

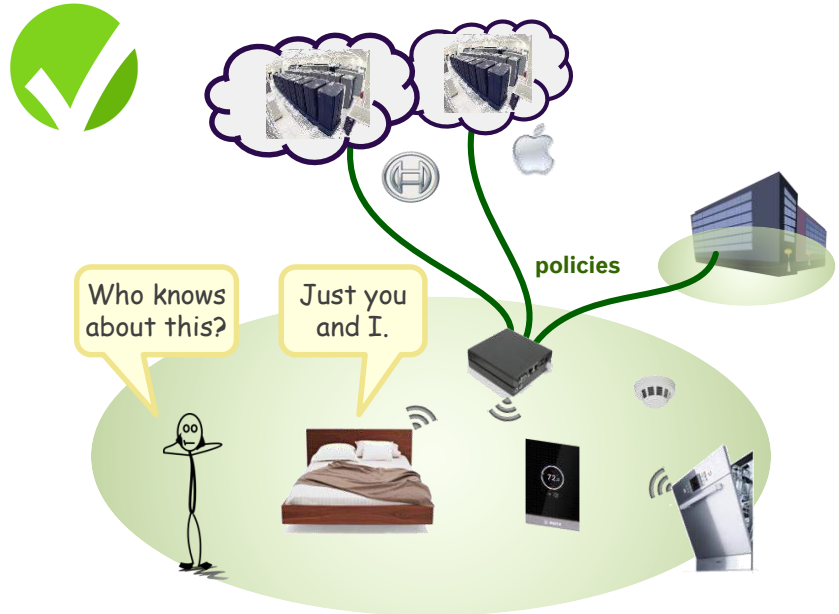


WHAT DID THE SMART-THING SAY? SEMANTIC INTEROPERABILITY FOR THE IOT

SATURN 2016, May 3
Cory Henson and Joao de Sousa

bezirk.com

Bezirk local, secure communications on IoT



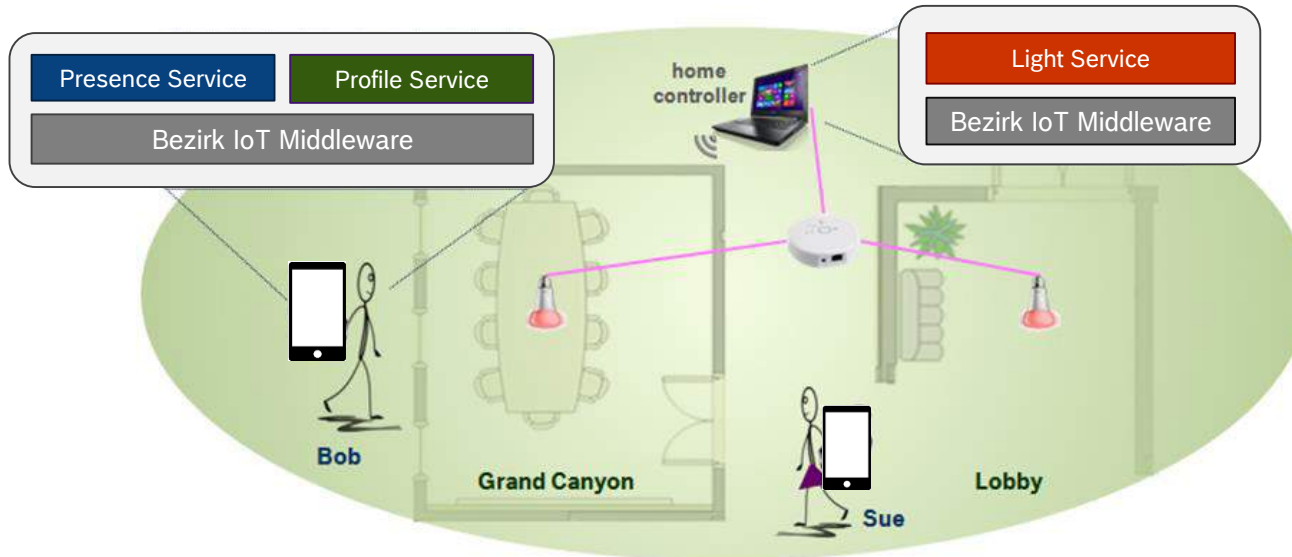
- ✓ **Quality: local integration**
- ✓ **Respectful: data ownership**

Communication on IoT interoperability is a challenge

- ▶ **Heterogeneous network:** Due to the heterogeneous nature of the network, interoperability is a bigger challenge on IoT than on the Web
- ▶ **Publish-subscribe architecture:** Pub-sub architecture may solve certain challenges, e.g., scale, but interoperability challenges remain
- ▶ **Message semantics:** To develop an IoT service, developers must write and maintain a collection of parsers to interpret messages from heterogeneous services



