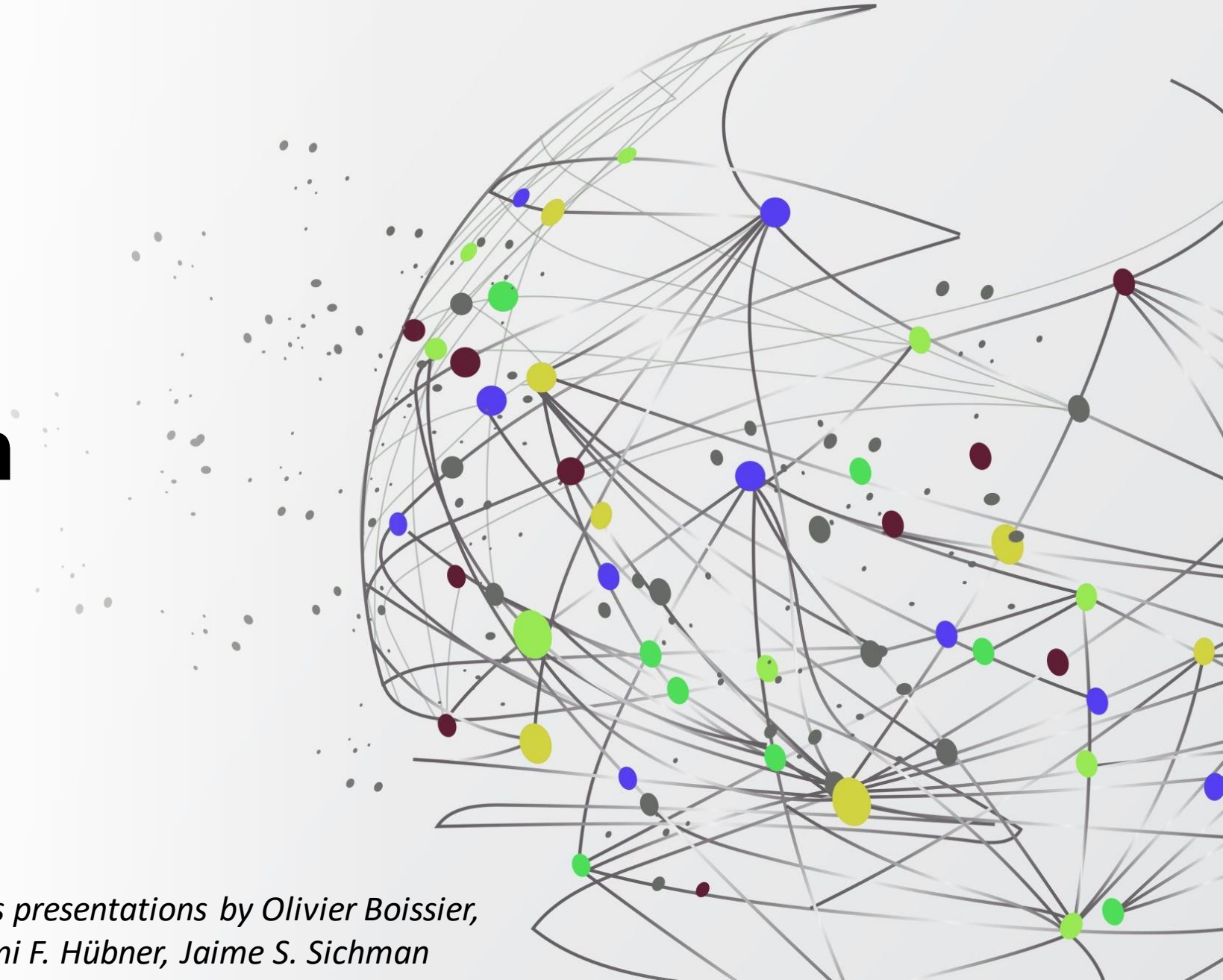
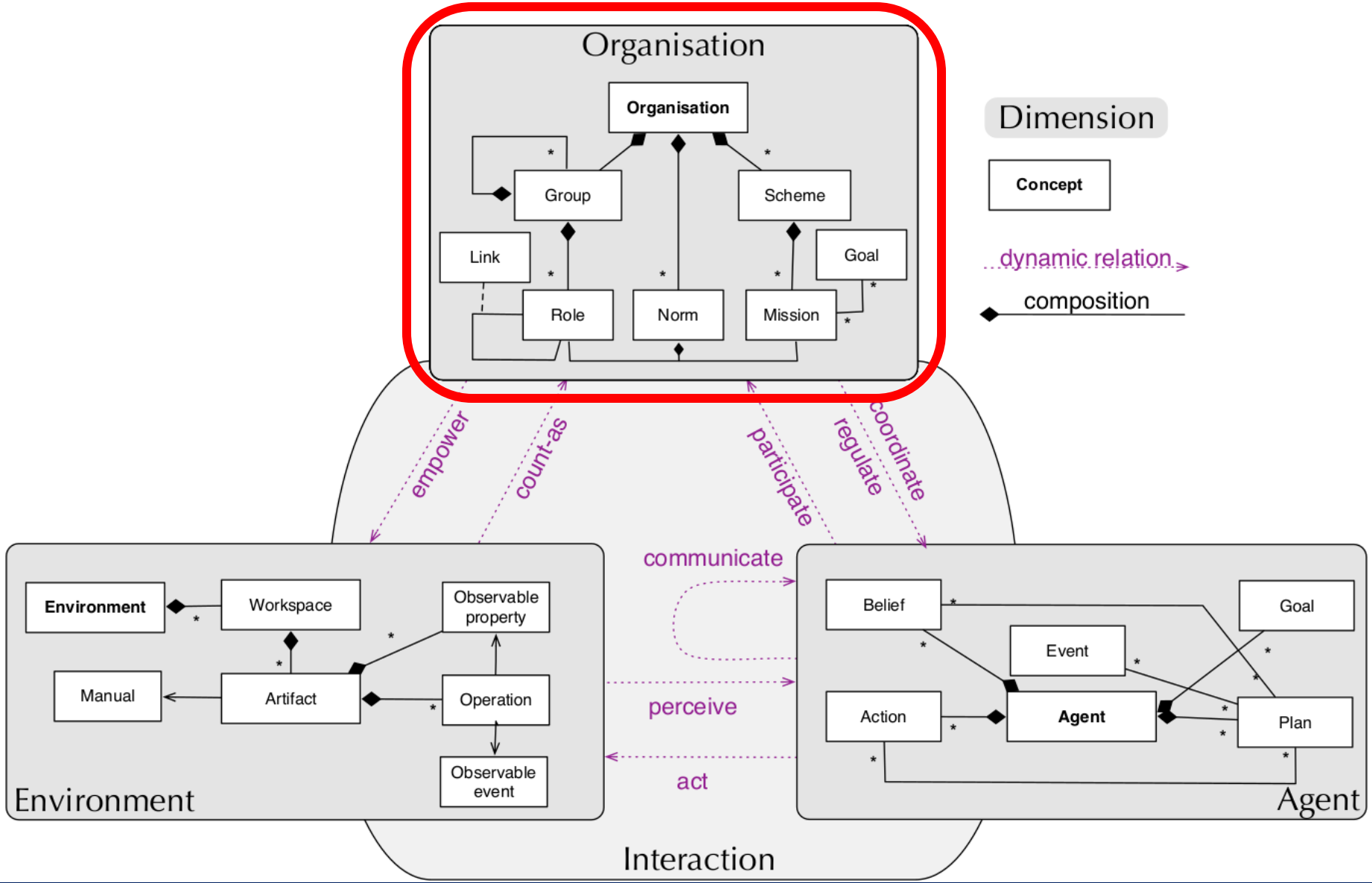
# Organization Dimension



***Credits**: Slides are based on previous presentations by Olivier Boissier, Rafael Bordini, Maiquel de Brito, Jomi F. Hübner, Jaime S. Sichman*

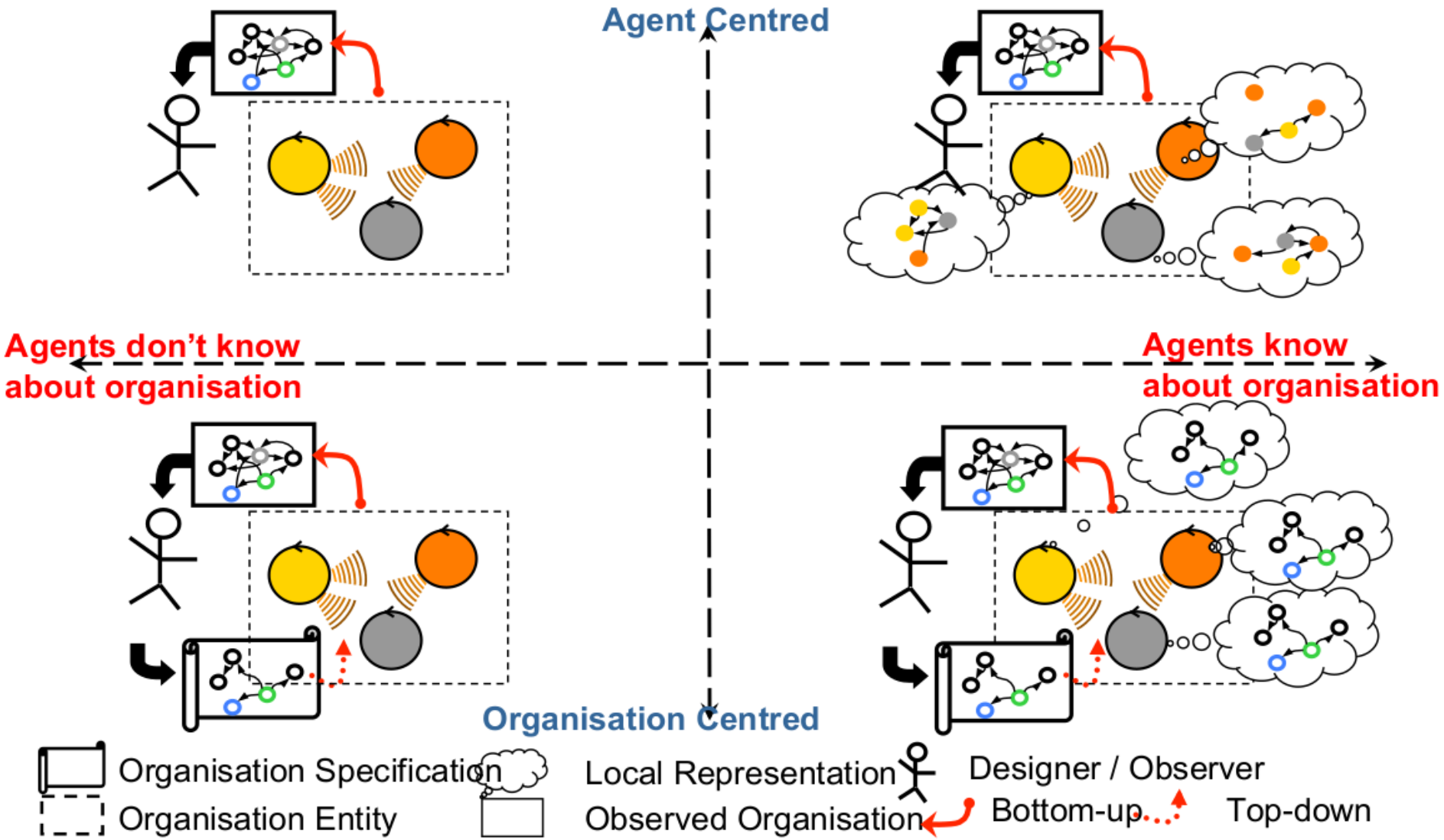
# JaCaMo Metamodel – Multi-Agent Concepts



