A Unified View on Regulation Management in Multi-Agent Systems

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Focus on...

1 Introduction

2 Perspectives on Regulation Management

3 A Unified View on Regulation Management

4 Analysis of Frameworks

5 Conclusions and Future Work

Context

In a multi-agent system (MAS), agents can be governed by *regulations*.

Regulation management denotes the capabilities (i.e., functionalities, procedures, mechanisms) and the representations (e.g., norms, rules, sanctions) used to regulate MAS.

Problematic

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- *collective* mechanism [Bicchieri, 2005] or *individual* mechanism [Conte et al., 2013]
- *centralized* architecture [Noriega and de Jonge, 2016] or *decentralized* architecture [Cliffe et al., 2006, Conte et al., 2013, Vasconcelos et al., 2012]

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- *centralized* architecture [Noriega and de Jonge, 2016] or *decentralized* architecture [Cliffe et al., 2006, Conte et al., 2013, Vasconcelos et al., 2012]
- *regimented* with rigid constraints or *enforced* with soft constraints [Jones and Sergot, 1994, Pasquier et al., 2006]

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Challenging to grasp the range of design options available and identify the most suitable to regulate MAS!

Objective

Propose *a unified view on regulation management in MAS* based on three perspectives and discuss the possible design options to govern MAS.

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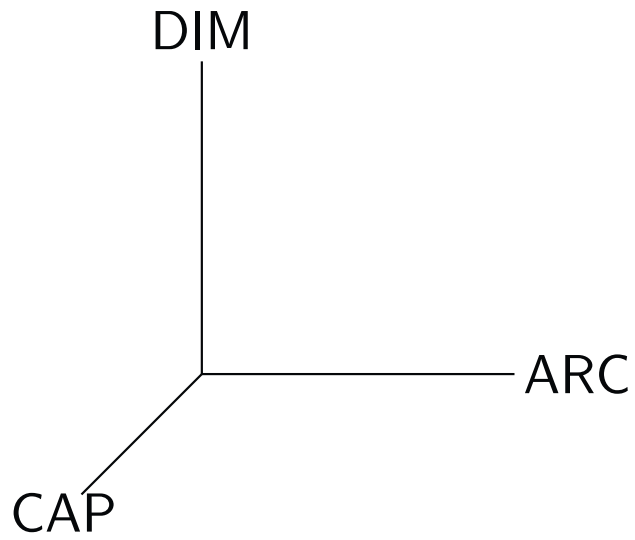
Perspectives on Regulation Management

- Regulation Management Capabilities Perspective (CAP)
- MAOP Dimensions Perspective (DIM)
- Architectural Perspective (ARC)



Capabilities View on Regulation Management

- *Regulation Management Capabilities Perspective (CAP)*
- MAOP Dimensions Perspective (DIM)
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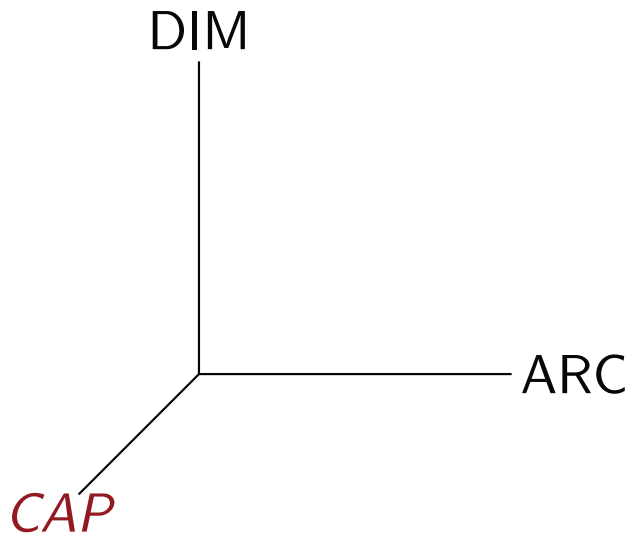

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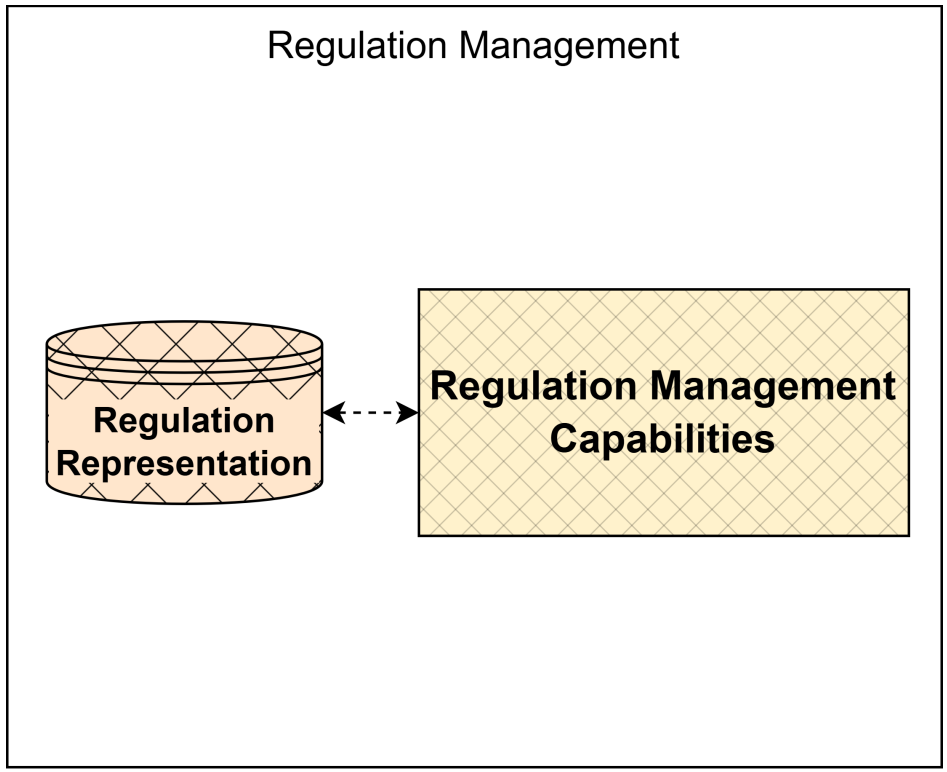

