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

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Contents

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
  - …

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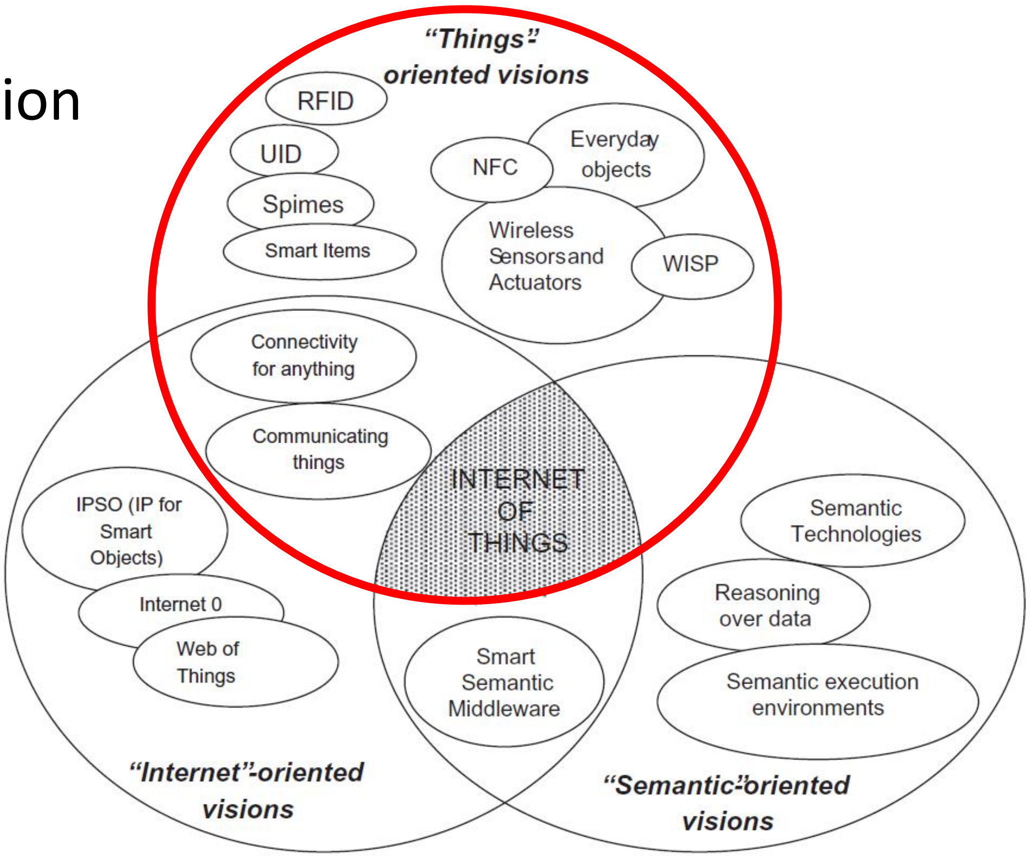
Motivation

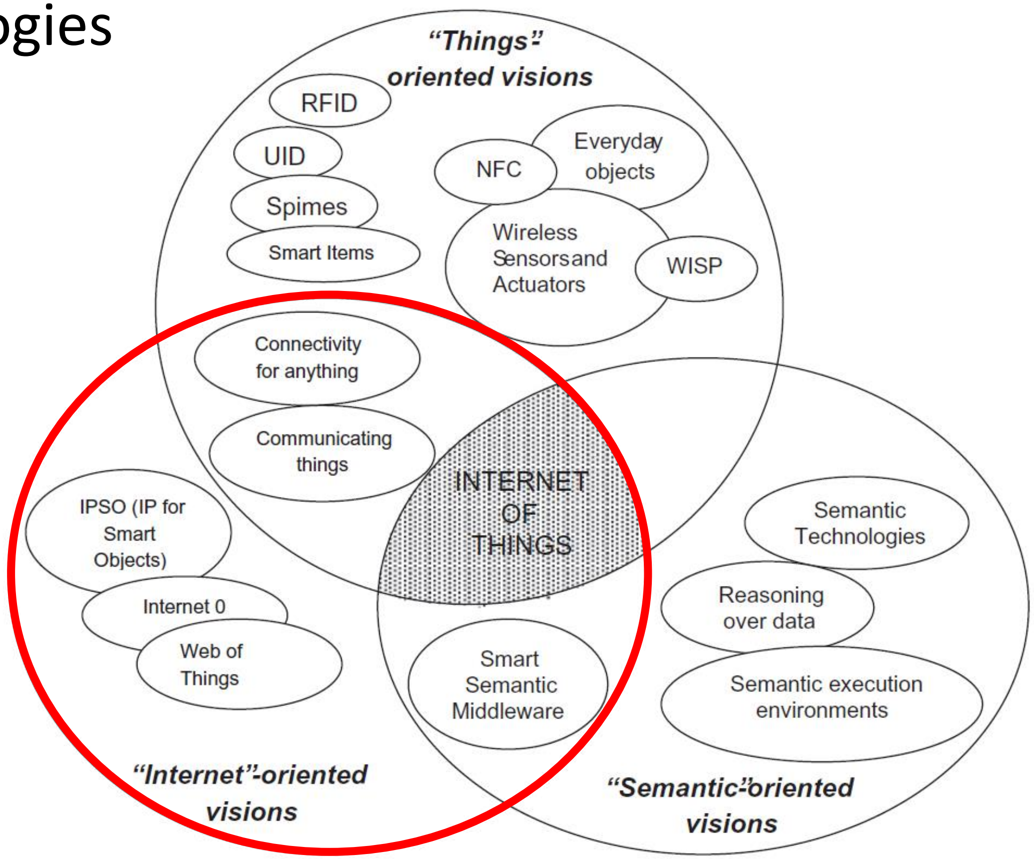
- Machine-to-machine (M2M) communication
  - Autonomous
  - No human intervention
- Technologies
  - Low-cost
  - Scalable
  - Reliable



