Using OGC SensorThings API for Boreal Environmental Monitoring

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Abstract

The boreal forest ecosystem of Alberta is increasingly affected by the elements of human footprint related to natural-resource extraction, pipelines, roads and seismic lines. One of the important challenges in the boreal forest region is to monitor both vegetation and wildlife communities in order to assess the efficiency of restoration treatments on seismic lines. This project aims at monitoring the physical conditions of a recovered seismic lines ecosystem using low-cost ground sensor networks. Internet of Things (IoT) devices created by different manufacturers follow heterogeneous proprietary protocols to communicate with each other. Therefore, interoperability is a major challenge in IoT which requires layers of standards to addresses the heterogeneity issues among sensors, data, and network. The main objective of this research is to evaluate an interoperable IoT prototype system for environmental monitoring based on the OGC SensorThings standards. OGC SensorThings API is a specification for servers and applications dealing with sensor data and communication over HTTP or MQTT. This paper demonstrates that OGC SensorThings API significantly simplifies and accelerates the development of an environmental sensor network, to collect large and accurate datasets while vastly decreasing the time and cost of gathering such data. A prototype of OGC SensorThings API is presented in this paper to monitor the physical conditions i.e. temperature, humidity, and pressure. In summer 2016, eleven device nodes were deployed in three remote sites in the boreal ecosystem in northern Albert. The sensor devices were used to send their data continuously to the University of Calgary Campus gateway node in real-time via 2.5G mobile networks. This prototype improves the accessibility of sensor data and provides a tools for downloading and visualizing data from any sensor at any time, without any proprietary software. To our best knowledge, this deployment is a novel geospatial cloud-based interface for IoT for a project monitoring environmental variables in the Boreal Forest.

Background and Relevance

In order to mitigate the effects of human developments in the boreal-forest region, resource-extraction companies and provincial regulators are working to monitor the effect of human footprint present in a given area, and measure the rate at which previously disturbed areas are being reclaimed. Monitoring both vegetation and wildlife communities in order to assess the efficiency of restoration treatments on seismic is challenging. Most of the regions are not easily accessible and it is time-consuming to travel to those sites. Furthermore, the cost of the field work (i.e., equipment, personnel, etc.) is high. Therefore, IoT could have tremendously positive impacts on monitoring environmental variables in the Boreal Forest environment (Atzori, 2010). Small size low power and low-cost environmental sensors can now be carried around and connected to the web to monitor the environment indicators such as temperature, soil moisture, air quality, radiation, water quality and many others.

One of the challenges of environmental monitoring using IoT is collecting data from various sensors and sharing them with other researchers. Often the data aren't available online or are available in a format which is not interoperable with other online tools (Gubbi et al., 2013). To prevent the interoperability issues of data, sensor and communication protocol, we have built an open-source web application interface that can be used to find and view datasets time series that are stored in Open Geospatial Consortium (OGC) SensorThings API, a standard created by the OGC (Liang et al., 2016). By using OGC SensorThings API, we are able to develop a lightweight JSON-based web service description to follow a coherent protocol to control and monitor the devices. These web services are managed in a cloud platform which connects devices easily and securely with cloud applications and other devices. This API also provides tasking capabilities to control the sensor where we want to monitor the physical conditions based on specific criteria.

Methods and Data

The system architecture (Figure 1) contains three main components: 1) Sensor devices which record the physical conditions such as temperature, humidity, and pressure using sensors and actuators; 2) Cloud server where store and share the field data using OGC SensorThings API; 3) Application user interface to visualize and analyze the sensor data. This information will appear in a variety of charts and integrates with the GIS maps.

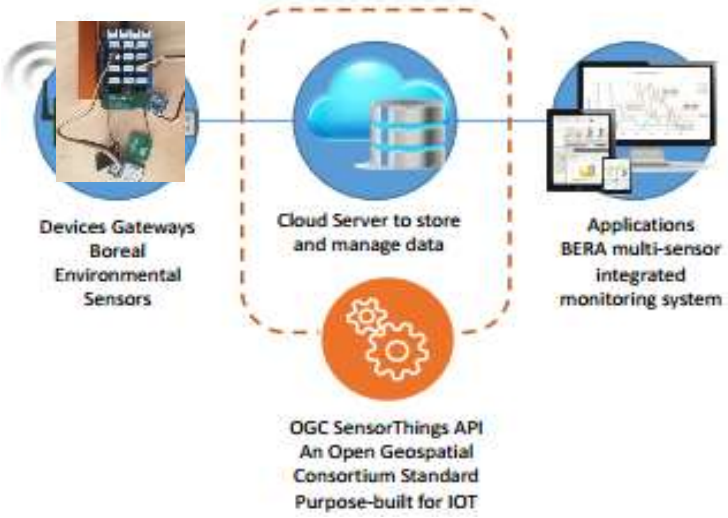

Figure 1: System architecture of OGC SensorThings API for boreal environmental monitoring

