THE ONEM2M STANDARD SUPPORTS GLOBAL CREATION OF SEMANTIC INTEROPERABILITY

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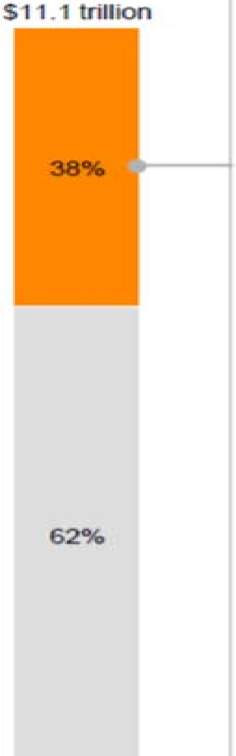
oneM2M www.oneM2M.org

40% of economic impact of IoT requires interoperability between IoT systems

Nearly 40 percent of economic impact requires interoperability between IoT systems

Potential economic impact of IoT[1]

$11.1 trillion



Value potential requiring interoperability $ trillion		**% of total value**	**Examples of how interoperability enhances value**
Factories	1.3	36	Data from different types of equipment used to improve line efficiency
Cities	0.7	43	Video, cellphone data, and vehicle sensors to monitor traffic and optimize flow
Retail environments	0.7	57	Payment and item detection system linked for automatic checkout
Work sites	0.5	56	Linking worker and machinery location data to avoid accidents, exposure to chemicals
Vehicles	0.4	44	Equipment usage data for insurance underwriting, maintenance, pre-sales analytics
Agriculture	0.3	20	Multiple sensor systems used to improve farm management
Outside	0.3	29	Connected navigation between vehicles and between vehicles and GPS/traffic control
Home	0.1	17	Linking chore automation to security and energy system to time usage
Offices	0[2]	30	Data from different building systems and other buildings used to improve security

1 Includes sized applications only; includes consumer surplus.
2 Less than $100 billion.
NOTE: Numbers may not sum due to rounding.

SOURCE: Expert interviews; McKinsey Global Institute analysis

Source: McKinsey

Definition

Semantic interoperability
is the ability of computer systems to
exchange data with unambiguous, shared meaning. *(Wikipedia)*

– Semantic interoperability is therefore concerned not just with the
  - ***packaging of data*** (syntax),

  but also the simultaneous
  - ***transmission of the meaning*** with the data (semantics) across the systems
    - – Need for self-describing "information packages" that are independent of any information system
    - – Need for adding metadata (semantic annotation) to the raw data
      - » by the entities (devices) that generate data – e.g.: W3C Web of Things
      - » By the IoT system that transports/processes raw data

Example: Industry 4.0

- German Industr**ie** 4.0 is designing it's next generation of the manufacturing industry

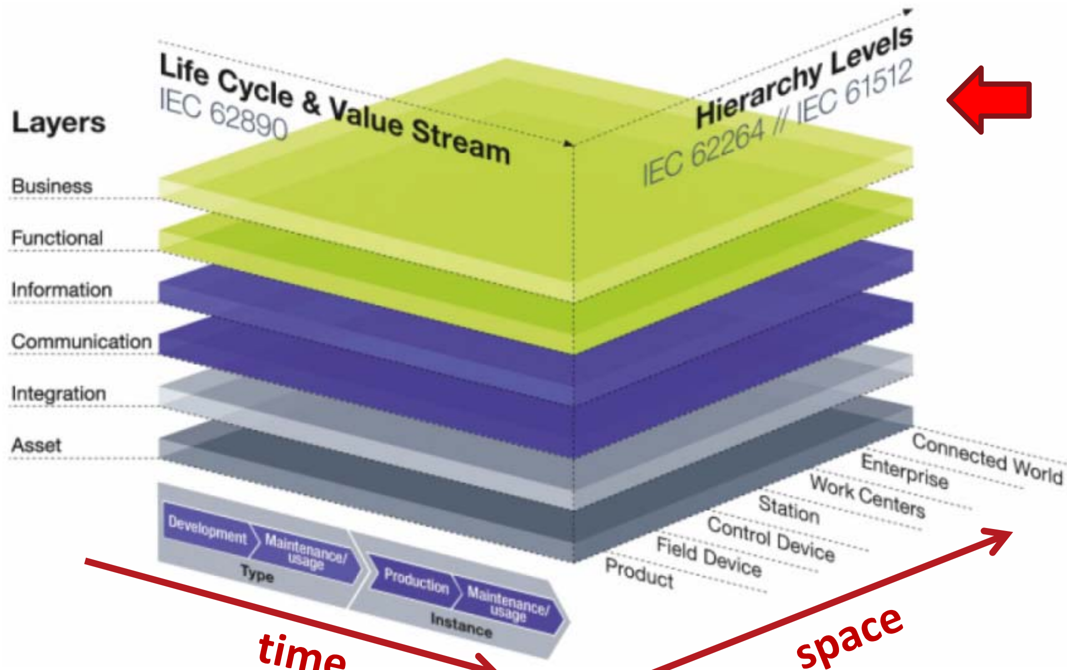
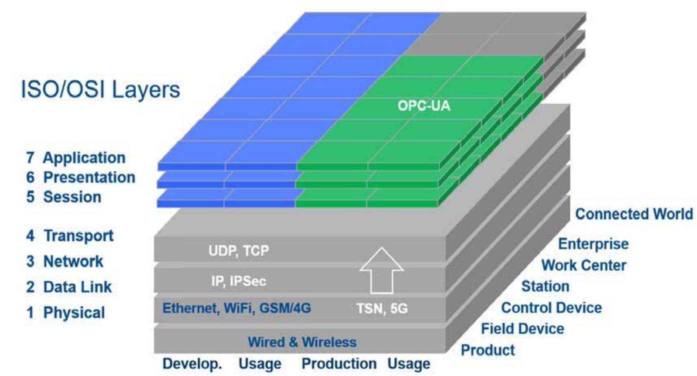


