Achieving Semantic Interoperability in the Internet of Things

IoT Interoperability workshop
26th March 2012, Paris

Payam Barnaghi
Centre for Communication Systems Research
University of Surrey
Guildford, UK
Semantic Interoperability

• “Meaning of data can be comprehended unambiguously by humans and computer programs.”

Mei Selvage et al, IBM.
IoT data: current status

• The current IoT data communications often rely on binary or syntactic data models which lack of providing machine interpretable meanings to the data.
  – Syntactic representation or in some cases XML-based data
  – Often no general agreement on annotating the data
    • requires a pre-agreement between different parties to be able to process and interpret the data
  – Limited reasoning based on the content and context data
  – Limited interoperability in data level
  – Data integration and fusion issues
What is expected in service/application level?

- Unified access to data
  - unified descriptions and at the same time an open frameworks
- Deriving additional knowledge (data mining)
- Reasoning support and association to other entities and resources
- Self-descriptive data an re-usable knowledge

- In general: Large-scale platforms to support discovery and access to the resources, to enable autonomous interactions with the resources, to provide self-descriptive data and association mechanisms to reason the emerging data and to integrate it into the existing applications and services.
Possible solutions?

- The semantic Web has faced this problem earlier.
  - Proposed solution: using machine-readable and machine-interpretable meta-data
    - Important not: machine-interpretable but not machine-untreatable!
    - Well defined standards and description frameworks: RDF, OWL, SPARQL
    - Variety of open-source, commercial tools for creating/managing/querying and accessing semantic data
      - Jena, Sesame, Protégé, …

- An Ontology defines conceptualisation of a domain.
  - Terms and concepts
  - A common vocabulary
  - Relationships between the concepts

- There are several existing and emerging ontologies in the IoT domain.
  - IOT-A information model and ontologies
  - SENSEI information model
  - W3C SSN ontology
  - And many more
Myth and reality

• #1: If we create an Ontology our data is interoperable
  – **Reality**: there are/could be a number of ontologies for a domain
    • Ontology mapping
    • Reference ontologies
    • Standardisation efforts

• #2: Semantic data will make my data machine-understandable and my system will be intelligent.
  – **Reality**: it is still met-data, machine don’t understand it but can interpret it. It still does need intelligent processing, reasoning mechanism to process and interpret the data.

• #3: It’s a Hype! Ontologies and semantic data are too much overhead; we deal with tiny devices in IoT.
  – **Reality**: Ontologies are a way to share and agree on a common vocabulary and knowledge; at the same time there are machine-interpretable and represented in interoperable and re-usable forms;
  – You don’t necessarily need to add semantic metadata in the source- it could be added to the data at a later stage (e.g. in a gateway);
  – Legacy applications can ignore it or to be extended to work with it.
What are the main requirements?

• Creating ontologies and defining data models are not enough
  – tools to create and annotate data
  – data handling components

• Complex models and ontologies look good, but
  – design lightweight versions for constrained environments
  – think of practical issues
  – make it as much as possible compatible and/or link it to the other existing ontologies

• Domain knowledge and instances
  – Common terms and vocabularies
    • Location, unit of measurement, type, theme, …

• Link it to other resource
  – Linked-data
  – URIs and naming
IoT.est project: Internet of Things Environment for Service Creation and Testing

http://ict-iotest.eu/iotest/

Payam Barnaghi
Centre for Communication Systems Research
Faculty of Engineering and Physical Sciences
University of Surrey
p.barnahgi@surrey.ac.uk
W3C SSN Ontology

SSN-XG annotations

```
<om:Observation>
  <om:samplingTime><gml:TimeInstant>...</gml:TimeInstant>
  <om:procedure xlink:role="http://www.w3.org/2009/1:
      xlink:href="http://www.w3.org/2009/1:
  <om:observedProperty xlink:href="http://www.w3.org.
    xlink:href="http://sws.geonames.o
  <om:result uom="http://www.w3.org/2009/Incubator/
</om:Observation>
```

SSN-XG Ontology Scope

- Observation
  - Sensor
    - Sensor Type X
      - sensor of type X

What it measures

units

units ontology

Where it is

location ontology

domain ontology

SSN-XG ontologies

makes observations of this type