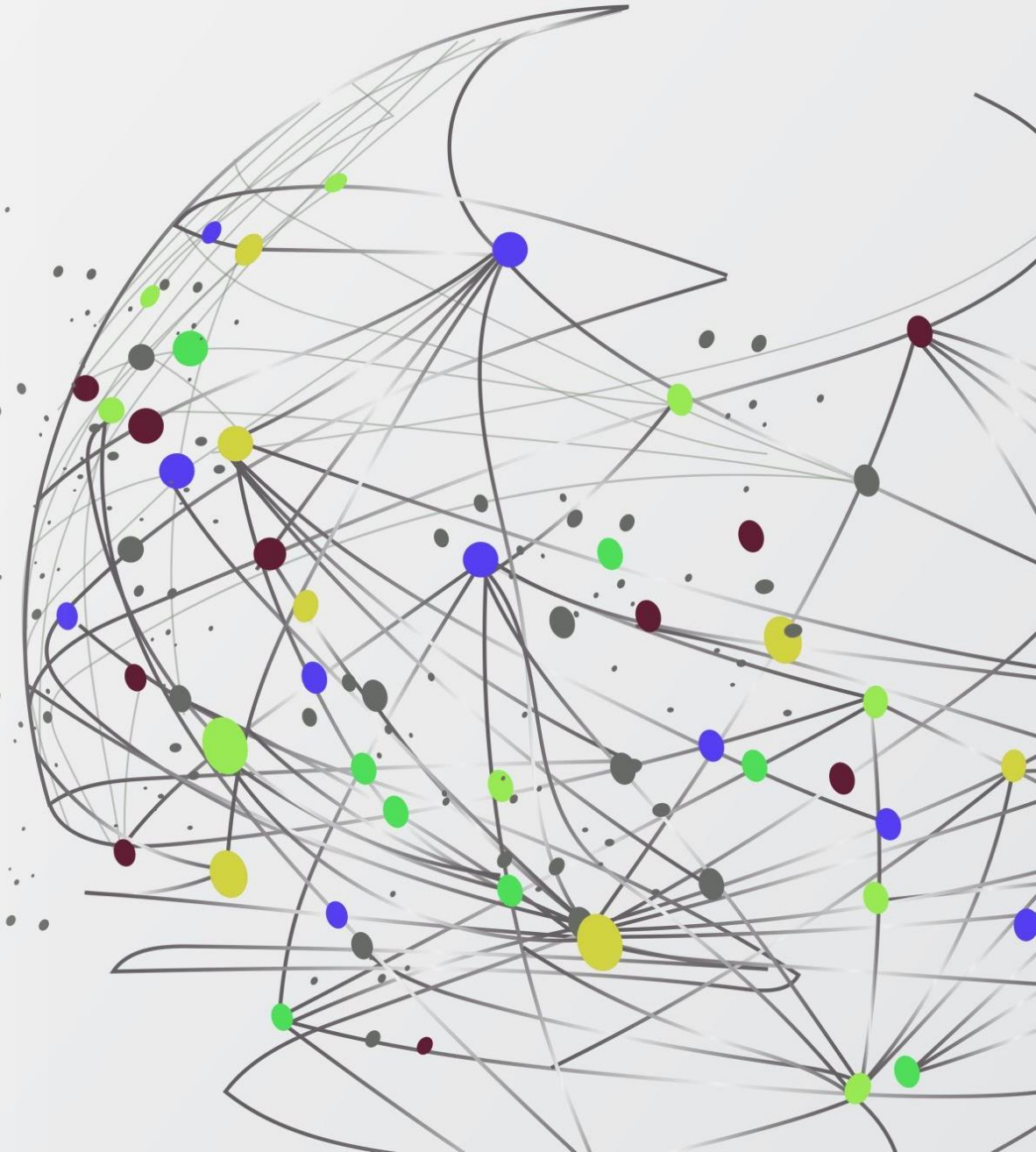
Multi-Agent Oriented Programming

Introduction



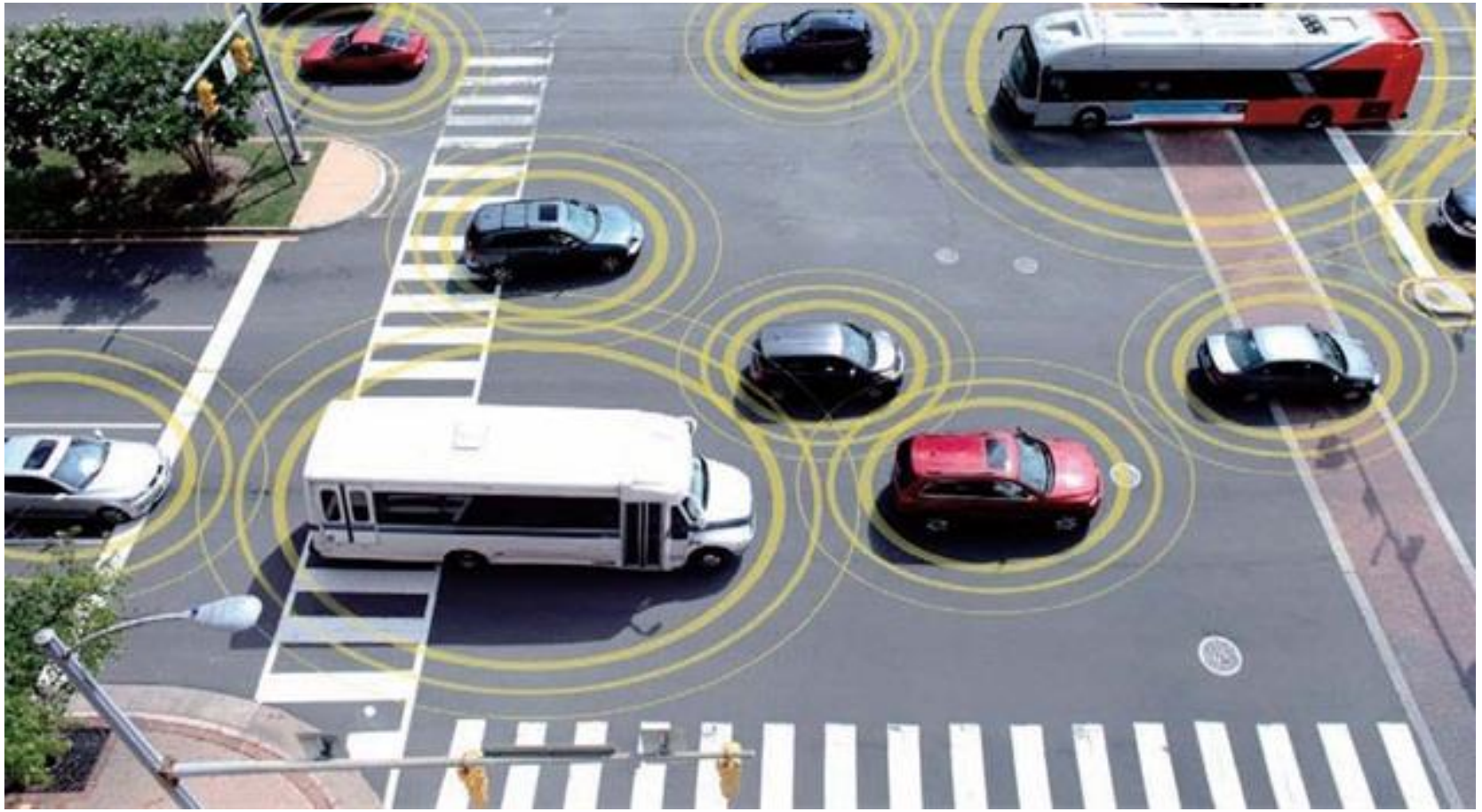
***Credits**: Slides are based on previous presentations by Olivier Boissier, Andrei Ciortea, Jomi F. Hübner*