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-*



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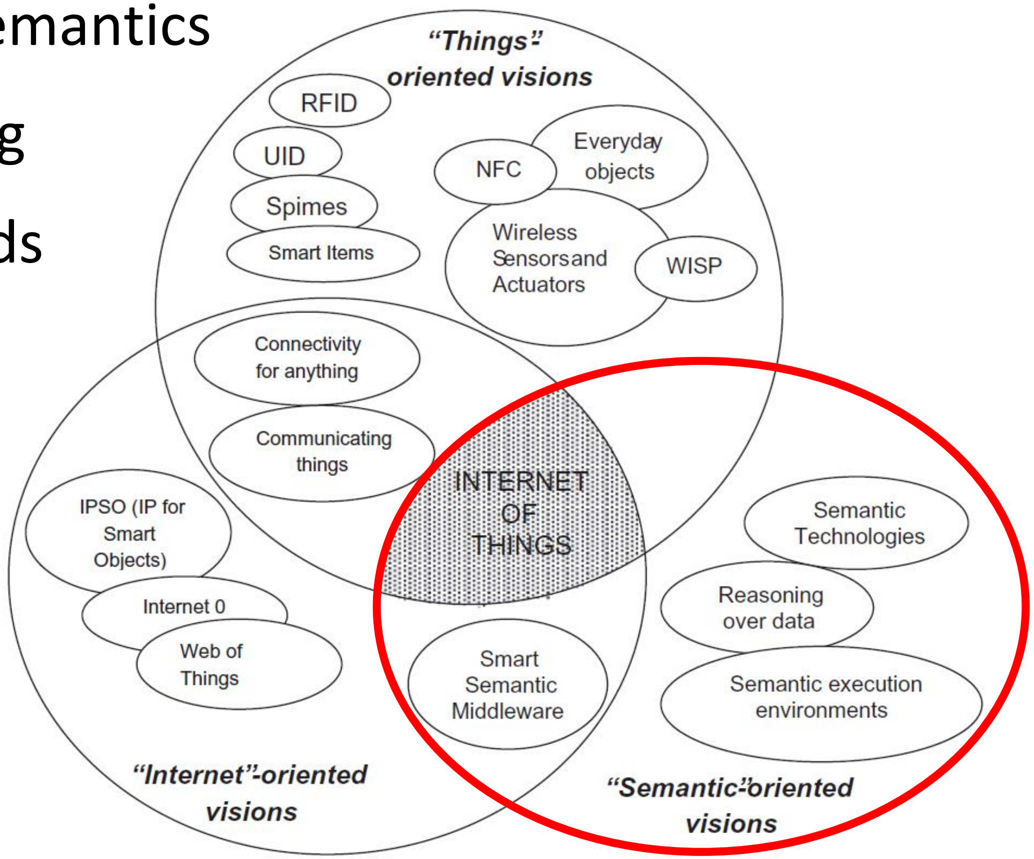
Motivation

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



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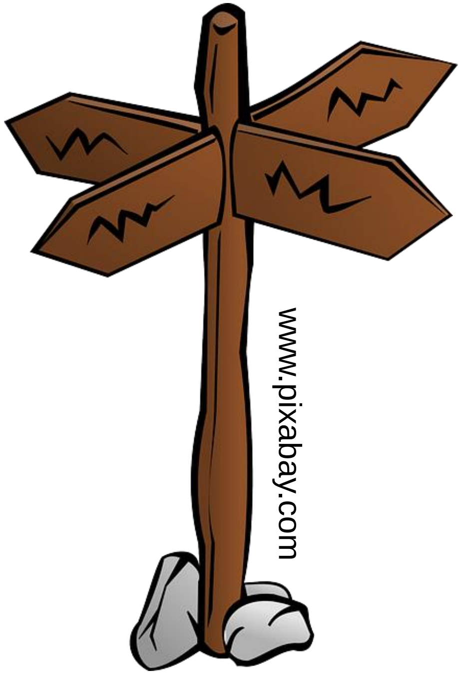
Motivation

