Impliquer les équipements en bordure de réseau pour raisonner à l'échelle du SWoT

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ADREAM, an example of smart building

- Over **6500 sensors** in the building

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- Small scale deployment in an **appartment**

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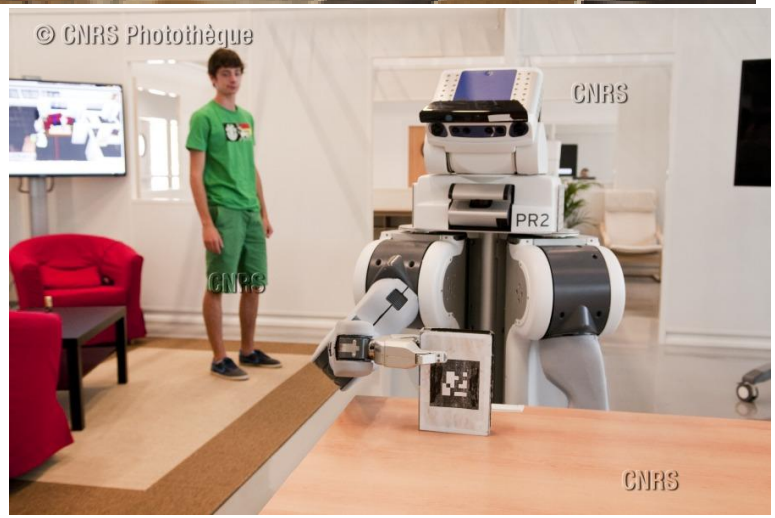
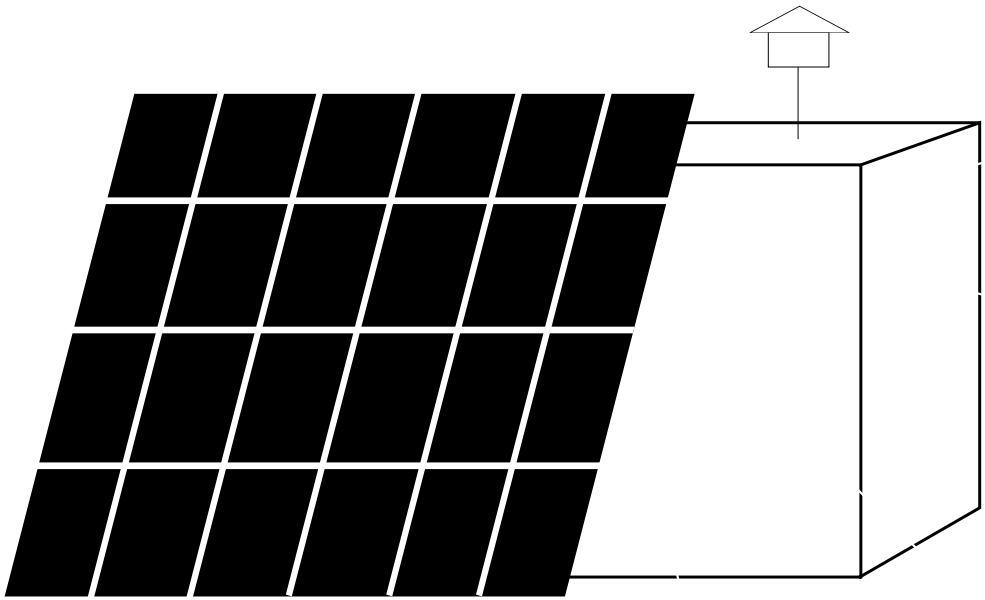
- A **shared** research platform



Motivational use case



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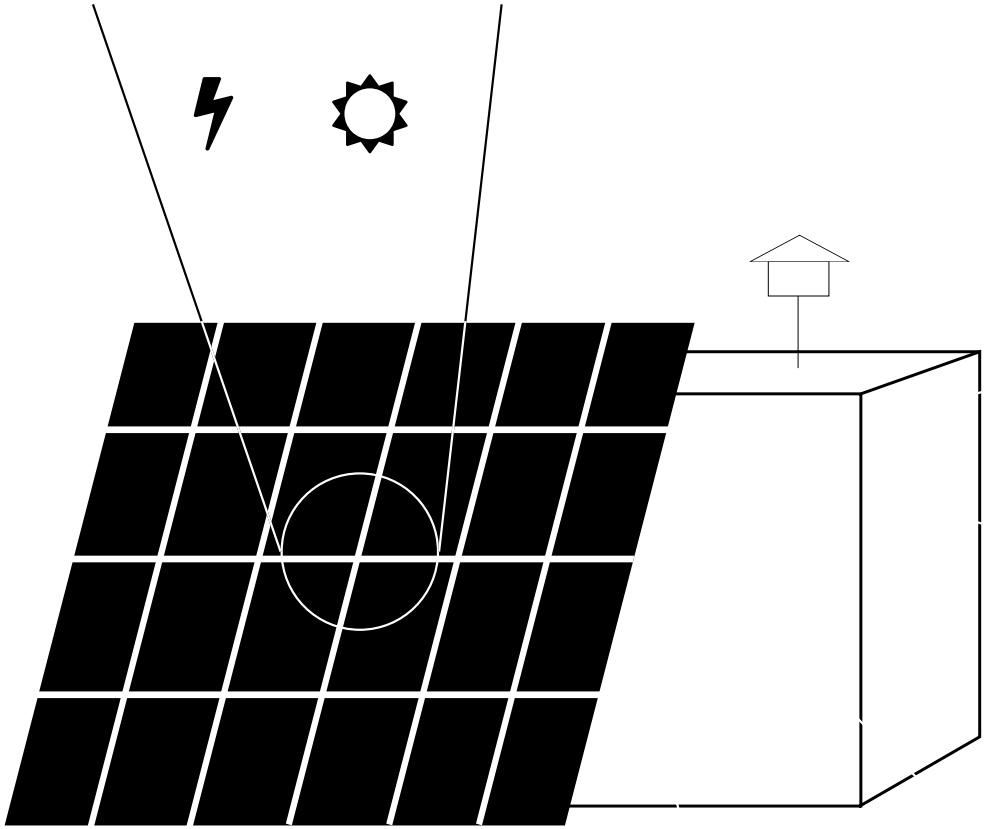

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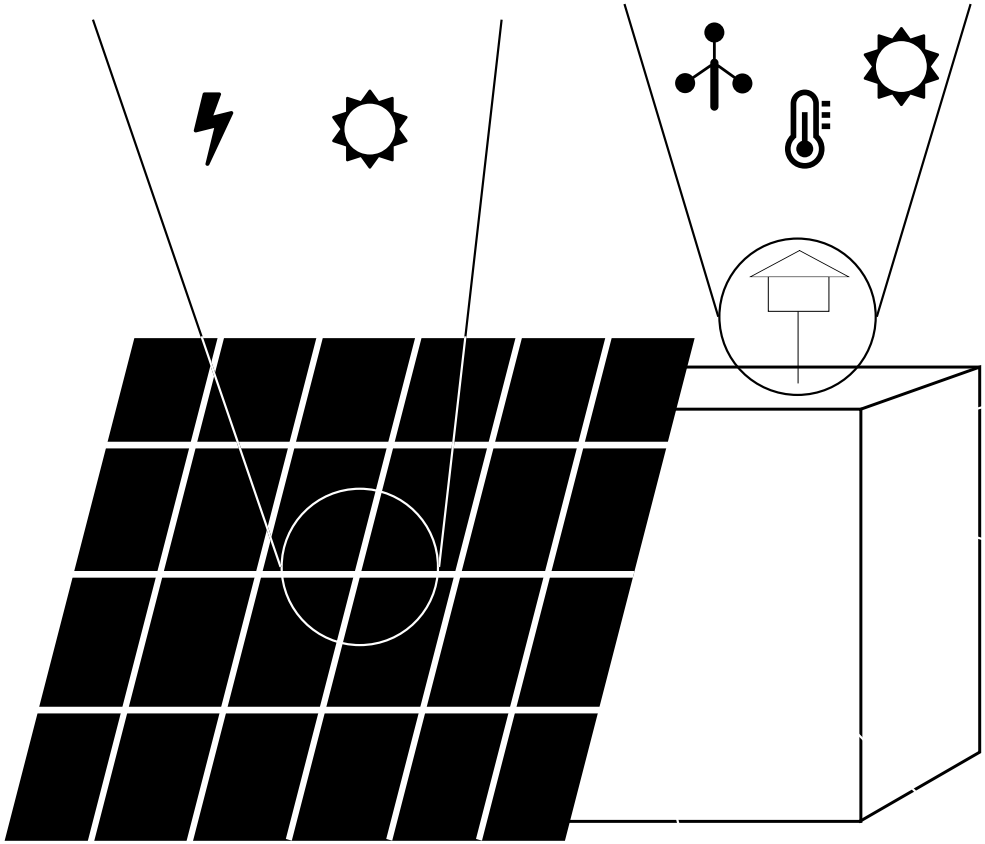

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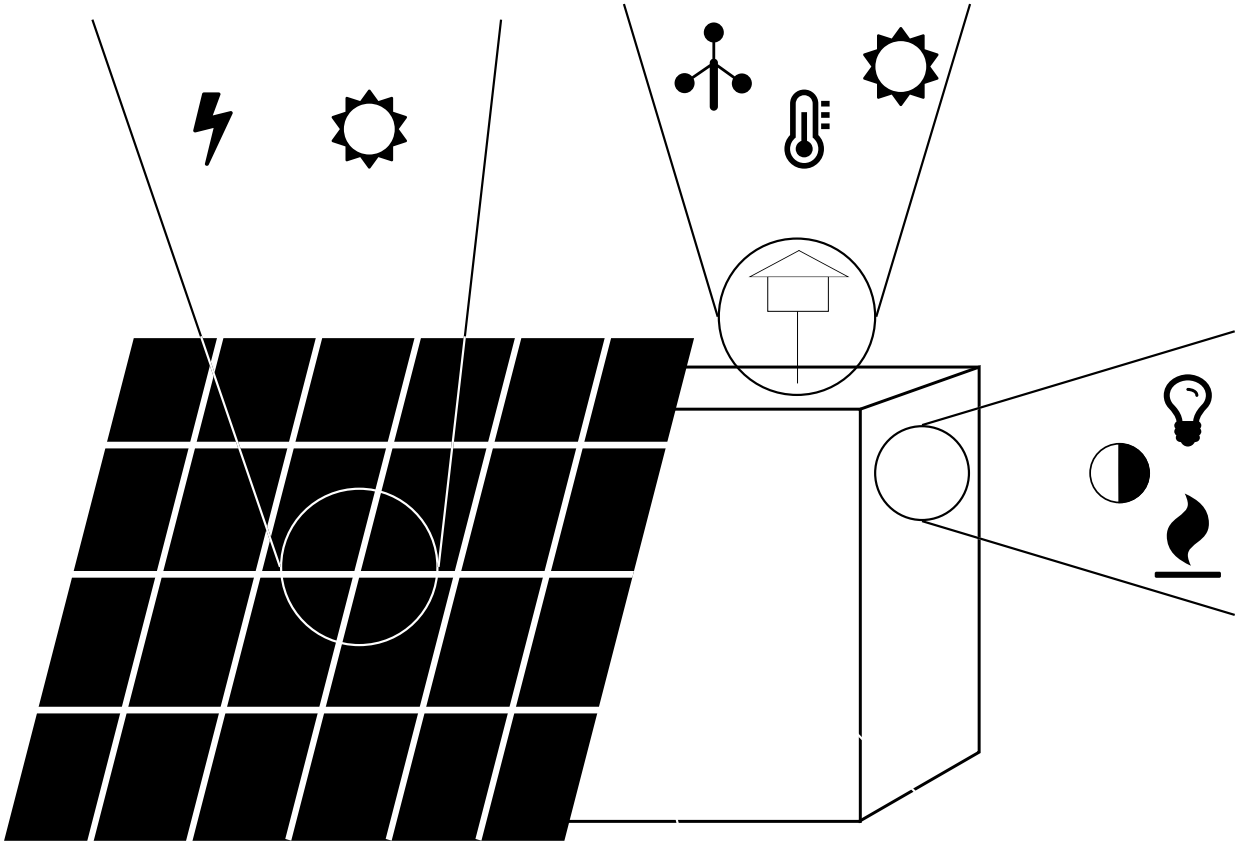

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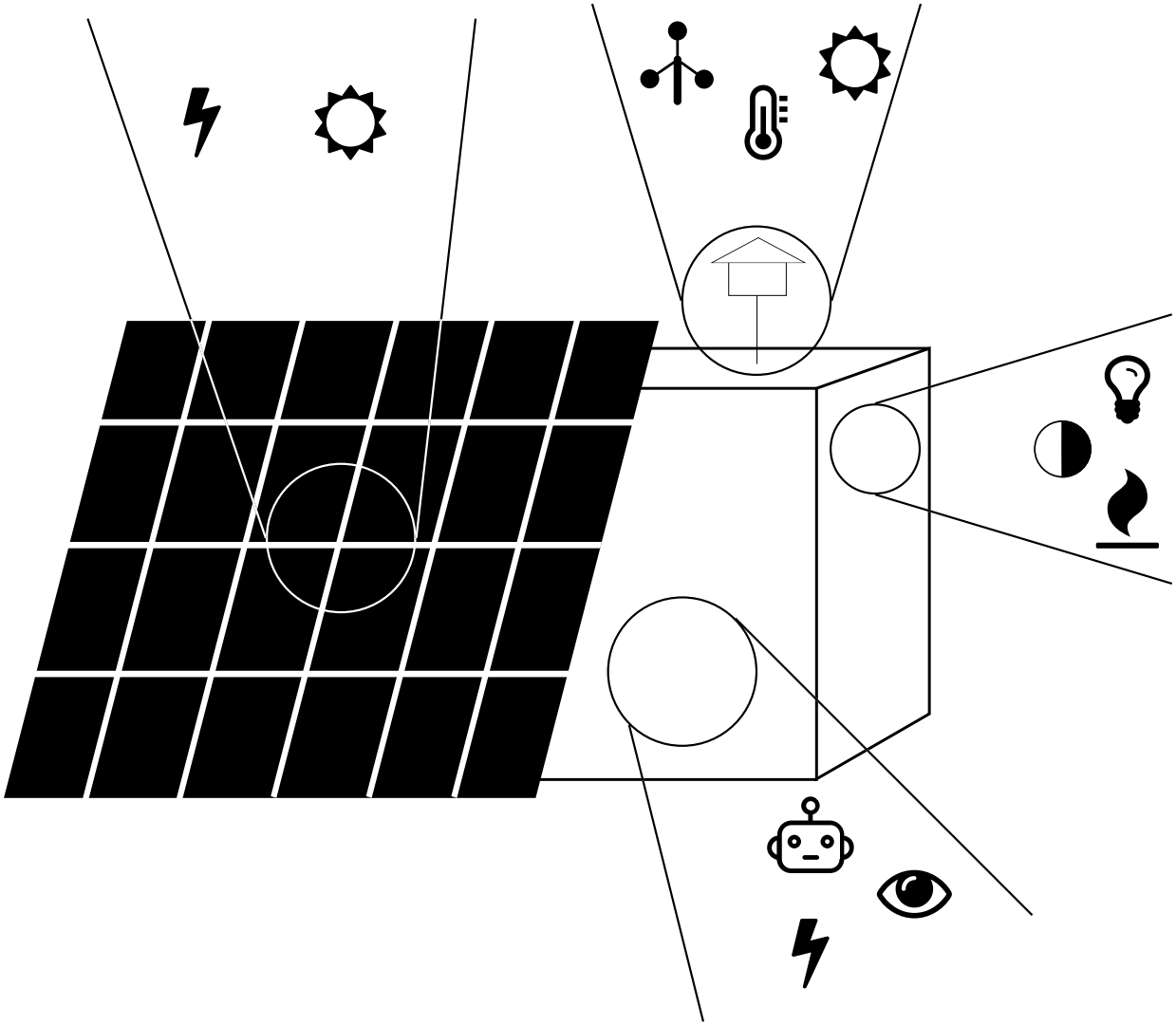

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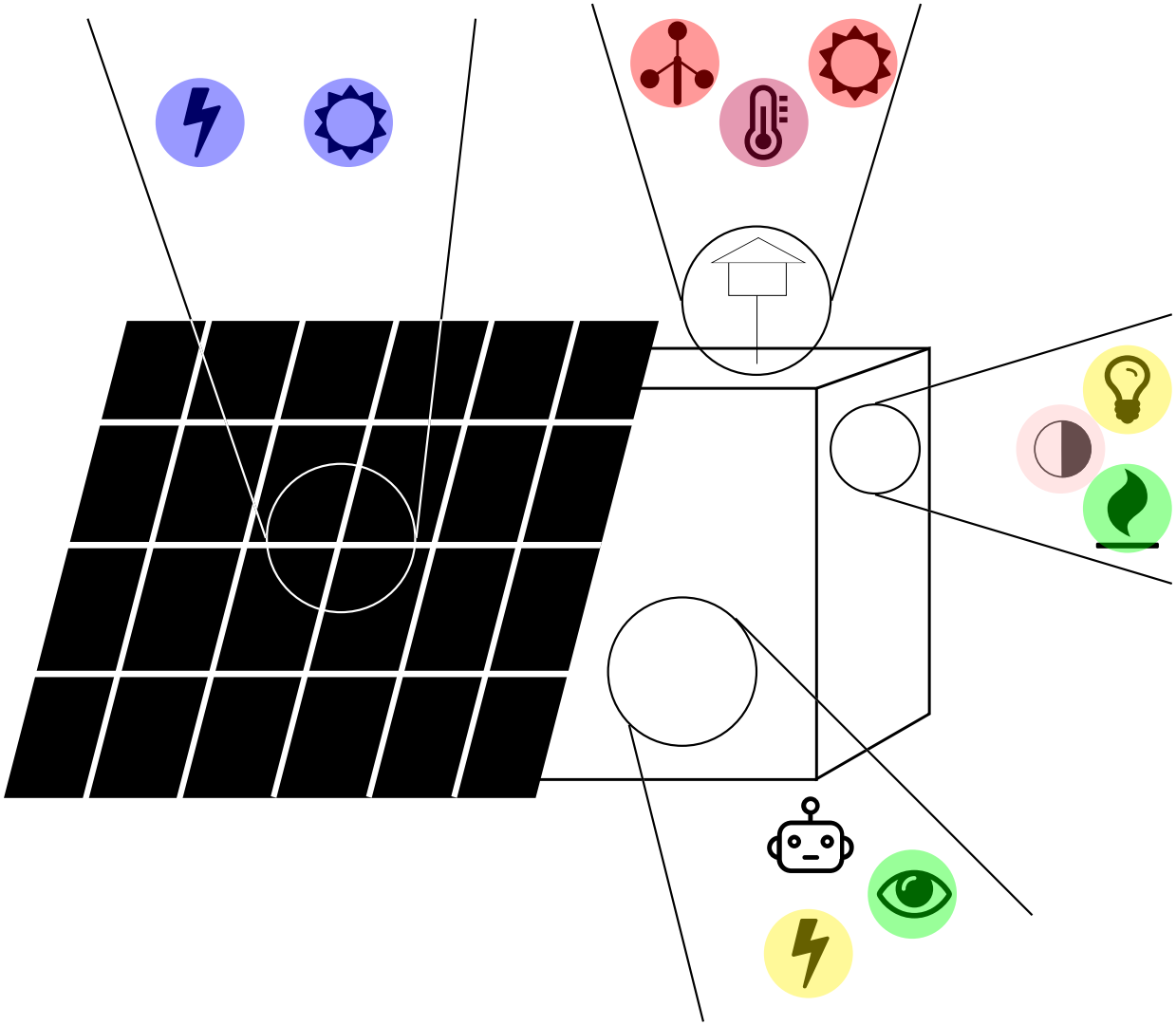

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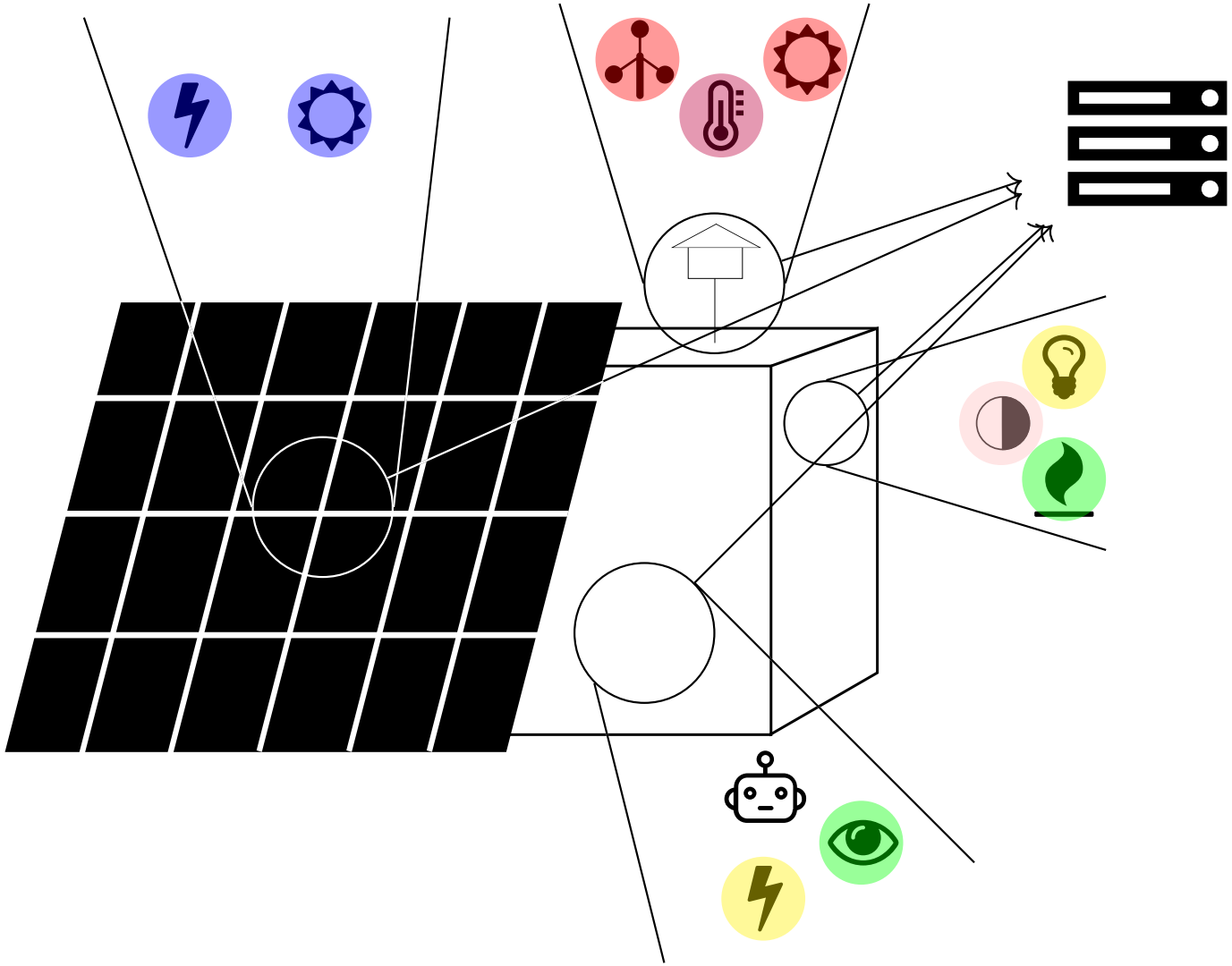
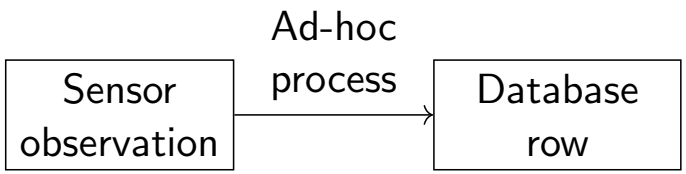


Open Platform for ADREAM



Linked Open Data stars[2]

[2] https://www.w3.org/DesignIssues/LinkedData.html

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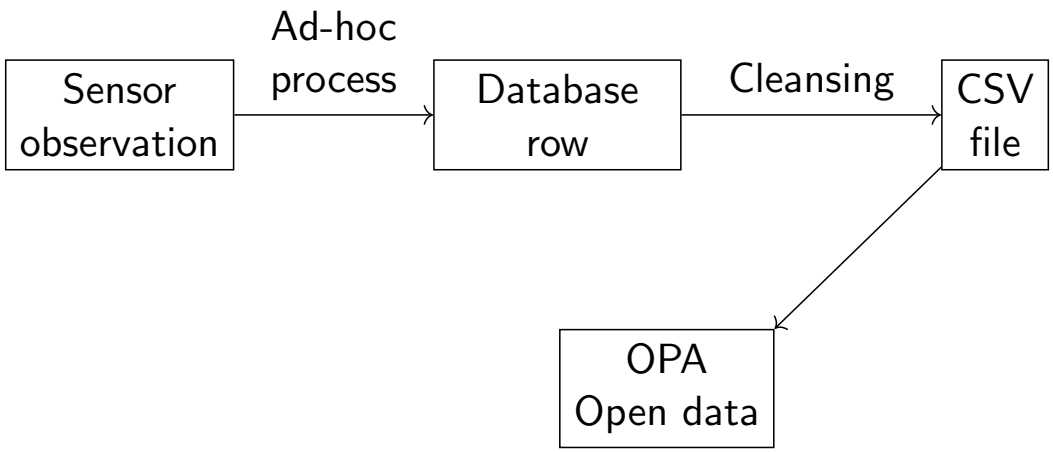

https://w3id.org/laas-iot

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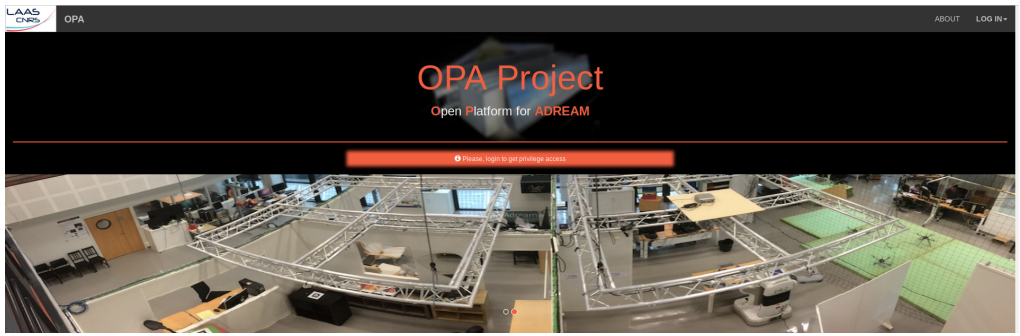

