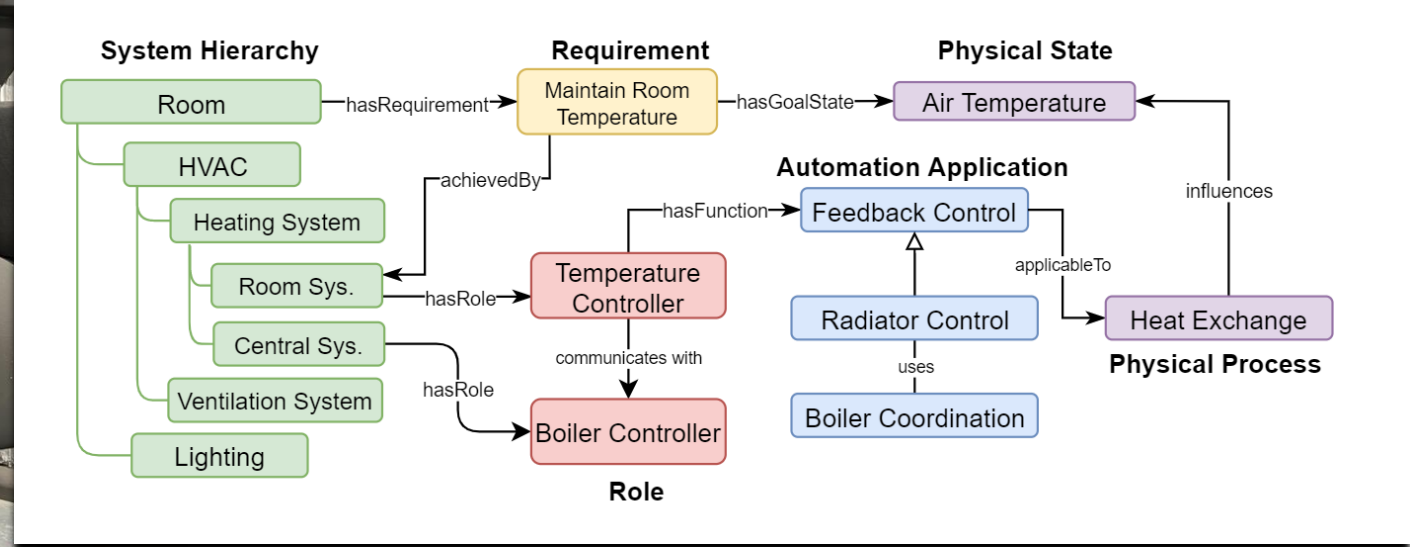# Synthesizing Multi-agent System Organization from Engineering Descriptions

Ganesh Ramanathan
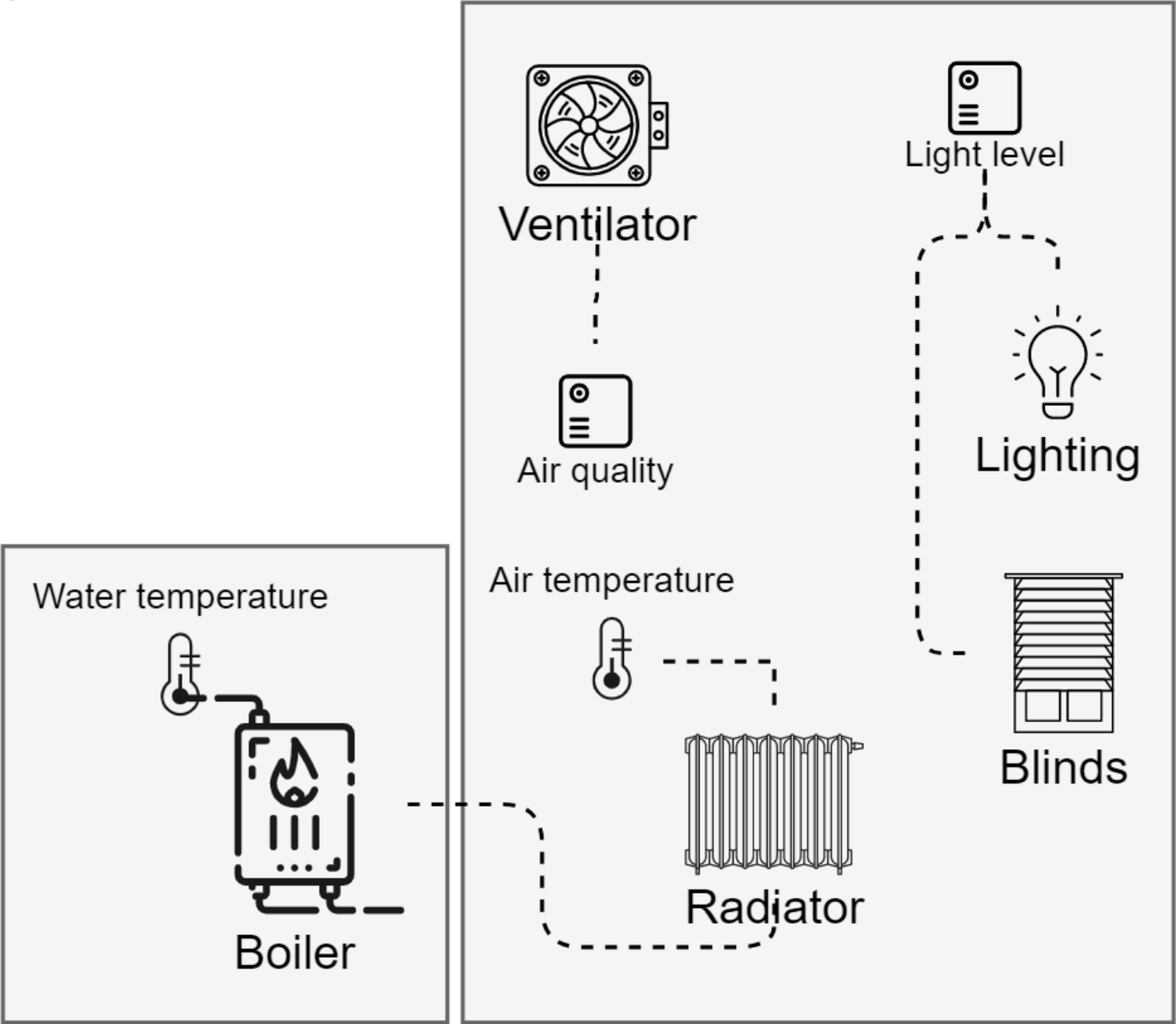
ganesh.ramanathan@siemens.com

