SenML: simple building block for IoT semantic interoperability

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Abstract

Standardized Internet protocols enable IoT devices to exchange data with each other in interoperable ways. However, for the devices – and whole applications and systems – to understand what can be done with the data, more information about the data itself is usually needed. There are various approaches for providing the needed metadata ranging from elaborate schemas to simple tags. In this paper we discuss systems utilizing IoT sensor and actuator data and an information and data model being standardized at the IETF that facilitates handling the data in interoperable yet efficient ways.

Introduction

Many IoT scenarios start rather simple. For example, a building automation system needs to measure temperature of rooms in order to adjust heating and cooling; an industrial control system measures gas or acidity levels of a process material to detect anomalies there; a smart city deployment detects whether parking spots are occupied and notifies smart vehicles accordingly. All these scenarios require a sensor system to detect the levels of real-world variables and communicate them to other systems so that they can act accordingly. These scenarios share a set of common characteristics: they need a unique identifier for the source of the information; they need a way to tell the value of the measurement and with what kind of units the measurement value is expressed; and they (often) need to convey information about when the measurement was made.

On the other hand, IoT scenarios have a tendency to evolve and more complex requirements emerge over the lifetime of the systems. Changing the fundamentals of the system to accommodate each round of evolution is not feasible and therefore the way data is exchanged and handled needs to be able to evolve over time. Also, since many IoT devices are extremely constrained and the more powerful systems may need to handle masses of data, it is essential to reduce the amount of resources needed to generate and handle the data and metadata. Using simple but extensible building blocks for the IoT data can facilitate this, and one example of such building block is the Sensor Markup Language (SenML).

Sensor Markup Language

SenML [1] is a simple information model for sensor measurements and device parameters currently being standardized at the IETF Constrained RESTful

Environments (CoRE) working group. The SenML information model includes a unique device name, an application specific name of the sensor or actuator, a well-defined hint ("unit") of what kind of value is presented in the value field, and an optional time stamp. SenML specification defines a data model and serialization for JSON, XML, CBOR, and EXI. Key design principle of SenML is that processors with very limited capabilities can encode it and servers receiving SenML can efficiently collect large amounts of SenML data. SenML also strikes a balance between highly optimized, binary representations and full-blown complex formats, and provides a developer-friendly textual representation that is both readable and compact enough for constrained environments. SenML is suitable for different data flow models, from sensors pushing data to a collector, to a web-resource style model where SenML data works as resource representation and is retrieved or changed by web clients.

Example of SenML JSON serialization in Figure 1 shows a temperature reading taken approximately "now" by a 1-wire sensor device that was assigned the unique 1-wire address of "10e2073a01080063".

```
[{ "n": "urn:dev:ow:10e2073a01080063", "v":23.1, "u":"Cel" }]
```

Figure 1 - SenML example

SenML requires no additional metadata or schema for building generic applications that can use the value and unit for wide array of uses. When multiple sources or destinations are used in a single message, the unique names tell them apart and the optional time stamp can be used to convey relative or absolute time information for each value. When single message contains multiple measurements or configuration values, SenML allows for a simple optimization, "base values", where the shared name (or prefix of the name), shared unit, and/or base time can be expressed once and re-used, or replaced, by each measurement entry. Example of SenML with base values is shown in Figure 2.

```
[{"bn": "urn:dev:mac:0024befffe804ff1/",
  "bt": 1276020076,
  "bu": "A" },
  { "n": "voltage", "u": "V", "v": 120.1 },
  { "n": "current", "t": -2,  "v": 1.5 },
  { "n": "current", "t": -1,  "v": 1.6 },
  { "n": "current", "t": 0,   "v": 1.7 }
]
```

Figure 2 - SenML with base values

Similar to measurement values retrieved from sensors, SenML can be used to control actuators. Whereas for measurements the name indicates the source sensor, for actuation the name indicates the actuator that is controlled. Time stamps can be used with actuators to change values over time with a single message.

For applications that want to add additional information for SenML messages can use e.g., web links when pointing to SenML data or extend the SenML data structures. The base value and each measurement entry structures are modeled as dictionaries with key-value pairs. New specifications or proprietary uses can define new key-value pairs to both structures.

Conclusions and current work

SenML provides a simple model for retrieving data from sensors and controlling actuators. It provides minimal semantics for the data inline and allows for more metadata with in-line extensions and links. This simple yet flexible model has already proven itself useful in various practical IoT scenarios and SenML has also been adopted by other standardization organizations. Currently we are working at the IETF on finalizing the encoding details of the data structures of SenML data models that enable good trade-off between simplicity and efficiency. Once the details are settled, SenML is ready to enable semantic interoperability for IoT applications across the board.

References

[1] "Media Types for Sensor Markup Language (SenML)". C. Jennings, Z. Shelby, J. Arkko, A. Keranen. January 13, 2016. Work in progress. https://tools.ietf.org/html/draft-jennings-core-senml-04