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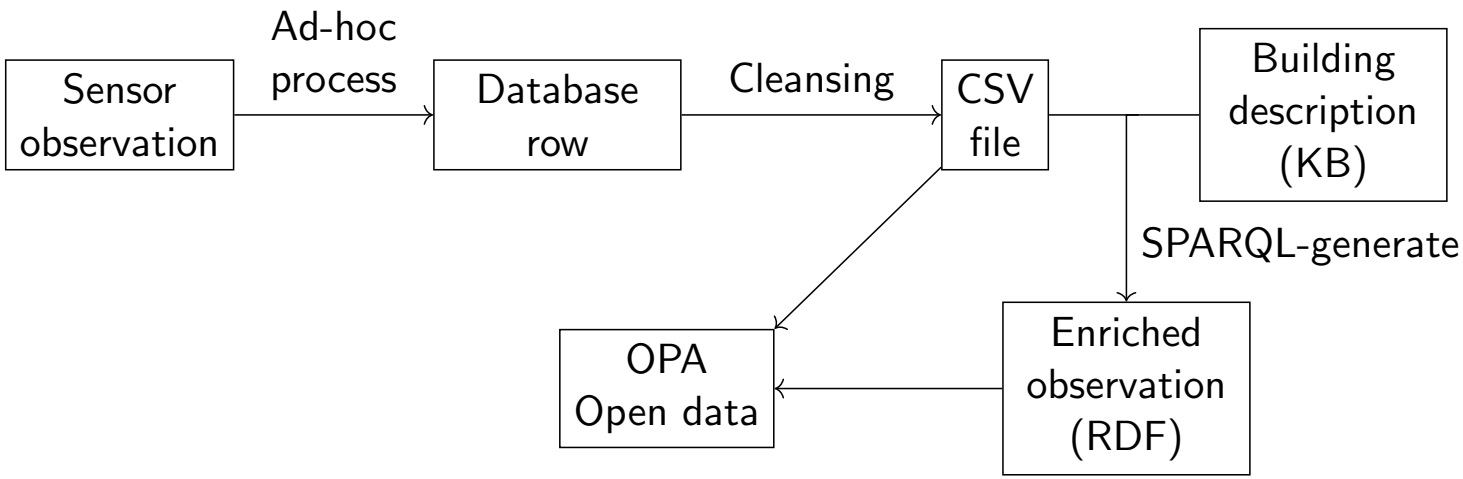

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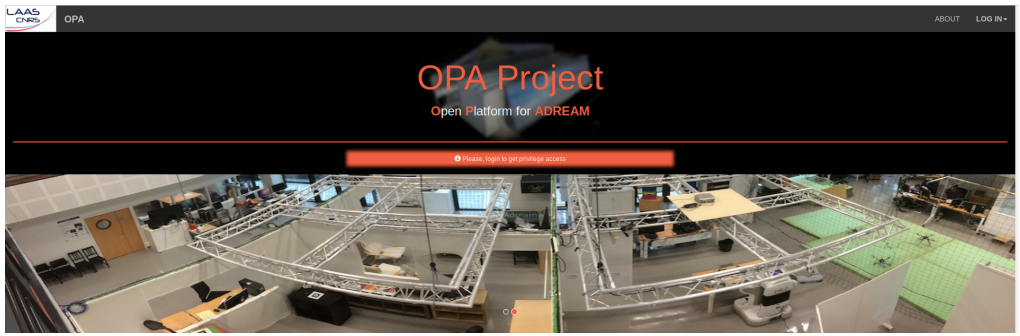

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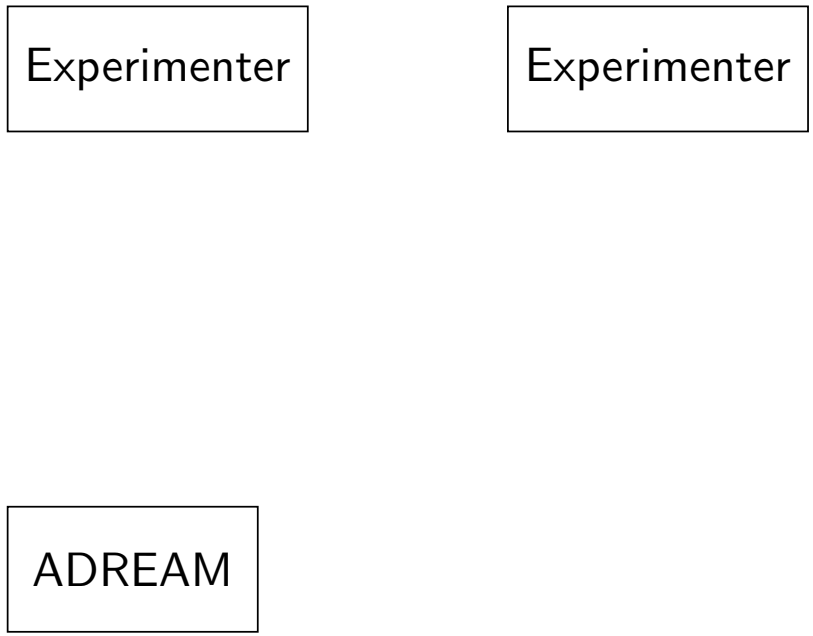
Federated experiments with FIESTA-IoT[3]

Interoperabilities

- Technical
- Syntactic
- Semantic



[2] [Sánchez et al., 2018]

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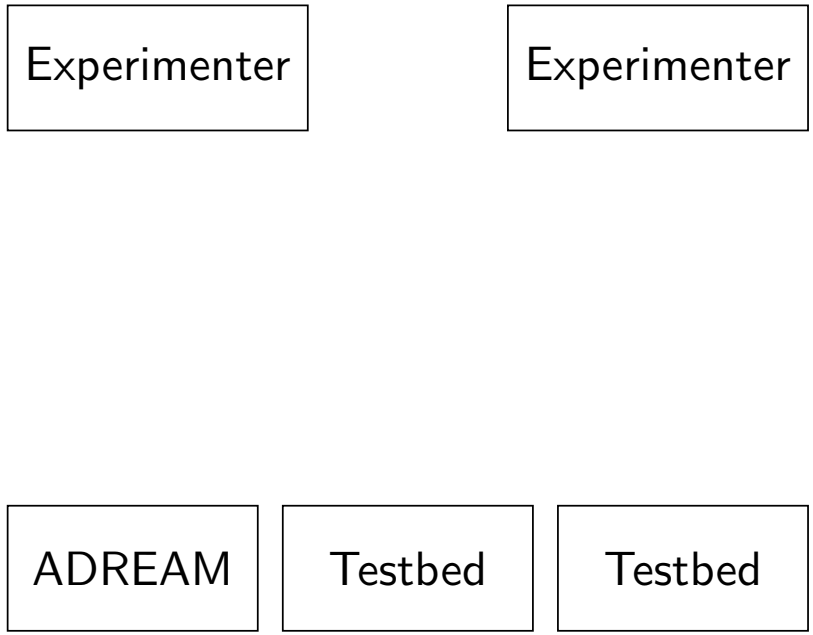

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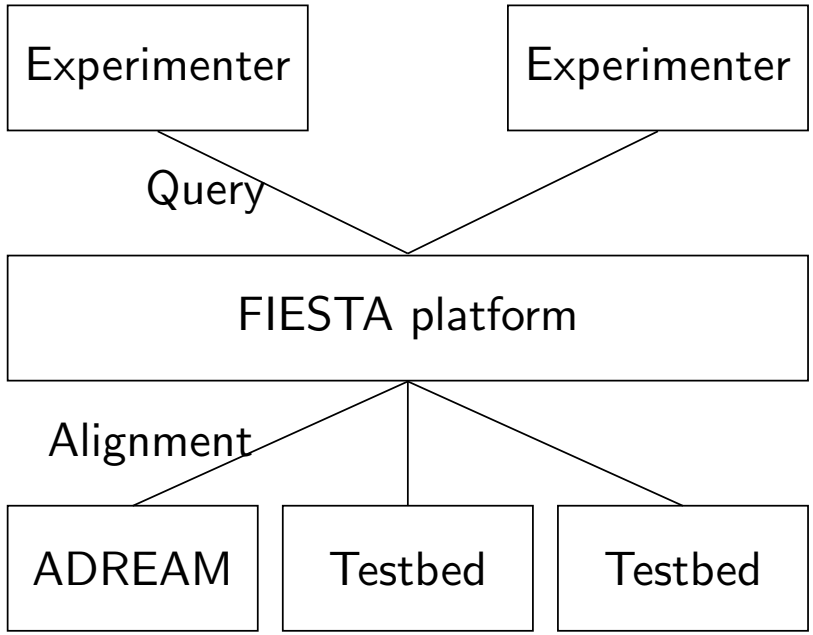

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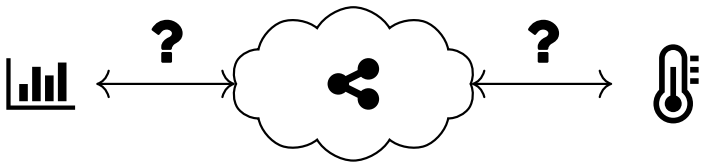
Research question

Masses of data, limited resources

How can Semantic Web technologies bridge from applicative requirements to resources available in an IoT deployment ?



Overview

1. **Definitions and state of the art**
   - Key concepts : the SWoT and its infrastructure
   - SWoT survey: How is the SWoT deployed ?
2. **EDR, for a decentralized, adaptative SWoT**
   - Approach
   - Evaluation
3. **Conclusion and future work**

From the IoT to the SWoT

IoT

- Multiple application domains (e.g. domotics, smart city, e-health...)
- Hardware, communication and software heterogeneity

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Semantic Web

- Native human and machine understandability
- Interoperability based on shared conceptualizations

  [Gruber, 1991]

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Semantic Web requirements

- Resource-consuming processing and formats
- Limited scalability

From the IoT to the SWoT

Semantic Web of Things (SWoT)

- Incepted early [Berners-Lee et al., 2001]
- Coming together recently [Scioscia and Ruta, 2009]

The Cloud and the Fog

Cloud computing [Mell and Grance, 2011]

- Massive resources, high availability
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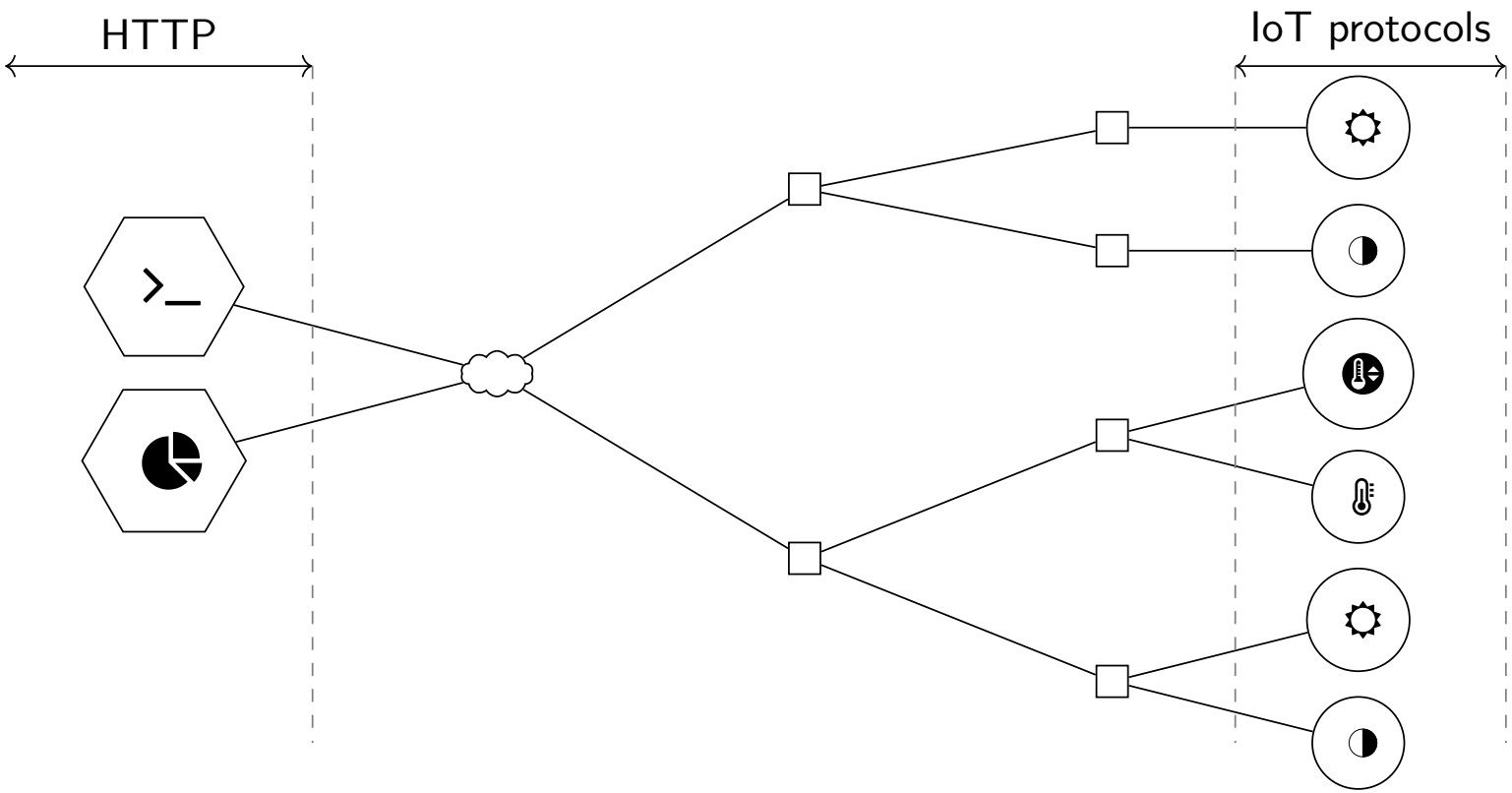
Fog computing [Bonomi et al., 2012]

- Limited resources, potentially mobile, and dynamically available
- Opportunistic, contextual provisioning
- Ubiquitous computing power : **edge of the network**

SWoT architecture



[Seydoux et al., 2017] (SWIT@ISWC)

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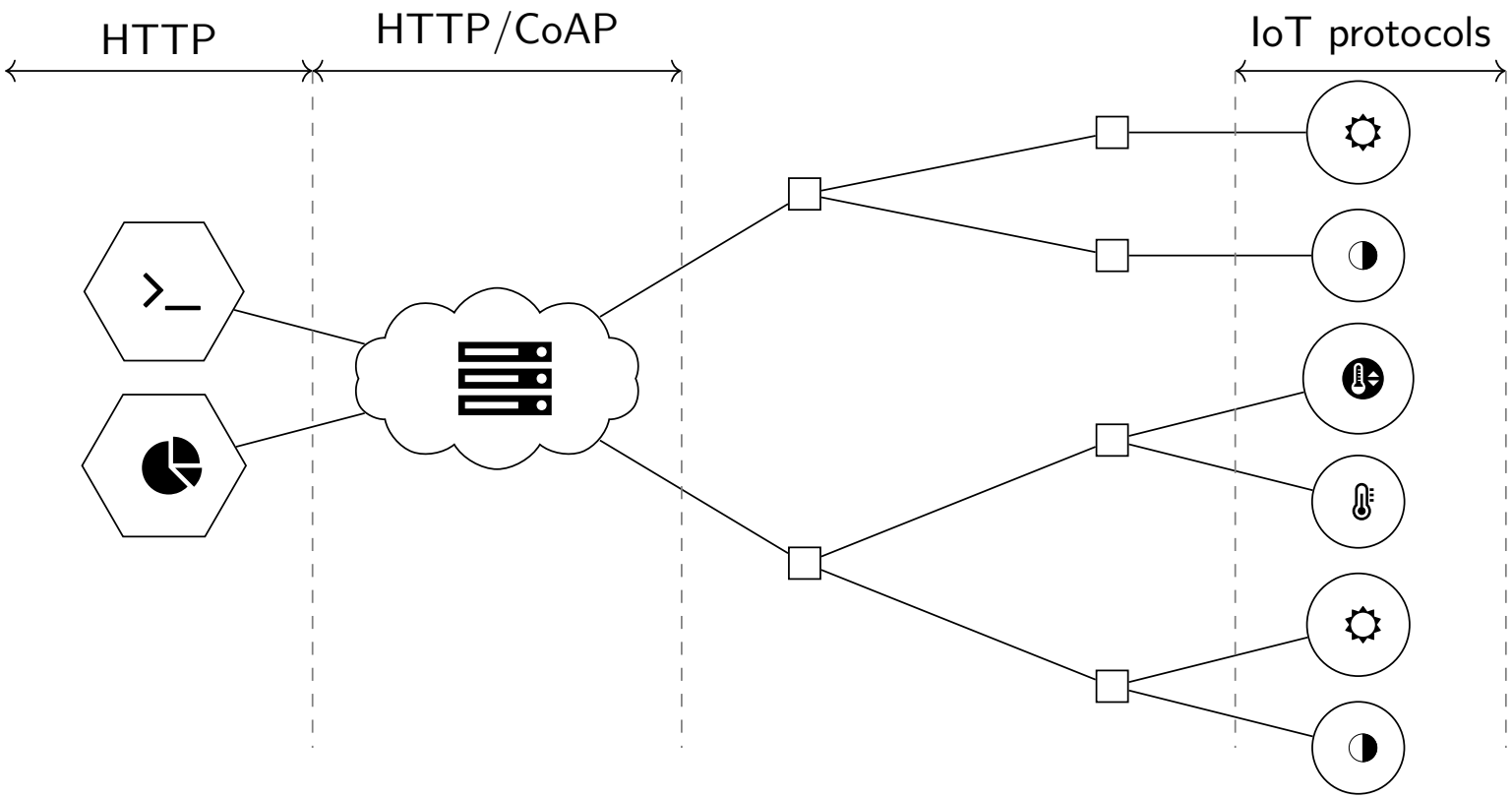

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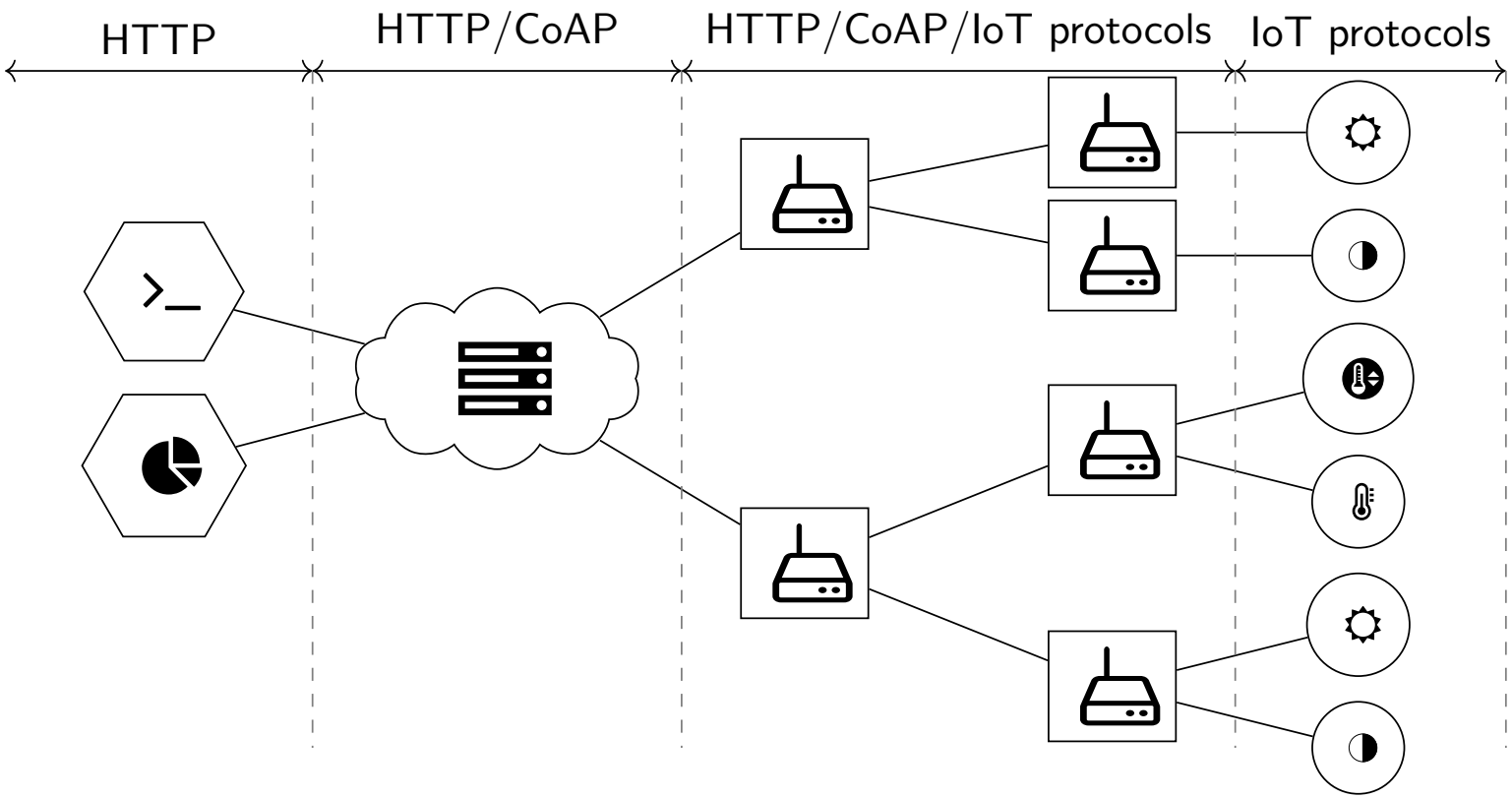

[Su et al., 2018, Xu and Helal, 2016, Ben-Alaya et al., 2015, Zanella et al., 2014]

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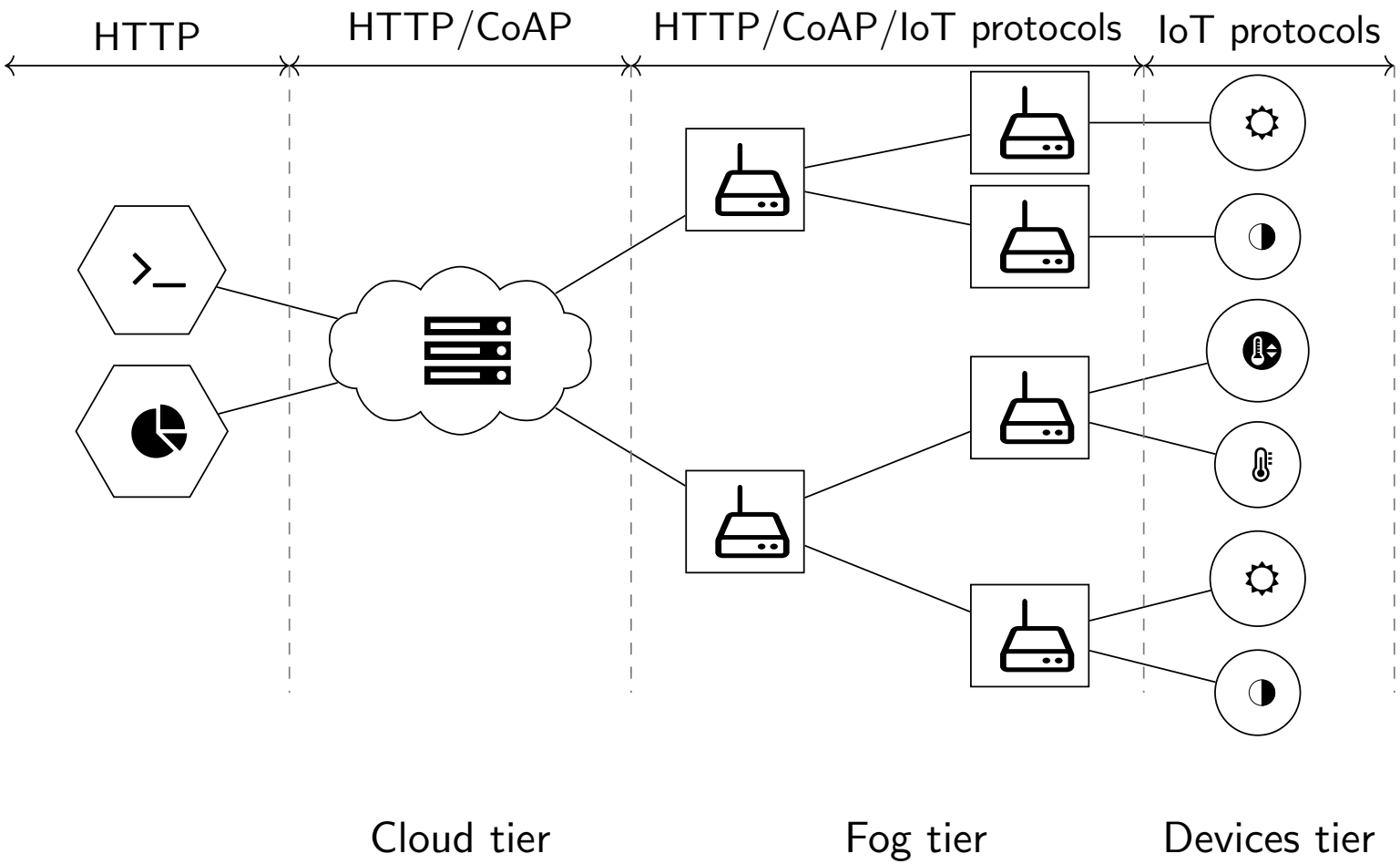