Figure 8 — Reference architecture model Industry 4.0 (RAMI4.0)

The famous "RAMI" cube (Reference Architecture Model for Industry)



... and its communication aspects

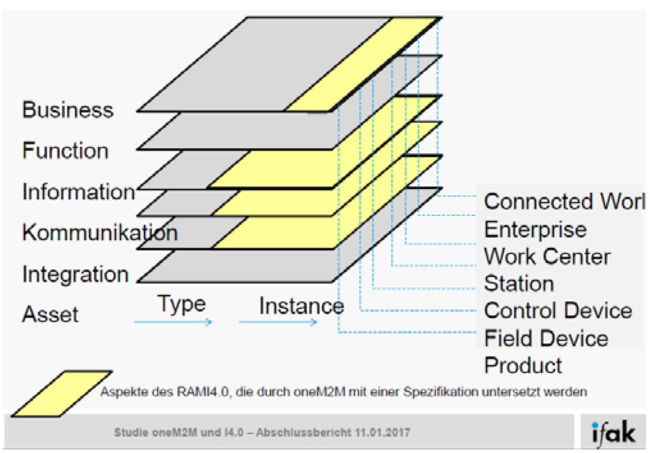
oneM2M in Industry 4.0
- how and where would it fit in?

Data (raw or processed) are traversing boundaries:

- In time: different stages of design/production/use
- In space: within a product .. enterprise wide .. global

On layers: “communication”, “integration” and “information”

The meaning of the data (semantics) needs to be accessible!



According to a study in I4.0 these are the areas where oneM2M could apply:

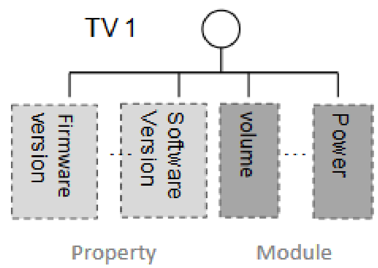
- for the “communication”, “**integration**” and “**information**” layer, also addressing “business” and “accounting”
- implement “profiles” of the OPC UA information model (***semantic models !!***)
- recommended to be used as **middleware for communication of industrial components** across IP domain borders

Main ingredients
for Semantic Interoperability

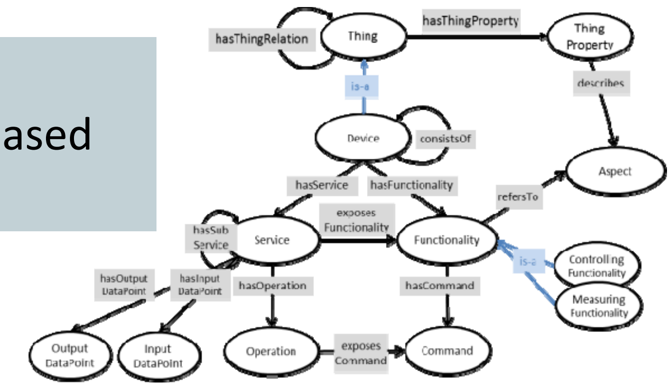
- **<u>Interworking</u>** with other (existing) solutions
  - communication layer - technologies - out of scope
  - Information layer of the interworked solution (data model) needs mapping into oneM2M resources
- **<u>Abstraction</u>** of commonalities
  - Similar data models can be abstracted (cf. SAREF)
  - Interworked data can be converted to/from abstracted model.
- **<u>Semantic annotation</u>** of data
  - Semantics need to be well described, electronically processable (e.g. as an ontology in owl/ttl.. format) and globally accessible
  - Not restricted to data used by electronic devices, but can describe data of "real world" effects
    - e.g. "Well-Being Index", "average temperature" ..
  - Allows semantic queries, creation of "Semantic Mashup" functionality ...