SIEMENS
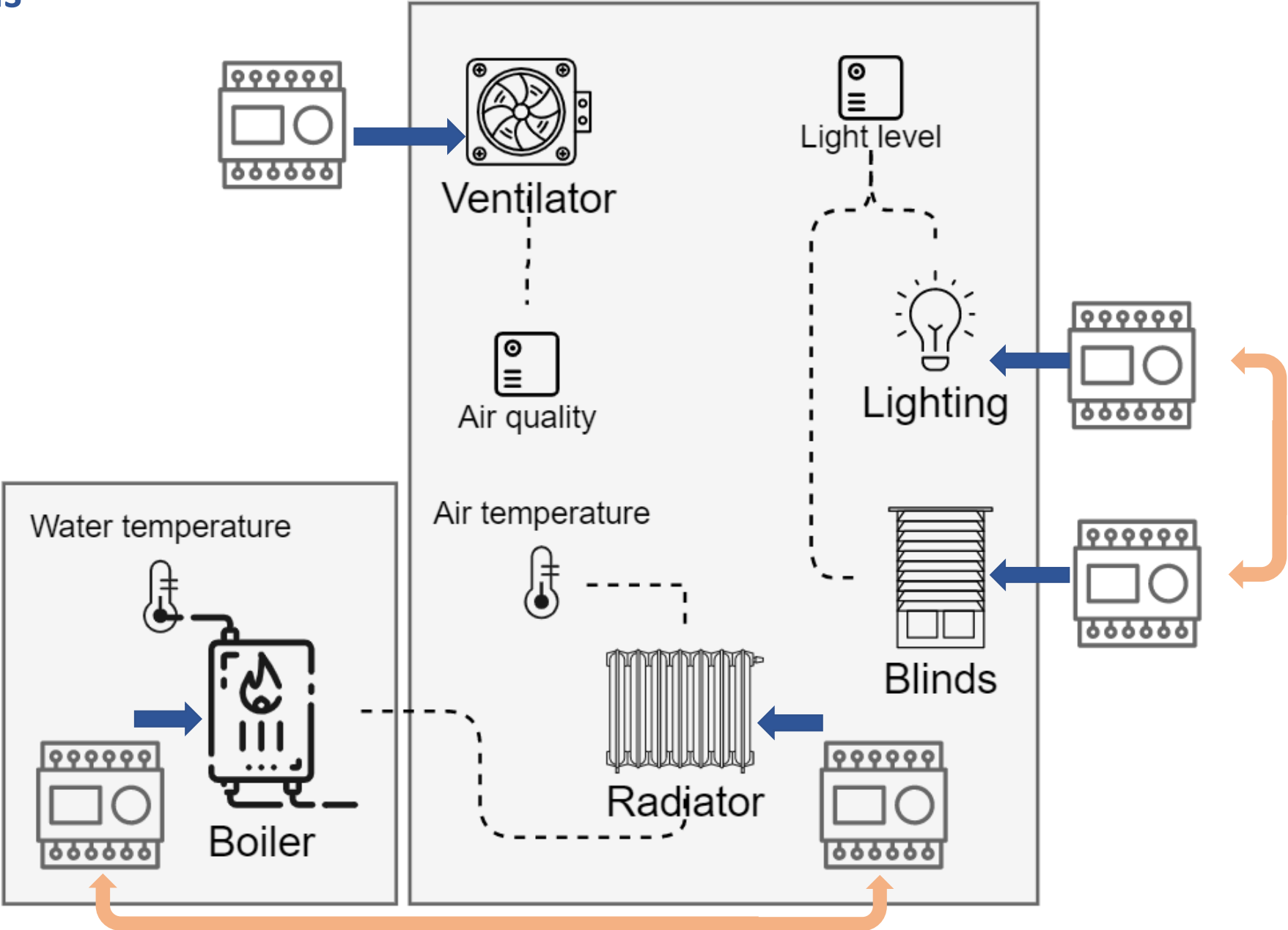*Ingenuity for life*
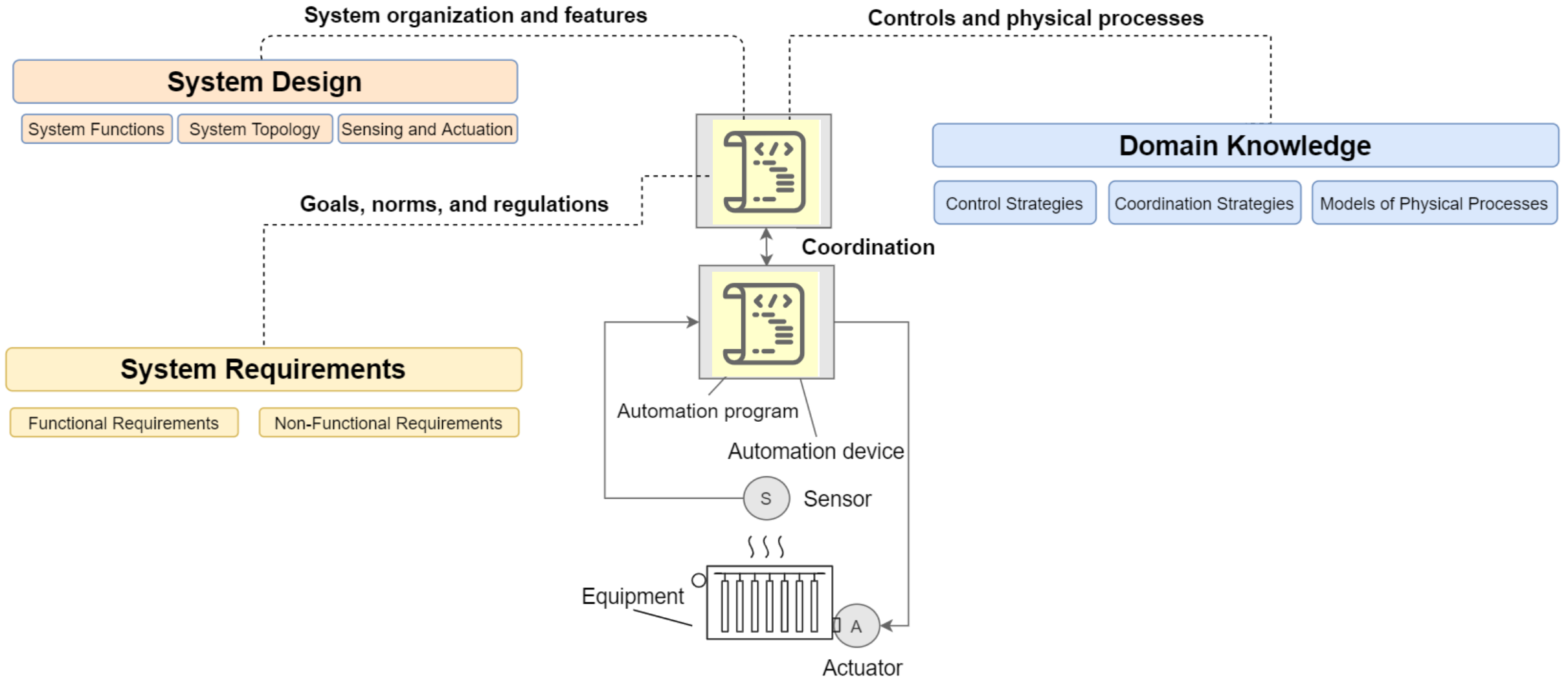
University of St.Gallen
Institute of Computer Science

