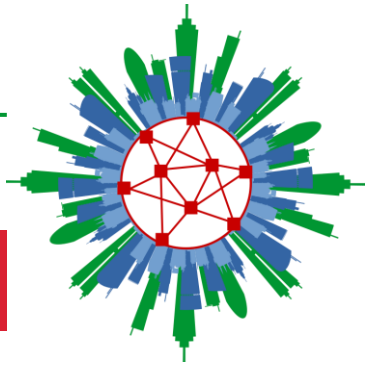
CARL VON OSSIETZKY universität OLDENBURG

SuMoCoS

Sustainability and Mobility in the Context of Smart Cities

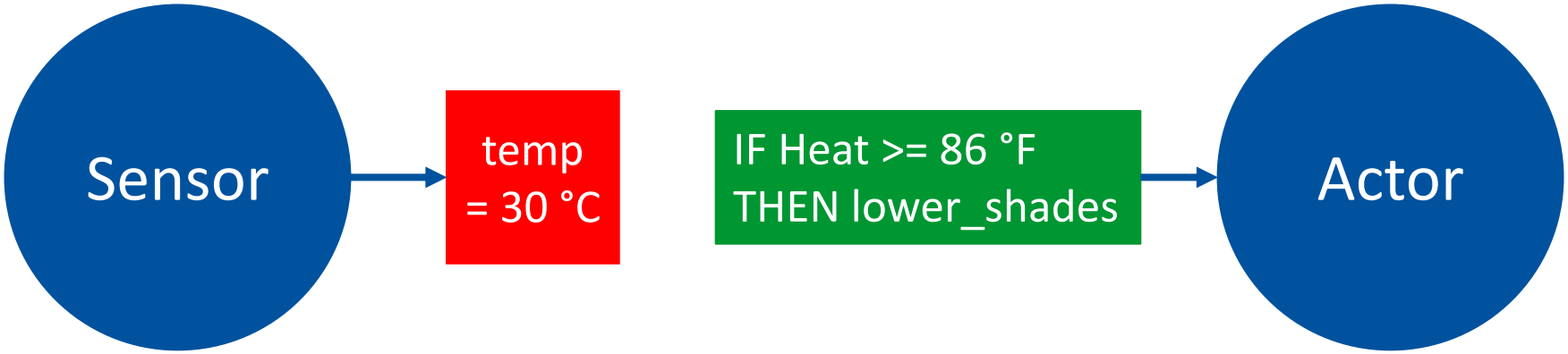


Semantic Technologies for Smart Cities

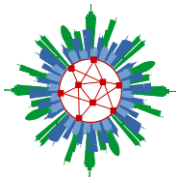
Dr. Christian Schönberg

christian.schoenberg@uni-oldenburg.de

Motivation

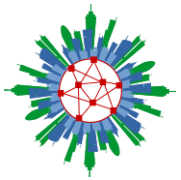

Sensor
temp
= 30 °C
IF Heat >= 86 °F
THEN lower_shades
Actor


temp = 30 °C
Heat >= 86 °F



Semantic Technologies

- Knowledge Management
  - Knowledge Representation
    - Ontologies
    - Taxonomies
  - Knowledge Inference

