A Community-based Smart Cities Air Sensing Internet of Things Pilot in Calgary

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Abstract

This long abstract describes a smart cities pilot project in Calgary. The smart cities pilot collected air quality data with open source Internet of Things (IoT) devices. The architecture uses the Open Geospatial Consortium (OGC) SensorThings API as the reference architecture, so that it is interoperable, extensible, and future-proof. In addition, this pilot uses a citizen science approach. More than 50 Calgarians set up IoT sensors at home and collectively form a citizen sensing platform. Currently 58 sensors have been online since October 2016 and continuously publishing air quality data to the SensorUp OGC SensorThings API cloud. This project demonstrated that it is economically and technologically feasible to build a large-scale, low-cost, and sustainable smart cities IoT sensing system with a citizen sensing approach and interoperable OGC IoT standards.

Background and Relevance

According to a WHO study (Shumake-Guillemot, Jalkanen, & Adhair-Rohani, 2014), ambient air quality has significant impact on human health. 3.7 million premature deaths per year could be attributed to ambient particulate matter pollution, and the fact places ambient air quality among the top health risk factors globally. Although the traditional air quality monitoring methods provide accurate results, they are very expensive to build and maintain. As a result, it is economically impossible to deploy a large number of air quality monitoring stations in any city or community. For example, Calgary Region Airshed Zone (CRAZ) (Calgary Region Airshed Zone, 2016) has only three air quality monitoring stations in the city of Calgary. Consequently, there is no street-level air quality pollution data available. An average person breath 13,000 litres of air per day (Holmes, 1994) and there is no data available to know the quality of that amount of air we breathed in and out every day. The high level research goal is to develop an affordable and useful air quality monitoring system based on the IoT technologies that offers high spatio-temporal resolution air quality data.d

Methods and Data

This research methodology has the following three components. First, we use a citizen sensing approach to build the proposed air quality sensing platform. Among the many well-identified benefits of citizen science projects, the most relevant benefit for this project is that citizen sensing is low-cost to set up, scale up, and maintain the sensing platform. The project recruits more than 50 volunteers in Calgary (SensorUp Inc., 2016a). A make-your-own-sensor workshop was held on October 8th 2016. All volunteers were able to assemble their own IoT air quality sensor devices and connect them online.

The second methodology is that we use the OGC SensorThings API (Liang, Huang, & Khalafbeigi, 2016) as the reference architecture. OGC SensorThings API is an interoperable standard framework to interconnect IoT sensing devices, data, and applications over the Web. OGC SensorThings API addresses both the syntactic interoperability and semantic interoperability of the IoT.

Finally, we use open source hardware to build the air quality device. Mediatek LinkIt 7688 Duo (MediaTk Inc., 2016) framework is chosen because it is affordable and provides Wi-Fi communication capability. Its IC and PCB layout design also provides simplicity and extensibility, so that we can customize it according to our own requirements. In addition, LinkIt 7688 Duo is also very affordable. It costs only $15.90 USD (Seeed Development Limited, 2016).

Results and Conclusions

58 air quality sensing nodes have been set up by Calgary citizens within an hour (SensorUp Inc., 2016b). We demonstrated that citizens without specialized training are able to set up the IoT devices by simply following the Web interfaces offered by the IoT device. Real-time air quality data are displayed on a web map allowing users to browse and see the sensor observations (Figure 1). All data can be accessed via the public OGC SensorThings API endpoint: http://example.sensorup.com/v1.0. IoT interoperability is demonstrated between IoT devices-to-cloud and cloud-to-web-applications. All sensors are able to register to any OGC SensorThings API compliant cloud service (Figure 2) without human provisioning. Any OGC SensorThings API client is also able to access, understand, and use the data from the pilot as the data model and ontology is compliant to Observation and Measurement Standard-OGC/ISO 19156:2011 (Cox, 2011).