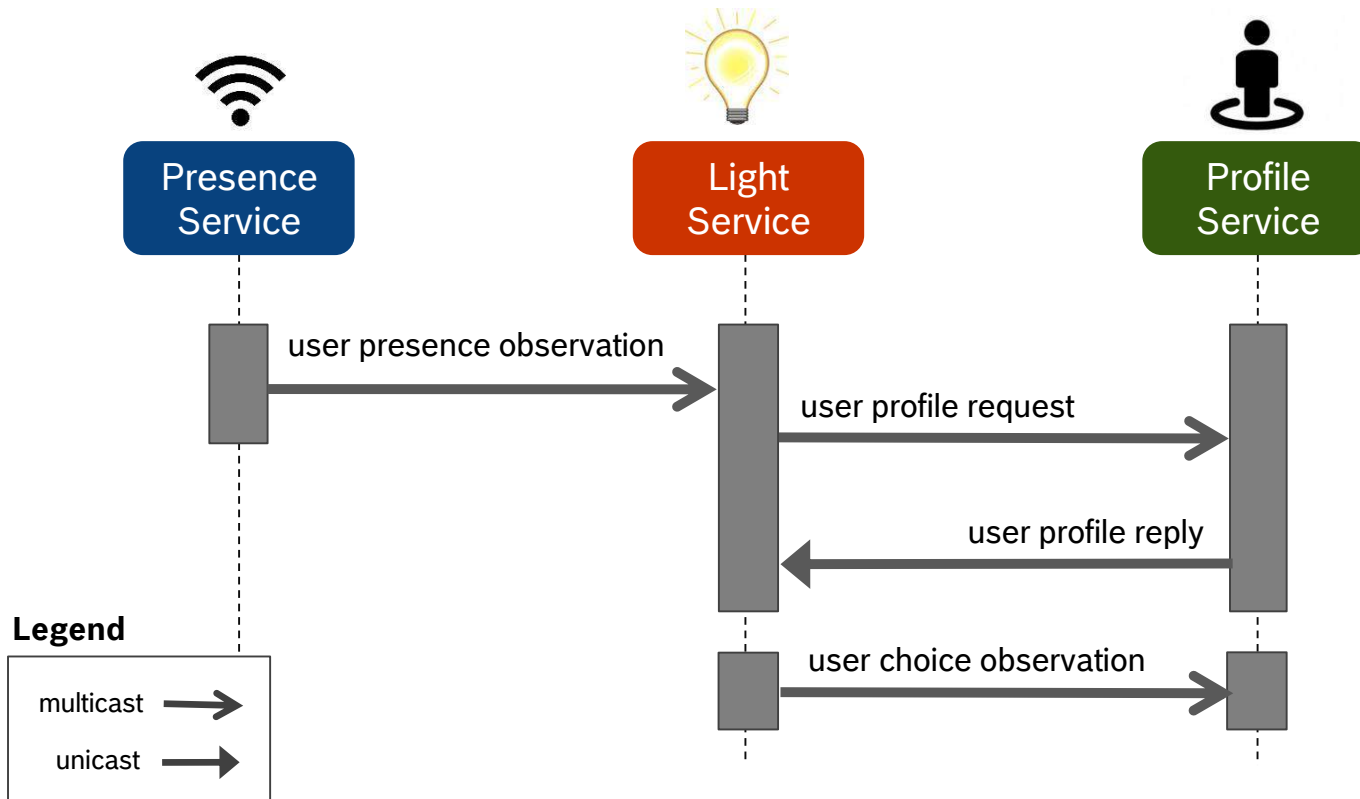
Example: Personalized Lighting overview



3 types of services

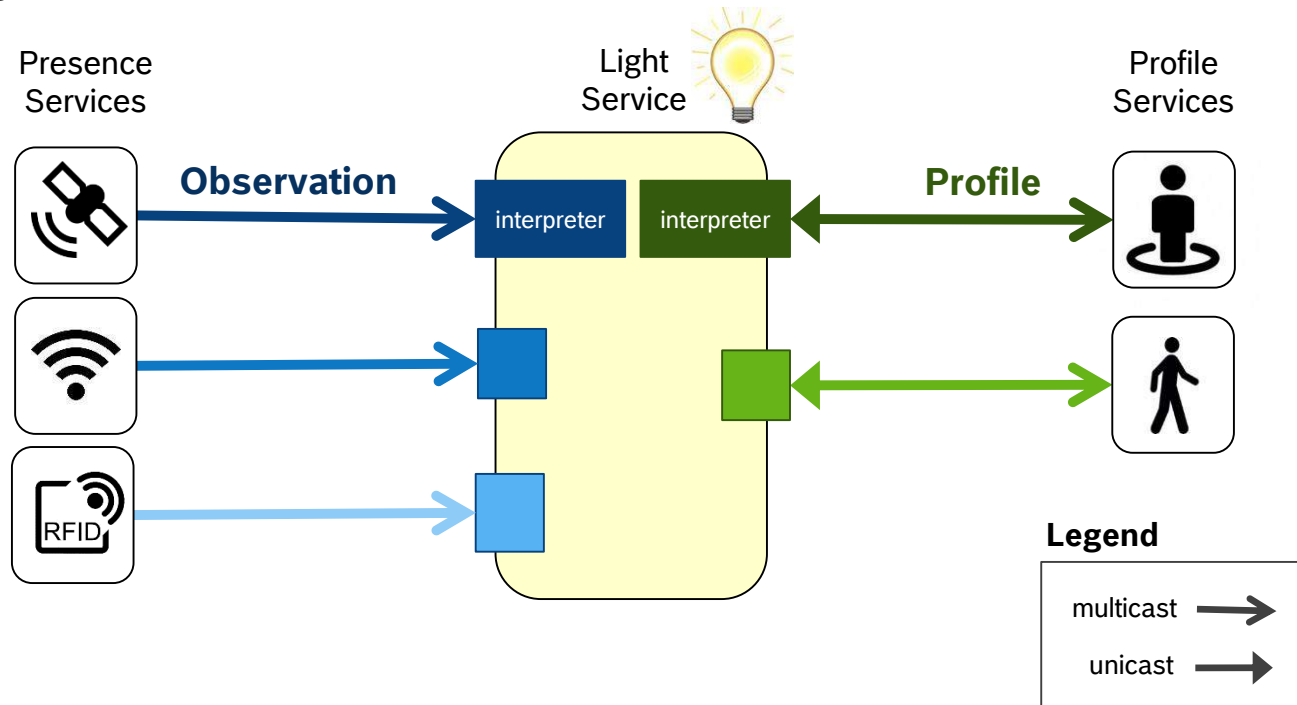
- ▶ **Presence service:** tracks the location of a user
- ▶ **Profile service:** manages and distributes user profile information (e.g., lighting preferences)
- ▶ **Personalized lighting service:** actuates the lights based on the preferences of a user

