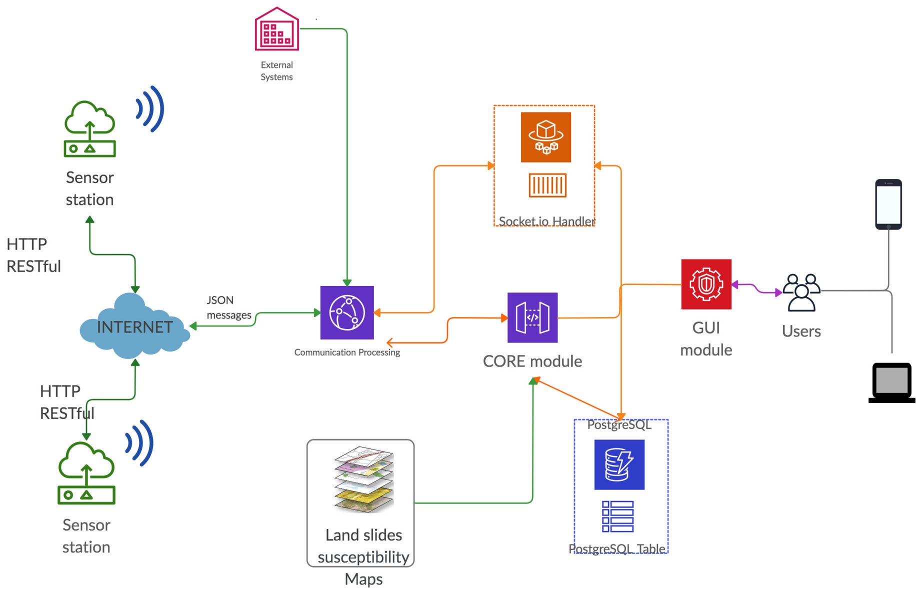


Fig. 3. Architecture of the platform

– **Core**: It is the main component of the platform that acts as a bridge linking other components. It receives data or request from **Communication** component, manipulates data store in PostSQL, then send back the results to the **Communication** and **GUI** component.

Messages exchanged between the platform with other clients including sensor stations, mobile client, web client are defined as follows.

```
{
    "station_id": identification of monitoring station,
    "device_id": identity of device ,
    "gps_lati": lattitude value of the station,
    "gps_long": longtitude value of the station,
    "time_stamp": time of data collecting,
    "param": parameter name,
    "value": parameter value
}
```

where *param* field represents parameter that sensors in the monitoring station can collect such as air moisture, soil moisture, soil temperature, etc. and *value* is the value of corresponding parameter.

Web service provider implemented in Node.JS and Socket.io listens events from PostgreSQL whenever new data is updated, then notify to service subscribers (web or mobile applications). In order to store the data transferred from monitoring stations, the database of this platform is designed with four main

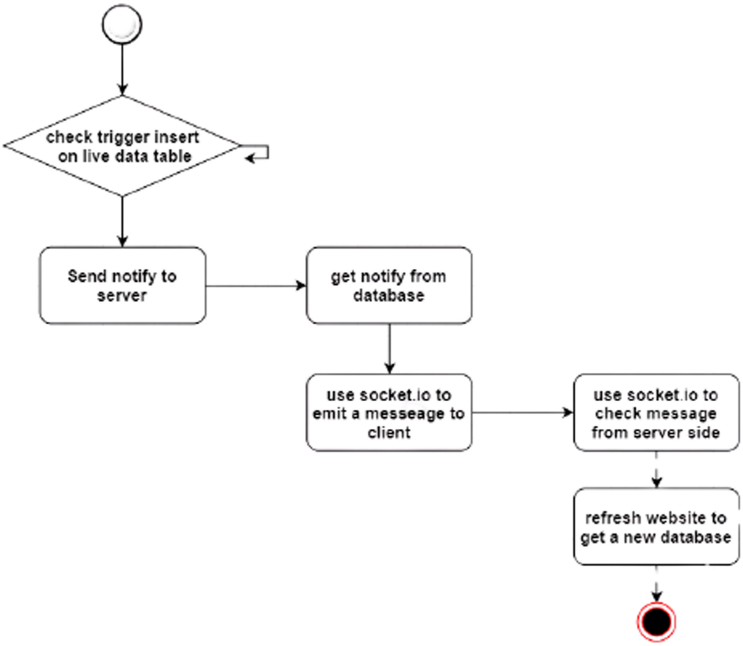


Fig. 4. Real-time communication flow

tables including stations, stations_params, live_data, and params. The purposes of each specific table is described as follows

- Stations: storing data of each stations equipped with IoT sensors containing station identifier, name, and location of the station.
- Params: defining monitoring parameters that sensors in stations can achieve. It allows users flexibly configure in each specific applied area.
- live_data: store data from each station with specific time stamp.
- stations_params: contains data packet structures which ingested by the station.

In order to support real-time communications between this platform and clients, we propose to use postgresql trigger and socket.io to implement this feature. Figure 4 depicts the real-time mechanism of the platform. The designed trigger which is fired when soil moisture and landslide are inserted by monitoring station will notify the server. The platform then send messages to clients using socket.io framework. After getting messages from platforms, clients will be refreshed.