Motivation

- *Complex system* are systems composed of **many components** which may **interact with each other** and present **non-trivial relationships** between cause and effect
  - each effect > multiple causes
  - each cause > multiple effects
  - feedback loops
  - non-linear cause-effect chains
- **Complex cyber-physical social systems**
  - Smart cities
  - Smart grids
  - Manufacturing
  - Mobility systems

Motivation – Requirements

Distribution of data, knowledge, decision, intelligence



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Explainability

Multi-Agent System

A Multi-Agent System (MAS) is a **loosely coupled** network of problem solvers that **interact** to solve problems that are **beyond the individual capabilities** or **knowledge** of each problem solver

Durfee & Lesser, 1989

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A set of autonomous agents interacting with each other within a shared environment, eventually under one to multiple organizations

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  pre-defined/emergent, static/adaptive, open/closed, …

  e.g., coordination and regulation activities

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A Multi-Agent System **is more than** a simple set of agents

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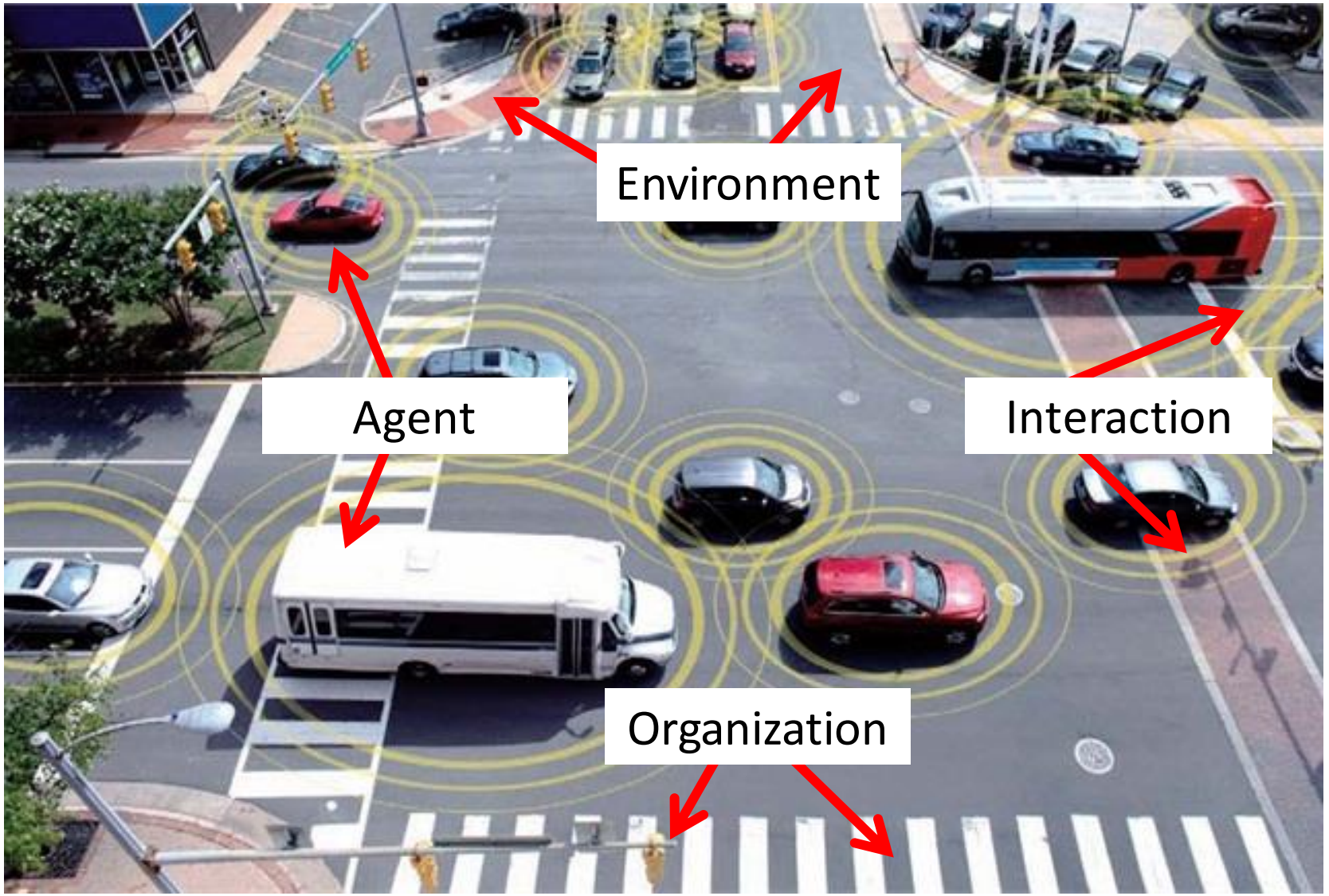


