UiO : Department of Technology Systems
University of Oslo

TEK5530 - Measurable Security for the Internet of Things

L5 – Security Semantics

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http://cwi.unik.no/wiki/UNIK4750, #IoTSec, #IoTSecNO

Overview

- Learning outcomes
- Recap: technology mapping
- Service requirements
  - ➡ Functional Requirements
  - ➡ Non-functional requirements
  - ➡ Security requirements
- Semantic technologies
  - ➡ why Semantics
  - ➡ elements of semantics
  - ➡ examples
- Security Ontologies
  - ➡ traditional view
  - ➡ Application-oriented view
- Map Security, Privacy, Dependability
- Conclusions

Expected Learning outcomes

Having followed the lecture, you can

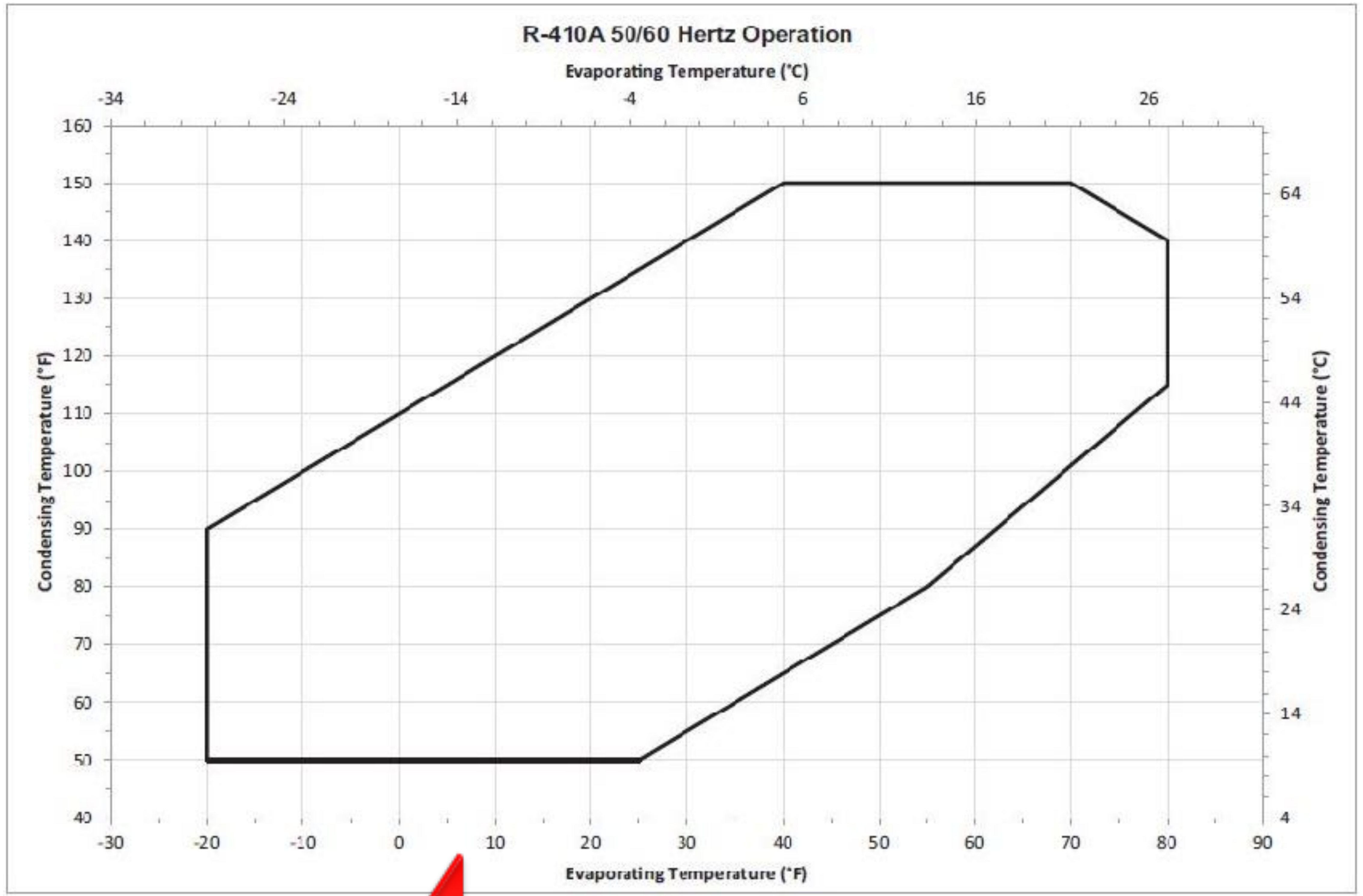
- explain components of the Smart Grid (AMS) System of Systems
- can explain the difference between functional, non-functional and security components
- provide examples of security challenges in IoT
- explain the difference between the web, the semantic web, web services and semantic web services
- explain the core elements of the Semantic Web
- apply semantics to IoT systems
- provide an example of attribute based access control
- discuss the shortcomings of the traditional threat-based approach
- list the main elements of the semantic descriptions of s,p,d functionalities
- perform a semantic mapping of s,p,d attributes

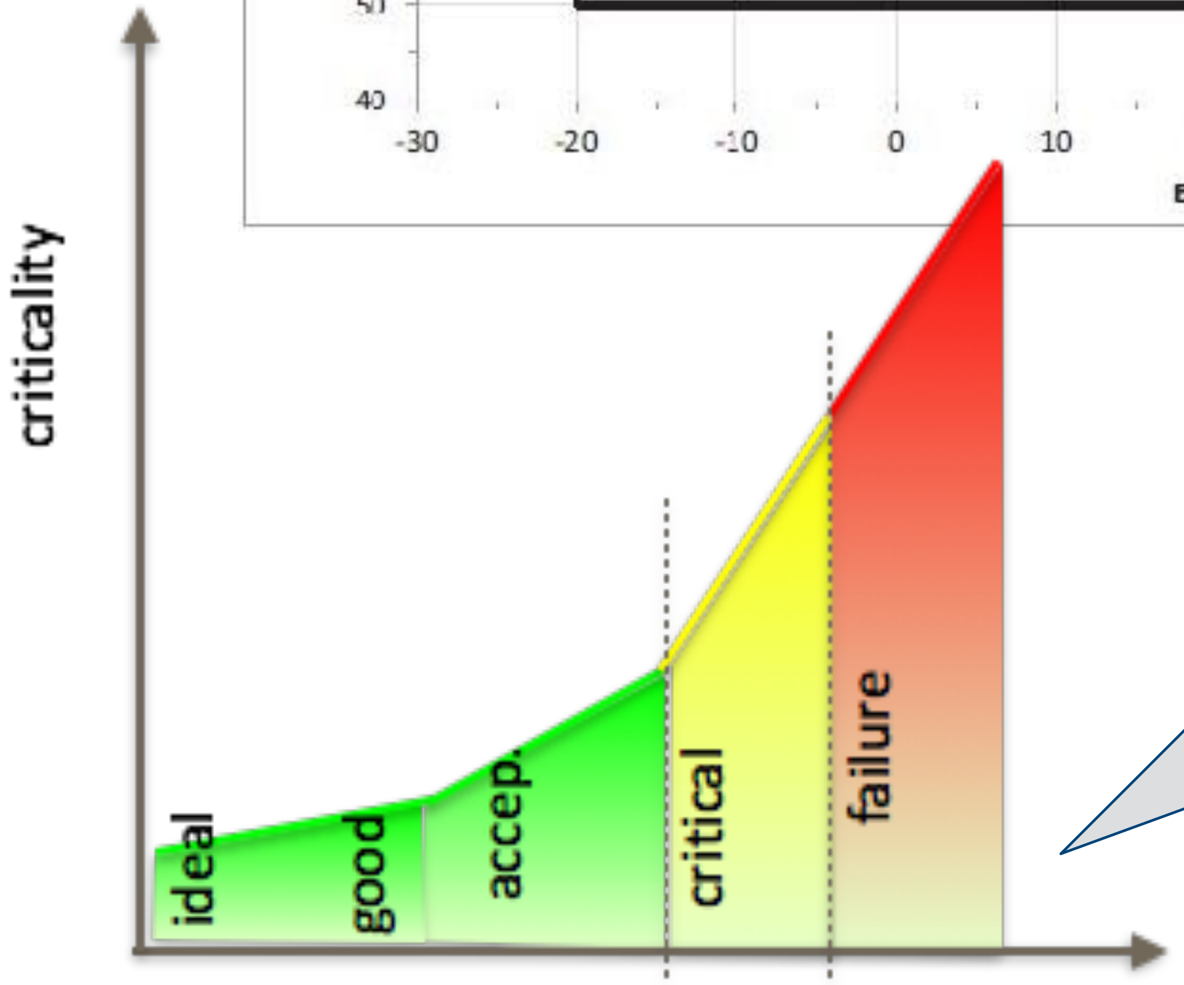
Service Requirements

- Functional Requirements,
  - ➡ e.g. report a value
- Non-functional requirements,
  - ➡ e.g. perform the operation in less than 0,5s
- Security requirements
  - ➡ e.g. ensure the confidentiality of the data

Recap:
Conversion and operating envelop

- Operating envelope: the operational parameters where our network can work "well", depends on the technology and on the task
- For traffic estimation we need it in "communication" QoS
  - ➡ Bandwidth, delay, jitter, (redundancy)
- Often can be done with simple arithmetic with a certain confidence level