Interworking in oneM2M

Specific Abstraction Models, e.g. Home Automation

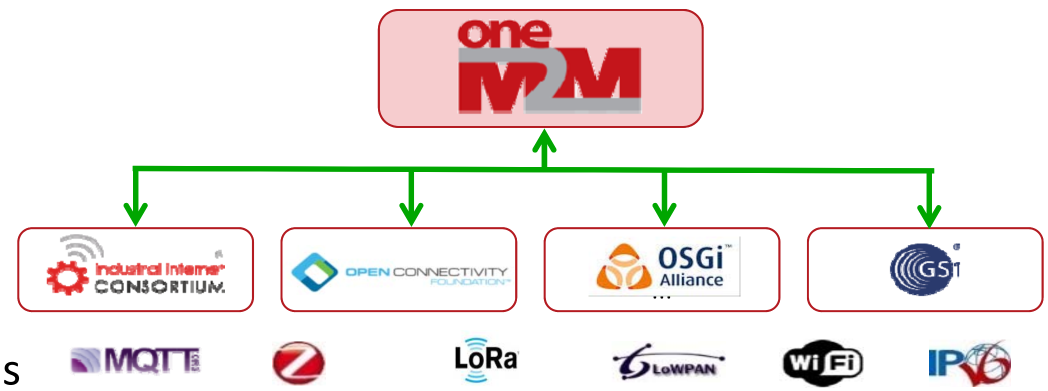


Unspecific, Ontology based Approach



Platforms

Technologies



Specific interworkings

- information models mapped to oneM2M

- Interworkings with specific non-oneM2M systems
  => data model described in a specification
  - TS-0005 Management Enablement (OMA)
  - TS-0006 Management enablement (BBF)
  - TS-0014 LWM2M Interworking
  - TS-0023 Home Appliances Information Model and Mapping
  - TS-0021 AllJoyn Interworking
  - TS-0024 OIC Interworking
  - TS-0026 3GPP Interworking
  - TS-0035 OSGI interworking

ONEM2M TECHNICAL SPECIFICATION

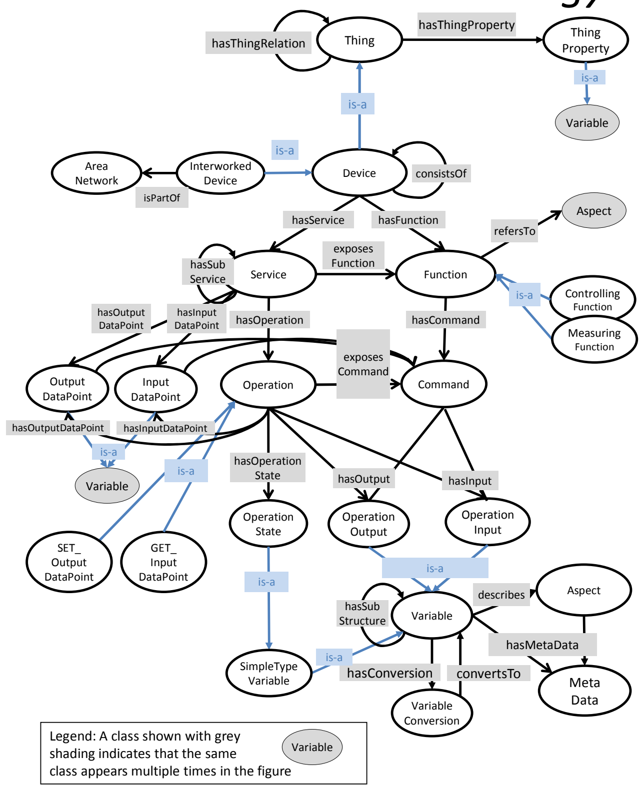
Document Number	TS-0023-V2.0.1
Document Name:	Home Appliances Information Model and Mapping
Date:	2017-July-07
Abstract:	This technical specification includes oneM2M defined information model for home appliances and the mapping with other information models from external organization.

Template Version:03 June 2015 (Dot not modify)

- Now developing information models in the Industrial Domain (TR-0018), Vehicular (TR-0026) and Smart City (TR-0046) Domains, in collaboration with experts in these domains.
- Recently also interworking with W3C – Web of Things (WoT) started