Multi-Agent System

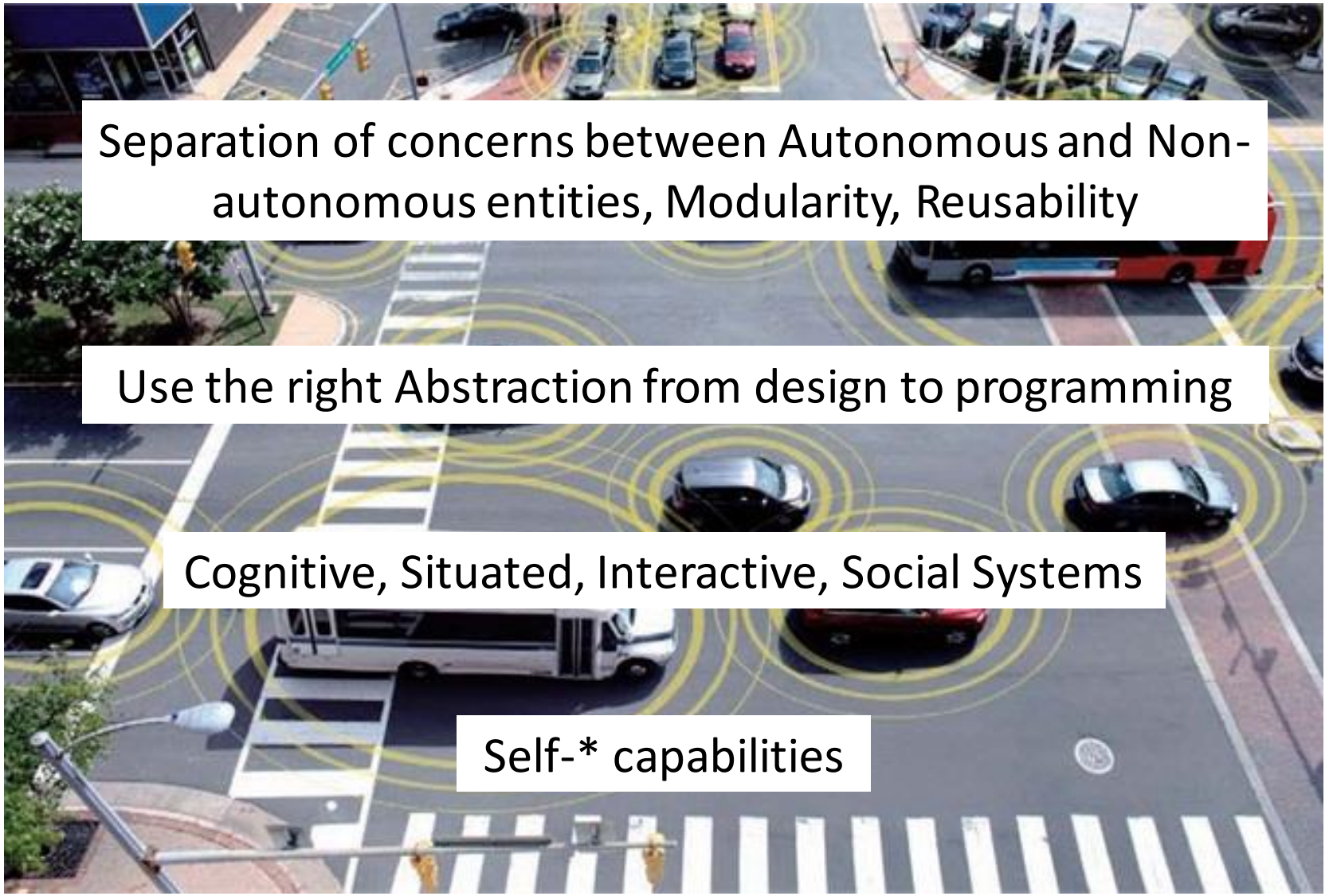
Multi-Agent-Based Simulation models used to describe and simulate complex systems, either natural or artificial, to analyze their properties

- Local representations of different points of view, decisions, goals, motivations, behaviors, etc.
- Interaction between local strategies, behaviors and global and common strategies of control
- Continuous operation and evolution
- Solution is the result of interaction between local processes

Multi-Agent-Based System Engineering models used to design and develop systems and applications

- Multi-* (sites, expertise, domains, points of view, decisions, goals, motivations, ...)
- Incremental and collaborative development
- Continuous execution and adaptation
- Increasingly user-centric

Multi-Agent-Based System Engineering



Multi-Agent Oriented Programming (MAOP)

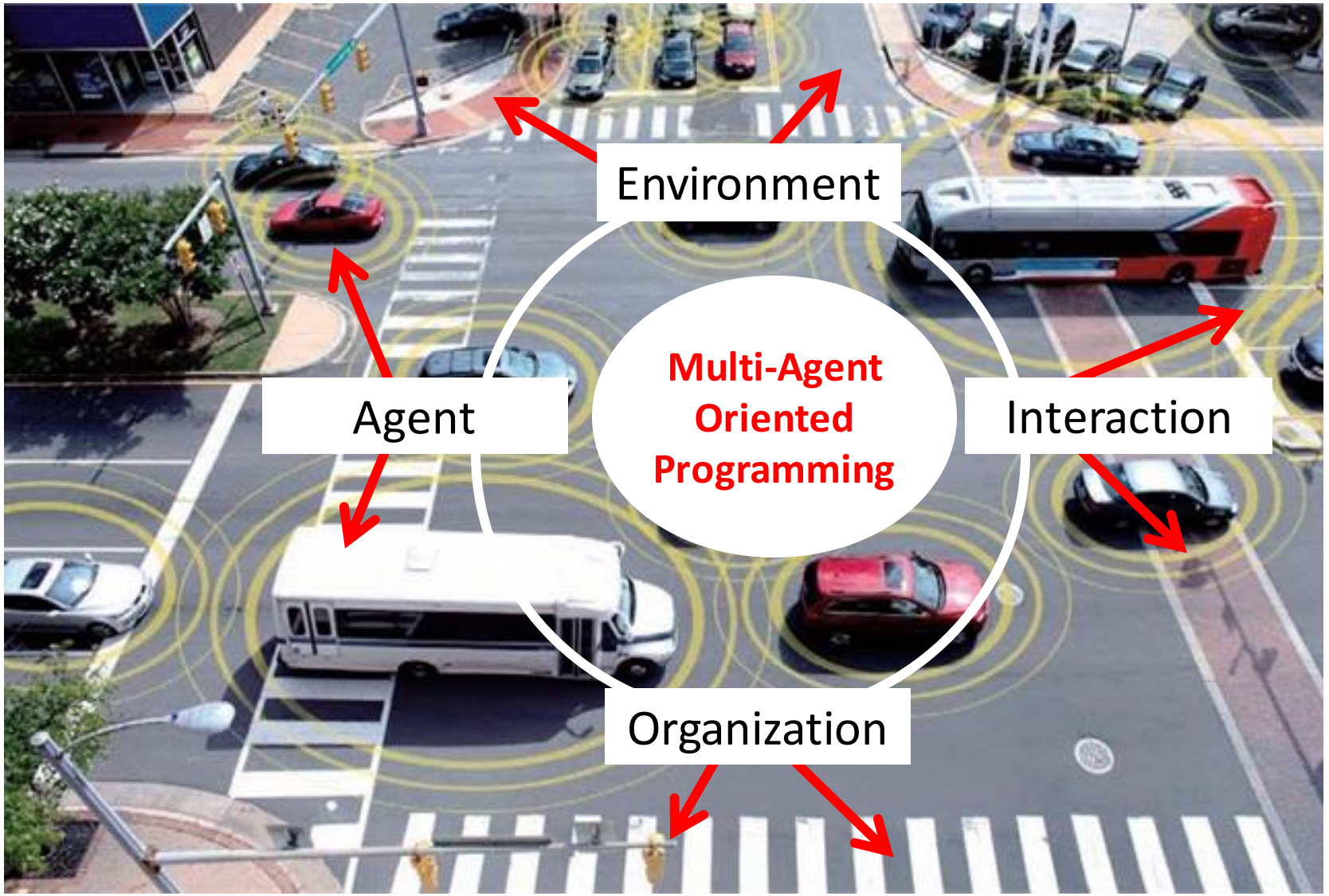
- Provide first-class abstractions to model and implement Agents, Environments, Interactions and Organizations

- MAOP aims at engineering systems
  - as organization of autonomous agents that interact with each other within a shared environment,
  - by keeping alive, from design to execution, concepts pertaining to each of the Agent / Environment / Interaction / Organization dimensions as well as their control/life cycles

NOTE: Inspired by the VOWELS' perspective (Demazeau, 1995)

Go beyond the AOP (Shoham, 1993), EOP (Ricci et al., 2010), IOP (Huhns, 2001), OOP (Pynadath et al., 1999) approaches

