
Semantic interface for machine-to-machine communication in building automation

Daniel Schachinger, Wolfgang Kastner

Institute of Computer Aided Automation
Automation Systems Group
TU Wien, Vienna, Austria
<https://www.auto.tuwien.ac.at>

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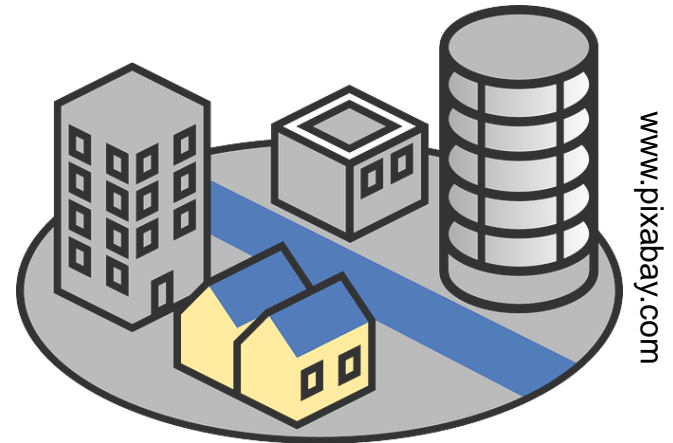
Motivation

■ Building automation (BA) in the Internet of Things (IoT)

- Smart homes and buildings
- Smart communities
- Smart factories
- ...

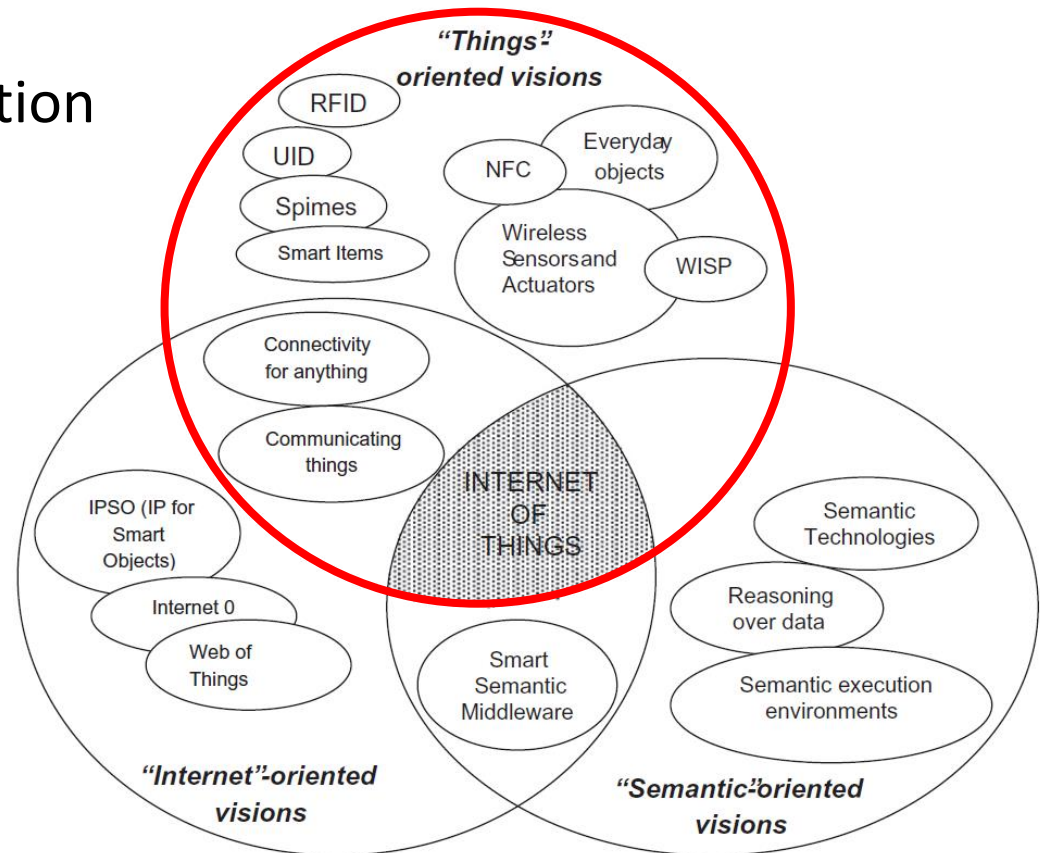
■ Requirements

- Horizontal system integration
- Vertical system integration
- Interoperable communication
- Autonomous communication
- ...