Example: Personalized Lighting service communications



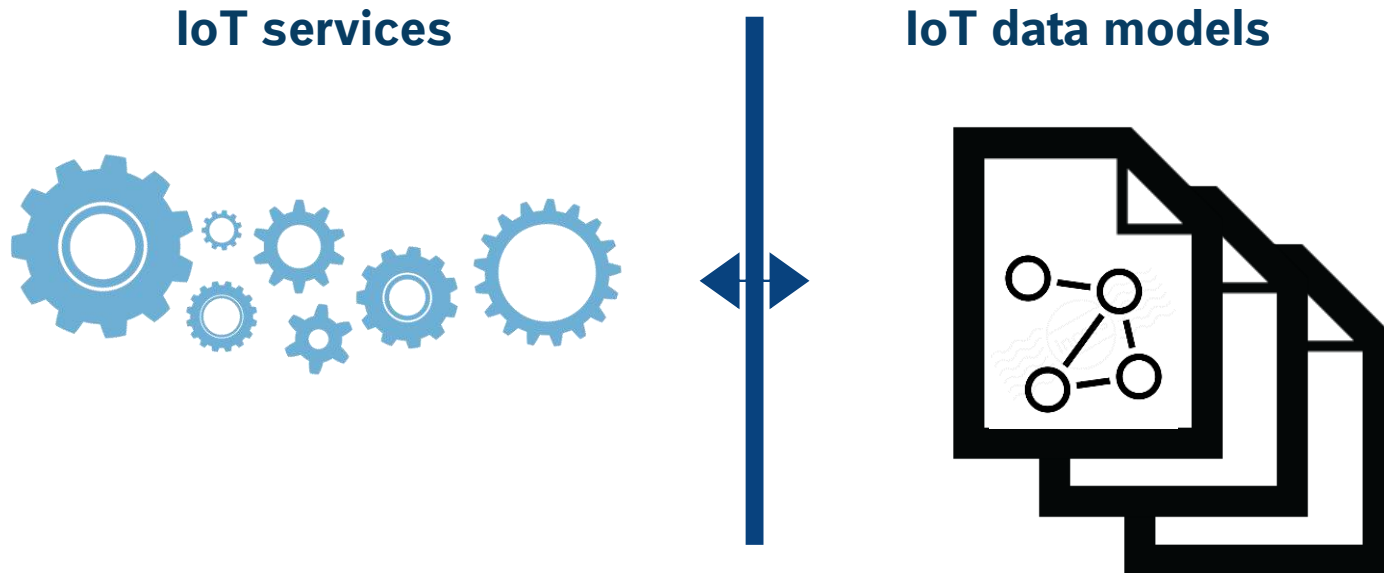
Example: Personalized Lighting communication bottleneck

- ▶ Each observation and profile service defines its own data models
- ▶ The light service must implement and maintain interpreters for each service



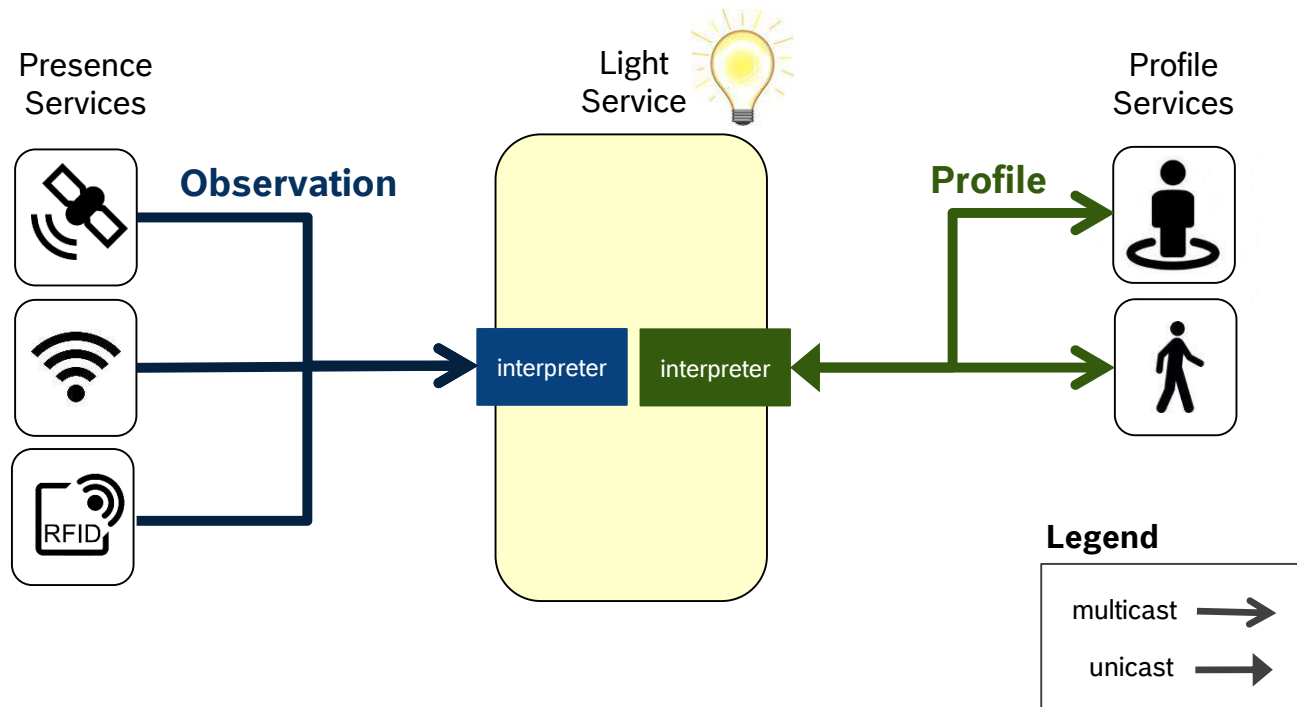
Example: Personalized Lighting data as a first class citizen

