Towards A Proposed Methane Fugitive Emission Data Model Using the OGC SensorThings API Standard

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ABSTRACT

Methane is one of the most potent greenhouse gases. Reducing methane emissions is an important issue to prevent global warming. Various regulations are in effect to reduce methane emissions in the oil and gas industry. The Open Geospatial Consortium (OGC) is an international consortium that develops and implements open standards for geospatial content and services, the Internet of Things (IoT), and data sharing, such as the OGC SensorThings API standard. The focus of this paper is to use the OGC SensorThings API standard as the fundamental data framework for enabling data interoperability for the Alberta Energy Regulator (AER) Directive 60 fugitive emissions. AER Directive 60 contains requirements for eliminating, reducing, and improving flaring, incinerating, and venting for upstream petroleum industry wells and facilities in Alberta. This paper proposes a profile to extend the OGC SensorThings API capabilities for exchanging and managing methane emissions data that covers existing regulations and frameworks for consistency in methane emissions data reporting in Canada. This paper demonstrates that the OGC SensorThings API has the potential and capabilities to enable the exchange and management of methane emissions data in methane reduction programs such as AER Directive 60.

1. Introduction

Methane (CH_4) is the second-most potent Greenhouse Gas (GHG), which has an enormous impact on global warming and climate change by trapping heat in the atmosphere. The Intergovernmental Panel on Climate Change (IPCC) estimates the Global Warming Potential (GWP) of methane to be 84 times over 20 years (Myhre, G., et al., 2013) and 28 times over a period of 100 years (Myhre, G., et al., 2013, Pachauri, R. K., et al., 2014). In Canada, Oil and Gas (O&G) facilities are the largest industrial emitters of methane. They release about 40% of total methane emissions (Environment and Climate Change Canada, 2021). Upstream activities such as exploration, drilling, production, and field processing contribute about 90% of methane emissions and account for 26% of Canada's total GHG emissions (Ganapathy, R., 2018). To reduce methane emissions, the Government of Canada has developed methane emissions regulatory frameworks to be applied in the upstream O&G industry. In Alberta, the O&G industry is the largest source of methane emissions. In 2016, the Alberta Energy Regulator (AER)[1] developed methane emissions reduction requirements in AER Directive 60 (AER, 2022), which took effect

[1] https://www.aer.ca/

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on January 1, 2020. In the O&G industry, methane emissions are often organized as either vent gas (i.e., intentional releases of methane) or fugitive emissions (i.e., unintended releases of methane). The AER Directive 60 requirements cover both vent gas and fugitive emissions.

Methane emissions data plays an important role in the efficiency of any regulation. Moreover, effective regulation greatly relies on further data assessment and analysis. Therefore, the collection of concise, consistent, and credible data is critical for both industry and regulatory bodies. In this regard, one challenge is the inconsistency of provincial regulations on reporting methane emissions. Therefore, O&G companies are supposed to follow different regulations for each province and need to provide distinct systems and platforms for each province to detect, record, and report methane emissions data. Another challenge is how regulations can adapt and adjust to the fast-growing rate of developing technologies for screening and detecting methane emissions. These novel technologies promise a higher spatiotemporal resolution for detecting methane emissions, which lowers the operation cost and speeds the detection process. Moreover, they are more efficient at detecting and identifying possible leaks. Therefore, a compatible standard to exchange and manage methane emissions data between O&G companies and regulatory bodies is required.

Based on these challenges, we suggest the introduction of a standard for exchanging methane emission data. Having a standard has various advantages for reducing methane emissions. The ability to repair a leak sooner after it is identified would be the immediate benefit of such a standard. This will have a significant impact on lowering methane emissions. For example, after identifying a leak in a facility using the deployed sensor networks, operators can send repair crews to fix the identified leak. Another advantage of having a standard is the ability to connect and combine methane emissions data from various detection sources on a standardized platform. This is possible among separate companies. For example, different companies can transfer their methane emissions data to regulatory bodies using a standard methane emissions format through the web. This facilitates data exchange between companies and regulatory agencies. Moreover, archived methane emissions data can be Findable, Accessible, Interoperable and Reusable (FAIR) using the methane emissions standard.