# Organization in MAS

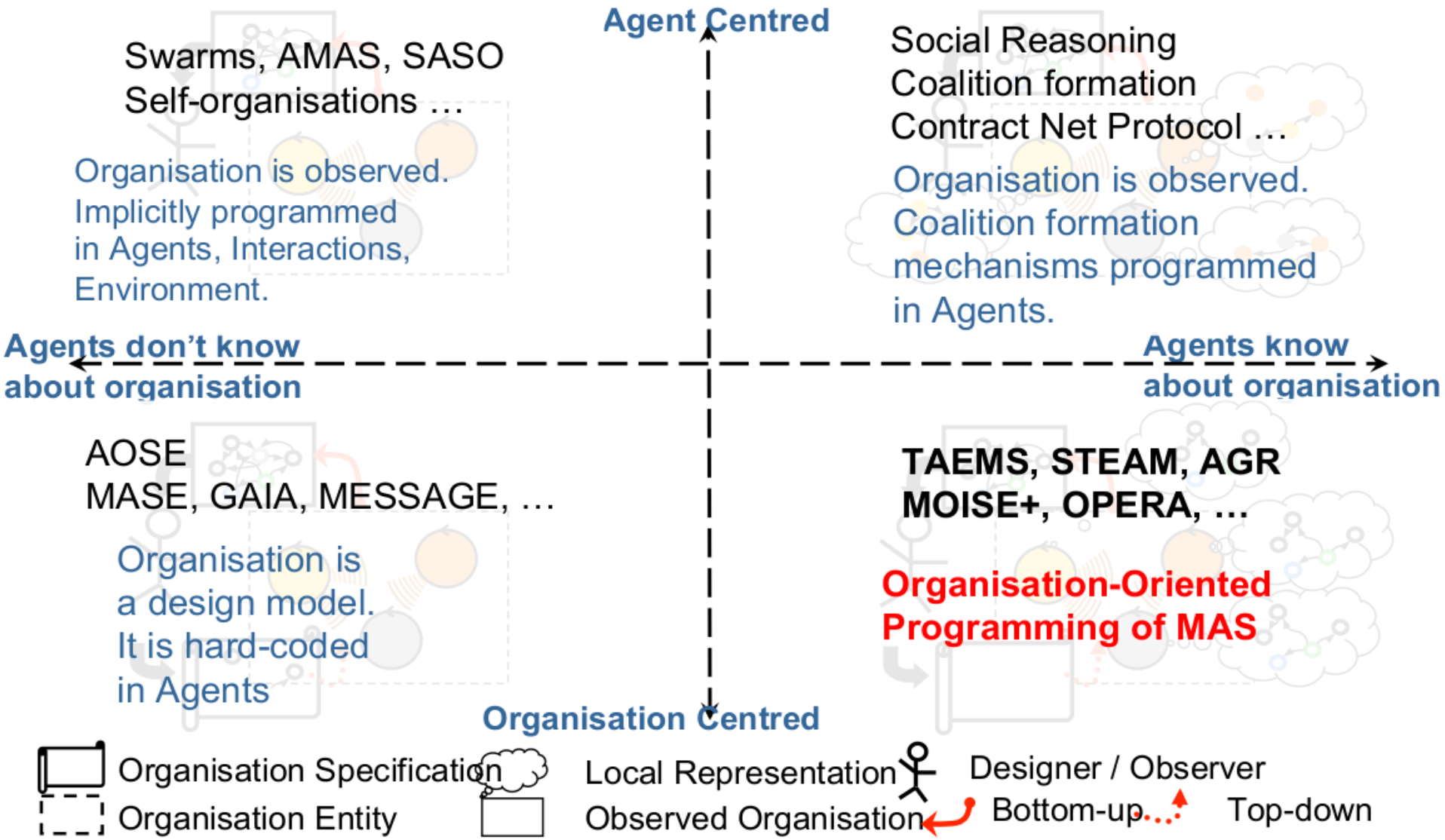
Purposive supra-agent pattern of emergent or (pre)defined agents' cooperation, that could be defined by the designer or by the agents themselves.

