IoT Big Data Platform Based Data Management System for West Tianshan Forest Ecosystem Research Station

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Abstract. This paper introduced a data management Web application for West Tianshan forest ecosystem research station by accessing the REST service API provided by an IoT big data cloud platform for eco-station management. The Web application manages the retrieved data by observation systems, and provides commonly needed functions including data query, data directory management, data sharing, data visualization and data report for each observation system. This Web application demonstrates the IoT big data cloud platform, with the help of API, is very powerful and versatile, suggesting an easy and fast approach for a single eco-station to develop a management system based on cloud platform.

Introduction

Ecosystem, as an important part of earth system\cite{1}, is the most active subsystem in the earth system, and the core contents of biosphere closely related with human activities \cite{2, 3}. Long-term positioning observation has been an internationally accepted approach for researching, revealing the change of structure and function of ecosystem\cite{4}. Chinese Forestry Ecosystem Research Network (CFERN) as a pioneer was initiated in the late of 1950s and has been developing and improving ever since to cope with the demands of 6 key forestry engineering\cite{5}. Chinese Terrestrial Ecosystem Research Network (CTERN) was founded in 2003 as network research becomes the trends, and CFERN becomes one of several sub-networks including Chinese Wetland Ecosystem Research Network (CWERN) and Chinese Desert Ecosystem Research Network (CDERN). There are over 180 national ecosystem positioning observation stations (hereafter as eco-station) distributed in different climate zones across China under CTERN to date, covering different types of ecosystems.

Since the beginning of long-term positioning observation, huge amount of data has been accumulated among eco-stations by manually recording, data logging\cite{6} and IoT (Internet of Things) based automated collecting \cite{7}, and these data are of great help to the research and analysis of structure and function changes of ecosystem, shedding lights on the changes of ecosystem and environment\cite{3, 8}, the composition, structure and function, as well as the impact of climate change and the feedback from forest ecosystem\cite{4}. However, huge amount of data also brings a lot of issues for researchers and eco-station maintainers. For example, it is very difficult for find those undiscovered information by data mining without an efficient data management scheme and data sharing is unlikely implemented as well\cite{6, 9}. Some attempts tried to address these issues, including proposing concept of digital forest eco-station and its implementation \cite{6}, MIS based eco-station management \cite{9}, WEB-GIS based information management for forest eco-station\cite{10}. But all these attempts focused only on a single station, not aiming at CFERN, especially when network
collaboration and research are becoming the trend of modern ecosystem research[3], increasing emphasis has been being placed on them.

Actually, as more and more IoT technologies are being used in forest eco-stations, it has become one of the most important big data source for forestry. The potential of applying big data technology in eco-station data management was also discussed [11]. After delicate and detailed design, we implemented a cloud platform for IoT big data management and sharing for forest eco-stations [7], it demonstrates that the platform is capable of managing multiple stations and providing functions of observation device register and management, data service and sharing, data analysis and visualization. Besides, the platform also provides a full set of APIs for client application development, especially suitable for development of a single eco-station data management application. In this paper, we introduce the development of the Web application for West Tianshan forest ecosystem research station, which is one of the managed eco-stations based on the cloud platform API.

**Application Design and Implementation**

**Web Application Design**

Considering that all the observation data from West Tianshan eco-station are actually stored in the IoT big data cloud platform, the cloud platform can be seeing as our data source. All the data can be retrieved through its API access. However, the Web application needs to address problems like, how to manage these retrieved data and how to organize those commonly needed functions. Actually, in a single eco-station, there are many observation systems totally independent with each other, so we can manage the retrieved data as each observation system. We also summed up the commonly needed functions for each observation system. Based on these consideration, we designed the framework of the Web application as showing in Figure 1.

![Diagram](image)

**Figure 1. Web app Framework for West Tianshan eco-station.**

According to the framework, observation data will be retrieved from IoT based big data platform for eco-station management system on the cloud via the REST service API. Data are managed by observation systems including weather gradient, FLUX, water vapor profile, snow & rain, Runoff plot, weather station and sample plot, etc. For each observation system, some main functions like data query, data directory management, data sharing, data visualization and data report are available.
Web Application Implementation

The Web application for West Tianshan eco-station data management was developed by employing trendy web app development tools, including JQuery, H5, CSS3, etc. Fig.2 shows the homepage of the application. There are menus and dashboard available for users. Observation systems are displayed on the dashboard, very easy to be used. And as the new observation systems are deployed in the eco-station, they can be added to the dashboard as well.