- **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



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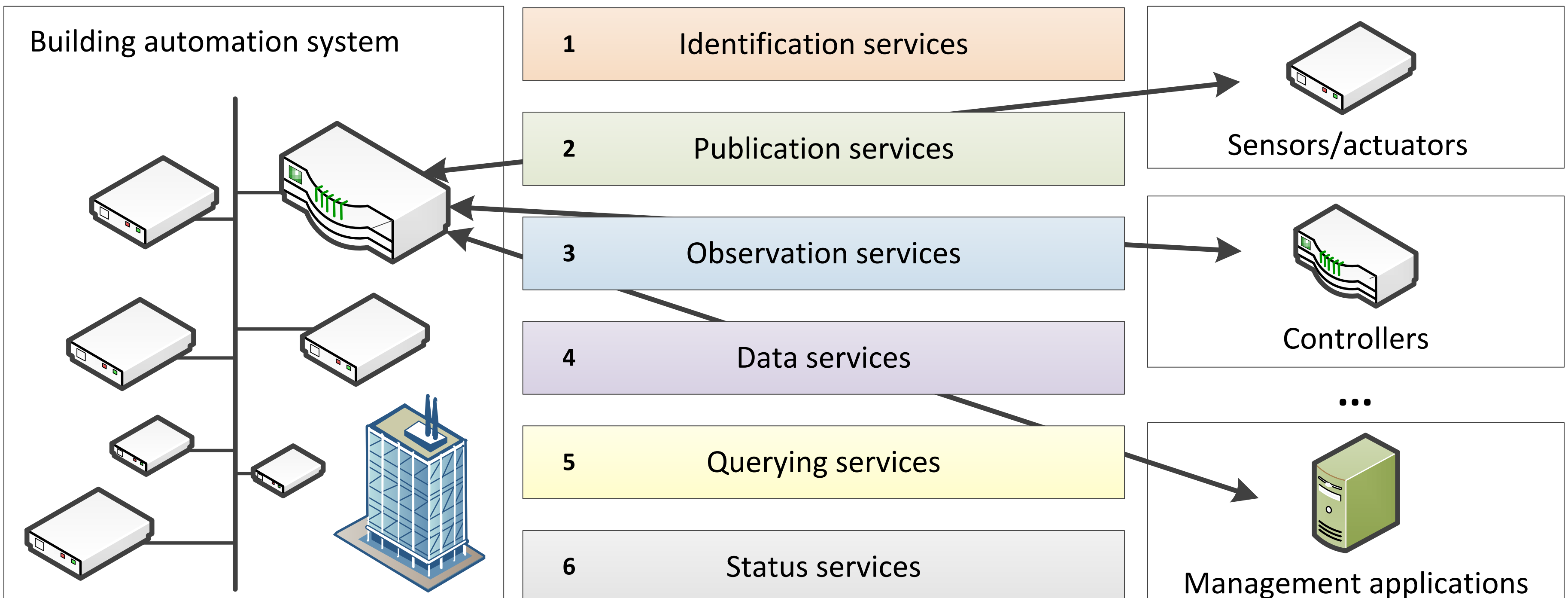
Requirements