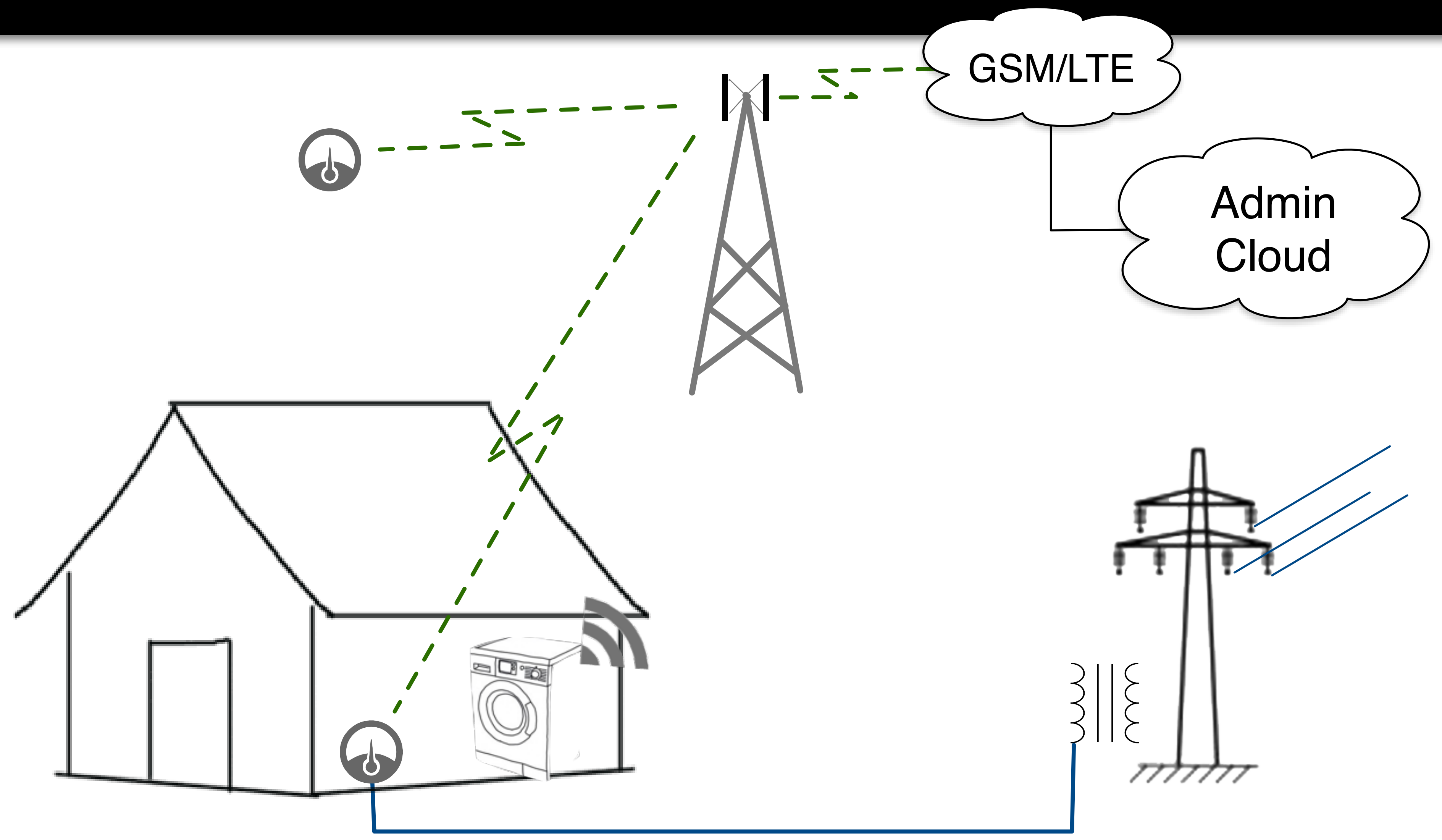


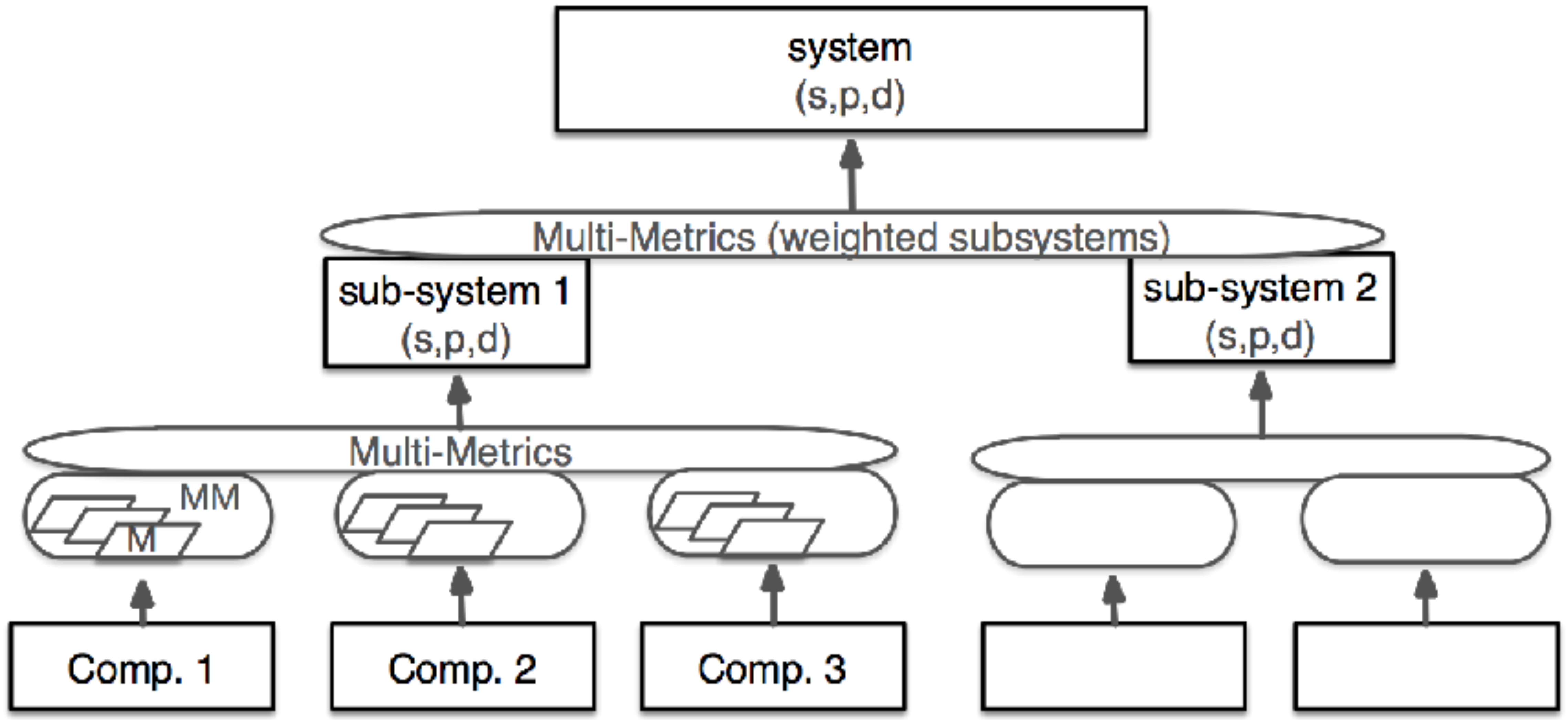


1) How does he Operating Envelope look like applying criticality?
2) How can the criticality be applied for SPD?

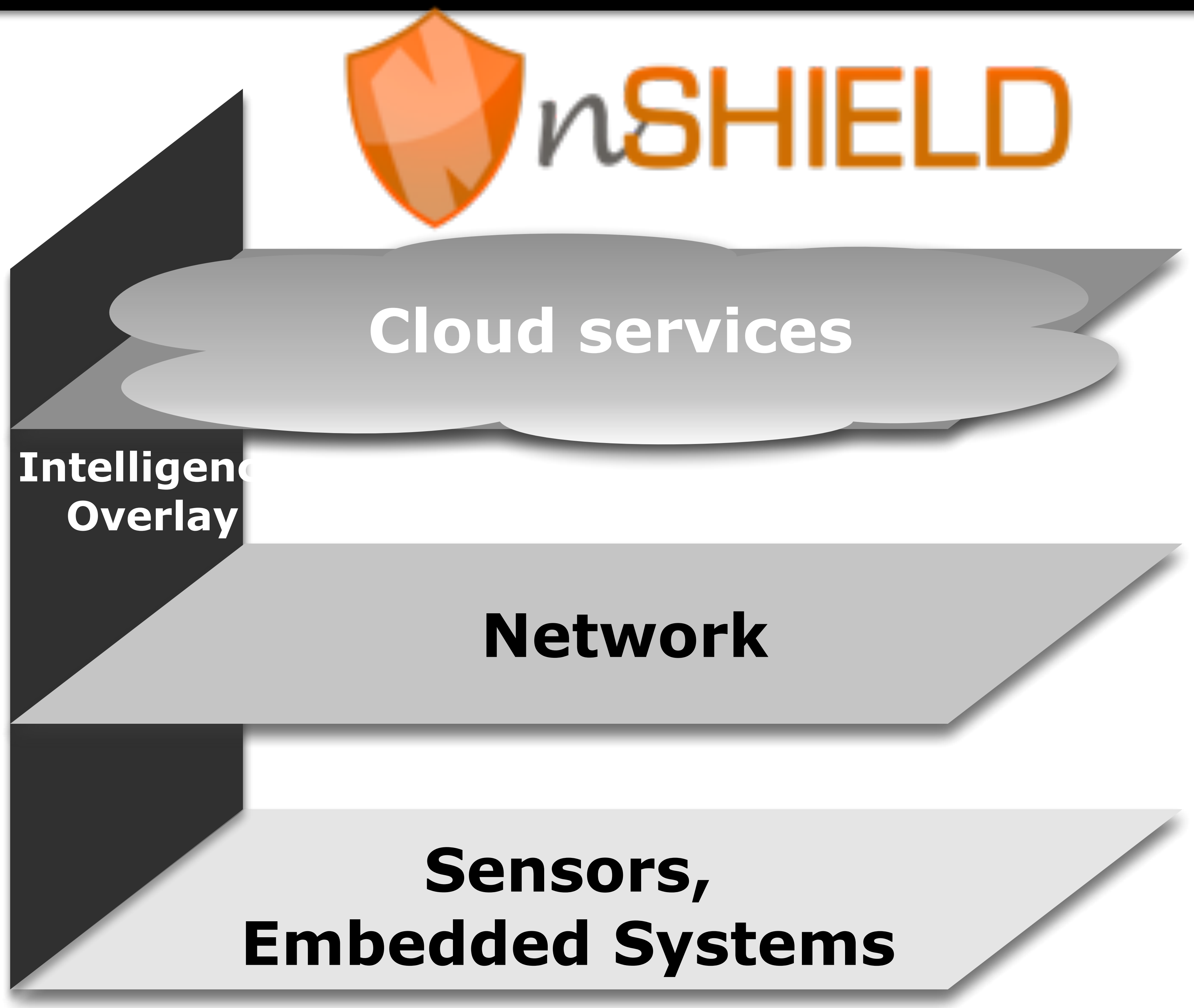
Example:
System of Systems

- A system consists of sub-systems
  - ➡ Example: Automatic Meter System (AMS) consists of reader (AMR), aggregator, communications, storage, user access
- A sub-system consists of sub-…-system
  - ➡ Example: AMR consists of power monitor, processing unit, communication unit
- A sub-….-system consists of components
  - ➡ Ex: AMR communication contains of a baseband processing, antenna, wireless link
- Components have parameters
  - ➡ Wireless link component: f=868 MHz, output power=?, Encryption=?

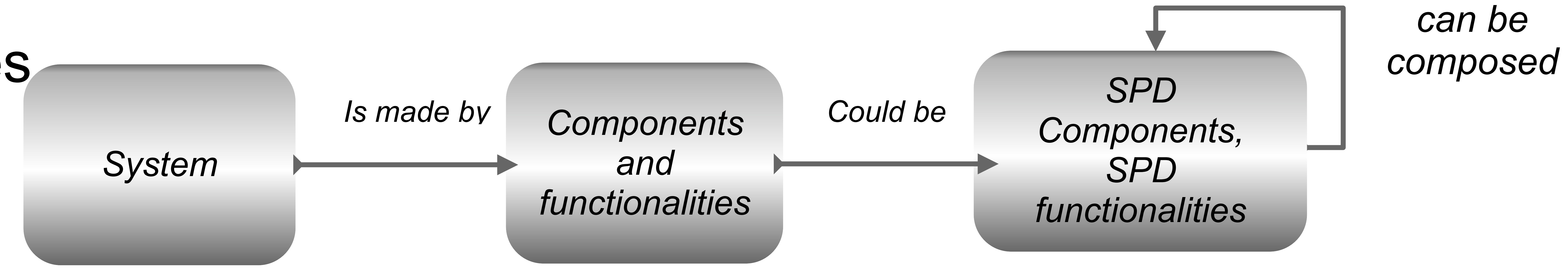




newSHIELD.eu approach



- Security approach by JU Artemis
  - ➡ Industry, National and EU supported (JU) activities
  - ➡ special focus on sensor systems
- Security, here
  - ➡ security (S)
  - ➡ privacy (P)
  - ➡ dependability (D)
- across the value chain
  - ➡ from sensors to services
- measurable security



Examples of
Security challenges in the IoT

- **System**: Intrusion awareness, fault-tolerance, data redundancy and diversity
- **Platform**: Auto start up on power failure, Auto reconfigurable on software failure, Auto synchronization on software failure, End-to-end secure communication, Mal-user detection, Access control for accessing sensor data
- **Middleware**: SPD Audit, Cryptographic Support, Identification and Authentication, Protection of the SPD functionalities, Security Management
- **Hardware**: SPD metrics, Self−recovery from hardware transient faults (through fault−injection), Auto−reconfiguration, Data encryption, Provision of security and privacy services, data encryption/decryption