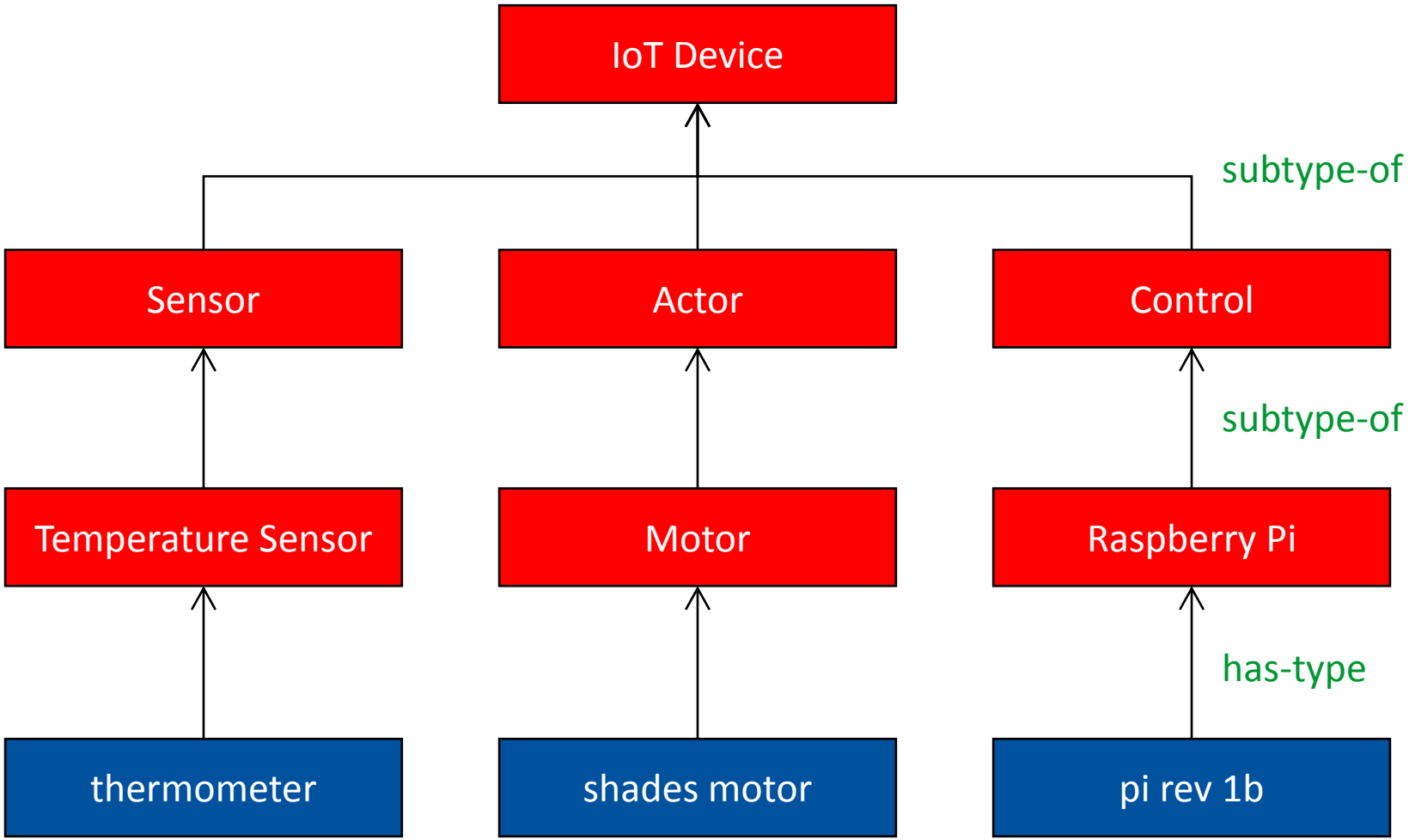


Ontologies

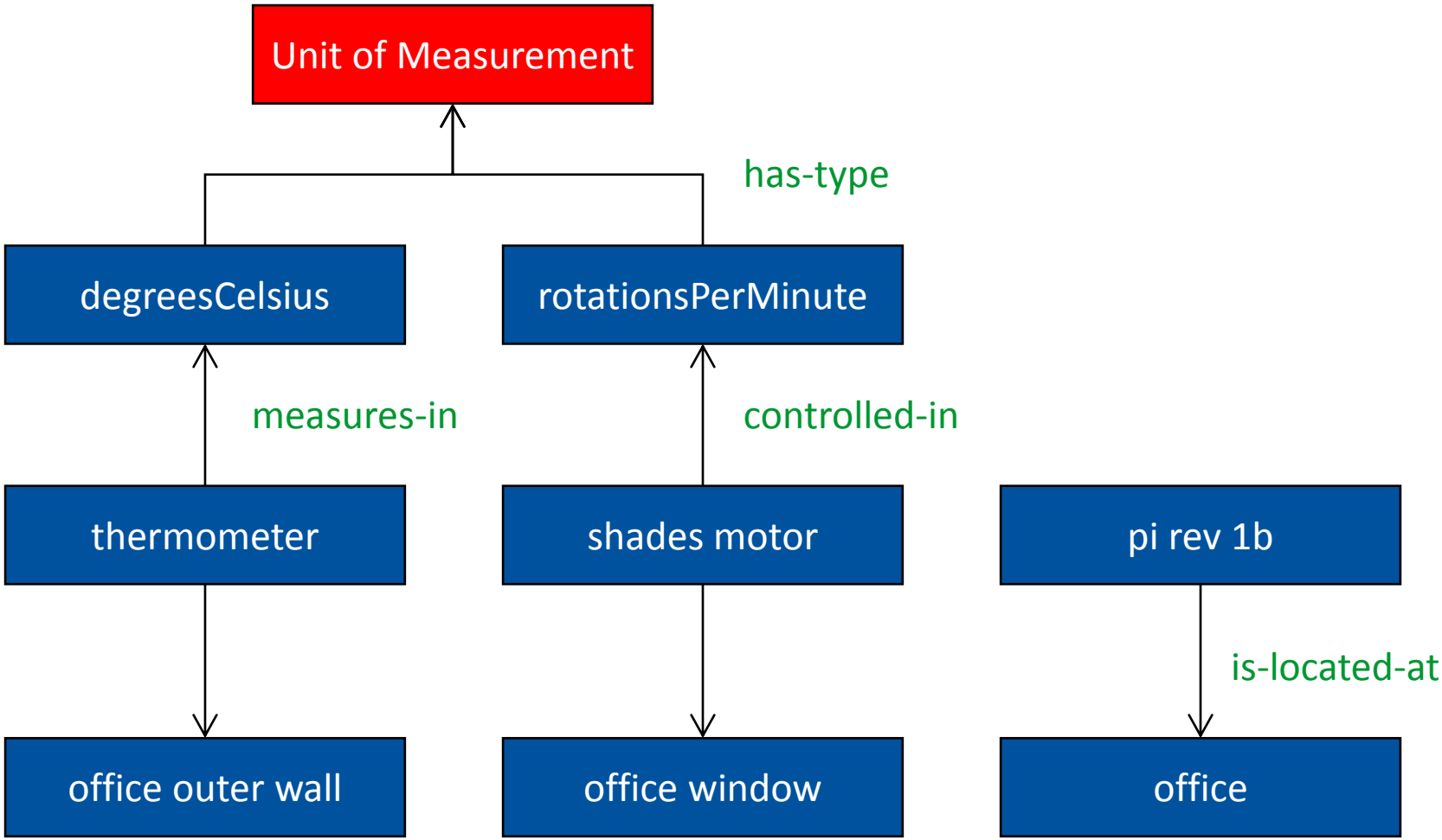
CARL VON OSSIETZKY universität OLDENBURG

- Describe Concepts, Individuals and their Relationships
- Concepts represent abstract types, such as *Temperature* or *UnitOfMeasurement*
- Individuals represent concrete data, such as *20°* or *degreesCelsius*
- Relationships represent connections between
  - concepts, such as Temperature *is-a* Measurement (specialisation)
  - individuals, such as 20° *is-measured-in* degreesCelsius
  - individuals and concepts, such as 20° *has-type* Temperature

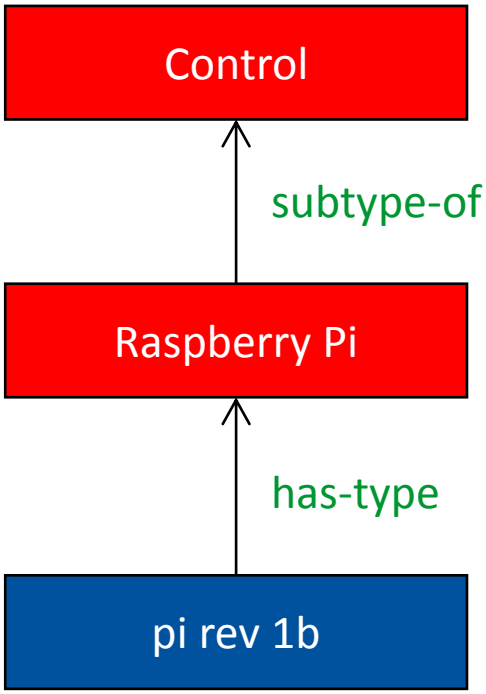
Ontologies: Example



Ontology: Example (continued)

