The Standards People

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Guidelines for using semantic interoperability in the industry

The ETSI Specialist Task Force 547

Presented by: **Mahdi Ben Alaya**

For: **IoT Week 2019**

ETSI STF 547
A global approach to IoT Systems

A framework for IoT standardisation

- Addressing interoperability across IoT domains
- Focusing on major aspects:
  - (Semantic) Interoperability
  - A User-centric approach to Privacy
  - Methods and techniques for Secure IoT

Whose essential objectives are to

- Identify guidelines and best practices
- Build a bridge for potential designers / implementers of IoT systems
- Provide comprehensive material for information, teaching/learning and demonstration with a very practical usage and implementation perspective

ETSI STF 547
A Set of Coordinated Deliverables

Seven Technical Reports

- Privacy; Standards Landscape and best practices — TR 103 591
- Security; Standards Landscape and best practices — TR 103 533
- Guidelines for using Semantic Interoperability in the industry — TR 103 535
- Plugtests™ preparation on Semantic Interoperability — TR 103 537
- Strategic / technical approach on how to achieve interoperability / interworking of existing standardized IoT Platforms — TR 103 536
- Teaching material; Part 1: IoT Security — TR 103 534-1
- Teaching material; Part 2: IoT Privacy — TR 103 534-2

A Special Report to introduce to a complex landscape

- Dedicated to all stakeholders — SR 003 680
  - Not just for the technology happy few (and the standards literate)
  - Overall SR document and Additional Slides (including Teaching Material)
- Based on the analysis of relevant use cases

Classification systems

- **Glossary** is a terminological dictionary which contains a list of designations from a subject field with equivalents in one or more languages.
- **Dictionary** is an alphabetical list of terms in a particular domain of knowledge with the definitions for those terms.
- **Taxonomy** is a simple hierarchical arrangement of entities where you have a parent-child kind of relationship.
- **Thesaurus** is a reference work that lists words grouped together according to similarity of meaning containing synonyms and sometimes antonyms. Unlike a dictionary, a thesaurus entry does not give the definition of words.
- **Topic map** A standard for the representation and interchange of knowledge, with an emphasis on the findability of information.
- **Meta data repository** is a database created to store metadata. Metadata is information about the structures that contain the actual data. Metadata may describe the structure of any data, of any subject, stored in any format.
- **Microformat** is a web approach to semantic markup which uses tags supported for other purposes to convey additional metadata and other attributes in different contexts.
- **Ontology** is the specification of conceptualizations used to help programs and humans share knowledge. Definitions of how concepts are inter-related which collectively impose a structure on the domain and constrain the possible interpretations of terms.

Existing solutions from academia, standards and industry

H2020 IoT European Platform Initiative (IoT-EPI):

- SymbIoTe
- Agile IoT
- Inter IoT
- Vicinity
- BIG-IoT

Industry Solutions:

- IBM Watson

Open source:

- Mainflux

Other projects:

- Pilot Test for interfacing oneM2M platform with Smart Agriculture (STF-542)

H2020 Large Scale Pilots (LSP):

- Autopilot
- Monica

Standards and specifications:

- oneM2M
- NGSI-LD
- OPC-UA
- ETSI SAREF
- W3C SSN

Complex integration and vendor lock in

- IoT service providers are faced with heterogeneous and vendor-specific installations.
- Centralized management of IoT solution oftentimes forces the owners to go through costly replacements to adopt mono-vendor solutions
- Installation of new equipment requires costly system integration because devices are often designed to communicate with specific applications only
- There is no uniform manner to access and filter the huge amounts of datasets that are generated.
- Huge amounts of data are generated but never get analyzed and used.
- IoT systems remain isolated from their surroundings and environment, resulting in poor or non-existing synergies

The need for semantic interoperability in industry

- **Continuous solution integration/operation**: The main idea is to quickly plug and play new equipment, networks and services in a cost-efficient manner and without disturbing the ongoing IoT system management operations.

- **Efficient data exposure:** IoT devices generate huge amounts of data. The exposure of these data sets through modern APIs allows proliferation of new services such as situational awareness, energy efficiency, preventive maintenance and smart data.

- **Centralized management of heterogenous IoT infrastructure** allows increased efficiency by setting global policies, quicker reactions and optimized decisions across all buildings. It also brings-down operational costs thanks to a single software set.

- **Wider integration** allows the IoT system to give rise to fully integrated solution supporting mass scale deployment in multiple domains. The IoT system stops existing on its own and starts to interwork with other verticals.

Status of semantic interop adoption by industry

- **Manual file export and import** is simplest method of integrating data from one application to another is to export the data to a file and import the file into the target system.

- **Extract, Transform and Load (ETL)** automates the process of integration data between two systems and keeping data synchronized with minimal human intervention. A copy of data is extracted from a source, then translated to match specific format and loaded into the destination system.

- **Point-to-Point integration (P2P)** is ad-hoc connections between applications for near real time processes such as monitoring, alerting or triggering. As the number of applications increases, the number of point-to-point connections required becomes unmanageable.

- **Enterprise Service Bus (ESB)** uses a hub-and-spoke approach in place of many point-to-point connections. It acts as a central broker, accepting messages from one application and sending messages to another application through near real time comm.

- **Integration Platform as a Service (iPaaS)** offers a user-friendly dashboard for designing and maintaining connections and integrations, monitoring results and resolving errors. It comes with a broad array of application and technology connectors.

- **Semantic interoperability platform** Semantic interoperability platform enables heterogeneous devices and applications to understand exchanged data in a similar way, implying a precise and unambiguous meaning of the exchanged information.

Market drivers

- **Improving existing services:** Vendors must be proactive at the early introduction of semantic to their customers.