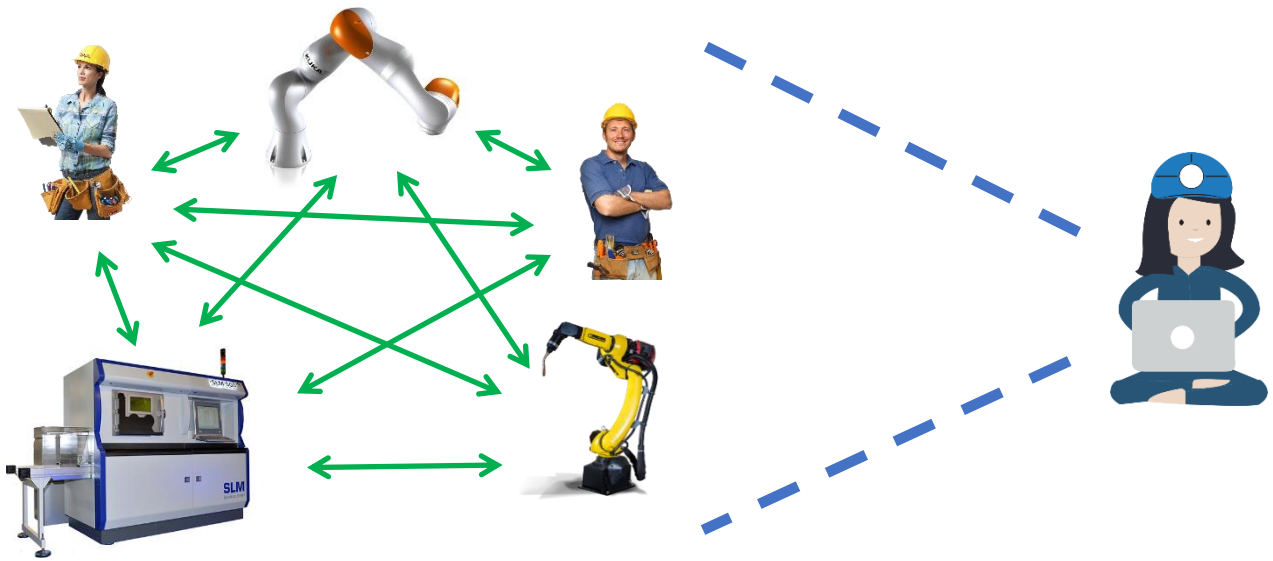
Multi-Agent Oriented Programming (MAOP)



Example: Flexible Industrial Manufacturing

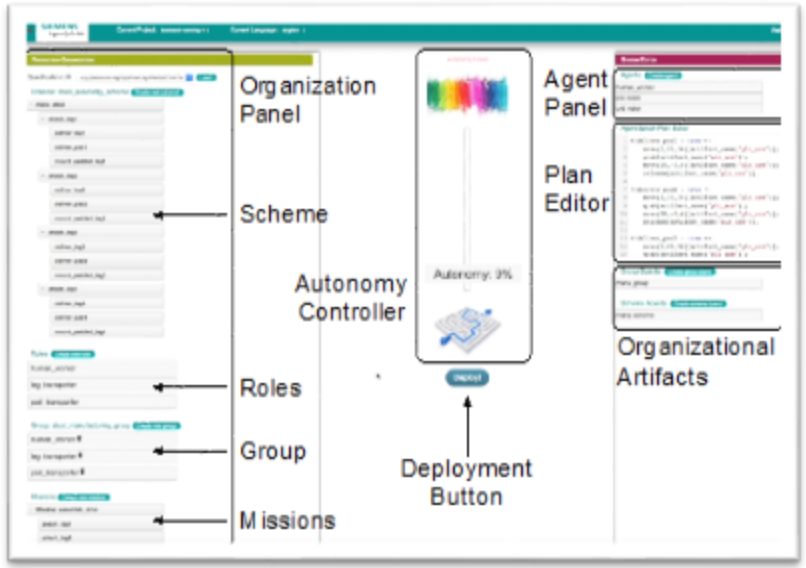
Domain problem ("lot-size-one manufacturing"): **unique** products at **mass production costs**

- customization is **expensive**: production lines are **optimized**, **inflexible**, and have **large lifespans** (> 30yr)
  - we need production lines that can be **repurposed on-the-fly**



Factory workers and artificial agents working towards shared goals

SIEMENS

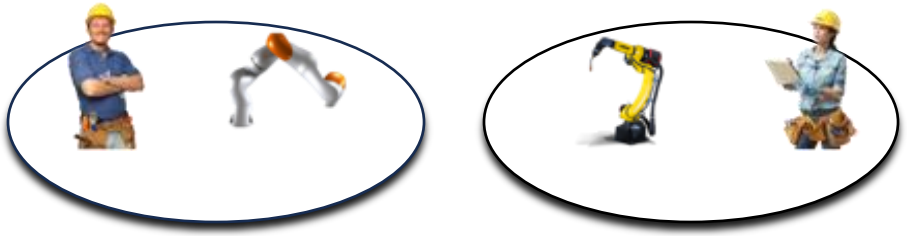


End-user programming for production engineers

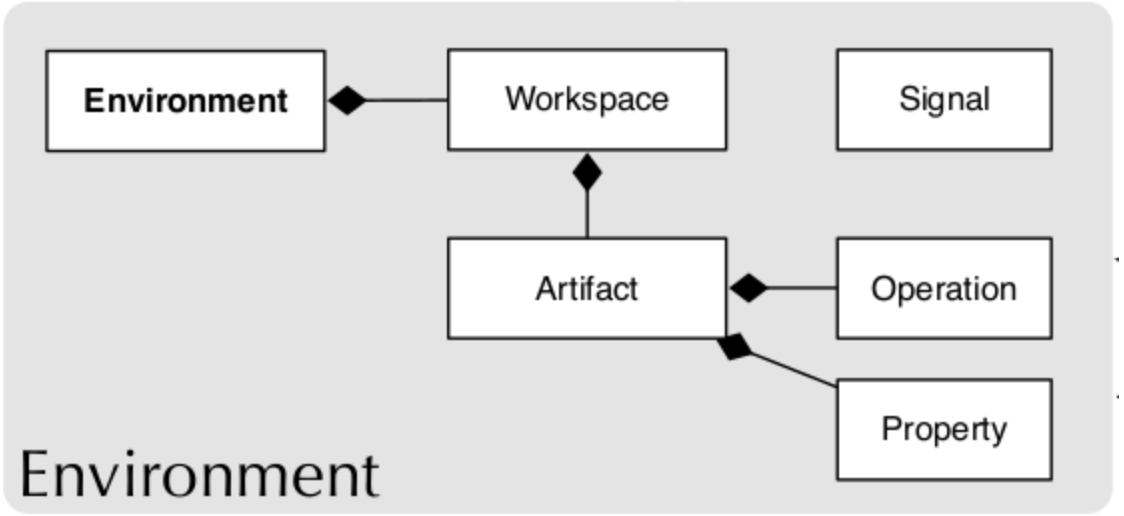
(Ciortea et al., 2018)