1

System of Systems

System of Systems

Design-time Dependency

System organization and features

Controls and physical processes

System Design

System Functions | System Topology | Sensing and Actuation

Domain Knowledge

Control Strategies | Coordination Strategies | Models of Physical Processes

Goals, norms, and regulations

Coordination

System Requirements

Functional Requirements | Non-Functional Requirements

Automation program

Automation device
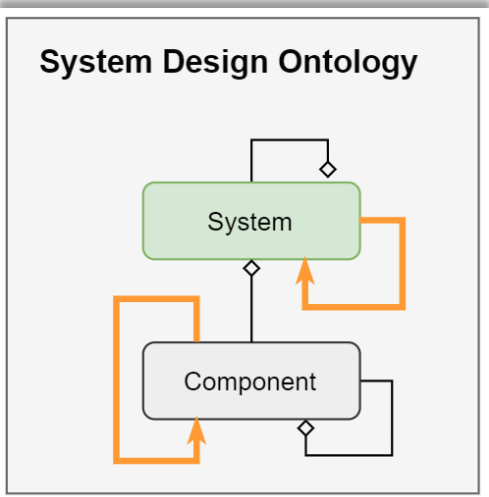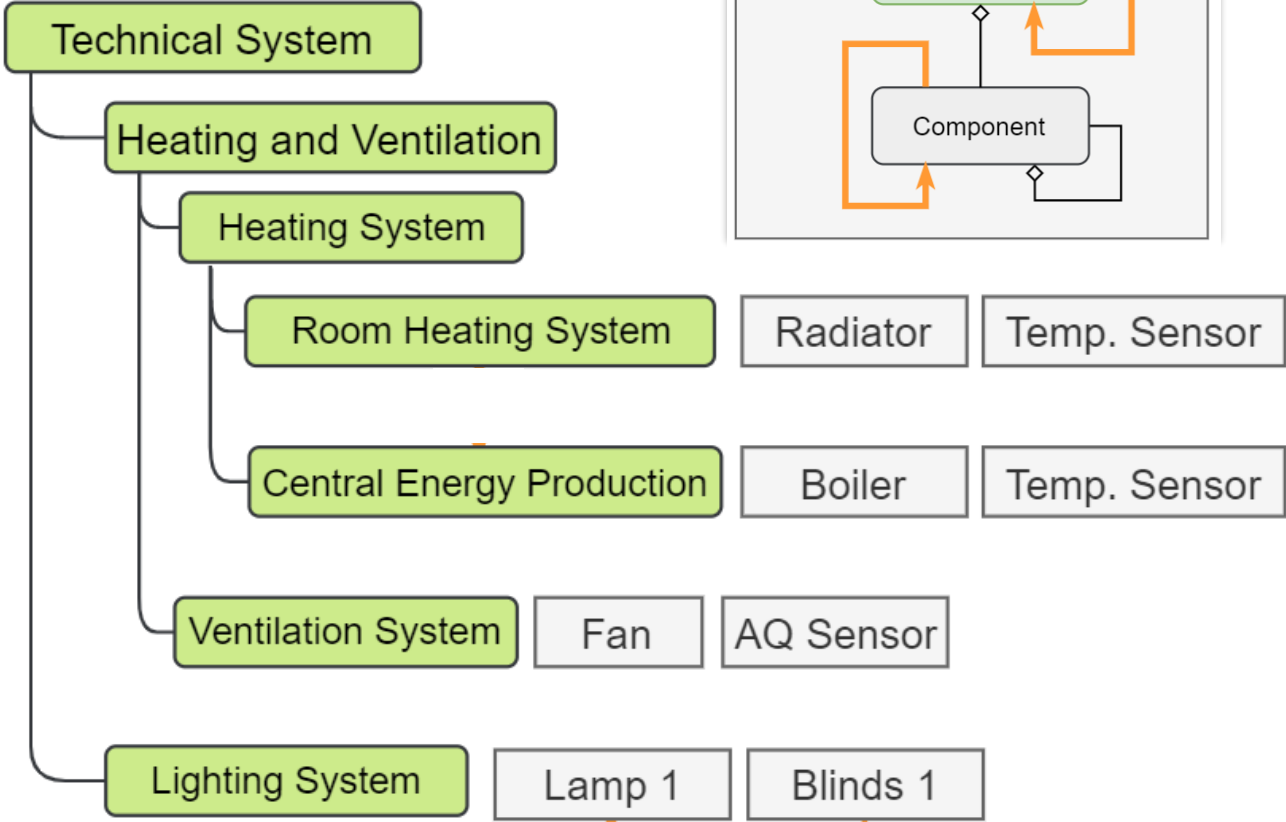
Sensor

Equipment

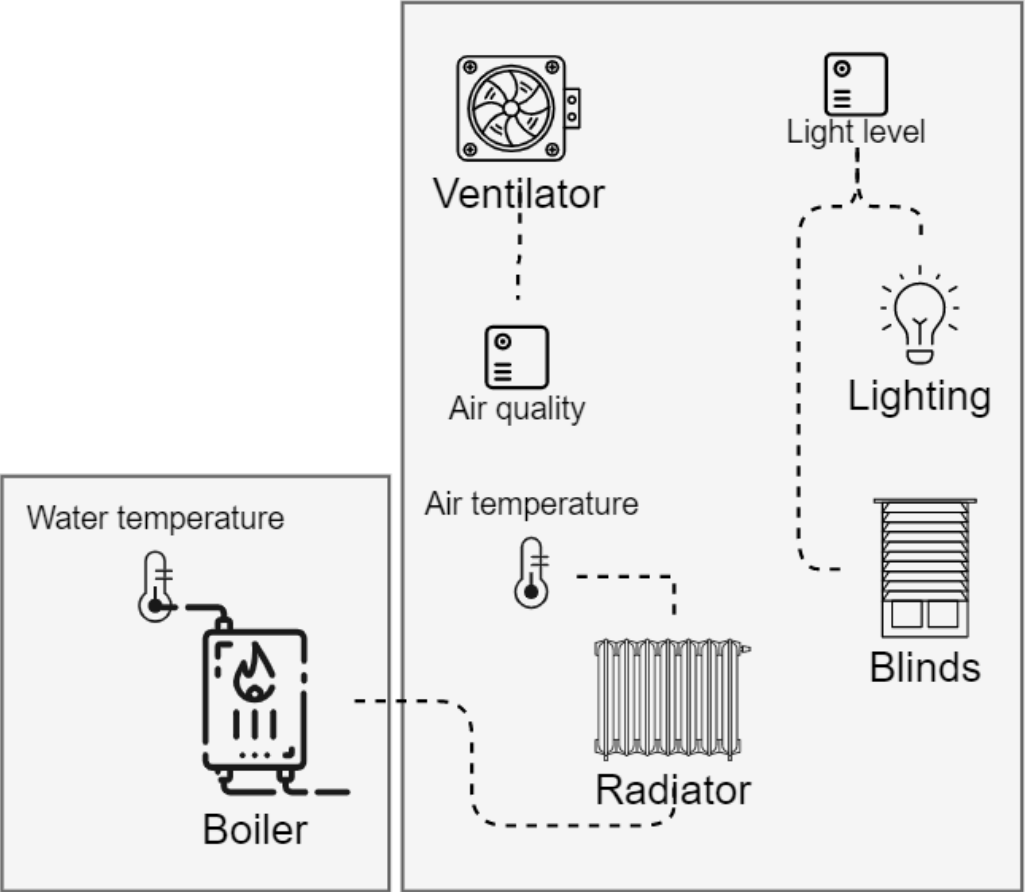Actuator

The Question(s) of Autonomy
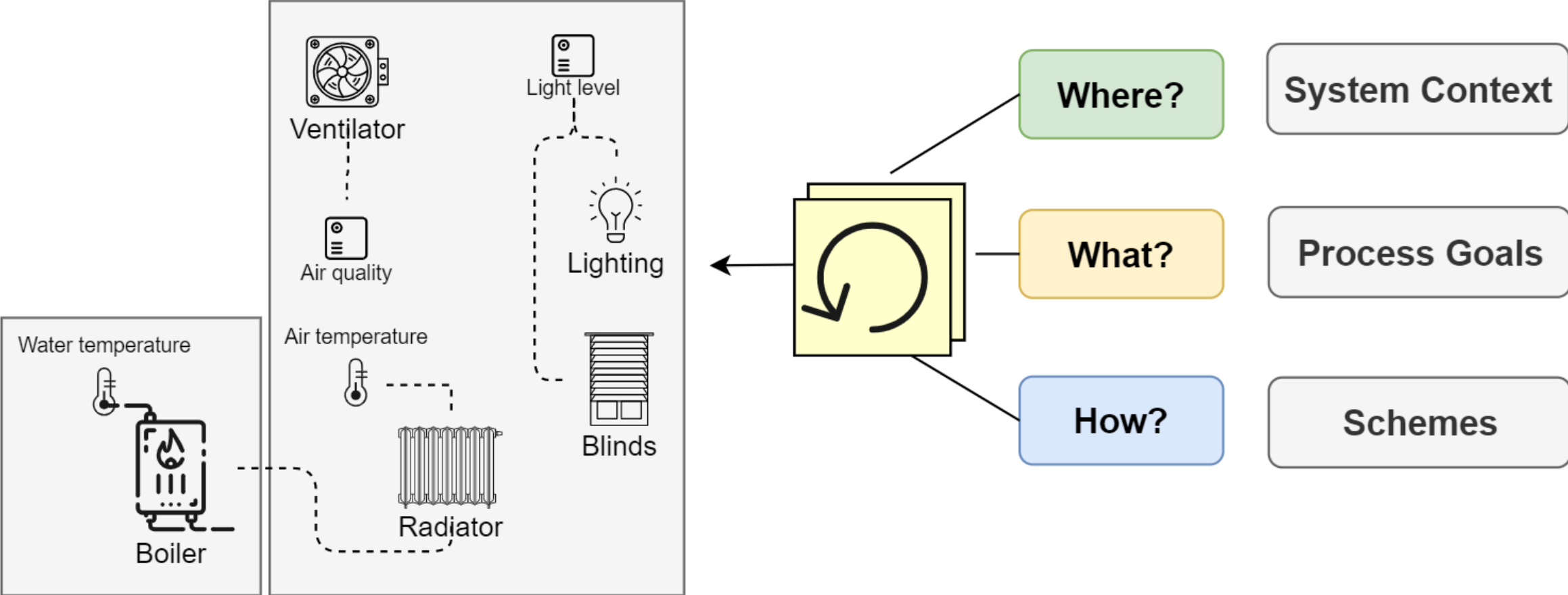
Multi-agent System