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SWoT functionalities

Bottom-up approach

- Recurring usage patterns in the litterature
- 14 functions identified

Node-oriented

- Abstraction
- Composition
- Configuration
- Discovery
- Selection

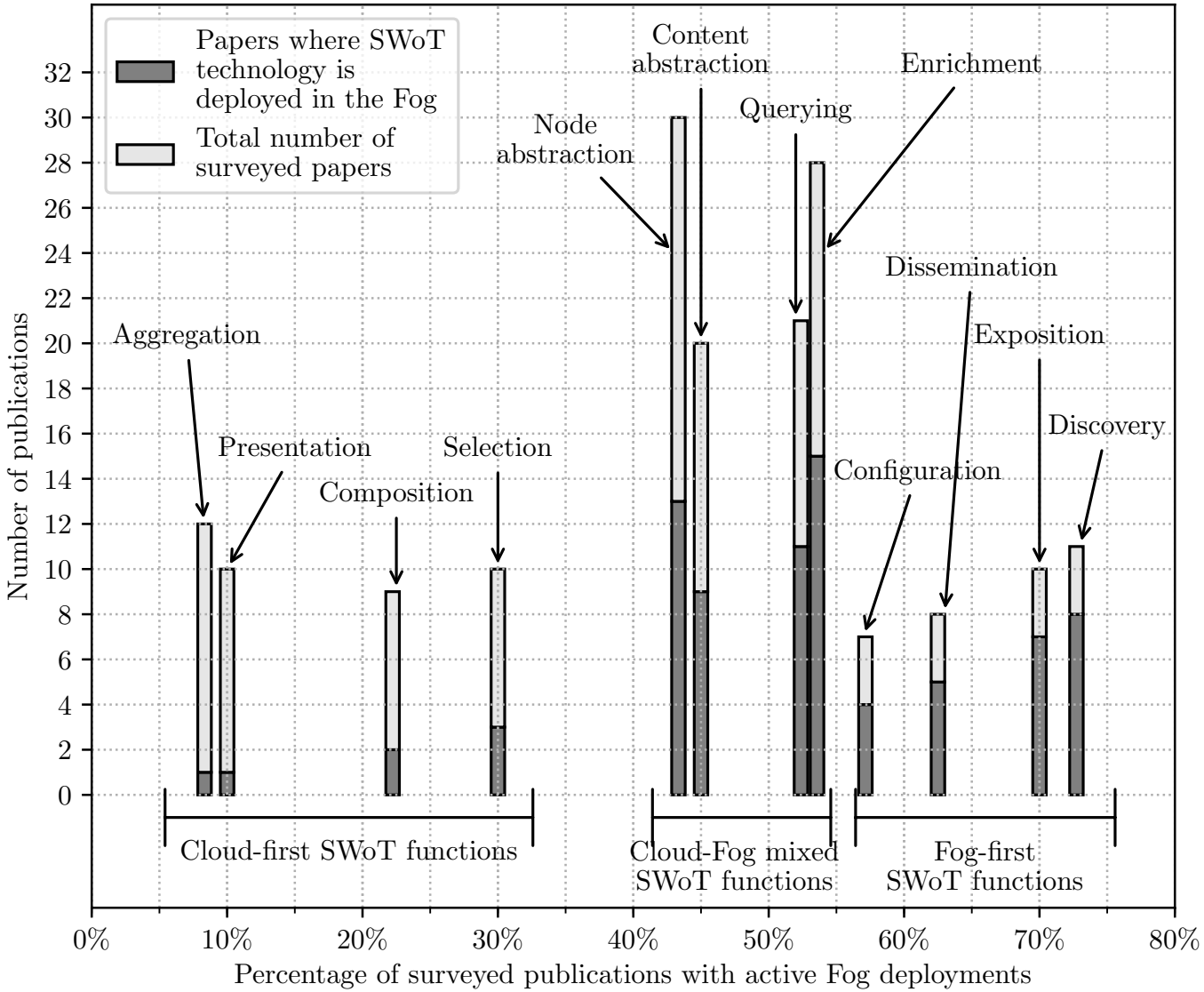
Content-oriented

- Enrichment
- Abstraction
- Aggregation
- Presentation

Node/content

- Dissemination
- Querying

Situating functions in the architecture



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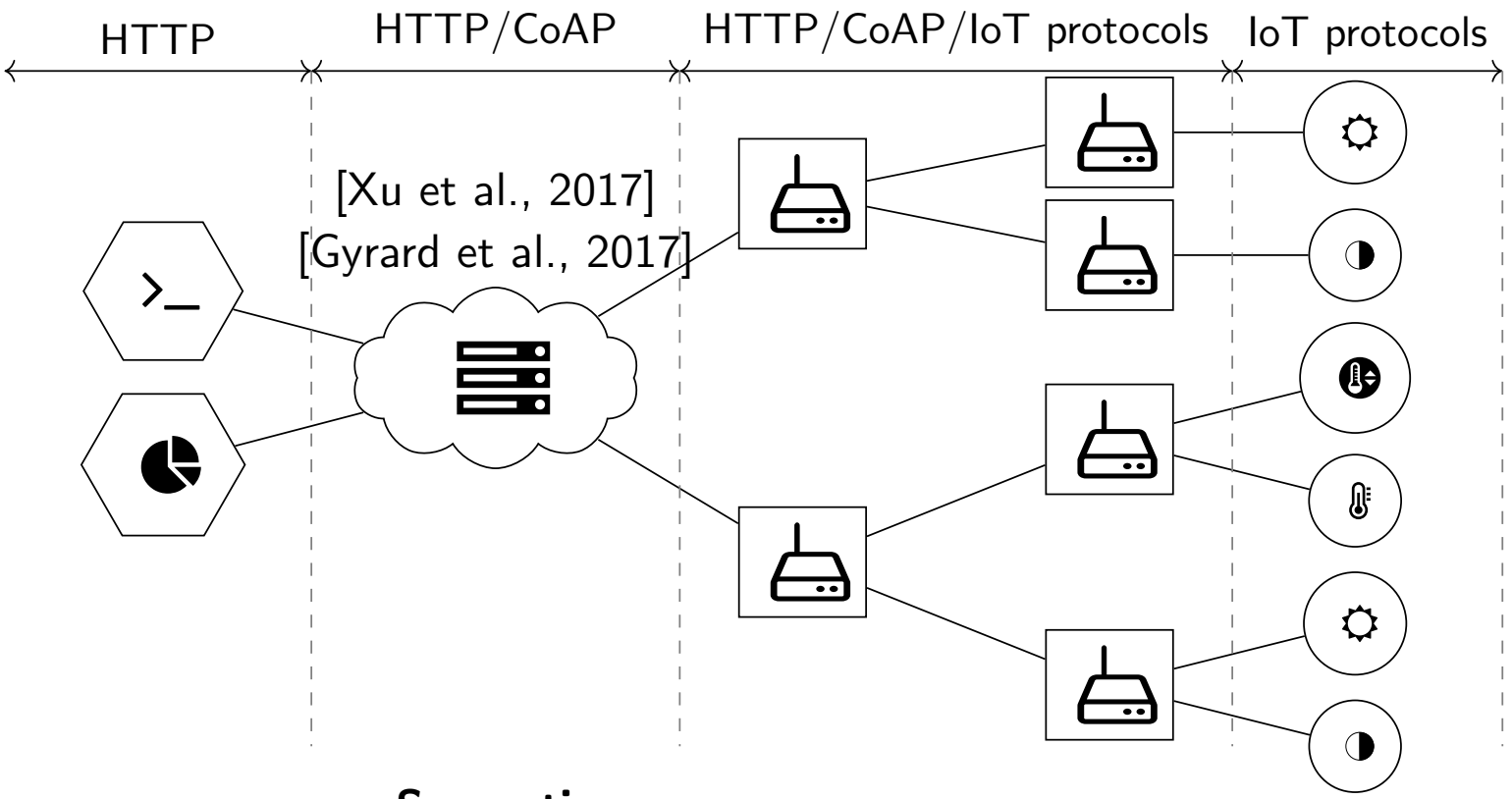

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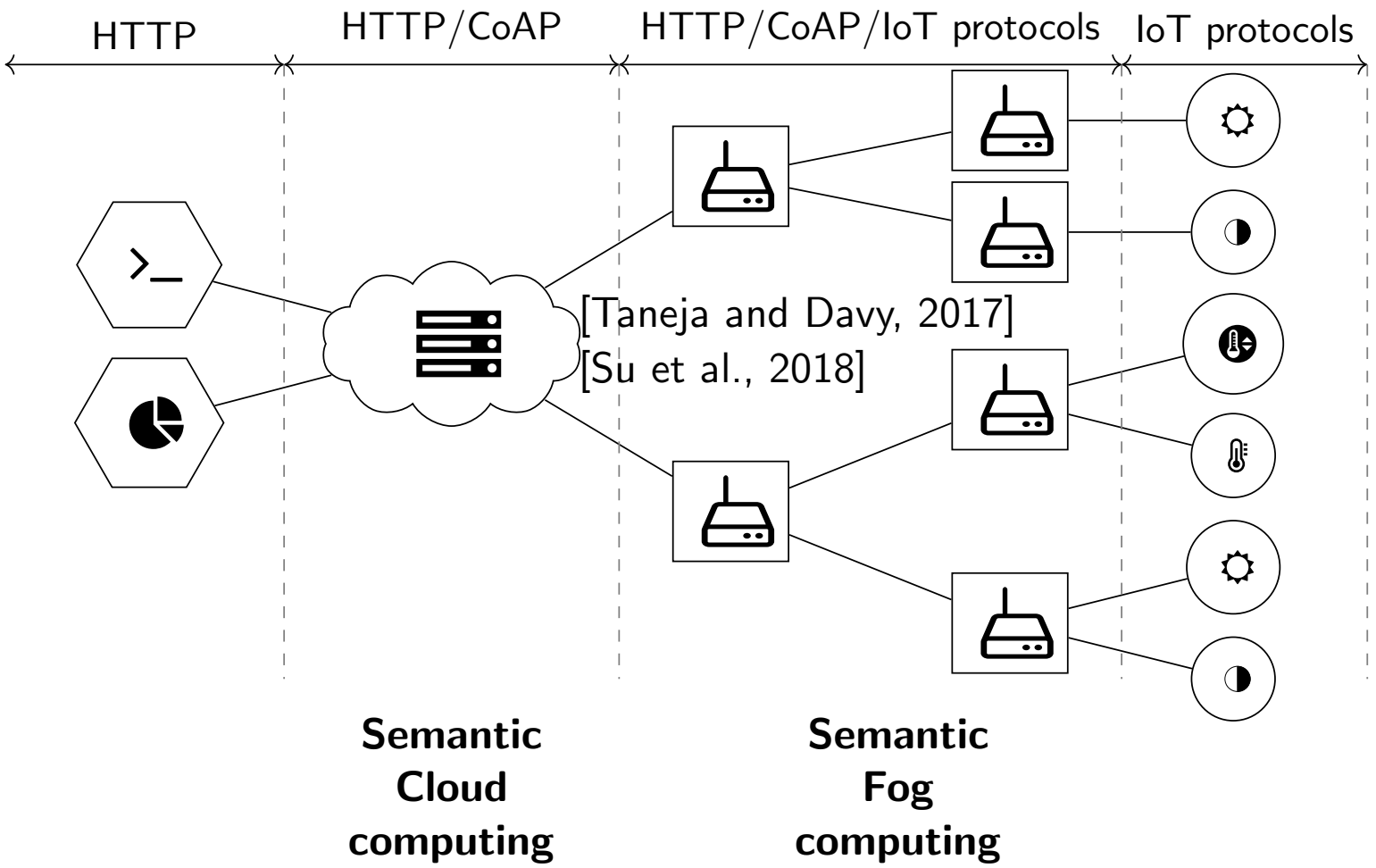

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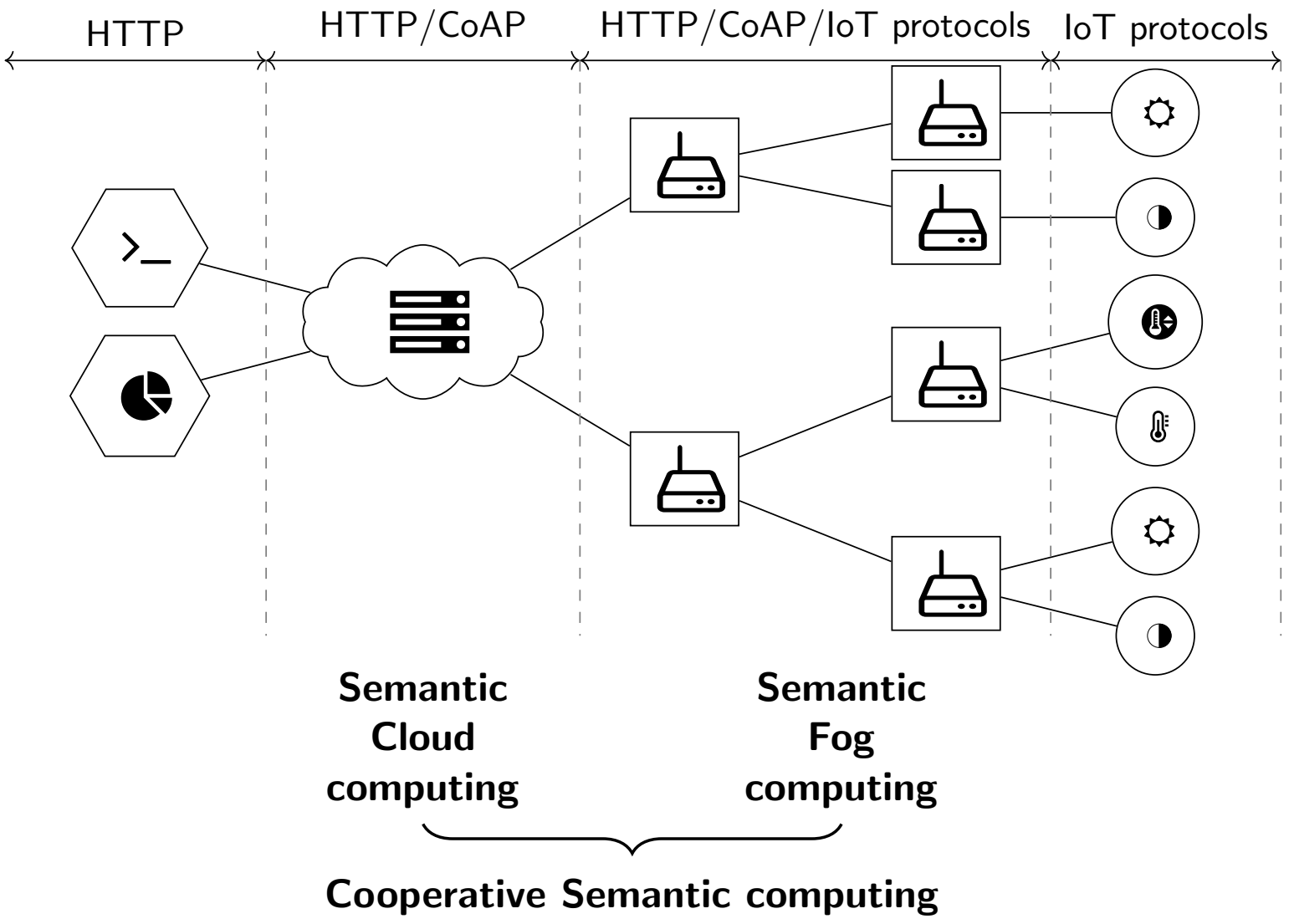

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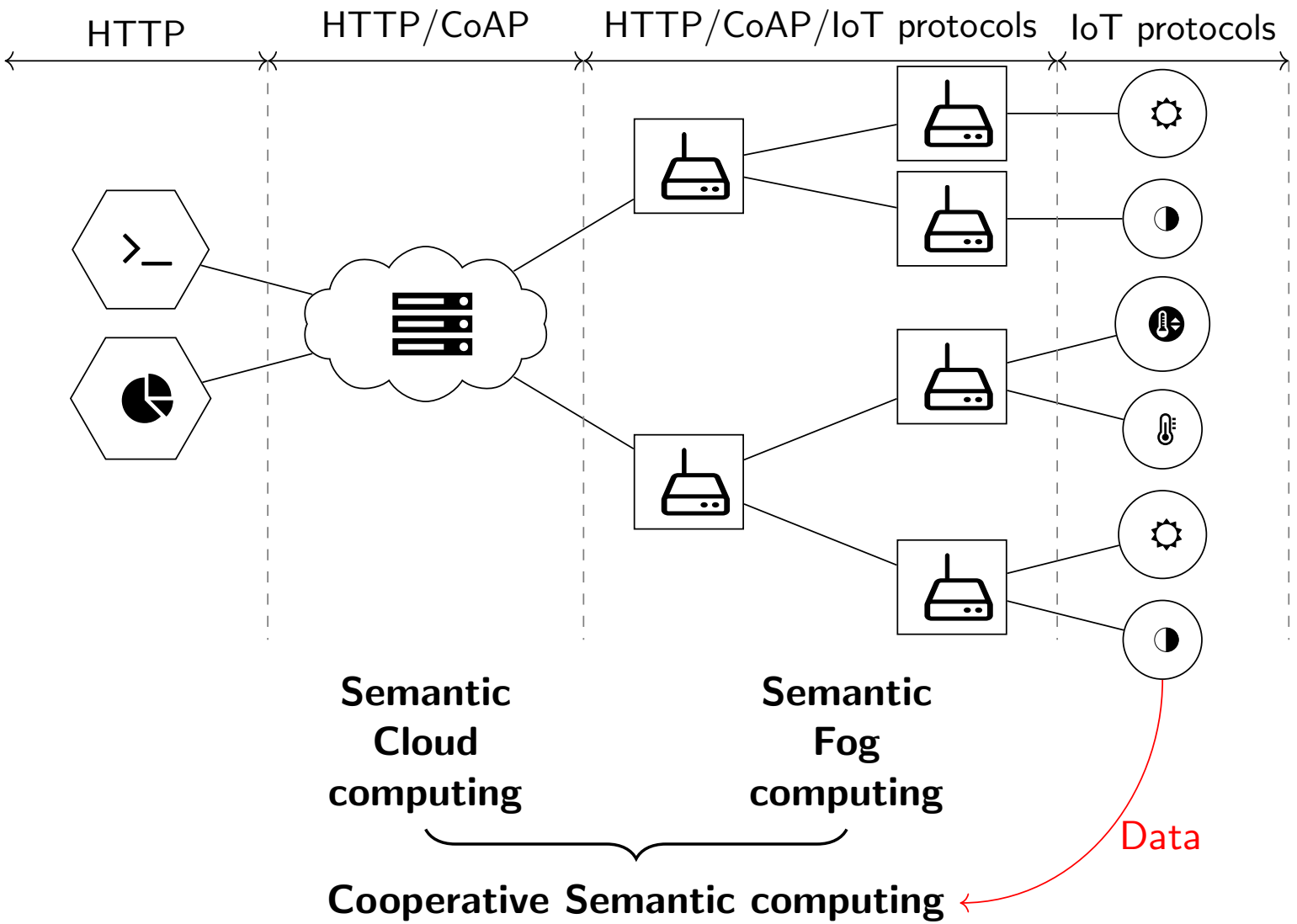

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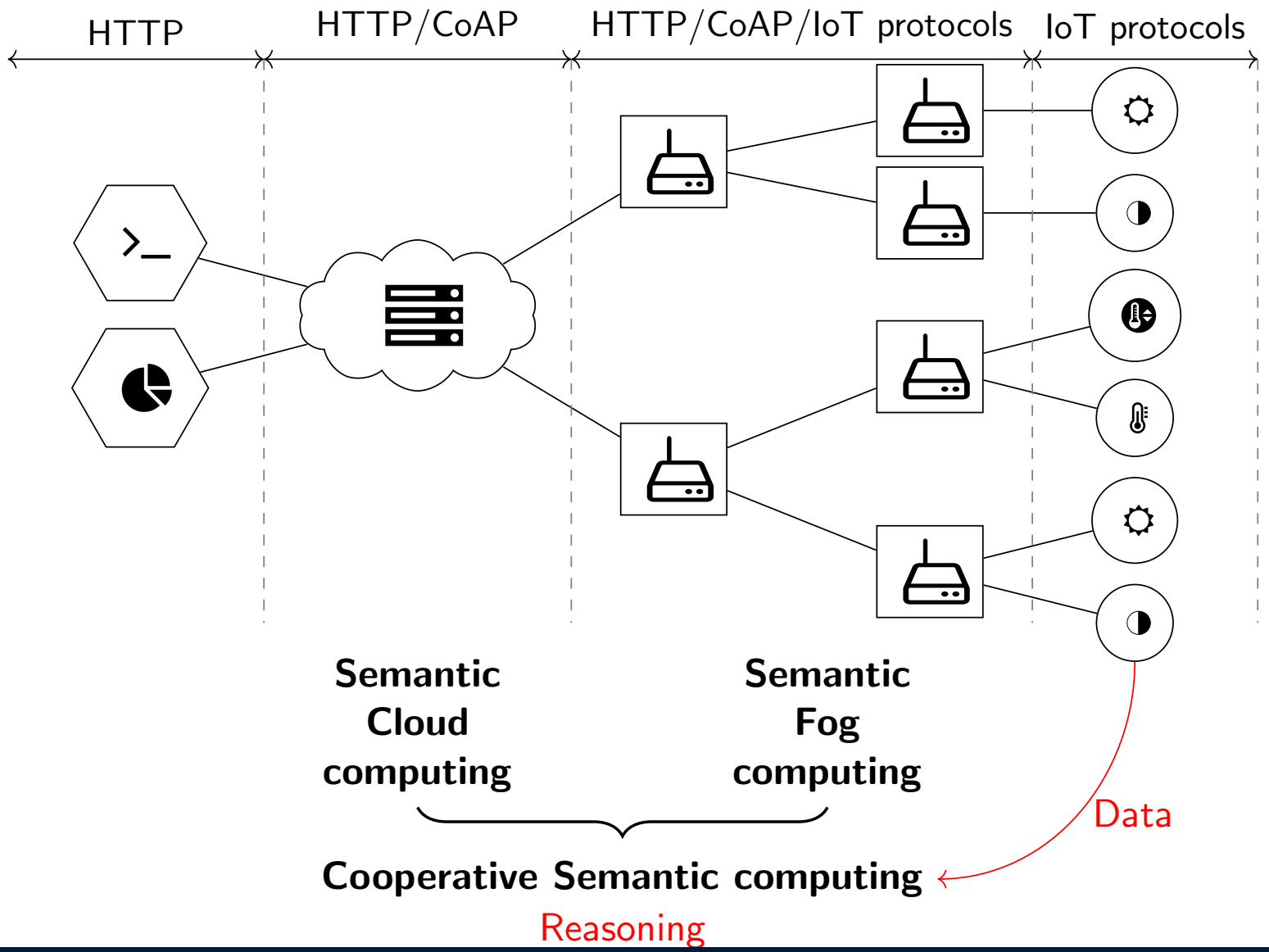

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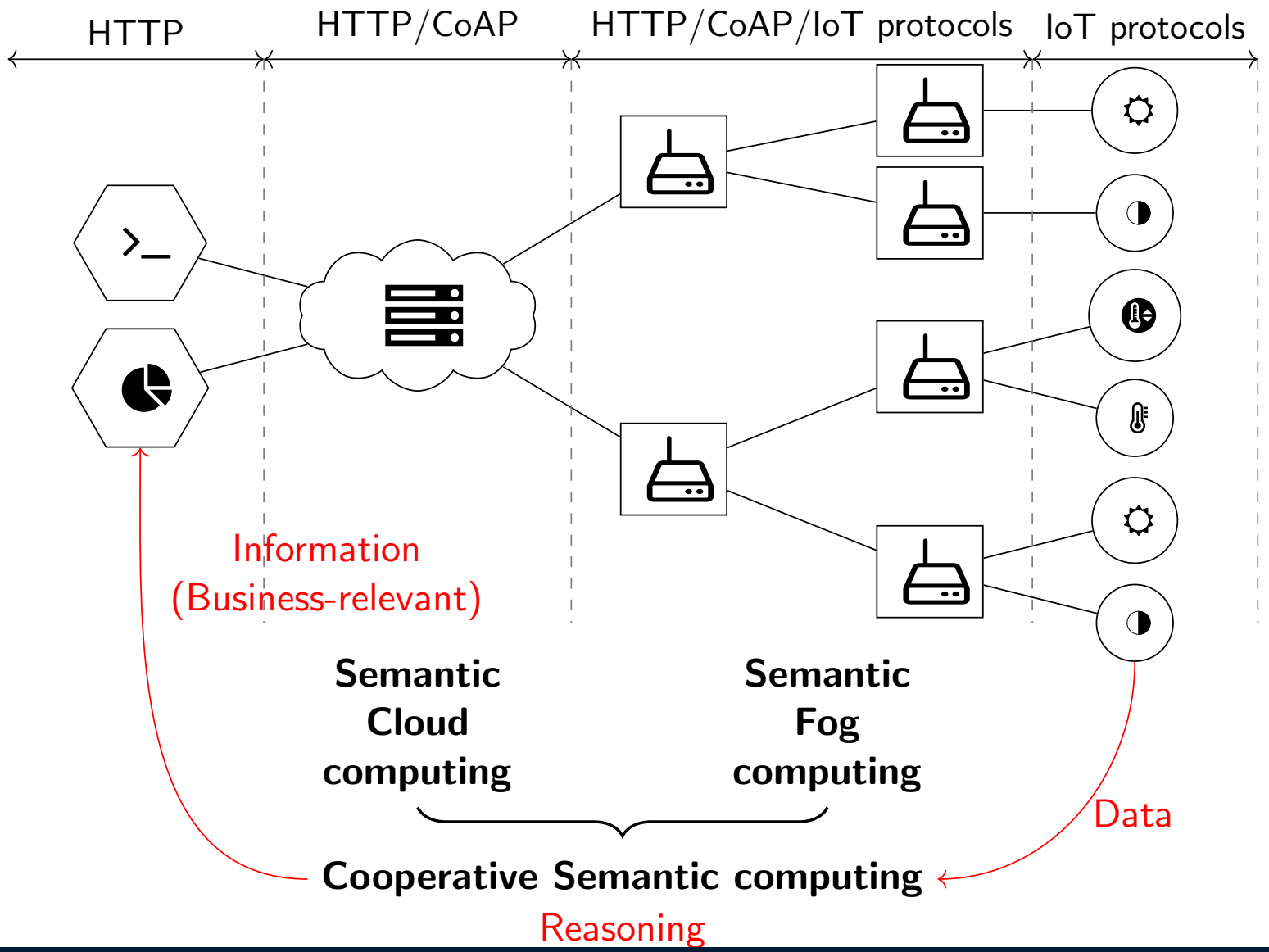

