

REGULATION MANAGEMENT IN MULTI-AGENT SYSTEMS

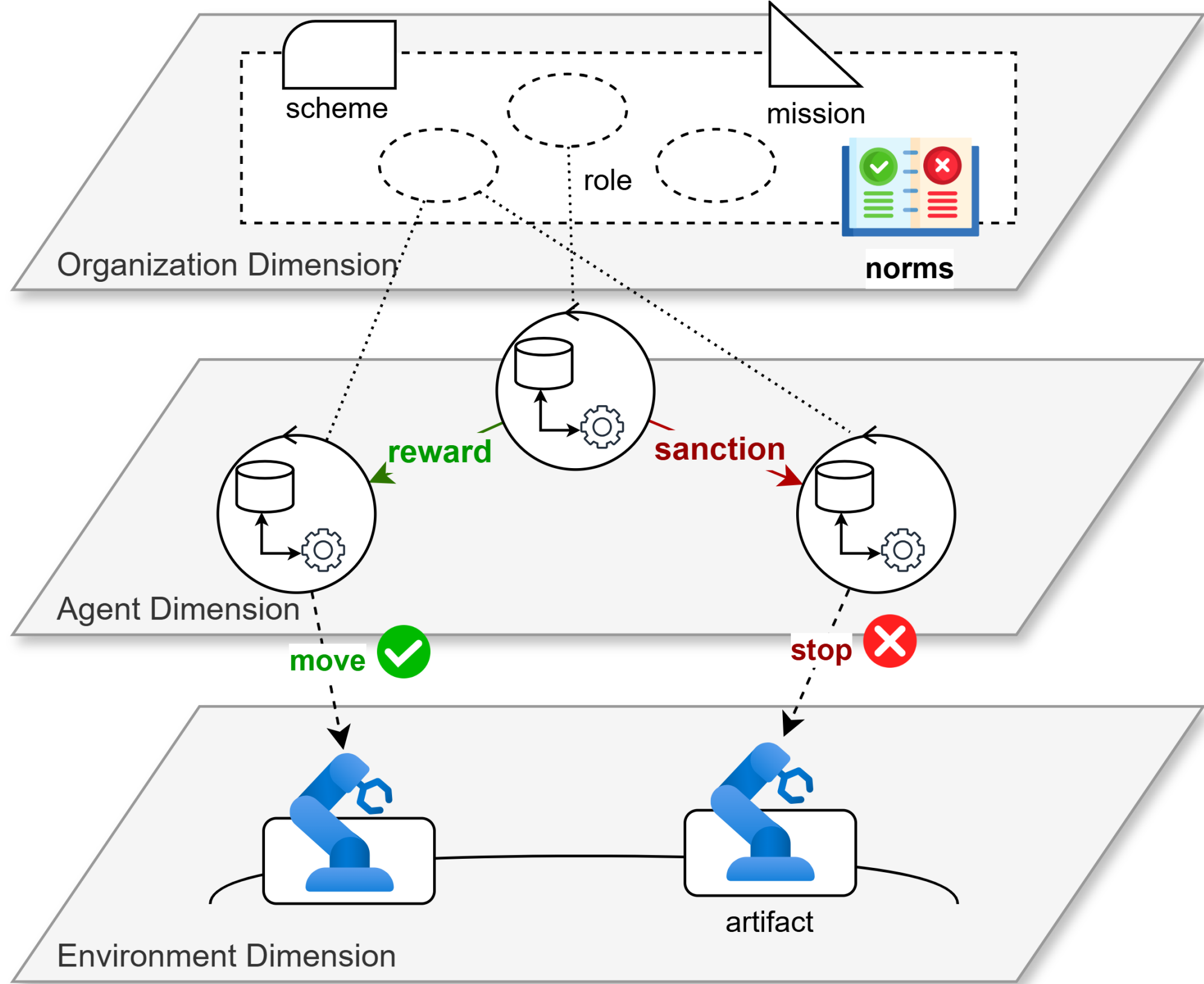
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I. Motivation



A **Multi-Agent System (MAS)** is composed of autonomous agents interacting with each other within a shared environment, eventually under one to multiple organizations [1].

→ *Agents' autonomy enables flexibility but poses challenges for coordination and control*

Regulations can be used in MAS to guide agents towards the overall objectives, while maintaining agents' autonomy

Research Questions:

- RQ1.** How to represent regulations in Multi-Agent Systems?
- RQ2.** How to design regulation management mechanisms in Multi-Agent Systems?