Capabilities View on Regulation Management

- *Regulation Management Capabilities Perspective (CAP)*
  - Regiment Capability
  - Enforce Capability
  - Adapt Capability
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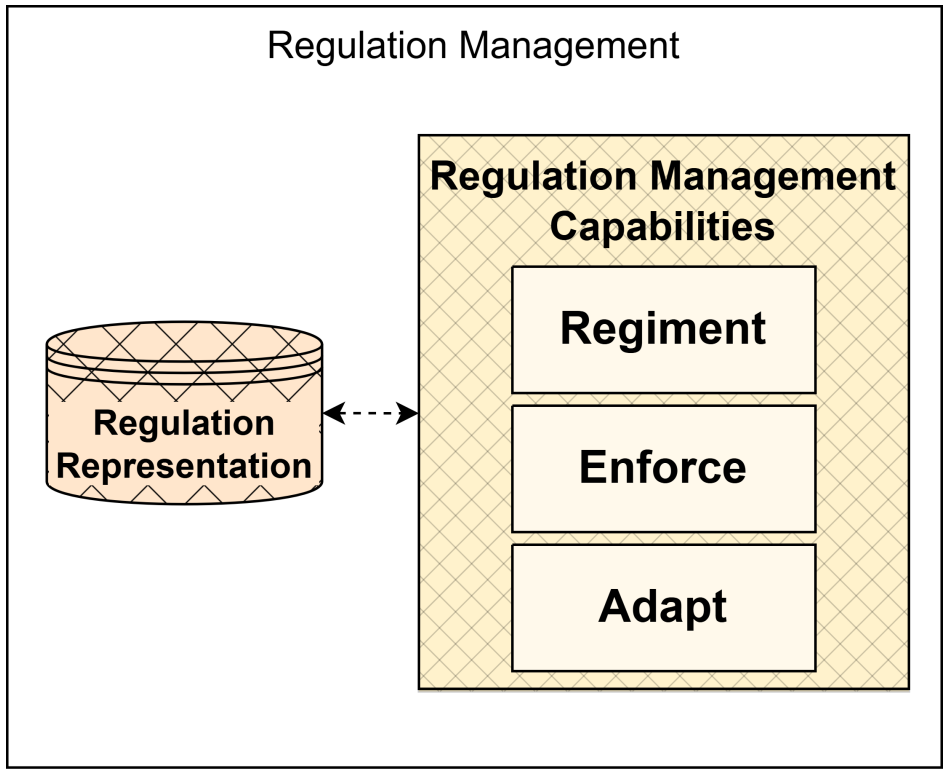

MAOP Dimensions Perspective

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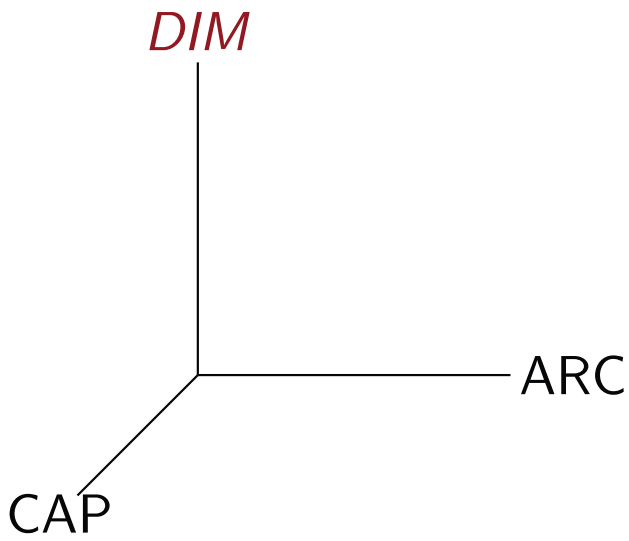

MAOP Dimensions Perspective

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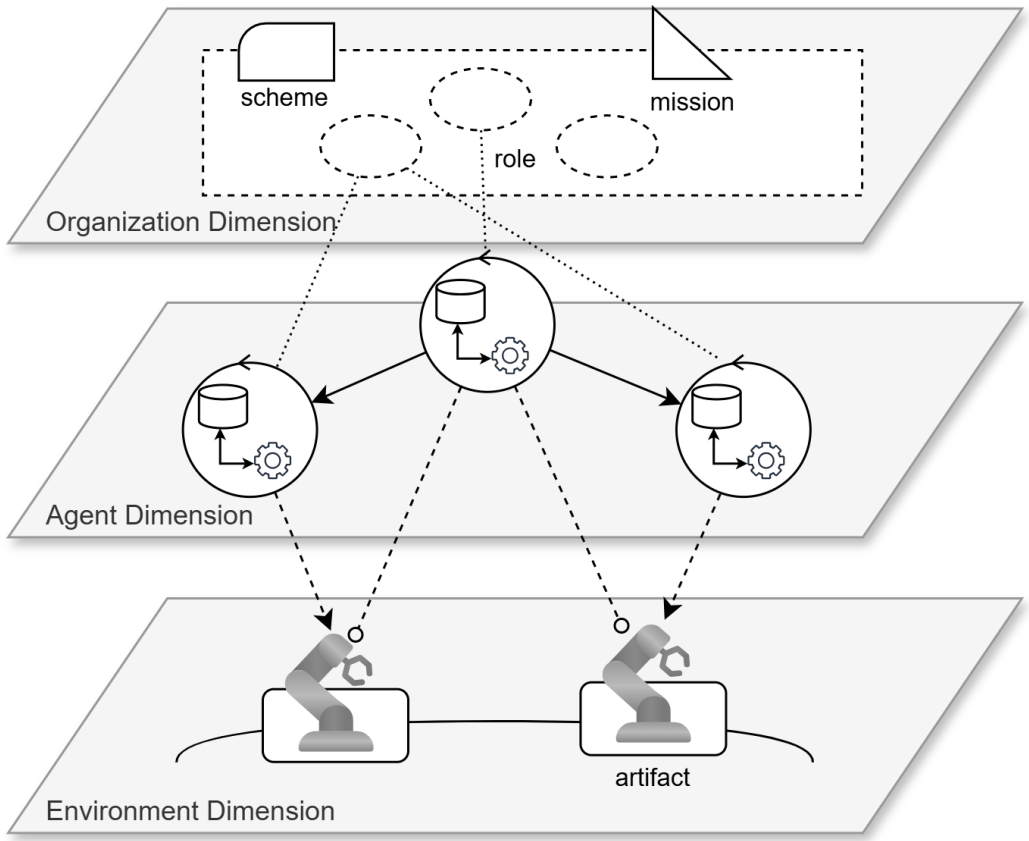
  - Agent Dimension
  - Environment Dimension
  - Interaction Dimension
- Architectural Perspective (ARC)



[Demazeau, 1997, Boissier et al., 2019]