# Perspective on Organizations



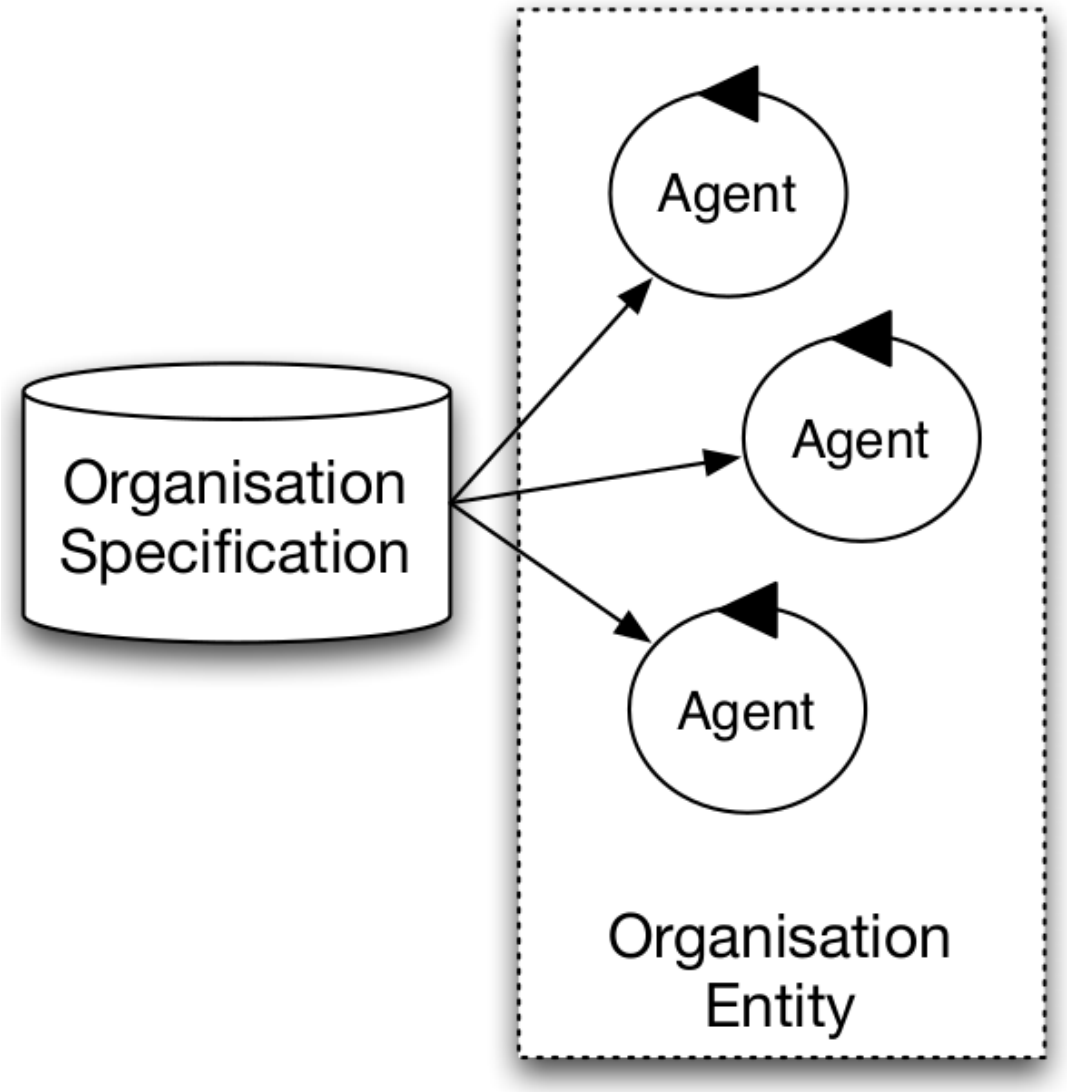

Boissier & Sichman, EASSS 2015

# Perspective on Organizations




Boissier & Sichman, EASSS 2015

# Organization Oriented Programming



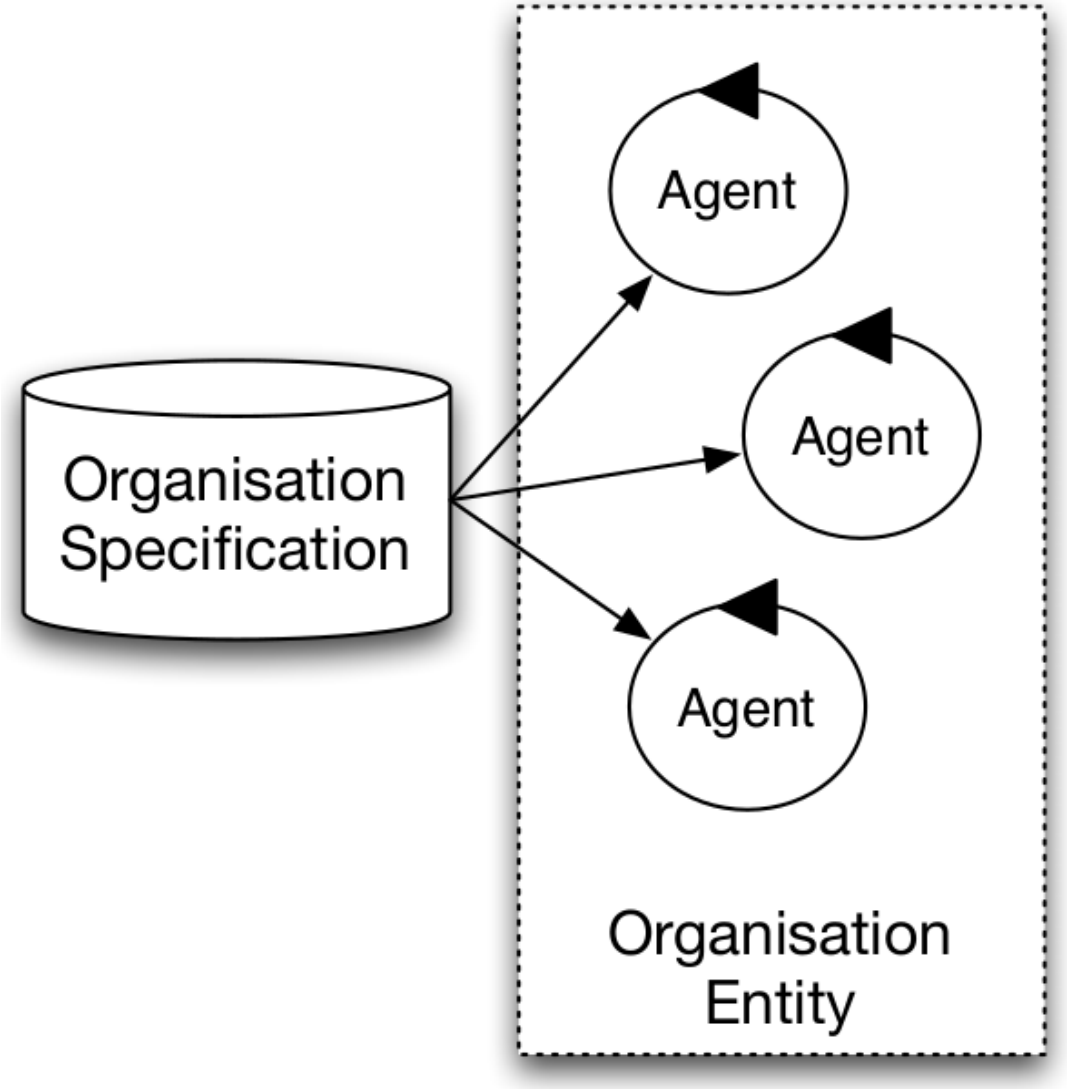

**Programming MAS** = Programming **Agents** + Programming the **Environment** + Programming the **Organization**

Programming **outside the agents** using of **organizational concepts** to **coordinating and regulating** autonomous agents

```
Program = Specification
```

By changing the specification, we can change the MAS behavior

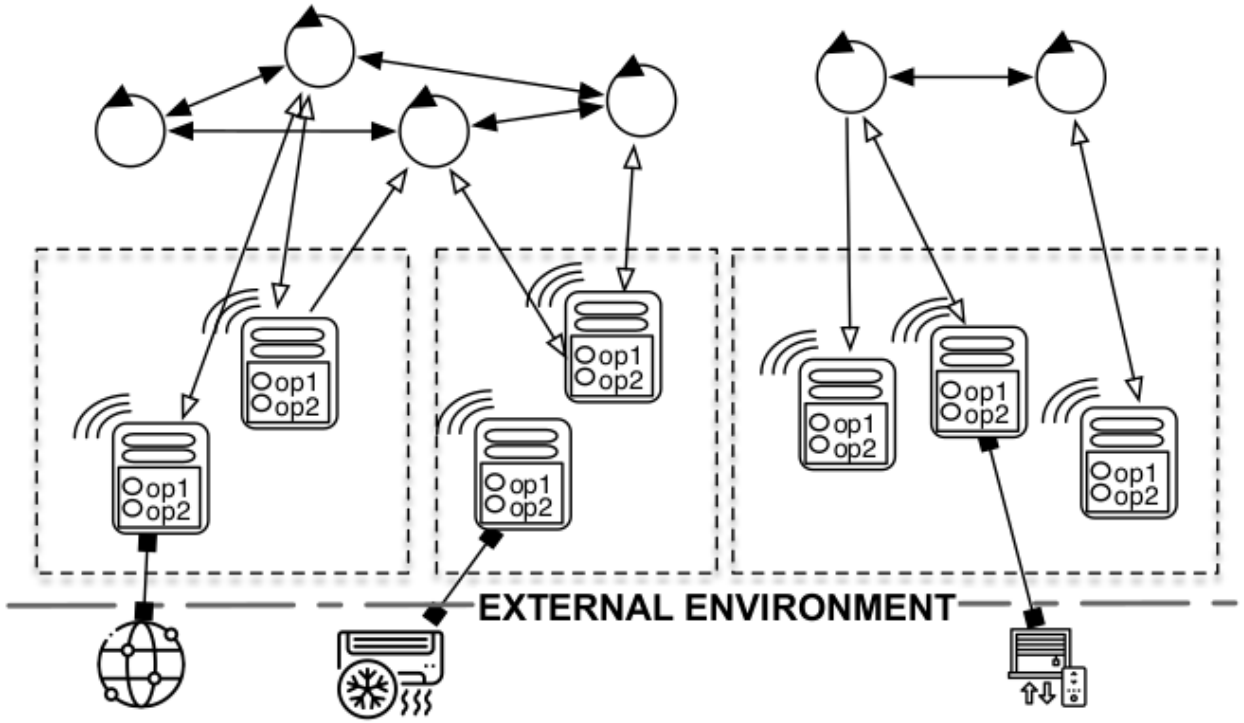
# Organization Oriented Programming



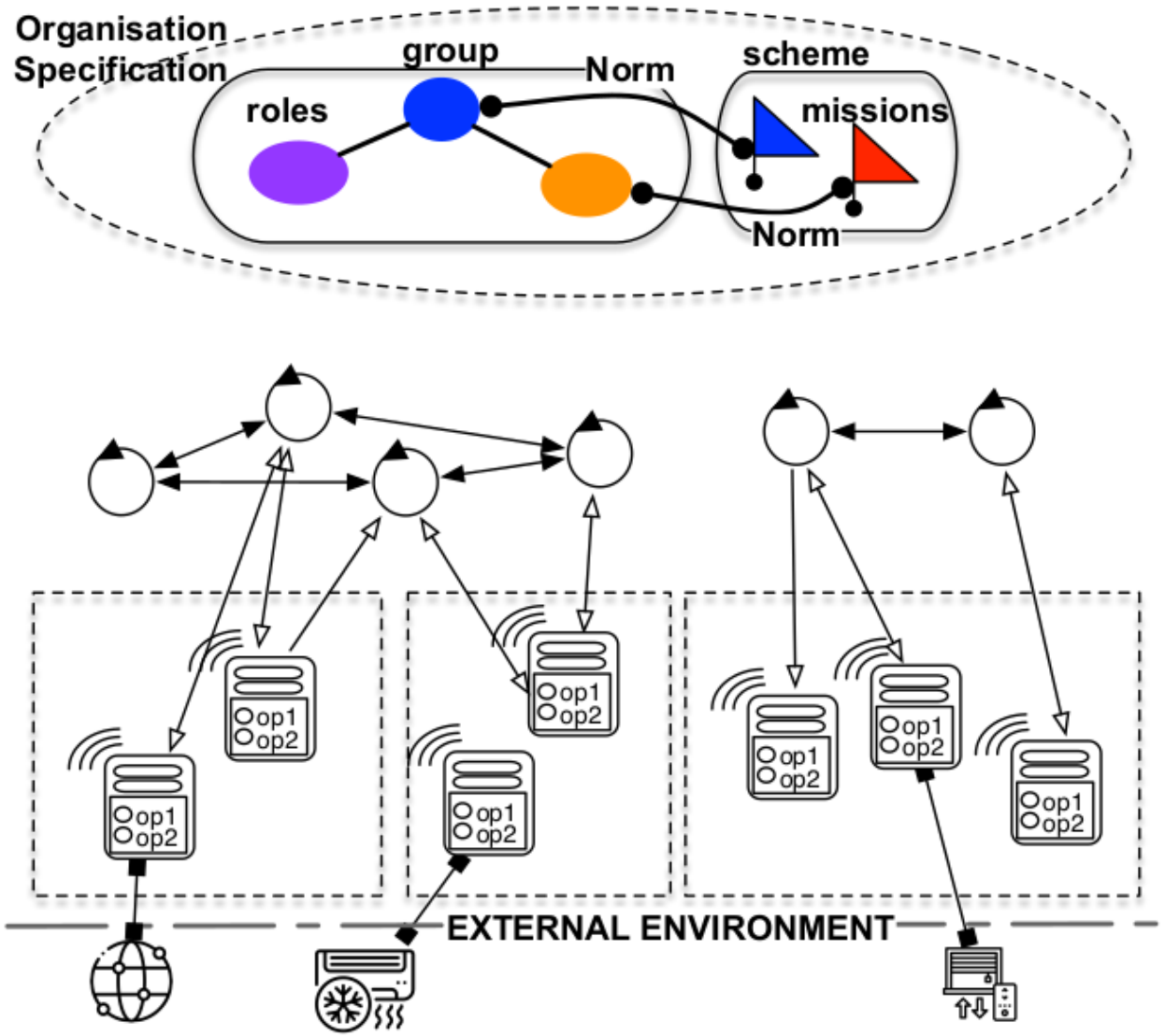

Components

1. Programming language
2. Organization Management Infrastructure
3. Integration to agent architectures and to the environment