Users can browse sensor location and view time series charts of the observation data between any two time periods. OGC SensorThings API which is a specification for servers and applications works like a record database for sensor data. Data producers can submit any sensor data in an open and well-defined format to a web URL and the data with sensor metadata will be stored in the API. Then data consumers can access web URLs provided by the OGC SensorThings API server and read or download the sensor data for their own applications. The web application works like a "dashboard", providing an overview of the data in the OGC SensorThings API server. As our visualization dashboard is web-based, the dashboard can use AJAX to make requests for data directly from the web browser without a proxy server. The dashboard is coded in JavaScript and viewed in a web browser. It is open source in an effort to encourage adoption and feedback from other users of SensorThings API that need a dashboard.

Results

For evaluating the performance of OGC SensorThings API in boreal forest monitoring, sensor devices were designed and developed to measure temperature, humidity, and pressure. Eleven LinkIT devices are deployed in three different boreal forest regions of northern Alberta in summer 2016. The sensor devices were used to send their data continuously to the University of Calgary Campus gateway node in real-time via 2.5G mobile networks. Three sensor devices transfer the data using mobile network coverage in near real-time. The data stream can be received by the OGC SensorThings API cloud server. Meanwhile, the other eight offline devices store data on the micro-SD card. The preliminary result shows that OGC SensorThings API properly used to connect the field sensor. The field devices were able to upload time-stamped and location-based observations into the SensorThings API cloud server with the various sampling rate and data quality. For this project, a dashboard application interface is developed to visualize sensor data. The following figure shows the dashboard application interface and it is available online at http:// dashboard.bera-project.org. The code is freely available via GitHub at https://github.com/ GeoSensorWebLab/sensorthings-dashboard. It has the readings of any sensor connected to it with its location on a map view. The uer can share and visualize their data and some basic statistics such as min, max or average.

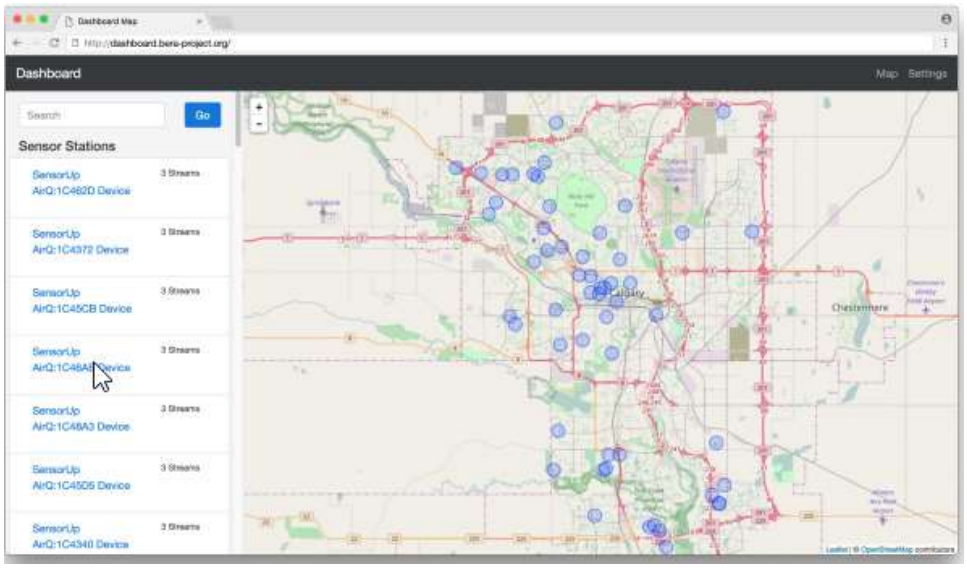

Figure 2: The dashboard application interface which is available at http://dashboard.bera-project.org

During the field tests, all the devices survive in the field. The devices with a large battery can run nearly one week without any power source. The relationship between device power and the sampling frequency of sending data were investigated to choose the best sensor data rate.

Conclusions

The contribution of this research is to develop and deploy an end-to-end ground sensor network prototype to collect, transfer, store and manage sensor data for monitoring environmental variables (i.e. temperature, humidity and pressure) in the boreal forest using OGC SensorThings API and standard. This prototype is used to monitor the physical conditions i.e. temperature, humidity, and pressure. Among the existing IoT standards, the Open Geospatial Consortium (OGC) SensorThings API standard has been used in this project to support interoperability

among the various data sources and provide comprehensive conceptual model and query functionalities. Using this API, each device can send data streams from different sensors. Each sensor has a data stream, observed property, metadata, data quality, data rate, location, and ID. This standard defines an open-source interface to interconnect IoT devices, data, and applications over the Web. This standard is non-proprietary, platform-independent, and perpetual royalty-free.

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