IPSO Sematic Working Group

Milan Milenkovic, IPSO Semantic Working Group, in collaboration with Michel Kohanim and Doug Migliori

IPSO Semantic Working Group is chartered to work on interoperability across specifications and domains, in effect on inter-domain interoperability. In contrast, most of the IoT data-model standards under development focus on a narrower, intra-domain interoperability. That works only for groups of IoT devices that implement a common specification. IPSO's departure into inter-domain space is intended to enable IoT interoperability in a world where no single data specification is likely to emerge as dominant to the extent of subsuming all others.

Charter, excerpt

"The group will focus on accomplishing interoperability across different information models developed by IPSO and other organizations. It will attempt to do so by developing and promoting a "meta" information model that represents key inherent properties and relationships of the physical entities that are being modelled. The expectation is that this "meta" model will serve as a universal data and meta-data exchange layer that can be mapped to specific bindings and representations of smart objects, such as OMA LWM2M which is effectively IPS[O] SO Gen 1. To accomplish this objective, the group will work closely with other organizations and domain experts from industry. W3C, IETF, OIC, Zigbee, and Bluetooth are obvious candidates.

To accomplish backwards compatibility and for those deployments that use OMA LWM2M, the group will define bindings (data models) for use with LWM2M. At least one other binding will be defined, such as OIC, to demonstrate and test cross-domain interoperability. Other bindings may also be defined, some of which may not even make use of RESTful communication protocols.

The group will perform this work in three mostly consecutive phases:

1. Definition of architectural principles and design guidelines for constructing interoperable semantic data models
2. Definition of meta-model for describing semantic properties for interoperability
3. Mapping of meta-model to specific bindings, such as LWM2M (IPSO gen 1) and OIC."

[NB: after this charter was written, OIC became OCF]

Motivation

Data interoperability is a pre-requisite for being able to deliver on the IoT big-data promise, i.e. aggregate large, diverse sets of understandable data. Achieving interoperability has the potential to increase the IoT market value by 40% as per McKinsey Global Institute study in 2015. To quote "In our analysis, of the total potential value that can be unlocked through the use of IoT, 40 percent of this value, on average, requires multiple IoT systems to work together."

A significant benefit of IoT data interoperability is the ability to create large, useful aggregations of sensor data for post-processing such as data mining, analytics, machine learning, and AI. It is well known that effectiveness of all those techniques increases with the size of the data set. At present, IoT data are fragmented and locked in silos due to incompatibility of formats in proprietary platforms and in numerous evolving standards that focus on limited domains. Another significant benefit of an architected approach to interoperability is the ability to incorporate volumes of existing sensor data being produced by legacy systems, including proprietary Supervisory Control and Data Acquisition (SCADA) systems, Building Management Systems (BMS), energy utilities, and various automation and manufacturing systems using legacy standards such as BACnet and Modbus.

Interoperabiltity Revisited

Based on common layered architectural frameworks for communication systems, there are two levels of interoperability of interest for IoT data interoperability (1) syntactic interoperability and (2) semantic interoperability. Those reside at levels 6 and 7 of the ISO OSI model, respectively, and have also been included in the recent IIC Connectivity Framework.

Ongoing Discussions and Observations

At present, the intent of IPSO Semantic WG is to tackle both levels of IoT interoperability, syntactic and semantic, across domains and specifications. Our work and discussions to date have led to several observations:

- Semantic data interoperability is sufficient for data aggregation purposes, such as creating large diverse data sets in a common format understandable to applications and services such as machine learning and analytics. However,
- being in essence command and control systems, IoT end points can generate events and send/receive commands, so syntactic interoperability in IoT systems should be able to extend beyond data to events and (bidirectional) commands.
- Semantic interoperability implies that there is some data semantics in the system to begin with, usually in the form of meta-data associated with data. Semantic interoperability means bringing existing meta-data annotations into a common format, it cannot create meaning where it did not previously exist.

Conjectures and Assumptions

It appears that inter-domain syntactic interoperability may be a more difficult problem to solve, as it needs to deal with data, events, and bidirectional commands. Our present belief is that it may be possible to combine the two solutions in the sense of having a common semantic (data) interoperability part for both, with the events and commands added for syntactic interoperability.

In order to help focus our discussions, we found it useful to articulate representative users/uses of the specific levels of interoperability, and to clarify the environmental assumptions, in terms of the assumed system state.

For semantic data interoperability, we are starting with a mental model of a cloud-based service retrieving data in a streamlined interoperable representation from an aggregation of IoT data sourced from sub-systems with disparate data standards and domain-specific representations.

For syntactic interoperability uses, we are starting with a mental model of a “universal” controller for a domain, such as home automation, enabling it to coordinate operations of heterogeneous devices that use different native protocols for data encoding, command and control.

In order to simplify the problem and focus only on interoperability, we are assuming that all constituent IoT systems are in a steady state of operation – with discovery completed and communication and security operational and established earlier by other parts of the system.

References

McKinsey http://www.mckinsey.com/business-functions/digital-mckinsey/our-insights/the-internet-of-things-the-value-of-digitizing-the-physical-world

IIC connectivity framework http://www.iiconsortium.org/IICF.htm

Cross-Industry Semantic Interoperability, Part I http://embedded-computing.com/articles/cross-industry-semantic-interoperability-part-one/