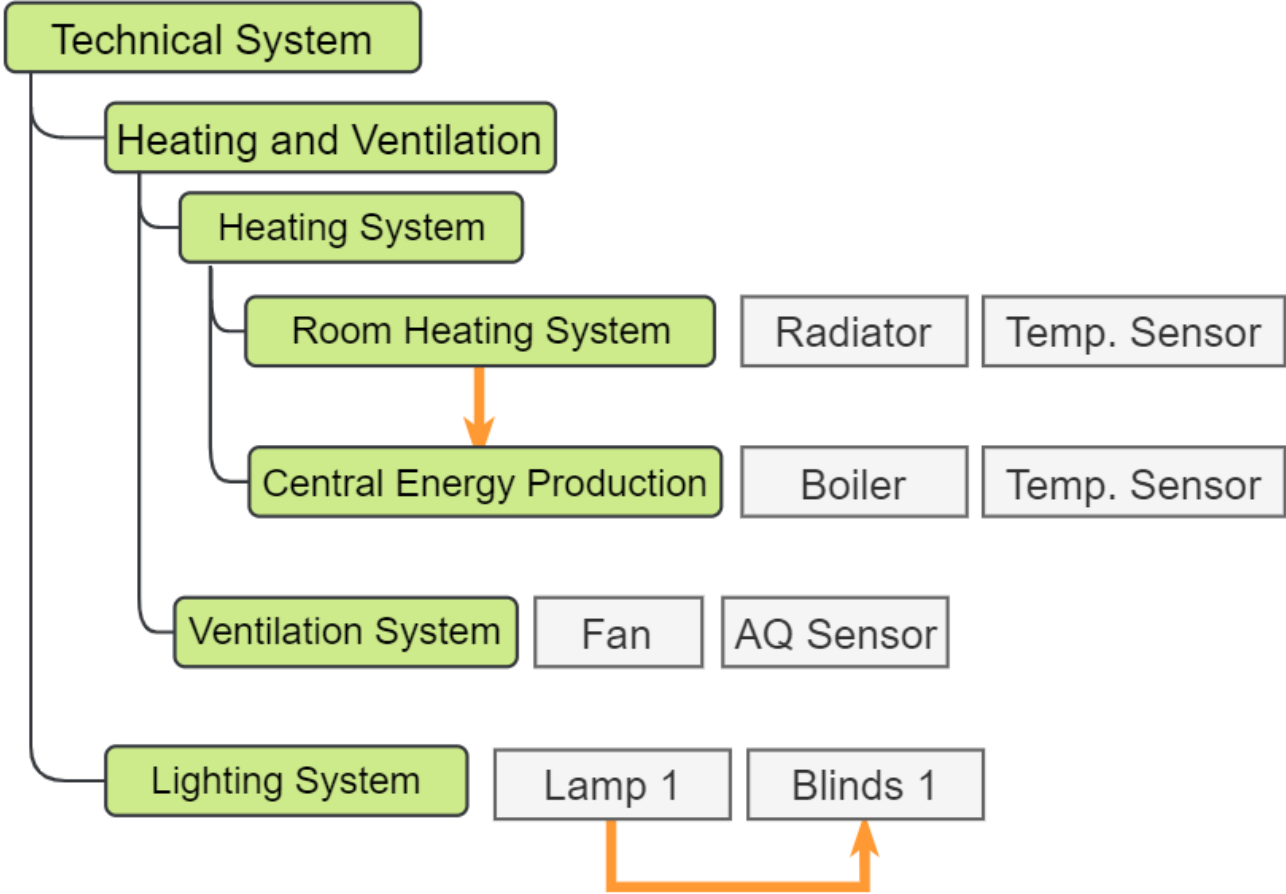**Social structure, roles, functions, and norms**
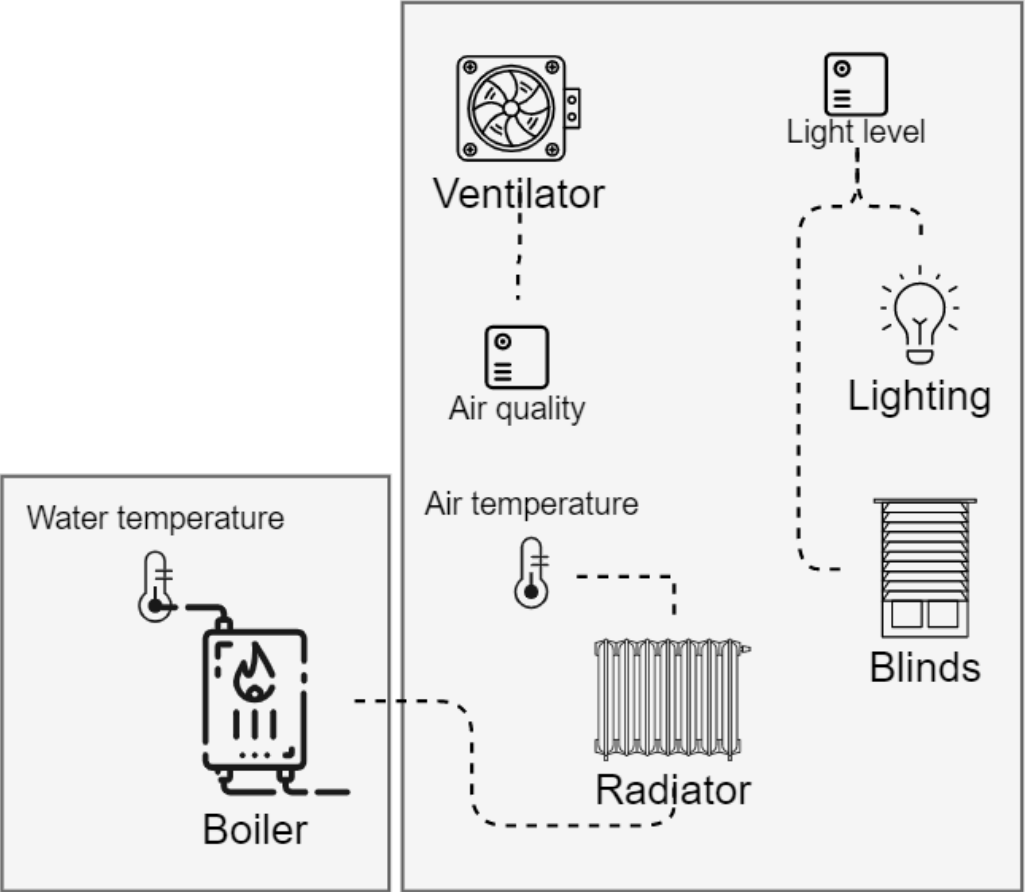
Agents
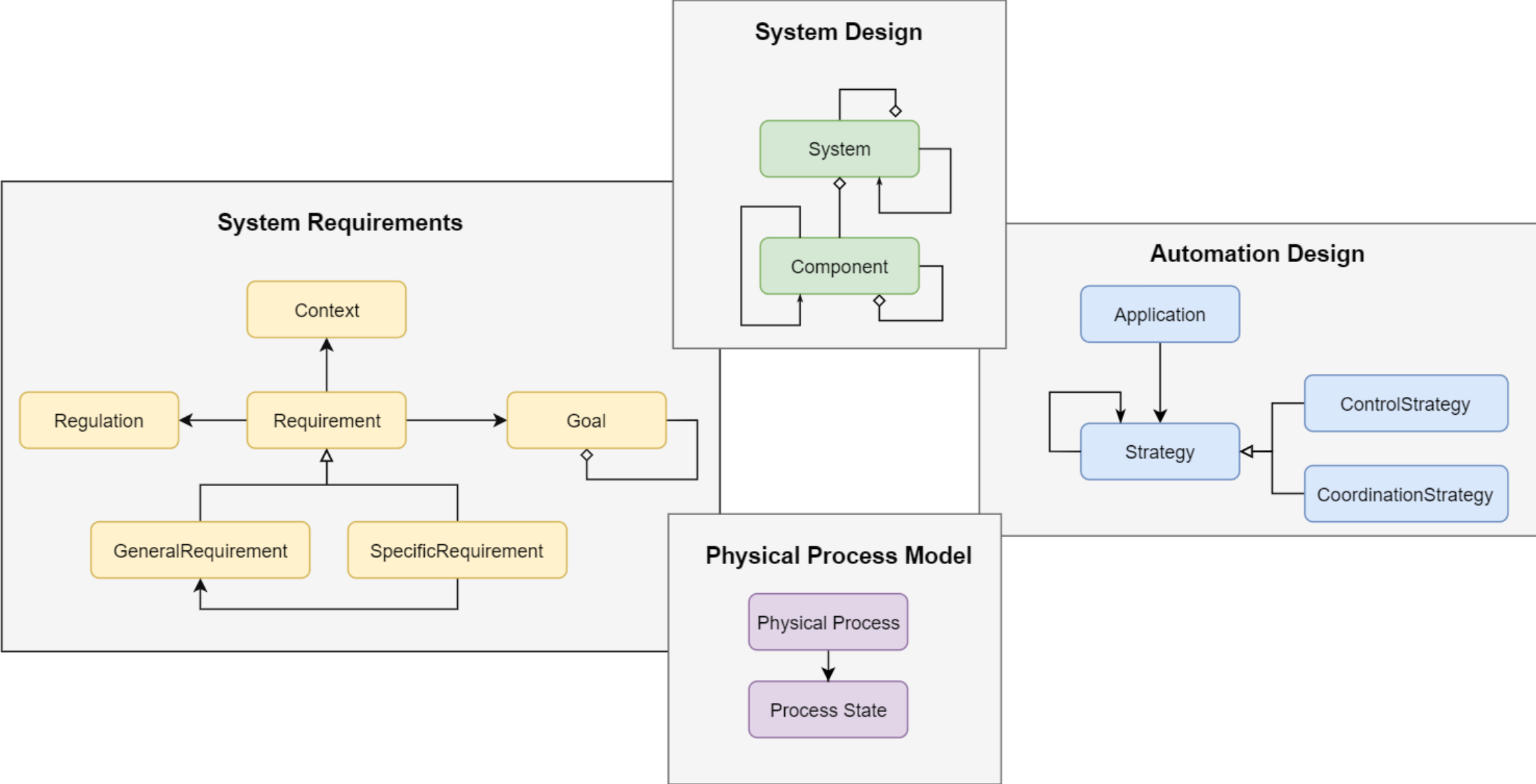
Environment

