A Model for IoT-Semantic Interoperability

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Background

With the advent of Internet of things, the mere possibility of these devices sharing information between them creates a whole new paradigm shift of how people leverage technology for realizing their personal, business, social & many other needs. This also transforms how enterprises conduct their business with automated manufacturing, transportation of goods etc.

There are many technical challenges [1] in this rosy picture and certainly the key one is how the information shared by one device is understood by the other device 'seamlessly'. It is evident that IoT devices are developed by various vendors to address specific requirement(s) of real-world. Unless these devices share a common information model the information they pass on to other devices makes no sense.

Challenges

In order to do so, all the IoT device manufacturers must define & agree to a common information model, thus enabling interoperable devices. Considering the different IoT alliances/ consortiums driven by various vendors, the task of agreeing/aligning to a standard model seems more difficult though possible.

To understand further the relevant questions to ask are,

i. What is the appropriate way of building an information model
ii. Will it be a centralized or decentralized or pseudo-centralized model
iii. Will it be used for peer-peer or any-any information exchange
iv. Who owns what part of the model

Then comes the question of evolution of the information model, it has to be ensured that the new model to be compatible with the old devices (adhering to the old model). Depending on the device's capability, this might be plausible by either a simple provisioning of new model to the old devices or by a little complex method of transformation the old information to the new information model by an additional application layer outside the device firmware/kernel. These transformation rules are semantically neutral, that is the rules do not convey why that mapping is needed.

Solution

The any-to-one decentralized model [3] addresses all of the questions above. To put it in some perspective, the conceptual information architecture (fig.1) reveals how the knowledge base (KB) that represents the information model as ontologies is organized in a layered manner. Each of the KBs corresponds to two parts:

a. A meta-model that is agreed & shared across all the stake-holders (device vendors, enterprise service providers, etc.)

b. A stakeholder specific model that is unique to each one but connects back to the meta-model

This meta-model will be used by the appropriate applications in each layer for sharing information across other devices/applications in the same layer and across other layers.

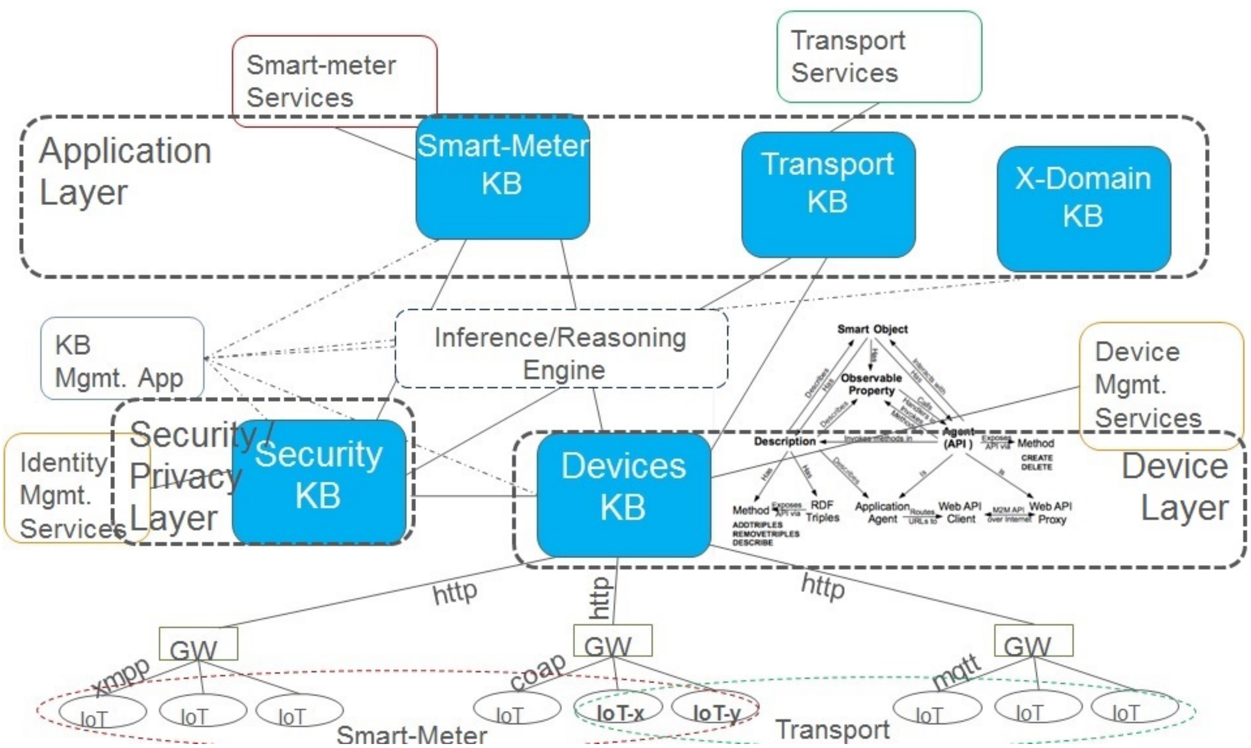

Fig.1

The inference engine plays an important role in identifying & interpreting the relationships among devices based on their respective roles in each of the domains they are associated with. Especially in finding the appropriate agents to be invoked in satisfying a business request that involves traversing from the meta-model to vendor-specific model based on the integration points. It also can resolve (to the best of its KB) trivial queries that results in incomplete models with the help of the associative, hierarchy, equivalency property types in the relationships of the objects in the KB.

To explain further the organization of the knowledge base, in the device layer the smart object semantic model [2] abstracts the IoT devices as smart objects and isolates the apis that govern them in an effective way.

This means that each of the vendors can associate their knowledge base with the smart object meta-model by simply creating an instance of the Agent API object with their own API methods and then create an instance-level model by associating their device instances with their own API agent instances. This is a clean method by which each vendor can maintain their own models and at the same time associate with the smart object meta-model thereby not necessarily changing their own models/methods.

Similar approach can be employed across each of the layers, there by isolating custom data models & methods and at the same time associating with a generic knowledge base that comprises of high-level abstracted classes & assertions defined at the type-level.

The second challenge on maintaining compatibility across different versions of the information model is also addressed with the help of the inference engine, which by means of the hierarchical relationship that gets created in the knowledge base between the old concepts (parent) and the new concepts (child). Any query those employees new concepts can easily be reasoned to the new concepts and vice-versa by the inference engine.

References:

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