Radio: Threats tolerant transmission

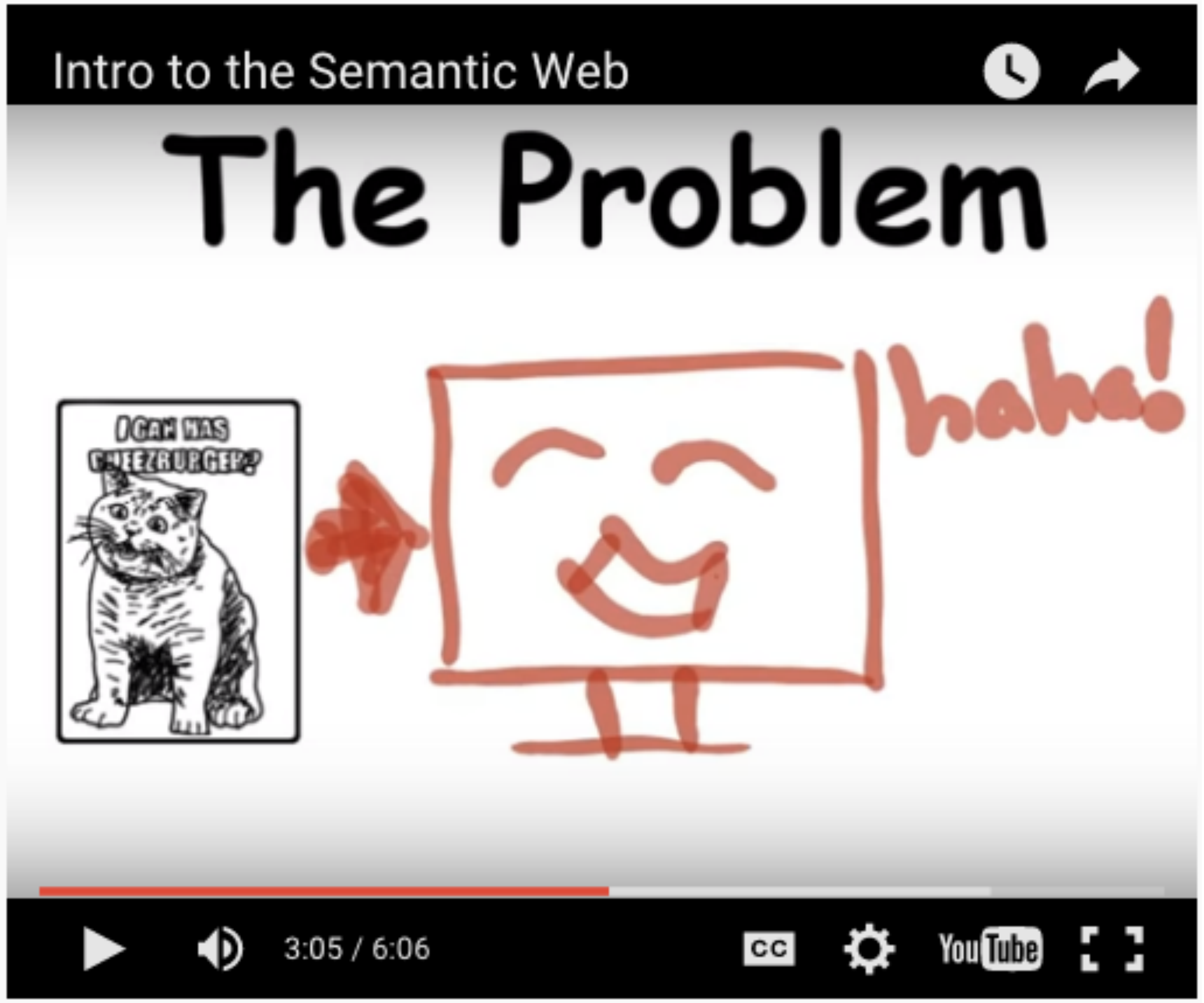
System components
classified after objective

- Functional components
  - input component (sensors, keyboard, mouse,..)
  - output component (alarm, screen, actuator,..)
  - processing component
  - Storing component (data base, files,)
  - Connection (wireless connection, wired connection)
- Security, Privacy, Dependability (SPD) components:
  - Encryption: Encryption algorithm, keys,..
  - Protocols
  - Authentication(mechanism (fingerprint, password, password complexity,.….) .
  - Authorization (privileges, ..)
- Management components (OS, Web server, data server)
- Human component (admin, user, ..).
- Physical component, car being a component in a car factory. (if treated as "sub-system)

Semantic technologies

- why Semantics?
- Elements of semantics
  - ➡ https://youtu.be/OGg8A2zfWKg

- Watch the video (6 min)
  then we discuss your impressions



The Semantic Dimension of the Internet of Things (IoT)

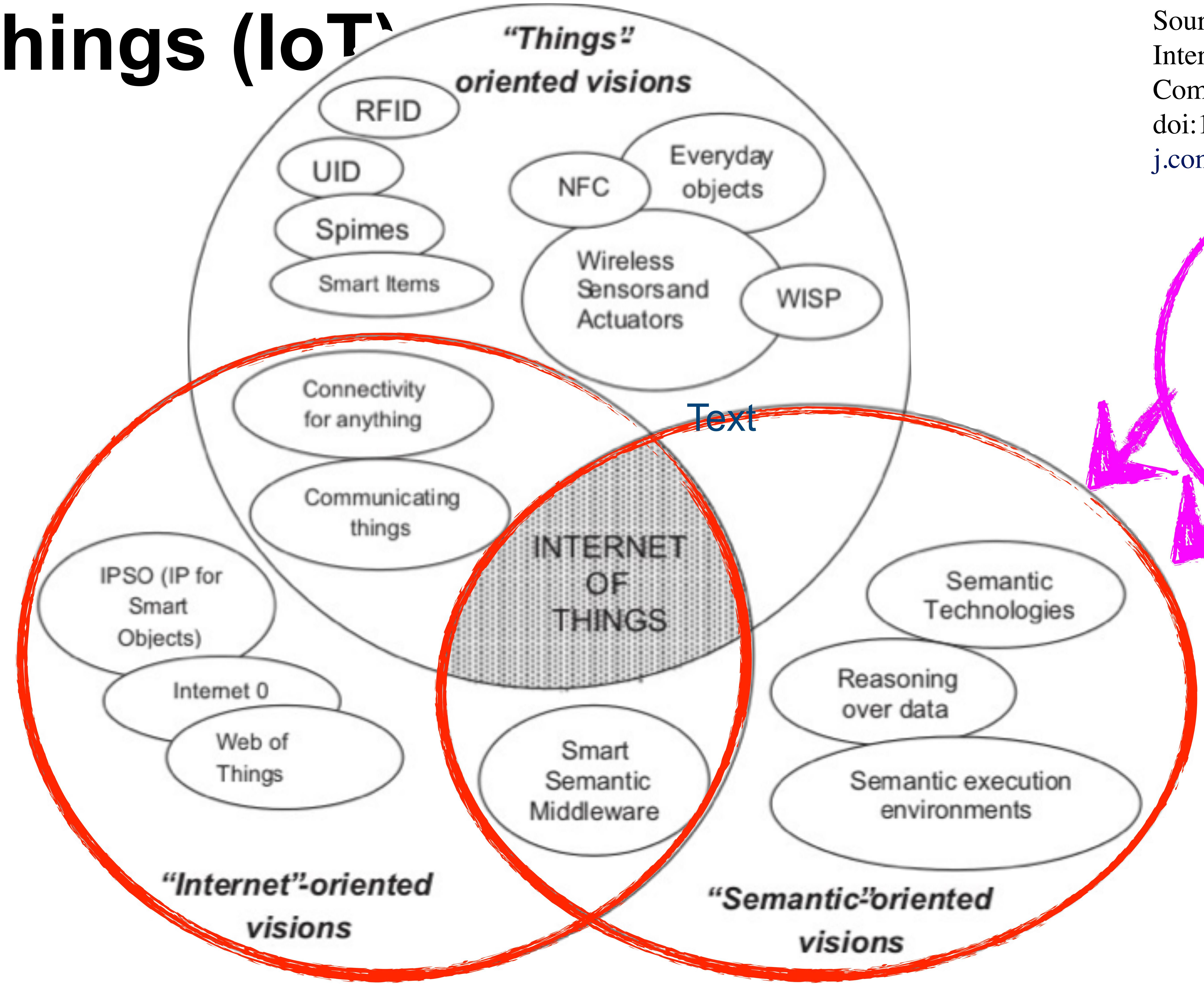
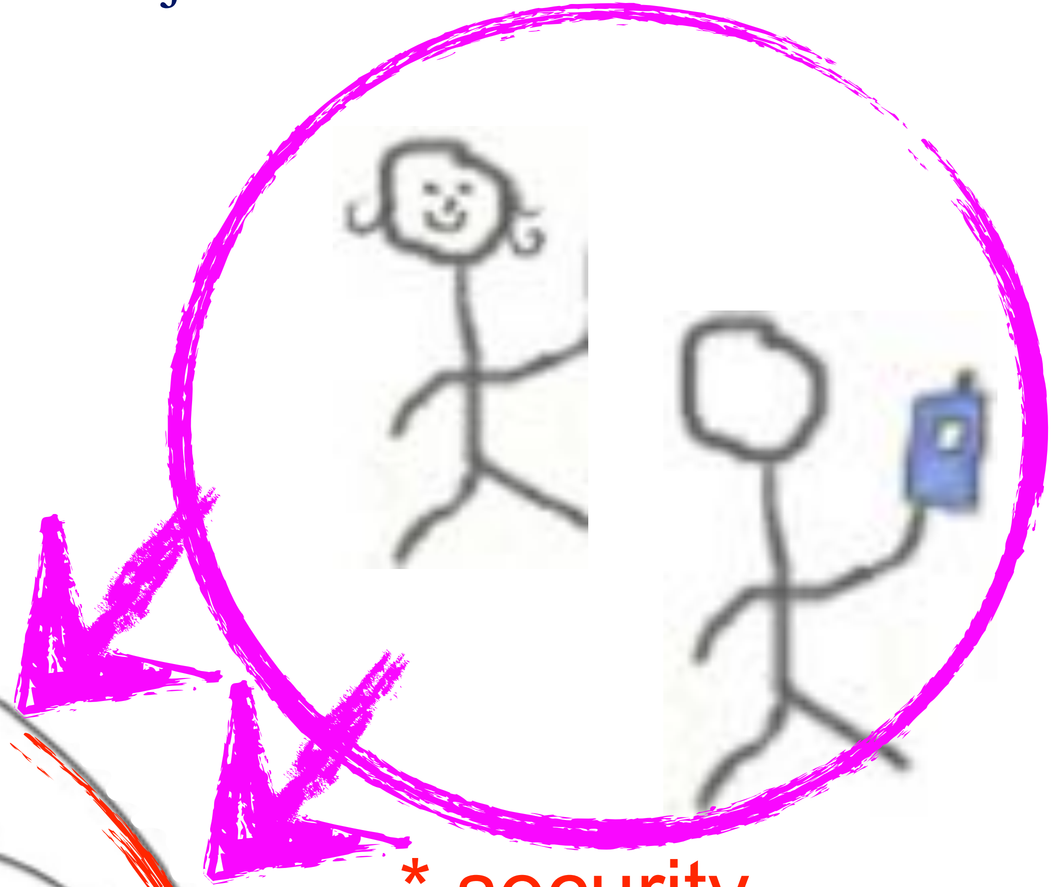


Fig. 1. "Internet of Things" paradigm as a result of the convergence of different visions.