Contribution for dynamically distributed reasoning

Emergent Distributed Reasoning (EDR)

- A generic approach to dynamic distribution of rule-based reasoning
- Based on SHACL **modular rules** [Kaed et al., 2018]
- Associated to a propagation **algorithm**
- **Strategy-agnostic**

[Seydoux et al., 2018c] (COOPIS)

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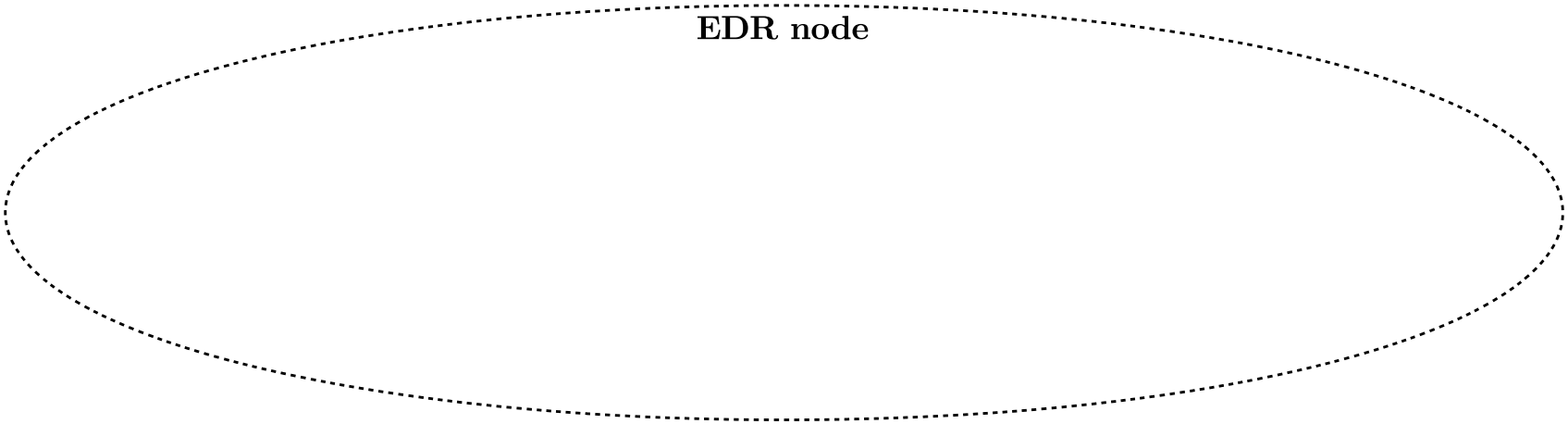
EDR$_{\mathcal{T}}$

- Refining EDR with a propagation strategy
- Propagates rules as close to sensors as possible

[Seydoux et al., 2018b] (ITL), **[Seydoux et al., 2018a]** (Web Intelligence)

Node-centric functional overview of EDR



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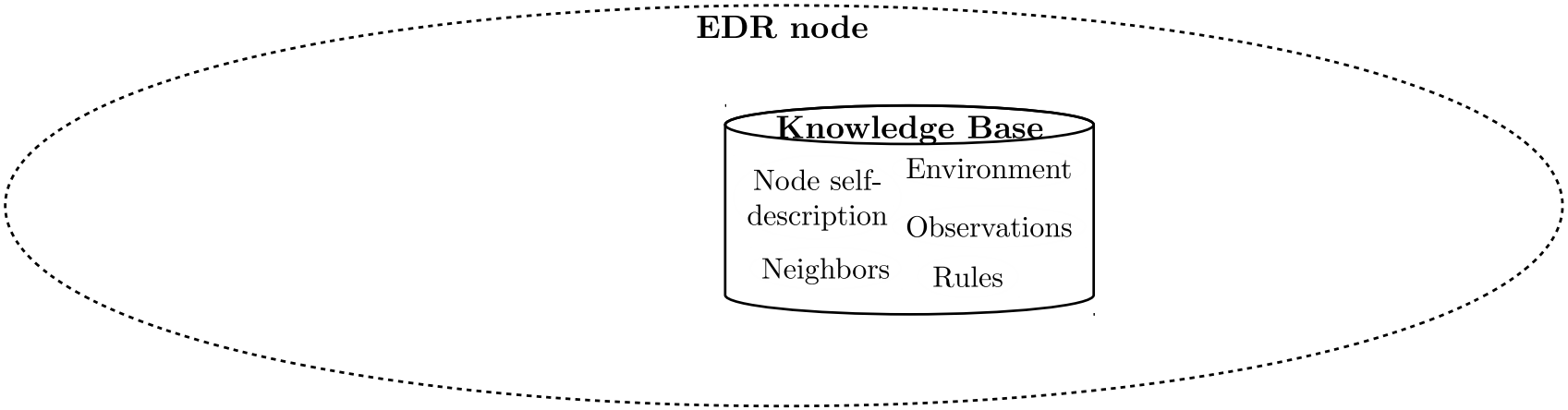

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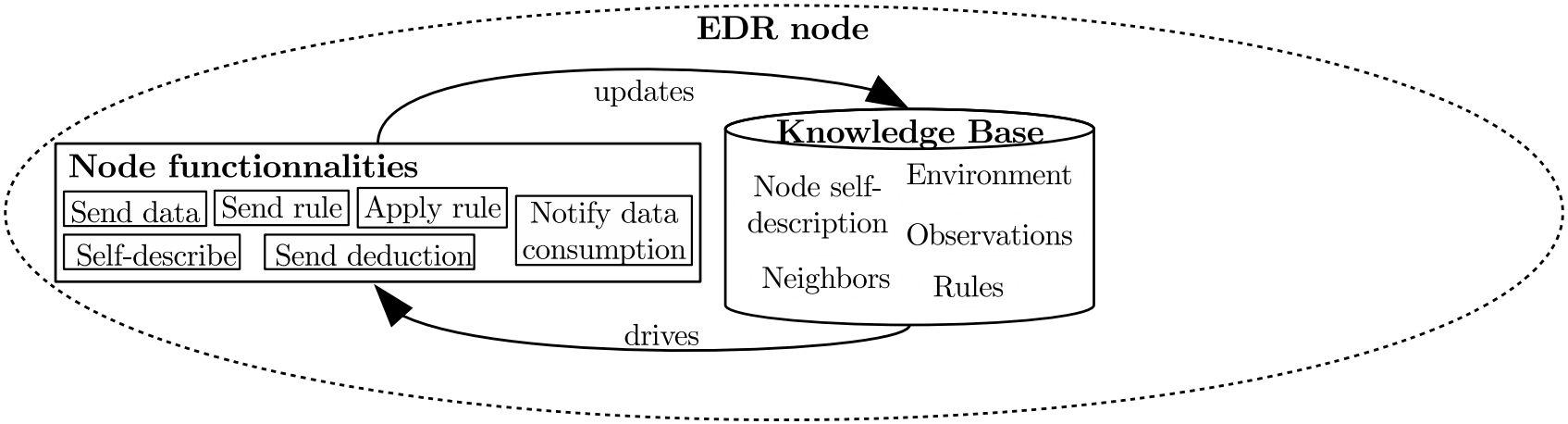

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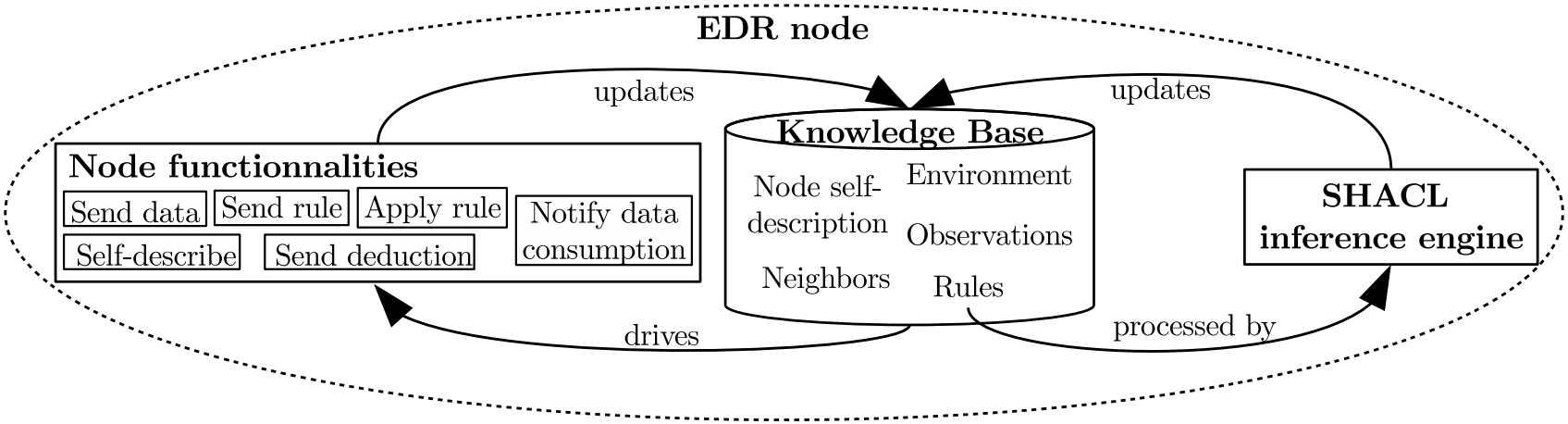
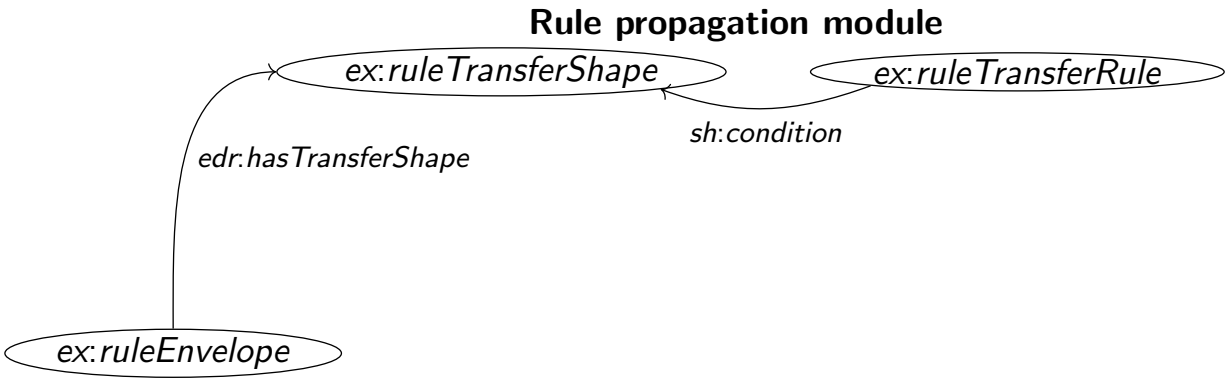


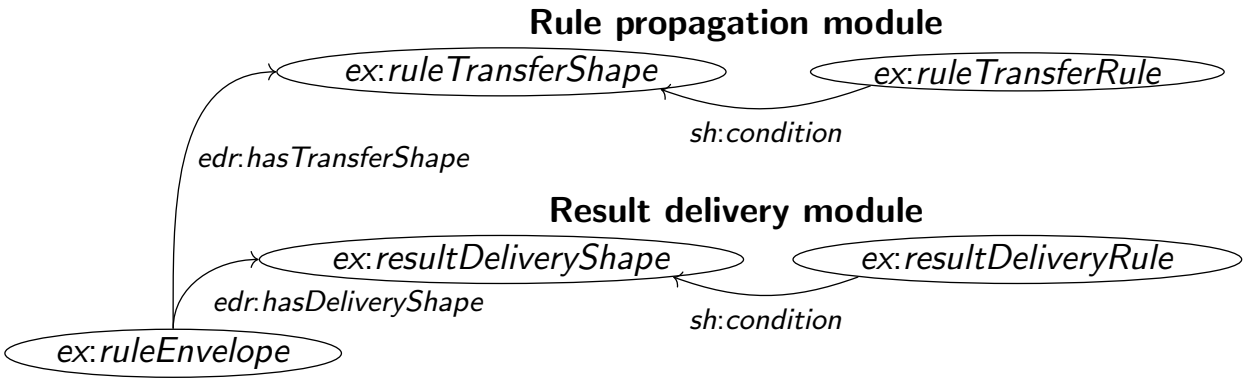
EDR modular rules



Example propagation rule

```
SELECT $this {
    FILTER NOT EXISTS {
      $this a lmu:Node ;
        edr:producesDataOn
          adr:Temperature ,
          adr:Luminosity ;
        lmu:hasUpstreamNode [
          a lmu:HostNode ;
        ].
    }
}
```

EDR modular rules



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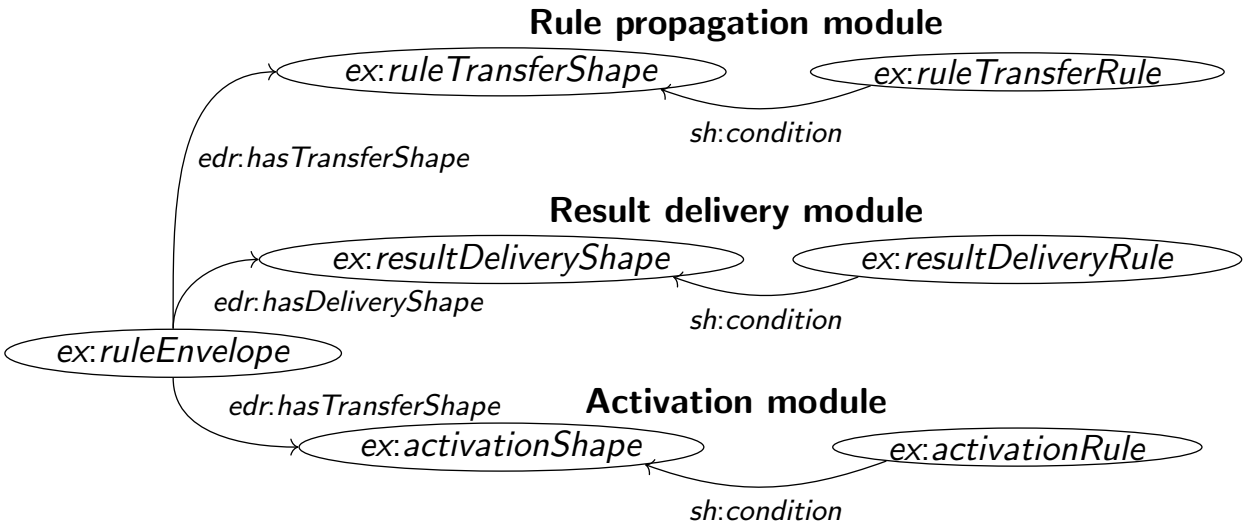

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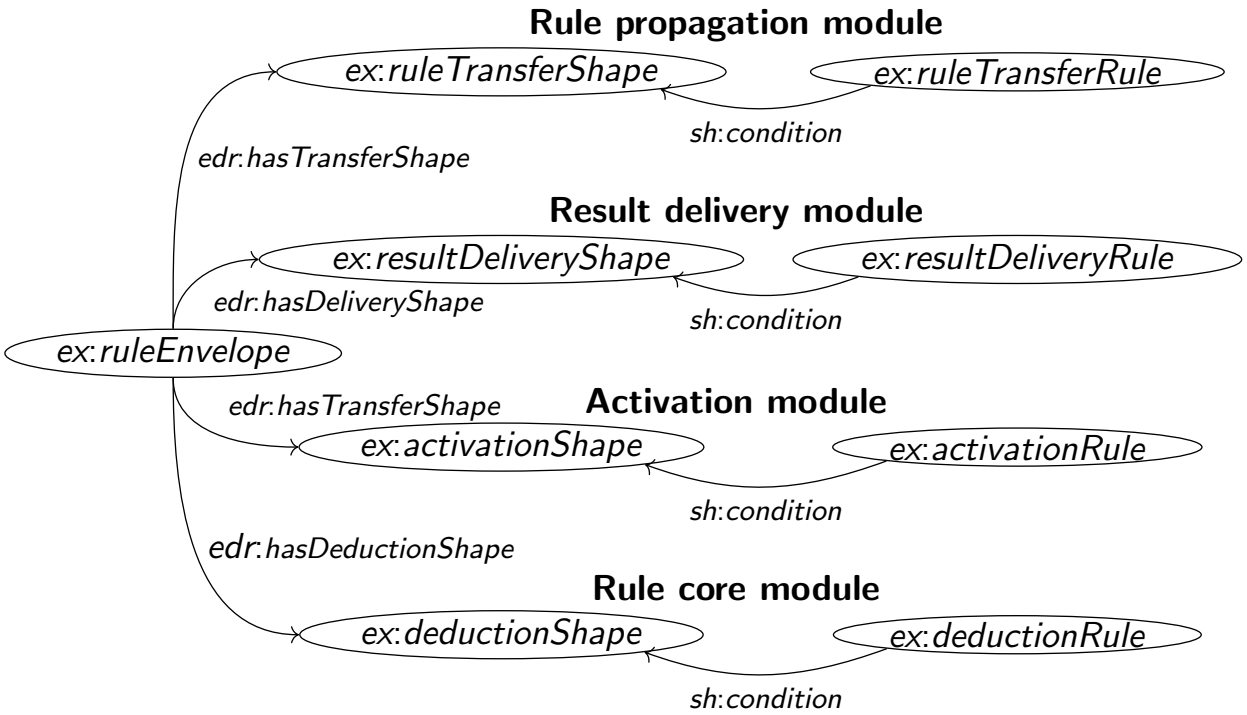
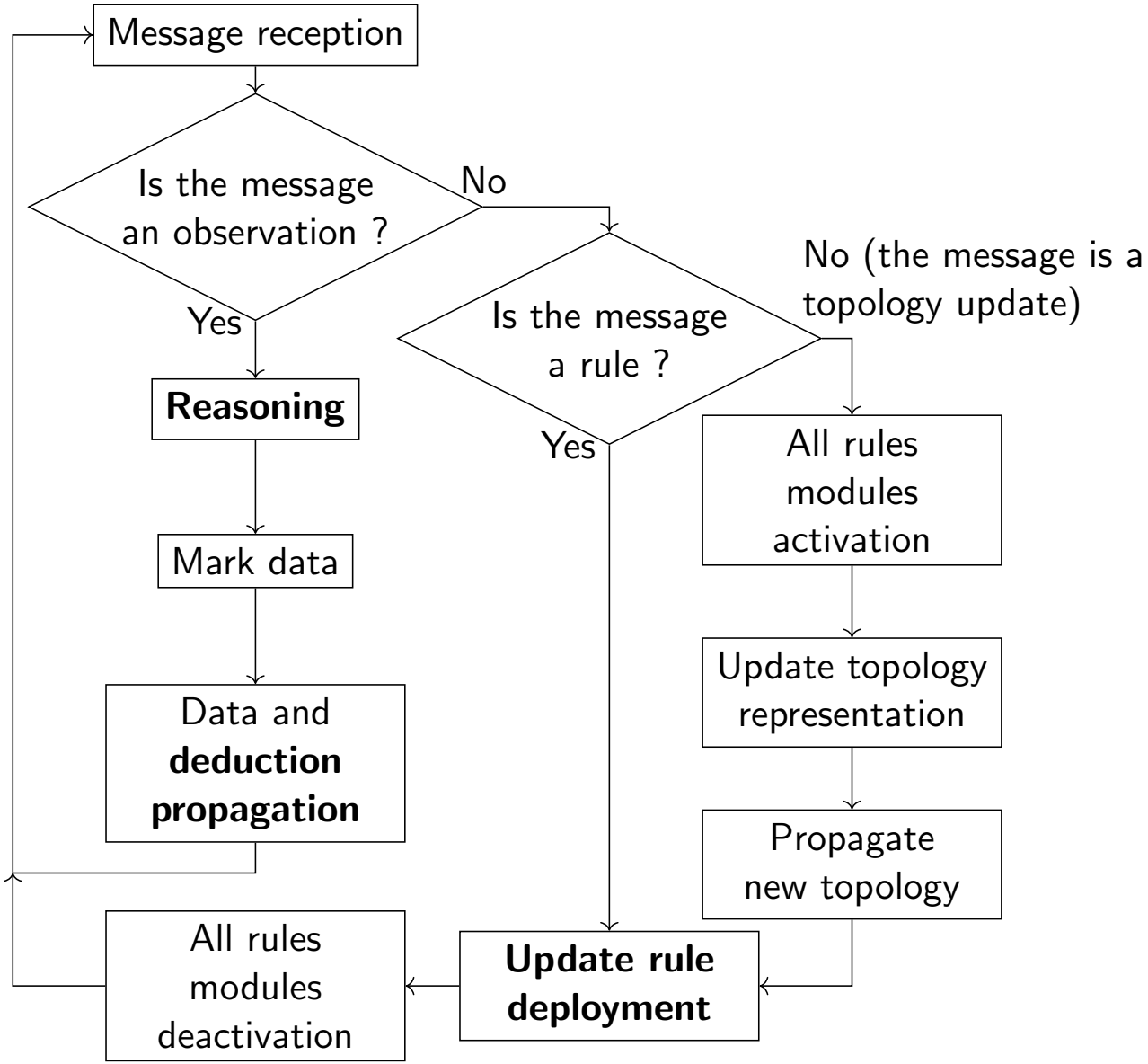


EDR propagation algorithm



Strategies for EDR

EDR$_\mathcal{T}$ strategy

- Bring computation close to sensors
- Consider productions and consumptions
- Based on a proxying mechanism