Ontology based Interworking
- an ontology for interworking and more…

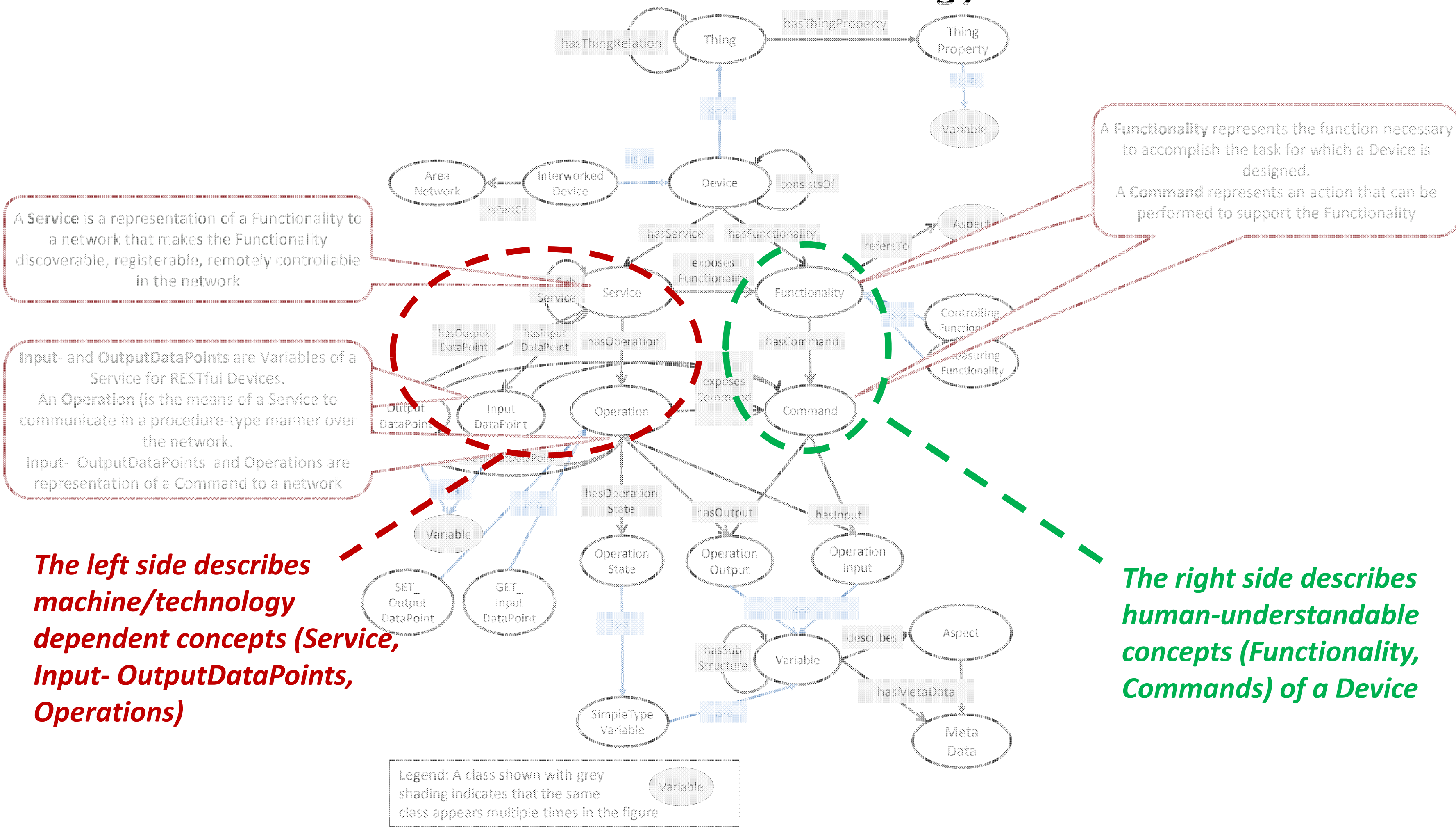
The oneM2M Base Ontology



- The oneM2M ***base ontology*** is a *top-level* ontology that allows to create sub-classes or equivalence classes for *application-level* ontologies
  - Example: Smart Appliances Reference Ontology (**SAREF**)
- application-level ontologies can be used in oneM2M to describe the application data model of an external system for interworking.
  - oneM2M ***Ontology Based Interworking*** uses such an ontology to enable interworking of oneM2M entities with devices of the external system
- *In principle (but not done yet) data models of **Specific Interworkings** can be converted into ontologies for **ontology based interworking***

The oneM2M Base Ontology
- design principle (aligned with SAREF)

The oneM2M Base Ontology



Mapping SAREF to oneM2M

- Equivalent classes:

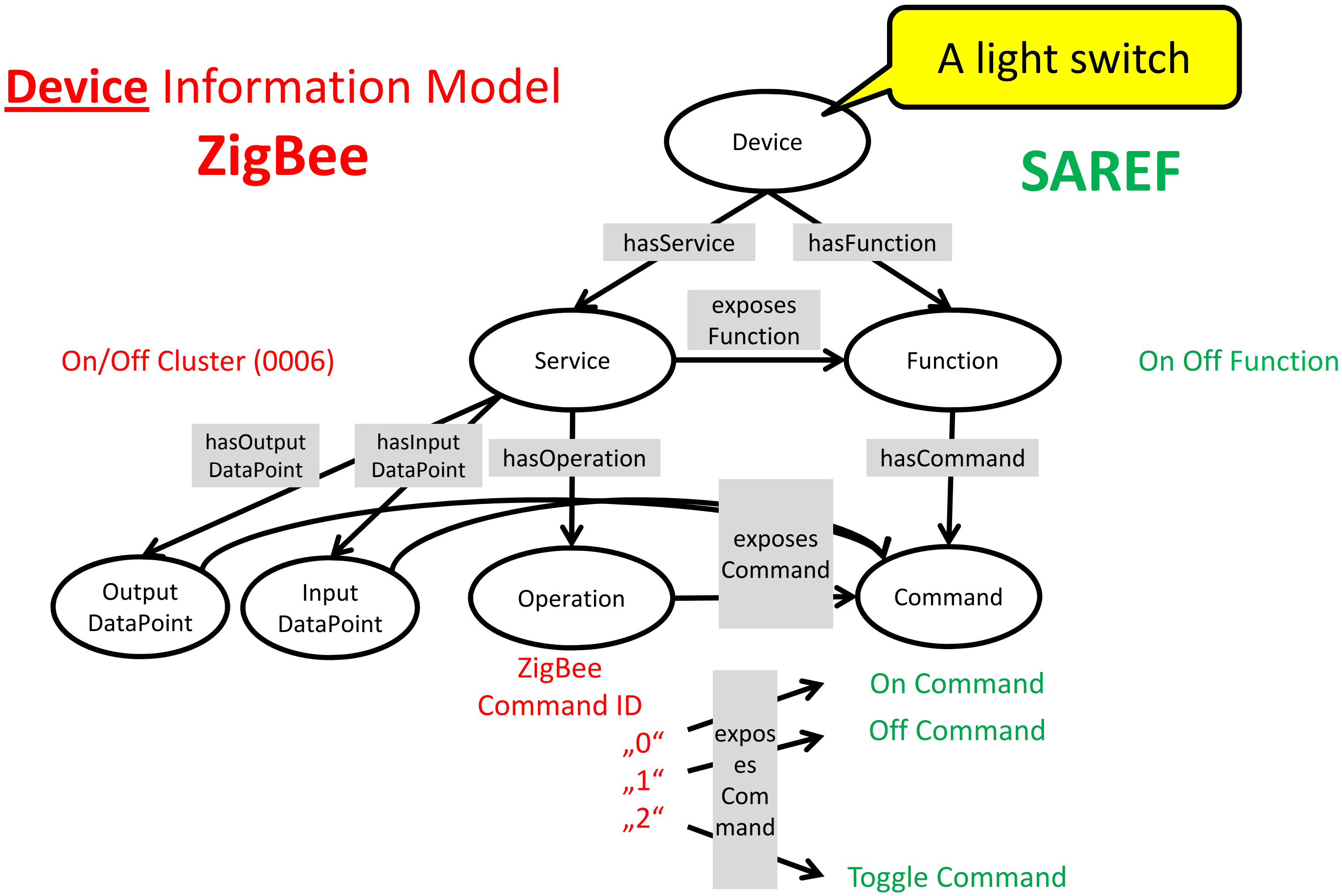
Class in SAREF	Mapping relationship	Class in Base Ontology
saref:Device	owl:equivalentClass	oneM2M:Device
saref:Command	owl:equivalentClass	oneM2M:Command
saref:Function	owl:equivalentClass	oneM2M:Function
saref:Service	owl:equivalentClass	oneM2M:Service
saref:ActuatingFunction	owl:equivalentClass	oneM2M:ControllingFunction
saref:SensingFunction	owl:equivalentClass	oneM2M:MesuringFunction

- Sub-classes:

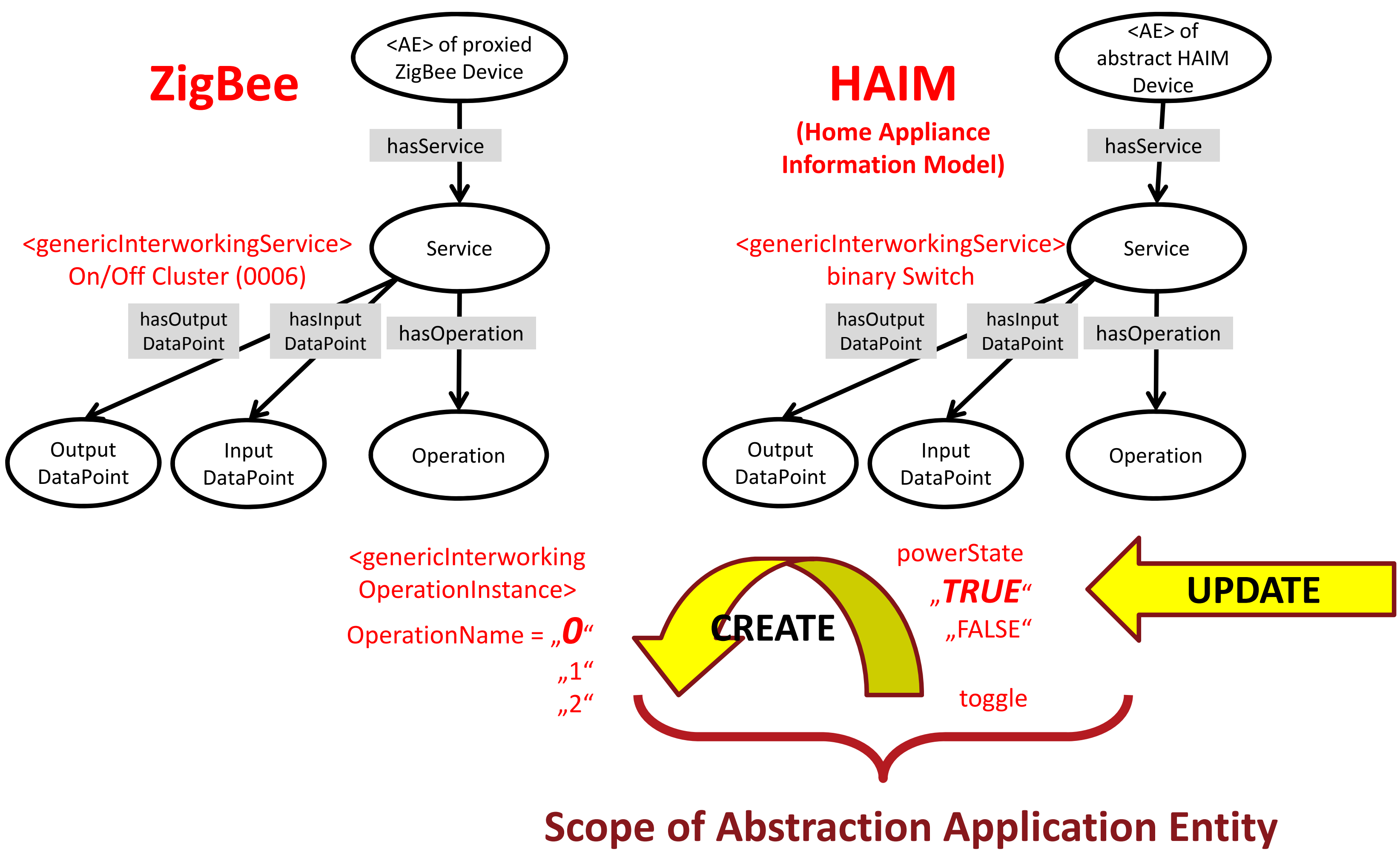
Class in SAREF	Mapping relationship	Class in Base Ontology
saref:BulidingObject	rdfs:subClassOf	oneM2M:Thing
saref: BulidingSpace	rdfs:subClassOf	oneM2M:Thing
saref :Commodity	rdfs:subClassOf	oneM2M:Thing
saref :Property	rdfs:subClassOf	oneM2M:InputDataPoint OR oneM2M:OutputDataPoint
saref :UnitOfMeasure	rdfs:subClassOf	oneM2M:MetaData
saref :MeteringFunction	rdfs:subClassOf	oneM2M:MesuringFunction
saref :State	rdfs:subClassOf	oneM2M:InputDataPoint OR oneM2M:OutputDataPoint
saref:Profile,	rdfs:subClassOf	oneM2M:Thing
saref:Task	rdfs:subClassOf	oneM2M:ThingProperty
saref:DeviceCategory	rdfs:subClassOf	oneM2M:ThingProperty
saref:FunctionCategory	rdfs:subClassOf	oneM2M:Aspect

- *Using equivalent- / sub-classing it is possible to **handle all SAREF entities in oneM2M***