Motivation

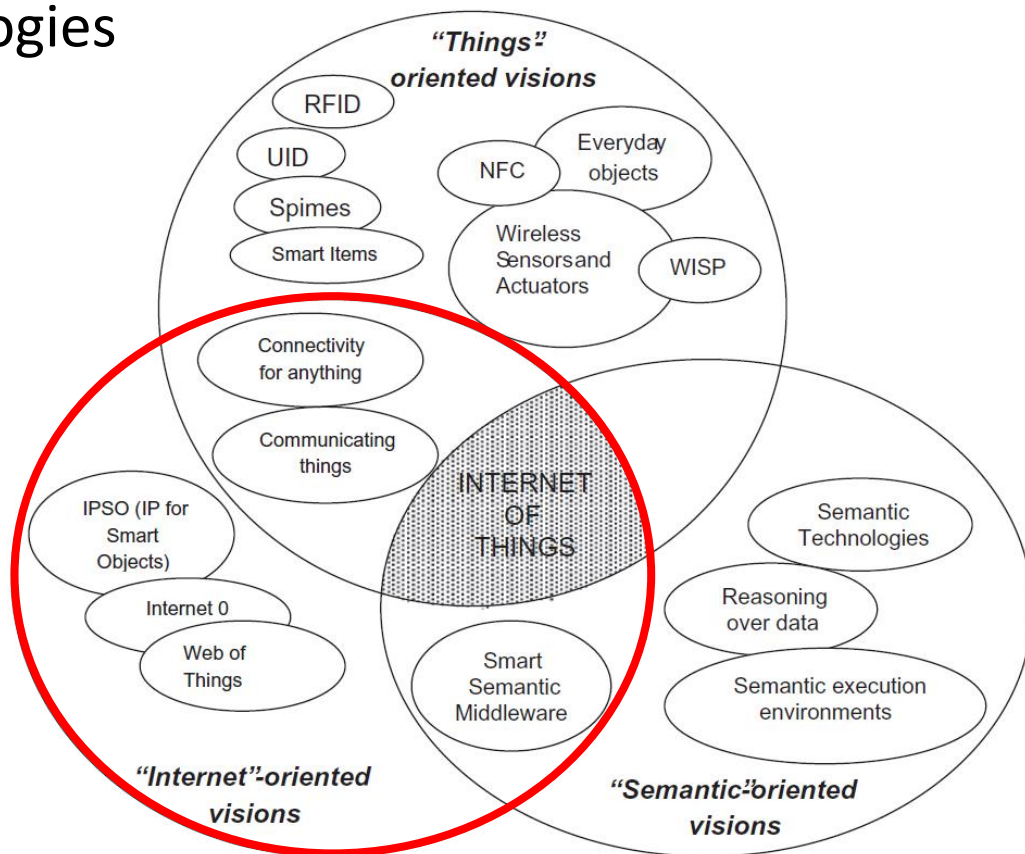
- Machine-to-machine (M2M) communication
 - Autonomous
 - No human intervention
- Technologies
 - Low-cost
 - Scalable
 - Reliable



Atzori et al., "The Internet of Things: A survey," Computer Networks, vol. 54, no. 15, pp. 2787-2805, 2010.

Motivation

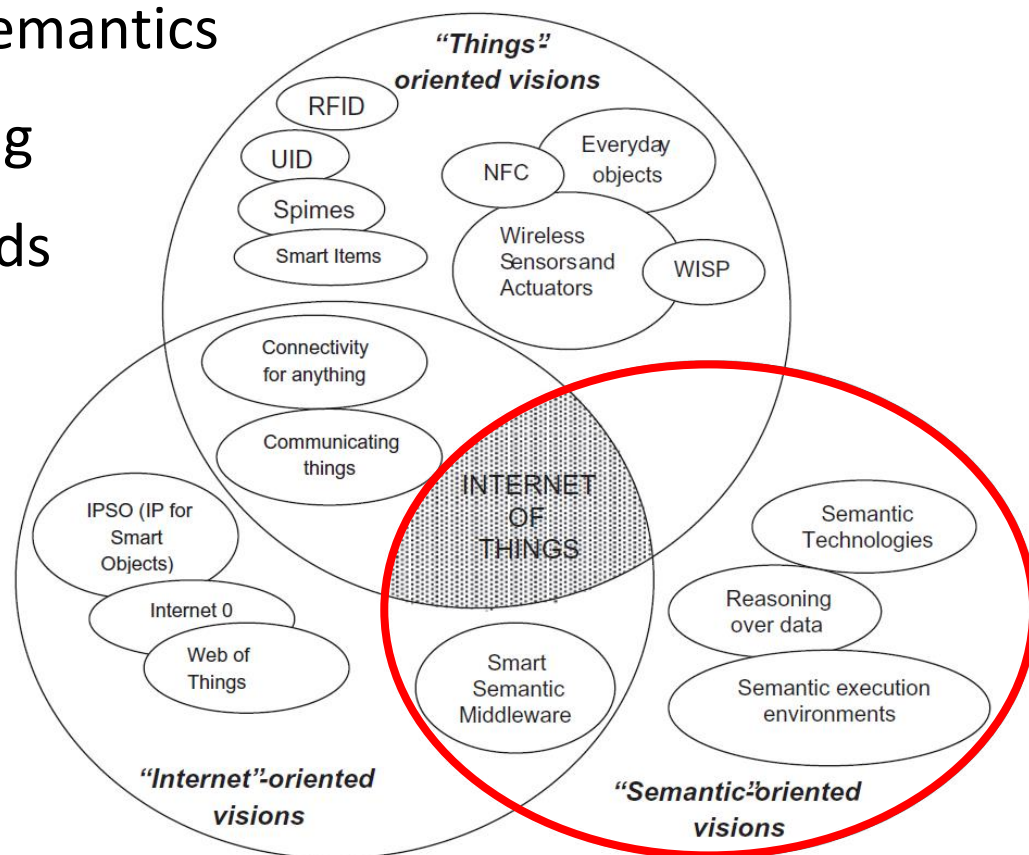
- Internet protocol suite
- Reuse existing technologies
- Service orientation
 - Autonomy
 - Interoperability
 - Flexibility
- Web services
 - REST
 - WS-*



Atzori et al., "The Internet of Things: A survey," Computer Networks, vol. 54, no. 15, pp. 2787-2805, 2010.

Motivation

- Complex management applications
- Machine-processible semantics
- Common understanding
- Semantic Web standards
- Existing Ontologies
 - ThinkHome
 - BASont
 - M3
 - ...



Atzori et al., "The Internet of Things: A survey," Computer Networks, vol. 54, no. 15, pp. 2787-2805, 2010.