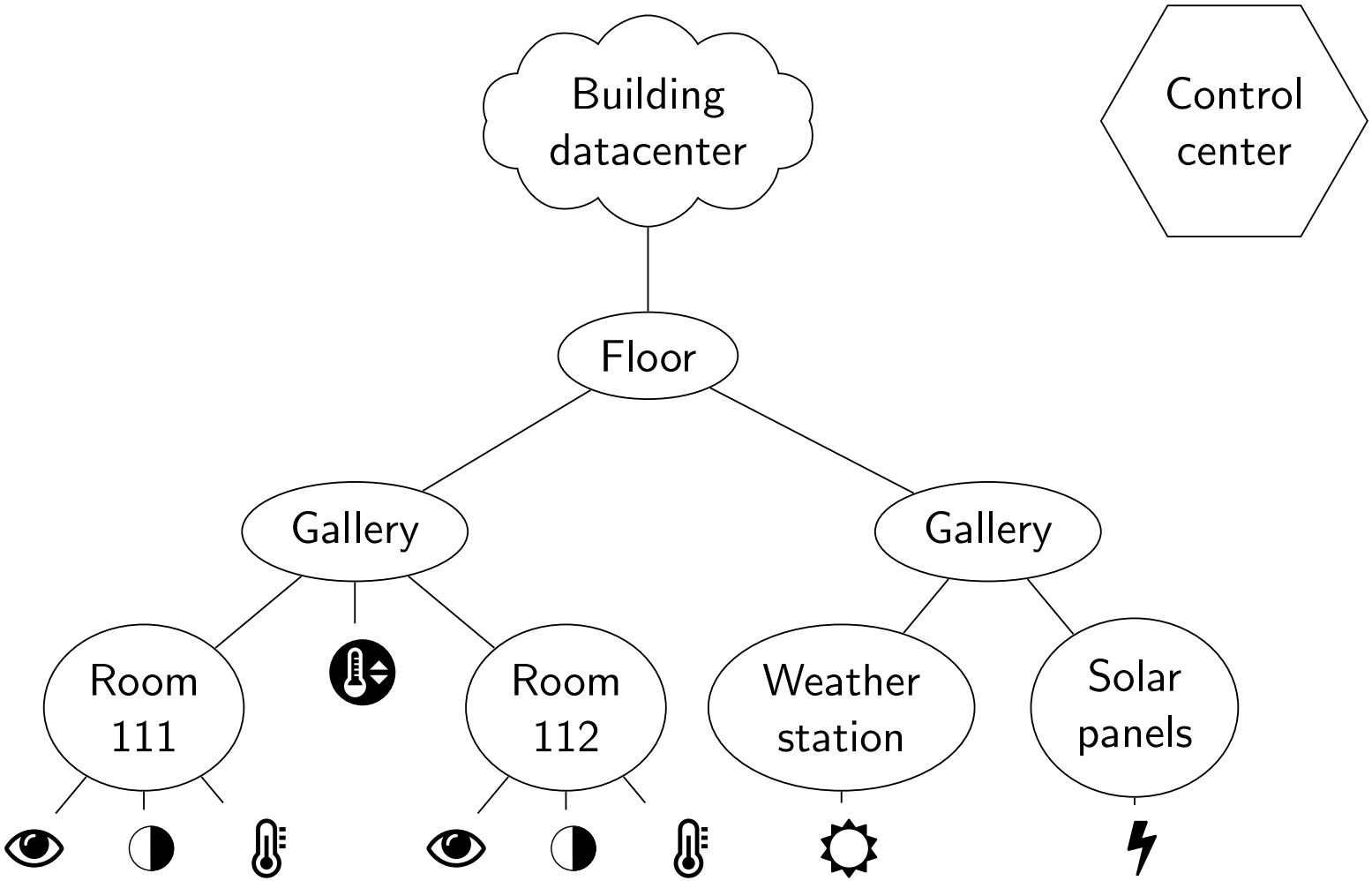
Hypothesis

- Distributing processing improves **scalability** and **response time**

Assumption

- Network **topology embeds** probability of **relatedness** among data

EDR$_\mathcal{T}$ by the example



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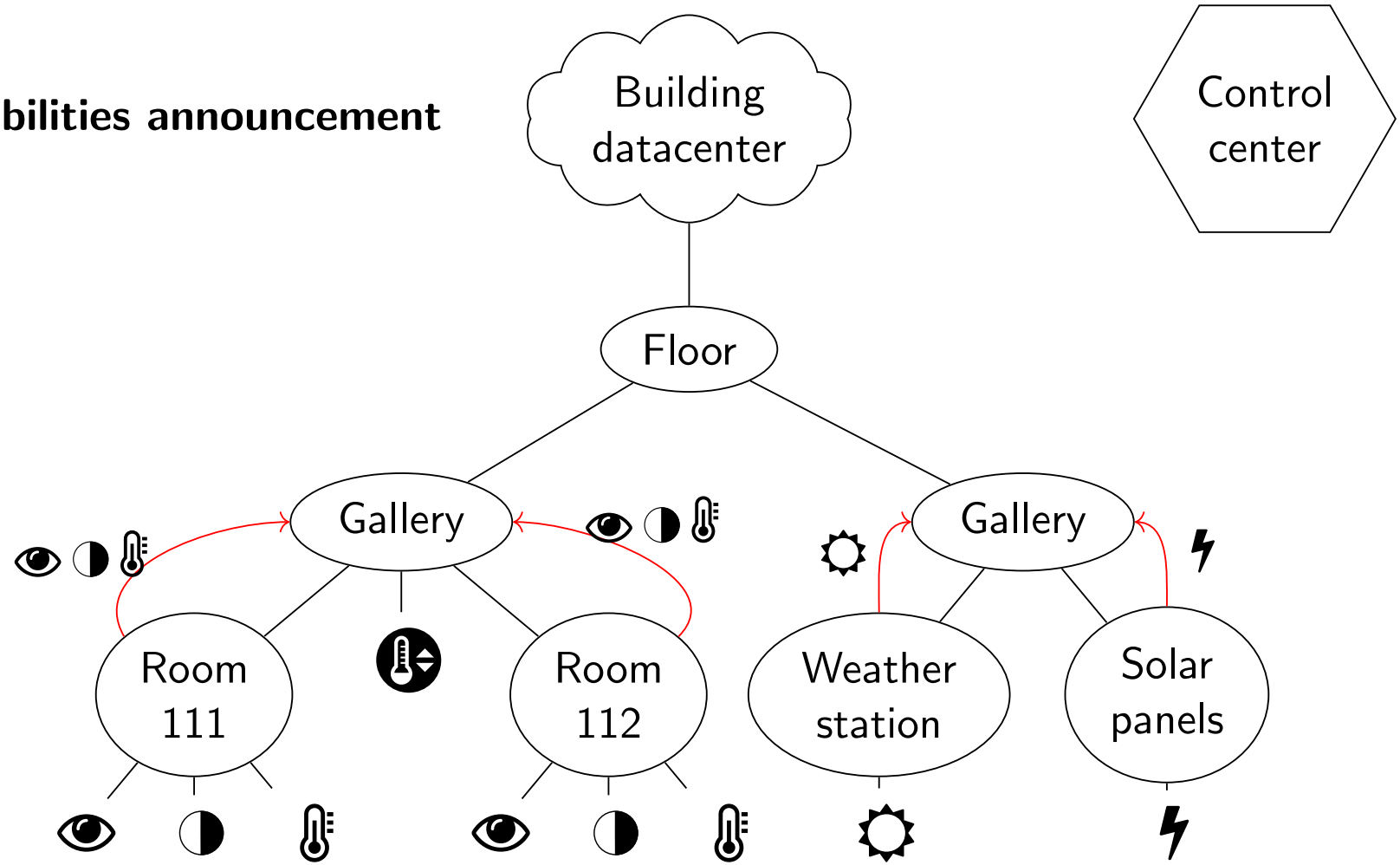
Capabilities announcement



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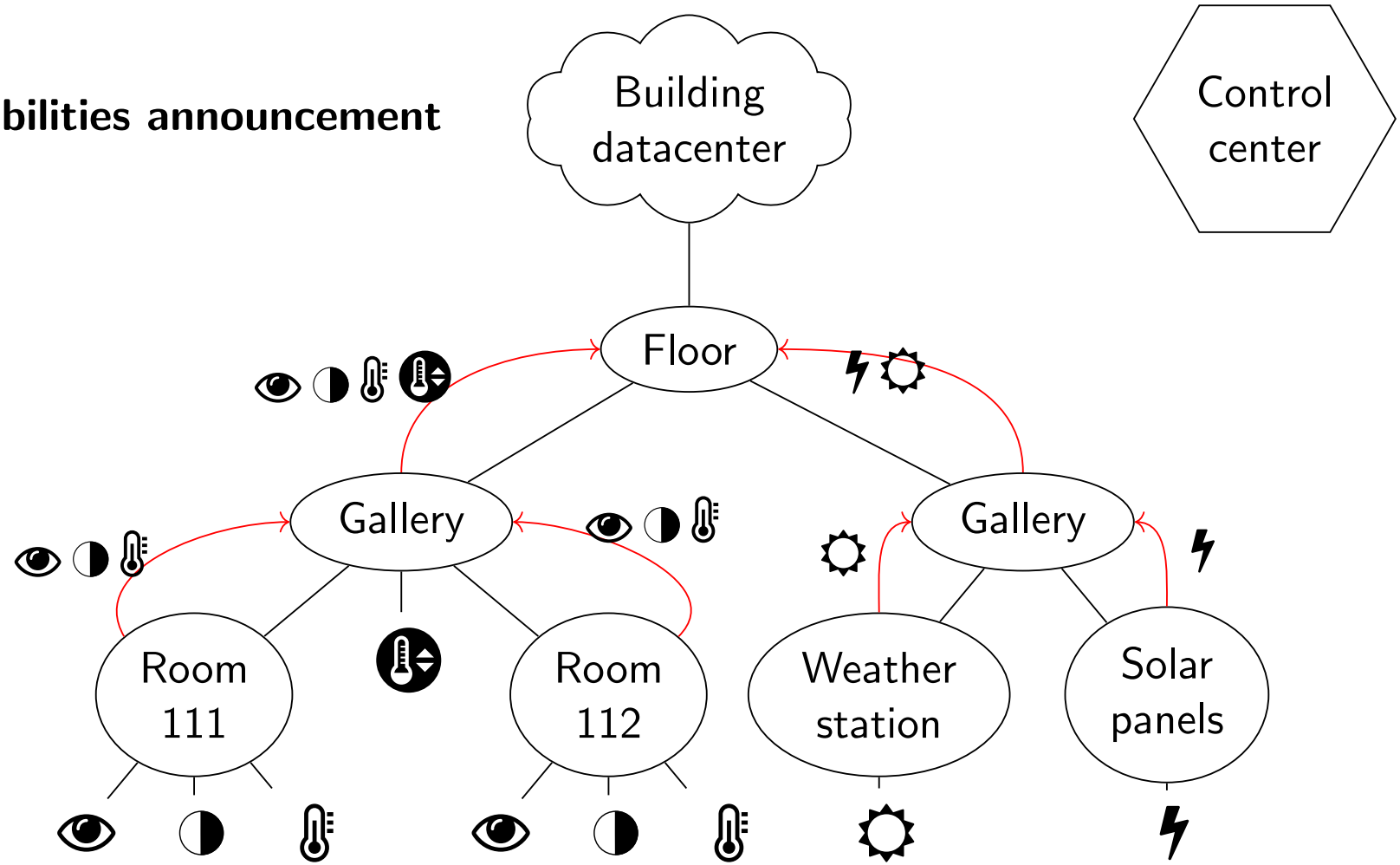

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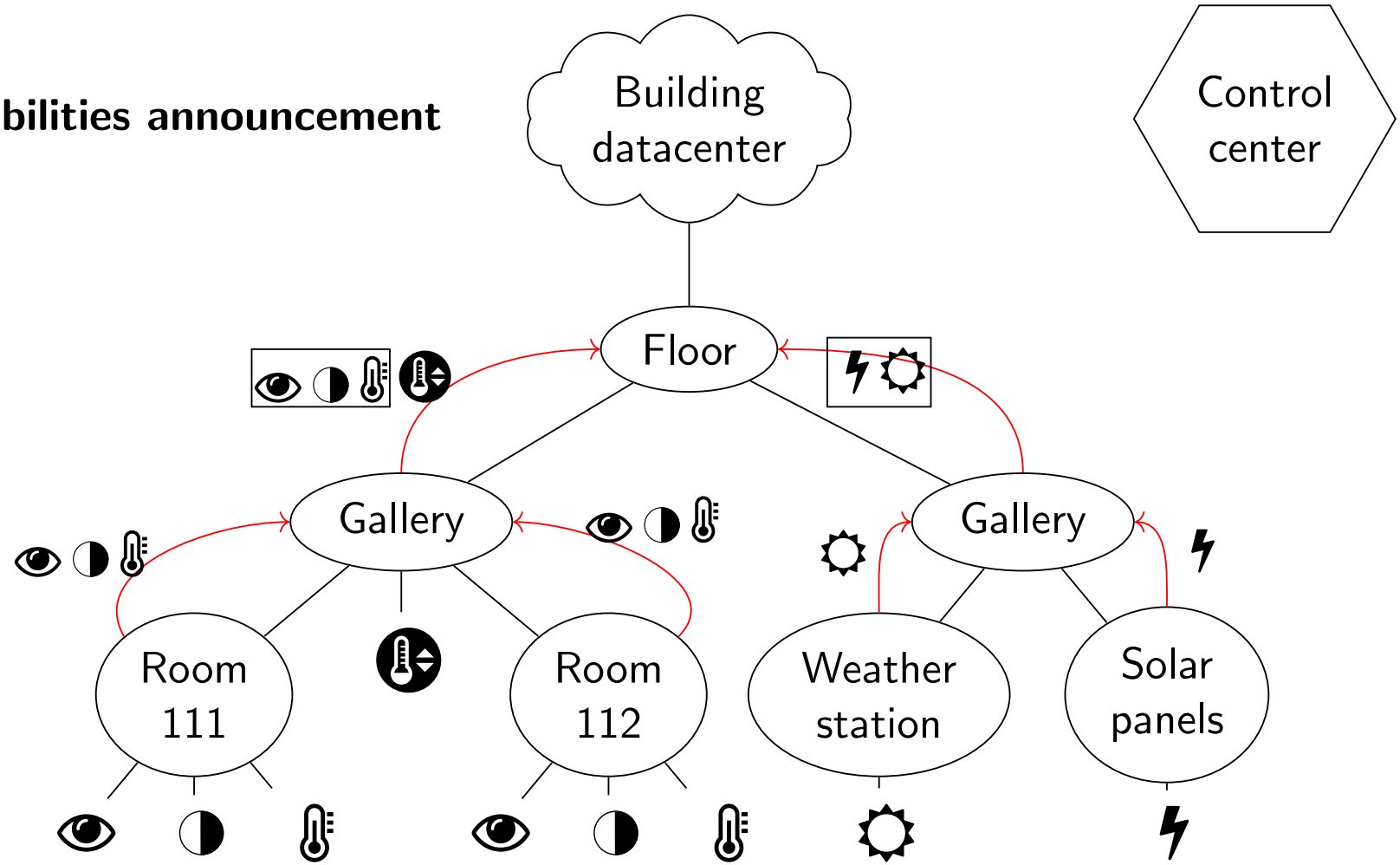

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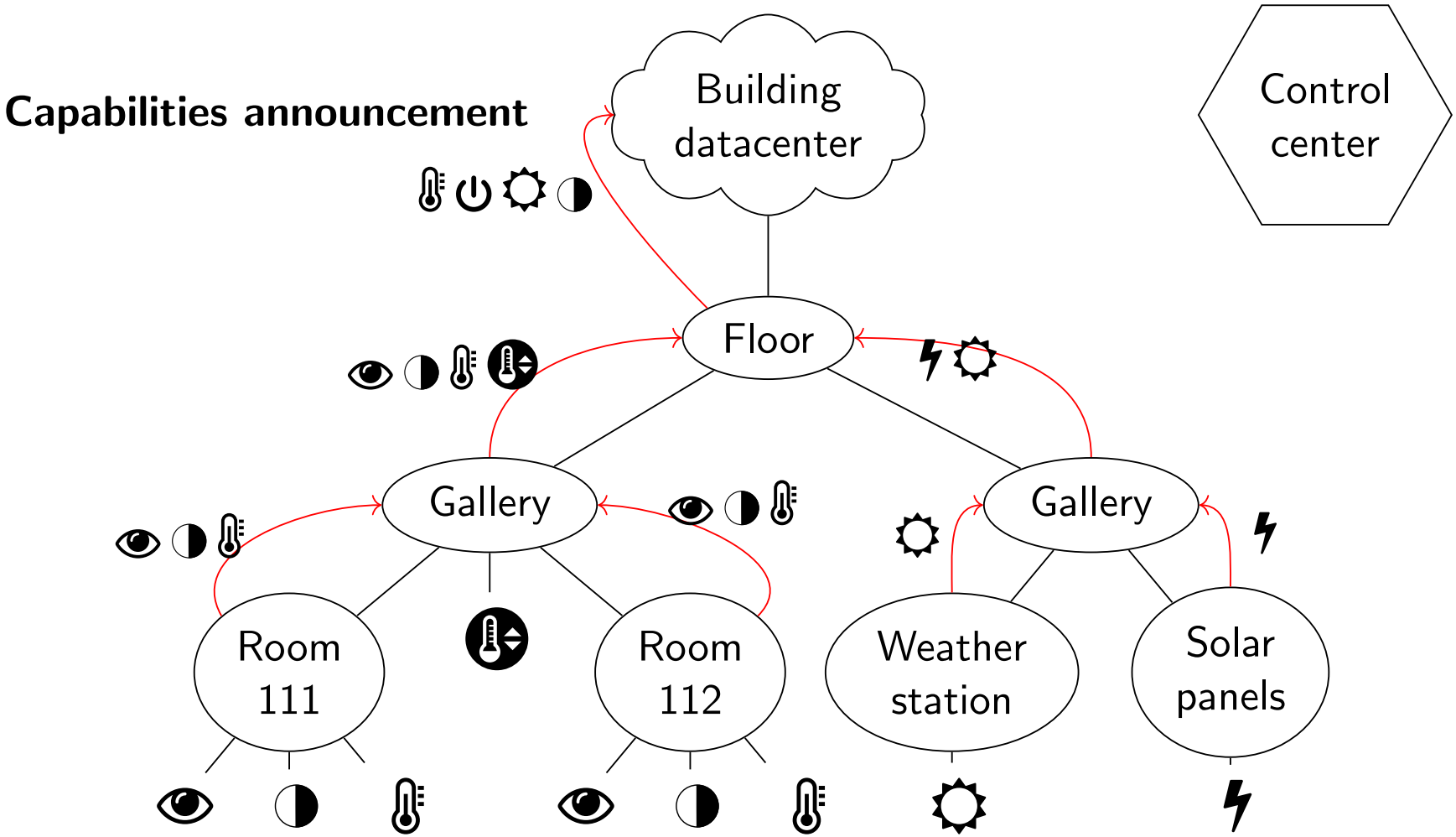

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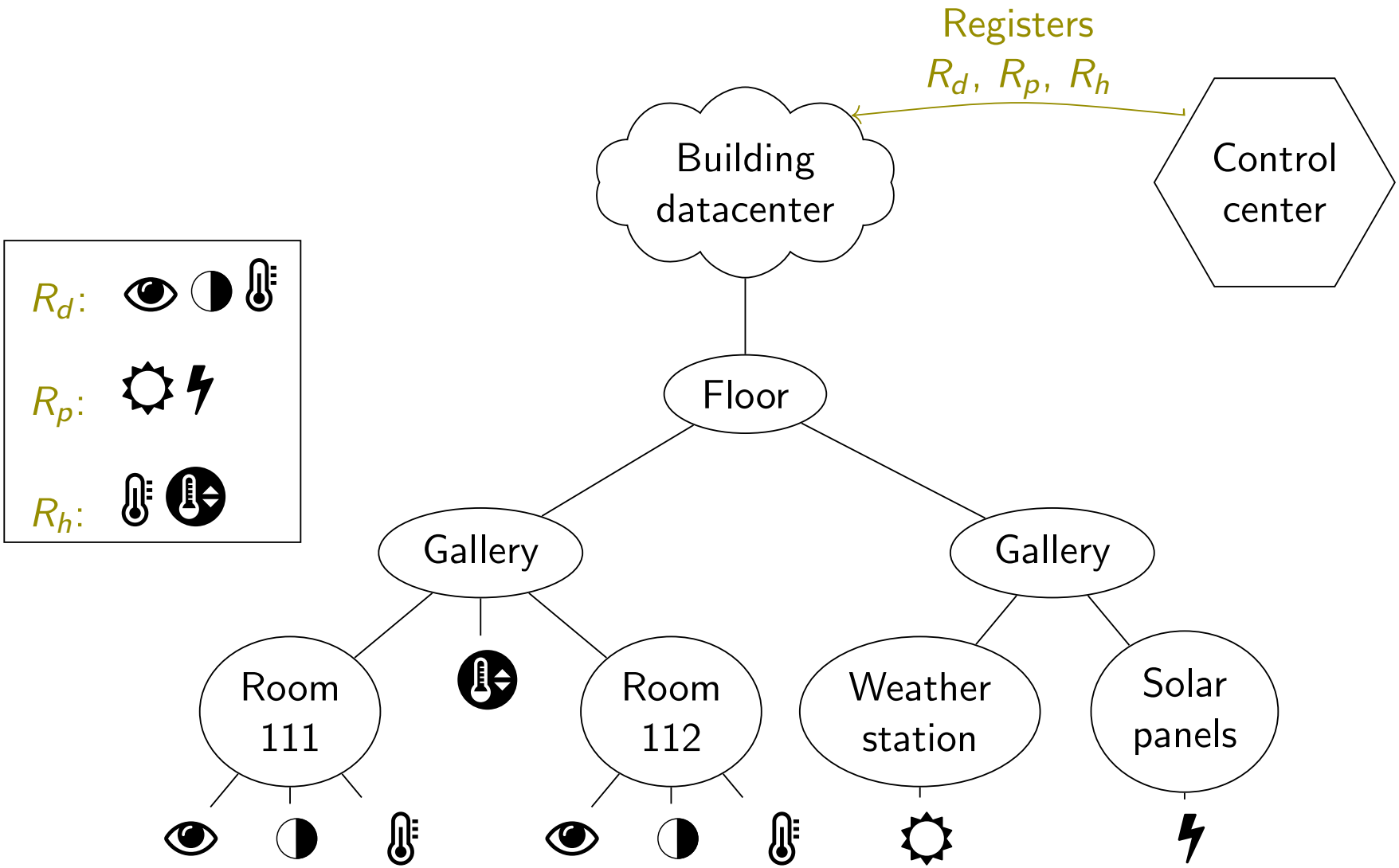

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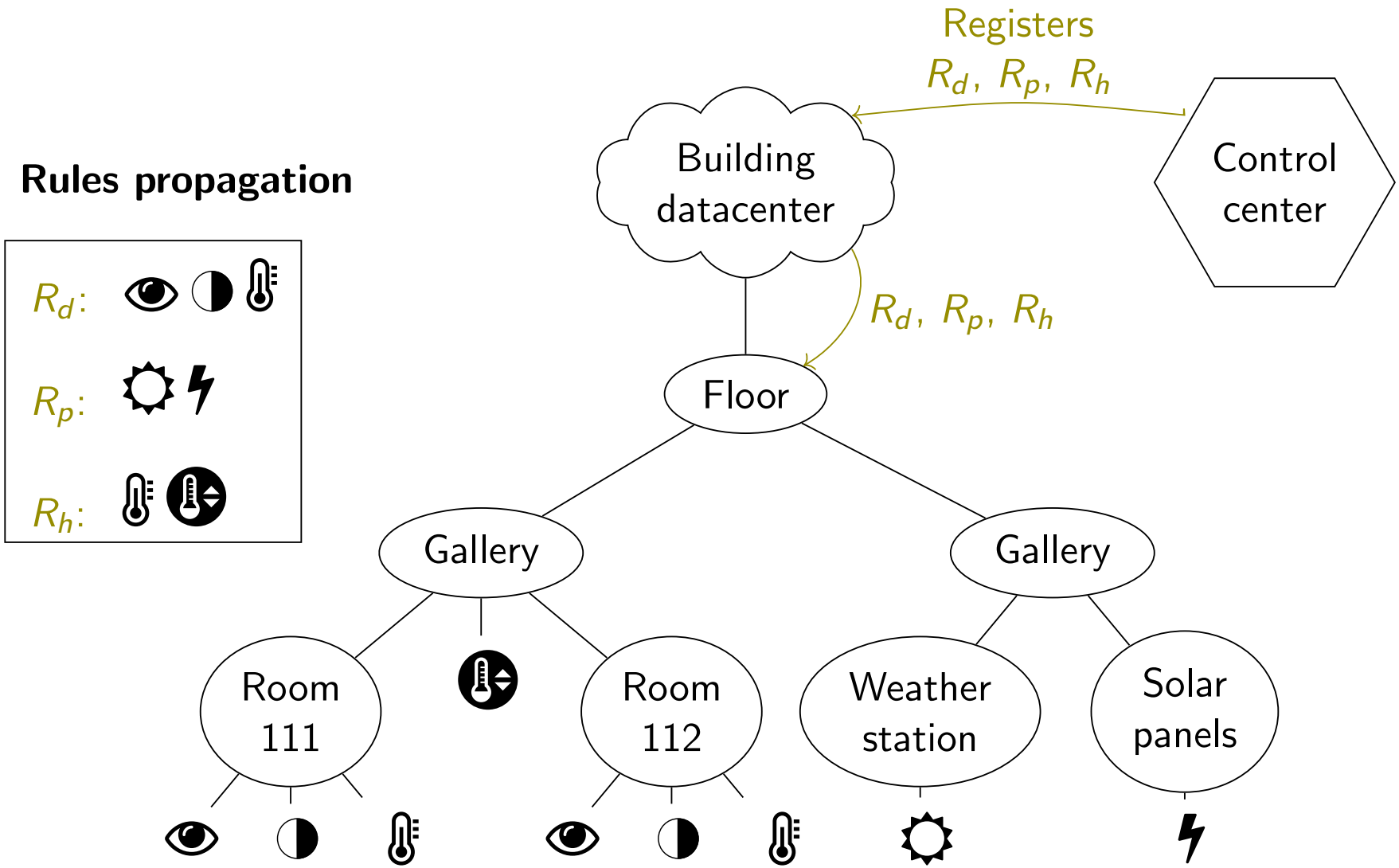