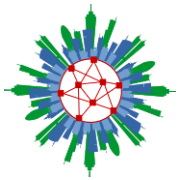


Foundation in Logics



$\texttt{Raspberry Pi} \sqsubseteq \texttt{Control}$

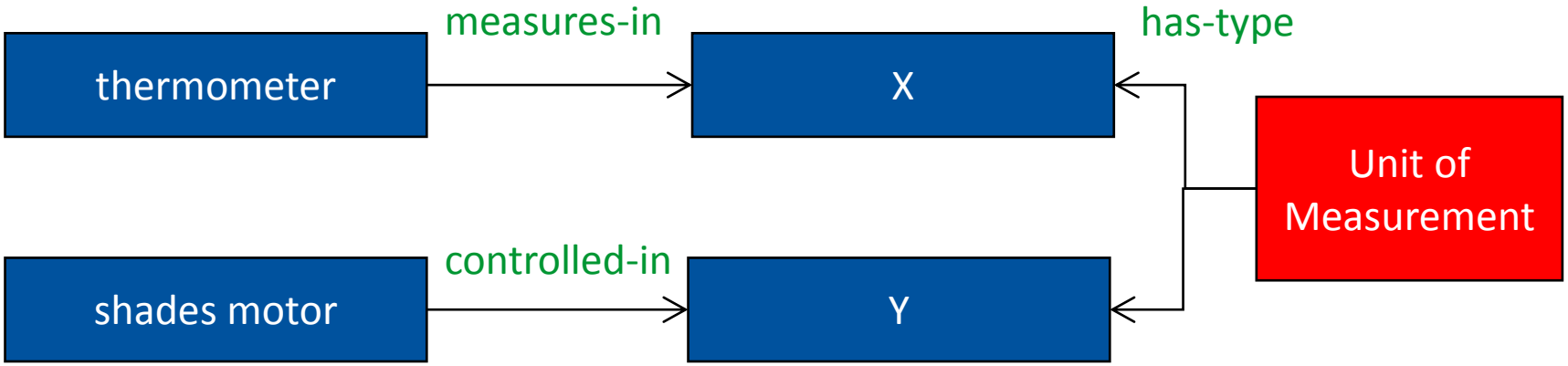
$\texttt{Raspberry Pi(pi rev 1b)}$



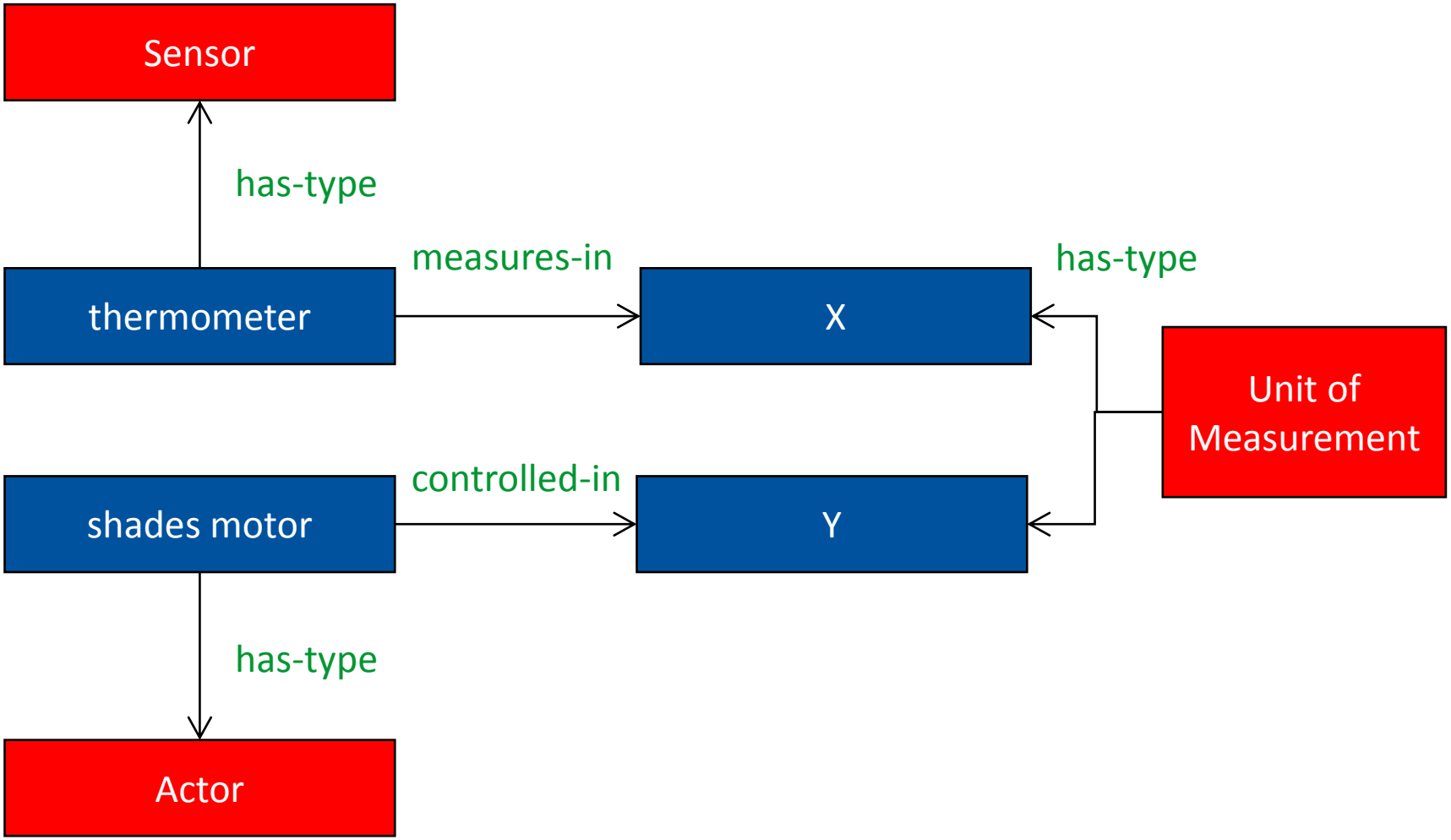
Inference

- Create new facts from existing facts and rules
- Automatic classification,
  e.g., determine type based on attributes
- Find inconsistencies