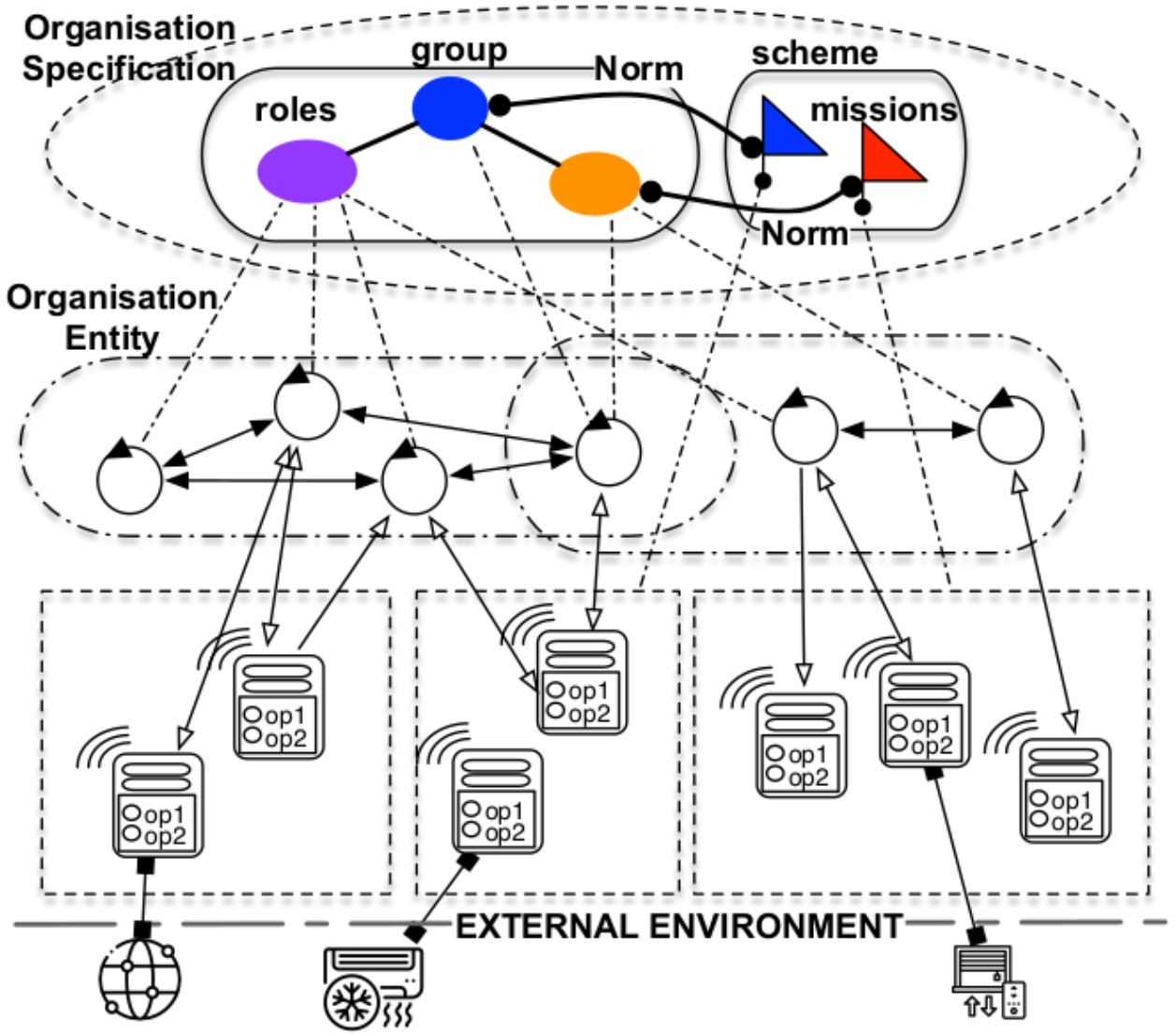
# JaCaMo Organization Dimension



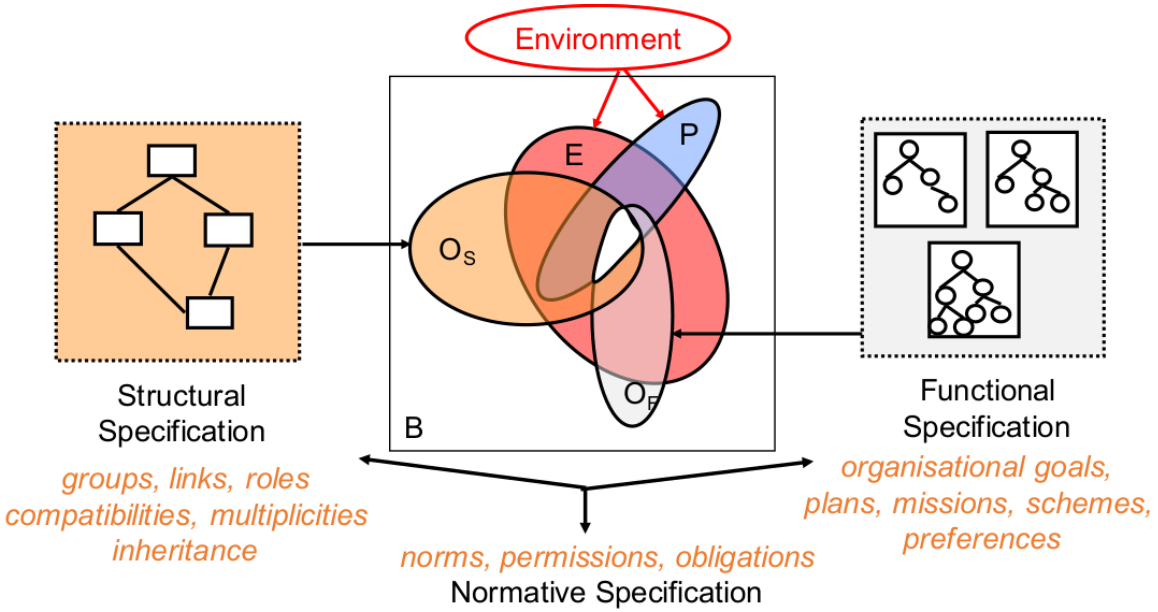
# JaCaMo Organization Dimension



# JaCaMo Organization Dimension



# JaCaMo Organization Dimension

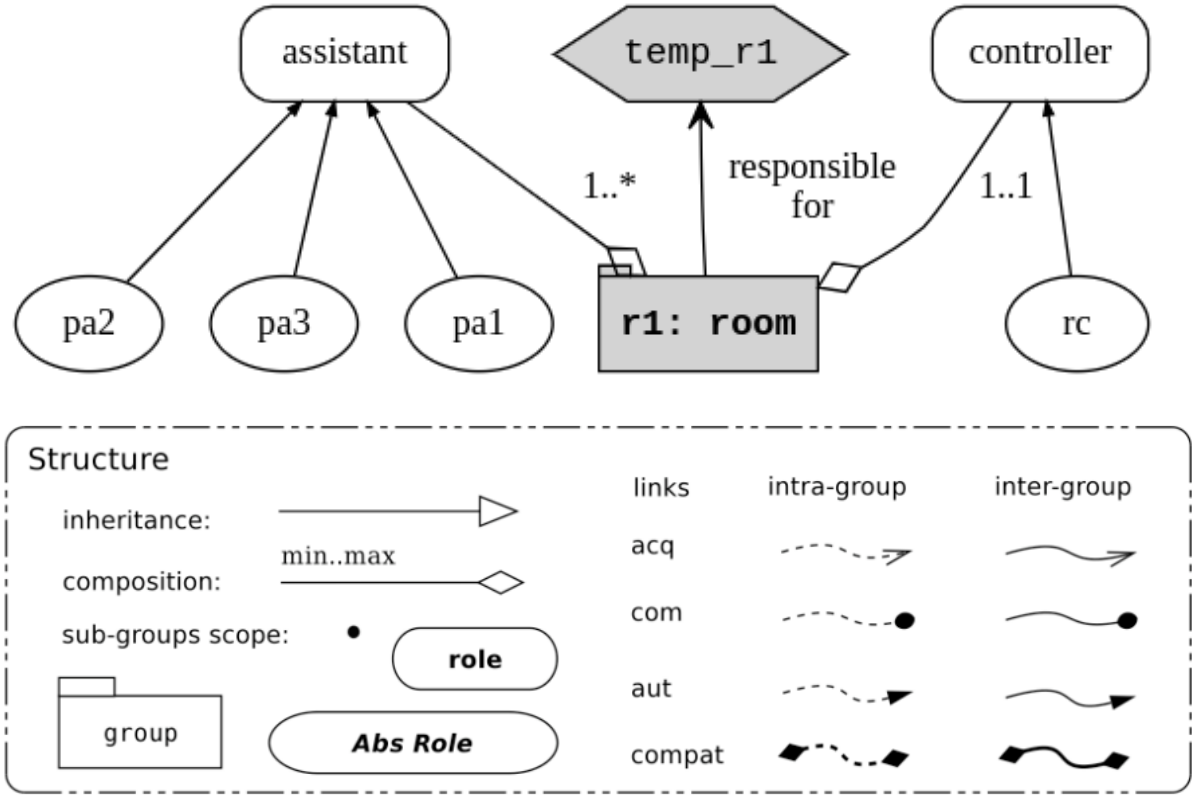



- Dimensions (Hübner et al. 2007)
  - **Structural** (i.e., Roles, Groups),
  - **Functional** (i.e., Organizational Goals, Missions, Schemes)
  - **Normative** (i.e., Norms with obligations, permissions, interdictions)
- Enable agent's autonomy w.r.t. organization (enforcement vs regimentation)
- Programming and representing the organization
  - make it accessible to the designers, the agents, the coordination and regulation management infrastructure (Hübner et al., 2010)