System Topology as Social Structure

System Topology as Social Structure

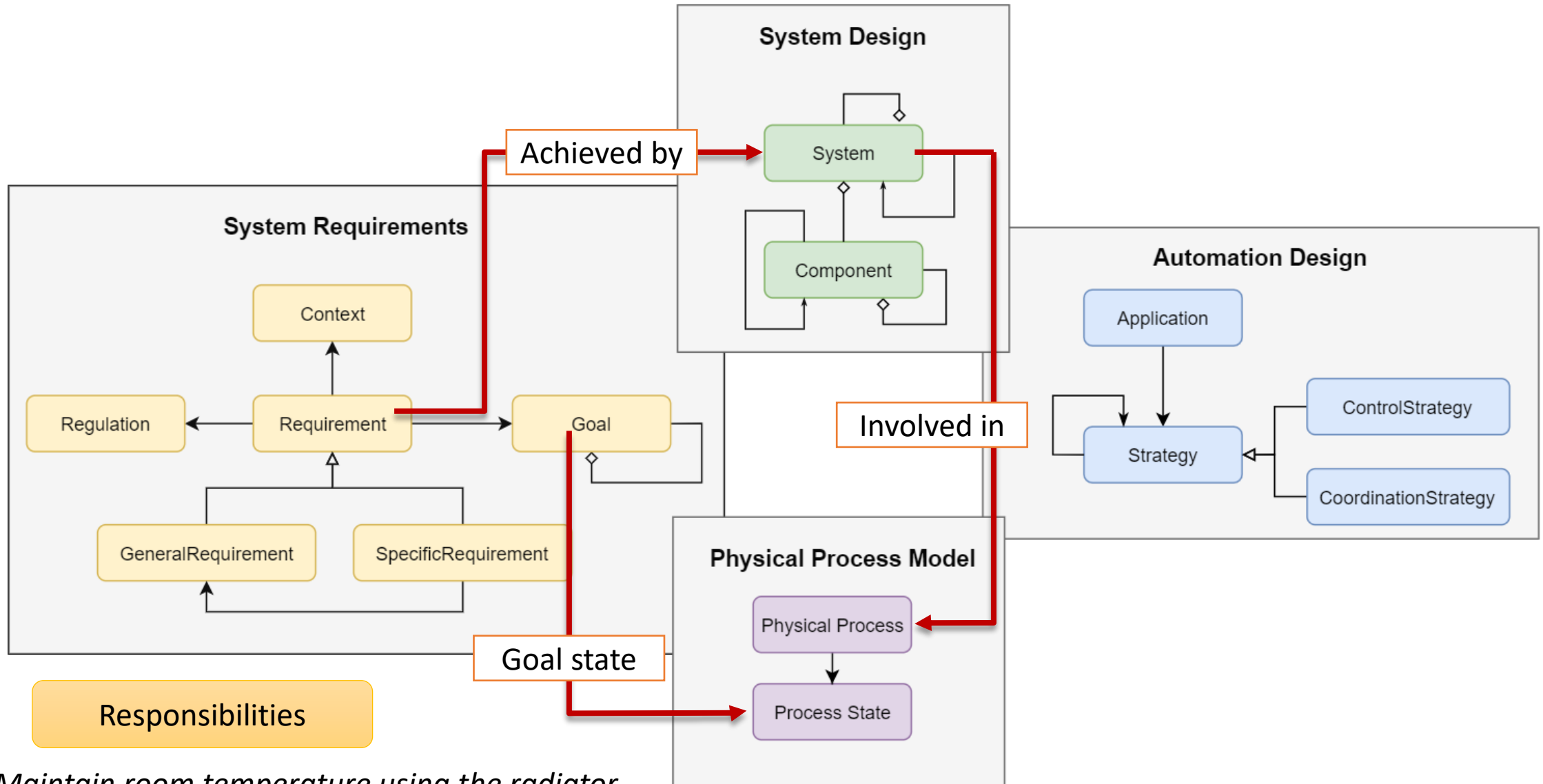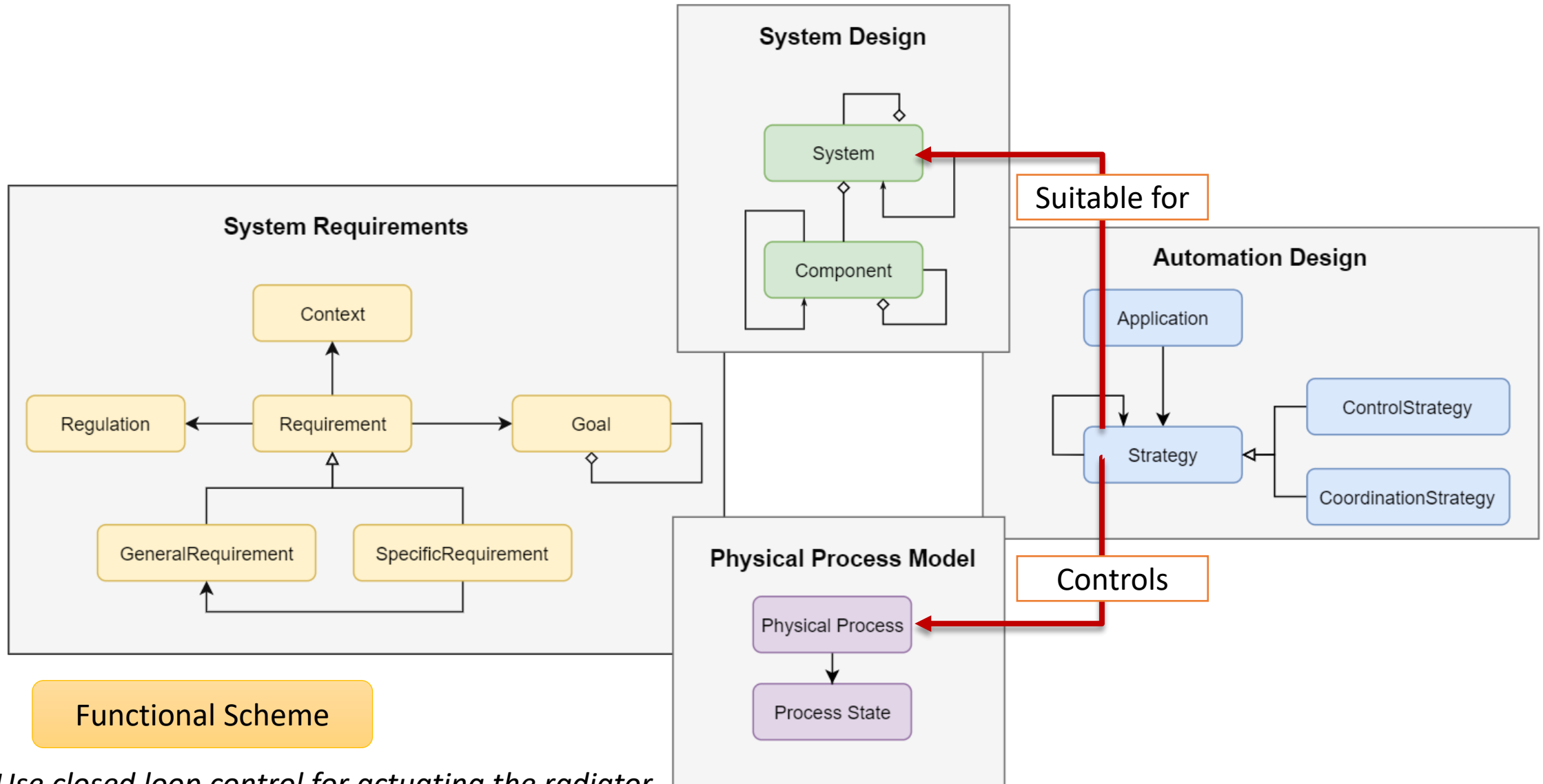# System Knowledge (but fragmented)
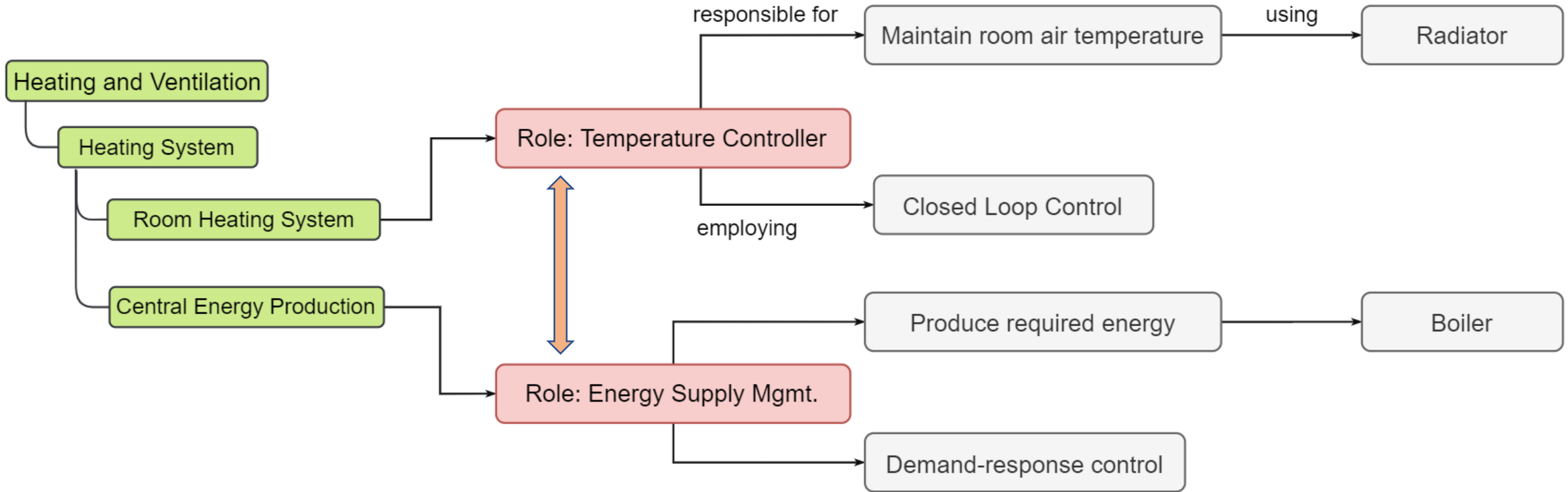
Inferring Process Responsibilites

