Chapter 32
Restful Web Service and Web-Based Data Visualization for Environmental Monitoring

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ABSTRACT

The Nevada Solar Energy-Water-Environment Nexus project collects a large amount of environmental data from a variety of sensors such as soil, atmosphere, biology, and ecology. Mostly, the environmental data is related to a development of renewable energy resources in the Nexus project. The environmental data can have an impact on other research fields if it can easily be shared with other researchers, students, teachers, and general users. Therefore, Nevada Climate Change Portal (NCCP) site was created for Nexus project with a purpose of sharing such data. However, there are some challenges to address in utilizing such data, collecting the data, and sharing the data among the users. In this research, the authors propose Extended Web Service Architecture for solving these challenges. The authors implement Arduino instead of CR1000 as a collector due to its cost effectiveness. The authors also use REST API to overcome the limitations of Arduino. Moreover, the authors experiment with popular Web-based data visualization tools such as Google Chart, Flex, OFC, and D3 to visualize NCCP data.

1. INTRODUCTION

Developing renewable energy resources is a national priority (U.S. Office of Management and Budget, 2012). In order to reach the national goal of extending renewable energy resources, University of Nevada, Las Vegas (UNLV), University of Nevada, Reno (UNR), and other Nevada institutions are collaboratively

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conducting Energy-Water-Environment Nexus project. Nexus project researchers have been collecting lots of data from environment for decades. The environmental data is valuable for people in various areas such as engineers, hydrologists, biologists, ecologists, soil scientists, atmospheric scientists, economists, and so on. Hence, numerous organizations focused on creating their own data centers to share such data. Accordingly, NCCP site was built to accommodate Energy-Water-Environment Nexus project. It has been collecting data and constructing data publications since 2011. NCCP site established the Nevada climate-eco-hydrology assessment network (NevCAN) for collecting environmental sensor data such as, precipitation, pant canopy interception of snow, subsurface soil water flow, soil water content, snow depth, soil temperature, thermal flux, solar radiation, and so on (Nevada Climate Change Portal, 2014). NCCP site can store environmental sensor data over four hundred millions data points per year by NevCAN. Visualizing the data in real-time requires lots of memories and resources on the web server. Pre-processing them is difficult because there are so many sensor data combinations, chart types, and the lengths of period which could be requested by the users.

The proposed architecture is composed of three main parts, i.e., sensor network, Web Service and Visualization. In this research, we suggest Arduino-based sensors for a reduced cost compared to CR1000. Also, we propose advance Restful Web Service for environmental monitoring system. REST performs better in a sensor network compared to Simple Object Access Protocol (SOAP) which is currently utilized by NCCP. It also has a flexibility of being fitted to numerous types of scale. Moreover, REST is suitable for web services based on Arduino. We test popular web-based data visualization tools with a huge amount of sensor data that are achieved from Nevada Nexus project.

2. RELATED WORK

Environmental data are growing bigger and becoming more important due to a significant development of environmental monitoring. Therefore, data portals, such as Climate Data Portal (Soreide, Sun, Kilonsky, & Denbo, 2001), NCCP, and GPS Explorer data portal, are becoming more important to share such data. Sensor Web Services-based observation/analysis/modeling is focused on collecting and sharing the environmental sensor data at the portal (Xianfeng, Chaoliang Kagawa & Raghavan, 2010. Bock, Crowell, Prawirodirdjo & Jamason, 2008).

However, majority of portals need to improve their data visualization for real-time visualization data Web Service. Most of visualization research is practiced with off-line tools. For example, Mathematical toolssuch as Matlab (Azemi, & Stook, 1996), Mathematica (Savory, 1995), GODIVA (Xiaosong, Winslett, Norris, & Xiangmin, 2004) and so on, are typically included in visualization routines and so are off-line visualization tools such as Origin (Yingqi, 2011), Mayavi (Ramachandran, & Varoquaux, 2011), and R-software (Voulgaropoulou, Spanos & Angelis 2012). These tools are not suitable for data portal as they are not based on on-line visualization.

In this research, we advanced the Web Service using second generation web service, REST Web Service. Additionally, we connected Arduino as a sensor to reduce cost for collecting data. Also, we examined the data processing frameworks of popular web-based data visualization tools and compared their performances to suggest suitable visualization tools for each data portal.

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