- ▶ Let's promote data models to first-class citizen, and separate the task of developing services from developing data models



Example: Personalized Lighting easing the burden of interoperability

- ▶ Now the light service only needs interpreters for each data type – e.g., observations, user profiles



Common data models seeking guidance from the Web

schema.org

A success story

- ▶ 31% of the Web uses schema.org
- ▶ 42% growth since Feb. 2015



* R. V. Guha, Dan Brickley, Steve Macbeth. Schema.org: Evolution of Structured Data on the Web. Communications of the ACM, Vol. 59 No. 2, Pages 44-51.

Common data models seeking guidance from the Web

schema.org

Can the IoT community reuse existing data models commonly used on the Web?

- A success story
- ▶ 31% of the Web uses schema.org
 - ▶ 42% growth since Feb. 2015



* R. V. Guha, Dan Brickley, Steve Macbeth. Schema.org: Evolution of Structured Data on the Web. Communications of the ACM, Vol. 59 No. 2, Pages 44-51.

Example: Personalized Lighting data models needed

Observation Data



Presence observations
Activity observations

User Profile Data

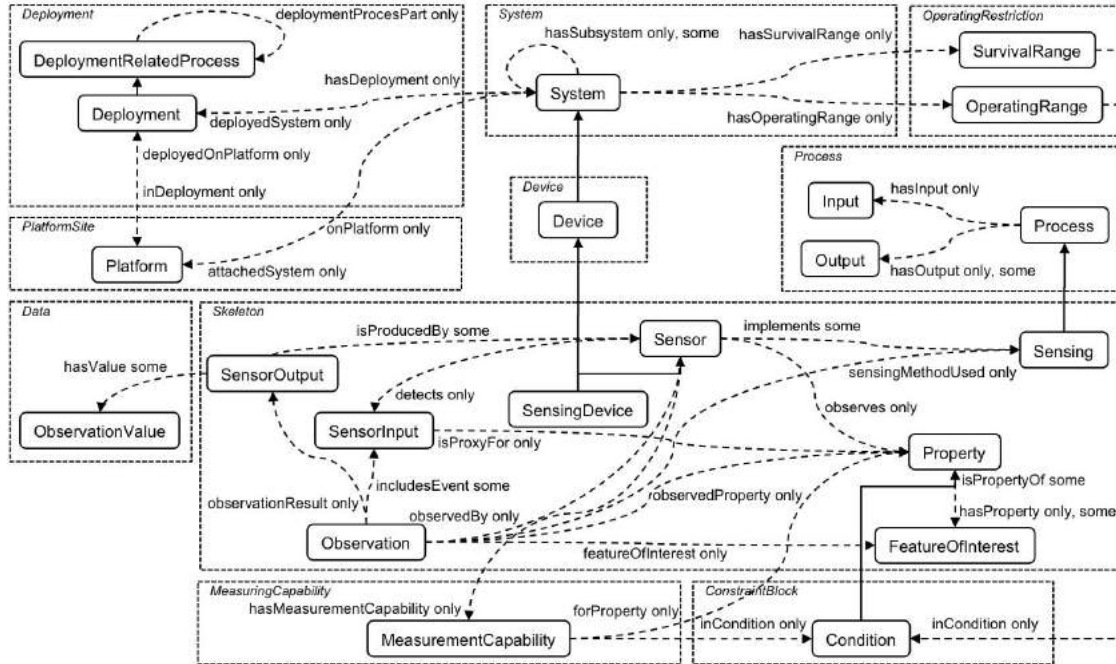


Preference information

Common data models modeling observations



Semantic Sensor Network Ontology

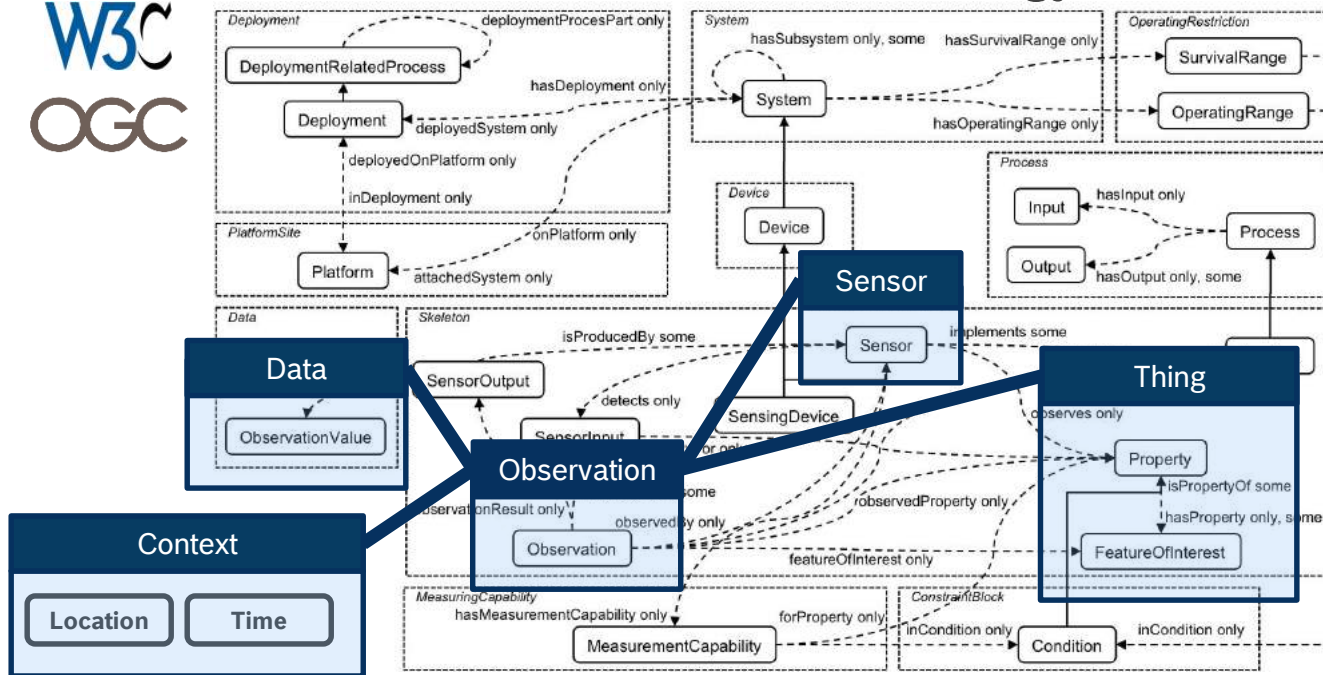


* Lefort et al.: Semantic Sensor Network XG Final Report, W3C Incubator Group Report (2011). <http://www.w3.org/2005/Incubator/ssn/XGR-ssn/>

Common data models modeling observations



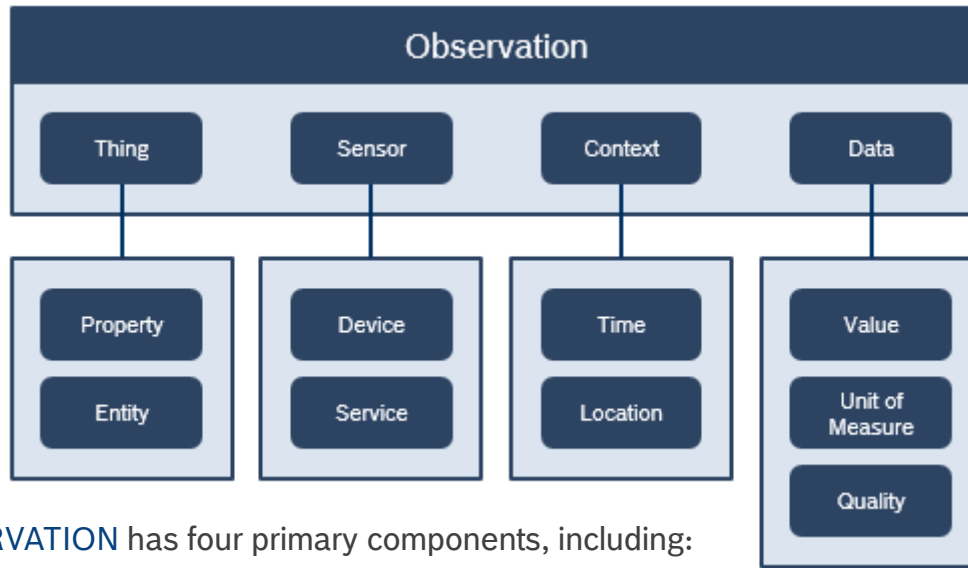
Semantic Sensor Network Ontology



Needed: a minimal subset of SSN, tailored for IoT applications

W3C SDW-WG Reqs (<http://www.w3.org/TR/sdw-ucr/>): **REQ 5.18 Lightweight Model for IoT** and **REQ 5.20 Machine-to-Machine**