# Structural Specification

- Specifies the structure of an MAS along three levels:
  - **Individual** with **Role**
  - **Social** with **Link**
  - **Collective** with **Group**
- Components:
  - **Role**: label used to assign rights and constraints on the behavior of agents playing it
  - **Link**: relation between roles that directly constrains the agents in their interaction with the other agents playing the corresponding roles
  - **Group**: set of links, roles, compatibility relations used to define a shared context for agents playing roles in it

# Structural Specification Example

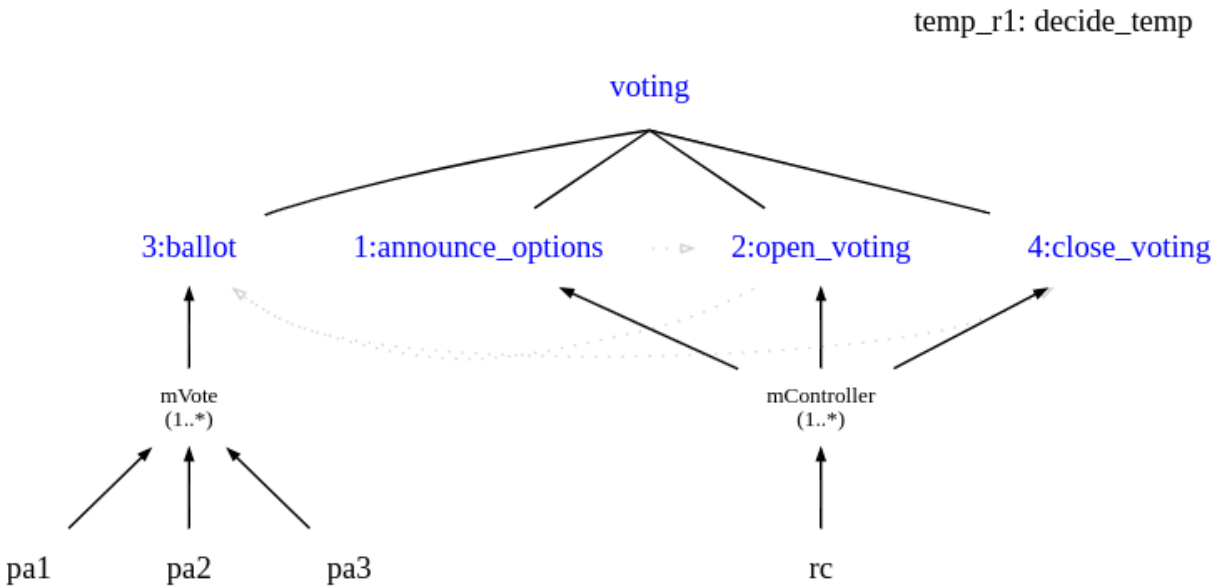



```
<structural-specification>
    <group-specification id="room">
        <roles>
            <role id="assistant" min="1" />
            <role id="controller" min="1" max="1" />
        </roles>
    </group-specification>
</structural-specification>
```

# Functional Specification

- Specifies the expected behavior of an MAS in terms of **goals** along two levels:
  - **Collective** with **Scheme**
  - **Individual** with **Mission**
- Components:
  - **Goals**:
    - **Achievement goal** (default type). Goals of this type should be declared as satisfied by the agents committed to them, when achieved
    - **Maintenance goal**. Goals of this type are not satisfied at a precise moment but are pursued while the scheme is running. The agents committed to them do not need to declare that they are satisfied
  - **Scheme**: global goal decomposition tree assigned to a group
    - Any scheme has a root goal that is decomposed into subgoals
  - **Missions**: set of coherent goals assigned to roles within norms

# Functional Specification Example




```
<functional-specification>
    <scheme id="decide_temp">
        <goal id="voting">
            <plan operator="sequence">
                <goal id="announce_options" />
                <goal id="open_voting" />
                <goal id="ballot" ttf="10 seconds">
                    <argument id="voting_machine_id"
                    />
                </goal>
                <goal id="close_voting" />
            </plan>
        </goal>
        <mission id="mVote" min="1">
            <goal id="ballot" />
        </mission>
        <mission id="mController" min="1">
            <goal id="announce_options" />
            <goal id="open_voting" />
            <goal id="close_voting" />
        </mission>
    </scheme>
</functional-specification>
```

# Normative Specification

- Explicit relation between the functional and structural specifications
- Permissions and obligations to commit to missions in the context of a role
- The normative specification makes explicit the normative dimension of a role

# Normative Specification Example

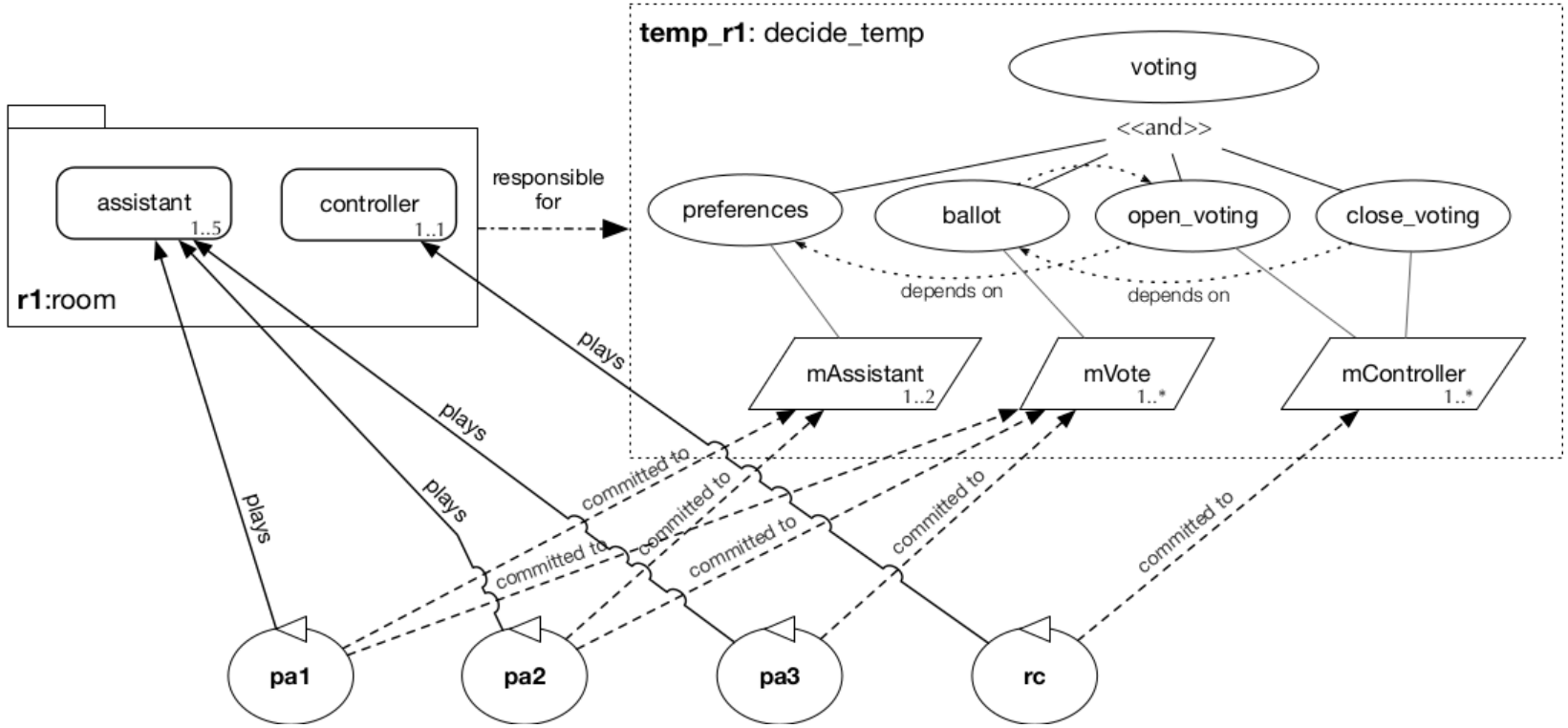
**Normative Specification**

| id | condition | role | relation | mission | time constraint | properties |
|---|---|---|---|---|---|---|
| n1 | | assistant | *obligation* | mVote | | |
| n2 | | controller | *obligation* | mController | | |

```
<normative-specification>
  <norm id="n1" type="obligation"
  role="assistant" mission="mVote" />

  <norm id="n2" type="obligation"
  role="controller" mission="mController" />
</normative-specification>
```

# Declarative Organization Programming




- Structural patterns (groups (r1:room), roles (assistant, controller), links)
- Coordination patterns (
  - goal decomposition trees (voting, preferences, ballot, open_voting, close_voting)
  - missions (mAssistant, mVote,mController)
- Rights and duties (norms)

# Organization Dynamics

## In the context of Organization life-cycle

- Creation/Deletion of an Organization from an Organization specification
- Entrance/Exit of an agent
- Change of Organization specification

## In the context of Organization structure life-cycle

- Creation/Deletion of a group
- Adoption/Leave of a role

## In the context of Coordination activity life-cycle

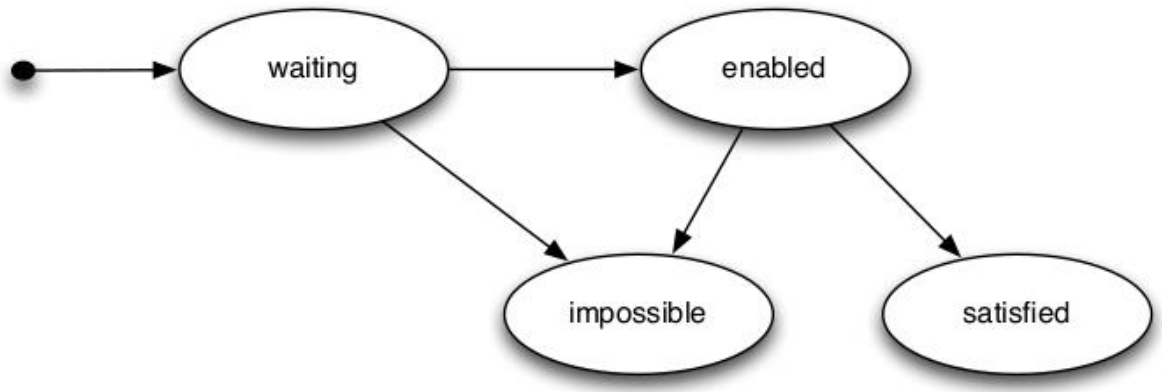
- Creation/End of a schema
- Commitment/Release of a mission
- Change of goal state