MAOP Dimensions Perspective

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  - Interaction Dimension
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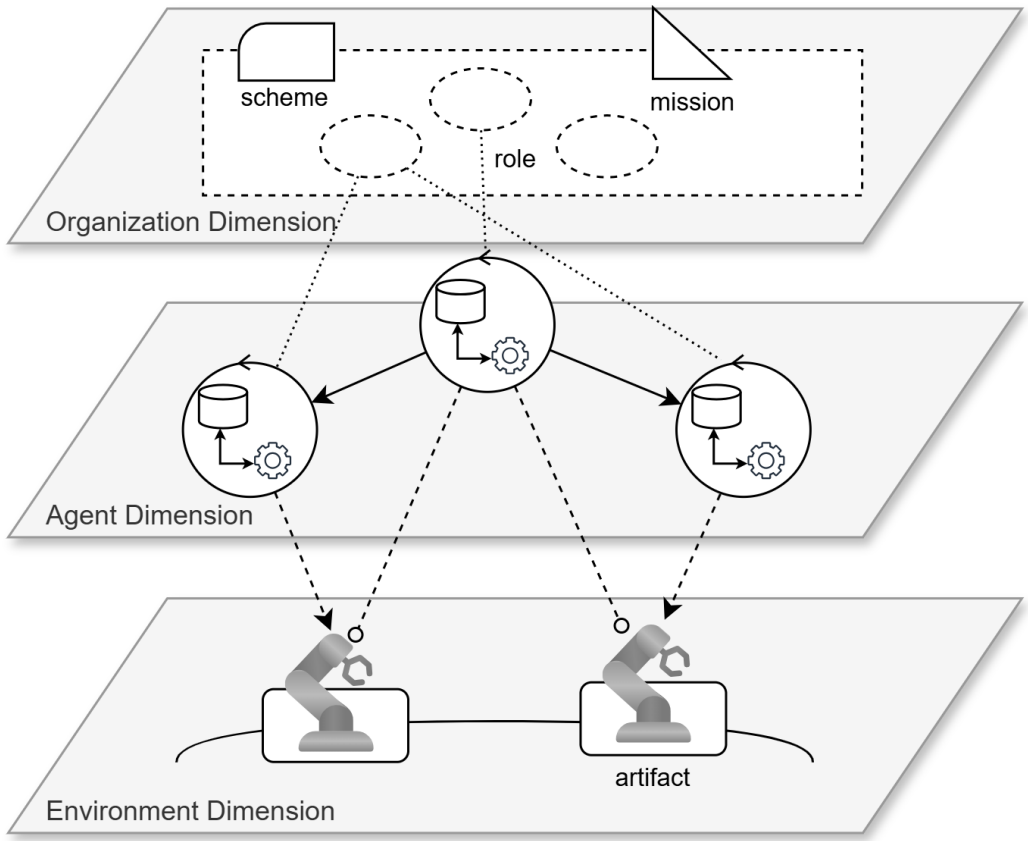
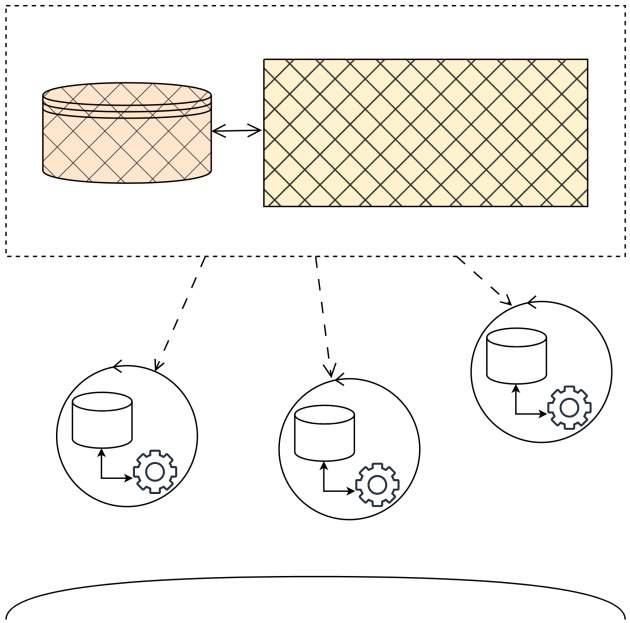


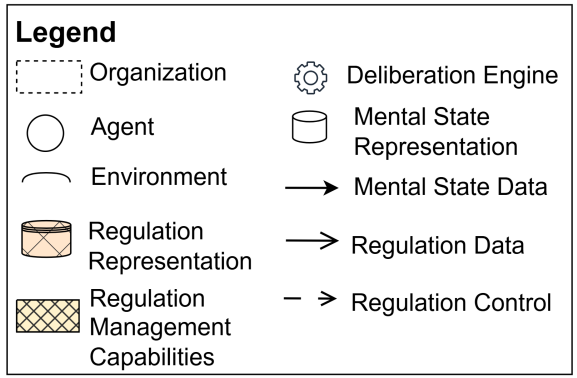
[Demazeau, 1997, Boissier et al., 2019]

Multi-Agent Oriented Views on Regulation Management

Organization-Centric Regulation Management

The regulation management representations and capabilities are made with abstractions (e.g., roles, groups, norms) and mechanisms of the **Organization dimension** of the MAOP paradigm





Multi-Agent Oriented Views on Regulation Management

Agent-Centric Regulation Management

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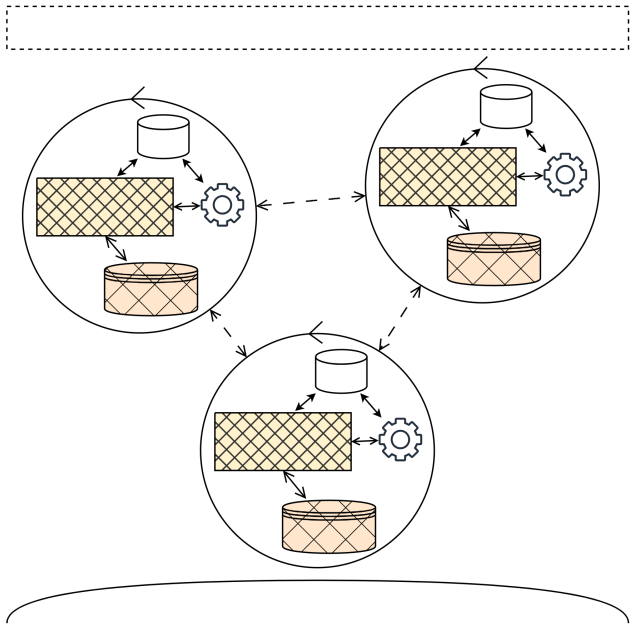
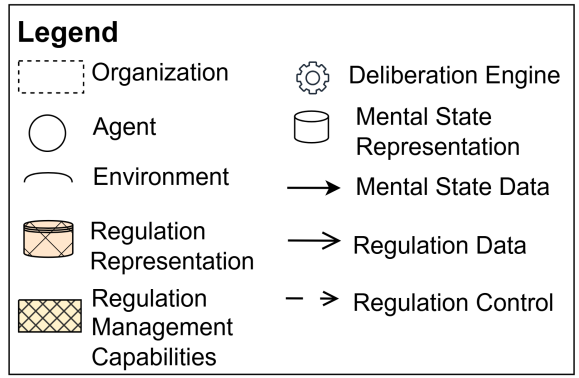
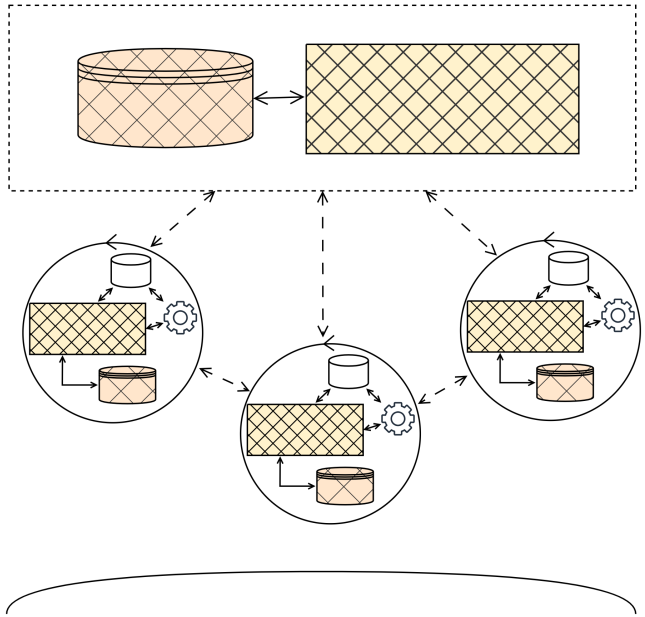