The Open Geospatial Consortium (OGC) SensorThings Application Programming Interface (API) (Liang S., et al., 2016) has a decent underlying framework to apply to methane emissions data, an open standard for handling the interoperability of the Internet of Things (IoT). IoT devices are machines and devices that can interact with each other in a global network. OGC SensorThings API provides an open, geospatial-enabled, and unified way to interconnect IoT devices, data, and applications over the web as well as interfaces to interact with and analyze their observations (Liang S., et al., 2020). The OGC SensorThings API is a RESTful API and uses JavaScript Object Notation (JSON) encoding. Representational State Transfer (REST) is an architectural style that defines a set of constraints. A RESTful API refers to a web API that conforms to the REST architectural constraints[2]. The MQ Telemetry Transport (MQTT) messaging protocol for IoT devices is supported by the OGC SensorThings API. MQTT is a lightweight publish/subscribe protocol used to connect remote devices with limited network bandwidth. The OGC SensorThings API standard is developed based on Sensor Web Enablement (SWE) standards (SensorThings API Part 1: Sensing Version 1.1, 2020). The OGC's SWE standards enable developers to make all types of sensors and sensor data repositories discoverable, accessible, and useable through the web. Figure 1 shows the Unified Modeling Language (UML) diagram that describes the entities of the OGC SensorThings API data model. These characteristics make the OGC SensorThings API a unique candidate for building a profile for exchanging and managing methane emissions data based on it. Modularity, scalability, interoperability, and simplicity are all provided by the OGC SensorThings API. One of the key features of the OGC SensorThings API is handling geospatial data. Reporting a leak location is one of the fundamental requirements in AER Directive 60 for

[2] Uniform interface, client-server, stateless, cacheable, and layered system are defied as architectural constraints.

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reporting methane emissions data. The OGC SensorThings API standard facilitates the development, sharing, management, and use of different data and services in Geographic Information Science (GIScience). The approval of using IoT devices such as continuous monitoring systems for detecting and reporting leaks by AER would be another privilege of using the OGC SensorThings API in the O&G industry for methane emissions data.
In this paper, we propose a profile to extend the OGC SensorThings API capabilities for exchanging and managing methane emissions data. The profile supports existing regulations for consistency in reporting methane emissions data in Canada.

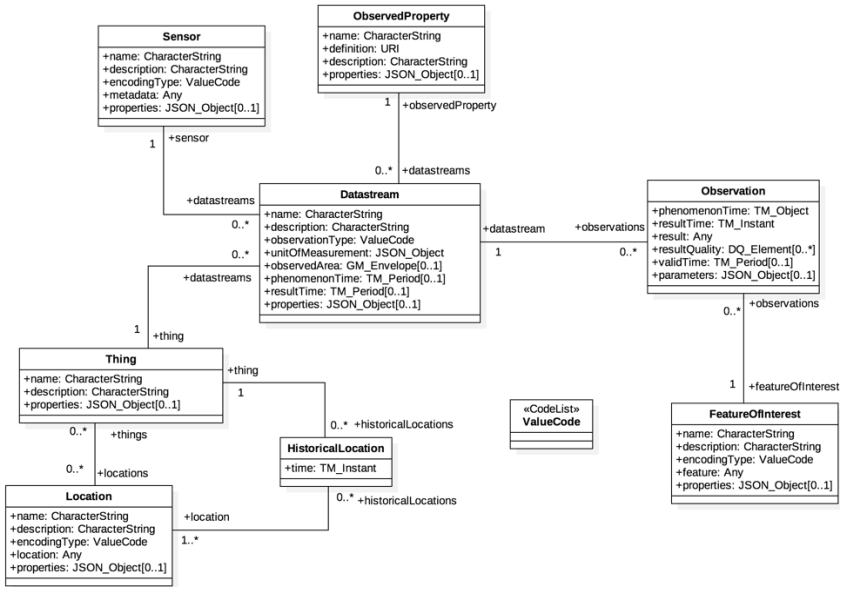

Figure 1: The core OGC SensorThings API data model (Liang S., et al., 2016). An asterisk (*) in the model denotes "many" instances in the "0 to many" and "1 to many" relationships.

2. Methods & Data

A data model was developed to report fugitive emissions data based on AER Directive 60 requirements and definitions (Figure 2). This model follows the OGC SensorThings API data model. The model describes the entities, their properties and values, and their relationships to report fugitive emissions. In Figure 2, each entity of the data model is adjusted based on the requirements of AER Directive 60. According to AER Directive 60, each detected fugitive emission is considered a "Thing". A "Location" refers to a valid Legal Sub-Division (LSD) in the Alberta Township Survey (ATS) system. AER Directive 60 requires that fugitive emissions from active sites be reported at the site where they occur. Site boundaries are polygons, not lines or points. Therefore, the location properties are GeoJSON polygons. In this model, each "Thing" must have three "Datastreams": the number of identified sources of fugitive emissions, fugitive emissions volume, and fugitive emissions mass. Entity properties are adjusted in the model as needed. For example, each "Datastream" has a unique unit of measurement. The "Sensor" entity is not an instrument, and it would be an observation process as described by AER Directive 60. This process generates the observation result.