Motivation

- **Results of this work...**
 - ... semantic interface for M2M communication
 - ... based on (Semantic) Web standards
 - ... ontology for semantic modeling
 - ... definition of relevant services
 - ... scope is BA domain
 - ... M2M between BA devices



Requirements

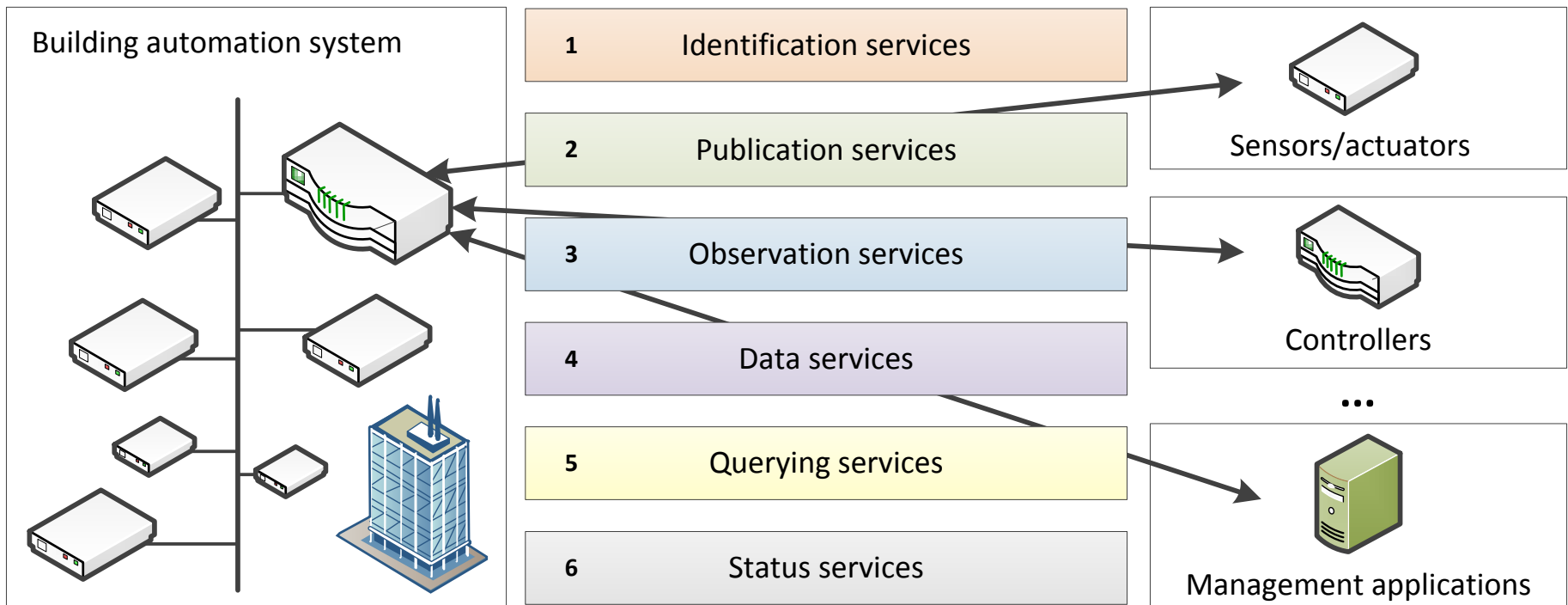
1. Architectural needs

- Potentially high number of connected devices
- Requirements are application-dependent
- Internet protocol suite solves most issues
 - BA domain with moderate latency
 - Bandwidth is sufficient
 - Mobility by wireless technologies
 - Scalable and reliable protocols
 - Secure transmission