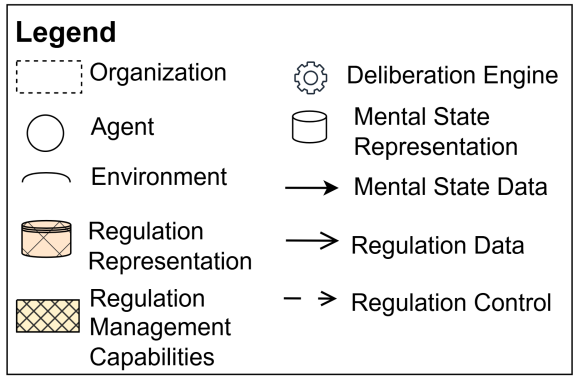


Multi-Agent Oriented Views on Regulation Management

Hybrid Organization-centric and Agent-centric Regulation Management

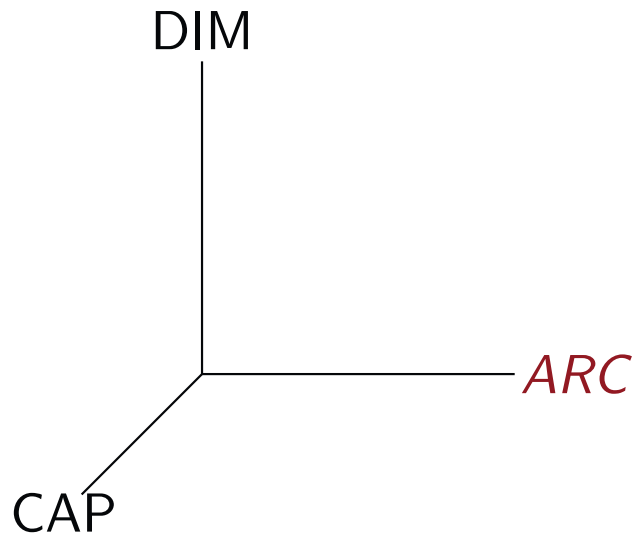
The regulation management representations and capabilities are made with abstractions and mechanisms of both the **Organization** and **Agent dimensions** of the MAOP paradigm





Architectural Perspective

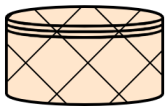
- Regulation Management Capabilities Perspective (CAP)
- MAOP Dimensions Perspective (DIM)
- *Architectural Perspective (ARC)*
  - Centralized Regulation Management
  - Decentralized Regulation Management
  - Semi-(De)centralized Regulation Management



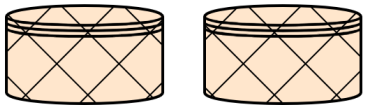
Architectural Views on Regulation Management

Regulation Representations

Centralized

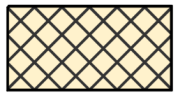


Distributed



Regulation Management Capabilities

Centralized



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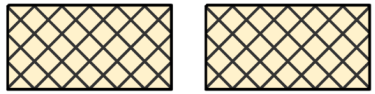

Architectural Views on Regulation Management

Regulation Representations	Regulation Management Capabilities: Centralized	Regulation Management Capabilities: Distributed
Centralized		
Distributed		

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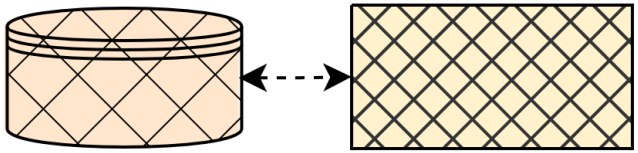
Centralized	 **Fully-Centralized Regulation Management (FCR)**	
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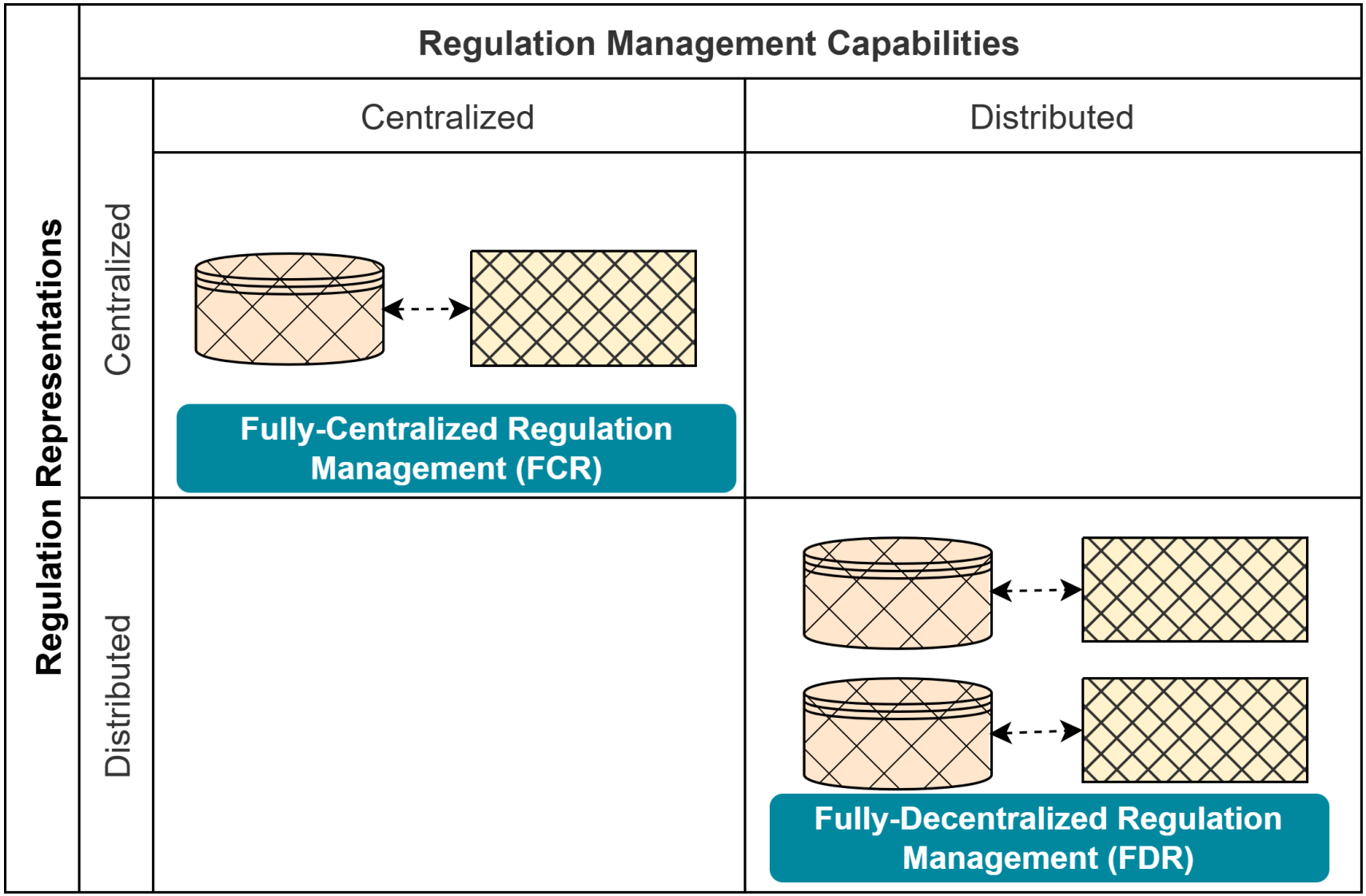