3.2 Functionalities

The proposed platform provides both graphical interfaces to users and services to programmers. The former is intended to for local authorities and residents who can use this platform to monitor live data of soil moisture and landslide of five stations in Lai Chau. The later are for developers who want to use the live data from stations to build their own applications, for example, Android applications can use the provided services to collect data at real-time. There are three actors including users (i.e., local residents), administrators (i.e., local authorities), and service subscribers. Functionalities for each actor are described as follows.

- Users:
  - Viewing live data for soil moisture and landslide from monitoring stations
  - Viewing live charts for the specific stations
- Administrators:
  - Managing the configuration of the platform such as stations, data packet parameters, etc.
- Service subscribers:
  - Gateway and mobile applications can exchange data in bi-direction using published services with HTTP REST API

4 System Implementation and Results

4.1 Implementation

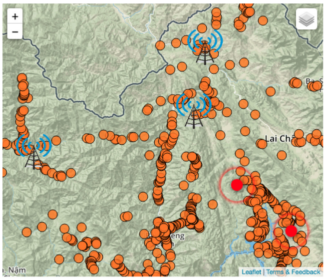
Recall that we make use of PostgreSQL's triggers and socket.io to implement real-time notification described in Sect. 2. The snippets below show the content of the trigger.

```
CREATE TRIGGER watch_realtime_table_trigger AFTER INSERT ON live_data
FOR EACH ROW EXECUTE PROCEDURE notify\_trigger ();
CREATE FUNCTION notify_trigger () RETURNS trigger AS $$
DECLARE
BEGIN
PERFORM pg_notify ('watch_realtime_table', row_to_json (NEW): : text);
RETURN new;
END;
```

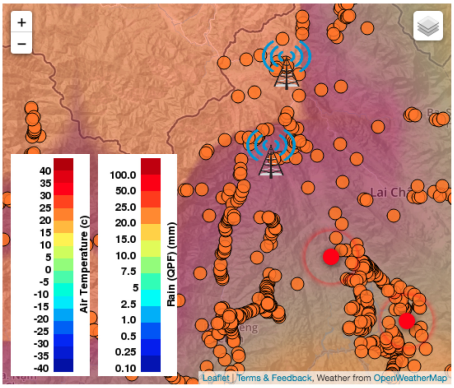
Trigger *watch_realtime_table_trigger* declares if there is any update on table *live_data*, it emits an event *watch_realtime_table* to the system. The listener service developed in Node.js receives the emitted event and pushes to the clients via HTTP REST APIs. Monitoring stations are able to push data to the system using HTTP POST method with data package defined in Sect. 3.1. Mobile and other external applications can get data from the system using HTTP GET method and custom queries. Custom queries allows users to define parameters to filter expected data.

4.2 Results

The monitoring system is deployed on the Internet for public usage[1]. Figure 5a shows the susceptible landslide sites and status of five monitoring stations located in Lai Chau. Users can observe the real-time data in each station and receive warnings from the decision support system. Figure 5b depicts the observation maps integrated with real-time online data sources from Weather Map[2].



(a) Susceptible land-slide sites



(b) Monitoring with on-line sources

Fig. 5. Land-slides monitoring system in Lai Chau

Besides the visualized and interactive map, the system allows local residents and officers monitoring real-time data from each station with a time line (Fig. 6). They can choose which station to observe in the interval of date. This would help local officers and experts give decision before natural hazard.

5 Related Work

VietNam Ministry of Natural Resources and Environment conducted a project that accomplished the susceptible landslide map in some provinces including Lai Chau. This project implemented a webGIS[3] for visualizing the information. This product, however, lacks of real-time factors such as sensors data.

Muandar *et al.* [6] presented a mobile-based real-time weather monitoring system. It also uses sensor in Automatic Weather Station to collect data. The advantages of our system in comparison to their system is that real-time communication between web server and mobile applies in their approach via FTP,

[1] http://103.145.62.106:3000.
[2] https://openweathermap.com.
[3] https://canhbaotruotlo.vn.