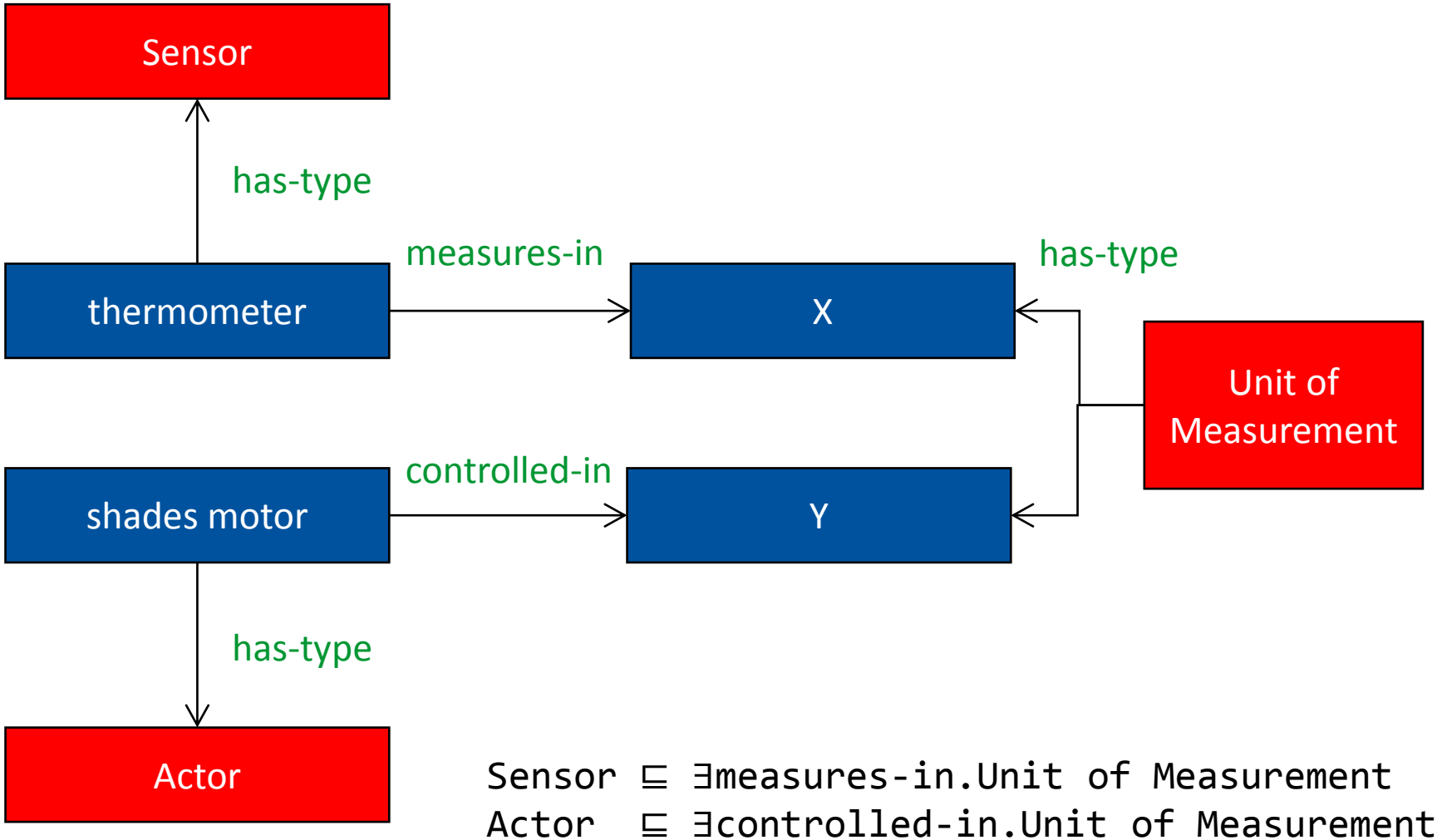
Automatic Classification: Example



Automatic Classification: Example

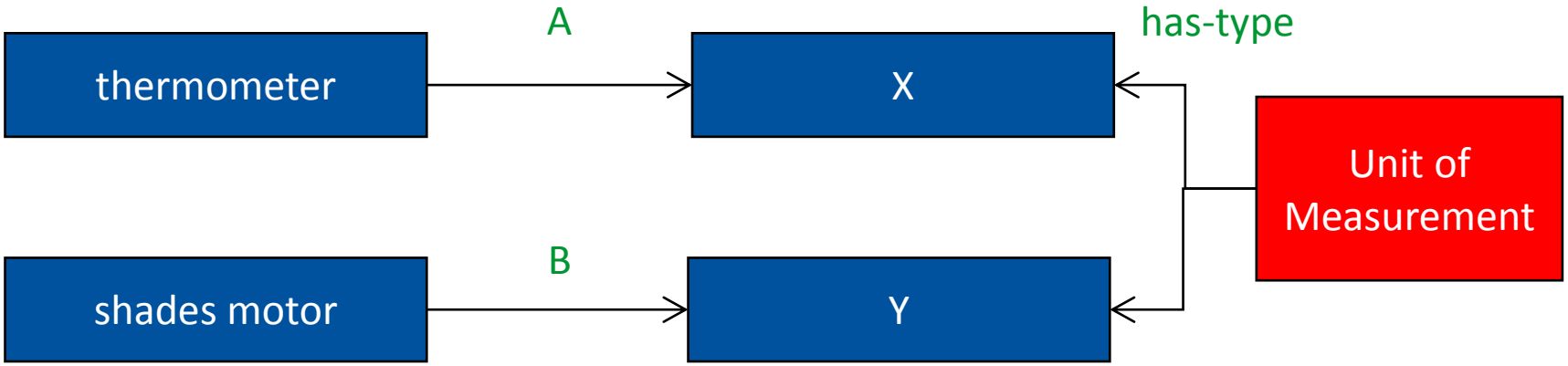


Automatic Classification: Example

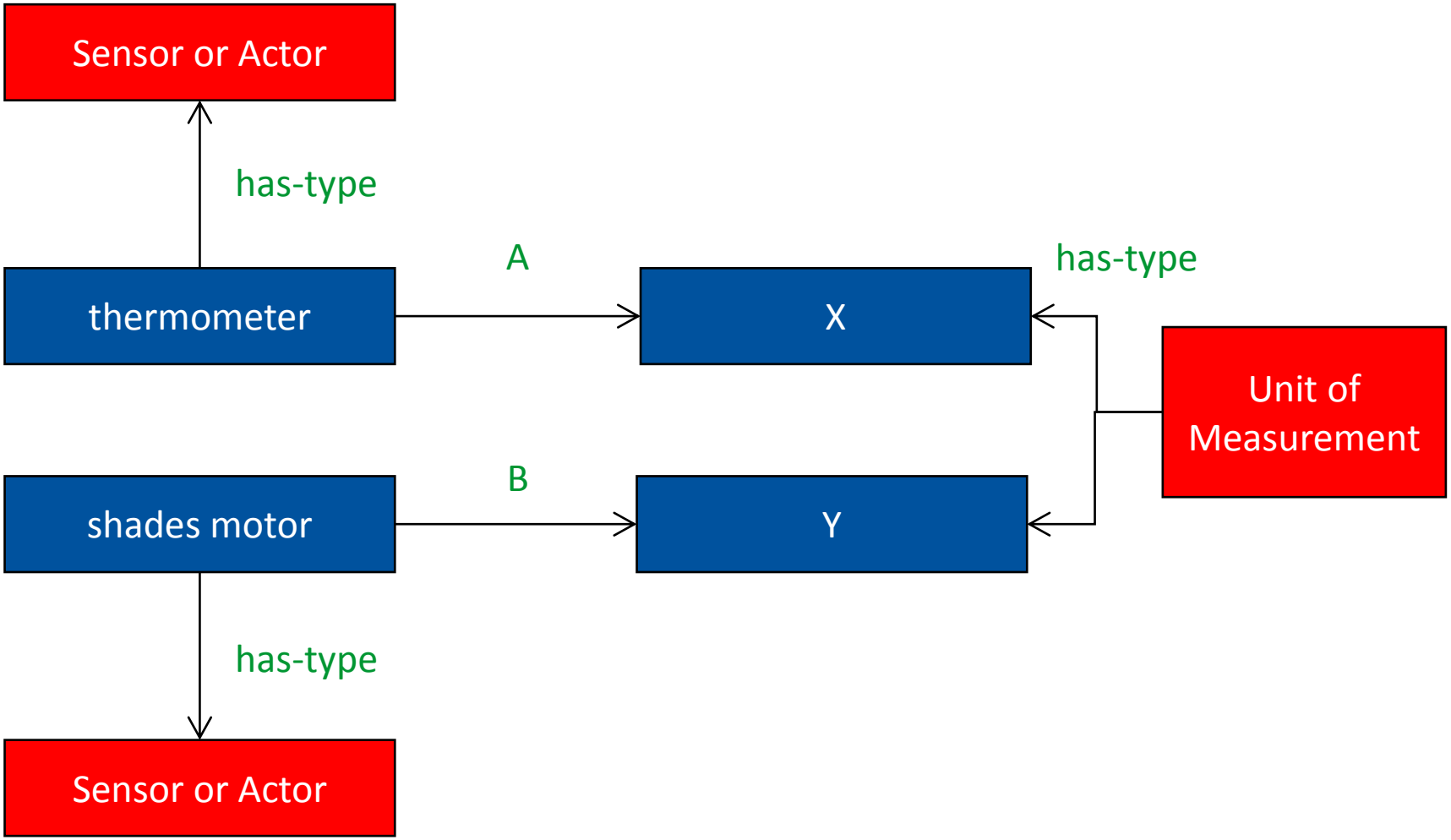


$$\text{Sensor} \sqsubseteq \exists \text{measures-in}.\text{Unit of Measurement}$$
$$\text{Actor} \sqsubseteq \exists \text{controlled-in}.\text{Unit of Measurement}$$

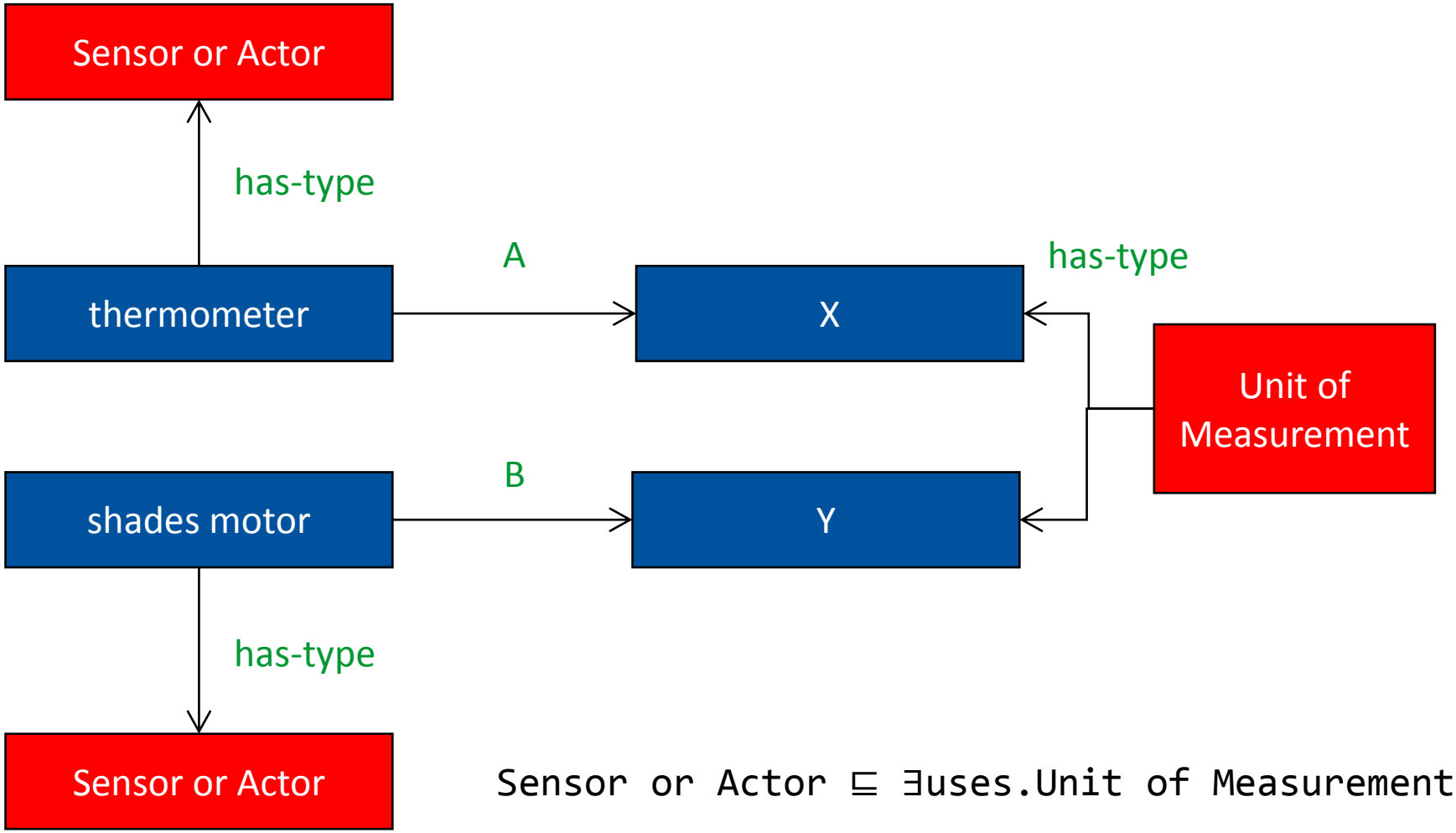
Automatic Classification: Example (2)