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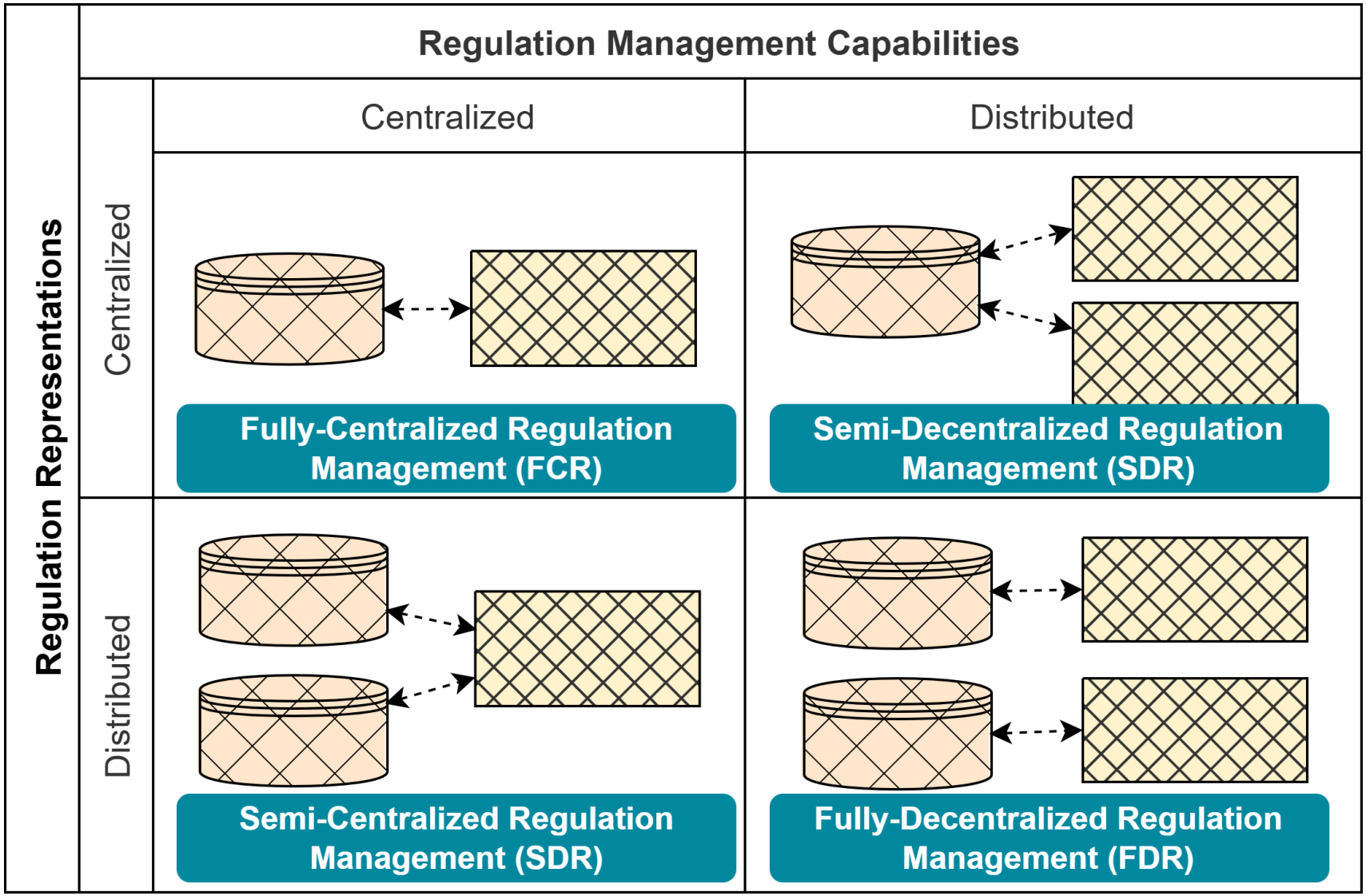

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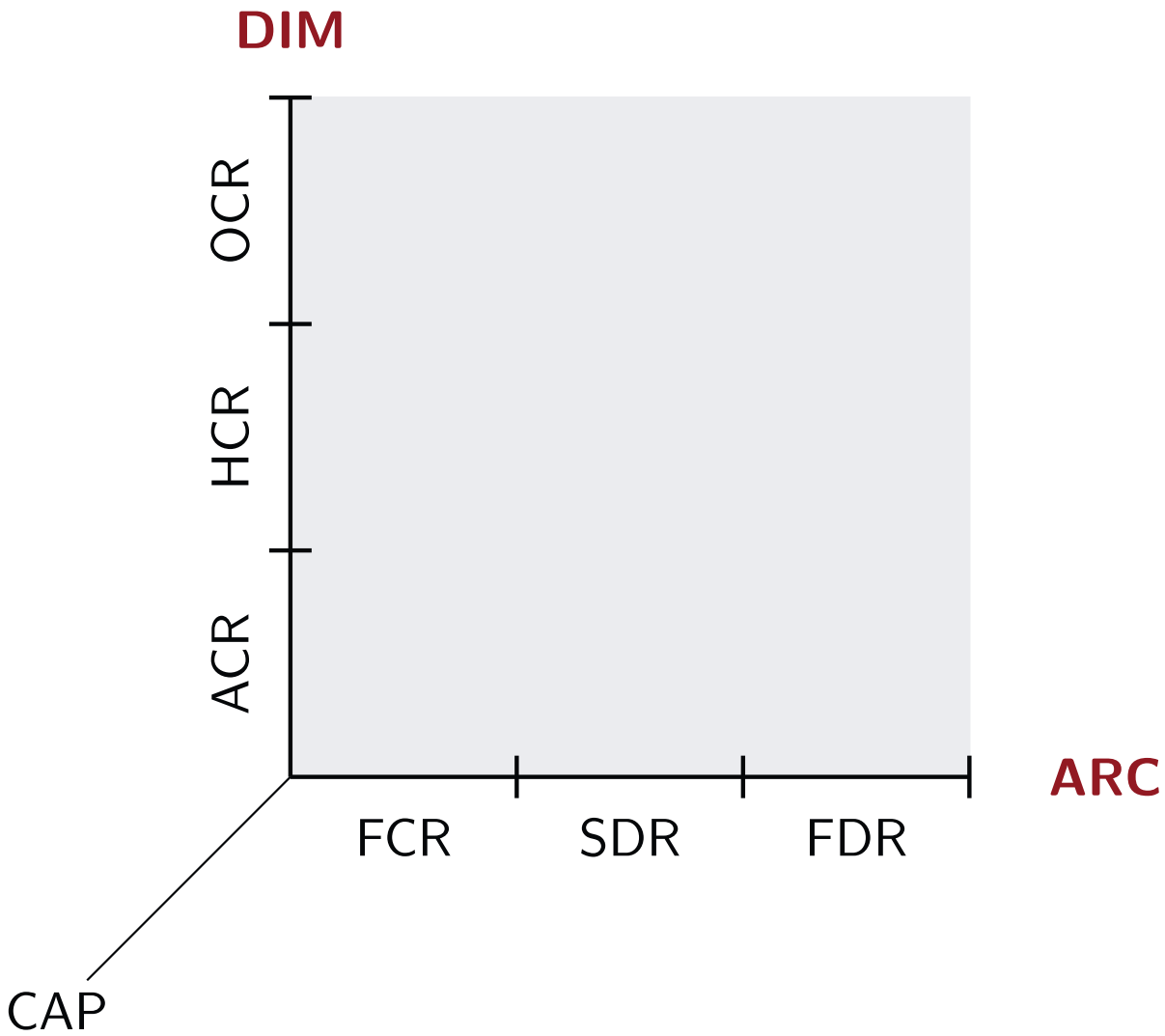