Requirements

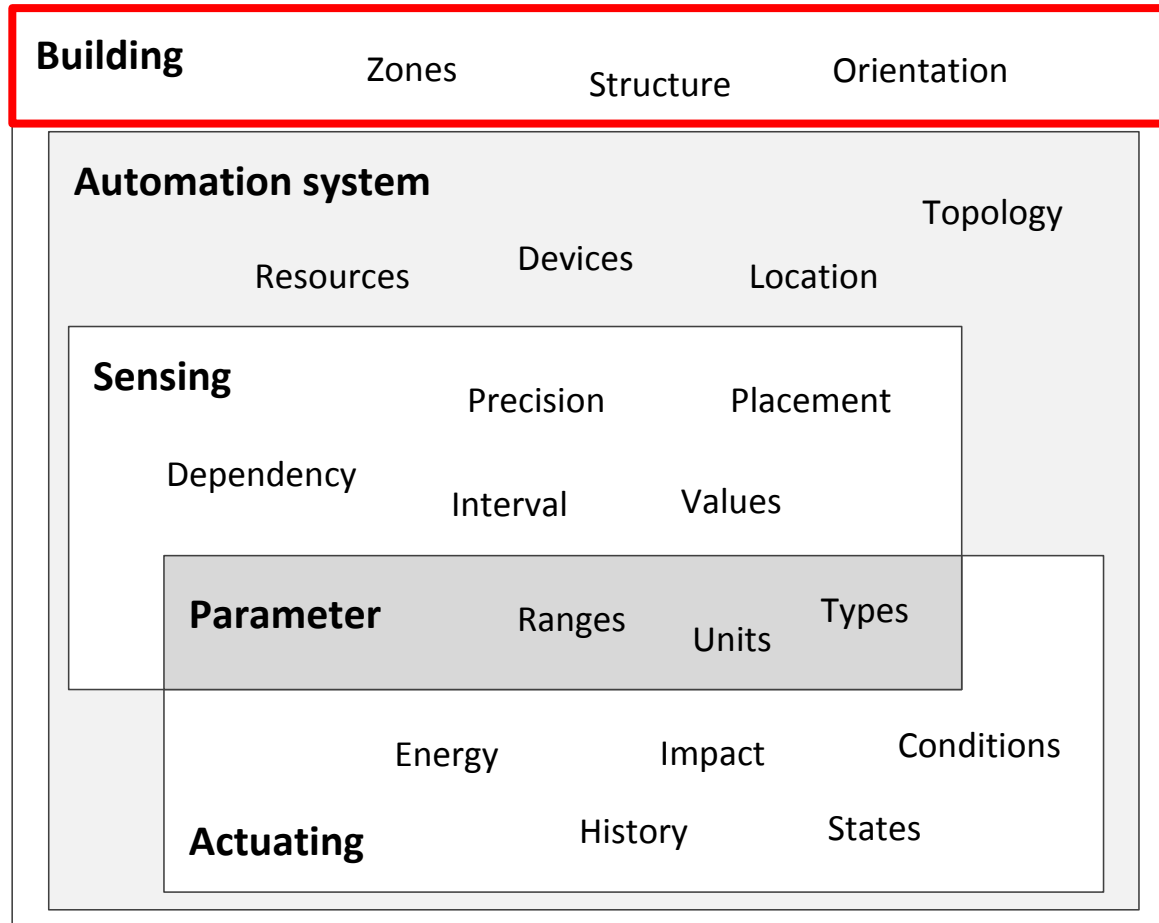
2. Application layer services

- Vertical and horizontal integration
- Bidirectional communication



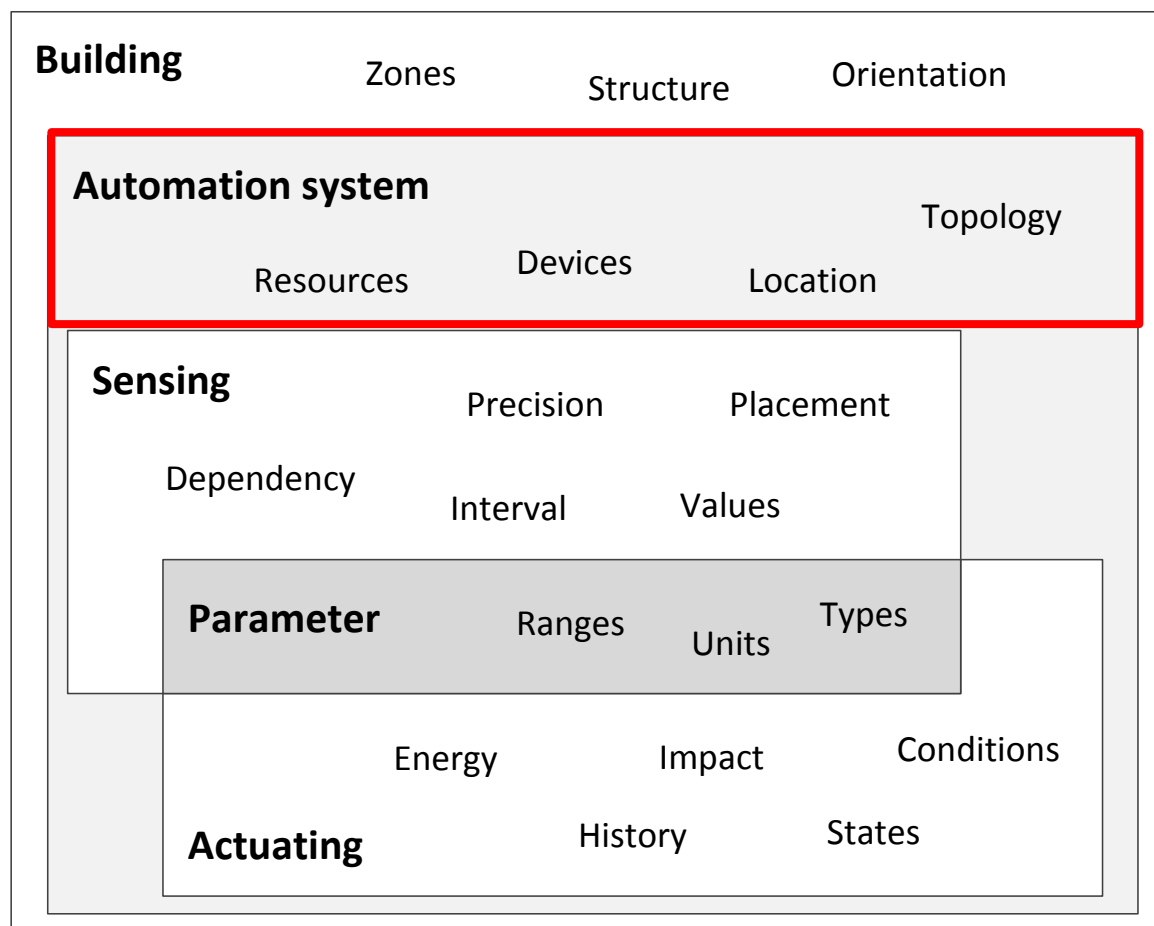
Requirements