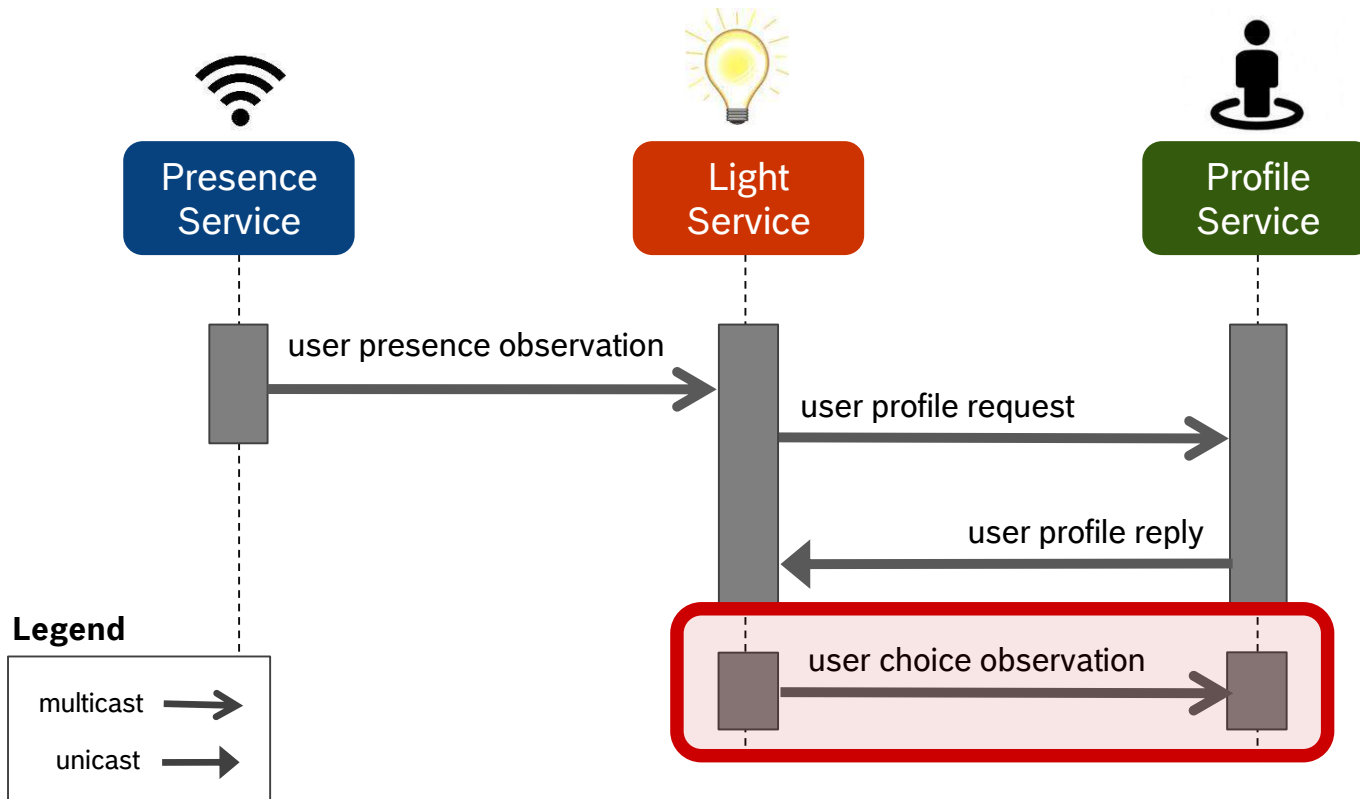
Common data models modeling observations



An OBSERVATION has four primary components, including:

- **THING** being observed
- **SENSOR** that observes the *THING*
- **CONTEXT** in which the *THING* is observed
- **DATA** produced by the *SENSOR*