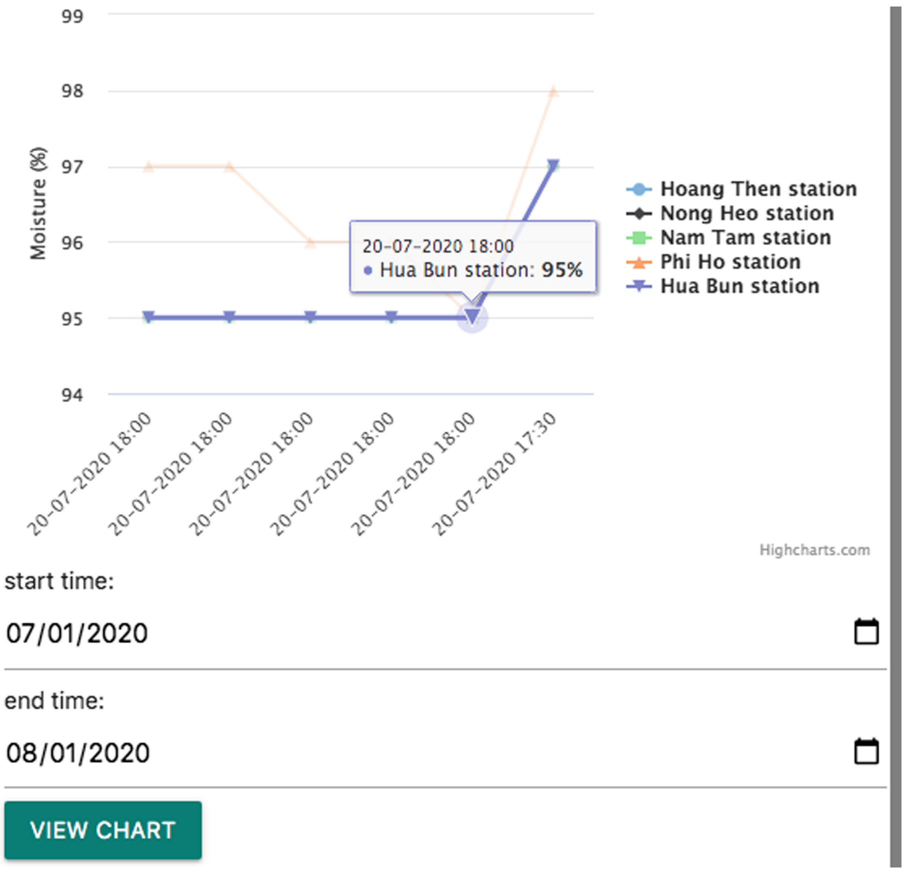


Fig. 6. Data monitoring in time-line charts

then Android applications read files and display the information. Their approach makes more delay than using socket and trigger mechanism. Their system is mobile-based while the proposed system is web service-based.

Song *et al.* [8] developed a real-time environment monitoring using Open GIS Specifications and Open Source GeoSpatial Software with low-cost sensors. There are several commons between their system and our one, for example, using sensors to retrieve air temperature and humidity and PostgreSQL for storage. Their approach, however, just provided a web-based feature and did not focus on landslide.

Recently, Rahmat *et al.* [7] used smart sensors to collect pH, soild moisture, air humidity, and light intensity for rice plants. However, the monitoring information are sent to users in form of SMS. It did not show the extension of the monitoring eco-systems including web and mobile applications.

6 Conclusions and Future Work

Natural hazard prediction and monitoring systems are vital for every country that help to reduce damages of both economy and human life. Such kind of systems depends much on characteristics of monitoring areas. In this study, we presented the system for monitoring landslide and soil moisture in Lai Chau. This system is developed using open source technologies such as Node.Js, socket.io and PostgreSQL. It provides both end users (local residents and government) to monitor live data from sensor stations. Besides, the system also offers web services interfaces for other software application can reuse. In the future, we will develop the mobile applications and components to control sensors remotely. Integrating GIS as a component which allows to flexibly manage maps of vulnerable areas with flooding and landslide in Lai Chau province is also another future work.

Acknowledgments. This work is supported by the project no. CT.2019.01.05 granted by Ministry of Education and Training (MOET).

References

1. Node.js (2020). https://Node.JS
2. Postgresql (2020). https://www.postgresql.org
3. Socket.io (2020). https://socket.io
4. Lee, S., Jo, J.Y., Kim, Y.: Restful web service and web-based data visualization for environmental monitoring. Int. J. Softw. Innov. (IJSI) **3**(1), 75–94 (2015)
5. Lee, S., Jo, J., Kim, Y., Stephen, H.: A framework for environmental monitoring with arduino-based sensors using restful web service. In: 2014 IEEE International Conference on Services Computing, pp. 275–282 (2014)
6. Munandar, A., Fakhrurroja, H., Rizqyawan, M.I., Pratama, R.P., Wibowo, J.W., Anto, I.A.F.: Design of real-time weather monitoring system based on mobile application using automatic weather station. In 2017 2nd International Conference on Automation, Cognitive Science, Optics, Micro Electro-Mechanical System, and Information Technology (ICACOMIT), pp. 44–47 (2017)
7. Rahmat, R.F., Pujiarti, T.Z.L., Hizriadi, A.: Implementation of real-time monitoring on agricultural land of rice plants using smart sensor. In: 2019 3rd International Conference on Electrical, Telecommunication and Computer Engineering (ELTICOM), pp. 40–43 (2019)
8. Song, X., Wang, C., Kagawa, M., Raghavan, V.: Real-time monitoring portal for urban environment using sensor web technology. In 2010 18th International Conference on Geoinformatics, pp. 1–5 (2010)
9. Thumtuan, P., Chub-Uppakarn, T., Chalermyanont, T.: Real time monitoring of soil moisture content for landslide early warning: wn experimental study. In: MATEC Web Conference, vol. 192, pp. 02032 (2018)
10. Zhou, Y., Liu, P., Tang, X.: Application of PDA forest fire monitoring based on web service technology. Front. For. China. **4**, 358–362 (2009)
11. Zhou, Y., Liu, P., Tang, X.: Environmental sensor monitoring with secure restful web service (2009)