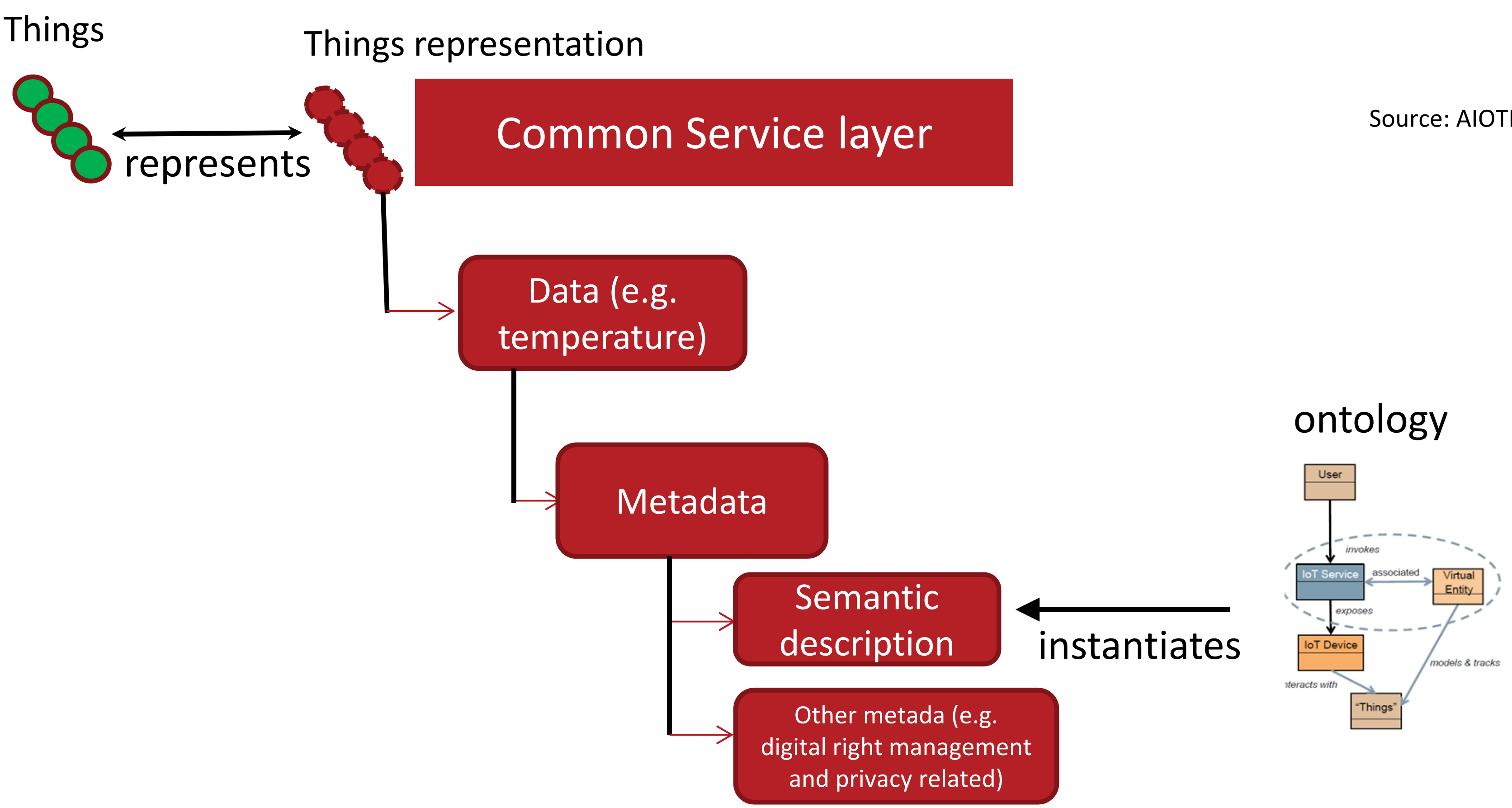
Abstraction:
example: ZigBee Device Information Model, Functions/Commands taken from SAREF



setting an *abstract HAIM binary Switch* to „TRUE“ invokes *Zigbee command* „0006 / 1“