Source: L. Atzori et al., The Internet of Things: A survey, Comput. Netw. (2010), doi:10.1016/j.comnet.2010.05.010



* security
* privacy
* dependability
  - context
  - content
* personalised

Why Semantics?

- Syntax vs. Semantics

Arab

الاسم: الهندسة فعلم التطو ر
المؤلّفون: آسنسيون غومزبرز
السّعر: $74.95
المنتج: الكتاب

<الاسم>الهندسة فعلم التطو ر </الاسم>
<المؤلّفون>آسنسيون غومزبرز </المؤلّفون>
<السّعر>$74.95</السّعر>
<الكتاب>المنتج </الكتاب>

English

Title: Ontological Engineering
Authors: Asunción Gómez-Pérez...
Price: $74.95
Product: Book

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<Author>Asunción Gómez-Pérez...</Author>
<Price>$74.95</Price>
<Product>Book</Product>

What do the tags mean for the machine?

Source: Juan Miguel Gomez, University Carlos III de Madrid

Why Semantics?

- Conceptual Level

lunch (.no)

lunch (.es)

Source: Juan Miguel Gomez, University Carlos III de Madrid

Semantic Web Services

Bringing the web to its full potential

Dynamic

Web Services
UDDI, WSDL, SOAP

Intelligent Web Services

Static

WWW
URI, HTML, HTTP

Semantic Web
RDF, RDF(S), OWL

Source: Juan Miguel Gomez, University Carlos III de Madrid

Requirements for Service Evolution

Web services

- Fixed service set, Static service composition, Low degree of automation
- Poor reliability
- Fixed Service Level Agreement

Semantic Web Services

- Flexible services, easy new services
- Alternative service provision
- Global, dynamic services

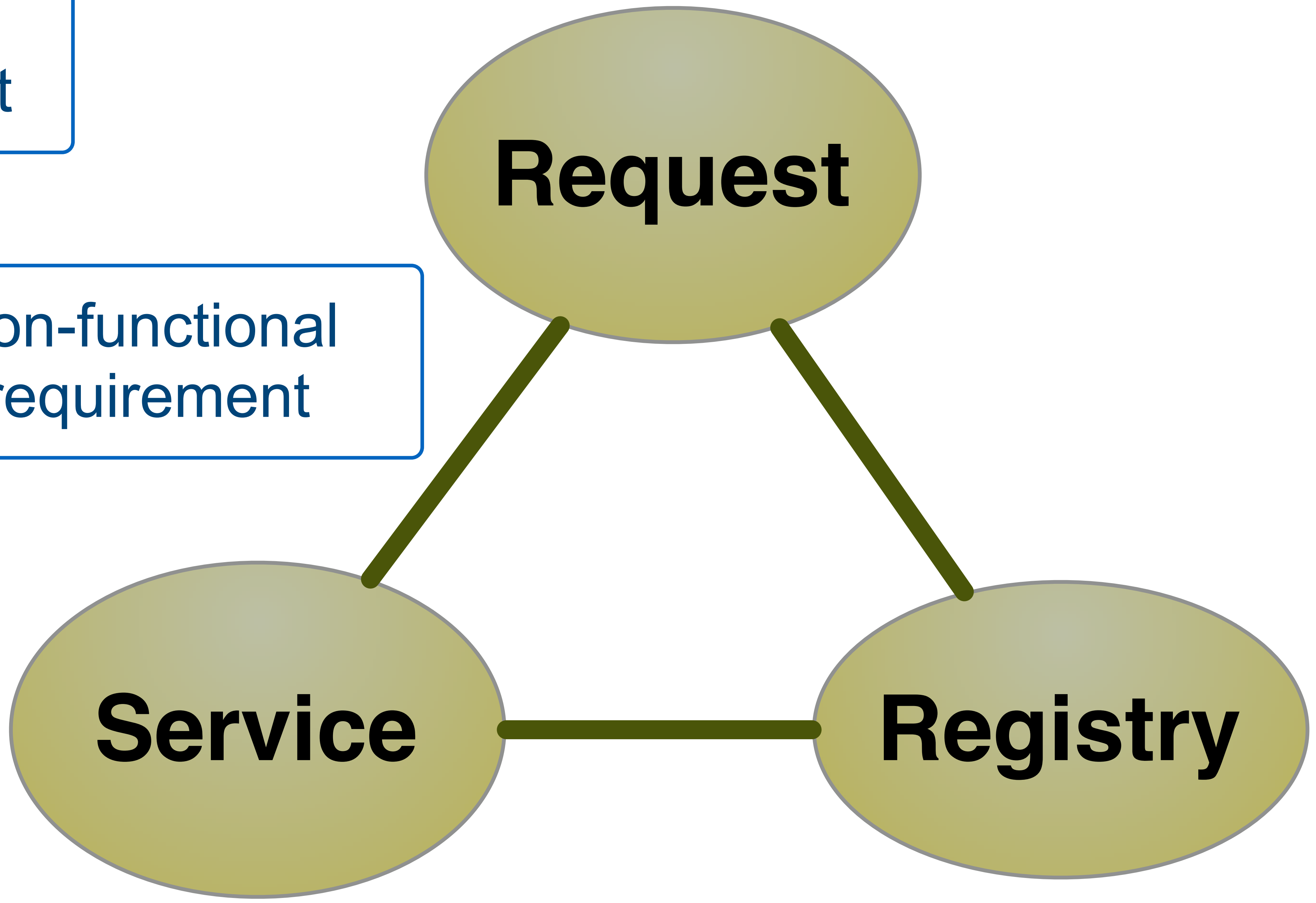
Elements of Web Services

- Service Request
  - want to come to Barcelona University
- Services
  - buy a flight ticket (cheap, direct, …)
  - buy a metro/bus ticket
- Service registry
  - link to ticket ordering at norwegian.no
- (Security) - Privacy attribute
  - only use company which does not sell my data