3. Considerations regarding semantics



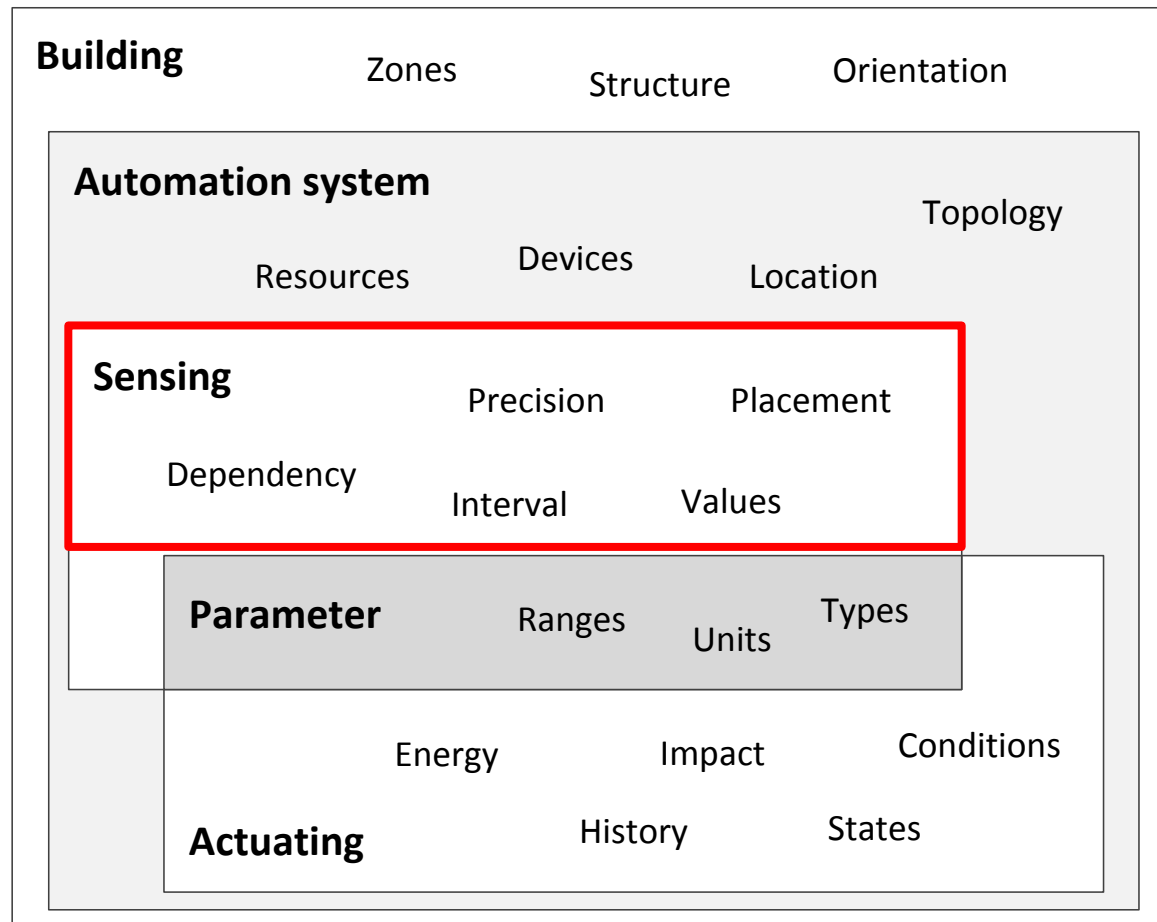
Requirements

3. Considerations regarding semantics



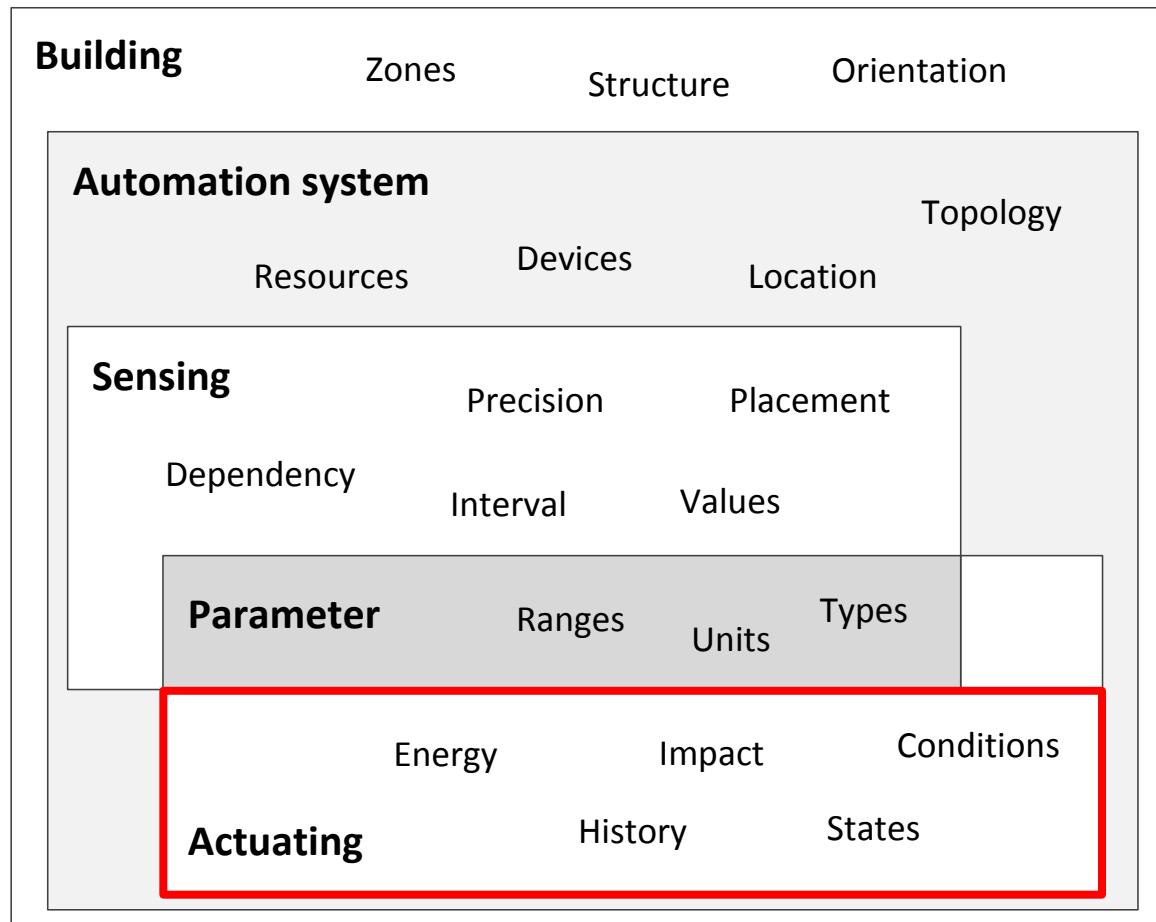
Requirements

3. Considerations regarding semantics