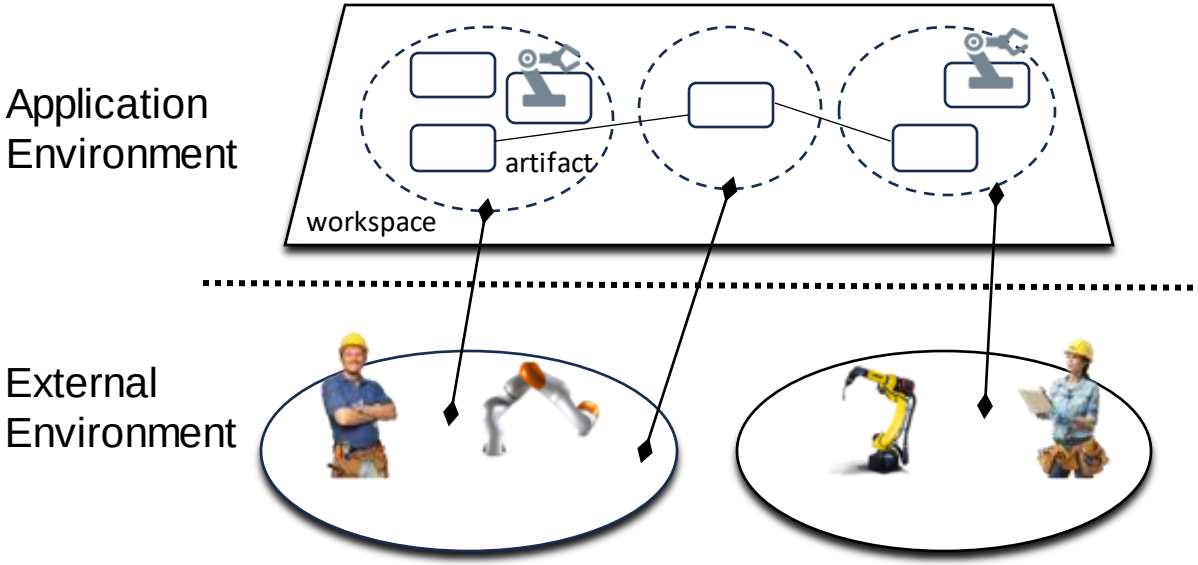
Flexible Industrial Manufacturing

External Environment

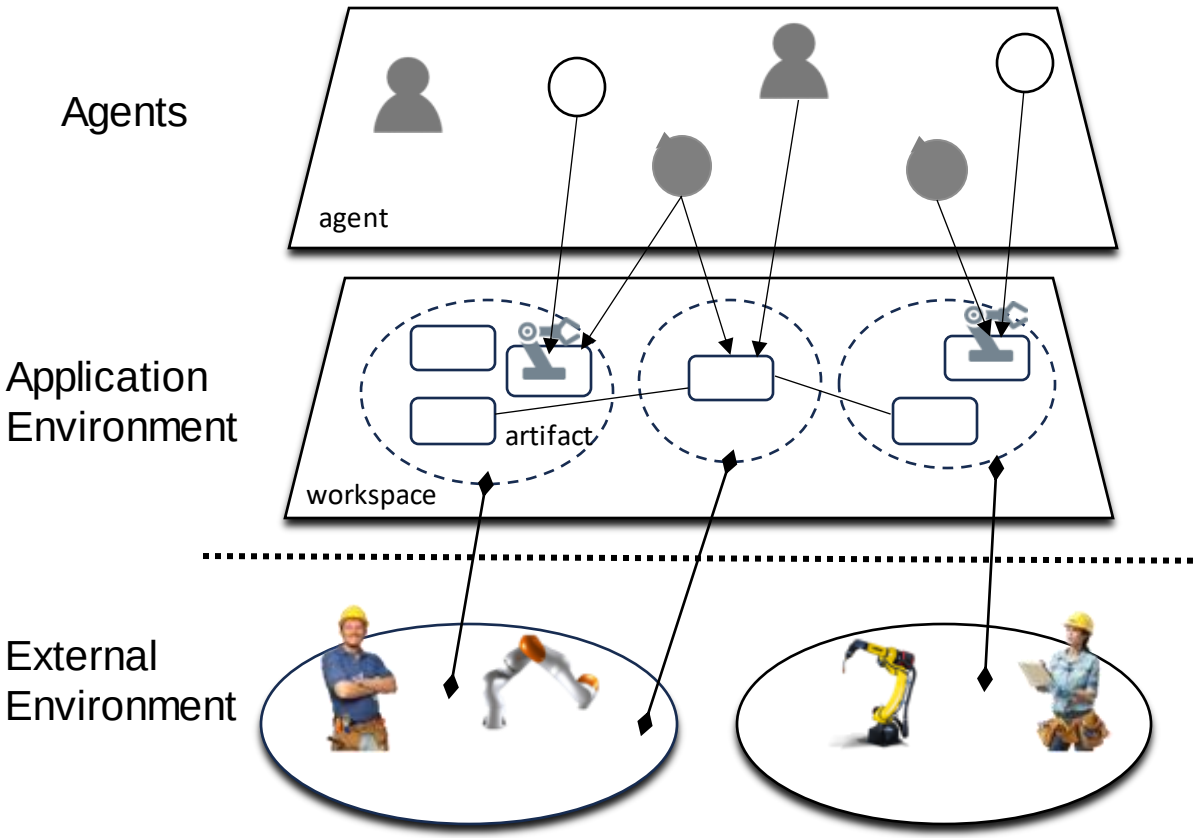


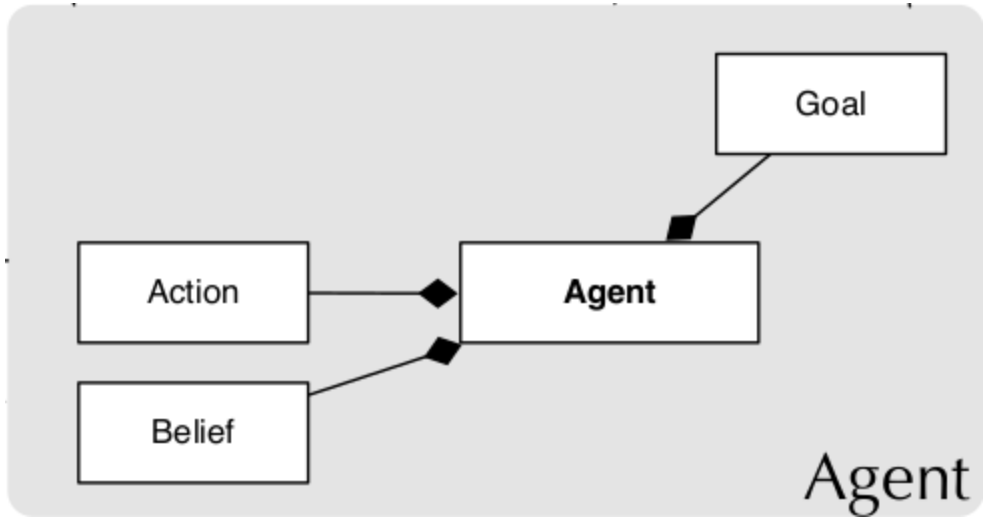
Environment Dimension



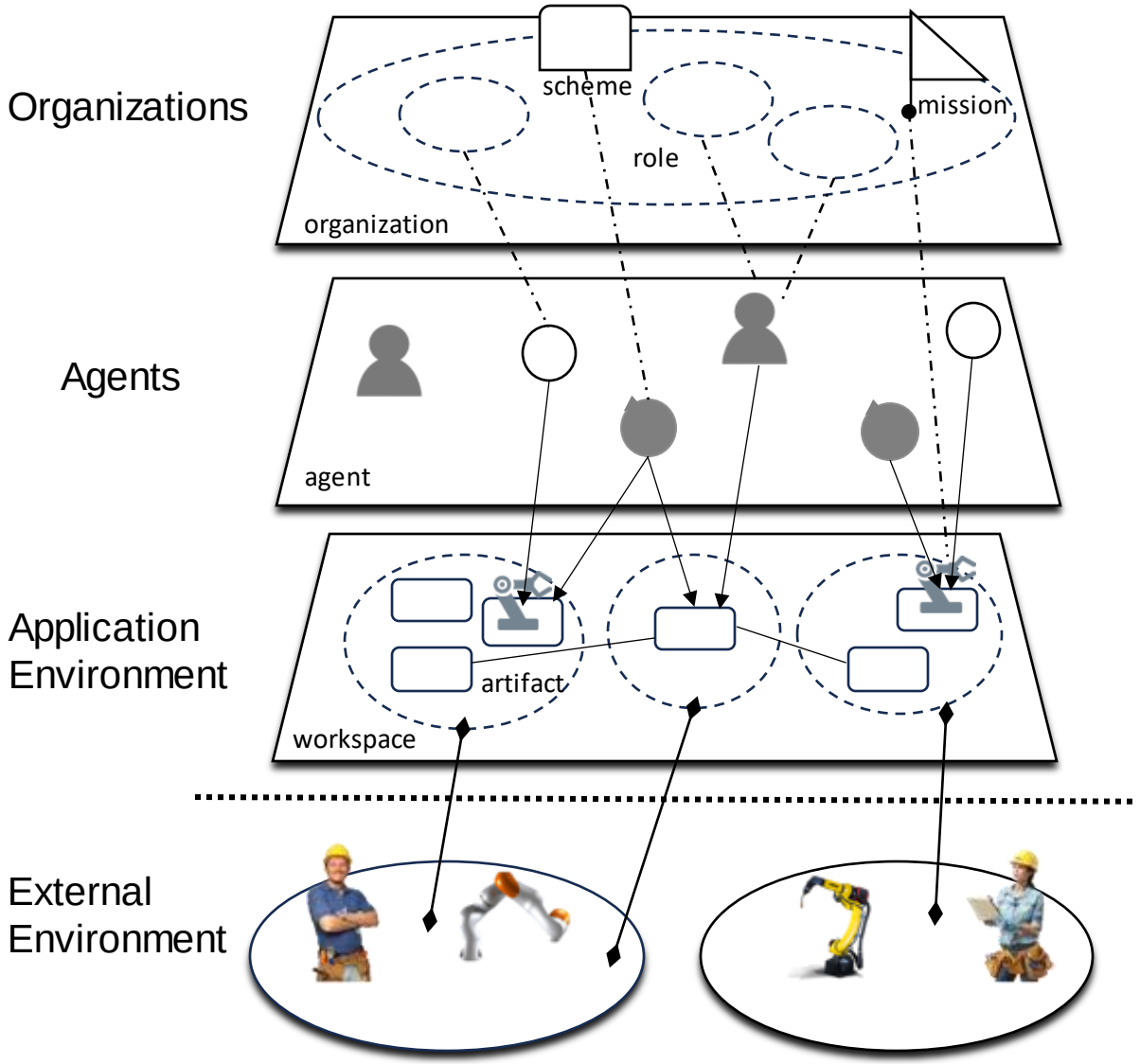


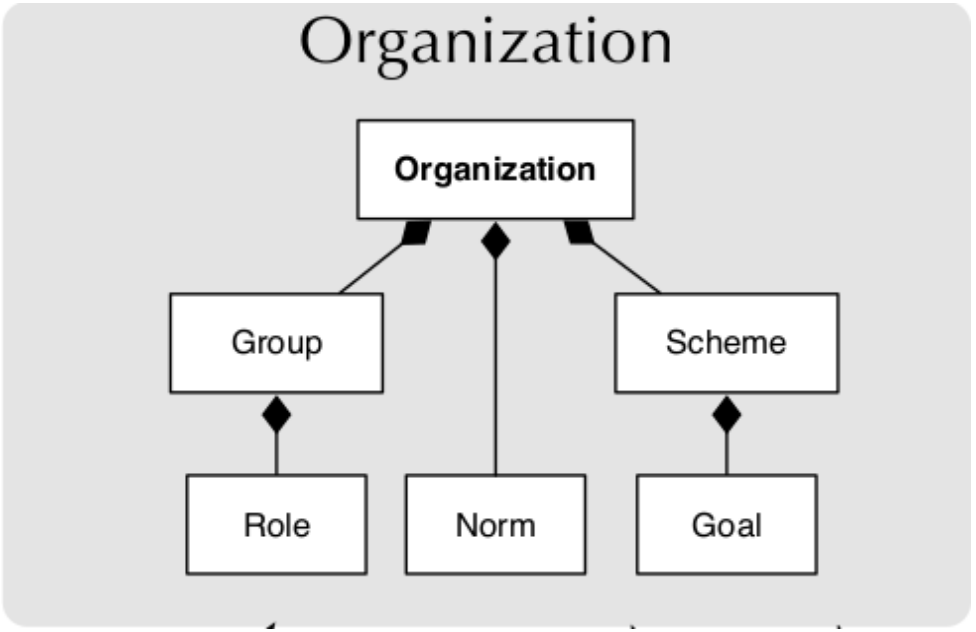
Agent Dimension



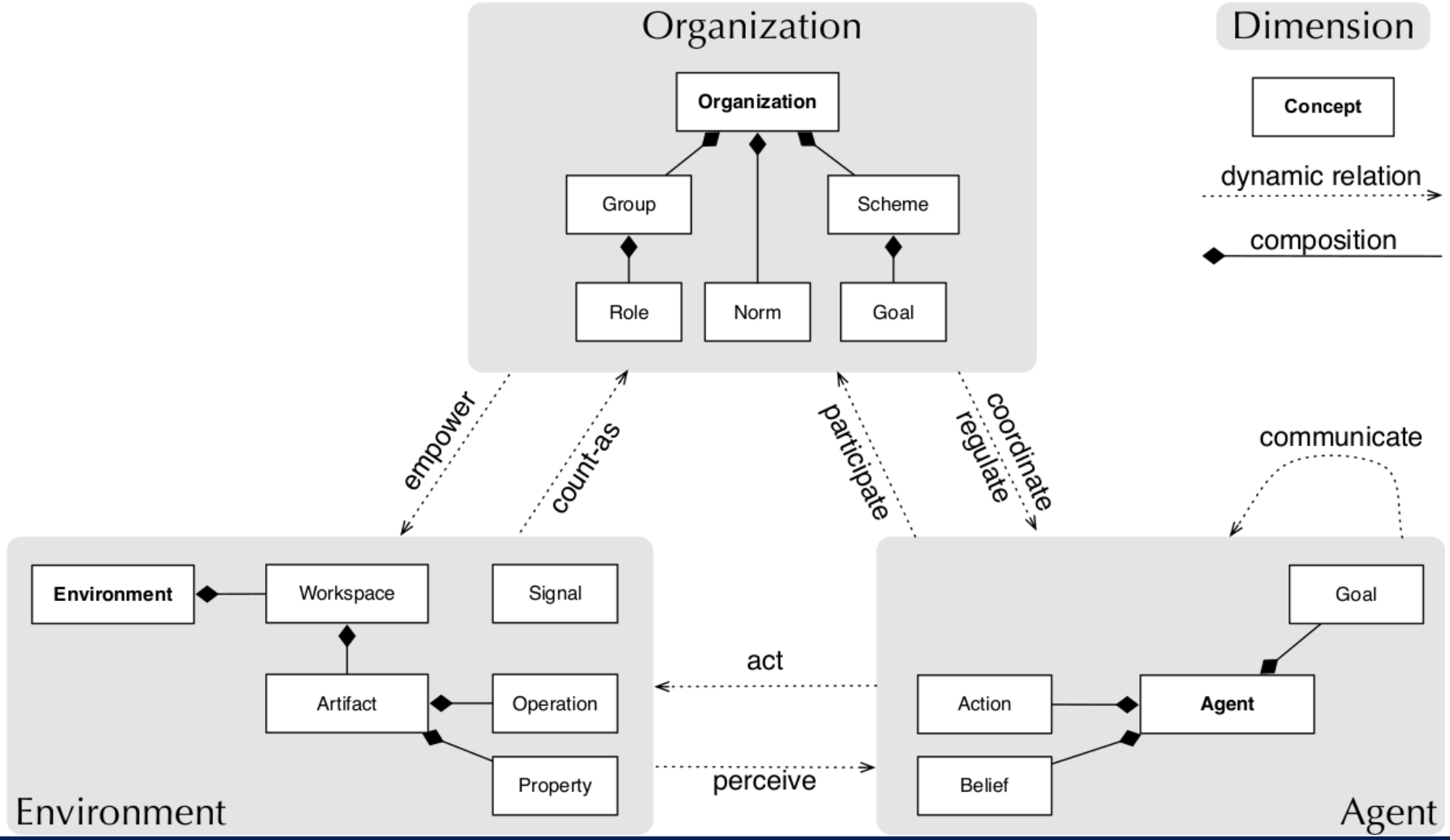