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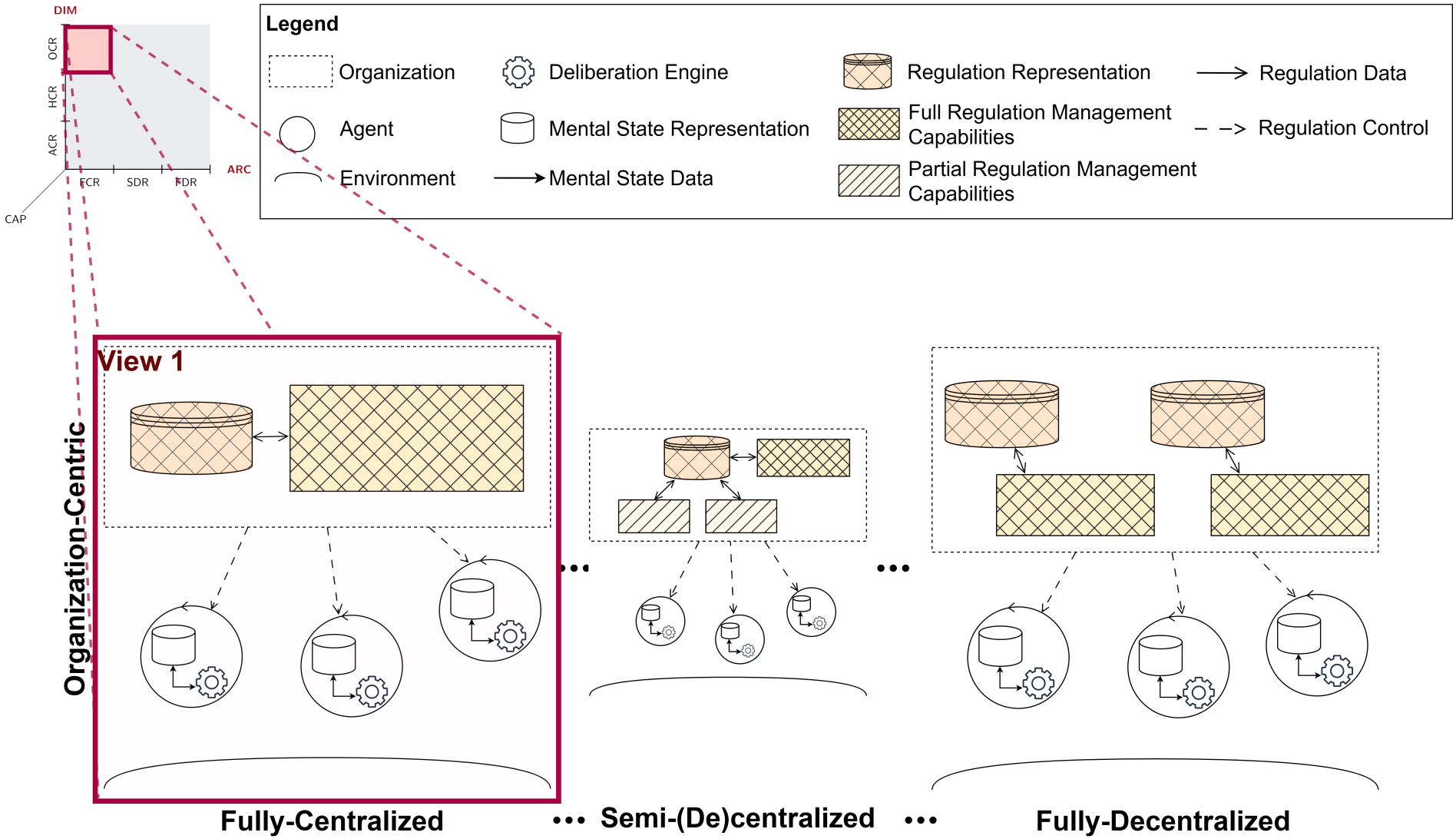

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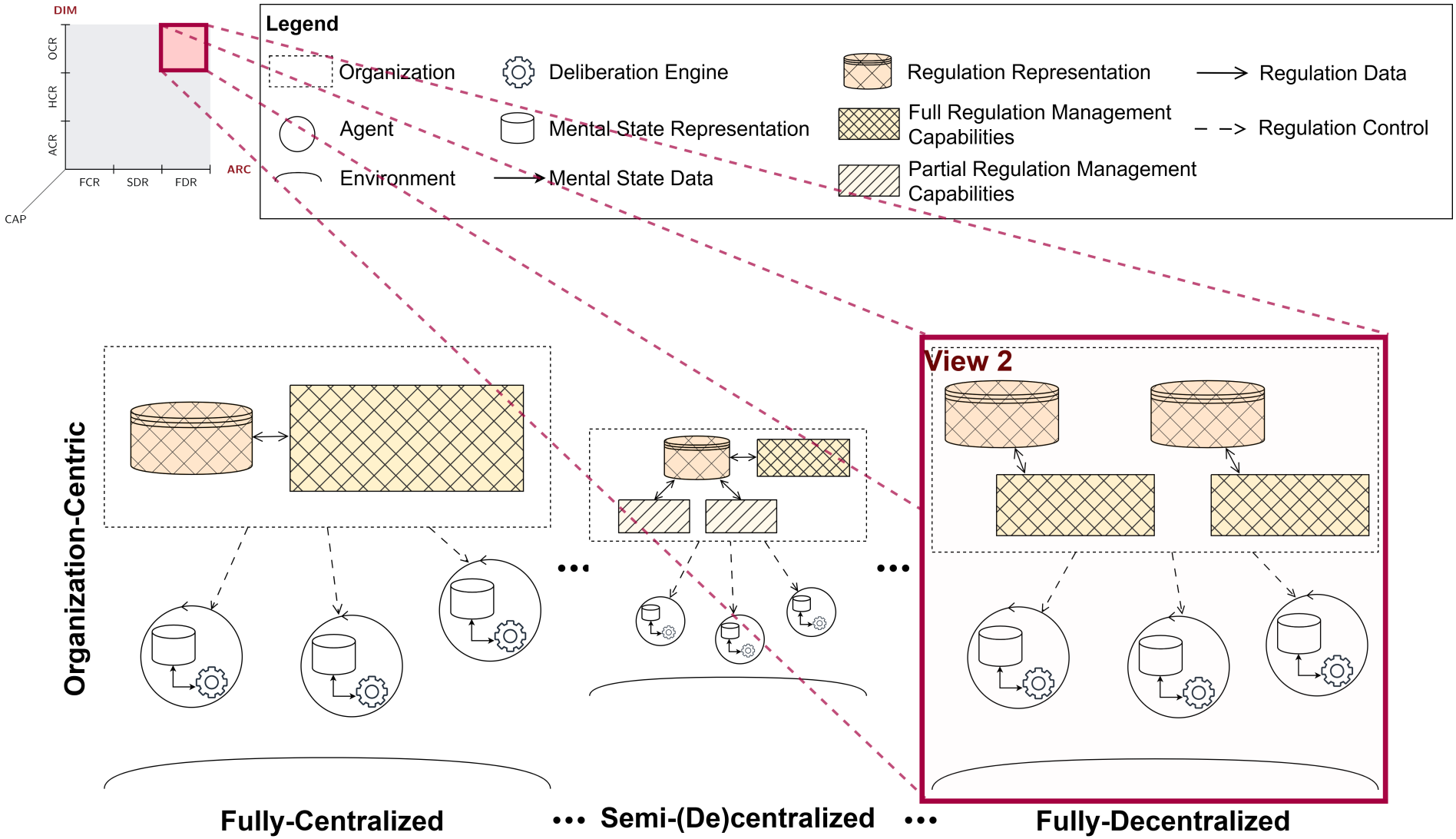