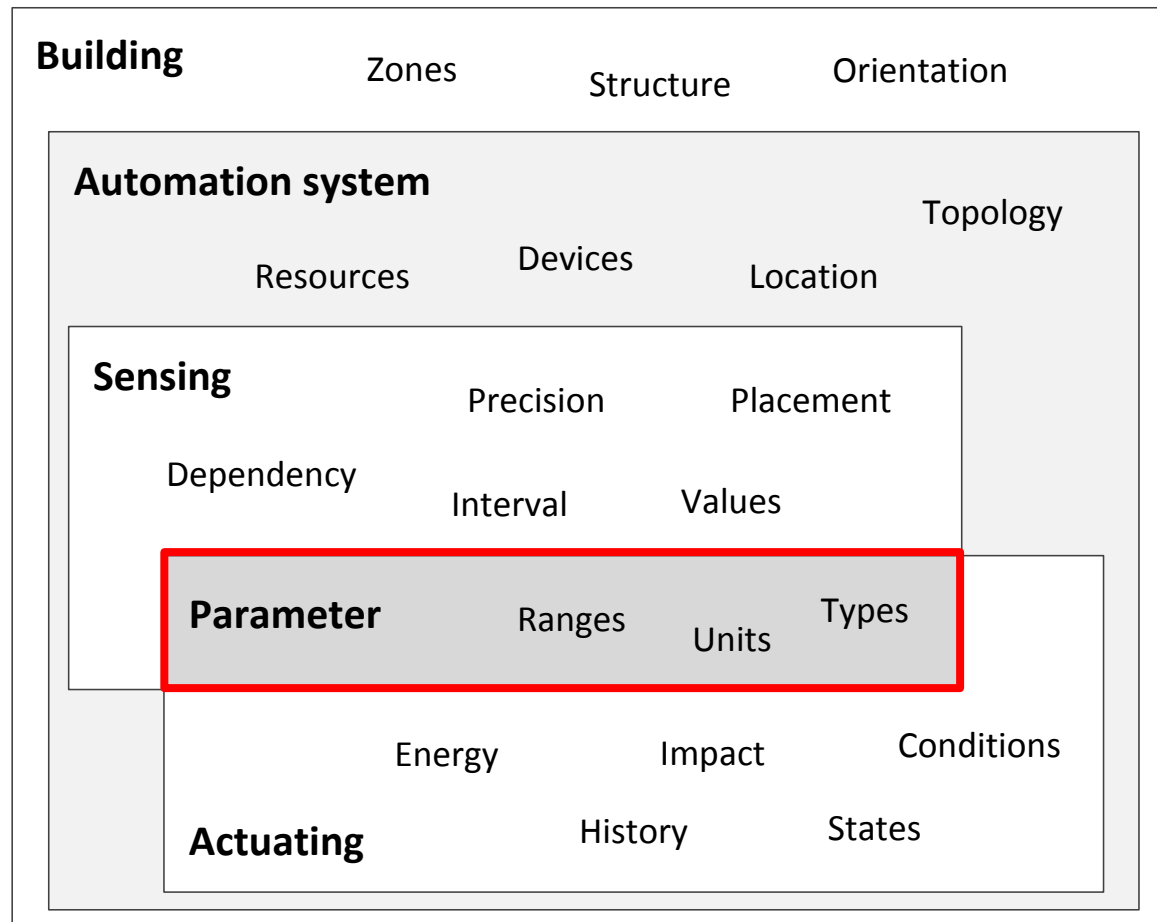
Requirements

3. Considerations regarding semantics



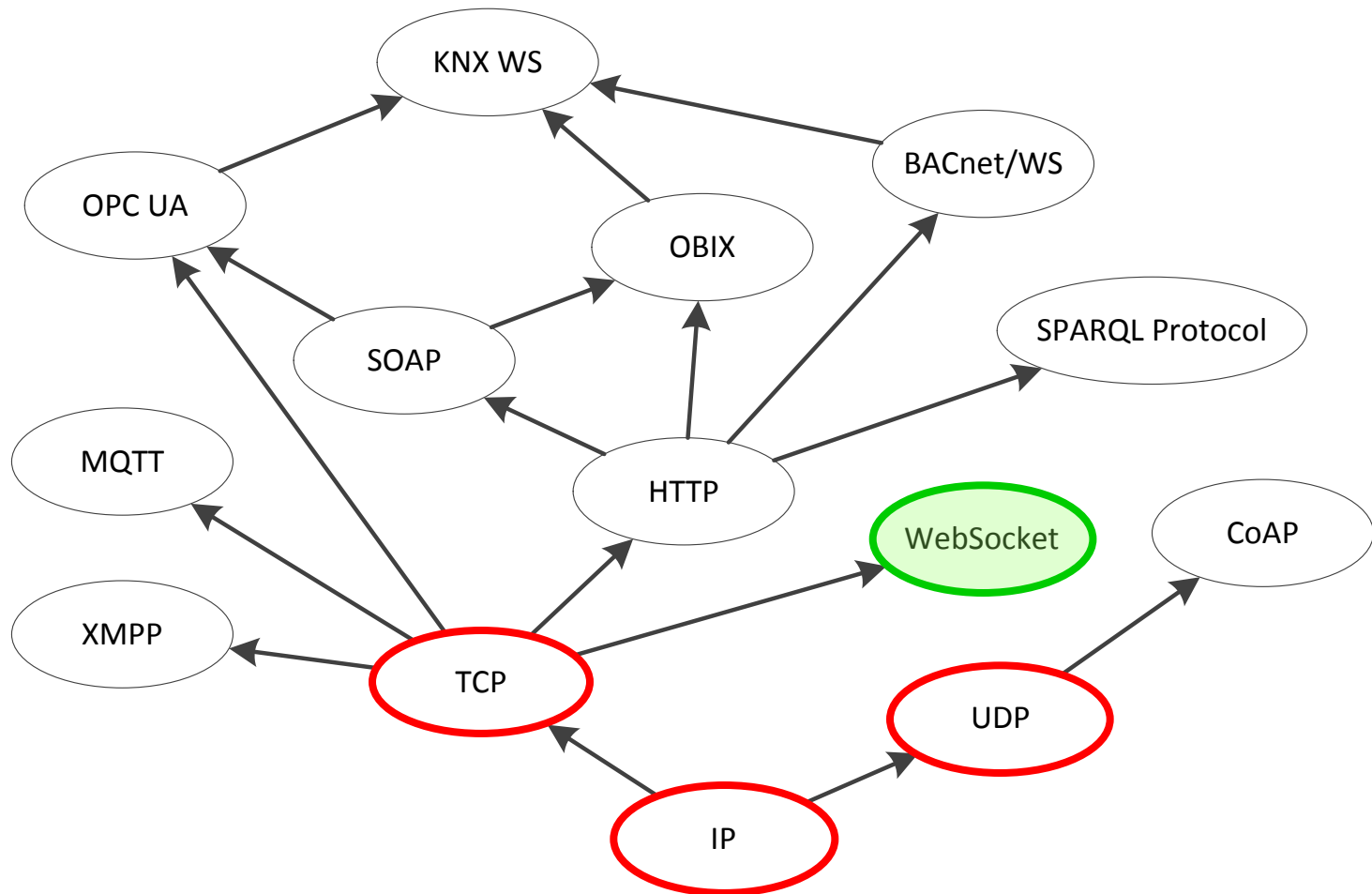
Requirements

3. Considerations regarding semantics



Interface definition

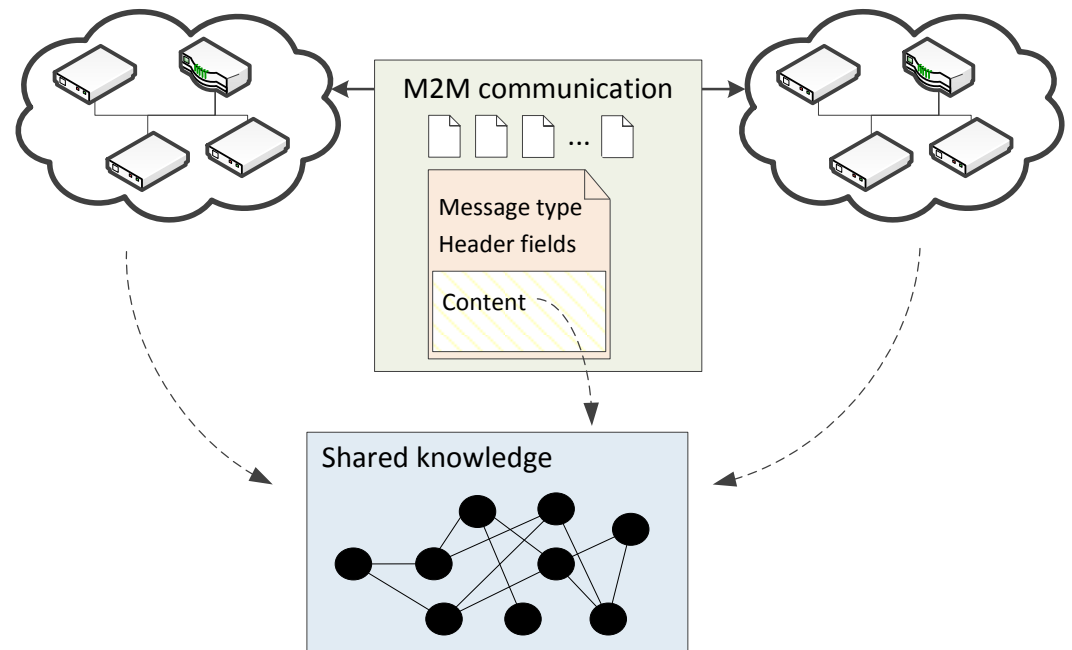
1. Protocol selection



Interface definition

2. Application services

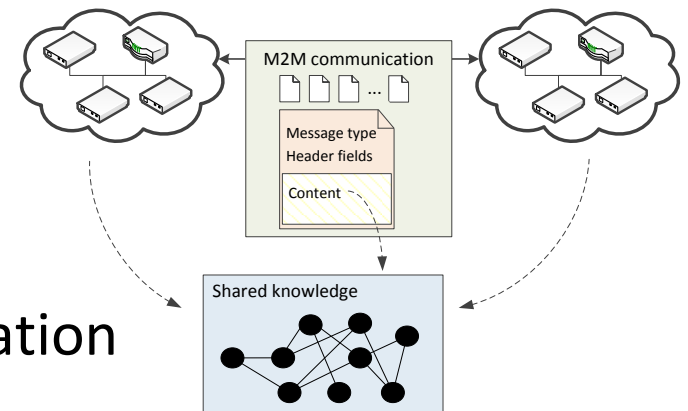
- 12 services
- Header fields
 - Message ID
 - Content type
 - Sent date
 - Expires date
 - Reference ID