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

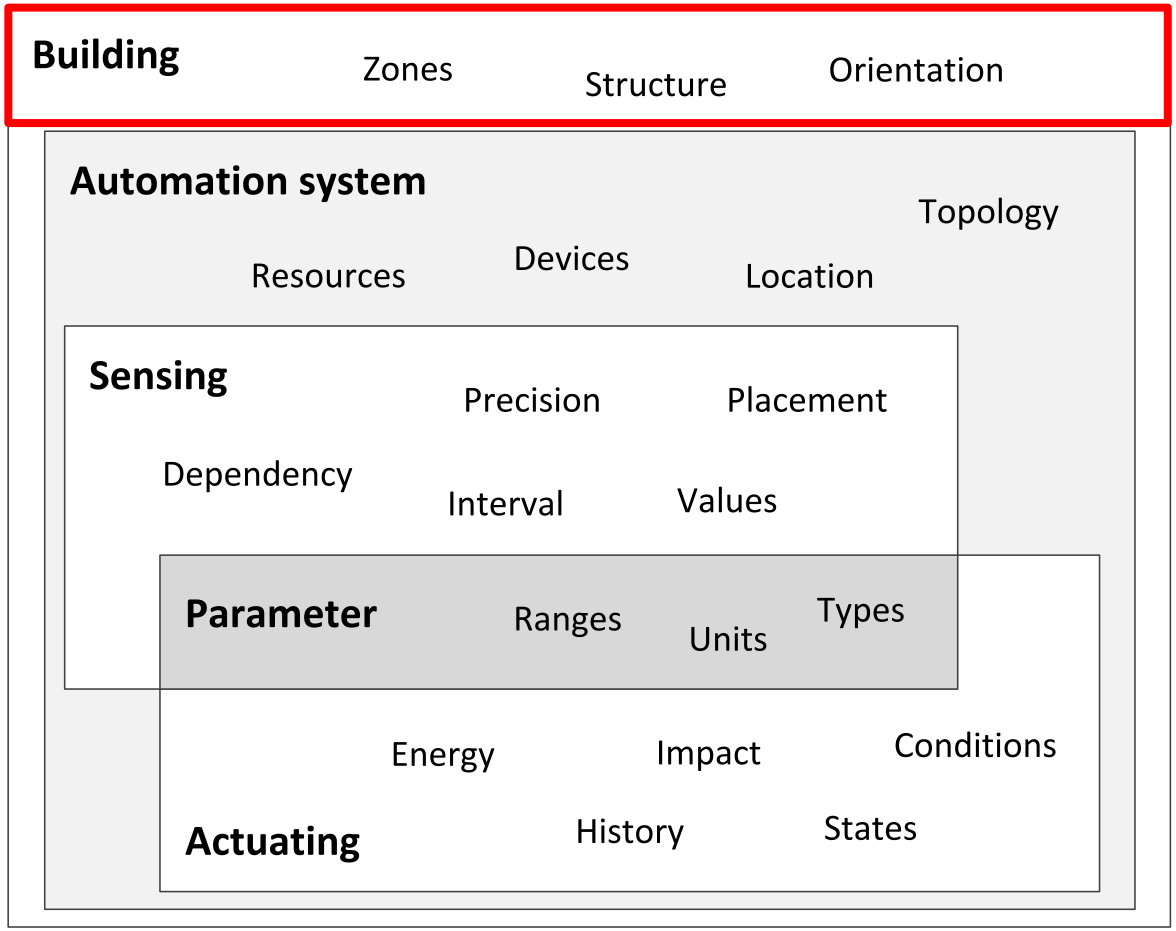
2. Application layer services

- Vertical and horizontal integration
- Bidirectional communication



Requirements

3. Considerations regarding semantics



Requirements

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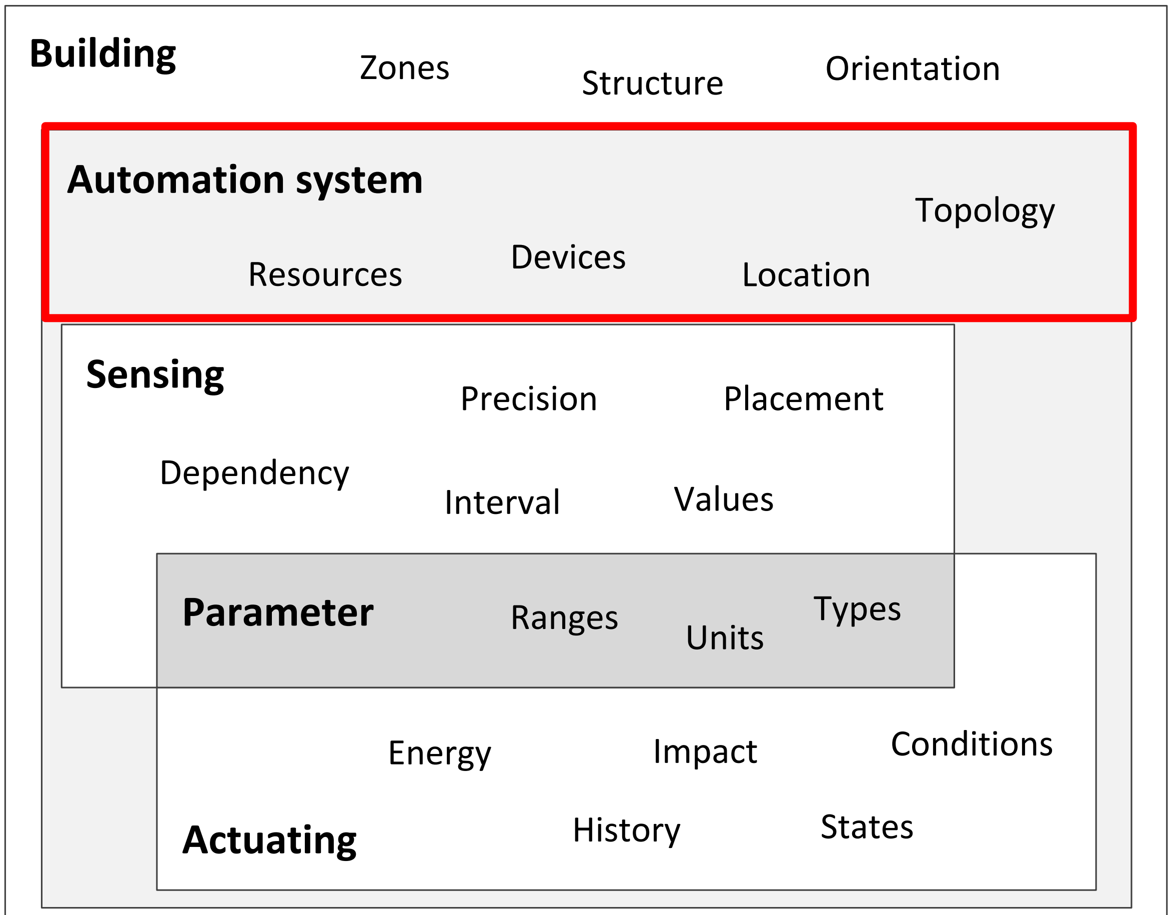