Example: Personalized Lighting service communications

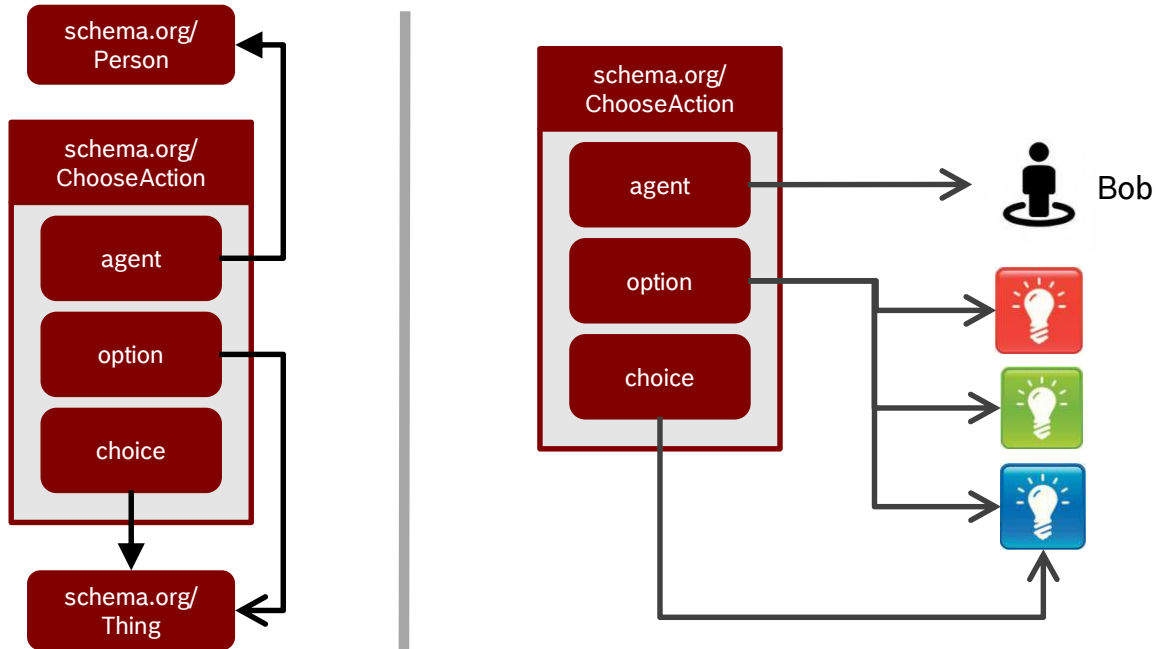


Common data models modeling user choice

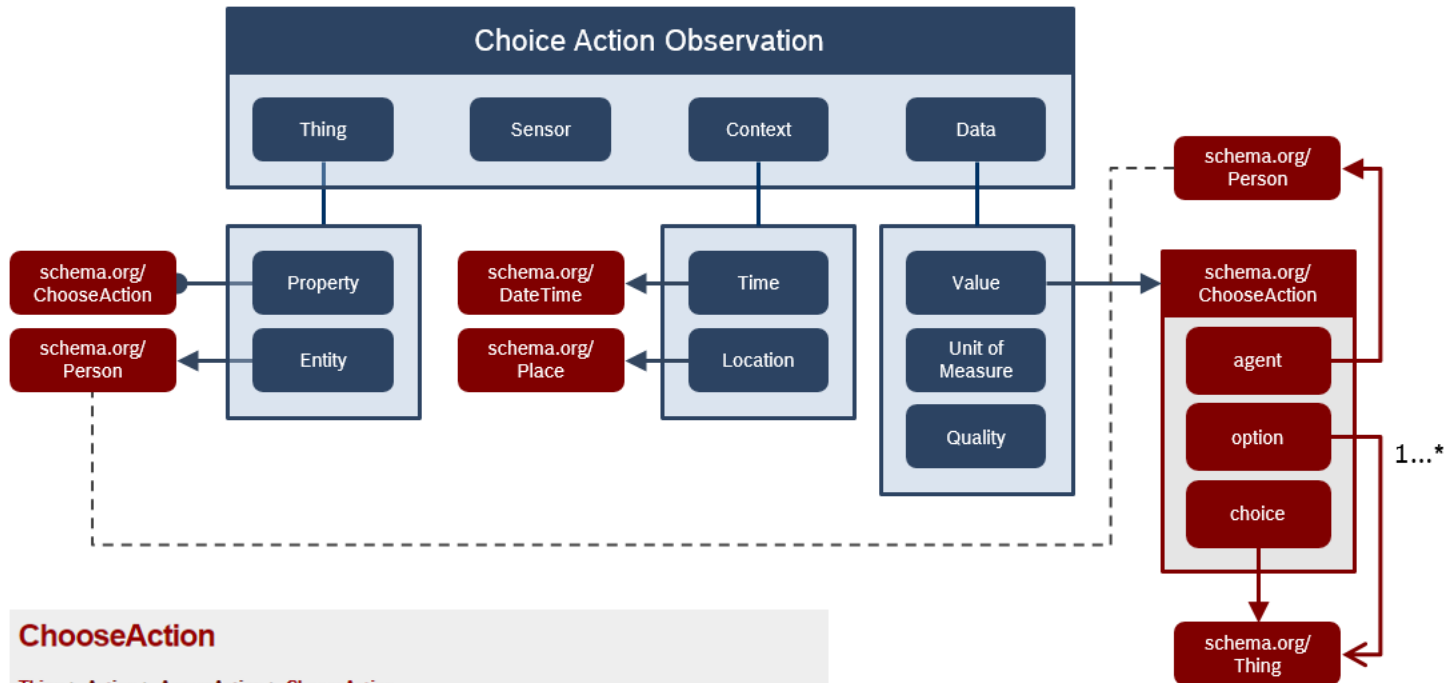
ChooseAction

Thing > Action > AssessAction > ChooseAction

The act of expressing a preference from a set of options or a large or unbounded set of choices/options.



Common data models modeling observations



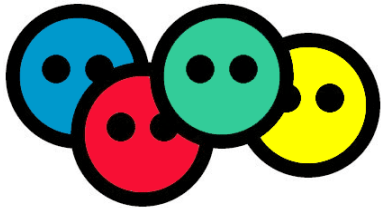
ChooseAction

Thing > Action > AssessAction > ChooseAction

The act of expressing a preference from a set of options or a large or unbounded set of choices/options.