Automatic Classification: Example (2)

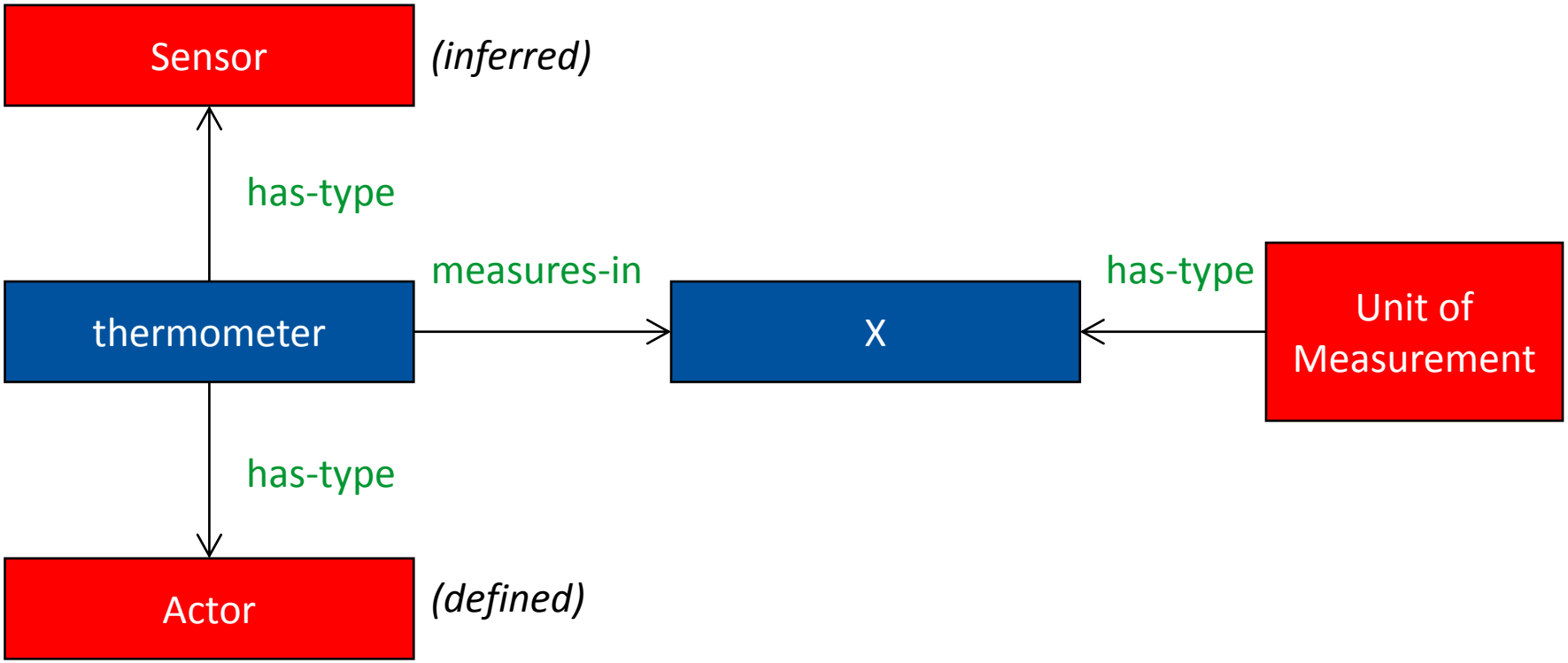


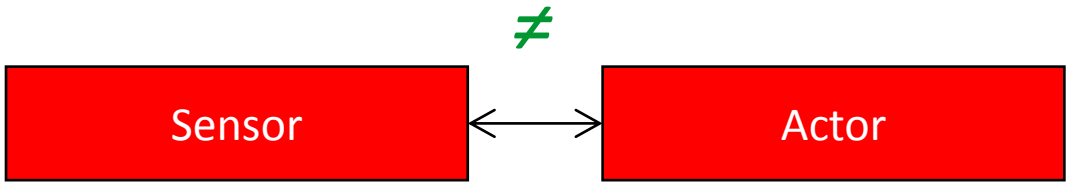
Automatic Classification: Example (2)



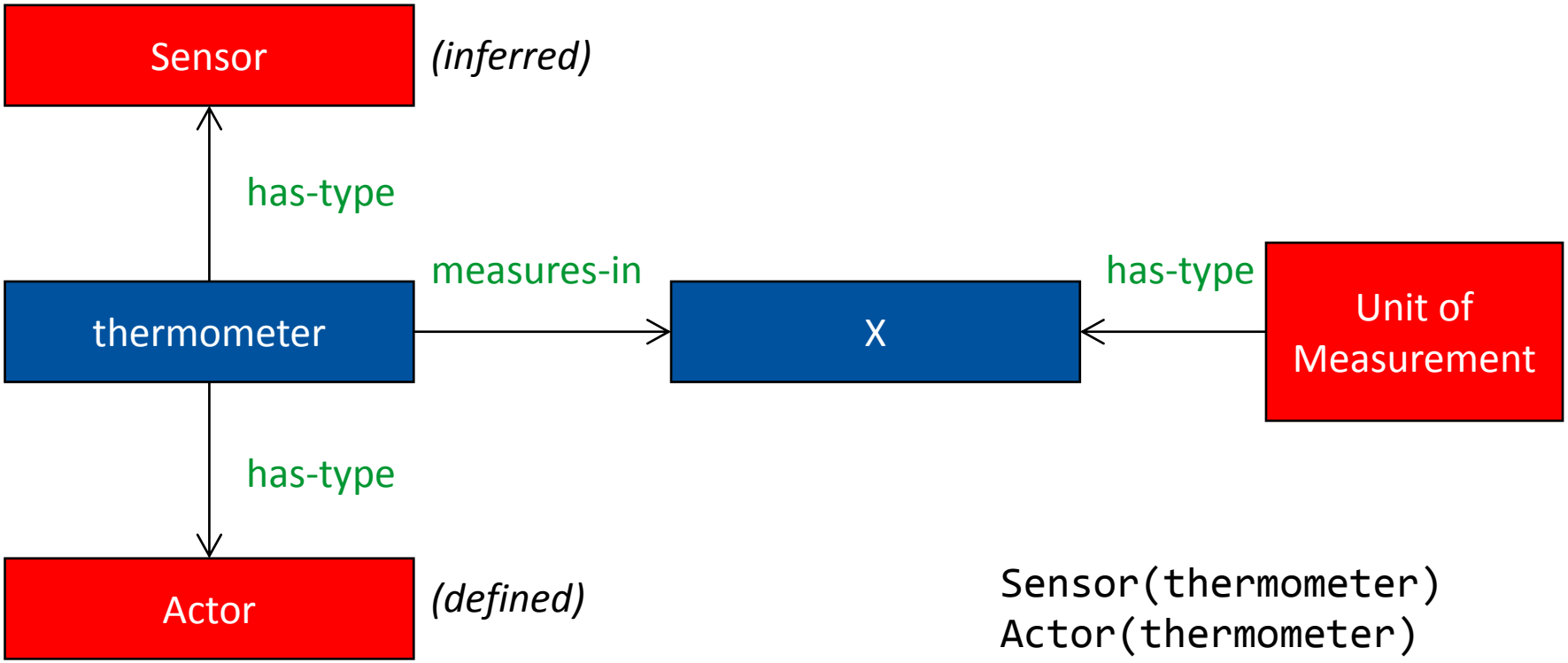
$$\text{Sensor or Actor} \sqsubseteq \exists \text{uses.Unit of Measurement}$$