- **Providing new services** The adoption of semantic resulted from new user requirements such as context-awareness, collaboration, data sharing and automation required today in in industrial areas including smart cities and industry 4.0.

- **Public policy support:** Many companies indicated that public sponsorship for the projects and proactive roles of standardization bodies led to increased focus on semantic and its adoption and become a driving force for innovation diffusion.

- **Wider integration** allows the IoT system to give rise to fully integrated solution supporting mass scale deployment in multiple domains. The IoT system stops existing on its own and starts to interwork with other verticals.

Market inhibitors

Lack of familiarity with semantic

- The current situation is not yet propitious to the awareness for semantic due to immature supplier technology, weak development capabilities, insufficiency of experts and culture issues in industry.

Lack of killer applications and successful cases

- Killer applications and successful cases become an excellent guideline for the successful adoption of the semantic adoption.
- Users want to demonstrate systems or predict test results before they adopt the semantic technologies.
- Suppliers are suffering from problems regarding demonstration, observation, and verifiability of the system.

Complexity and immaturity

- Many developers feel that semantic is complex to understand in terms of its application process.
- Complexity makes developers feel uncertain about the result of semantic adoption.
- Low opinion of the maturity level of Semantic tools as a result of the perceived gap between academic and industrial perspectives.

Uncertainty regarding scalability and performance

- Current semantic reasoning systems have difficulties processing large-scale data.
- lack of technology standards and tools supporting project development, difficulty in cost projection and quality assurance.

Difficulties to perceive immediate value

- The potential value of a new technology is associated with the perception of its benefits. Semantic interoperability is a long process.
- Service improvement should be expected in the mid-long future rather than immediate increase in productivity.

Ontologies types and concepts

Ontology types

- Upper ontology is a model of the common relations and objects that are generally applicable across a wide range of domain ontologies. It usually employs a core glossary that contains the terms and associated object descriptions as they are used in various relevant domain ontologies.
- Domain ontology represents concepts which belong to a part of the world, such as building, energy or environment. Each domain ontology typically models domain specific definitions of terms. Since domain ontologies are written by different people, they represent concepts in very specific and unique ways, and are often incompatible within the same project.

Ontology concepts

- Classes represent a set or class of entities or things within a domain including both primitive and defined concepts.
- Relations describe the interactions between concepts or a concept's properties including taxonomies and associative relationships. Both concepts and relations could be organized into taxonomy.
- Instances are the things represented by a concept.
- Axioms are used to constrain values for classes or instances.

The ontology problem

No generally-accepted upper ontology in use today

- Upper Ontologies are difficult to design compared to domain ontologies because they describe our consensus reality and concepts, they define are more abstract.
- The skillsets needed to design Upper ontologies are quite different domain ontologies.

Many fragmented knowledge niches

- There are many knowledge niches containing tens of thousands of class definitions that still relatively limited in their conceptual breadth, depth and resolution.
- Today, most vertical domains have yet to be modelled ontologically.
- Domain ontologies need to be made publicly and connected together so that they can be normalized and mapped to one another.

The ontology integration nightmare

- It easy for developers to develop new ontologies from scratch but quite hard to make them compatible with other existing ontologies.
- In theory, we should be able to integrate all ontologies together, however the task of actual doing such integration is difficult in practice.
- Hard to express the similarity and difference in meaning between concepts, relationships, attributes and their constraints.
- The complexity of ontology integration increases exponentially to the number of concepts being integrated.

Strategic guidelines for using semantic interop in the industry

Decide adoption and promote it

- Proactive attitude in analysing trends or technological features and a determined will for a successful introduction is required
- Experts must persuade internally their department heads and resolved any conflict with managers who have a negative opinion of the semantic.

Invest in communication and training

- Provide educational programs for developers who do not have enough understanding or knowledge of semantic and persuaded them to participate in the programs.
- Communicate with sales and train them is essential to overcome their knowledge gap and can align the capability of the semantic with the needs of customers.

Outline expectation upfront

- There is a gap between the user perspective expecting substantial performance and that of supplier recognizing some limitations due to the early stage nature of semantic.
- The gap resulted from the frequent promotion that the reasoning engine can enable fantastic services that are not possible with existing technologies such as database and data mining.

Promote success and expand diffusion

- Even though semantic is adopted, further efforts will be necessary to make it easier for the system to get diffused in an organization.
- A stage model of technology diffusion consists of initiation, adoption and acceptance, adaptation, routinization, and infusion. T

Technical guidelines for using semantic interop in the industry

Use an upper ontology

- Provide a common ontological foundation for semantic interoperability across domains (e.g. oneM2M base ontology)
- High-level compatibility and plausibility check for domain ontologies and their semantic integration.
- Fundamental concepts defined by upper ontologies covers space and time, categories and individuals, time, space, processes, etc.

Reuse existing domain ontologies

- The ability to effectively and efficiently perform ontology reuse represents a potential solution to the problem of standardization.
- It is more cost effective to build an ontology reusing existing ontologies than from scratch.
- Reusing an ontology is far from an automated process, and instead requires significant effort from developers and experts.

Insert ontologies in the development process

- During the proof of concept phase, the need for semantic interoperability is not necessarily visible.
- If not initially adopted, semantic interoperability becomes extremely costly and almost impossible to integrate properly in the future.
- Semantic interoperability in general and ontologies in particular should be inserted at an early stage in the development process to ease the mass scale deployments of IoT systems and avoid vendor-lock in.

Thank you for your attention!

Contact Details: Mahdi Ben Alaya
Sensinov
benalaya@sensinov.com

STF547: https://portal.etsi.org/STF/STFs/STFHomePages/STF547

CREATE-IoT: https://european-iot-pilots.eu/project/create-iot/