Organization Dimension

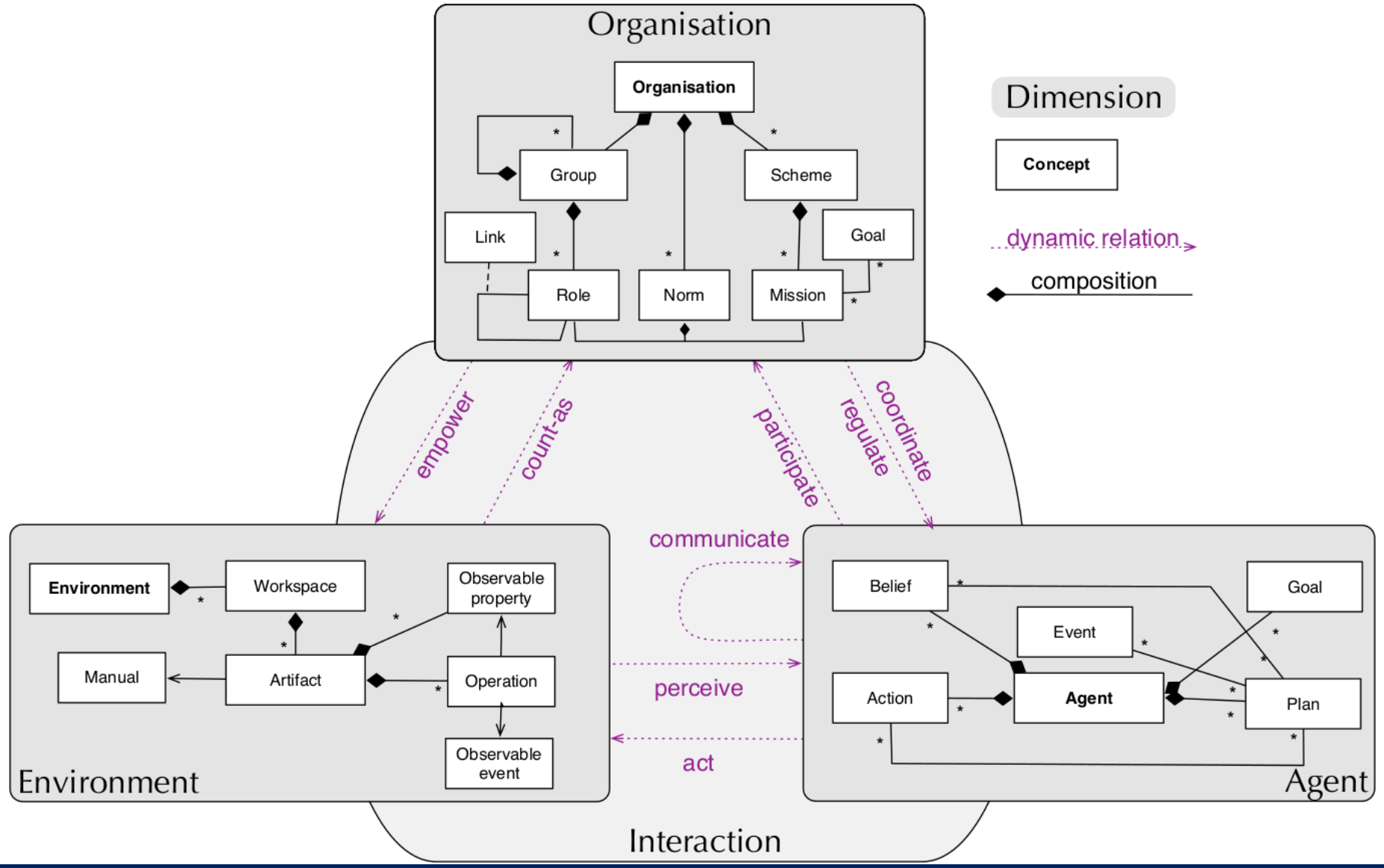




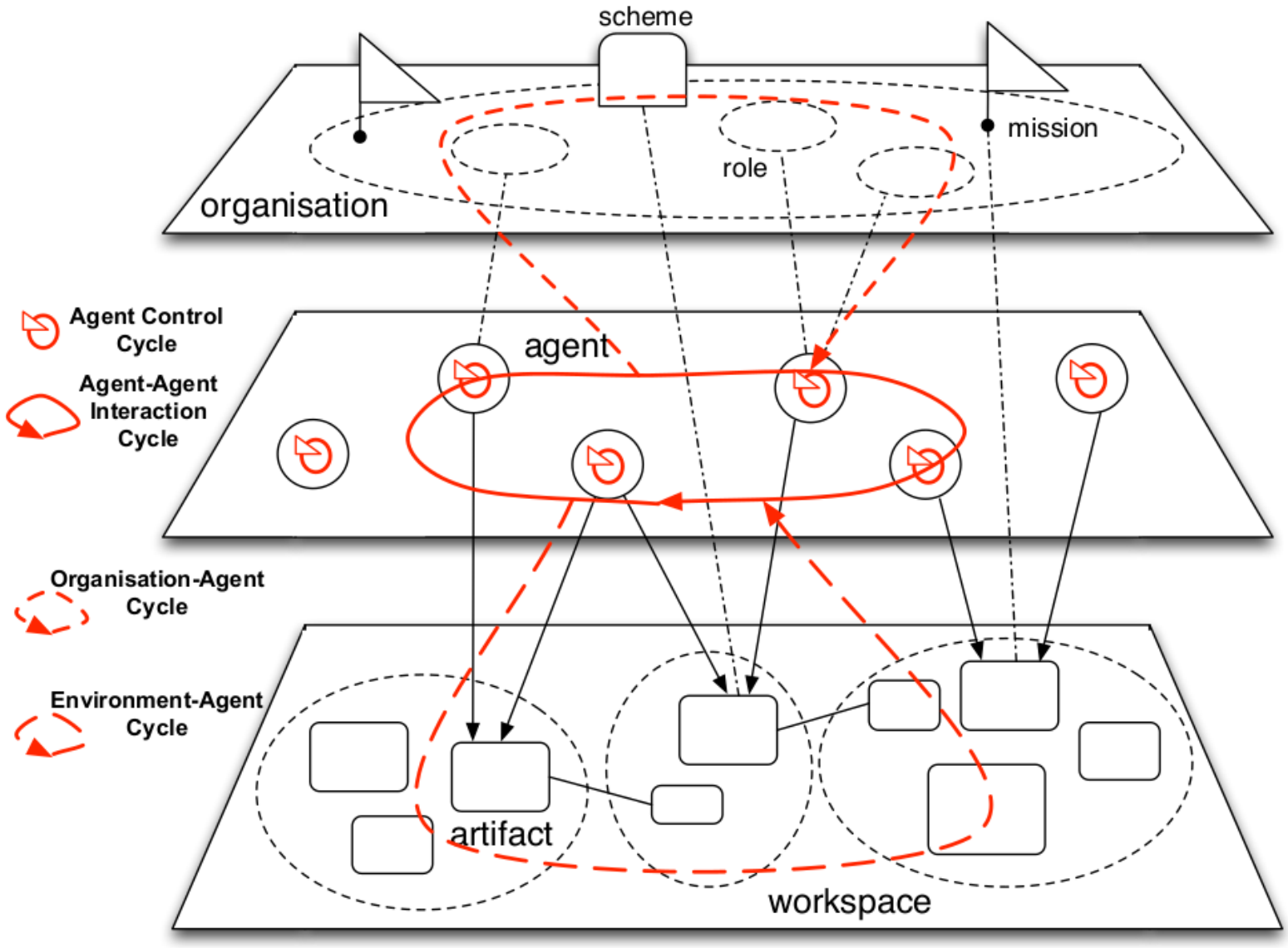
Interaction Dimension



JaCaMo Metamodel – Multi-Agent Concepts



JaCaMo Metamodel – Multi-Agent Dynamics



Applications

- Governance of Room Allocation in a Smart Co-working Space
- Governance of a Machine-To-Machine Management Infrastructure