## In the context of Normative Regulation activity life-cycle

- Activation/De-activation of norms
- Fulfillment/Violation of norms
- Enforcement of norms

# Organization Dynamics

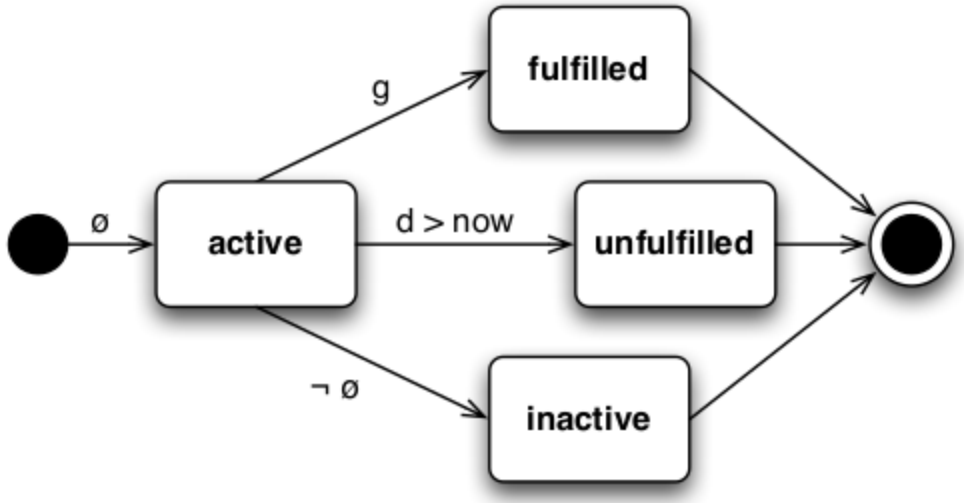
## Organization Goal Dynamics




**waiting** initial state
**enabled** goal pre-conditions are satisfied and scheme is well-formed
**satisfied** agents committed to the goal have achieved it
**impossible** the goal is impossible to be satisfied

**NOTE**: goal state from the Organization point of view may be different of the goal state from the Agent point of view

## Norm Dynamics

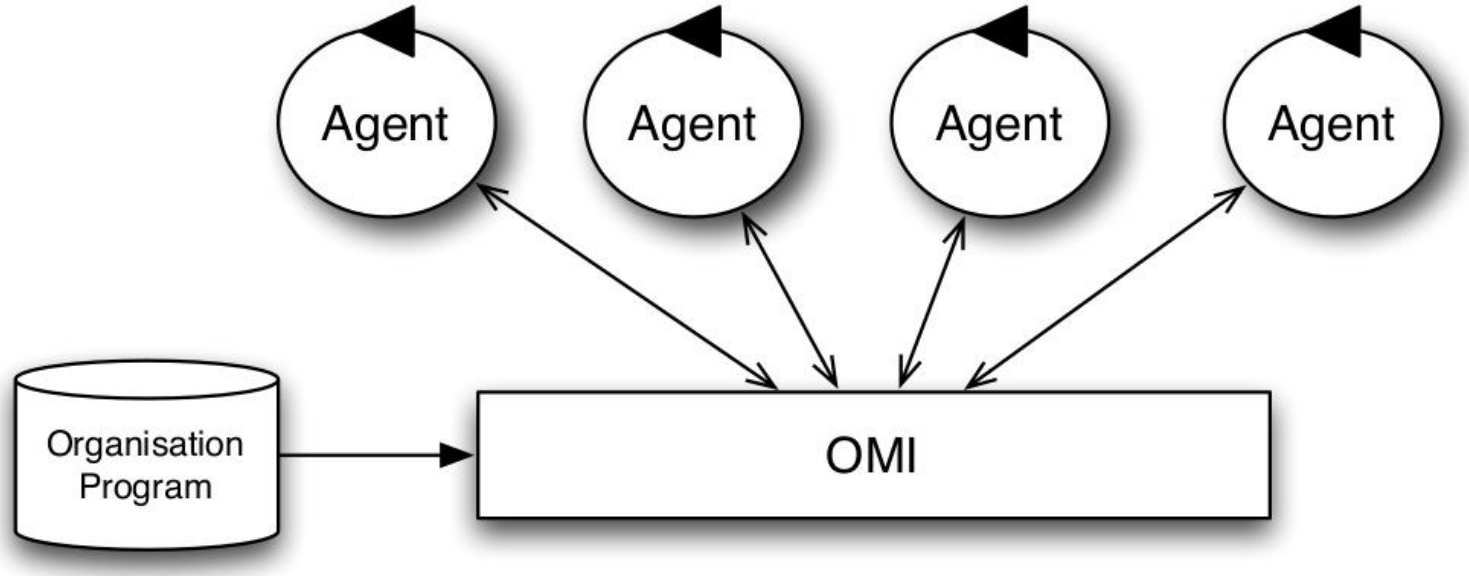



norm n : ϕ -> obligation(a, r, g, d)

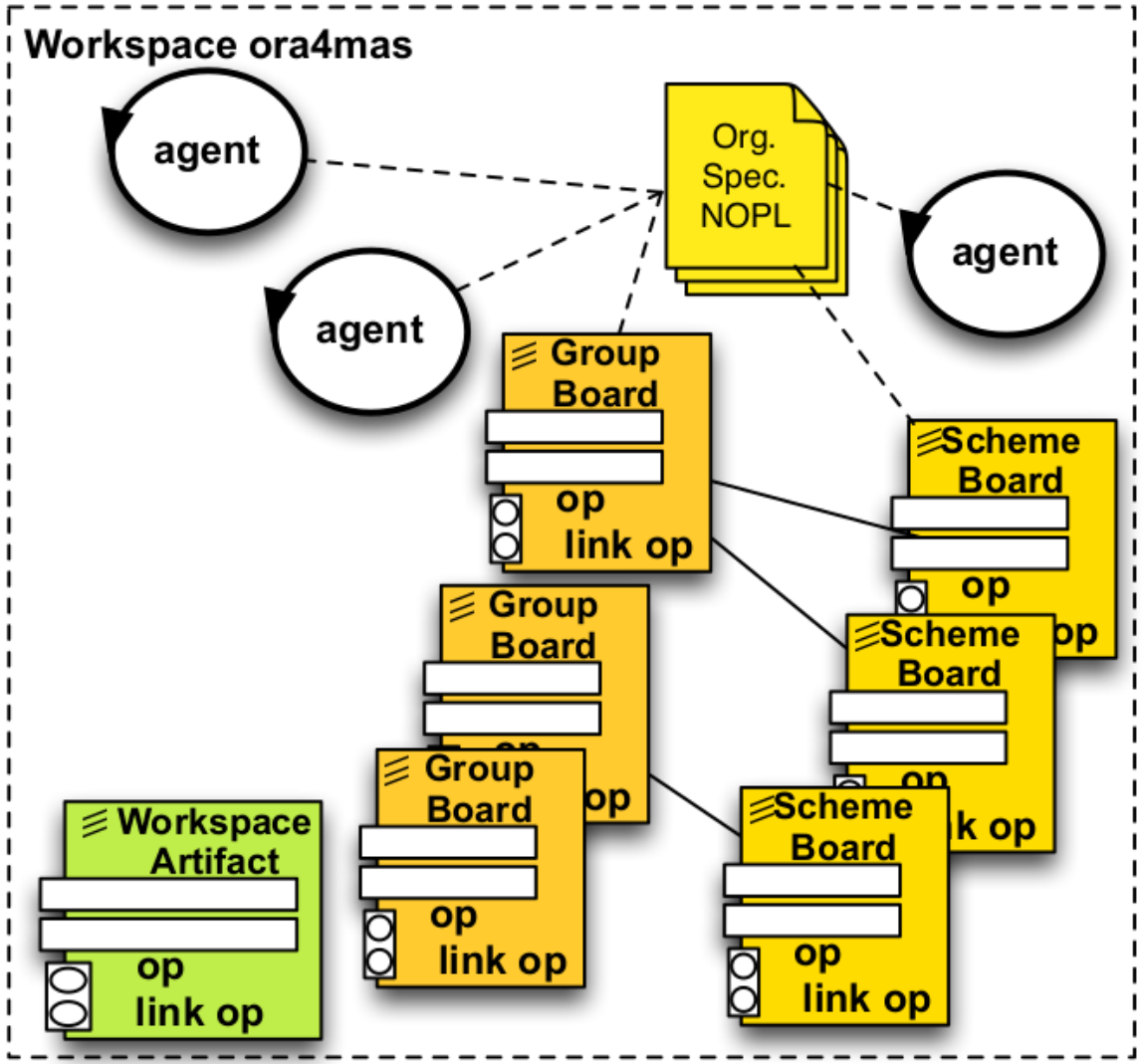
**ϕ**: activation condition of the norm (e.g., play a role)
**g**: the goal of the obligation (e.g., commit to a mission)
**d**: the deadline of the obligation

# Organization Management Infrastructure (OMI)

Managing – coordination, regulation – the agents' execution within organization defined in an organization specification