II. Regulation Representation (RQ1)

- Constitutive Rules** (i.e., institutional interpretation of environmental facts) using **SAI** [2] programming language:

$id : x \text{ count-as } y \text{ while } c$

- Regulative Norms** (i.e., expected behavior of agents) and **Sanction Rules** (i.e., consequences for compliance or violation of norms) using **NPL(s)** [3] programming language:

$\text{norm } id : \phi \rightarrow \psi \text{ if } \phi : sr_i(args).$

$\text{sanction-rule } sr_i(args): \rho \rightarrow \text{sanction}(\alpha, \gamma).$

III. Regulation Management Mechanisms (RQ2)

Perspectives on design regulation management mechanisms [4]:

Regulation Management Capabilities (CAP) Perspective:

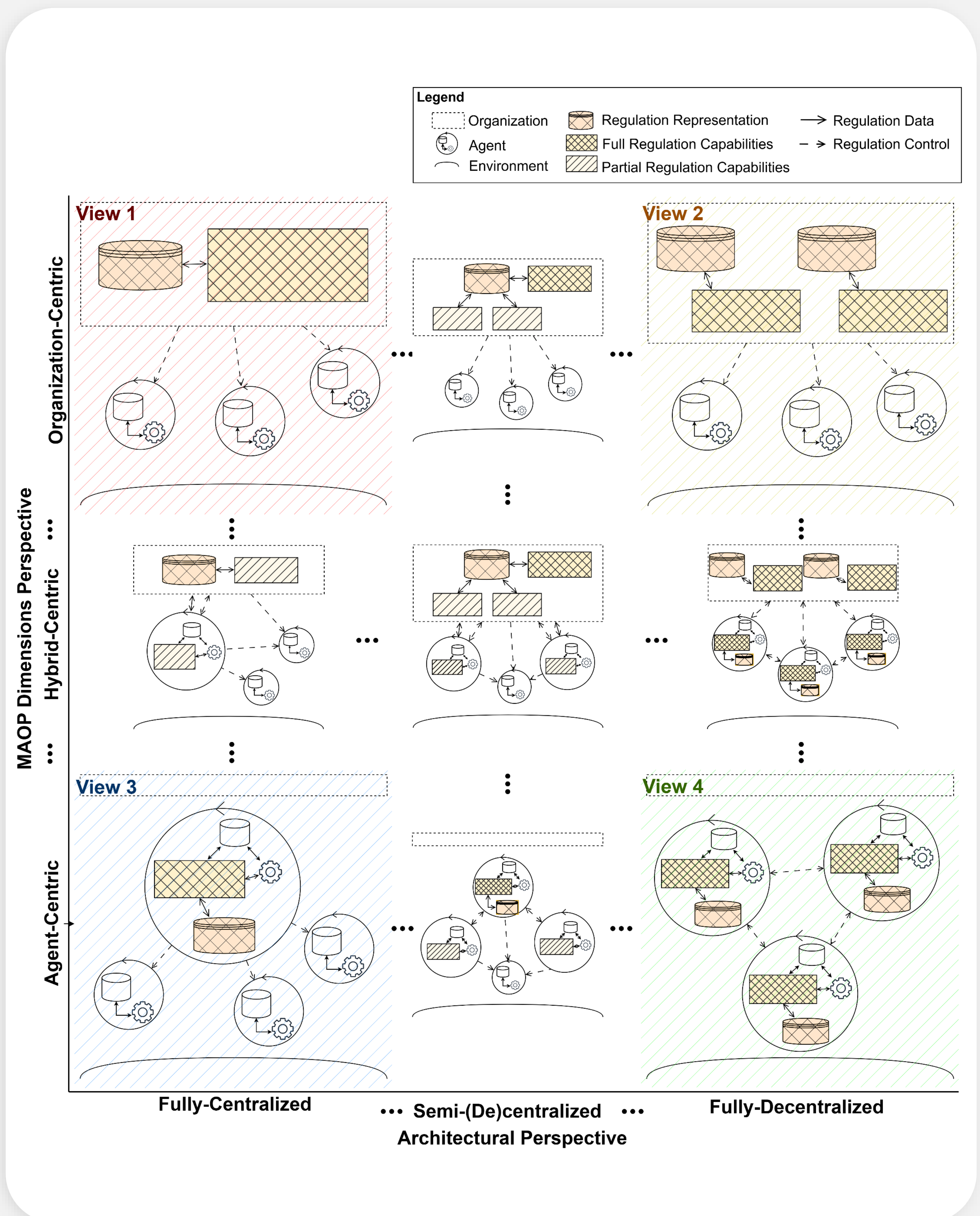
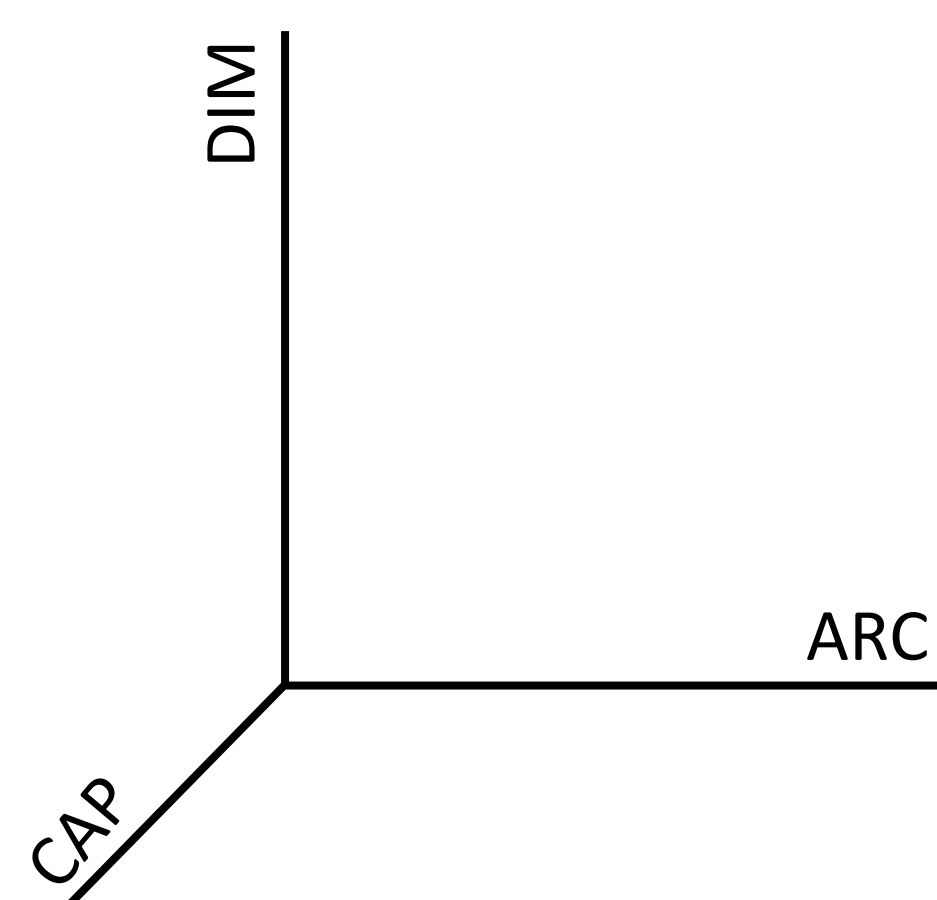
- Regiment
- Enforce
- Adapt