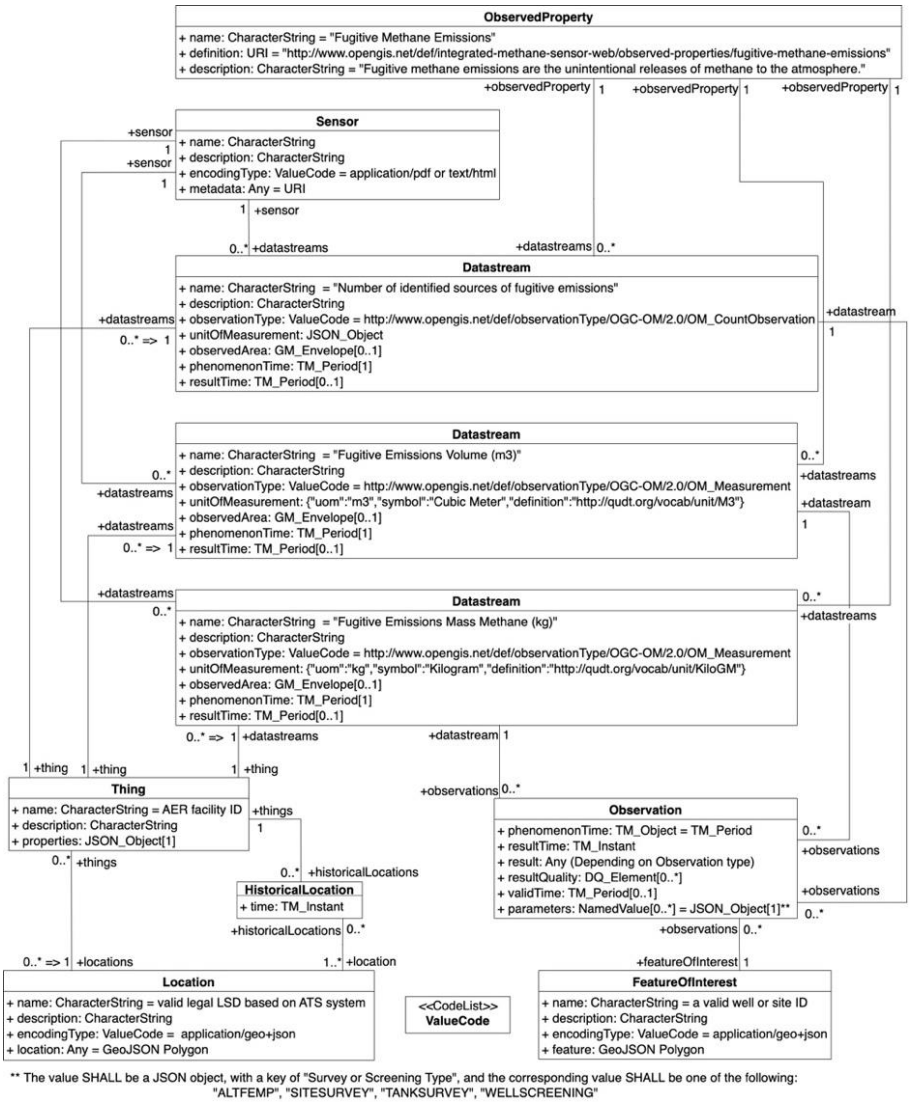

Figure 2: OGC SensorThings API entities and relationships for AER Directive 60 – fugitive emissions data.

The developed model is deployed and tested as shown in Figure 3. This figure shows reporting sample fugitive emissions data for five different sites in a SensorUp dashboard. The SensorUp dashboard can visualize OGC SensorThings API entities in table format. It also provides different tabs for each entity, such as Locations, Datastreams, Features of Interest, etc. Users can use this dashboard to create OGC SensorThings API entities. To access the SensorUp dashboard, go to http://dashboard-demo.sensorup.com/#/home. Five different Things with the required properties have been created to test the developed data model. Sample data can be accessed using the OGC SensorThings API endpoint: https://methane-sensor-web.sensorup.com/v1.0. As shown in Figure 4, the endpoint provides all entities' names and their URL to access their details. For instance, by clicking on the Things URL, you have access to all created “Things” with their details and links to their connected entities. The capabilities and compatibility of the OGC SensorThings API as a methane emissions data exchange standard were demonstrated in this paper. Conformance class test suits are developed in accordance with the OGC SensorThings API. The purpose of these tests is to assess the conformance of an implementation to the requirements of the OGC SensorThings API.