Requirements

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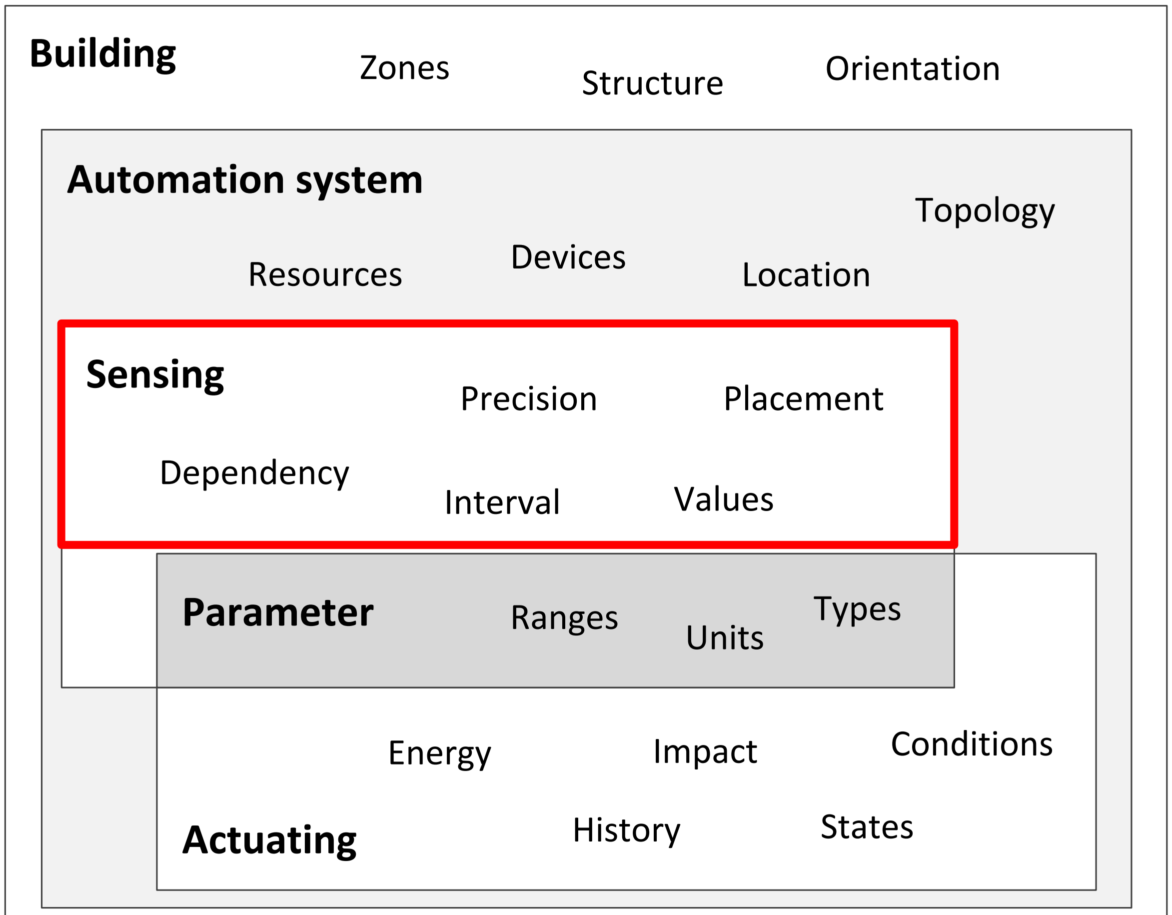
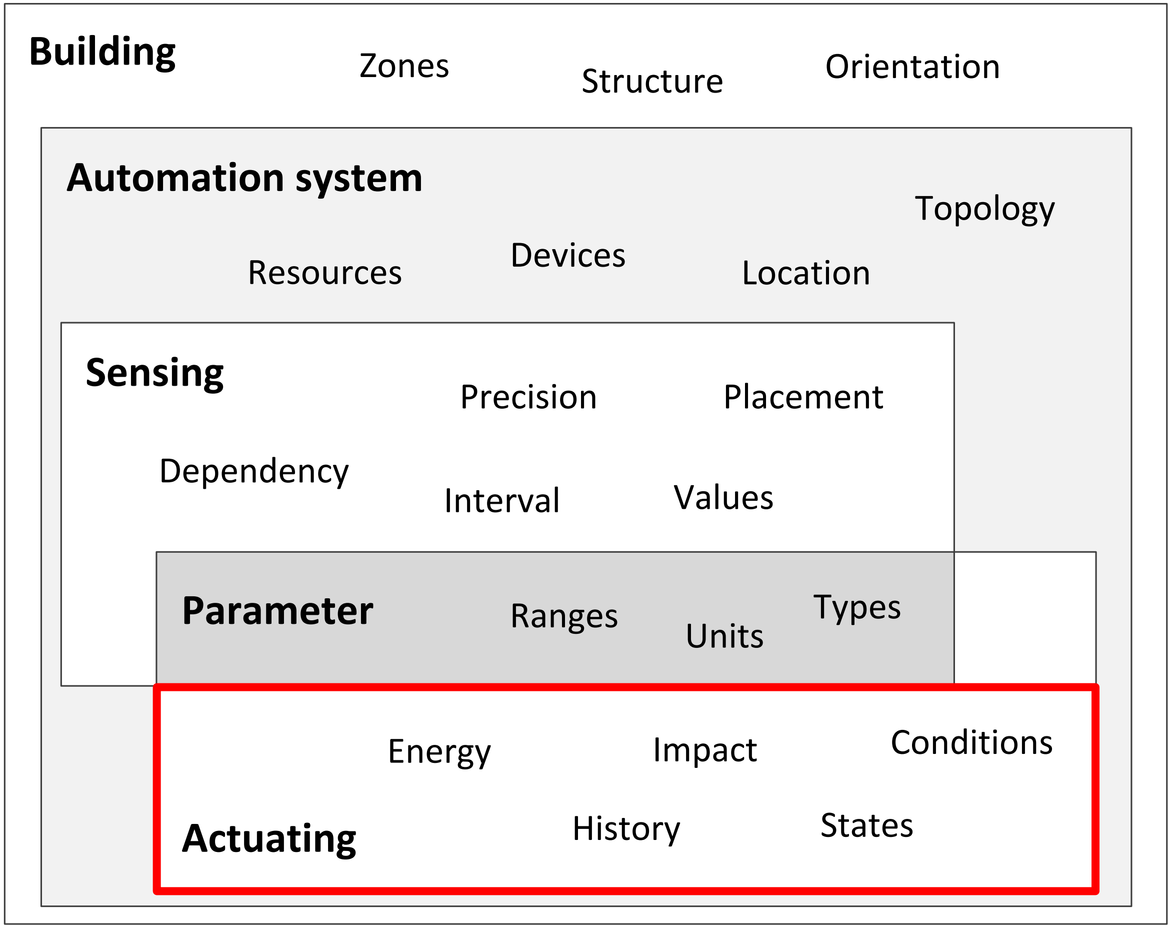