Inconsistency: Example

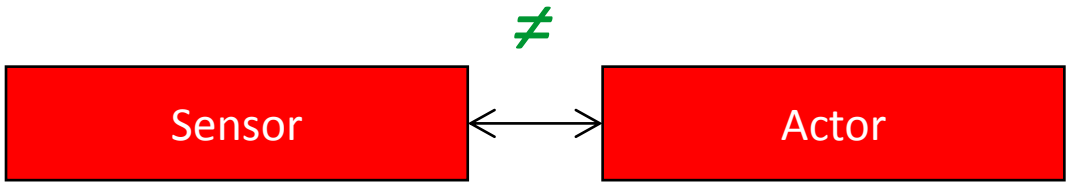




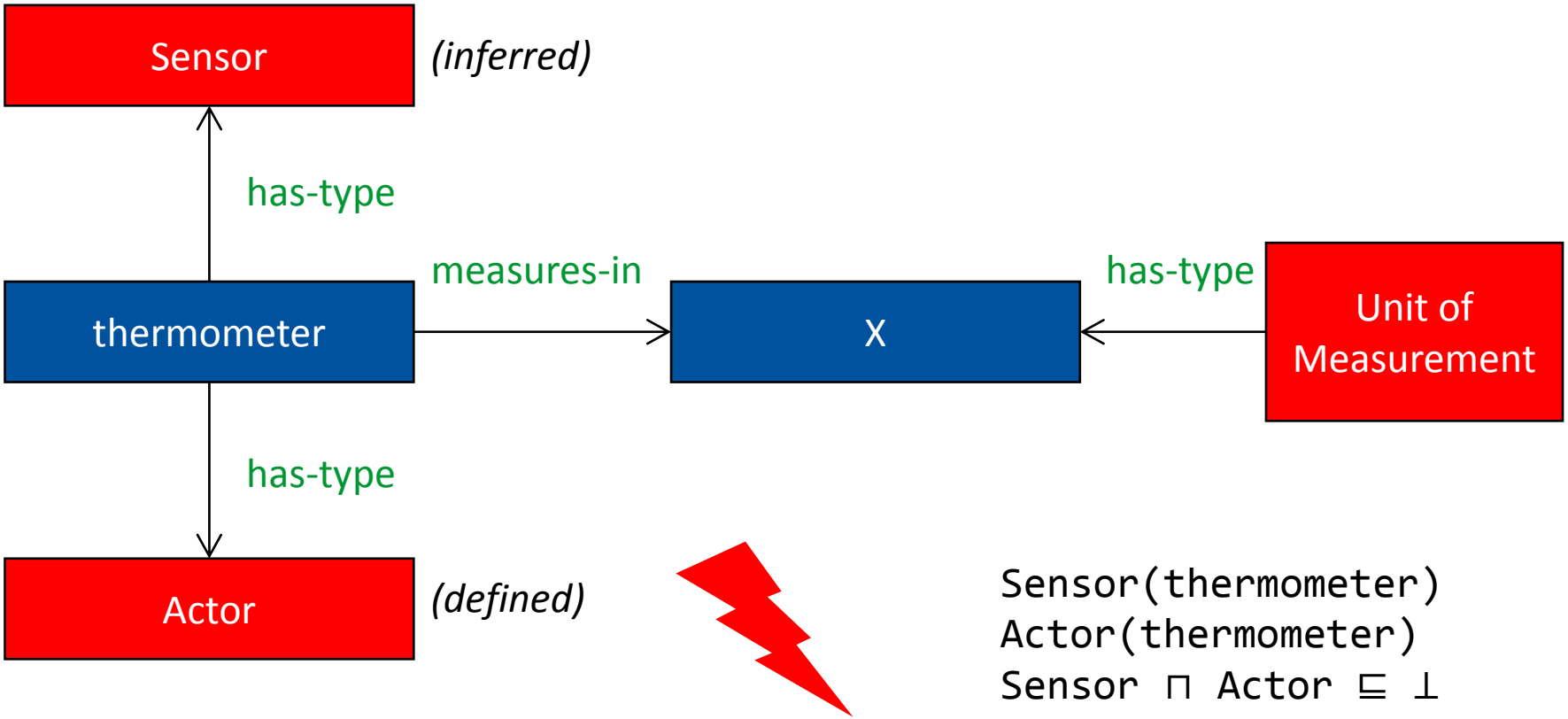
Inconsistency: Example

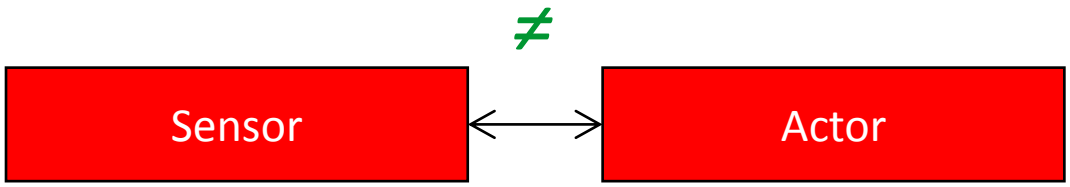


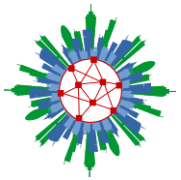

```
Sensor(thermometer)
Actor(thermometer)
Sensor ⊓ Actor ⊑ ⊥
```