Interface definition

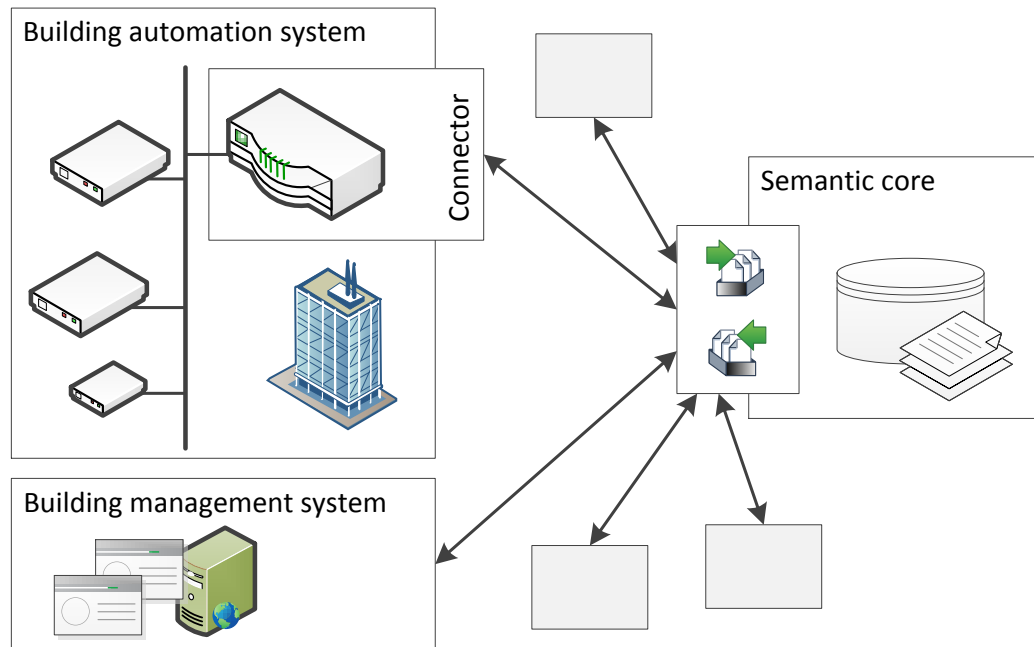
3. Semantic modeling

- Common understanding
- Local knowledge bases
- Platform-independent representation
- Ontology reuse (*previous work*)
 - Building: Zones, zone delimiters, ...
 - Automation system: BA resources, appliances, ...
 - Parameter: Units, values, parameter types, ...
 - Sensing: Data service, parameter configuration, ...
 - Actuating: Control service, states, conditions, ...



Feasibility evaluation

- Proof-of-concept implementation
 - KNX installation as BAS
 - Web application as demo BMS
 - Semantic core as message broker



Feasibility evaluation

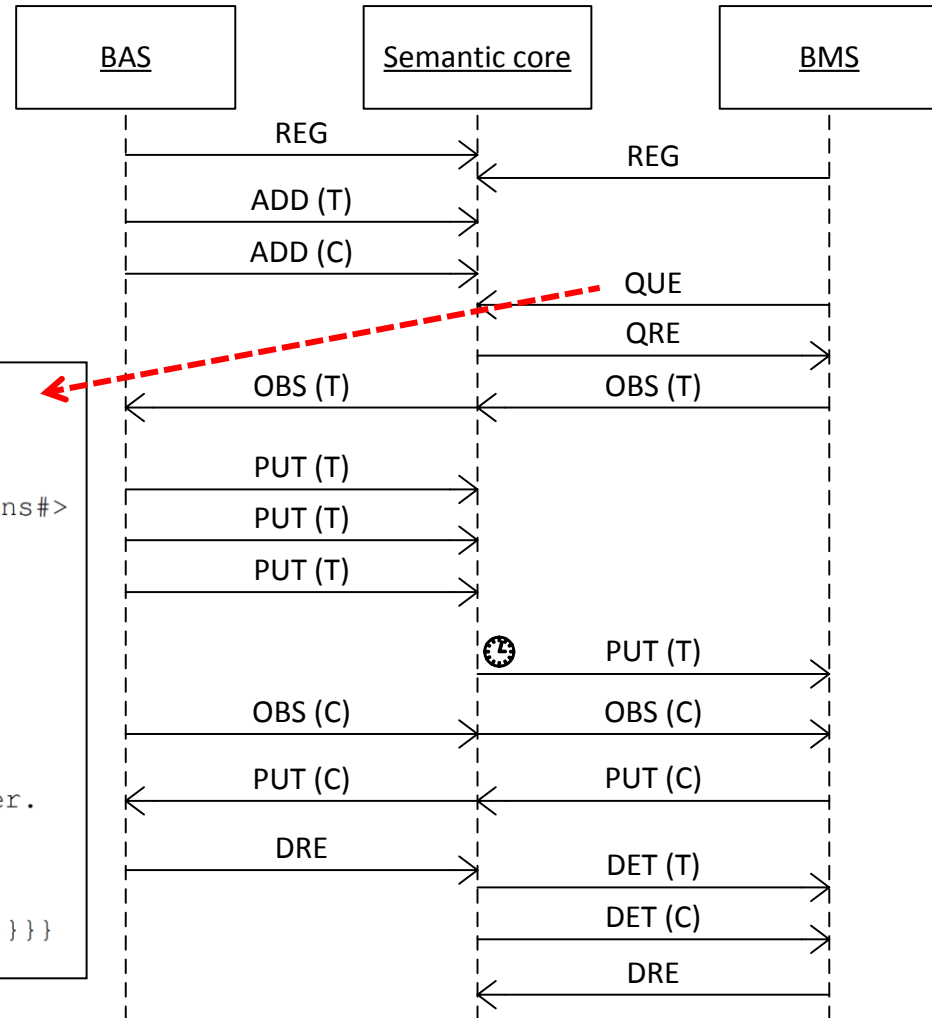
- Functional capability
 - Atomic test cases
 - Test scenarios

```

QUE
Content-Type: application/sparql-query
Message-Id: 2017030123

PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX colibri: <https://[...]/colibri.owl#>

SELECT (?f as ?function) ?c ?t ?u
WHERE {{ ?f rdf:type colibri:DataService.
  BIND ('sensing' AS ?c).
  OPTIONAL { ?f colibri:monitorsParameter ?p.
    ?p rdf:type ?t.
    ?t rdfs:subClassOf colibri:EnvironmentalParameter.
    OPTIONAL {?p colibri:hasUnit ?u. }}}
UNION { ?f rdf:type colibri:ControlService.
  BIND ('actuating' AS ?c)
  OPTIONAL { ?f colibri:controlsParameter ?p. [...] }}}
ORDER BY ?function
    
```



Feasibility evaluation

- Hardware requirements
 - Memory
 - 25MB after garbage collection ($\leq 21,000$ triples)
 - Transmission time
 - Comparable to other non-critical BA communication
 - Processing time
 - Ontology reasoning as performance bottleneck

→ Feasible for constrained hardware (Raspberry Pi)

Conclusion

- **Semantic interface for M2M communication in BA**
 - Existing M2M combined with semantic modeling
 - Service set based on WebSocket
 - Automatic message interpretation
 - Feasible for constrained hardware
- **Outlook**
 - Improvement of proof-of-concept implementation
 - Detailed performance evaluation (throughput, response times, content encodings, ...)
 - Investigate ontology reasoning over message contents

Thank you!