functional requirement

non-functional requirement

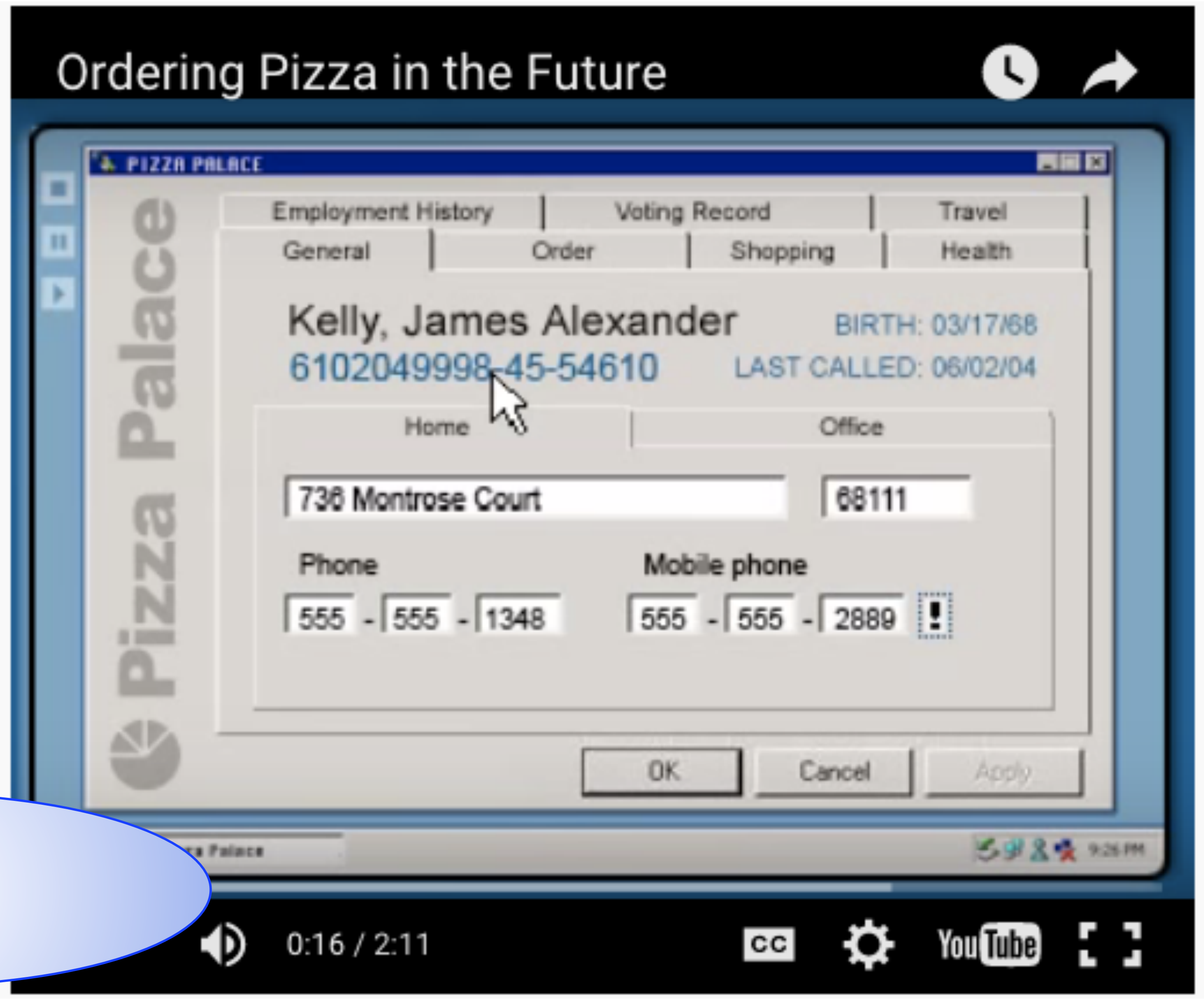
s,p,d requirement

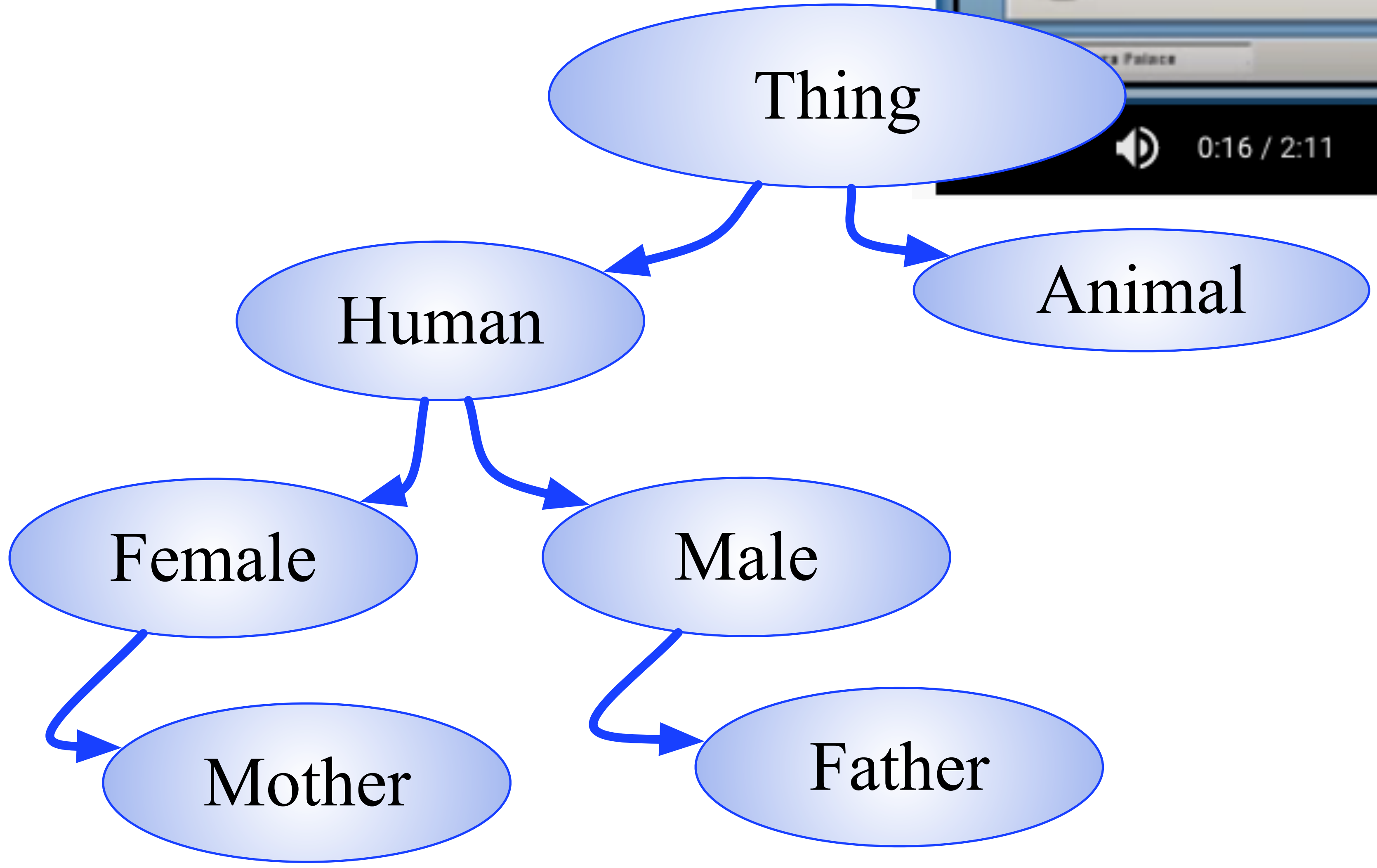


Elements in Semantic Technologies

[Source: Wikipedia]

- Extensible Markup Language (XML) is a markup language that defines a set of rules for encoding documents in a format which is both human-readable and machine-readable.
- RDF - Formal semantics is built upon a W3C XML standard for objects called the Resource Description Framework (RDF)
- OWL - The Web Ontology Language (OWL) is a family of knowledge representation languages for authoring ontologies.
- A semantic reasoner, reasoning engine, rules engine, or simply a reasoner, is a piece of software able to infer logical consequences from a set of asserted facts or axioms.
- Classes (concepts) are abstract groups, sets, or collection of objects (example: human, woman)
- Individuals (instances) are the specific objects, e.g. Josef is a Father
- Attributes (properties) describing objects (individual and classes) in the ontology. Example: Human hasName, Josef has name Josef Noll



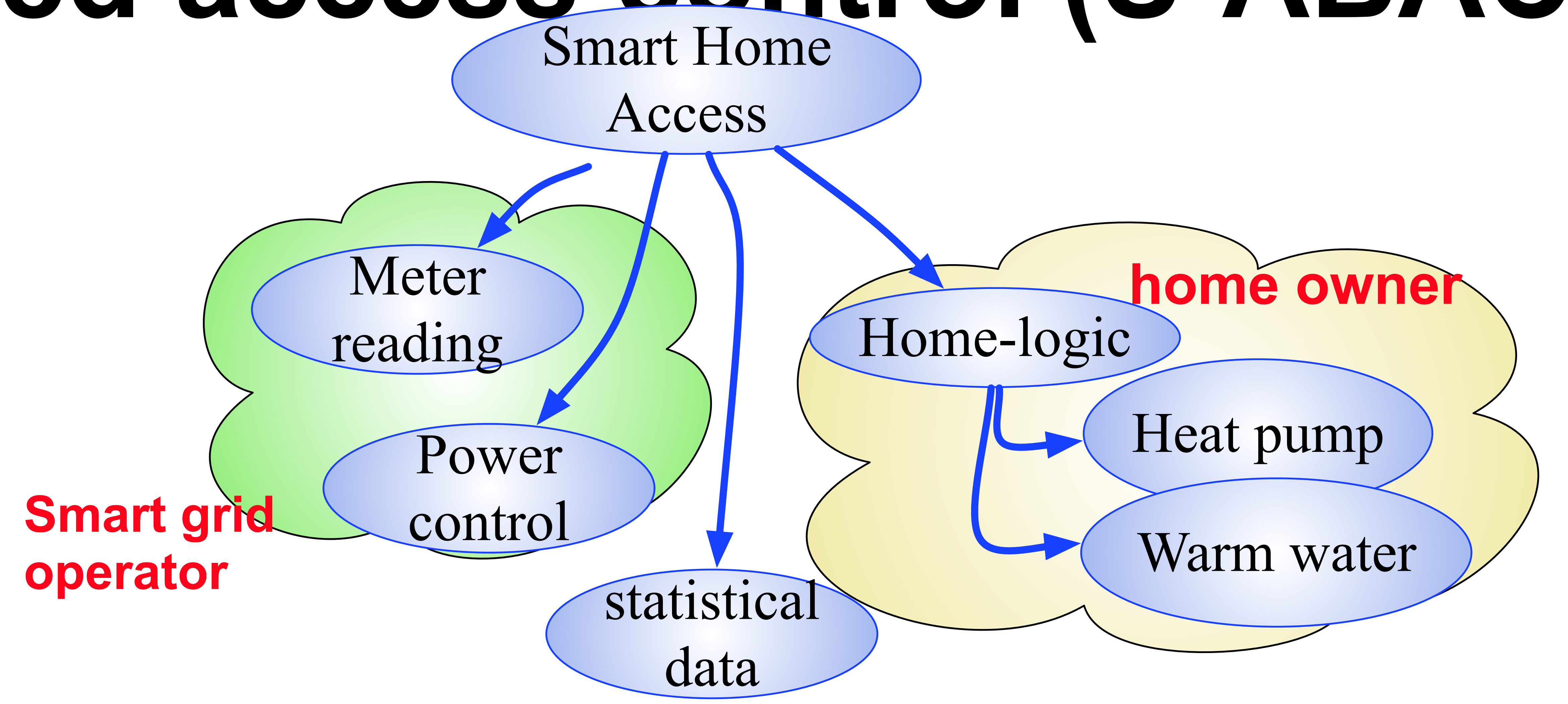


further reading: https://www.slideshare.net/marinasantini1/09-semantic-webontologies?qid=8b178746-ea3c-48db-b4f6-6bc9b0923d9b

Semantic attribute based access control (S-ABAC)

- Access to information
  - ➡ who (sensor, person, service)
  - ➡ what kind of information
  - ➡ from where
- Attribute-based access
  - ➡ role (in organisation, home)
  - ➡ device, network
  - ➡ security tokens
- OWL & SWRL implementation

Rules inferring security tokens

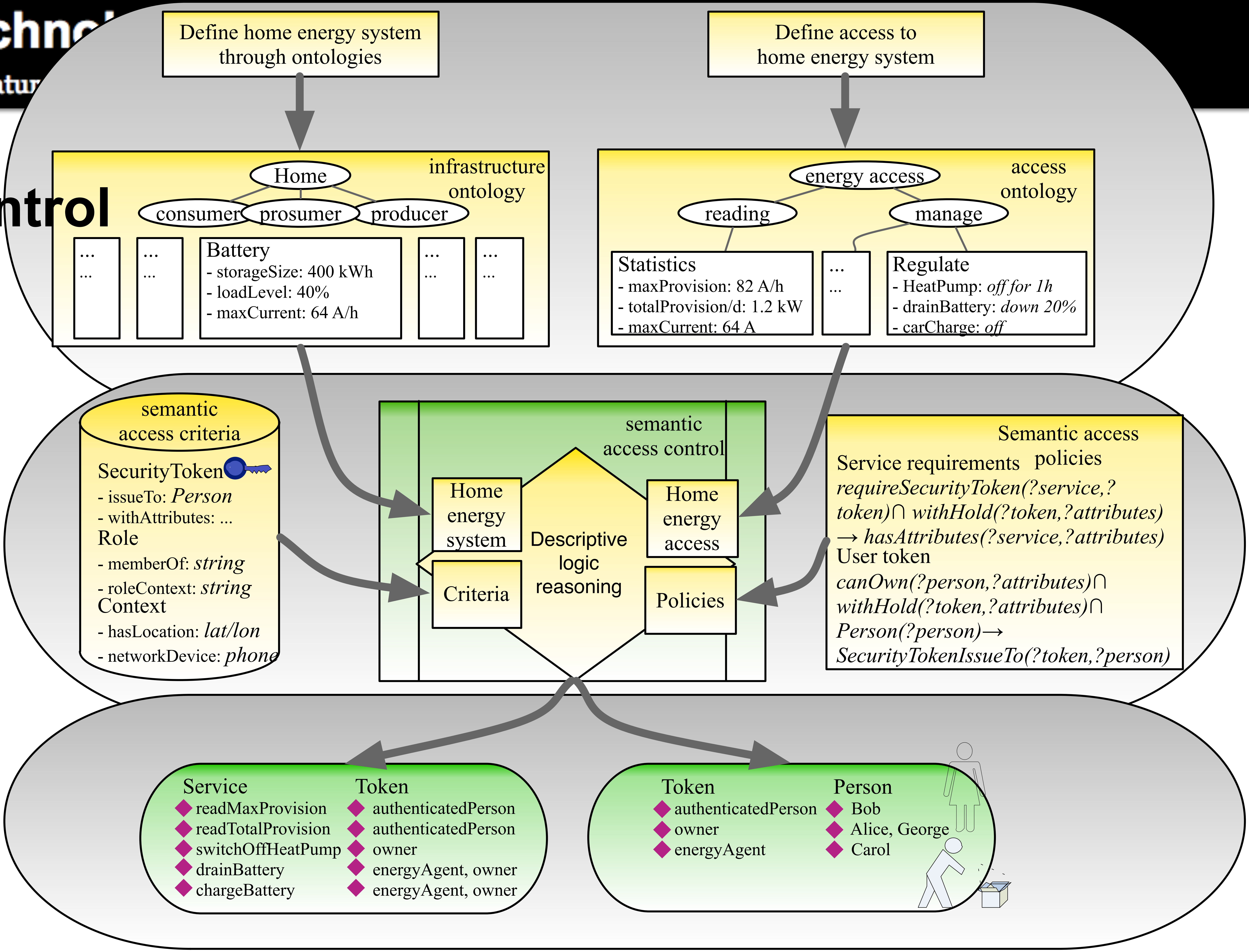


Attributes: roles, access, device, reputation, behaviour, ...

canOwn(?person,?attributes) ∩ withHold(?token,?attributes) ∩ (Person(?person) -> SecurityTokenIssueTo(?token, ?person)