Requirements

3. Considerations regarding semantics



Requirements

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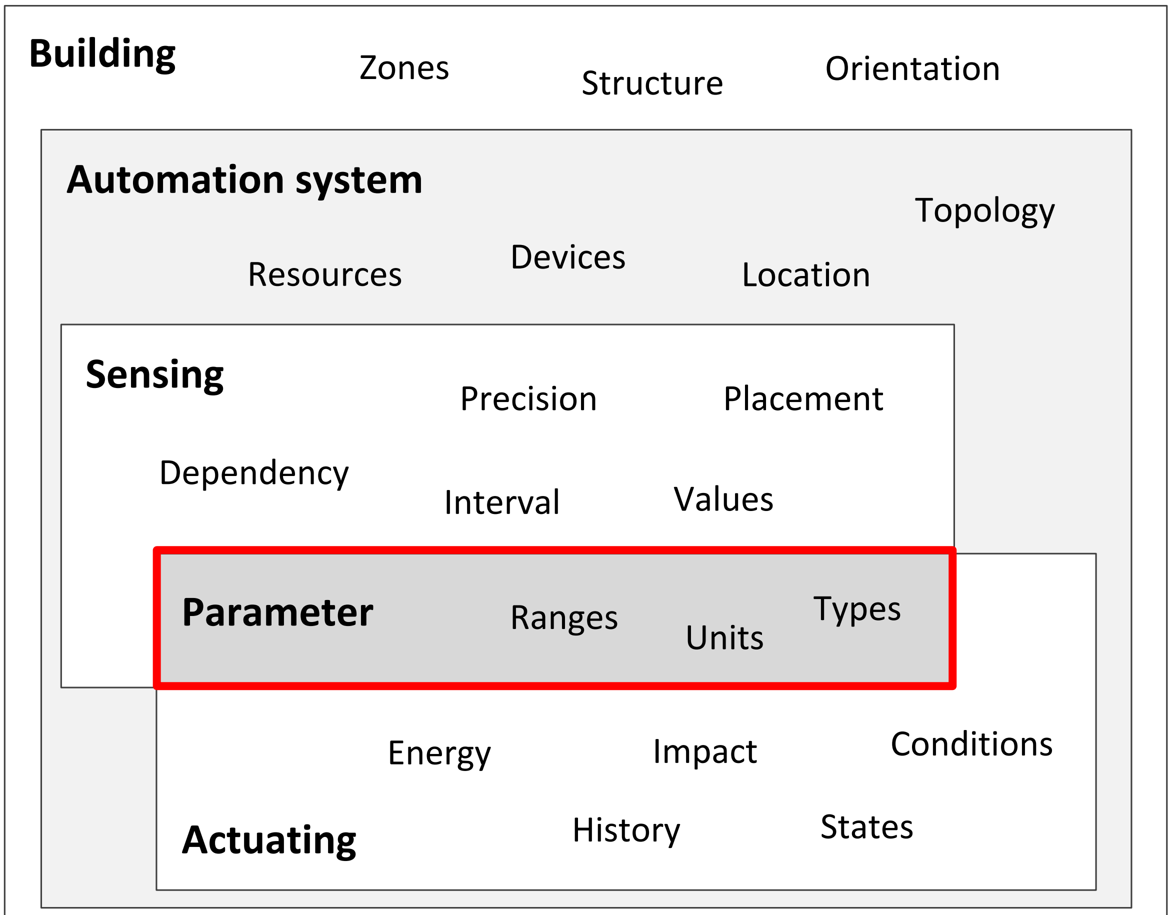
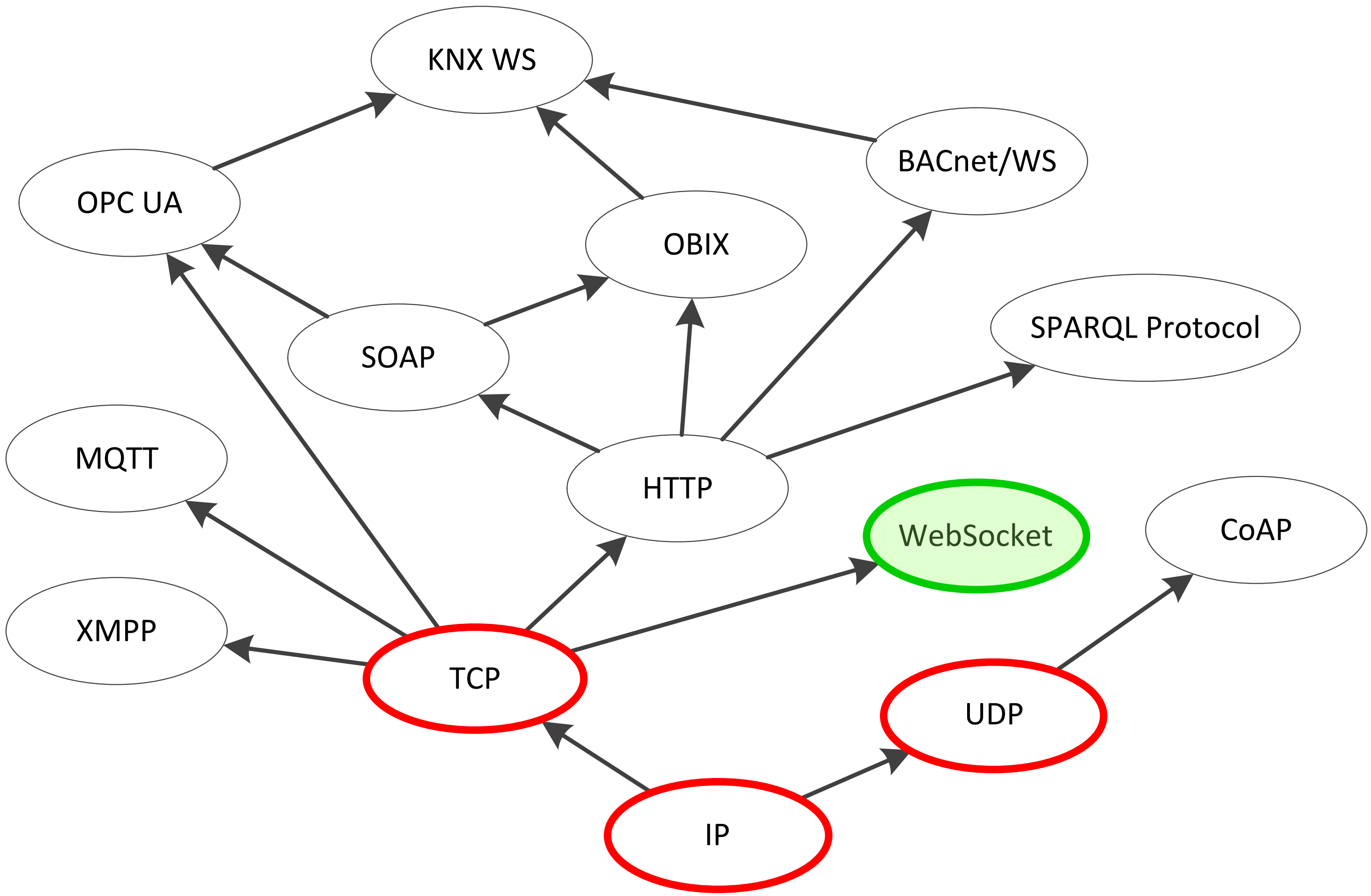