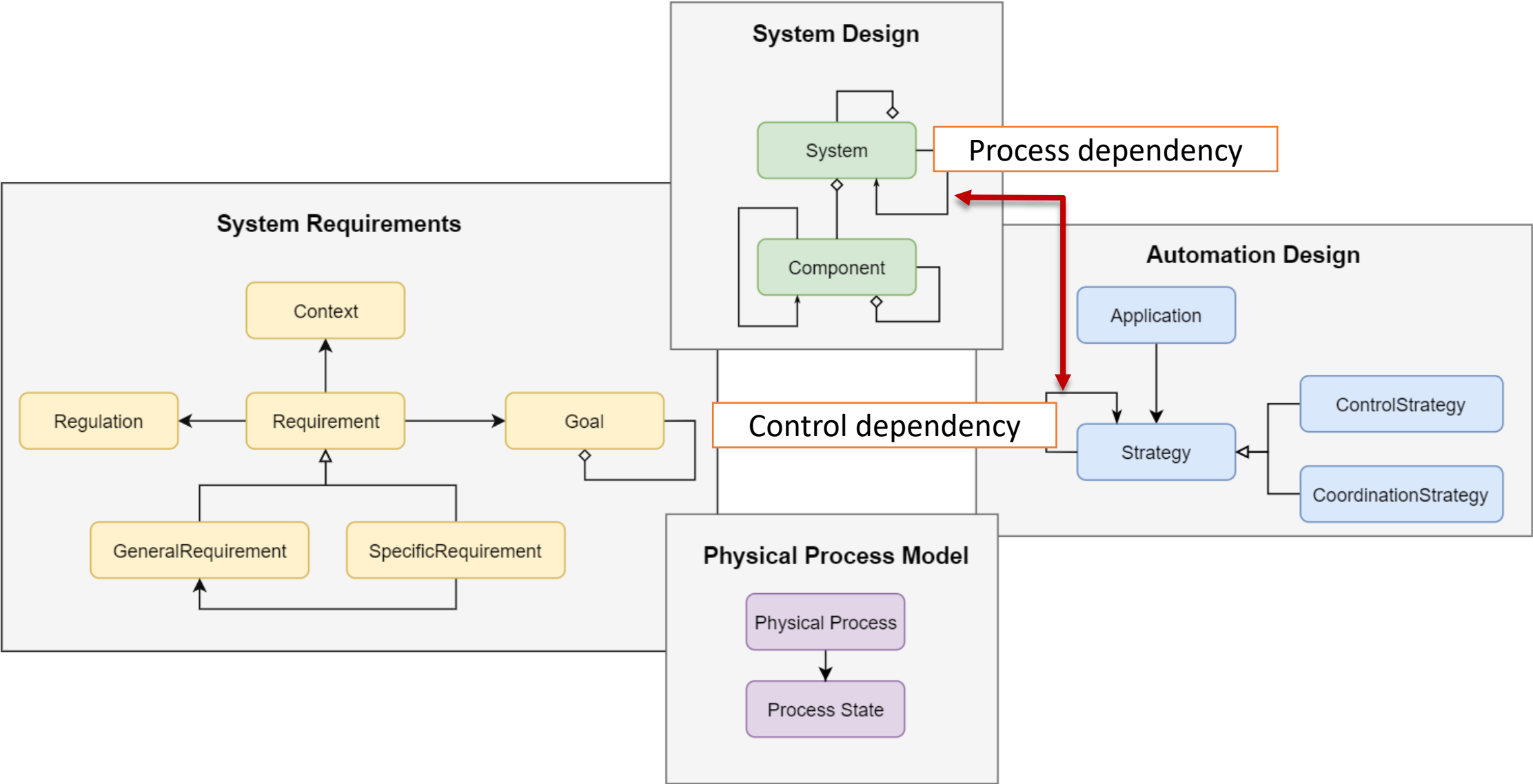e.g., *Maintain room temperature using the radiator*

Inferring Functions

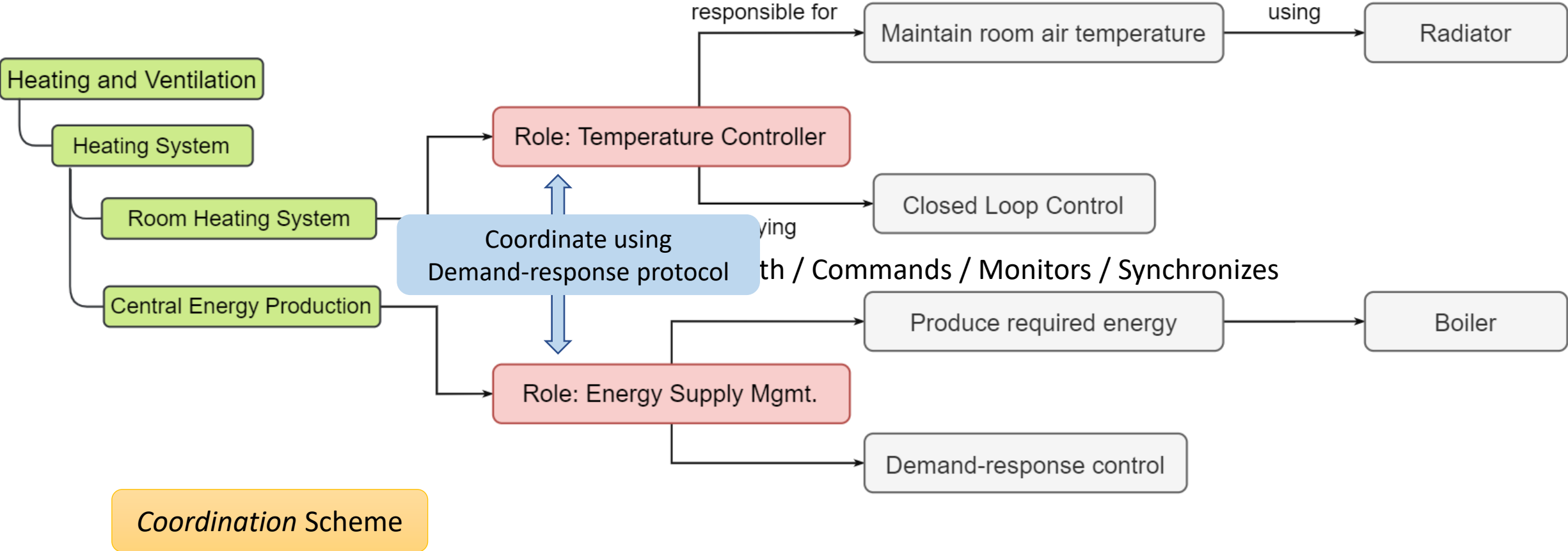e.g., *Use closed loop control for actuating the radiator*

Roles and Schemes

But what about role relationships?
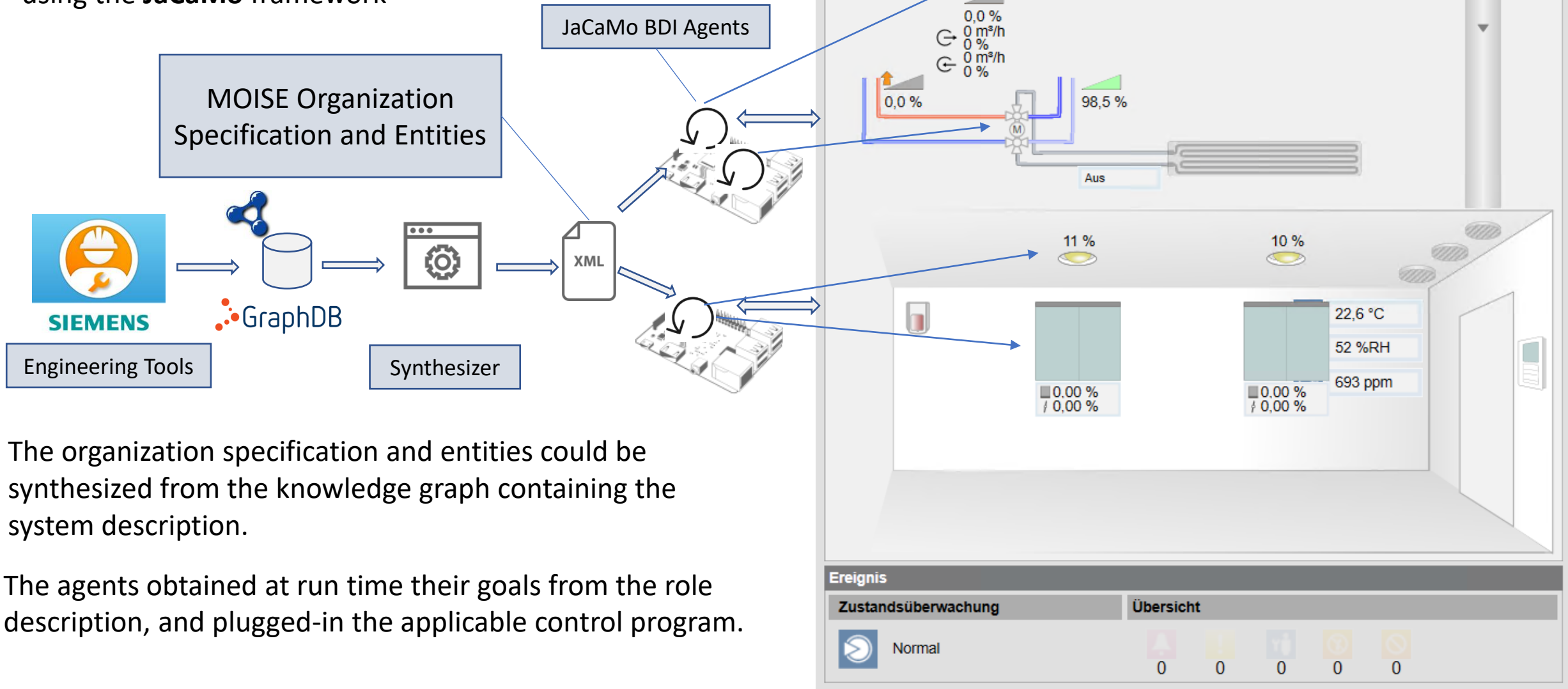
Inferring Required Interactions

Adding Interactions

Evaluation

MAS for automation of an office room was implemented using the **JaCaMo** framework

JaCaMo BDI Agents

MOISE Organization Specification and Entities

SIEMENS

GraphDB

XML

Engineering Tools

Synthesizer

The organization specification and entities could be synthesized from the knowledge graph containing the system description.