Semantic Annotation

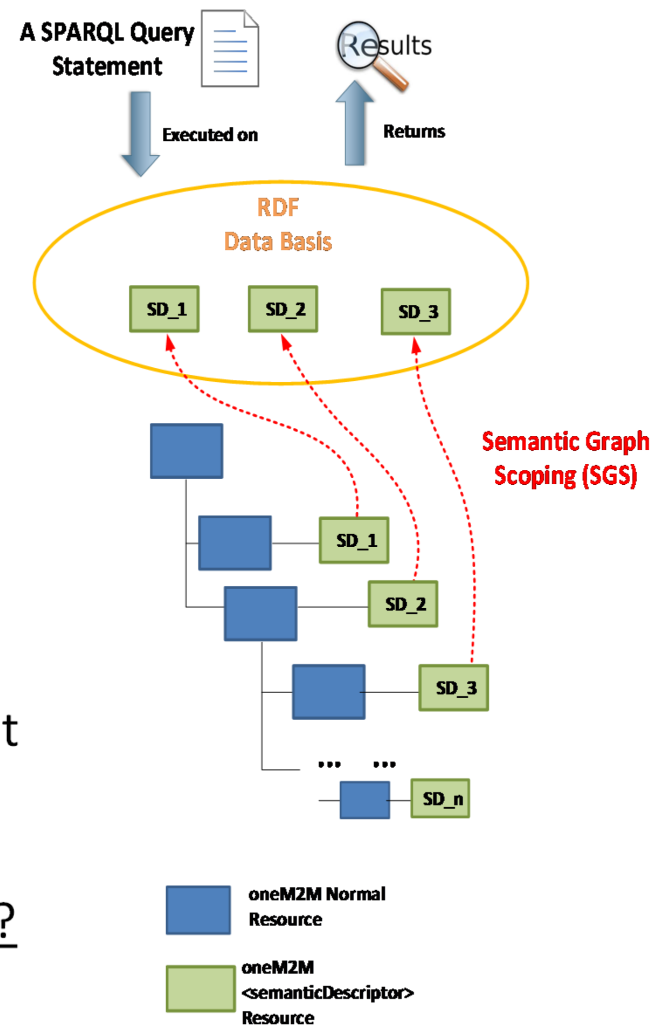


Source: AIOTI

Discovery – Consistency – Scalability – Efficiency

Work on Semantics – Semantic Query

- oneM2M includes a **semantic query** feature that includes both **discovery** and **query capabilities**
  - Semantic resource discovery is used to discover resources: Give me the resources that represent the temperature sensors located in Room 1.
  - Semantic query is used to extract "useful knowledge" (to answer the query) over a set of "RDF data basis". What is the manufacture name and production year of the temperature sensors located in Room 1?

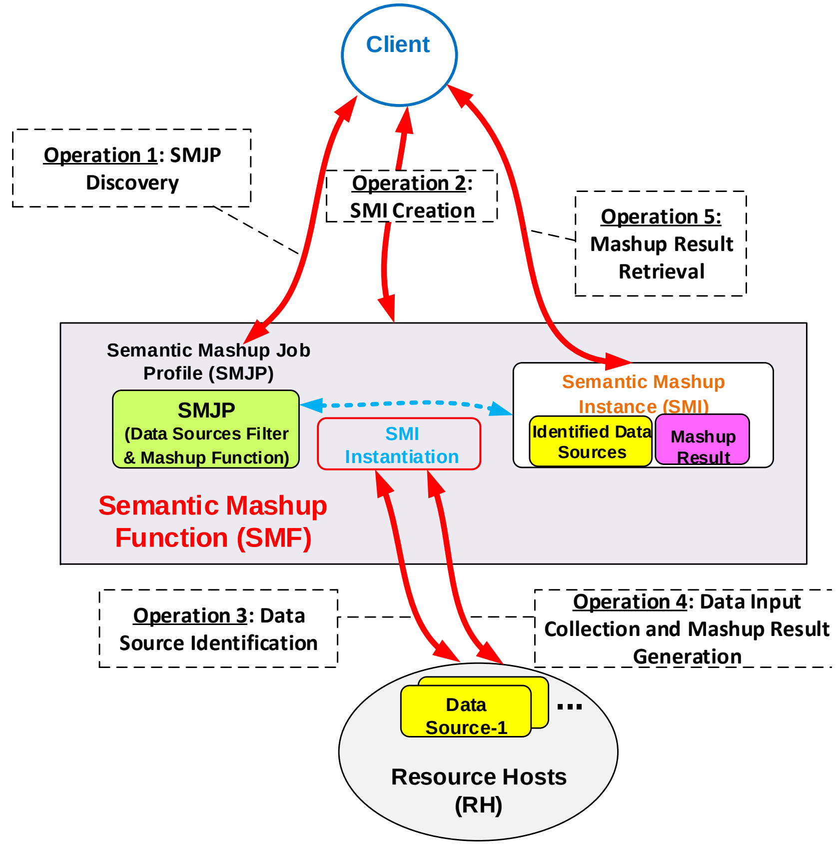


Semantic Query Examples

- **Semantic discovery (R2):** Give me the resources that can provide occupancy information for meeting rooms.
- **Semantic query (R3):** What are the meeting rooms for which I can retrieve the current occupancy information? [Semantic Descriptor]
- **Semantic query including content (R3):** Give me the current occupancy information for meeting rooms. [Semantic Descriptor + *content*]
- **Semantic query including content with restriction (R3):** Give me the meeting rooms whose current occupancy is „empty“. [Semantic Descriptor + *content*]

Work on Semantics Mashup

- oneM2M will support semantic mashup, which fully leverages semantic-related technologies and is defined as a process to discover and collect data from more than one source as inputs, conduct business logic-related mashup function over the collected data, and eventually generate meaningful mashup results.
- Example: Users/clients are interested in a metric called "weather comfortability index", which cannot be directly provided by physical sensors, and in fact can be calculated based on the original sensory data collected from multiple types of sensors (e.g. temperature and humility sensors).



TAKE AWAYS

Take aways

- **Semantic Interoperability is key** for the economic success of large scale IoT
- **Only global open standards – like oneM2M – can enable semantic interoperability**
  - Globality and openness needed to **avoid lock-in** … also a matter of national sovereignty
  - Potential for bringing different stakeholders to agree on **common terminology**
- oneM2M provides **Interworking** with other IoT systems
  - **Specific interworking**
  - **Unspecific,** ontology-based interworking
  - Alignment with SAREF, Interworking W3C- WoT, Alljoyn, …
- oneM2M is able to provide meaning of data by **Semantic annotation**
  - Enables **semantic queries** and **semantic mashups**

- oneM2M can provide mechanisms for **Abstraction**, using its base ontology