[token]	principal
◆ BasicToken_1	◆ Carol
◆ BasicToken_2	◆ Alice

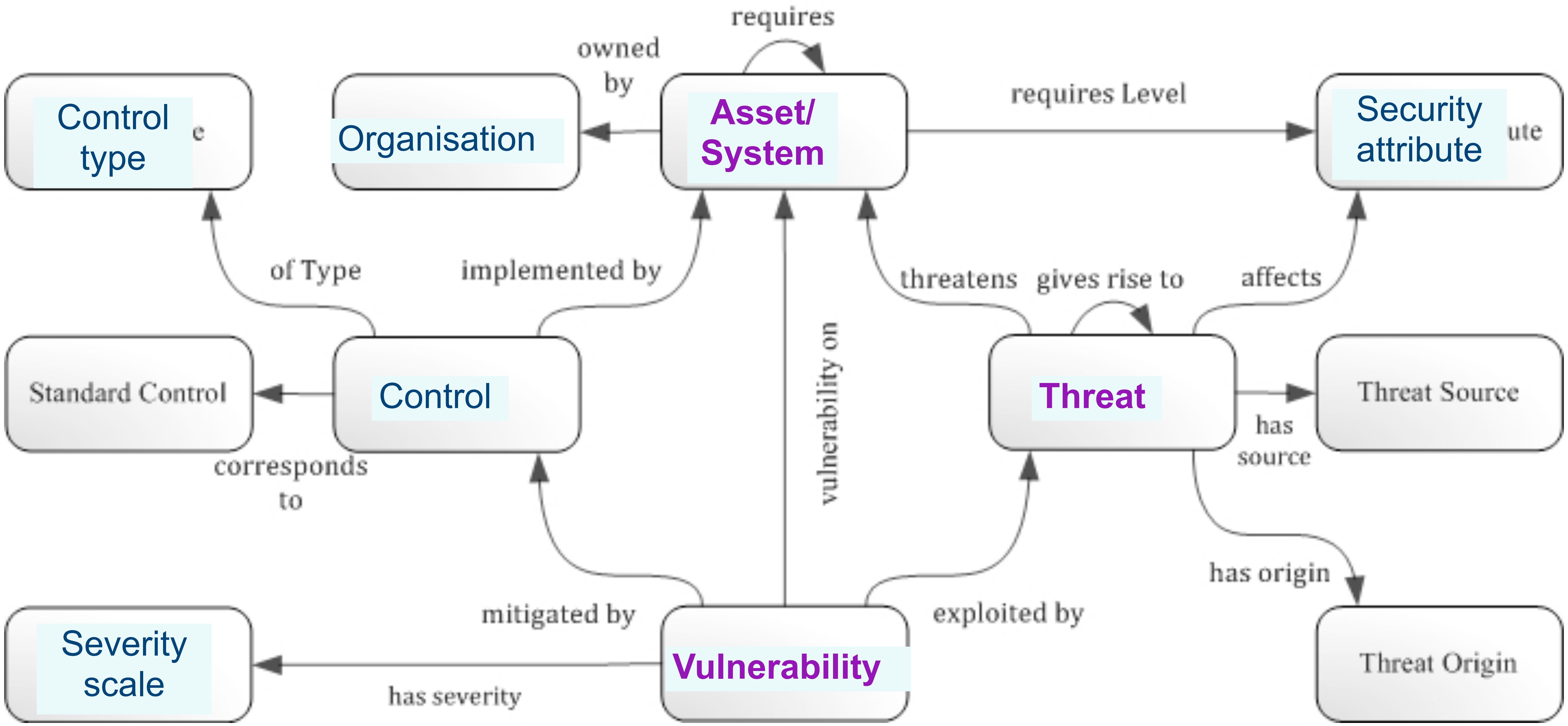
Smart Home: Complex access control



Security Ontologies
- traditional view
- Application-oriented view

Traditional approach

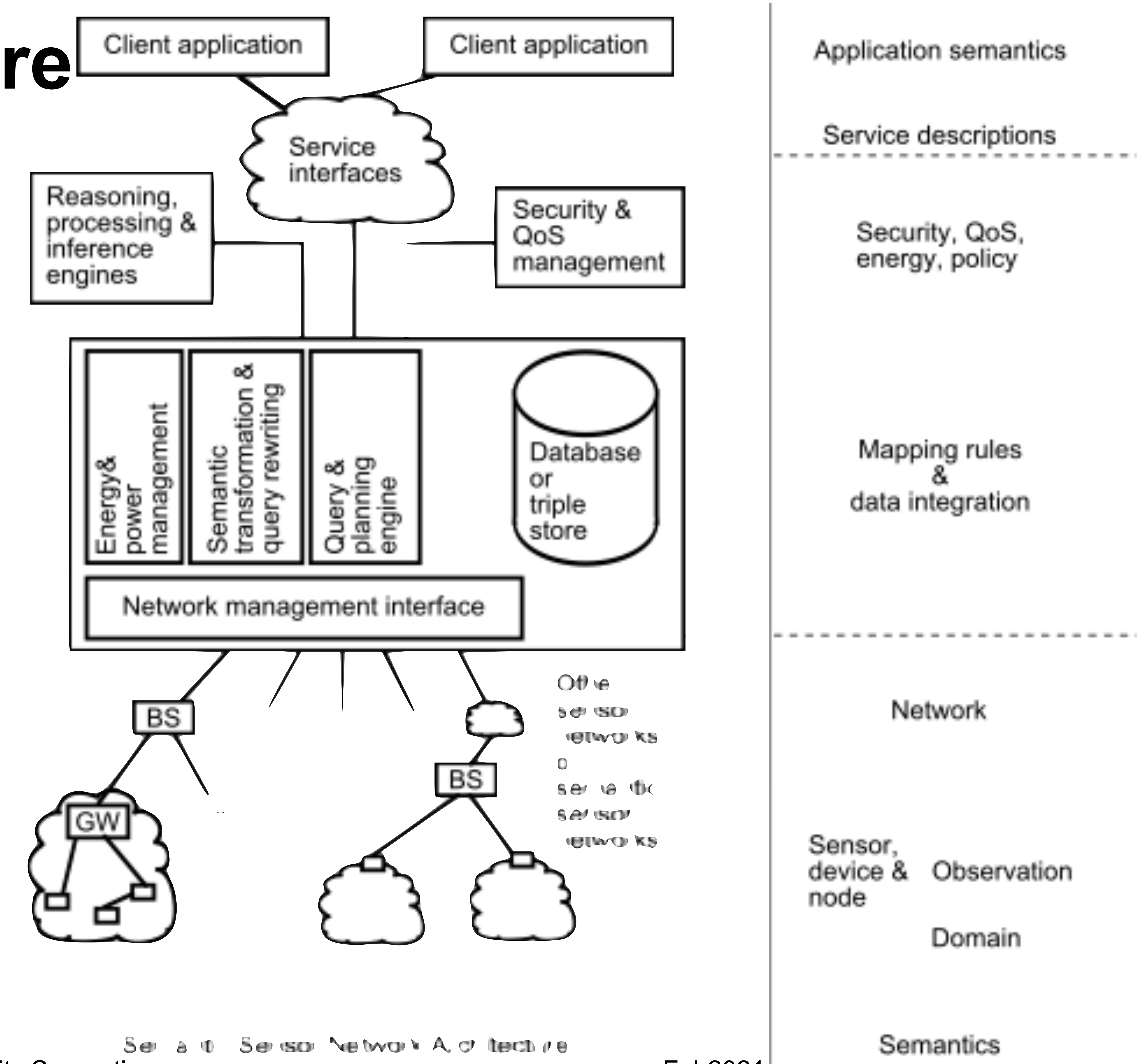
- Combined approach, addressing threat, vulnerability, system impact and control



[source: http://securityontology.sba-research.org/]

Sensor Network Architecture

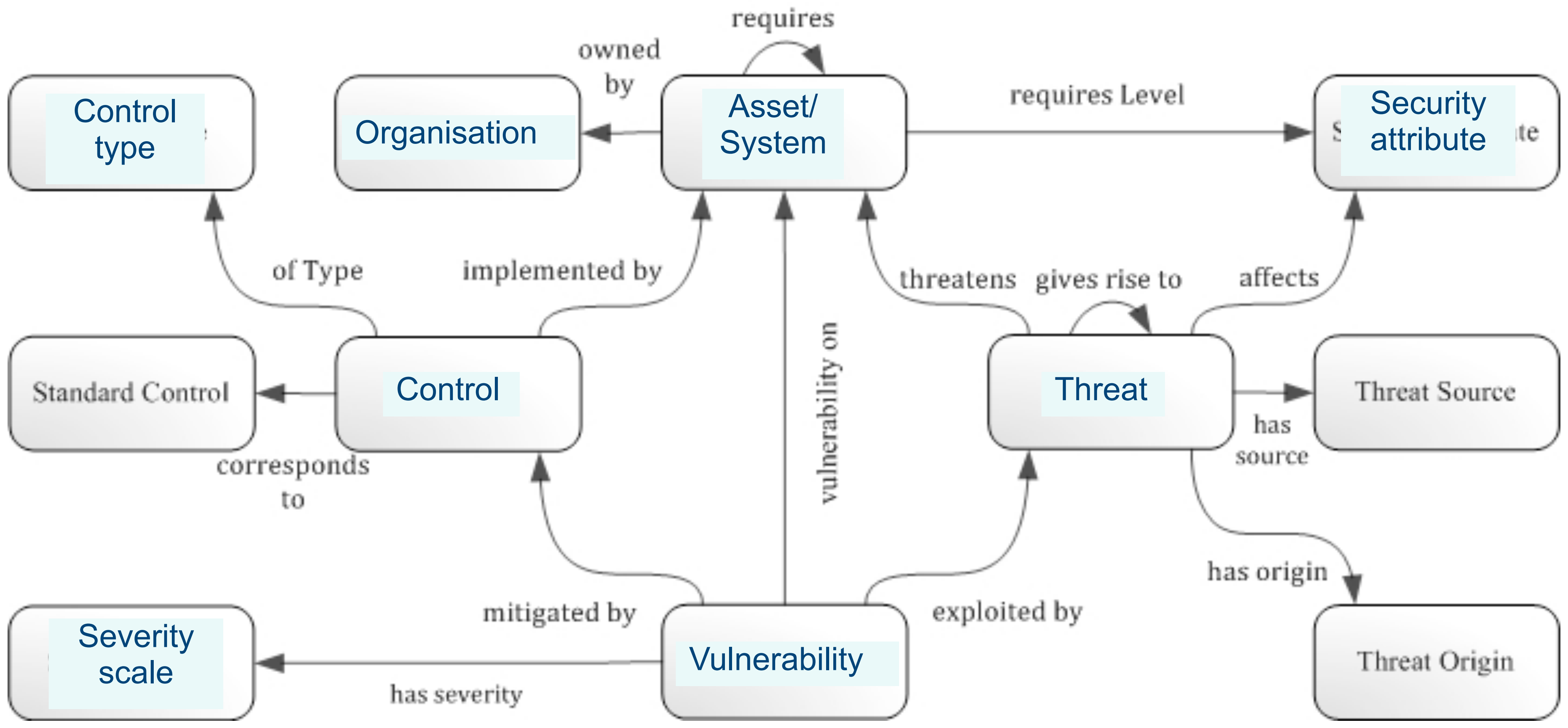
- Semantic dimension
  - Application
  - Services
  - Security, QoS,
  - Policies
  - mapping
- System
  - sensor networks
  - gateway
  - base station



Source: Compton et al., A survey of semantic specification of sensors, 2009

Limitations of the traditional approach

- Scalability
  - ➡ Threats
  - ➡ System
  - ➡ Vulnerability
- System of Systems
  - ➡ sensors
  - ➡ gateway
  - ➡ middleware
  - ➡ business processes