Common data models modeling user profiles

Friend-of-a-Friend



foaf:Person

vCard



vcards:Individual

Schema.org



schema:Person

Common data models modeling user profiles

Friend-of-a-Friend

vCard

Schema.org



Unfortunately, these models are not able to represent context-sensitive user information.

foaf:Person

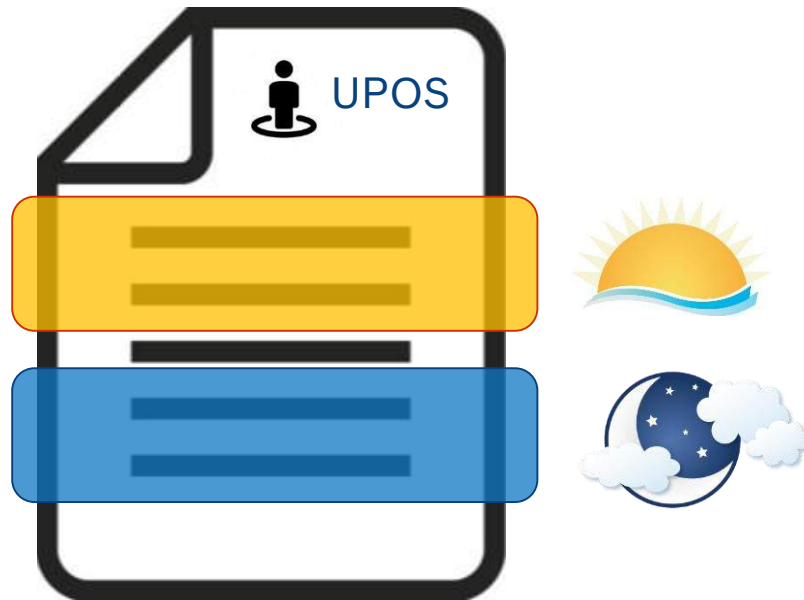
vcard:Individual

schema:Person

Common data models modeling user profiles

- ▶ Modeling context-sensitive user profile information with the UPOS
- ▶ UPOS: User Profile Ontology

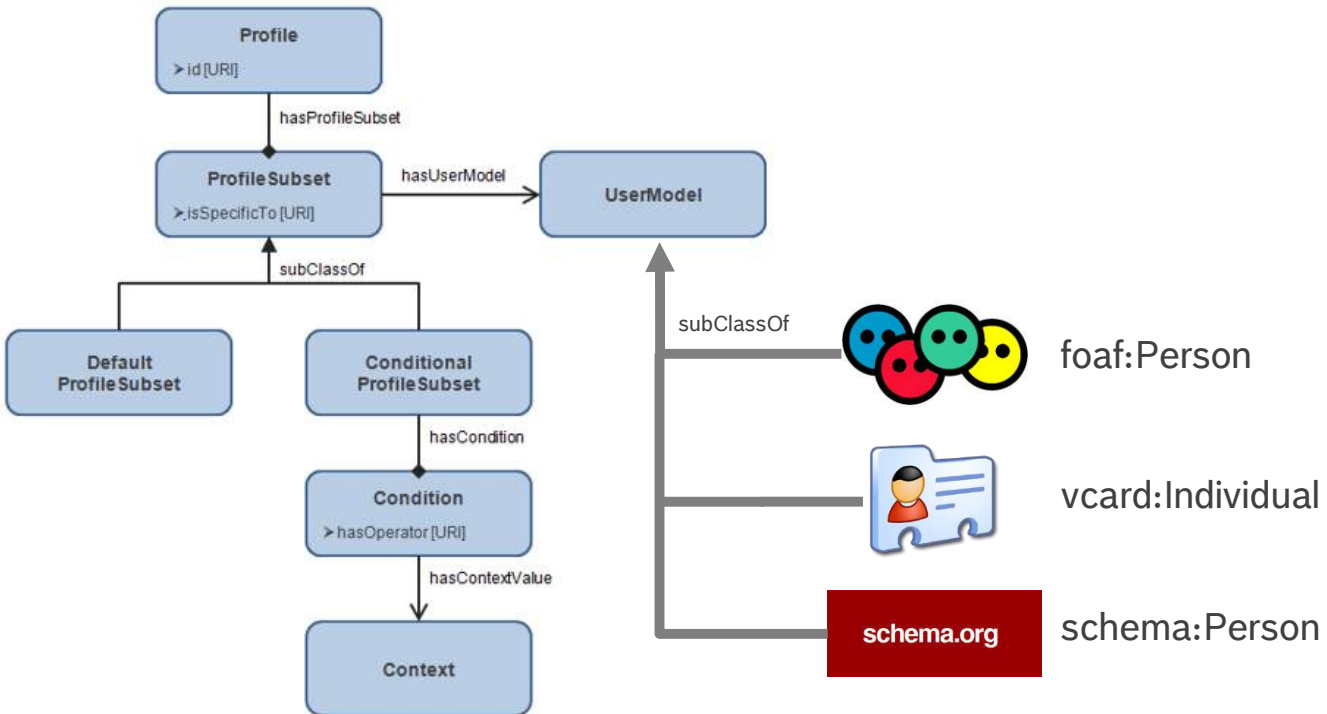
Annotating user
profile data with the
context in which the
data is valid.



* M. Sutterer, et al.: UPOS: User Profile Ontology with Situation-Dependent Preferences Support. 1st International Conference on Advances in Computer-Human Interaction, 2008, pp. 230-235.

Common data models modeling user profiles

- ▶ Extending UPOS with common user profile models



- ▶ Interoperability is perhaps a bigger challenge on IoT than on the Web (because of the dynamic and heterogeneous nature of the network)

- ▶ When defining IoT data models, we should seek to re-use existing common data models whenever possible
 - W3C/OGC SSN: observation model (e.g., user presence, user action)
 - UPOS: user profile model (e.g., context-sensitive preferences)
 - Schema.org: Various common data models (e.g., locations, date/time, actions)

- ▶ Some Web data models may require adjustment based on IoT specific challenges, e.g., lightweight M2M communications



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