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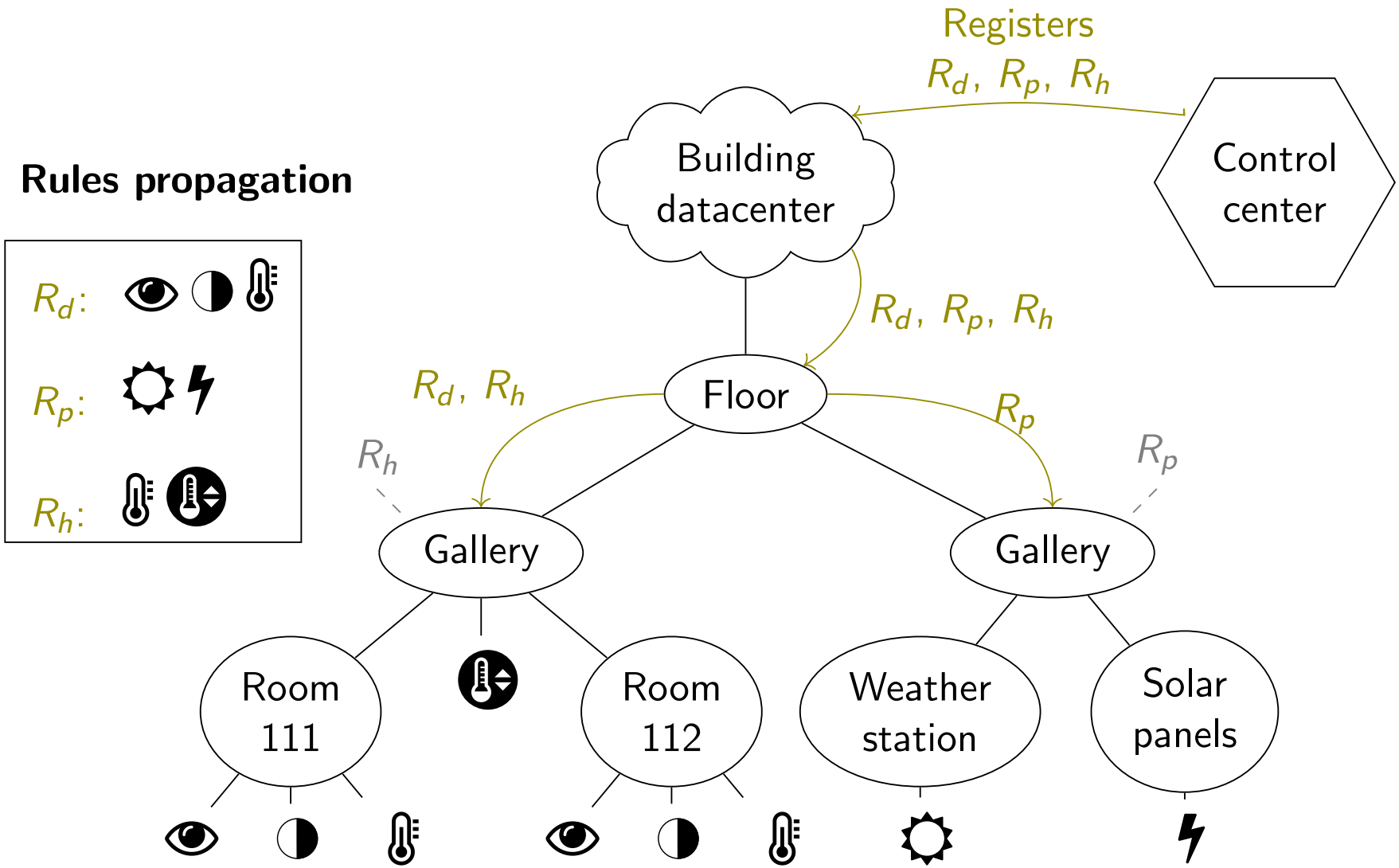
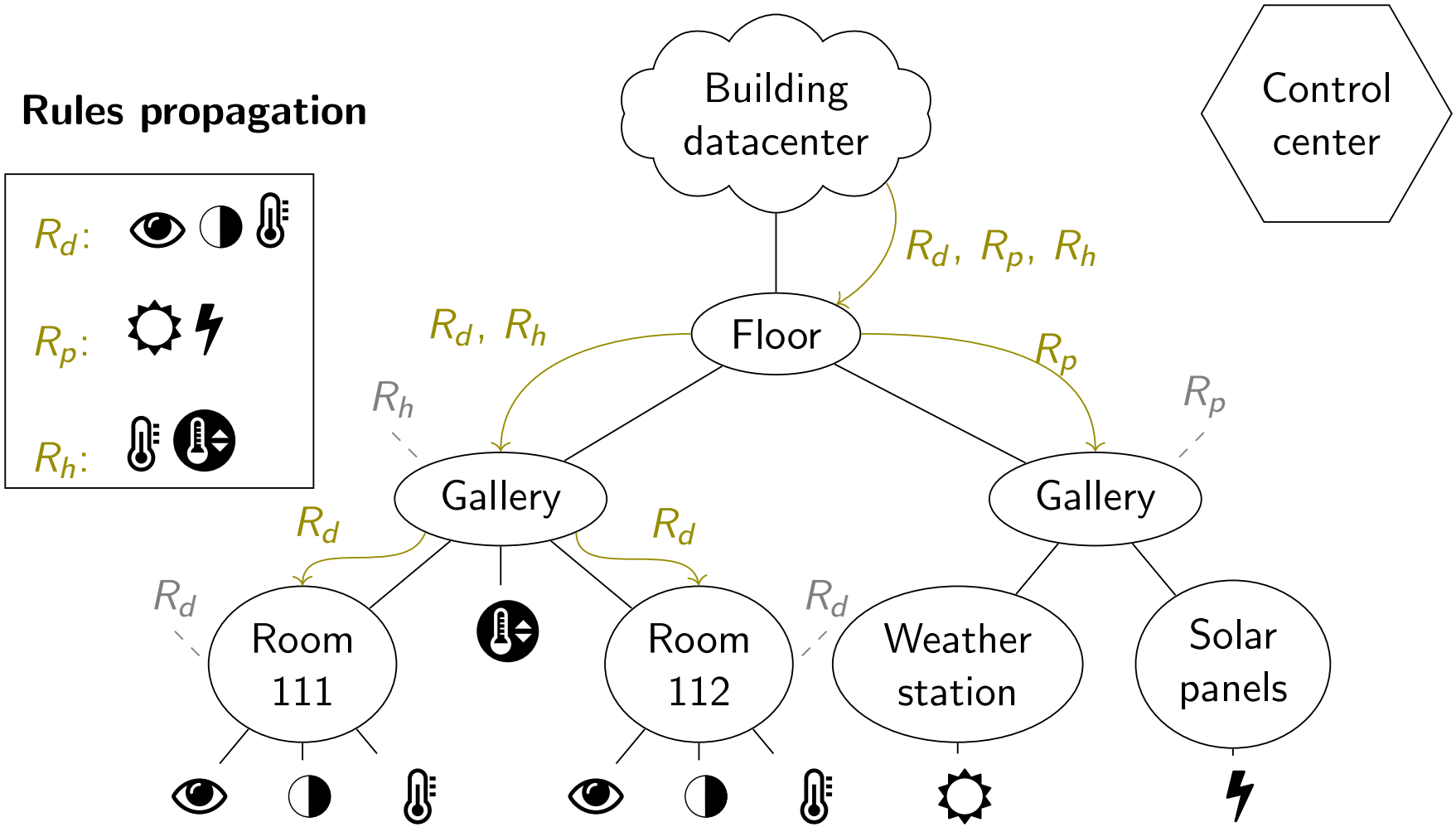
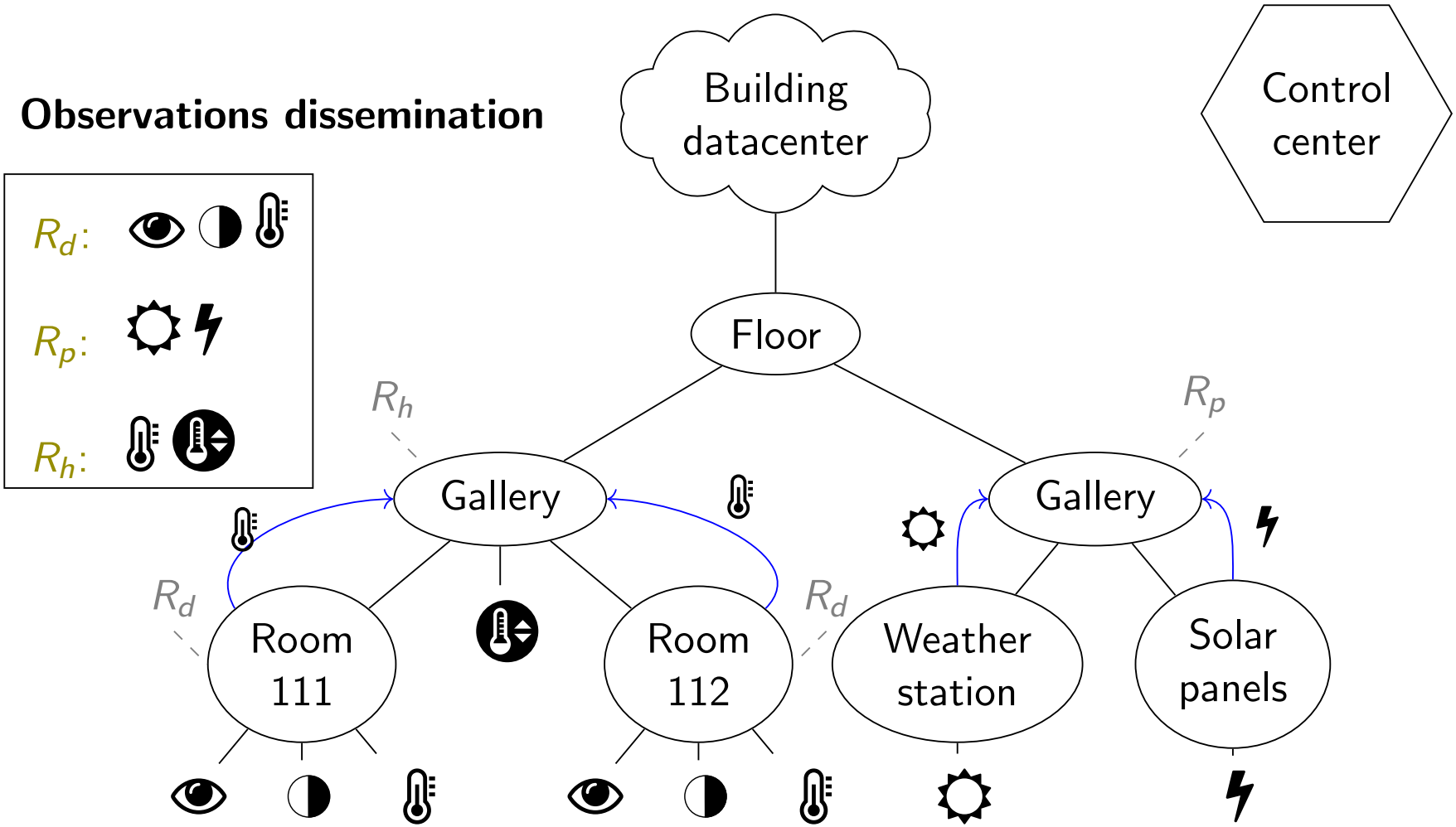


$EDR_{\mathcal{T}}$ by the example



$\text{EDR}_{\mathcal{T}}$ by the example



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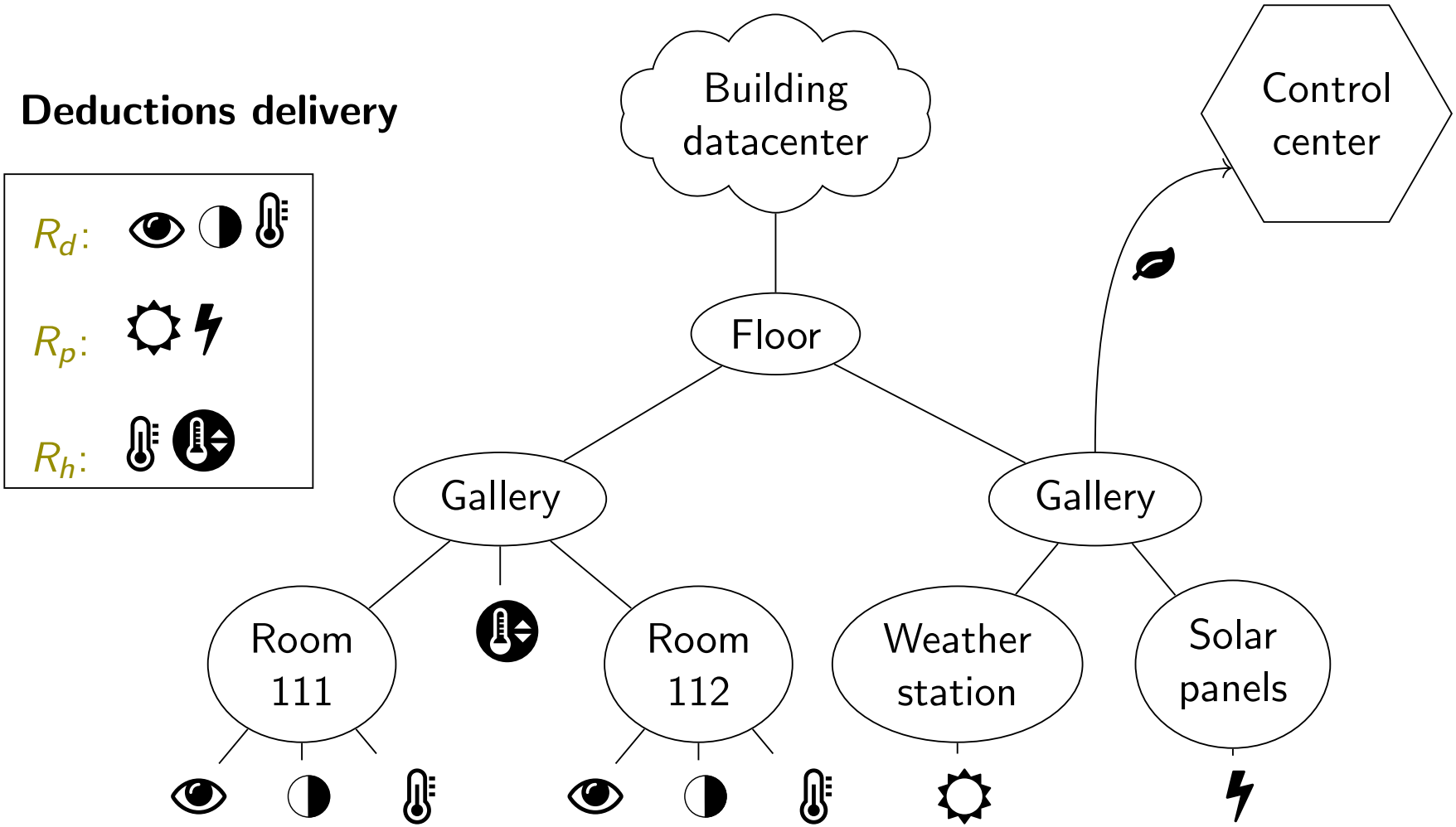

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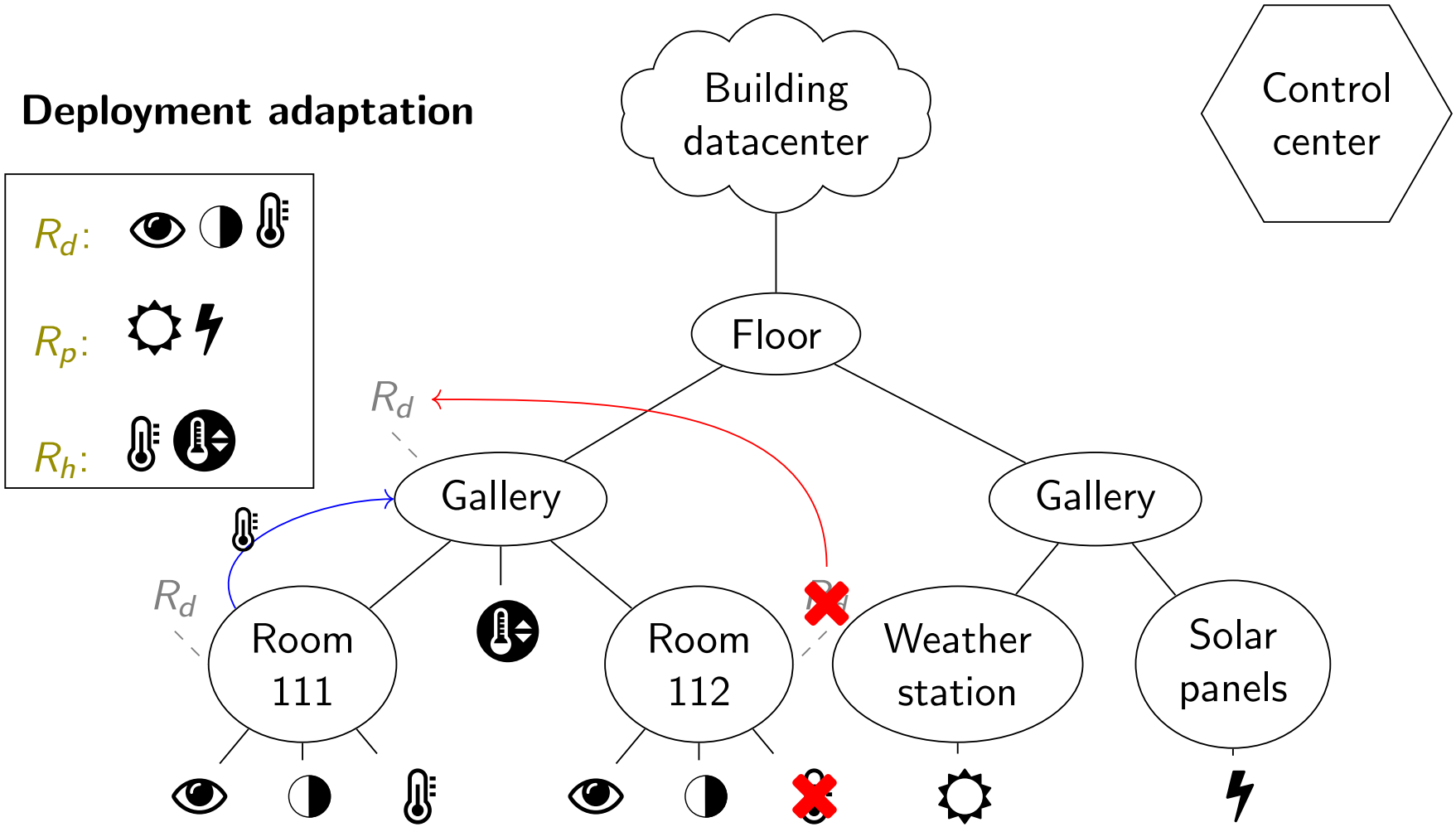


Evaluation

Measured parameter

Delivery delay, interval between observation and deduction reception by the application

Experimentations

- Scalability
- Distribution

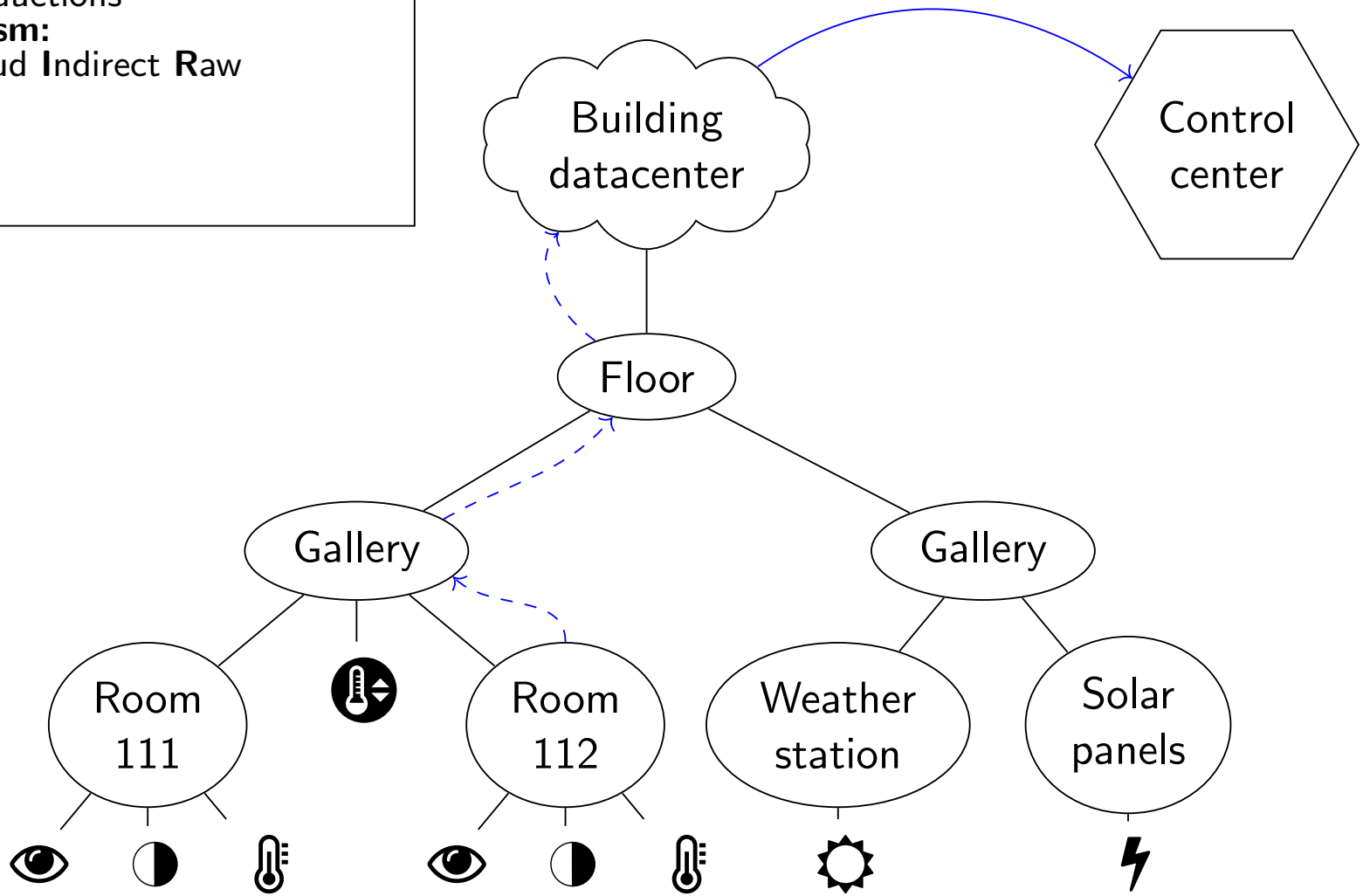
Defining an baseline and its variations

- Comparing centralized and decentralized resoning
- Nuancing the evaluation

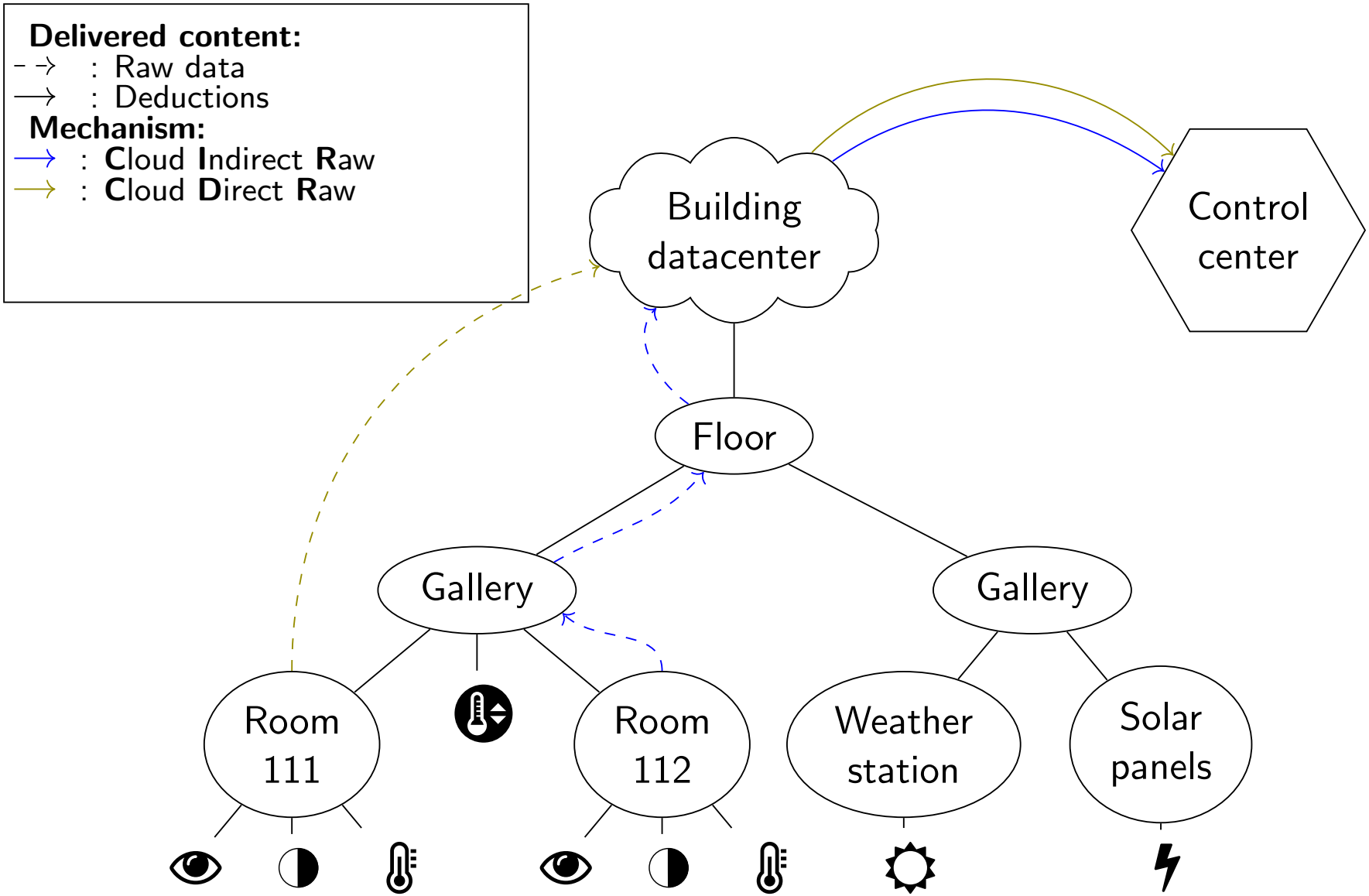
Comparing delivery mechanisms

Delivered content:
- -→ : Raw data
- ⟶ : Deductions

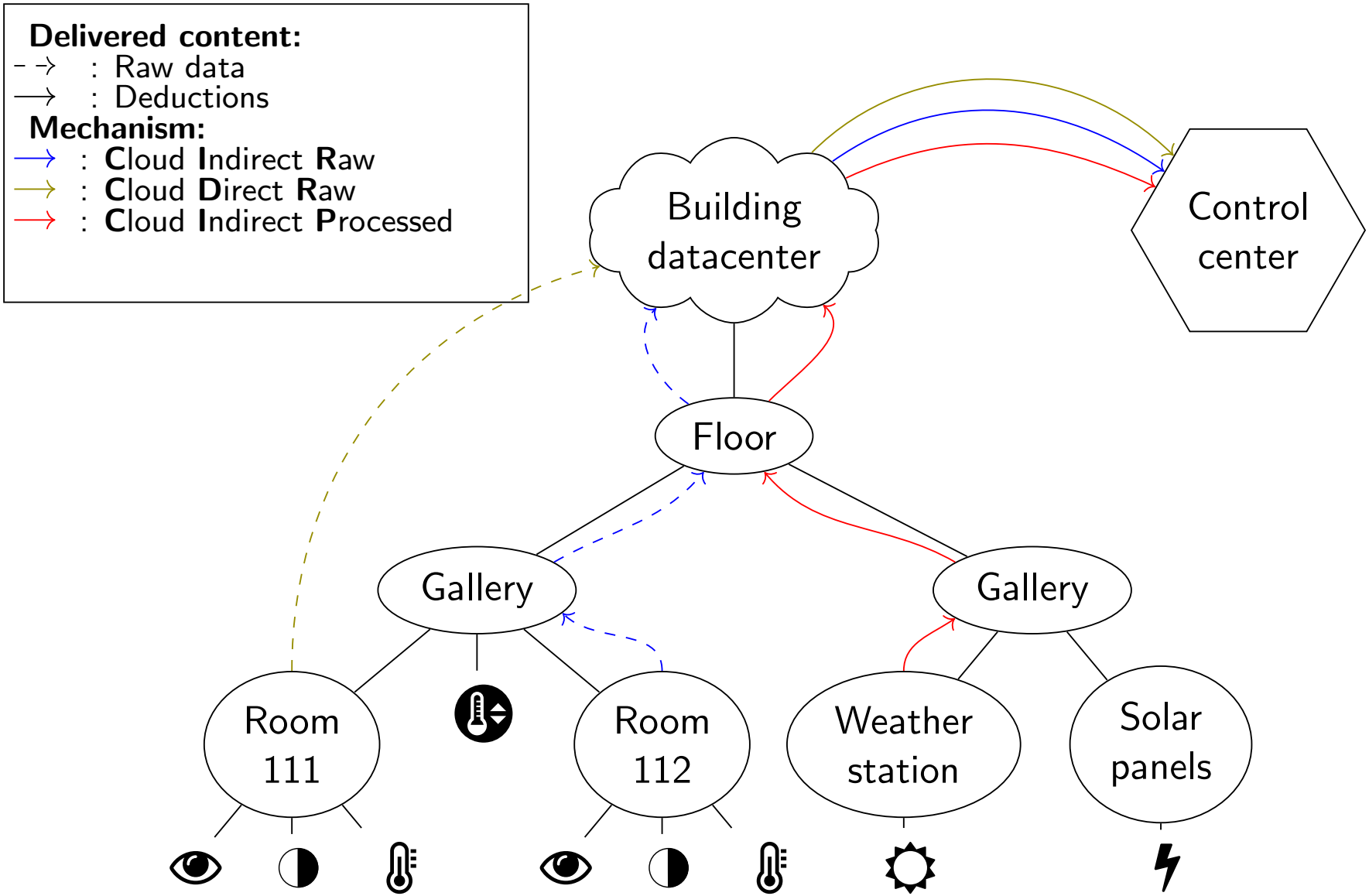
Mechanism:
- → : **C**loud **I**ndirect **R**aw