The agents obtained at run time their goals from the role description, and plugged-in the applicable control program.

R151as1 [HLK/Lgt/Bls R151as1]

0,0 %
0 m³/h
0 %
0 m³/h
0 %

0,0 %

98,5 %

Aus

11 %

10 %

22,6 °C

52 %RH

693 ppm

0,00 %
0,00 %

0,00 %
0,00 %

Ereignis

Zustandsüberwachung

Übersicht

Normal

0   0   0   0   0

Conclusions

Engineering system description contain the abstractions from which MAS organization specification can be synthesized in an automated manner.

However, to facilitate such synthesis, currently available engineering ontologies need be conceptually bridged.

The possibility to make expert knowledge accessible to autonomous agents provides a major impetus for application of MAS in industrial applications.

Open topics include infusing system knowledge into the components, modeling regulations, norms, and safety mechanisms.
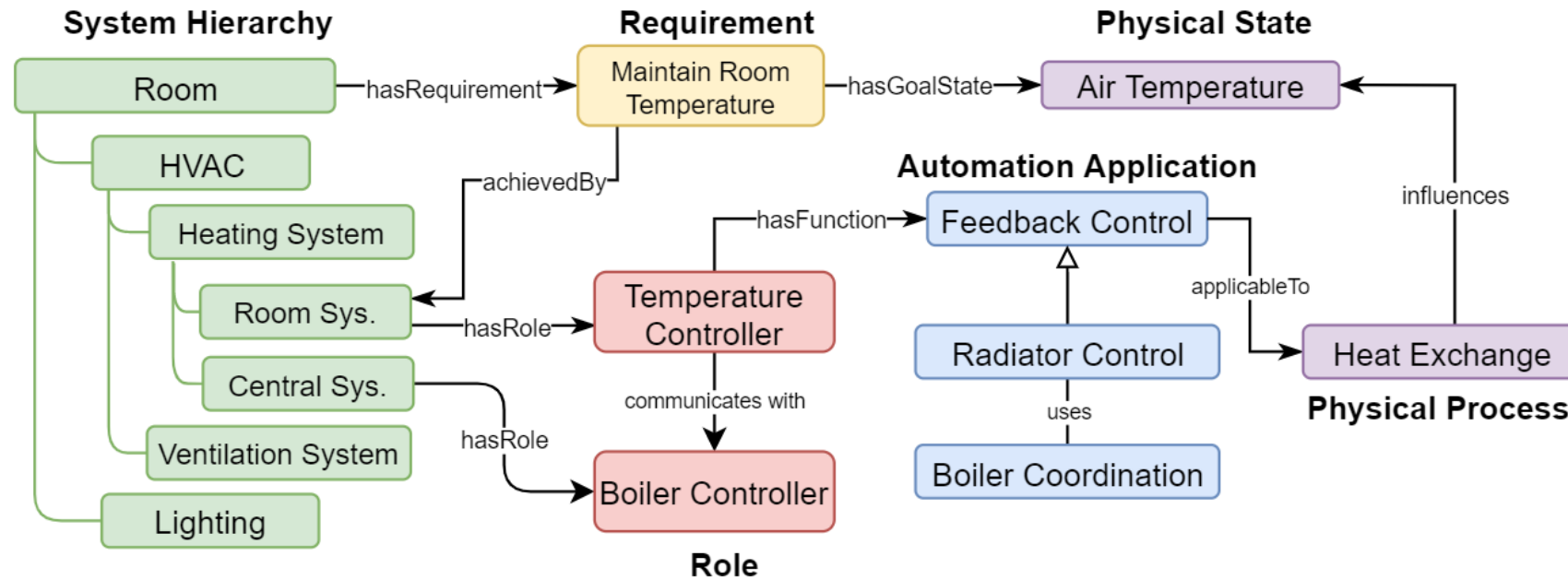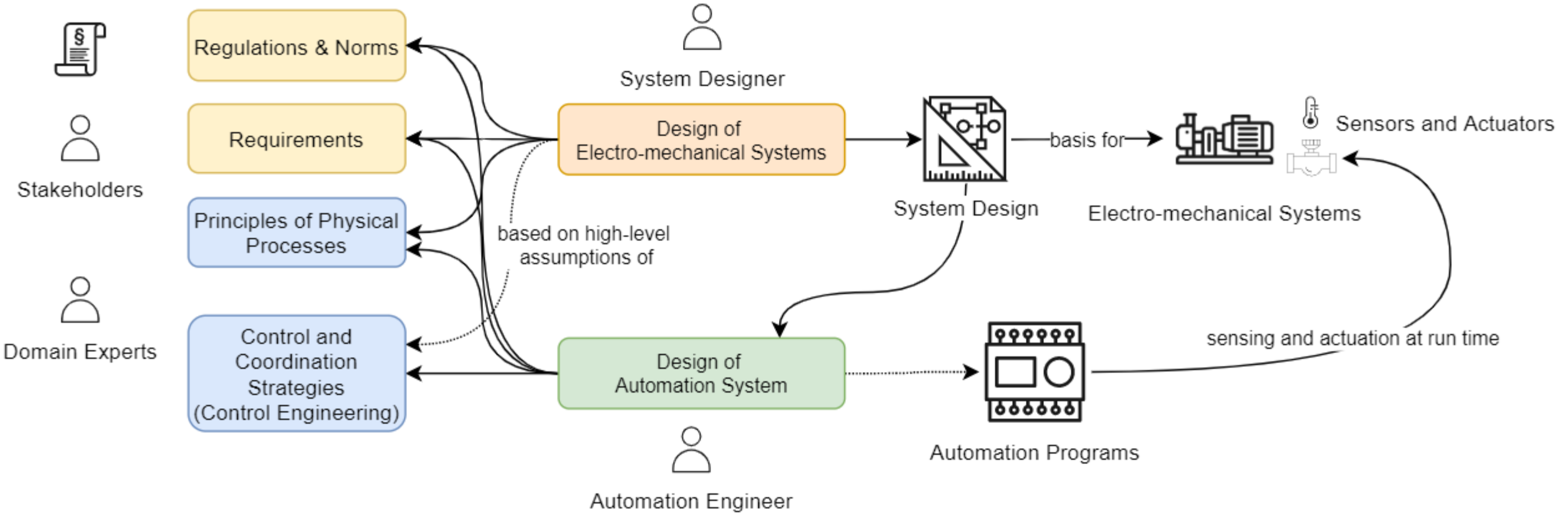
Thank you!

Questions?

Comments?

Ideas?

Recognizing Automation Roles

Engineering of the System

```
SELECT ?system ?goal WHERE {
  ?req a :Requirement.
  ?req :achievedBy ?system
  ?req :hasGoal ?goal.
  ?goal :hasState ?state.
  ?system :involvedIn ?process
  ?process :hasState ?state.
}
```

```
SELECT ?strategy WHERE {
  urn:role1 :employs ?system.
  ?strategy :suitableFor ?system.
  ?system :involvedIn ?process.
  ?strategy :controls ?process.
}
```