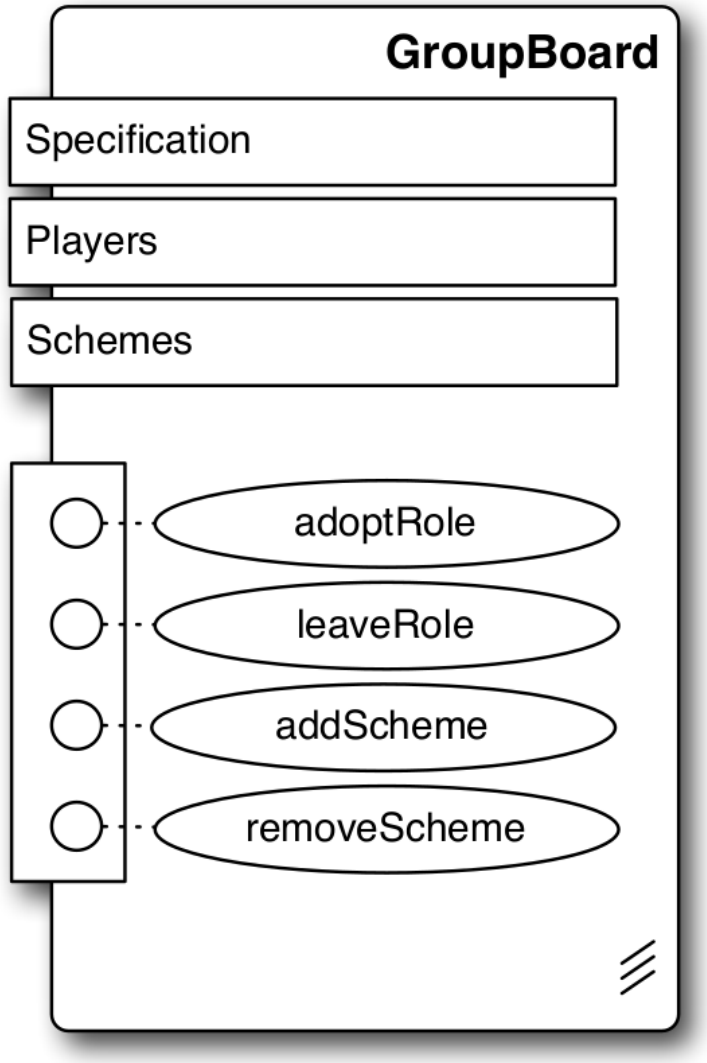


# Organizational Artifacts in JaCaMo




- based on A&A and Moise
- agents create and handle organizational artifacts
- artifacts in charge of regimentations, detection and evaluation of norms compliance
- agents are in charge of decisions about sanctions
- distributed solution

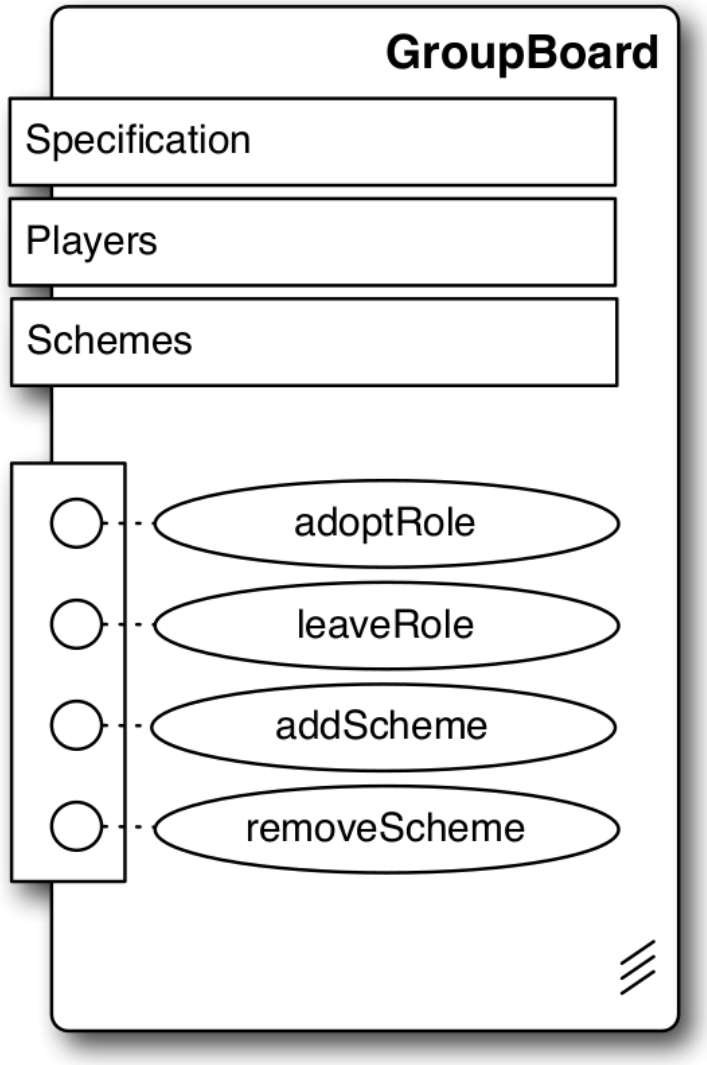
# GroupBoard Artifact




## Observable Properties

- **specification**: the specification of the group in the OS
- **players**: a list of agents playing roles in the group. Each element of the list is a pair (agent x role)
- **schemes**: a list of scheme identifiers that the group is responsible for

# GroupBoard Artifact




## Operations

- **adoptRole(role)**: the agent executing this operation tries to adopt a role in the group
- **leaveRole(role)**
- **addScheme(schId)**: the group starts to be responsible for the scheme managed by the SchemeBoard **schId**
- **removeScheme(schId)**

# SchemeBoard Artifact


## Observable Properties

- **specification**: the specification of the scheme in the OS
- **groups**: a list of groups responsible for the scheme
- **players**: a list of agents committed to the scheme. Each element of the list is a pair (agent, mission)
- **goals**: a list with the current state of the goals
- **obligations**: list of obligations currently active in the scheme

# SchemeBoard Artifact


## Operations

- **commitMission(mission)** and **leaveMission**: operations to "enter" and "leave" the scheme
- **goalAchieved(goal)**: defines that some goal is achieved by the agent performing the operation
- **setGoalArgument(goal,argument, value)**: defines the value of some goal's argument

# Organization Entity

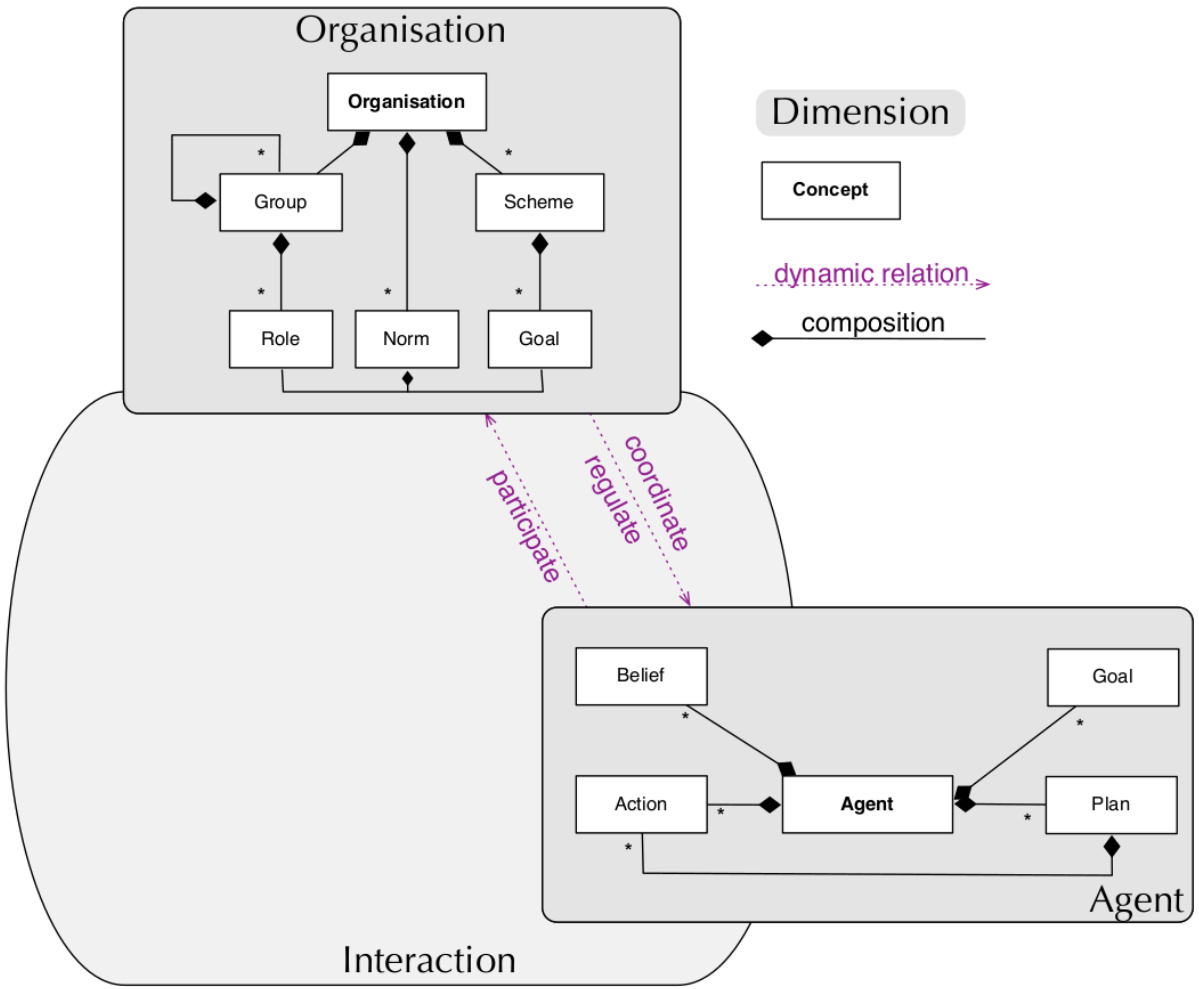
**smart-room.jcm**

```
mas smart_room {
    …

    organisation smart_house_org : smart_house.xml {
        group r1 : room {
            players: pa1 assistant
                     pa2 assistant
                     pa3 assistant
                     rc controller
            responsible-for: temp_r1
        }

        scheme temp_r1: decide_temp
    }
}
```

# Integrating Agent and Organization Dimensions




- Agents can interact with organizational artifacts as with ordinary artifacts by perception and action
- Agent integration provides “internal” tools for the agents to simplify their interaction with the organization:
  - maintenance of a local copy of the organizational state
  - production of organizational events
  - provision of organizational actions