Comparing delivery mechanisms



Comparing delivery mechanisms



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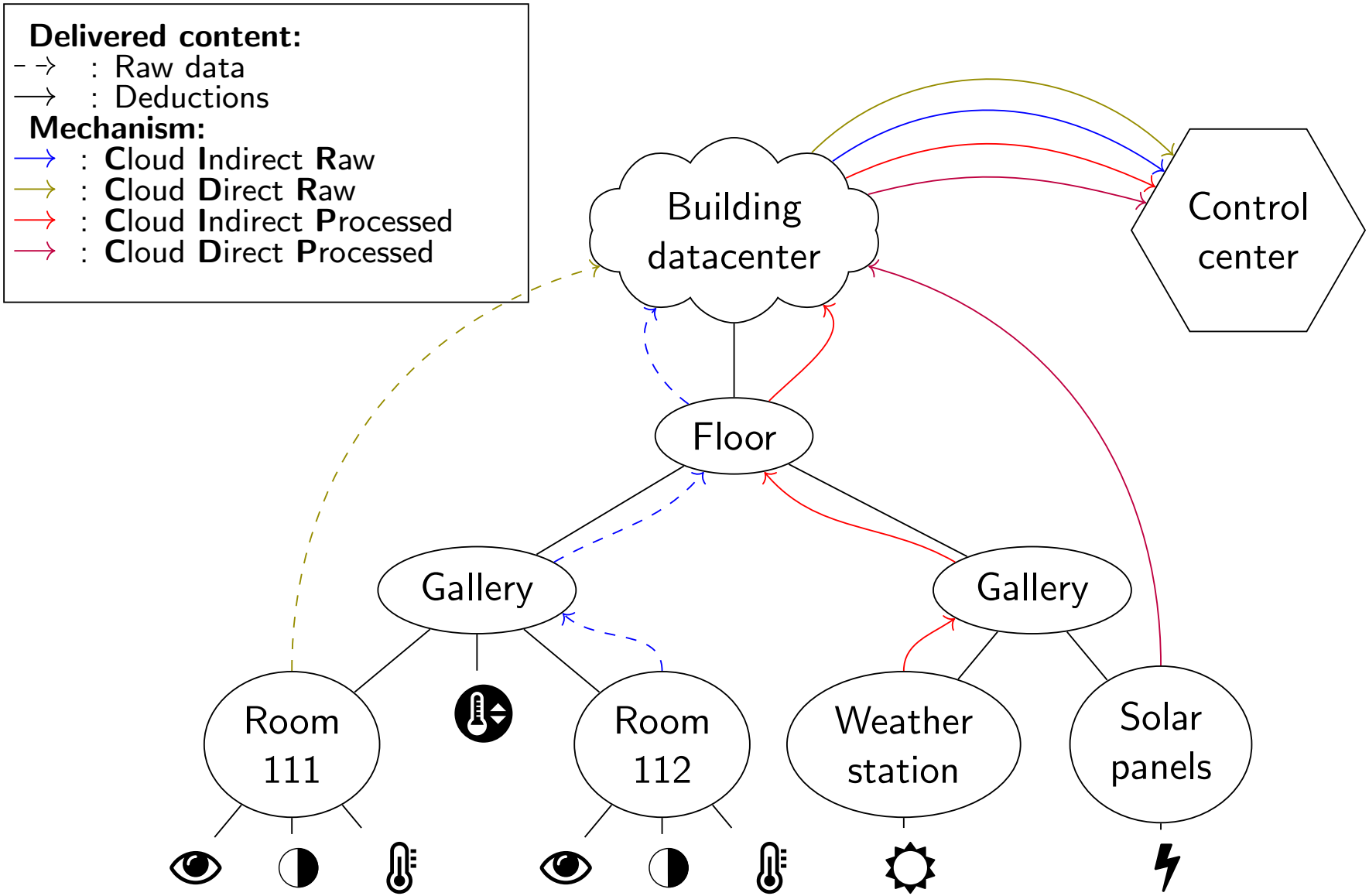

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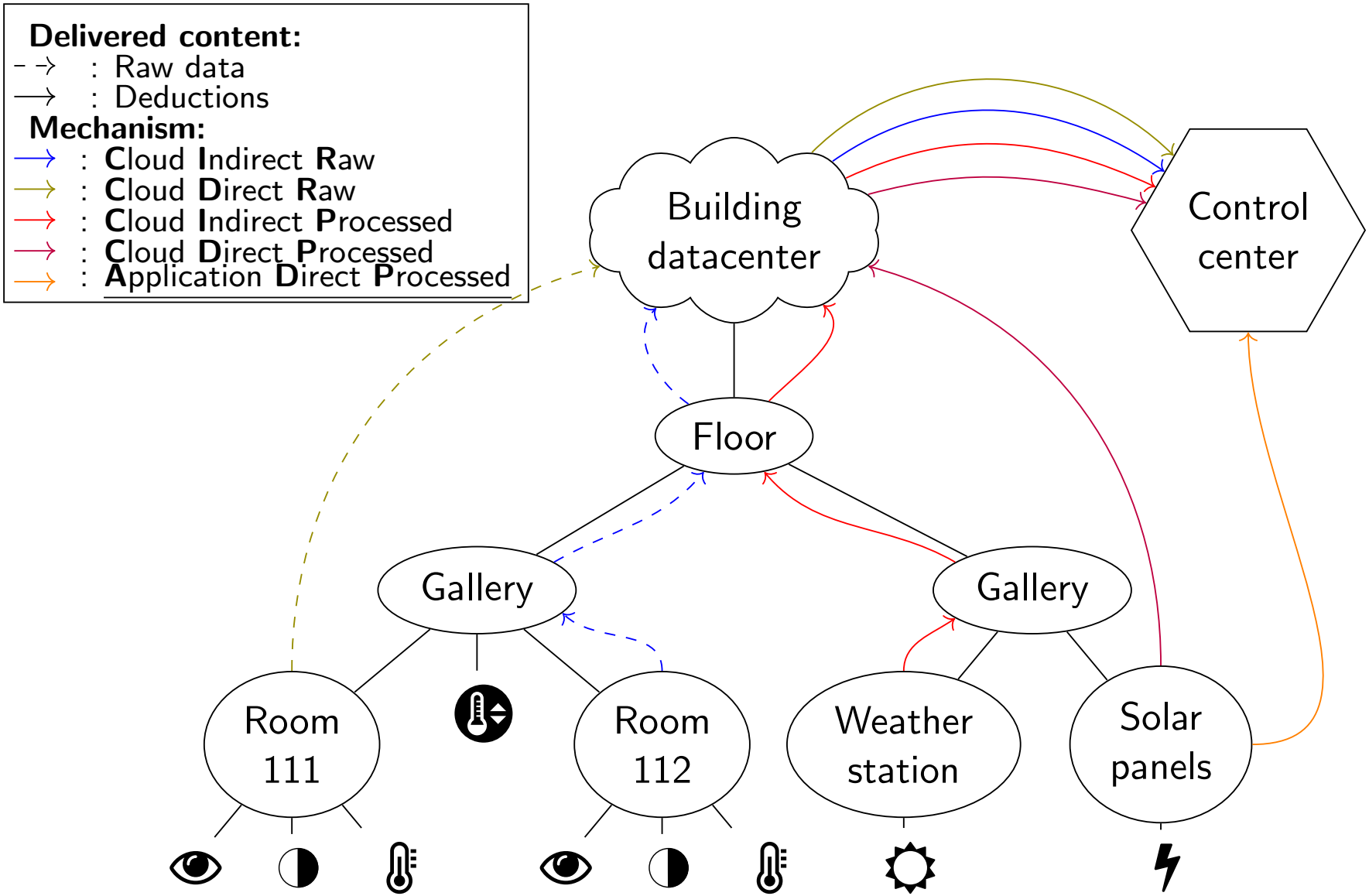
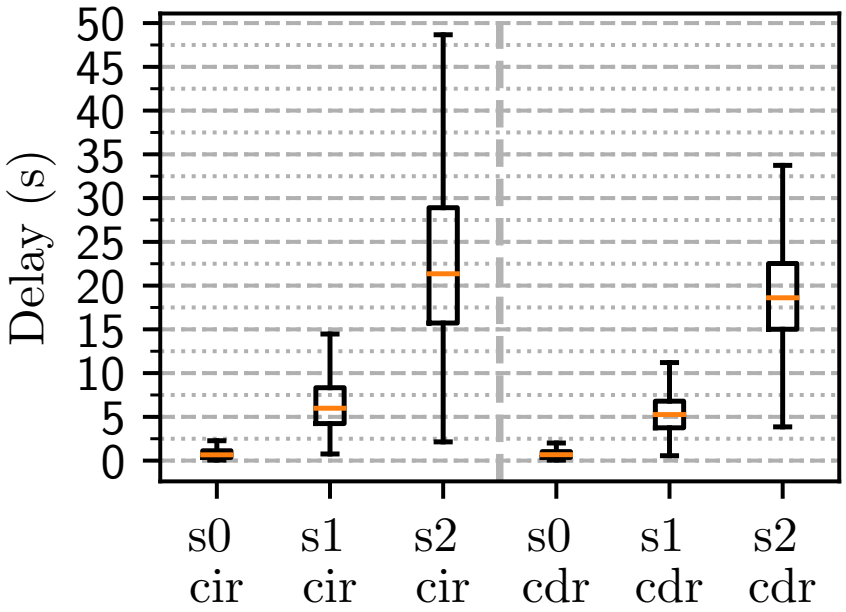
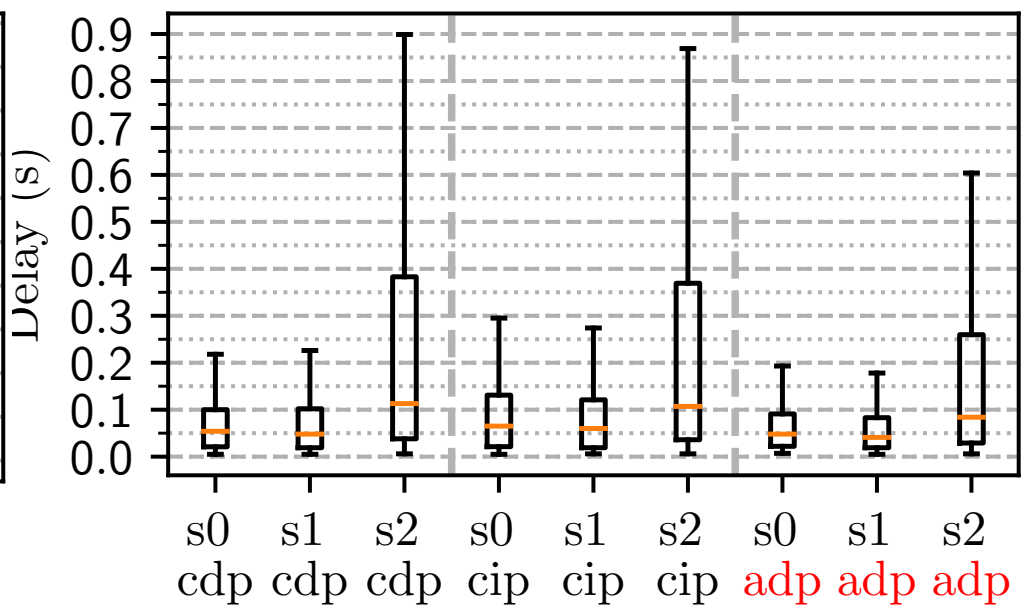


Scalability of the proposed approach

Topology	s0	s1	s2
Nodes	31	61	91

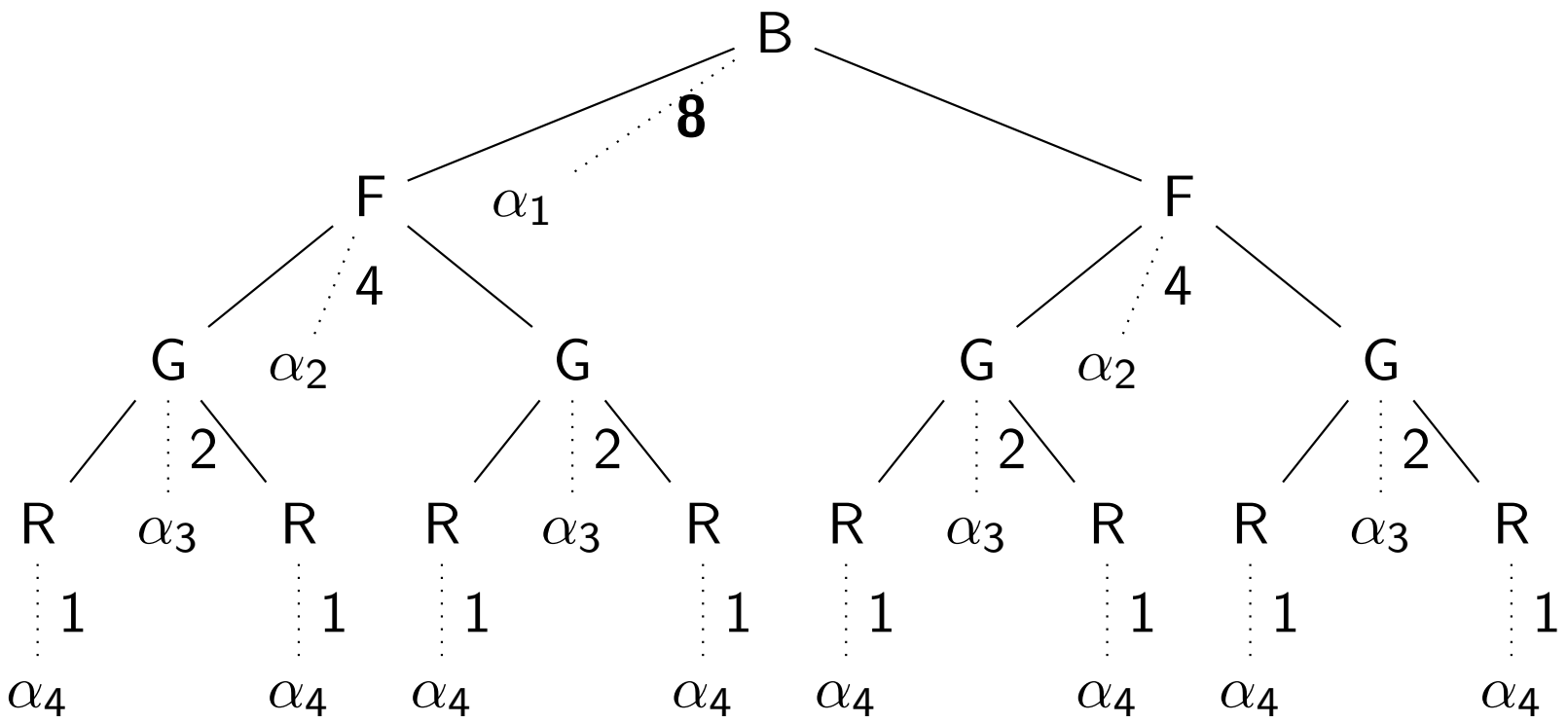


Centralized reasoning



Distributed reasoning

Distribution experimentations



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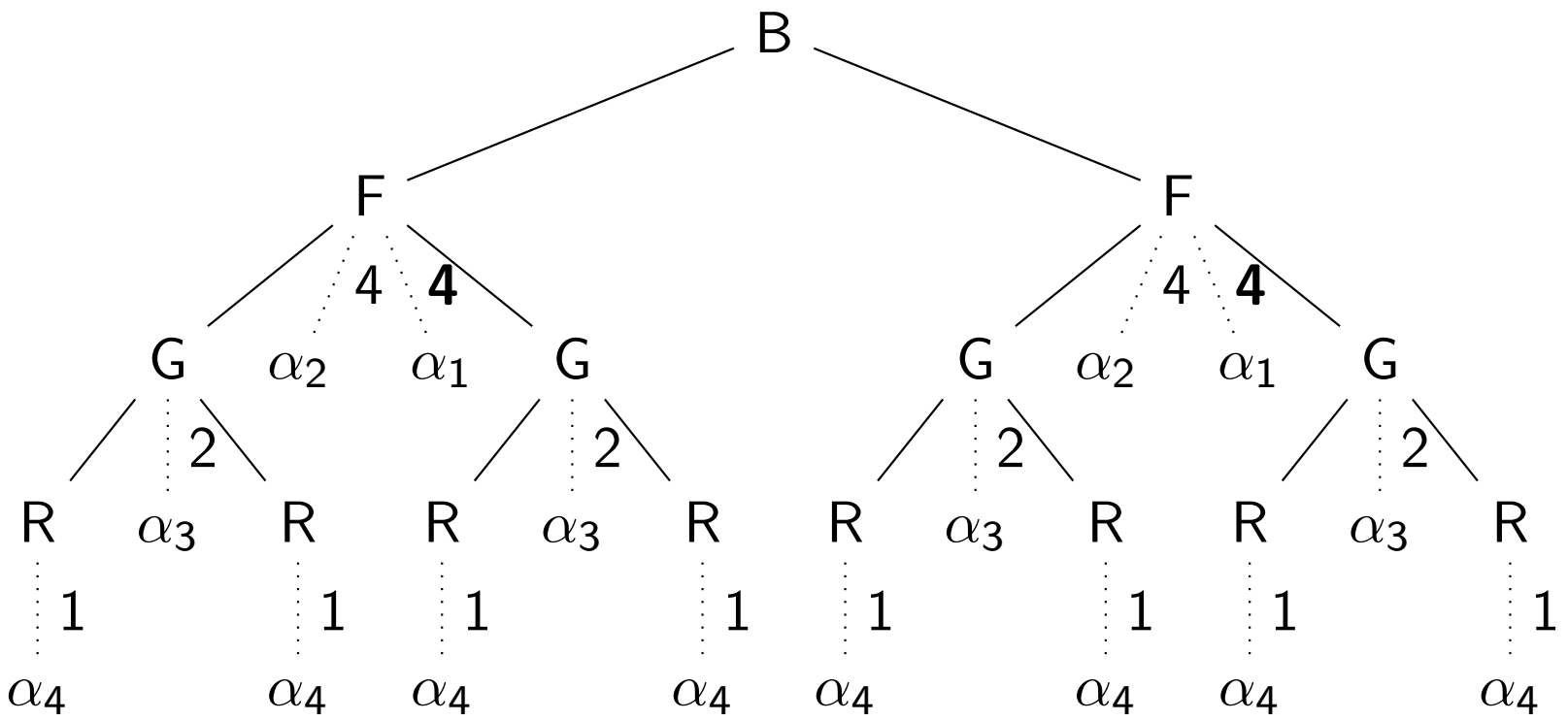

