

REGULATION MANAGEMENT IN MULTI-AGENT SYSTEMS

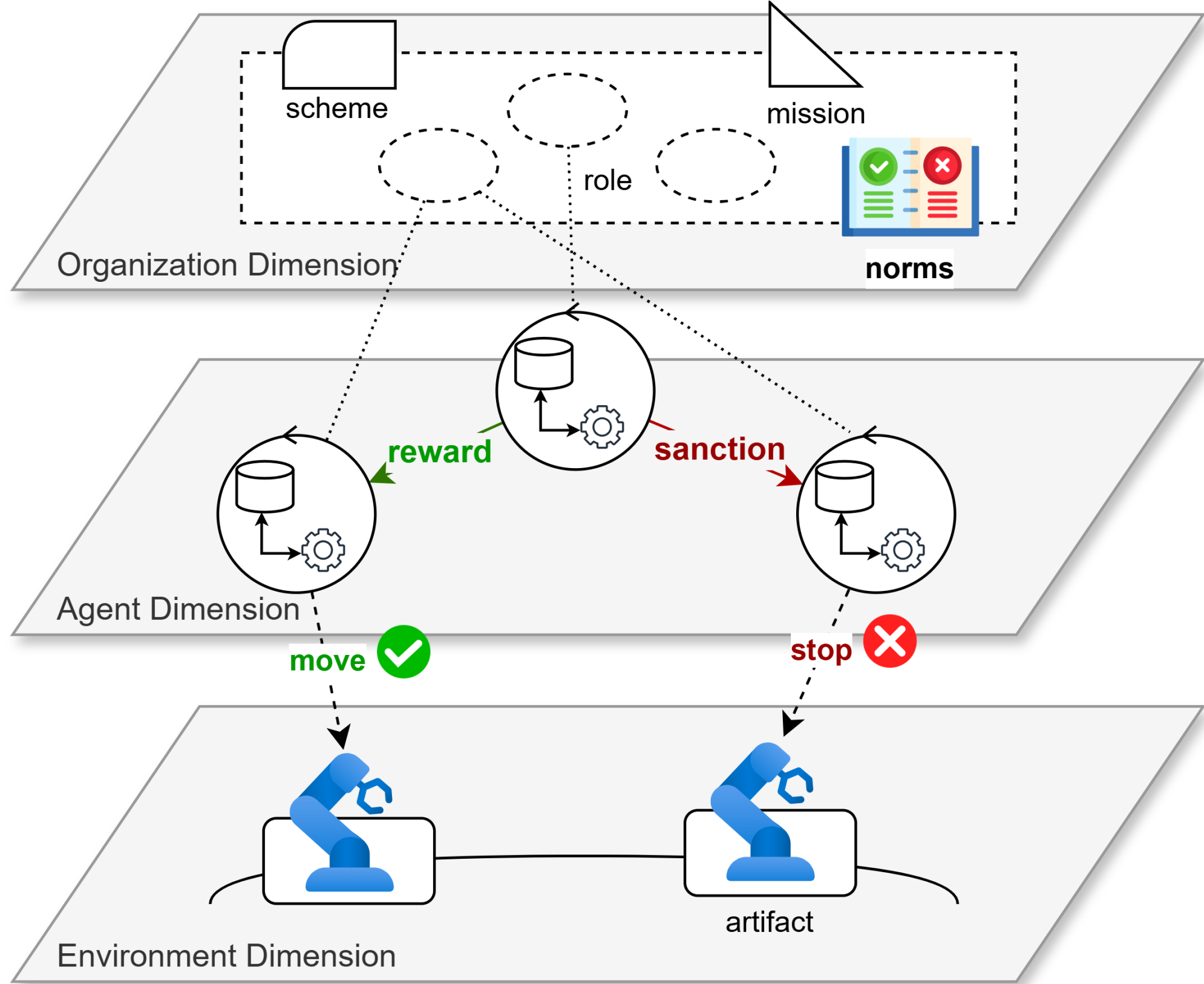
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I. Motivation



A **Multi-Agent System (MAS)** is composed of autonomous agents interacting with each other within a shared environment, eventually under one to multiple organizations [2].

→ *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 agent 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** [1] 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:

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

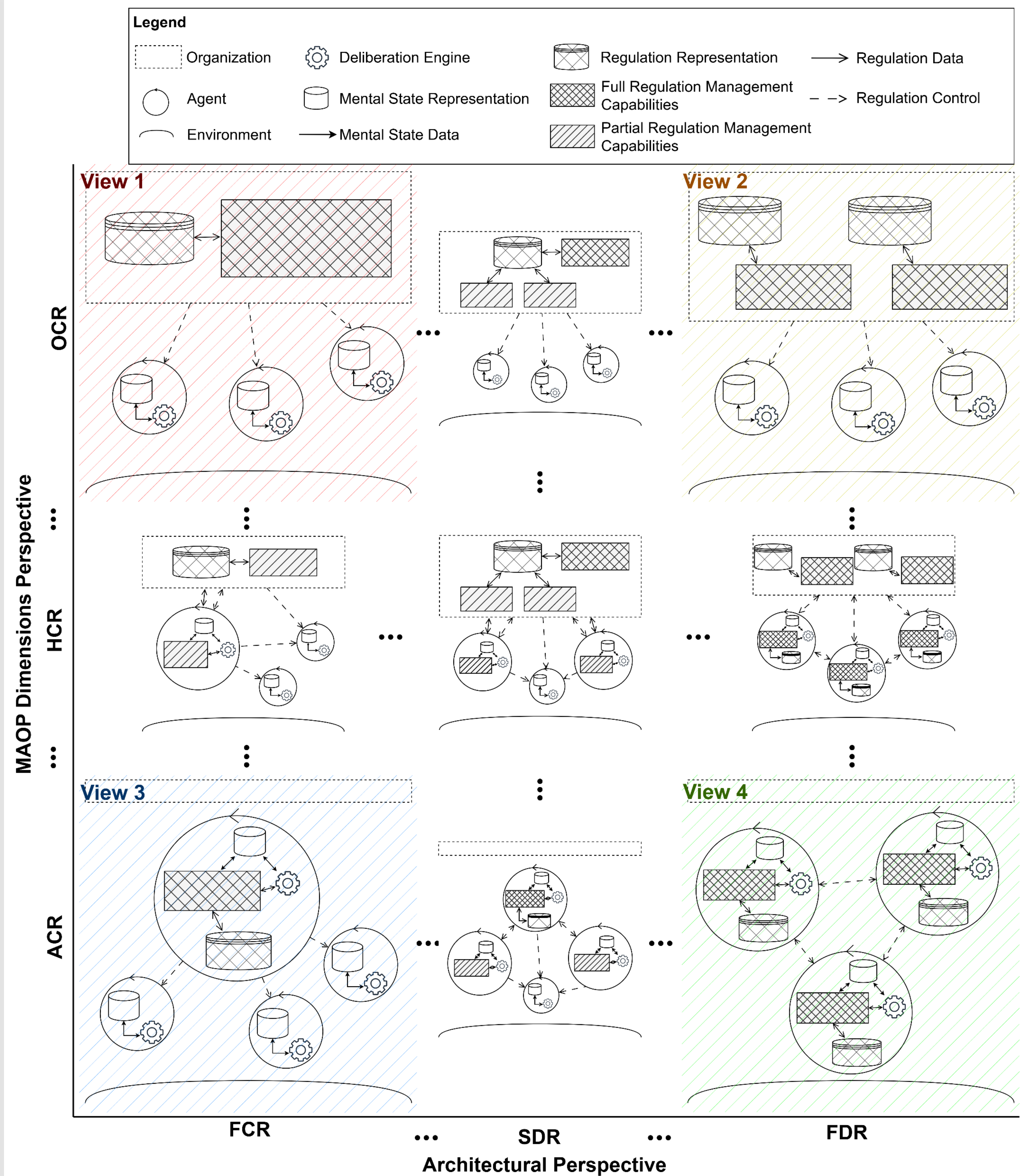
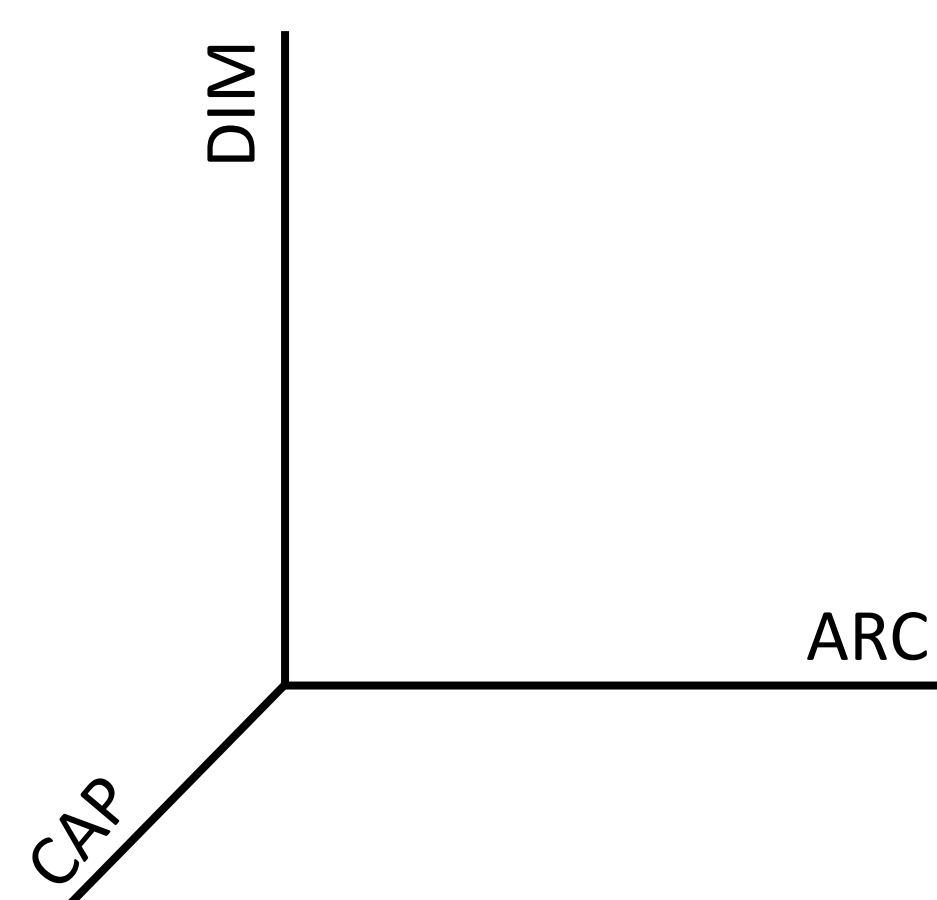
- Regiment
- Enforce
- Adapt

MAOP Dimensions (DIM) Perspective:

- Agent-centric (ACR)
- Organization-centric (OCR)
- Environment-centric
- Interaction-centric

Architectural (ARC) Perspective:

- Fully-Centralized (FCR)
- Semi-(De)centralized (SDR)
- Fully-Decentralized (FDR)



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

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- [2] Boissier, O., Bordini, R. H., Hubner, J., & Ricci, A. (2020). Multi-agent oriented programming: programming multi-agent systems using JaCaMo. *Mit Press*.
- [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*.

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