# Integrating Agent and Organization Dimensions

**GroupBoard**

```
...
joinWorkspace("ora4mas",O4MWsp);
makeArtifact(
    "auction",
    "ora4mas.nopl.GroupBoard",
    ["auction-os.xml", auctionGroup],
    GrArtId);
adoptRole(auctioneer);
focus(GrArtId);
...
```

**SchemeBoard**

```
...
makeArtifact(
   "sch1",
   "ora4mas.nopl.SchemeBoard",
   ["auction-os.xml", doAuction],
   SchArtId);
focus(SchArtId);
addScheme(Sch);
commitMission(mAuctioneer)[artifact_id(SchArtId)];
...
```

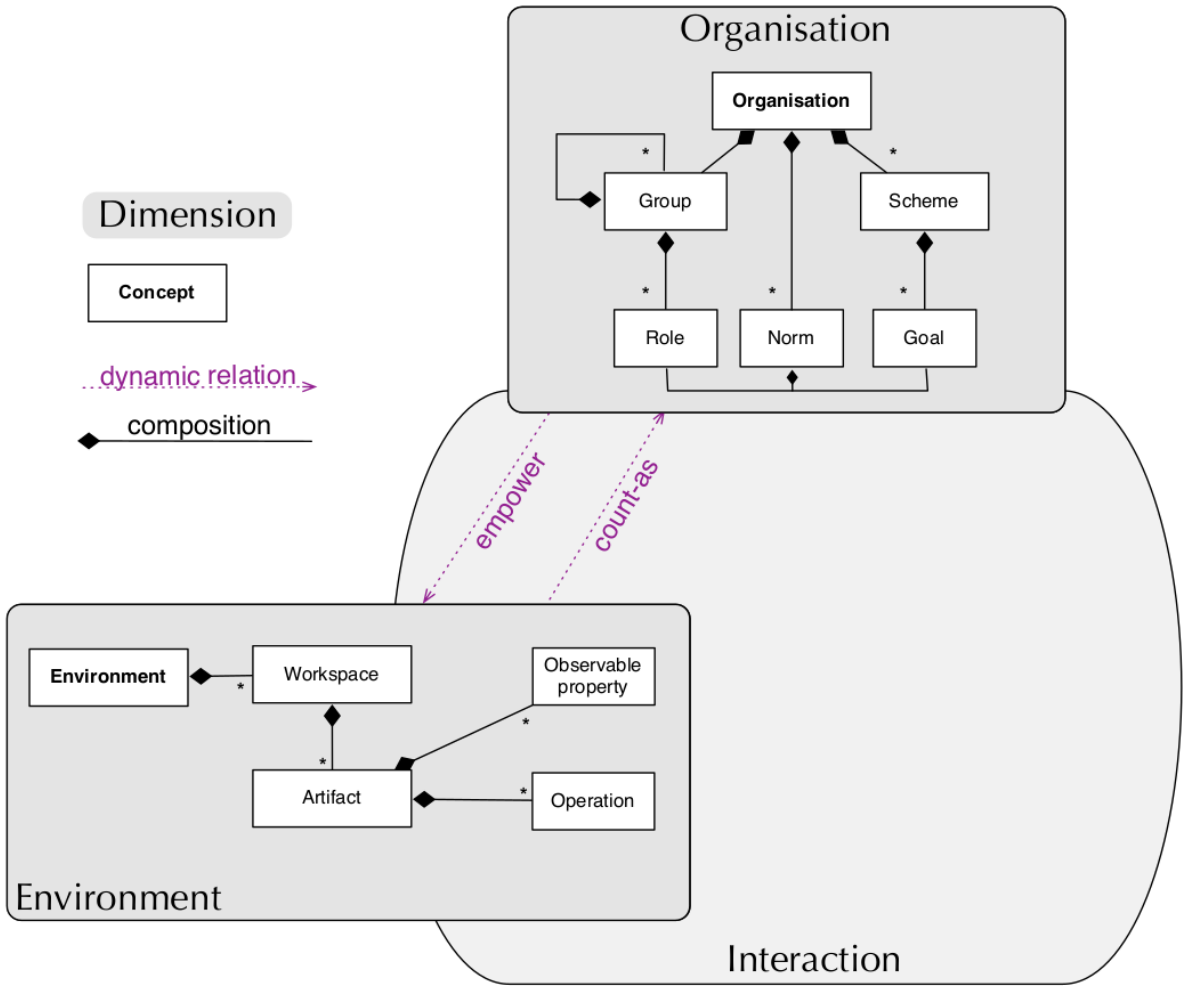
**Including organization-reasoning abilities into agents**

```
+play(Ag,assistant,GrId) <- .send(Ag,tell,hello).
+goalState(_,close_voting,_,_,satisfied) <- ...
```

**Including norm-reasoning abilities into agents**

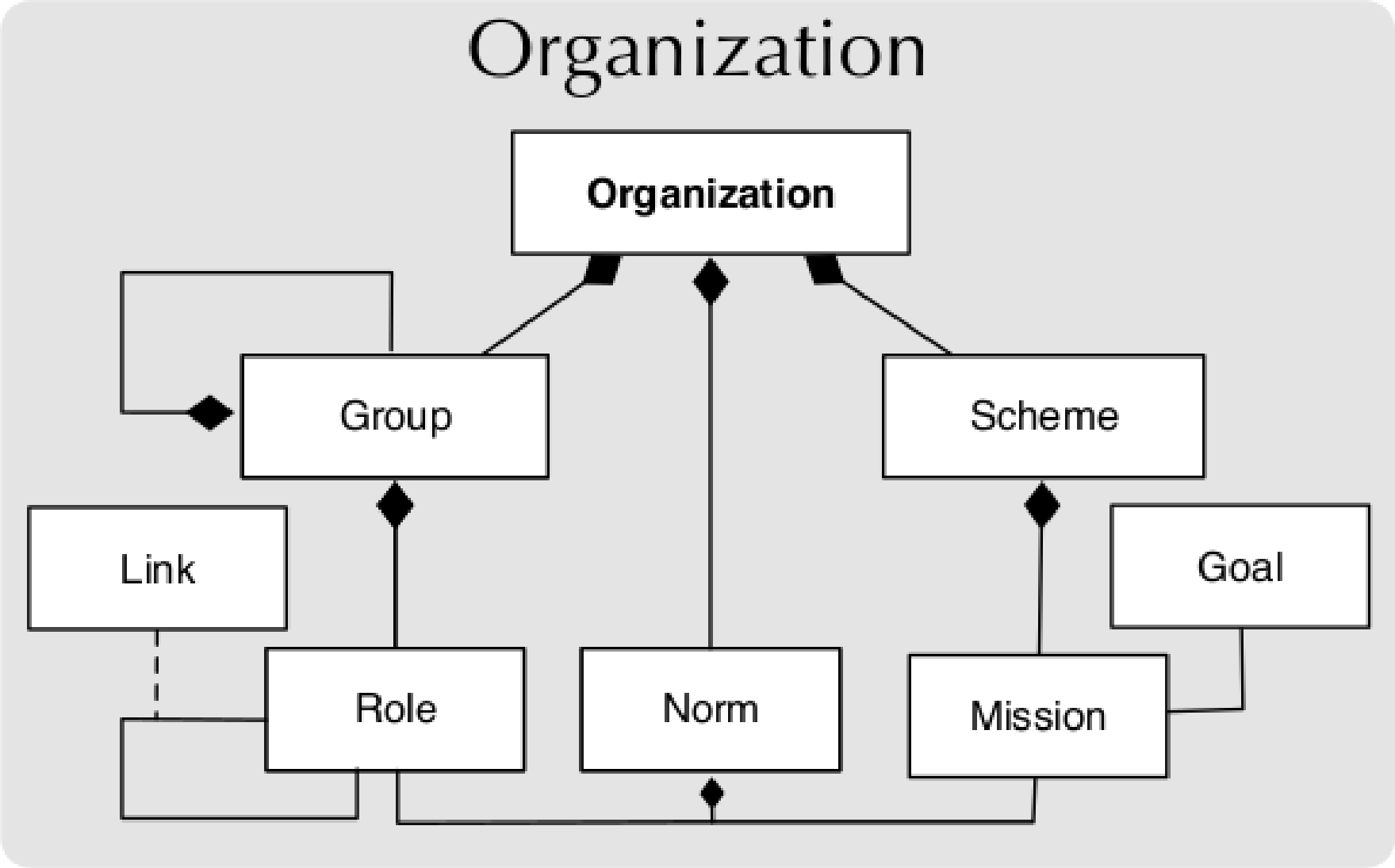
```
+obligation(Ag,Norm,achieved(_,Goal,_),DeadLine)
    : .my_name(Ag) & good(mood)
<- !Goal.
```

# Integrating Environment and Organization Dimensions




- Changes in the state of the environment may **count-as** changes in the state of the organization (de Brito et al., 2015)
- This dynamic relation is a **practical way of situating organizations in an environment**, as happens for the agents, regulating some part of the environment (e.g., a traffic light at a crossroads) in a particular way and ruling it differently in other parts
- Organizations may **empower** the elements of the environment by allowing them to control and regulate actions or perception of the agents

# Wrap-up: Organization Dimension



# Wrap-up: Organization Dimension

- Model to specify global orchestration
  team strategy is defined at a high level
- Ensure agents follow some of the constraints specified by the organization
- Help agents to work together
- The organization is interpreted at runtime, it is not hardwired in the agents' code
- The agents can ‘handle’ the organization (i.e., their artifacts)
- It is suitable for open systems as no specific agent architecture is required
- Organization can easily be changed by the developers or by the agents themselves

# References


- de Brito, M., Hübner, J. F., & Boissier, O. (2015). Bringing constitutive dynamics to situated artificial institutions. In *Proc. of 17th Portuguese Conference on Artificial Intelligence (EPIA 2015)*, LNCS, vol. 9273, pp. 624–637. Springer.
- Hübner, J. F., Boissier, O., Kitio, R., & Ricci, A. (2010). Instrumenting multi-agent organisations with organisational artifacts and agents: “Giving the organisational power back to the agents”. *Journal of Autonomous Agents and Multi-Agent Systems*, 20(3):369–400.