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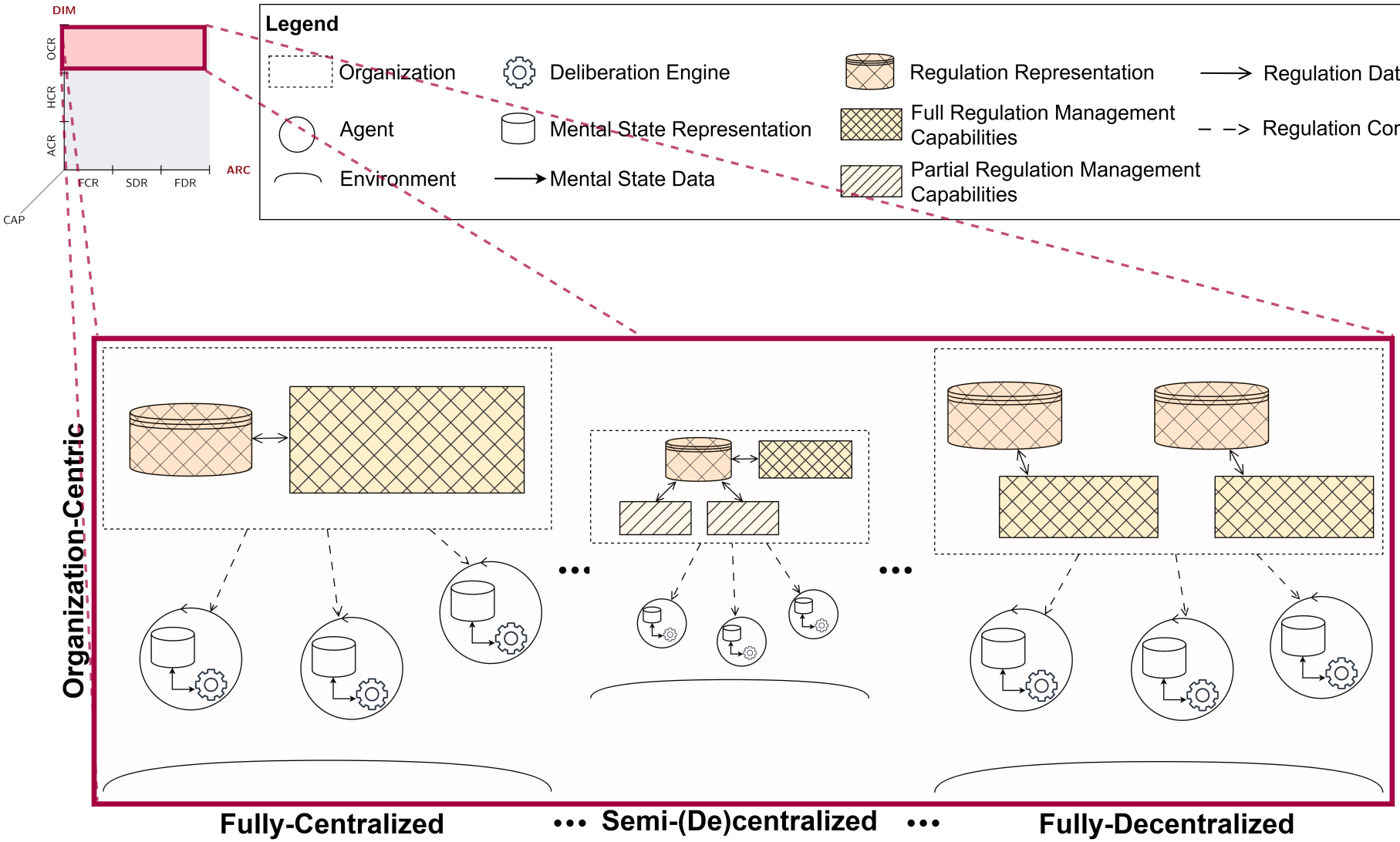

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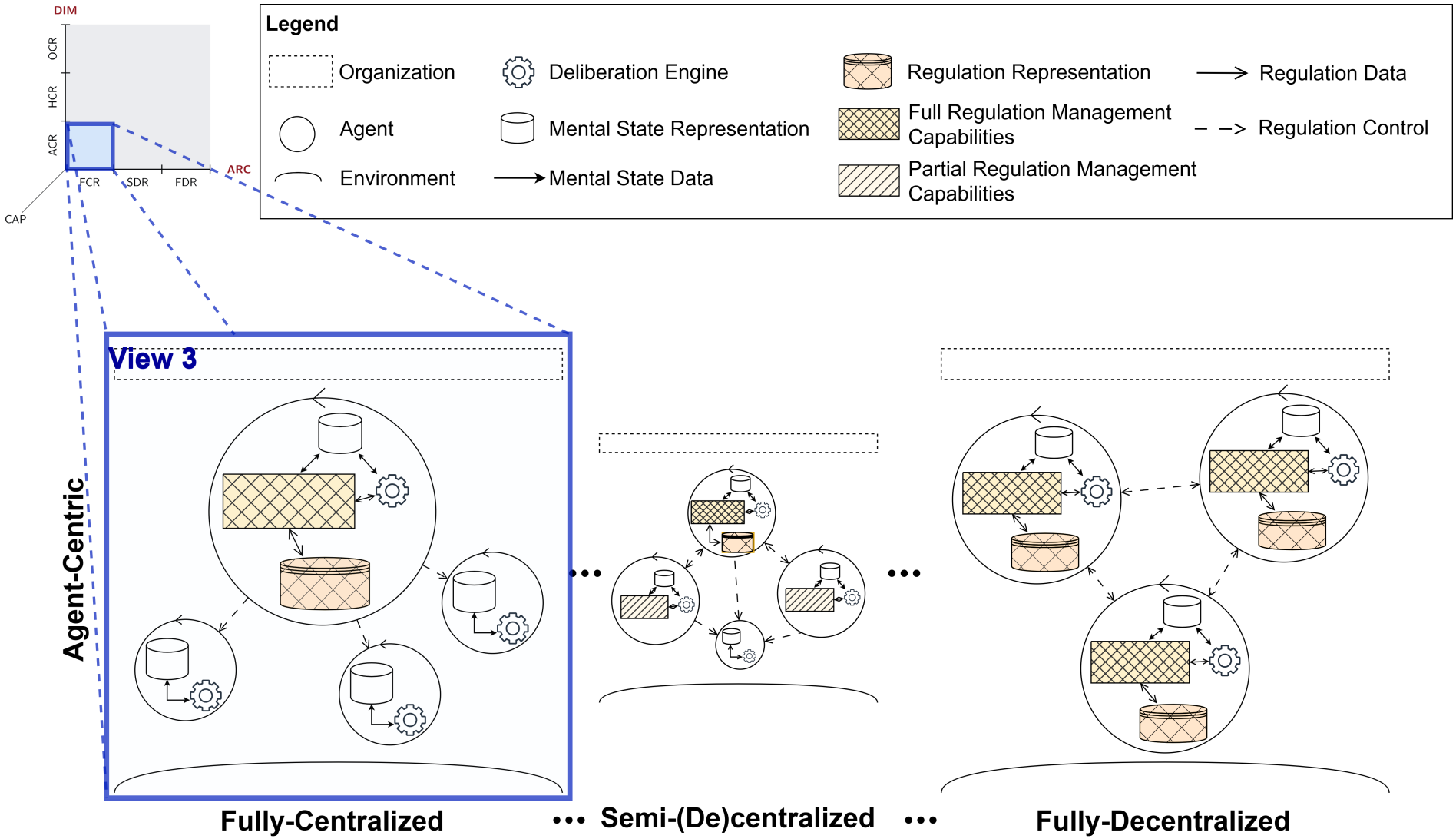