MAOP Dimensions (DIM) Perspective:

- Agent-centric
- Organization-centric
- Environment-centric
- Interaction-centric
- Hybrid-centric

Architectural (ARC) Perspective:

- Fully-Centralized
- Semi-(De)centralized
- Fully-Decentralized



IV. Conclusions and Perspectives

Normative programming languages: provide expressive representations, enabling agents to reason about regulations

Regulation management: different perspectives to consider when designing regulation management mechanisms in MAS

→ What are the concepts required to develop self-regulated and self-adaptive systems in MAS?

→ How to deploy regulation management to support sustainability manufacturing systems in the Industry of the Future?

References

- [1] Boissier, O., Bordini, R. H., Hubner, J., & Ricci, A. (2020). Multi-agent oriented programming: programming multi-agent systems using JaCaMo. Mit Press.
- [2] De Brito, M., Hübner, J. F., & Boissier, O. (2019). Coupling the normative regulation with the constitutive state management in Situated Artificial Institutions. The Knowledge Engineering Review, 34, e21.
- [3] Yan, E., Nardin, L. G., Hübner, J. F., & Boissier, O. (2025). An agent-centric perspective on norm enforcement and sanctions. In International Workshop on Coordination, Organizations, Institutions, Norms, and Ethics for Governance of Multi-Agent Systems (pp. 79-99). Cham: Springer Nature Switzerland.
- [4] Yan, E., Nardin, L. G., Boissier, O., & Sichman, J. S. (2025). A unified view on regulation management in multi-agent systems. In International Workshop on Coordination, Organizations, Institutions, Norms, and Ethics for Governance of Multi-Agent Systems.

Partially funded by ANR-FAPESP NAIMAN project (ANR-22-CE23-0018-01, FAPESP 2022/03454-1)