Inconsistency: Example





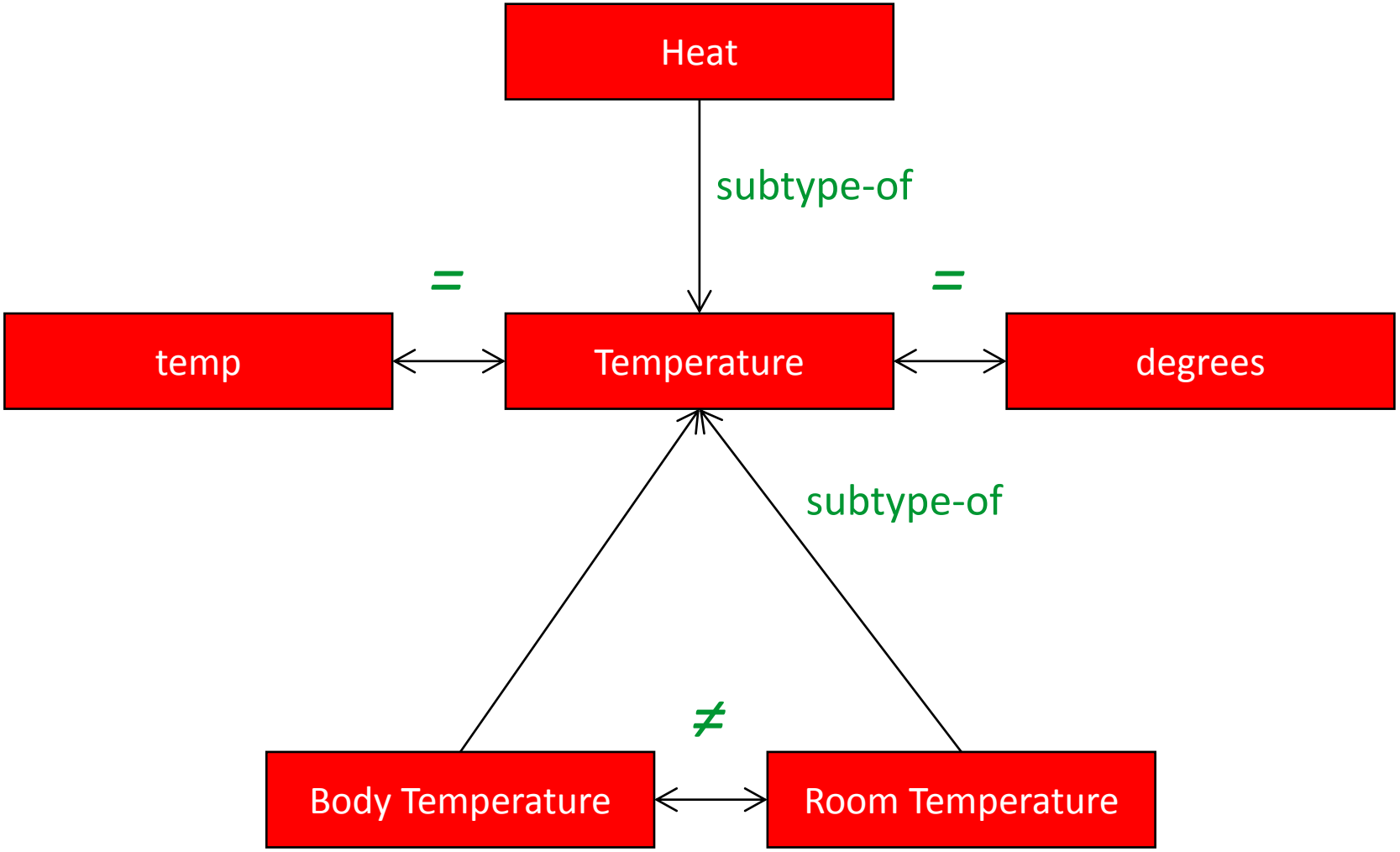


Ontologies for Smart Cities

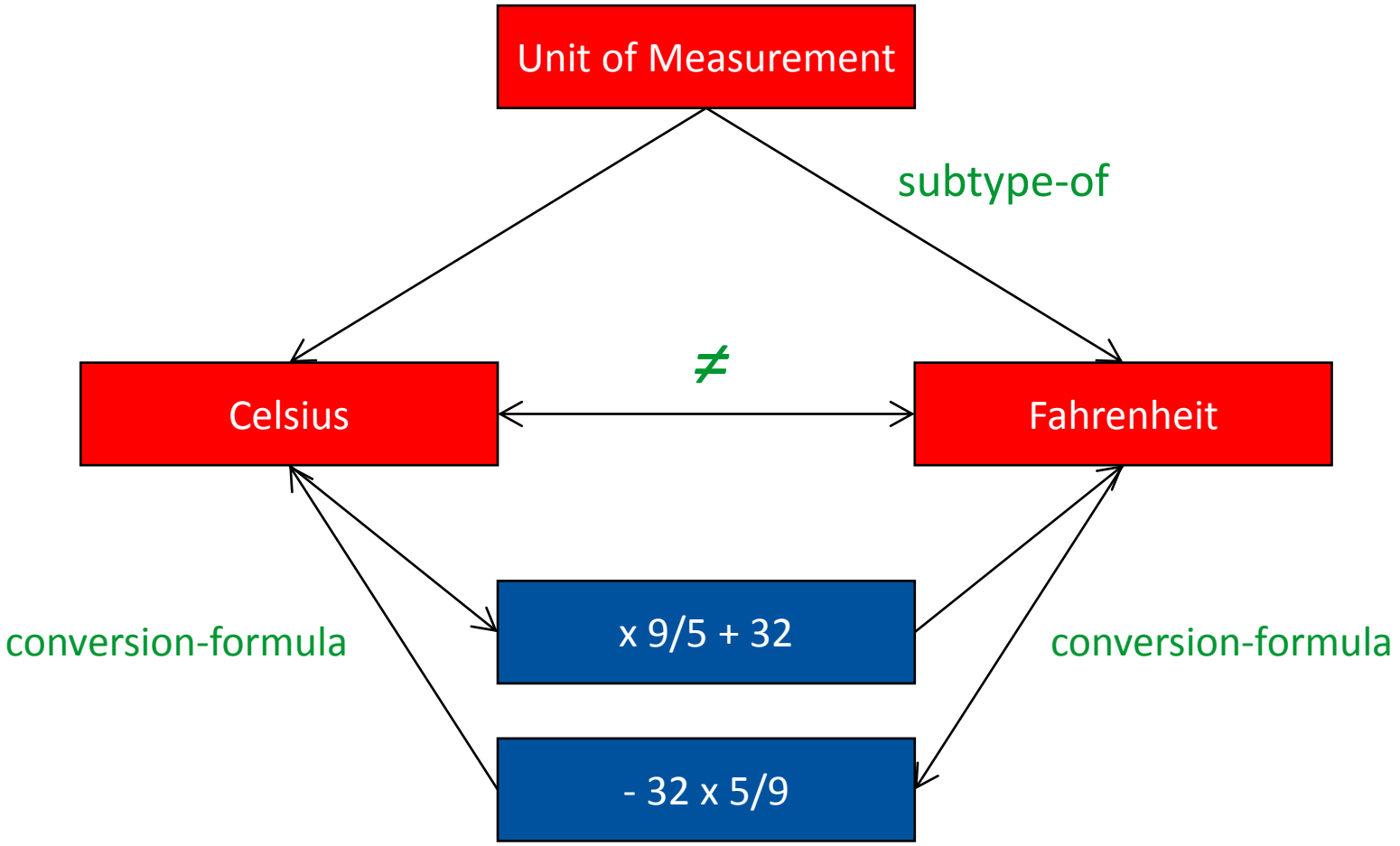
CARL VON OSSIETZKY universität OLDENBURG

- Documentation
- Semantic description of devices
- Thesaurus
  - different devices and domains use different terminology
  - map devices and data

Ontologies for Smart Cities: Example



Ontologies for Smart Cities: Example (2)