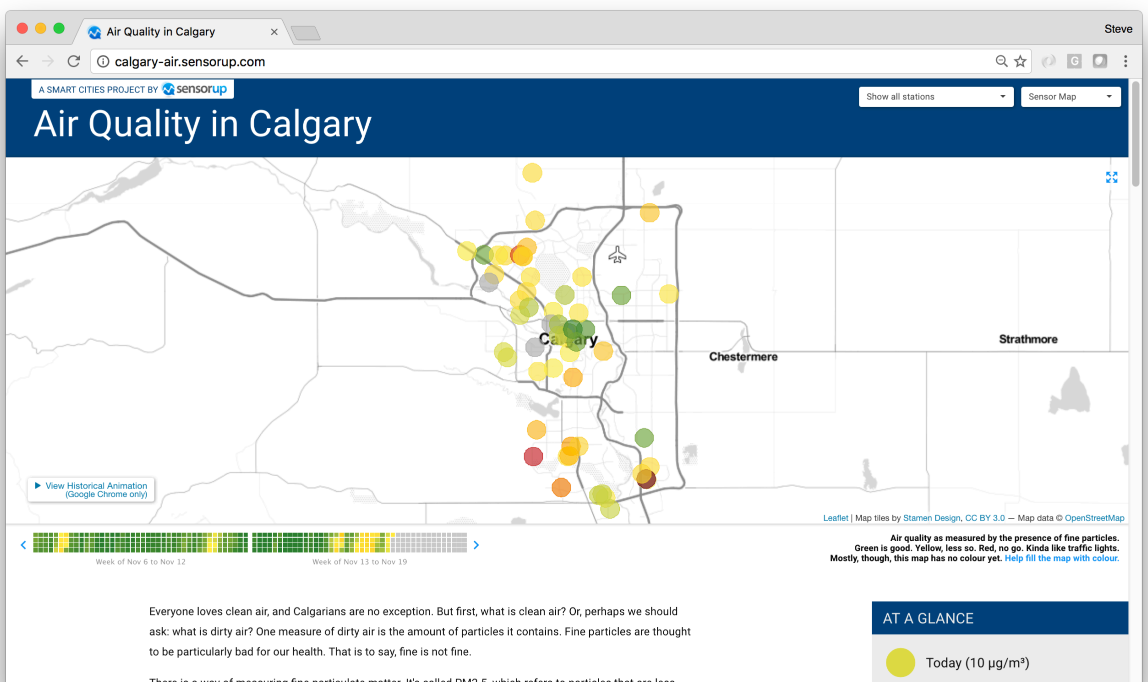

Figure 1 Frontend Interface of the Calgary Air Quality Sensing Pilot (Retrieved from http://calgary-air.sensorup.com/)

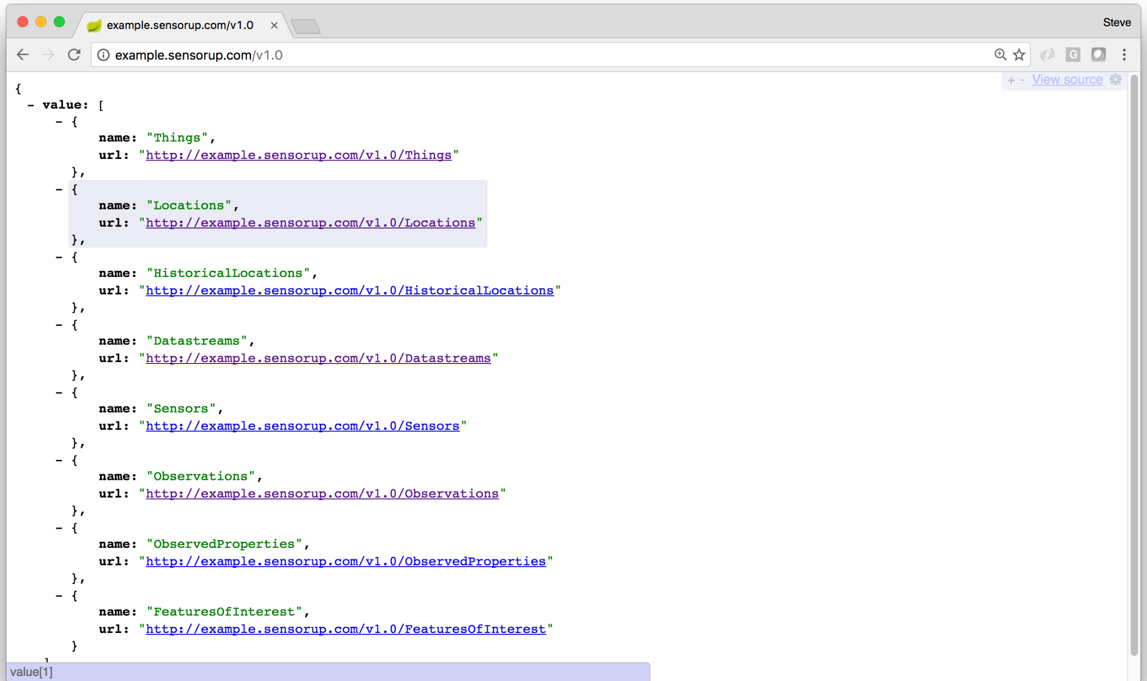

Figure 2 Screen capture of the OGC SensorThings API root endpoint (Retrieved from http://example.sensorup.com/v1.0)

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