- Governance of Online Forum
- Tackling Online Disinformation
- Coordination of Rover on Mars
- Coordination of Fleet of Autonomous Vehicles

Smart Room Scenario

Develop one room controller agent to manage a "Heating, Ventilating and Air Conditioning" (HVAC) device to reach a desired temperature based on agents' preferences acting on behalf of users

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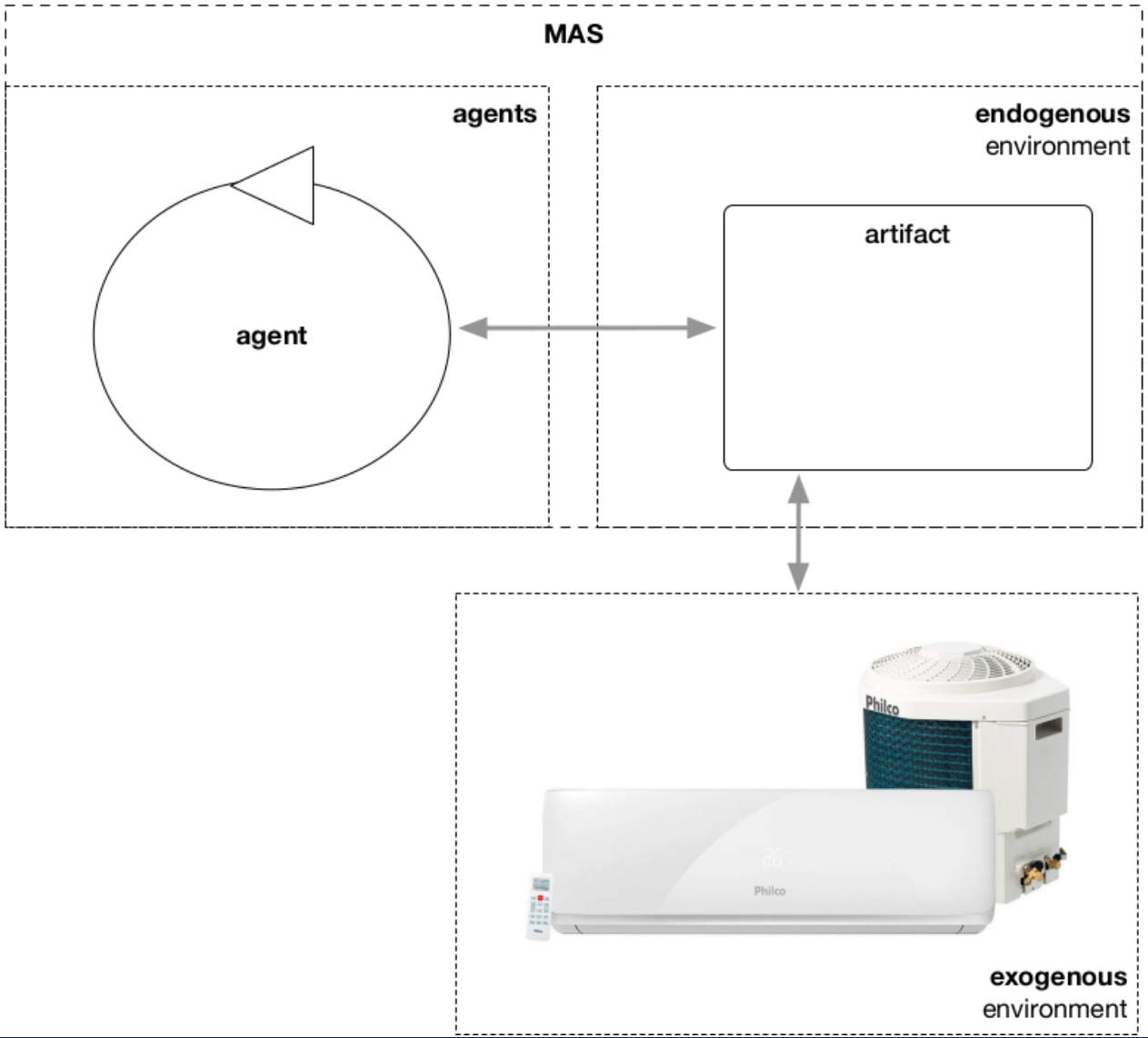
Separation of concerns

- Integration and interoperability with the HVAC
  - **environment** modeling
- Strategy to keep the right temperature
  - **agent** modeling

Smart Room Scenario



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