Existing Ontologies for Smart Cities

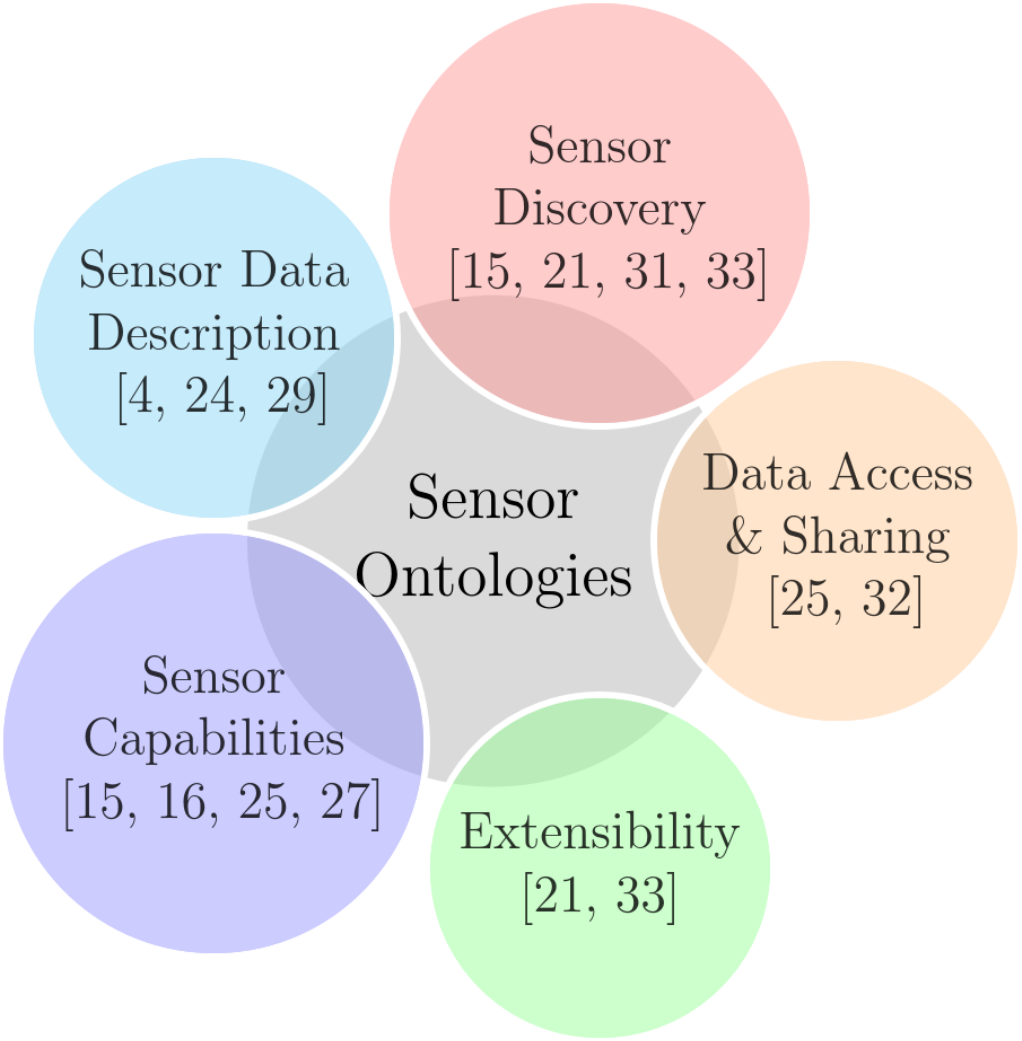
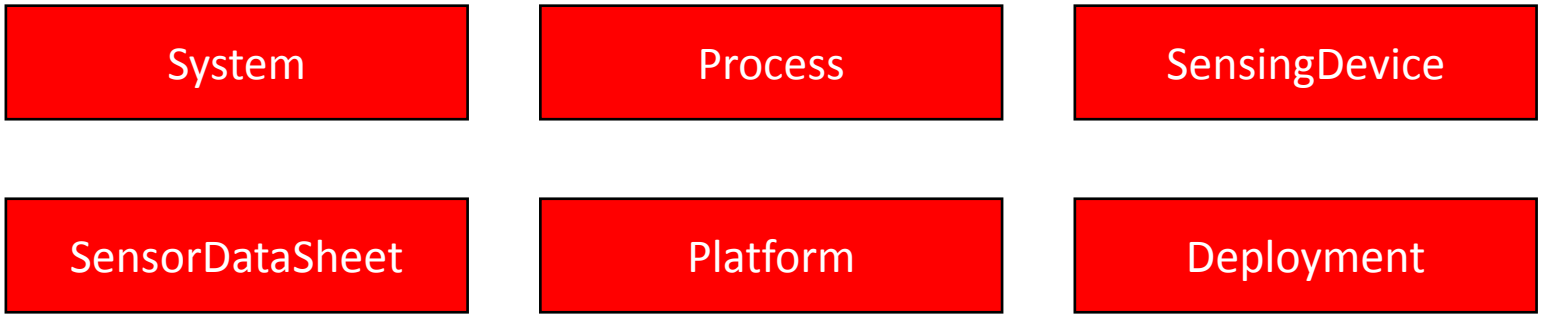


Image taken from Garvita Bajaj, Rachit Agarwal, Pushpendra Singh, Nikolaos Georgantas, and Valerie Issarny: *A study of existing Ontologies in the IoT-domain*. CoRR, 2017.

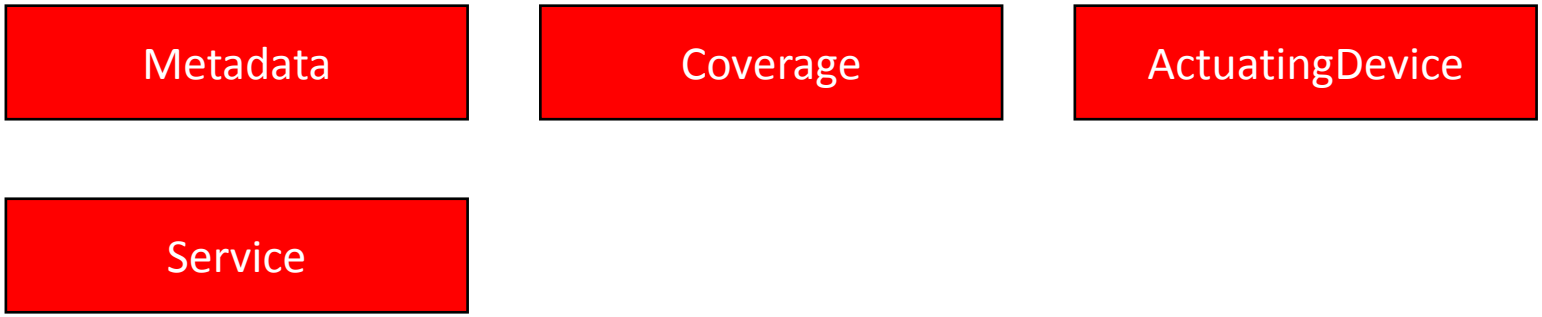
Existing Ontologies for Smart Cities

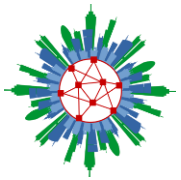
- Semantic Sensor Network Ontology (SSN)
  - W3C ontology
  - describes sensors, observations and related concepts
  - does not describe domain concepts, time, locations, … (but can be included from other ontologies)



Existing Ontologies for Smart Cities (2)

- IoT-Lite
  - W3C member submission
  - lightweight ontology to represent IoT resources, entities and services
  - instantiation of SSN

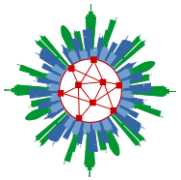




Existing Ontologies for Smart Cities (3)

CARL VON OSSIETZKY universität OLDENBURG

- OpenIoT
  - describes observations, sensors, locations, and metrics for SLAs
  - instantiation of SSN
- OntoSensor
  - sensor categories, behaviour, functions and meta-data
  - extends SensorML
- OWL-Time
  - specifies date/time information
  - point in time and intervals



Analysis

CARL VON OSSIETZKY universität OLDENBURG

- Semantic technologies can
  - help with relating various sensors, actors and other devices
    - from different manufacturers
    - from different application domains
    - of different types
  - identify inconsistencies and errors in the system description
- Semantic technologies are
  - often restricted to a single domain (but can be combined)
  - expensive to create (but can be mitigated)

Contact

SuMoCoS
Sustainability and Mobility in the Context of Smart Cities

Dr. Christian Schönberg

University of Oldenburg

Faculty II, Department of Computing Science
Software Engineering Group
26111 Oldenburg

+49 441 798-5173

https://uol.de/se?schoenberg

christian.schoenberg@uni-oldenburg.de