Interface definition

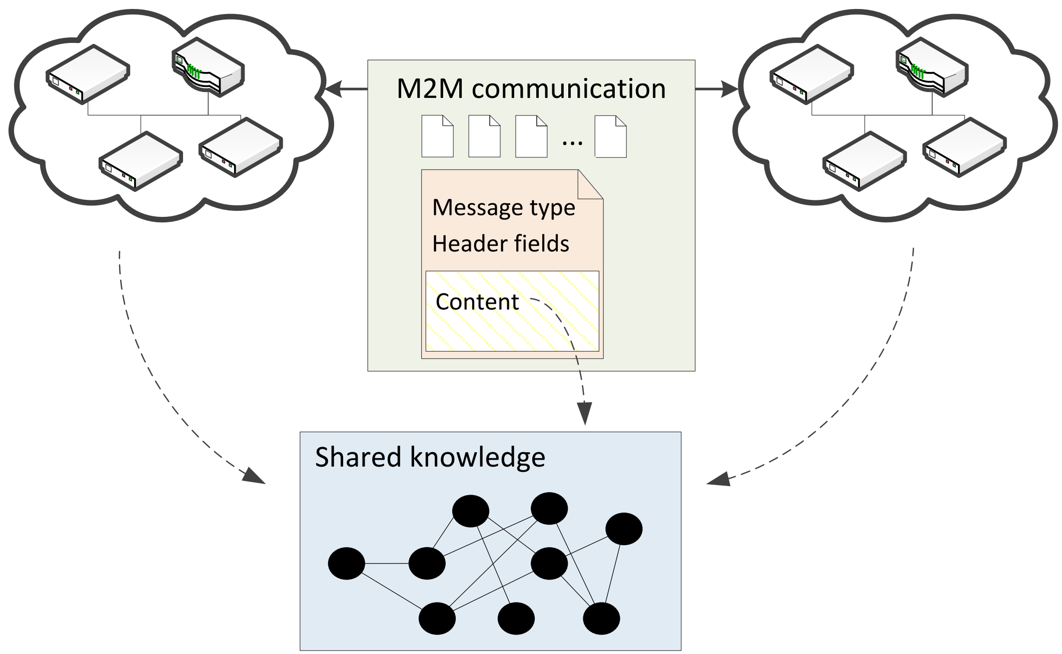
1. Protocol selection



Interface definition

2. Application services

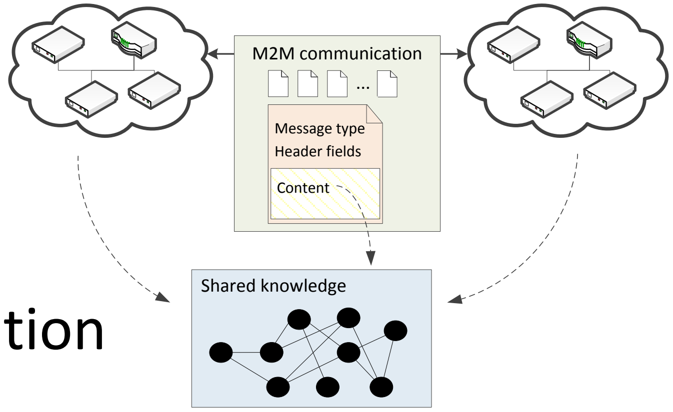
- 12 services
- Header fields
  - Message ID
  - Content type
  - Sent date
  - Expires date
  - Reference ID