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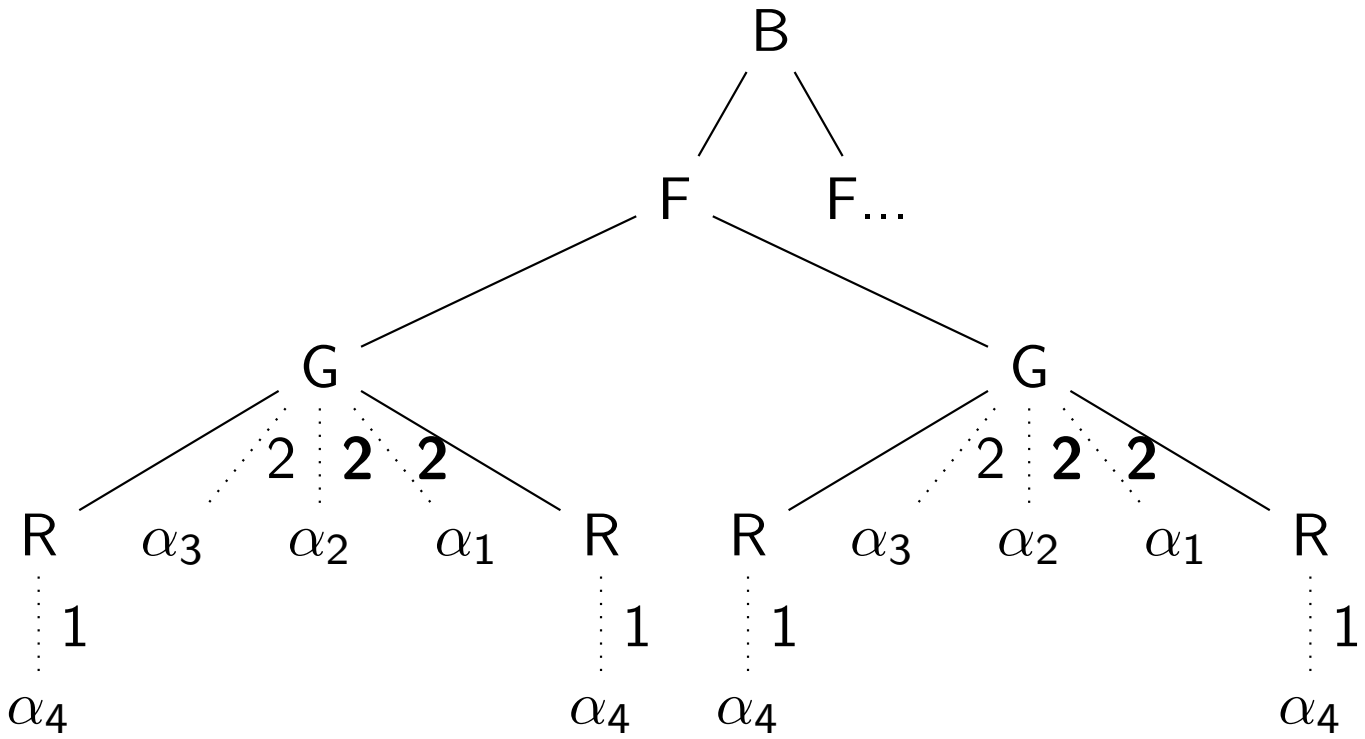
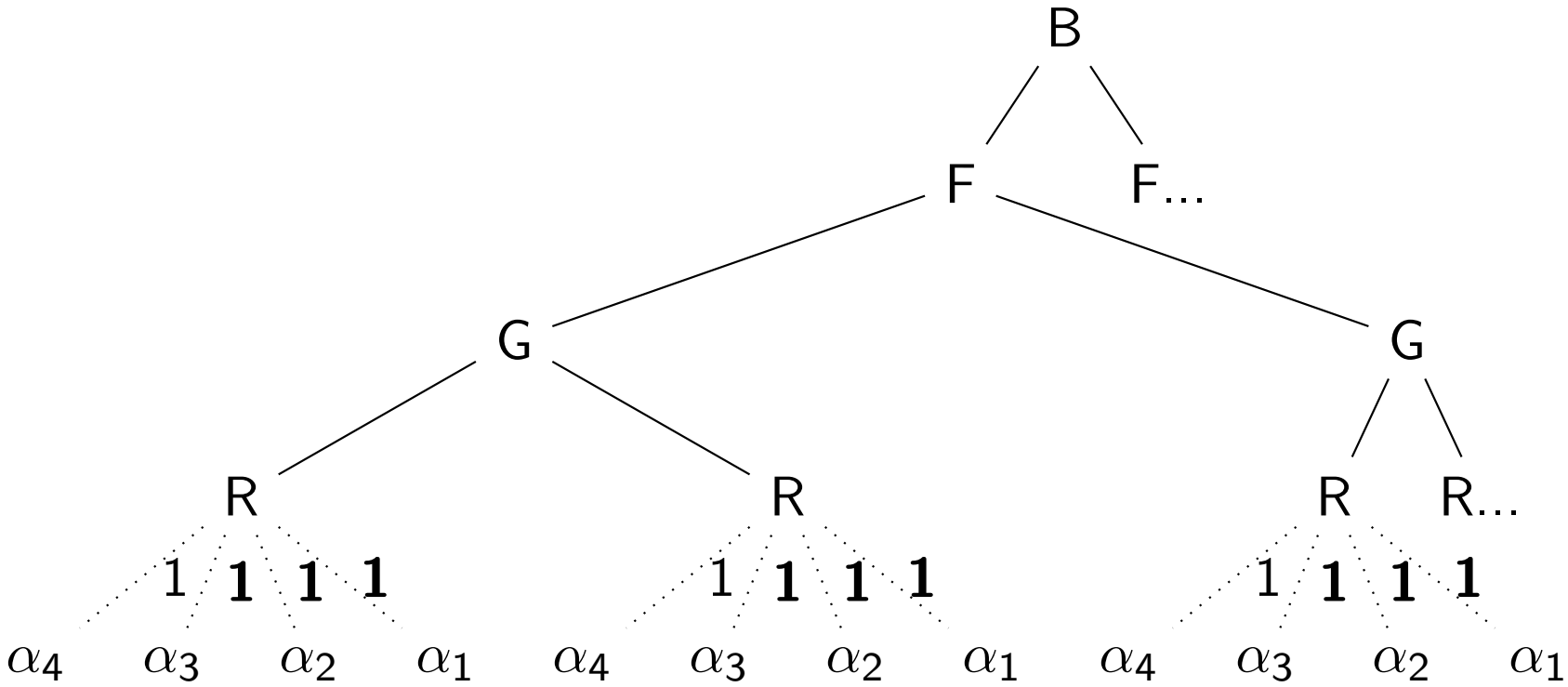
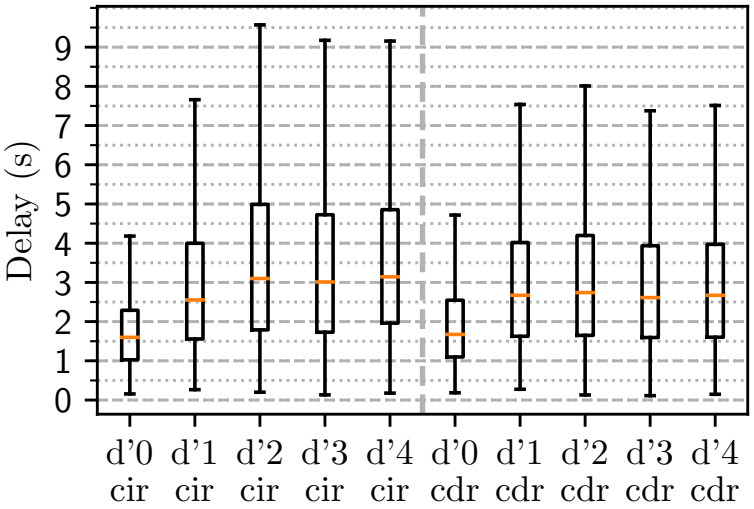


Distribution experimentations

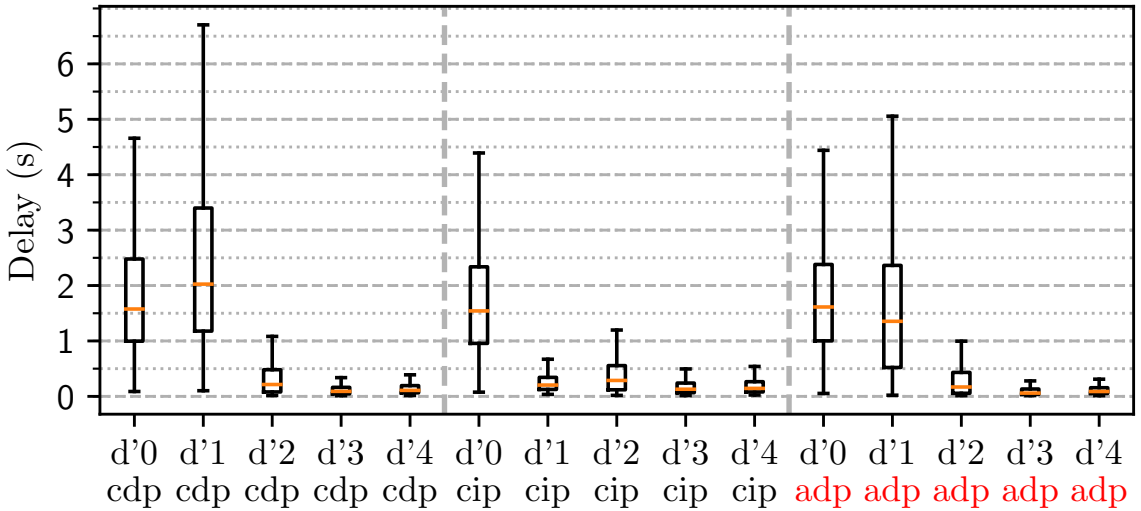


Validation of the hypothesis

	R1	R2	R3	R4	R5	R6	R7
d'0	0	0	0	0	0	0	0
d'1	0	1	0	1	1	0	0
d'2	1	1	0	1	1	0	0
d'3	1	1	0	3	3	1	3
d'4	3	2	2	3	3	2	3



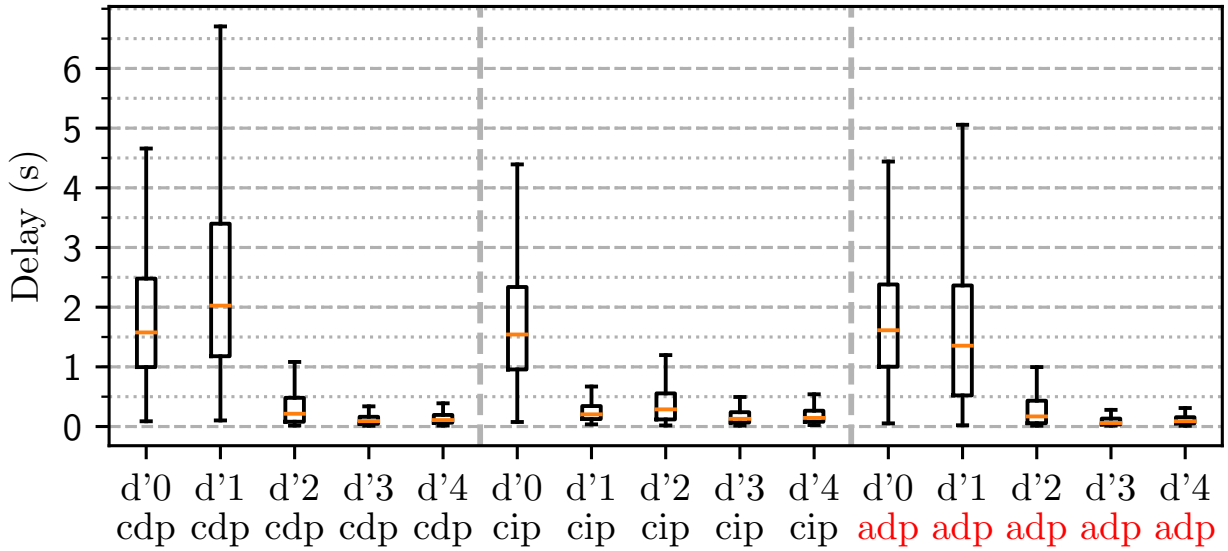
Centralized reasoning



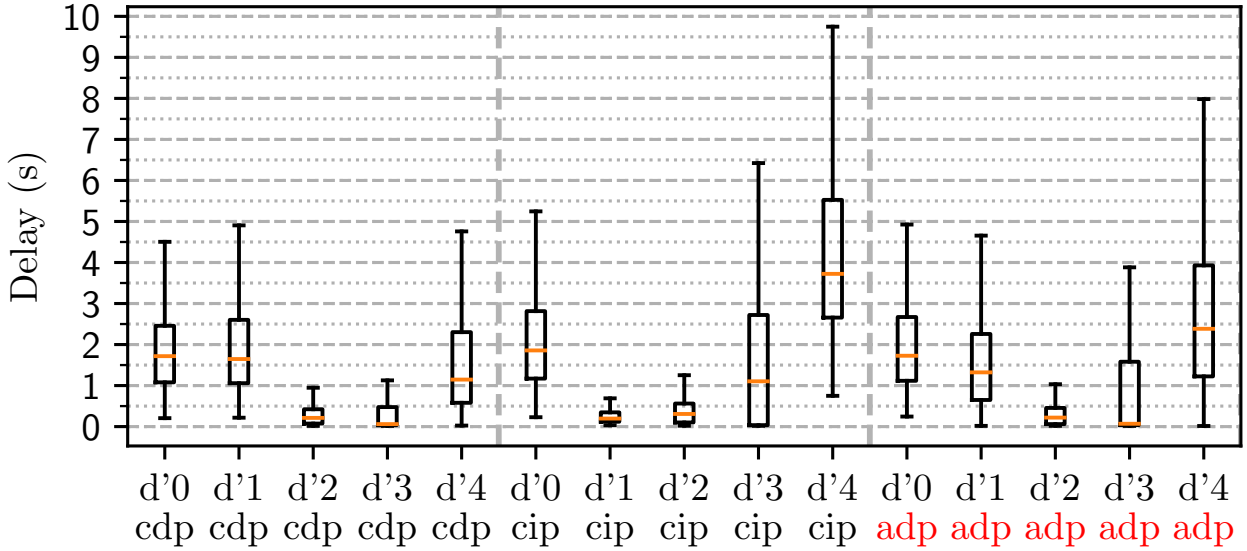
Distributed reasoning

Discussion: Considering constrained devices

Powerful hardware
(16 cores,
32Go RAM)



Constrained hardware
(Raspberry Pi 3)



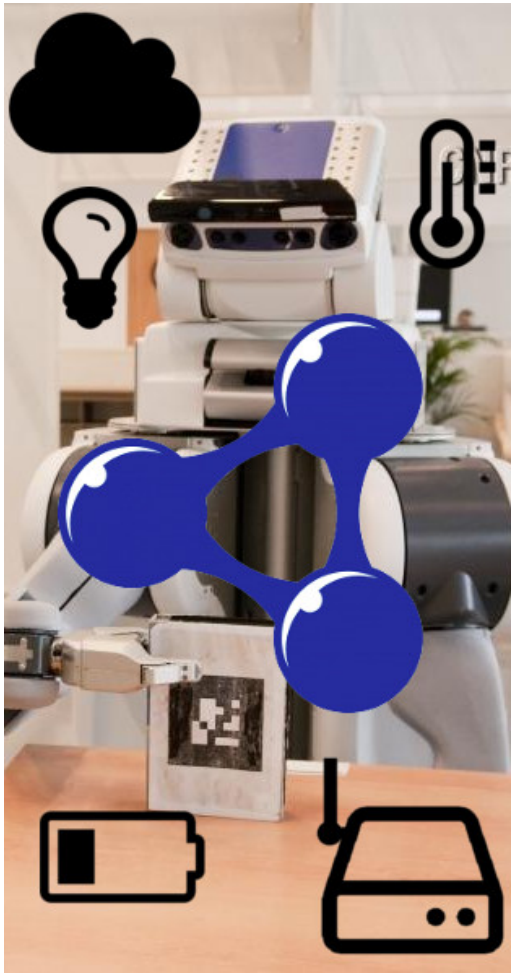
Conclusion

The SWoT brings forward challenges

- Interoperability vs. constrained resources
- Contextual data vs. global analysis
- Need for scalability and response time

Distributed reasoning is a partial solution

- Combining Cloud resources and Fog pervasiveness
- Distributing processing where it is relevant
- EDR empowers the emergence of local autonomic systems



(current) Future work: New EDR strategies

EDR for privacy

- Define a **privacy-aware** propagation strategy
- Exchange rules, **keep control of data**
  - SOLID integration
- **Challenge**: Data has to be routed up and downstream

Functional properties

- Consider heterogeneous networks **without Fog-app direct communication**

Thank you

Do you have any questions ?

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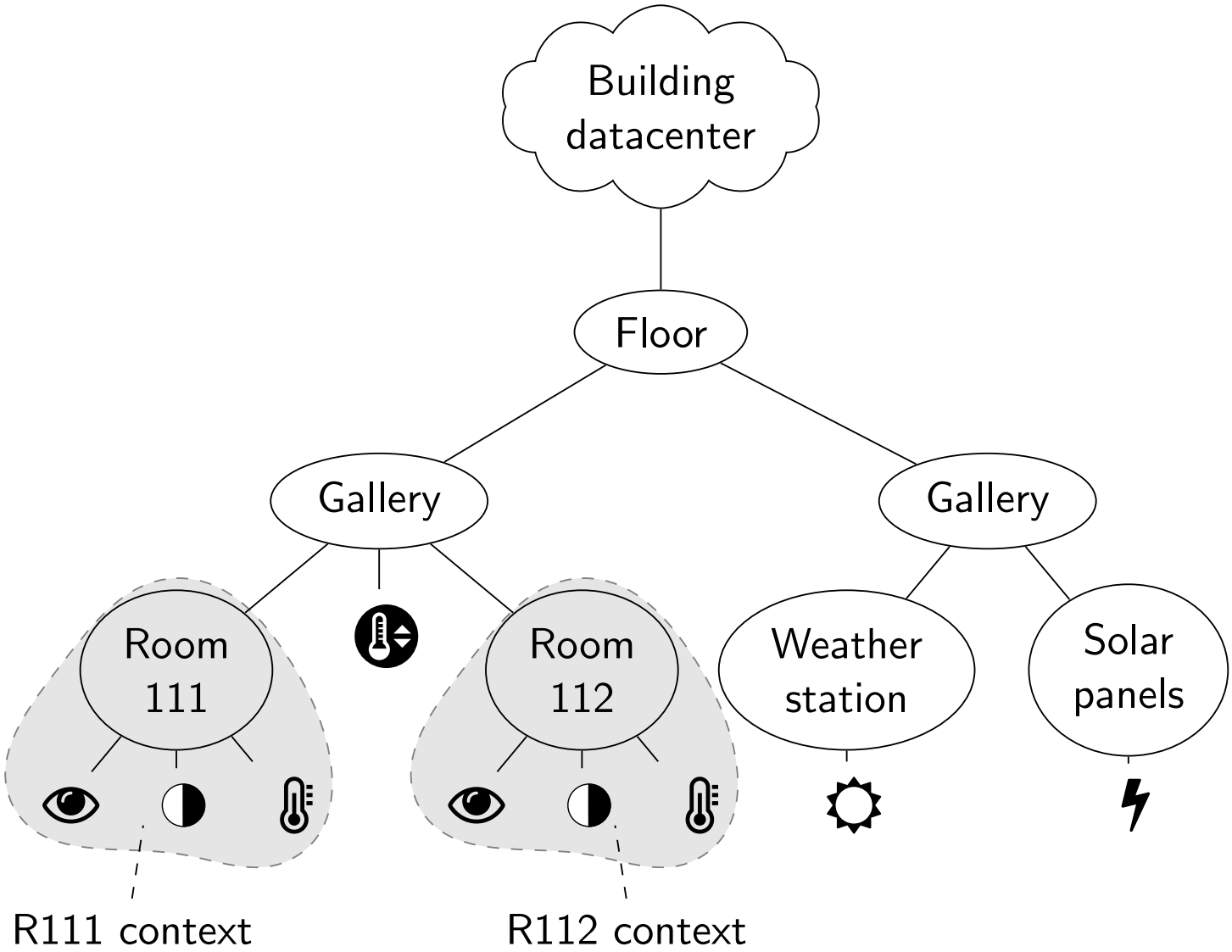
zwifi.eu

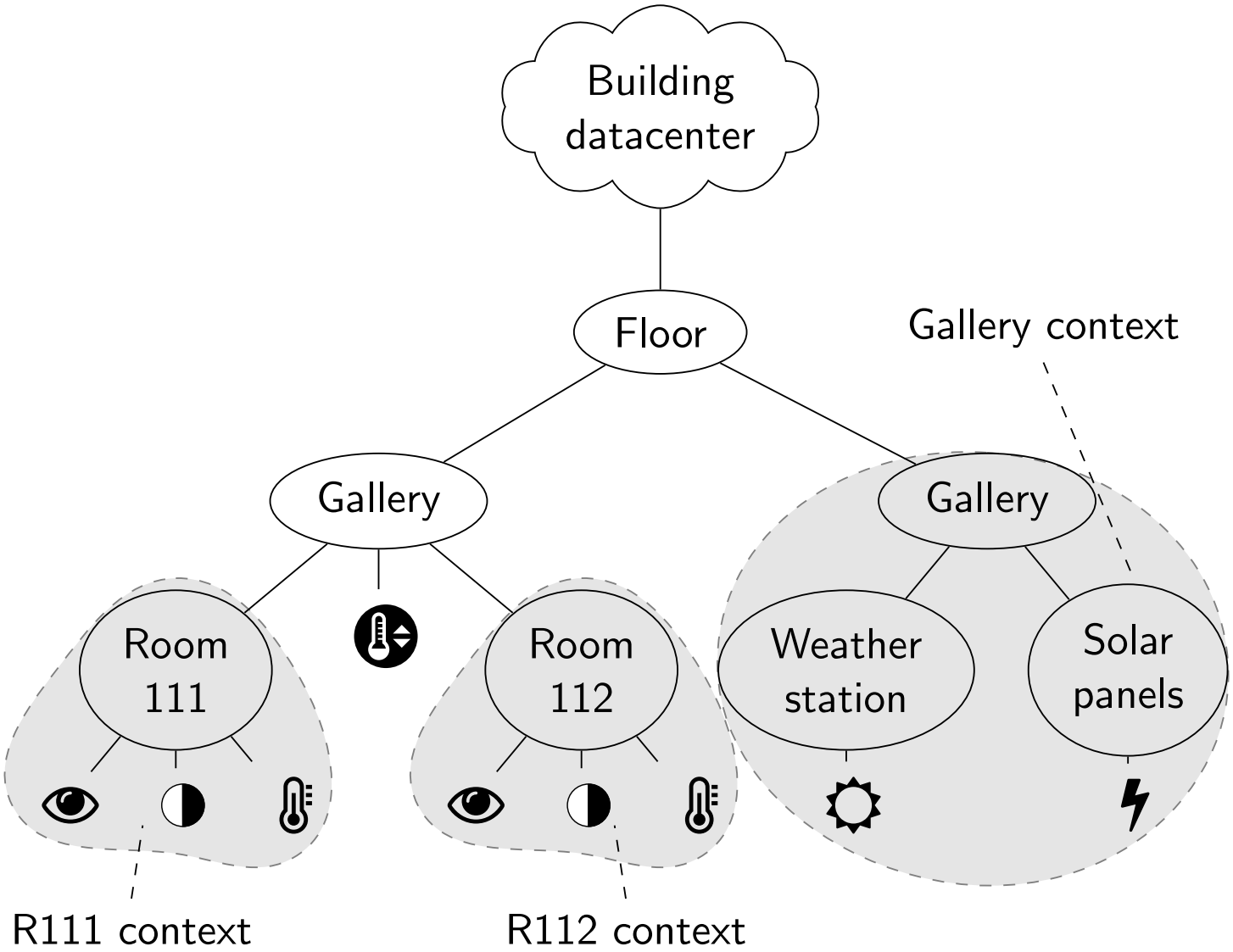
Overview

- Home page
- Table of content
- Contextuality

Contextualizing properties with $\text{EDR}_{\mathcal{T}}$



Contextualizing properties with EDR$_{\mathcal{T}}$



Contextualizing properties with $\text{EDR}_{\mathcal{T}}$

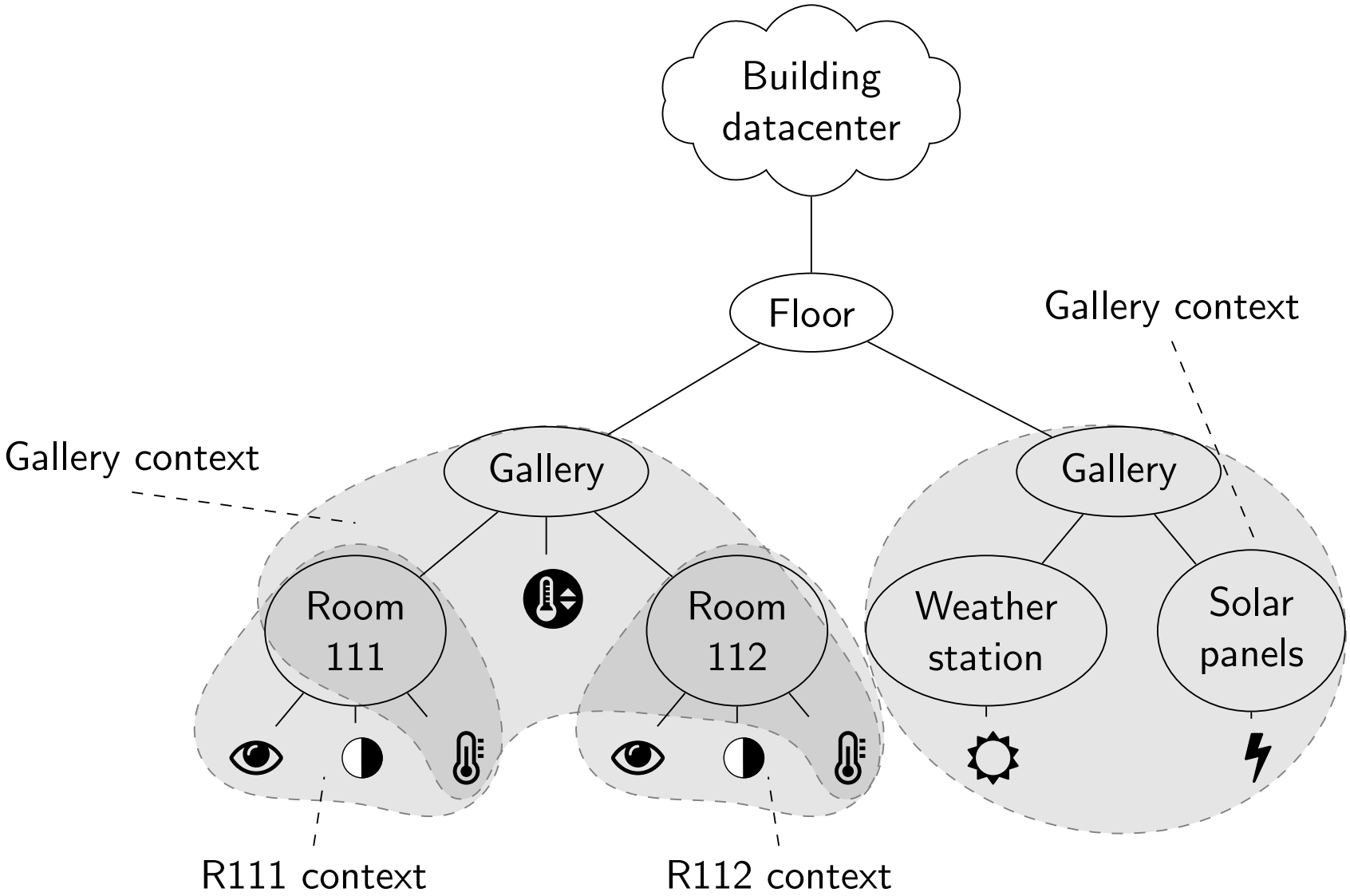


Image credit

- Robot by Tang Ge from the Noun Project

Toward semantic interoperability in oneM2M architecture.

The Semantic Web.

Fog Computing and Its Role in the Internet of Things.

The role of common ontology in achieving sharable, reusable knowledge bases.

Sensor-based Linked Open Rules (S-LOR): An Automated Rule Discovery Approach for IoT Applications and its use in Smart Cities.

SRE: semantic rules engine for the industrial internet-of-things gateways.

The NIST Definition of Cloud Computing Recommendations of the National Institute of Standards and Technology.

Building a Semantic Web of Things: Issues and perspectives in information compression.

Capturing the contributions of the semantic web to the IoT: a unifying vision (extended abstract).

A Distributed Scalable Approach for Rule Processing: Computing in the Fog for the SWoT.

Reasoning on the edge or in the cloud?

Towards Cooperative Semantic Computing: a Distributed Reasoning approach for Fog-enabled SWoT.

Distribution of Semantic Reasoning on the Edge of Internet of Things.

Federation of Internet of Things Testbeds for the Realization of a Semantically-Enabled Multi-Domain Data Marketplace.

Resource aware placement of IoT application modules in Fog-Cloud Computing Paradigm.

Network security situation awareness based on semantic ontology and user-defined rules for internet of things.

Scalable Cloud–Sensor Architecture for the Internet of Things.

Internet of Things for Smart Cities.