![Figure 2. Homepage of the Web application for West Tianshan eco-station data management.](image)

Each observation system will lead to detailed data management functions. Fig. 3a shows the visualization result of weather gradient data. Data visualization can be customized by user. Sample plot is very important for ecological research, Fig. 3b shows the sample plot data management.

![Figure 3. a. Data visualization for weather gradient  b. Sample plot data management.](image)

Formatted data report function is very helpful to researcher, providing periodical data report of monthly, seasonally or yearly in table and figures for user. This function is automatically finished in background according to user’s pre-configuration, there are several options for the configuration, user just need to choose some compositions. Fig. 4 shows the monthly data report for weather gradient of April, 2015.

![Figure 4. Monthly data report for weather gradient of April, 2015.](image)

Data integration is critical for data analysis, but is also very difficult, especially when multiple data systems of one site are independently stored. This Web app provides an effective way for data
integration across observation systems. Integrated data can be showed in both table and figures, and, more conveniently, be exported to csv file for download, user can do more detailed or complicated processing/analysis thereafter.

Figure 5 shows a data integration query across different observation systems. User can choose multiple observation systems as data source and different data fields for each observation system, and then produce an integrated data sheet of specified time duration. As aforementioned, the integrated data can be shared as an exported csv file.

![Figure 5. Data integration across different observation system and file export.](image)

Summary

A Web application system for West Tianshan forest eco-station data management was design and implemented through accessing the REST service API provided by the IoT big data cloud platform for eco-station management[7]. It demonstrates that this is a fast and easy approach for a specified eco-station to develop an own data management Web application. All the data are stored in cloud platform, the web app does not have to manage the data entity, however, it only manages how to retrieve user needed data and how to deal with these retrieved data in a virtual space.

The REST service API provided by the cloud platform is very versatile, various web apps can be developed via this API. Web apps can be easily extended to mobile version by the help of HTML5 technology, making the eco-station data be available at any time anywhere, and this is the key feature for IoT application.

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References

[1] Fu, B., Niu, D., Yu, G., The Roles of Ecosystem Observation and Research Network in Earth System Science, Progress in Geography. 26(1) (2007) 1-16.

[2] Wang, J., Gao, F., Zhang, Z., Bibliometrical analysis of competitive situation of international ecosystem research, Advances in Earth Science. 25(10) (2010) 1101-1111.

[3] Fu, B., Niu, D., Yu, G., The Roles of Ecosystem Observation and Research Network in Earth System Science, Progress in Geography. 26(1) (2007) 1-16.

[4] Fu, B., Liu, Y., Global ecosystem observation and research programs: evolution and insights for future development, Progress in Geography. 33(7) (2014) 893-902.
[5] Wang, B., Cui, X., Yang, F., Chinese forest ecosystem research network (CFERN) and its development, Chinese Journal of Ecology. 23(4) (2004) 84-91.

[6] Wang, B., Li, S., Construction and Techniques of the Digital Forest Long-term Ecological Research Station, Scientia Silvae Sinicae. 42(1) (2006) 116-121.

[7] Wang, H., Zhang, W., Yu, X., et al., Design and implement of Network management platform for forest ecological positioning observation system, World Forestry Research. 31(3) (2018) 28-33.

[8] Fu, B., Trends and priority areas in ecosystem research of China, Geographical Research. 29(3) (2010) 383-396.

[9] She, Jiyun, Tian, D., Shen, C., et al., Study of the information management system of Huitong ecological location research station, Journal of Central South Forestry University. 23(1) (2003) 40-44.

[10] Shen, J., Chen, Z., The WebGIS-based information management system for Forest Eco-stations, Forest Resource Management. (2) (2006) 92-96.

[11] Song, Q., Niu, X., Wang, B., Review on forest ecosystem services assessment based on Big data, Chinese Journal of Ecology. 34(10) (2015) 2914-2921.