Interface definition

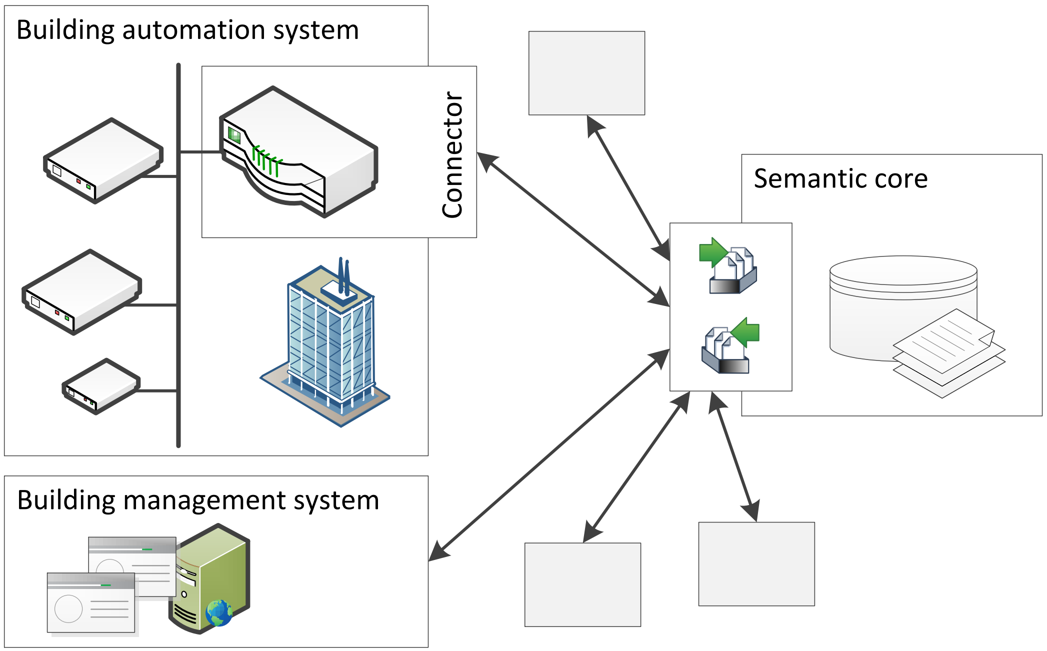
3. Semantic modeling

- 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, …



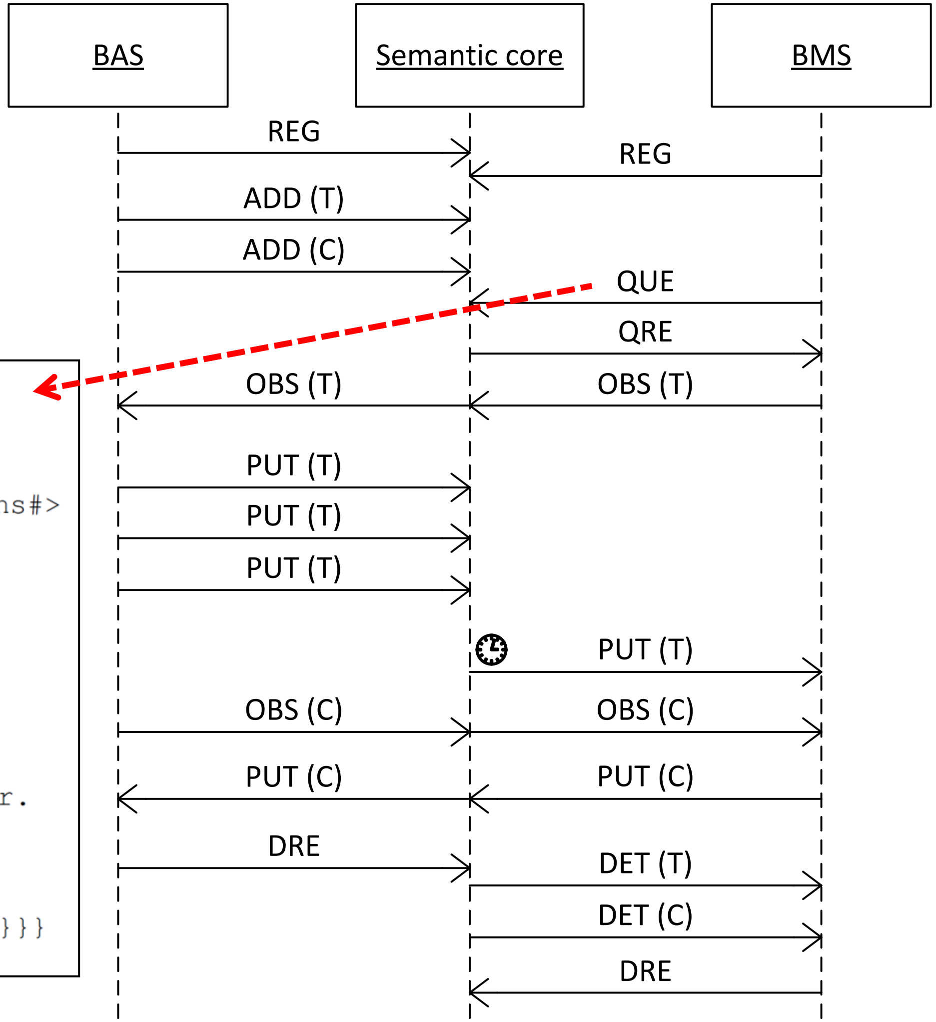
Feasibility evaluation

- 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 (<= 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!