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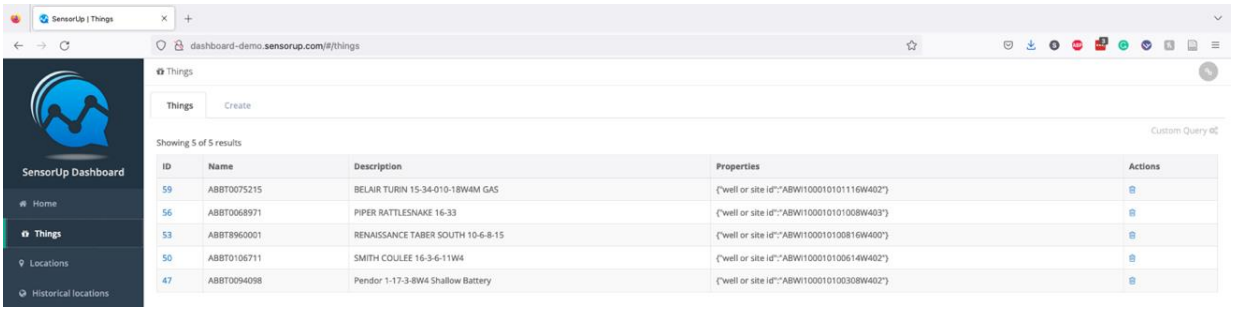

Figure 3: Five sample fugitive emission datasets based on AER Directive 60 requirements using OGC Sensor Things API.

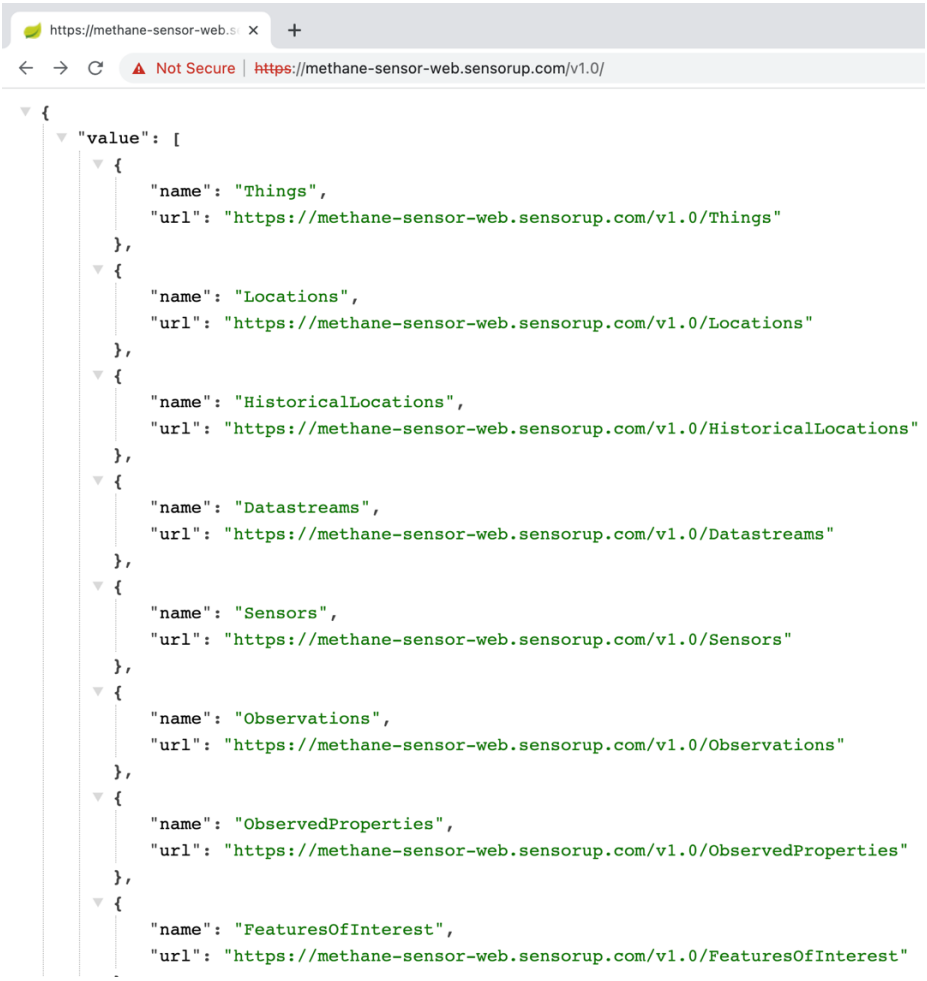

Figure 4: OGC SensorThings API endpoint of methane sensor web (https://methane-sensor-web.sensorup.com/v1.0/)

3. Results and Conclusions

We presented a data model and a profile of the OGC SensorThings API for exchanging and managing fugitive emissions data. This profile follows the requirements of AER Directive 60. This paper has shown the potential of the OGC SensorThings API standard to be used as a methane

emissions data exchange standard in the O&G industry. Furthermore, it has been demonstrated that it can be used by a variety of organizations. For instance, methane emissions service providers and facility operators in the O&G industry can benefit from this model to exchange methane emissions data. In future work, we plan to develop a vent gas data model using the OGC SensorThings API.

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