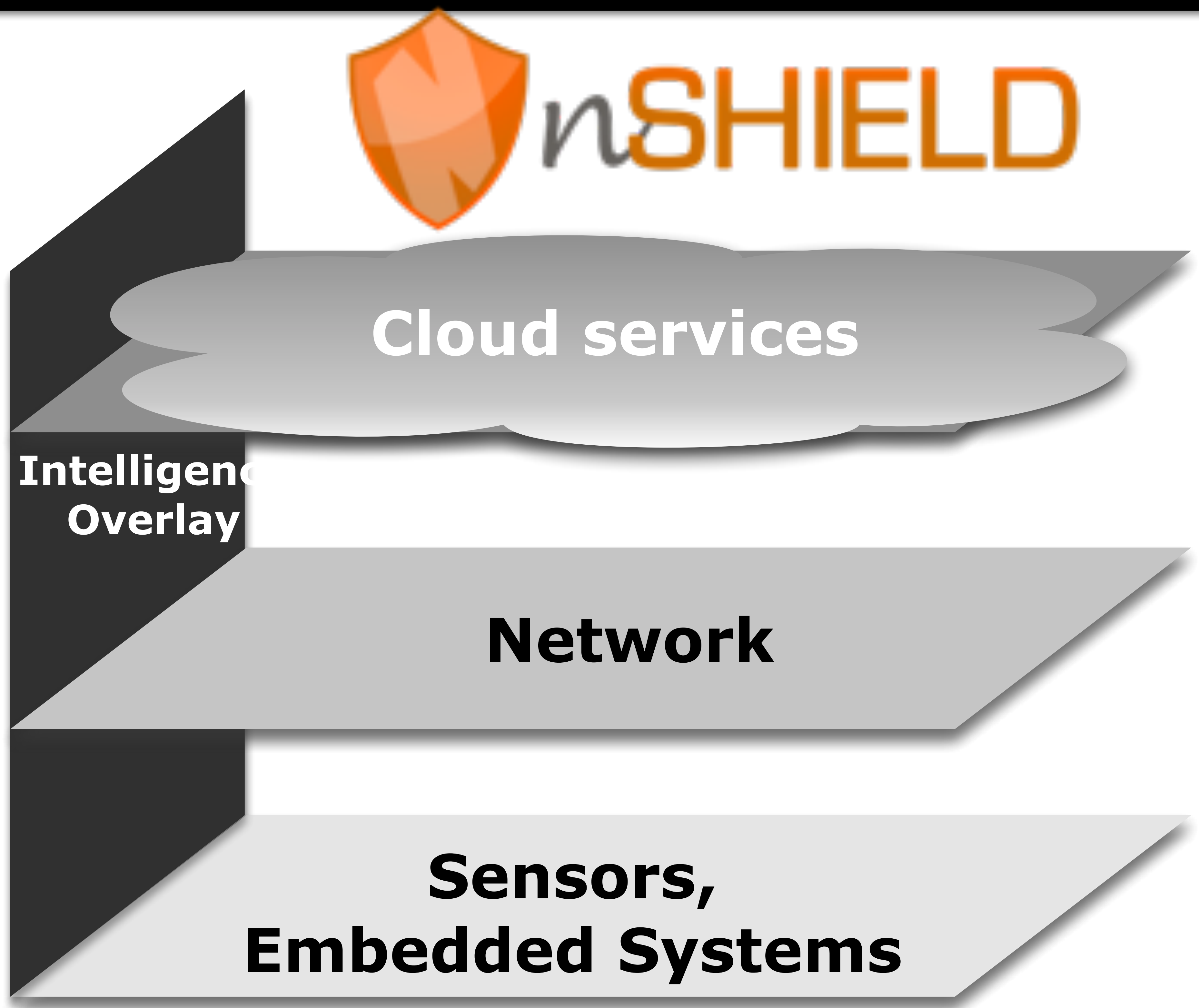


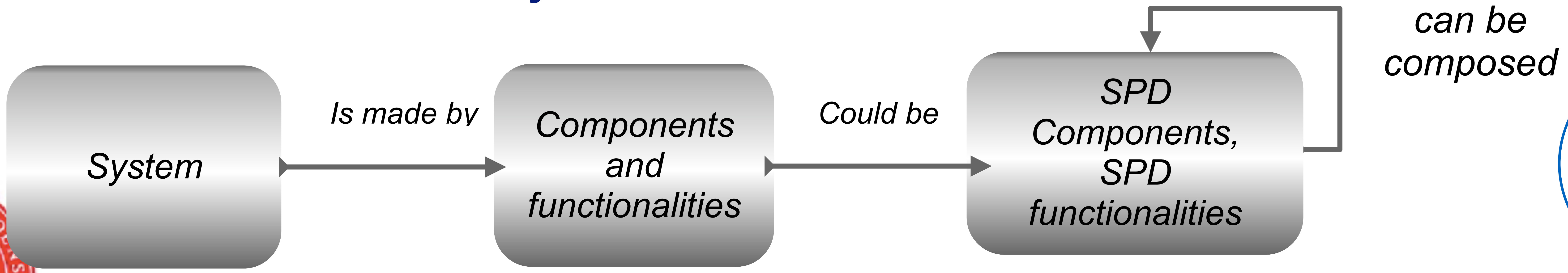
Recommendation:

One ontology per aspect:
- security
- system
- threats
...

Applied security

- Security, here
  - ➡ security (S)
  - ➡ privacy (P)
  - ➡ dependability (D)
- across the value chain
  - ➡ from sensors to services
- measurable security

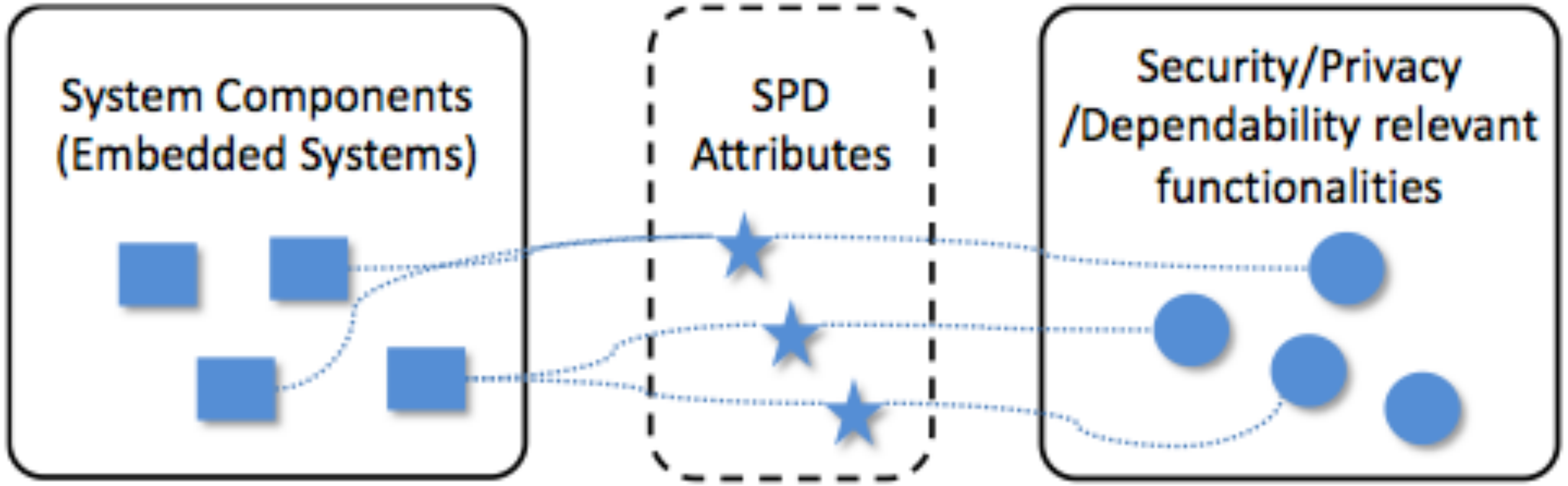


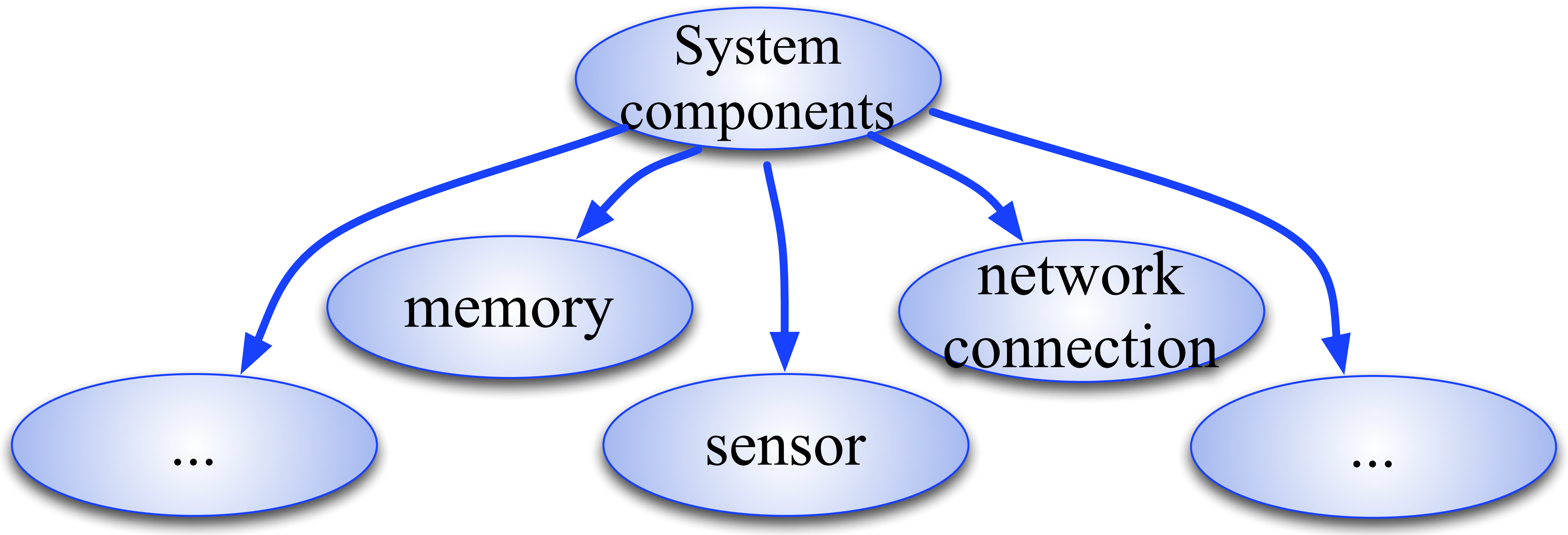


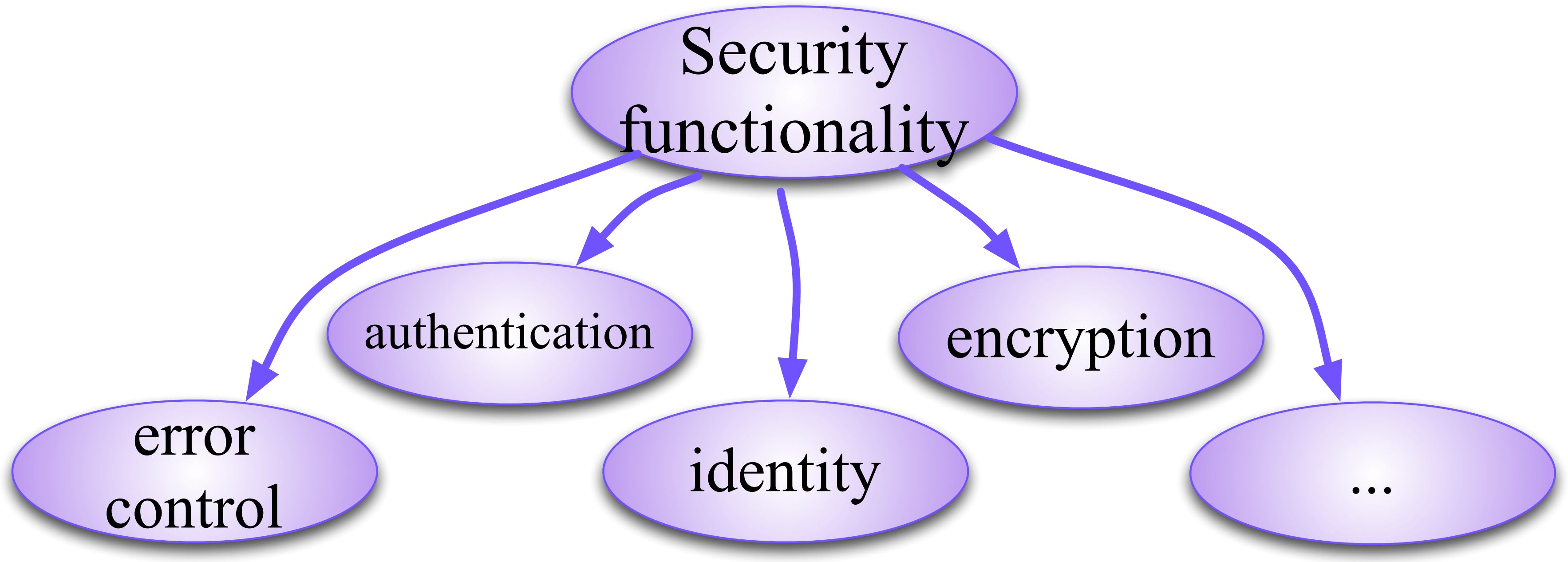
What ontologies are needed?

Security description

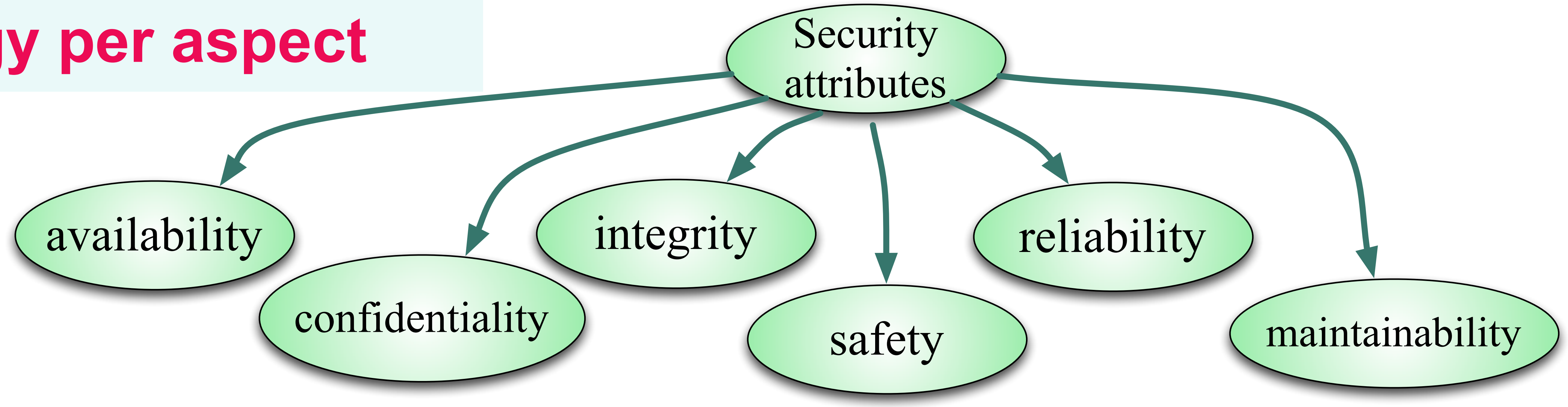
- Ontologies for system, security attributes, security functionality





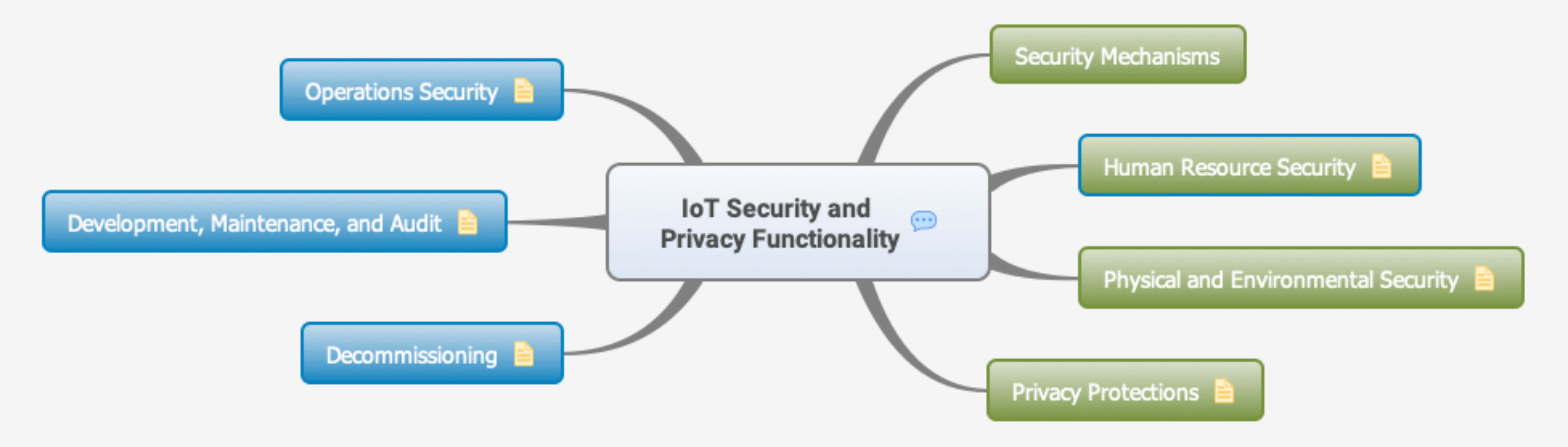


Recommendation: One ontology per aspect



IoT Security & Privacy Lifetime Security

see: SPF.IoTSec.no

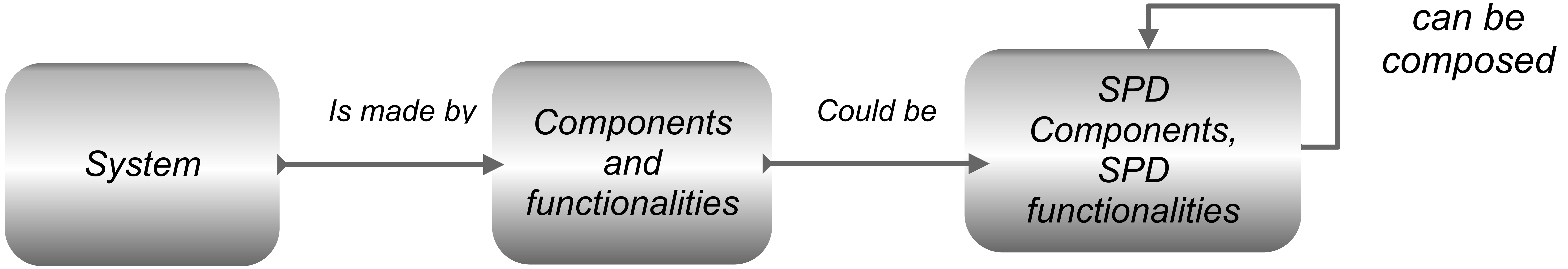


[Source: Elahe Fazeldehkordi https://its-wiki.no/images/d/d0/IoT_SecPrivFunc_LifeMap_v2.pdf]

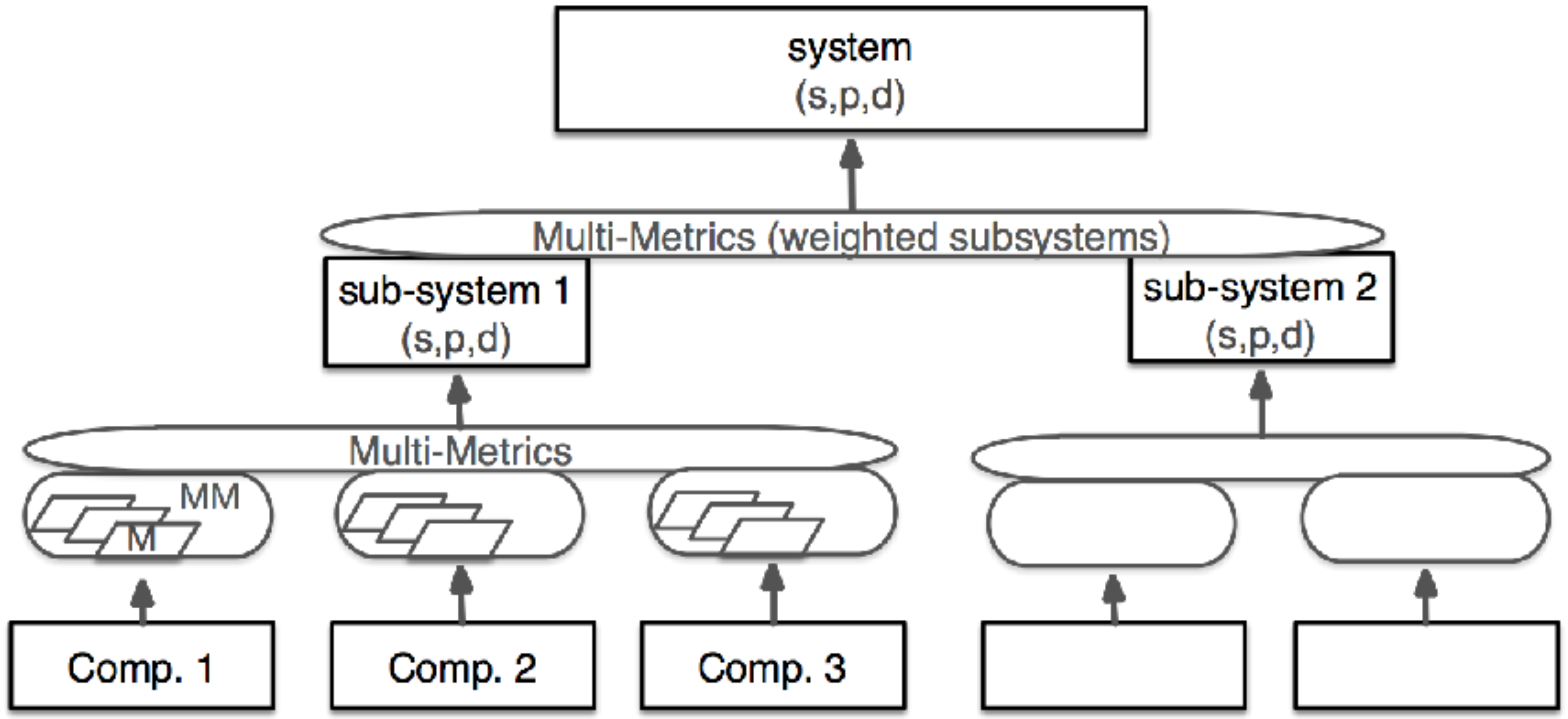
IoT Security - Access control
see: SPF.IoTSec.no

Upcoming lectures

- L6: Multi-Metrics Method for measurable Security



- …. applying Multi-Metrics



Learning outcomes

Having followed the lecture, you can

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- provide examples of security challenges in IoT

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- explain the core elements of the Semantic Web

- apply semantics to IoT systems
- provide an example of attribute based access control

- discuss the shortcomings of the traditional threat-based approach
- list the main elements of the semantic descriptions of s,p,d functionalities
- perform a semantic mapping of s,p,d attributes *(future work)*