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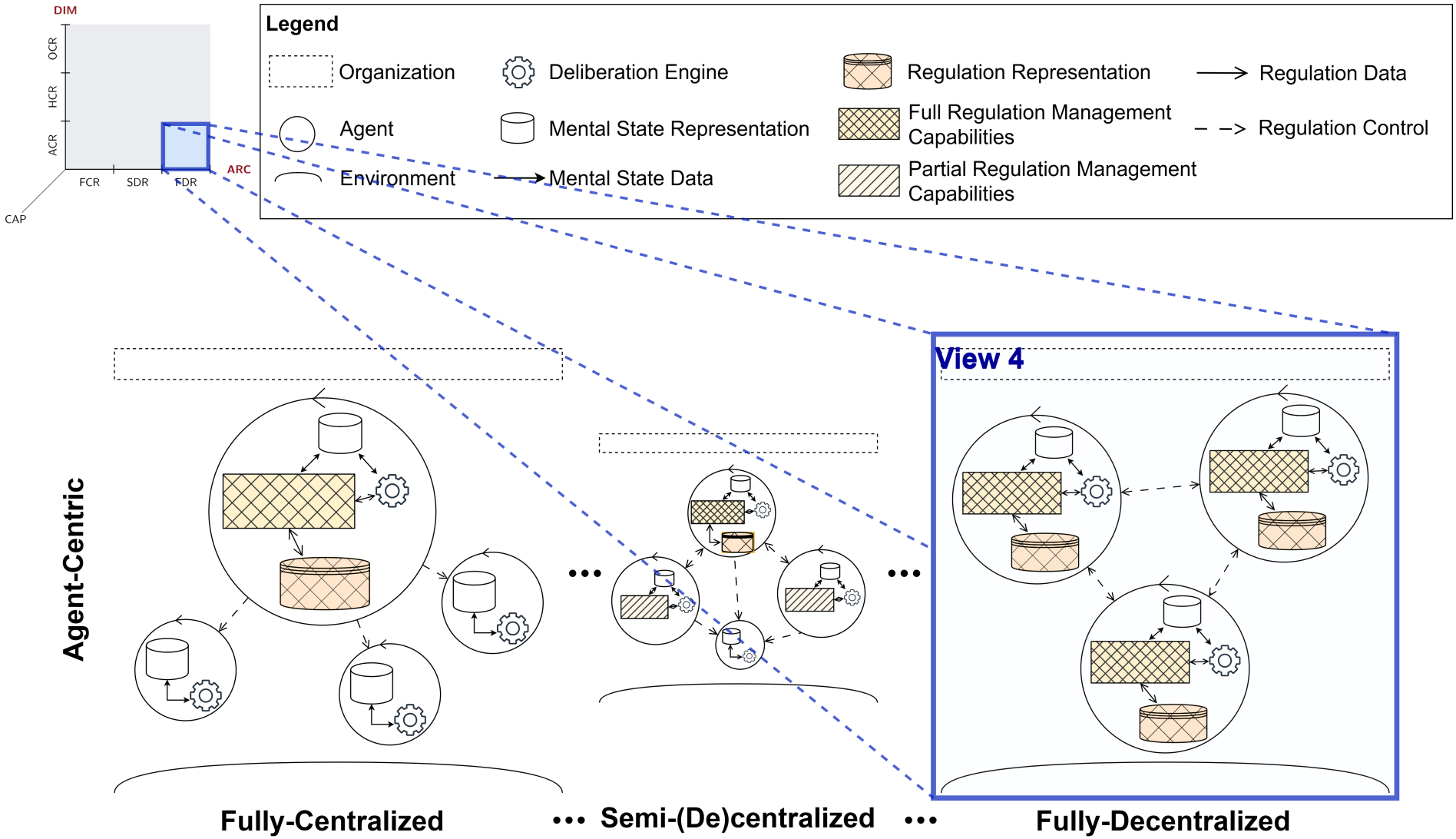

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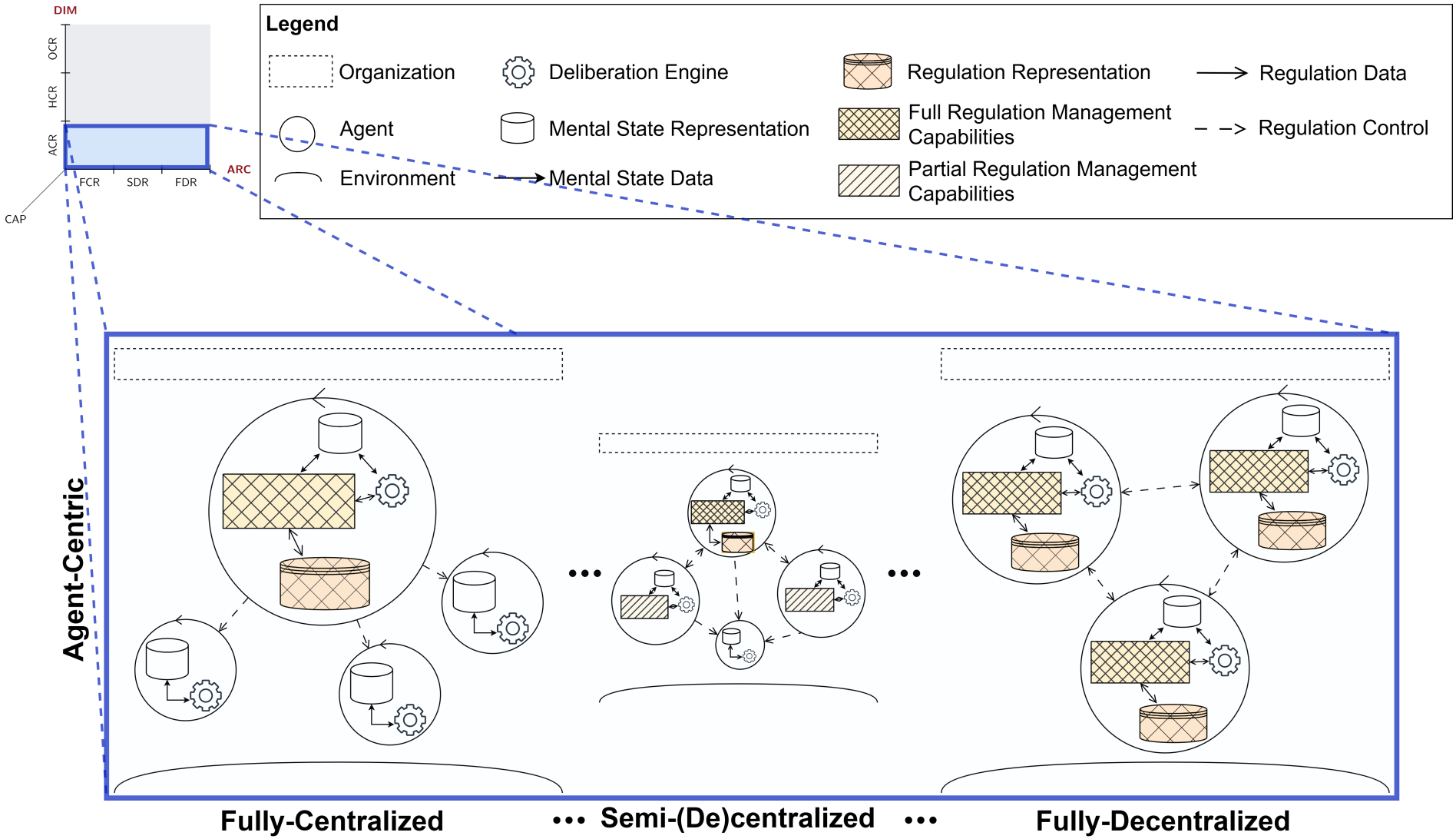

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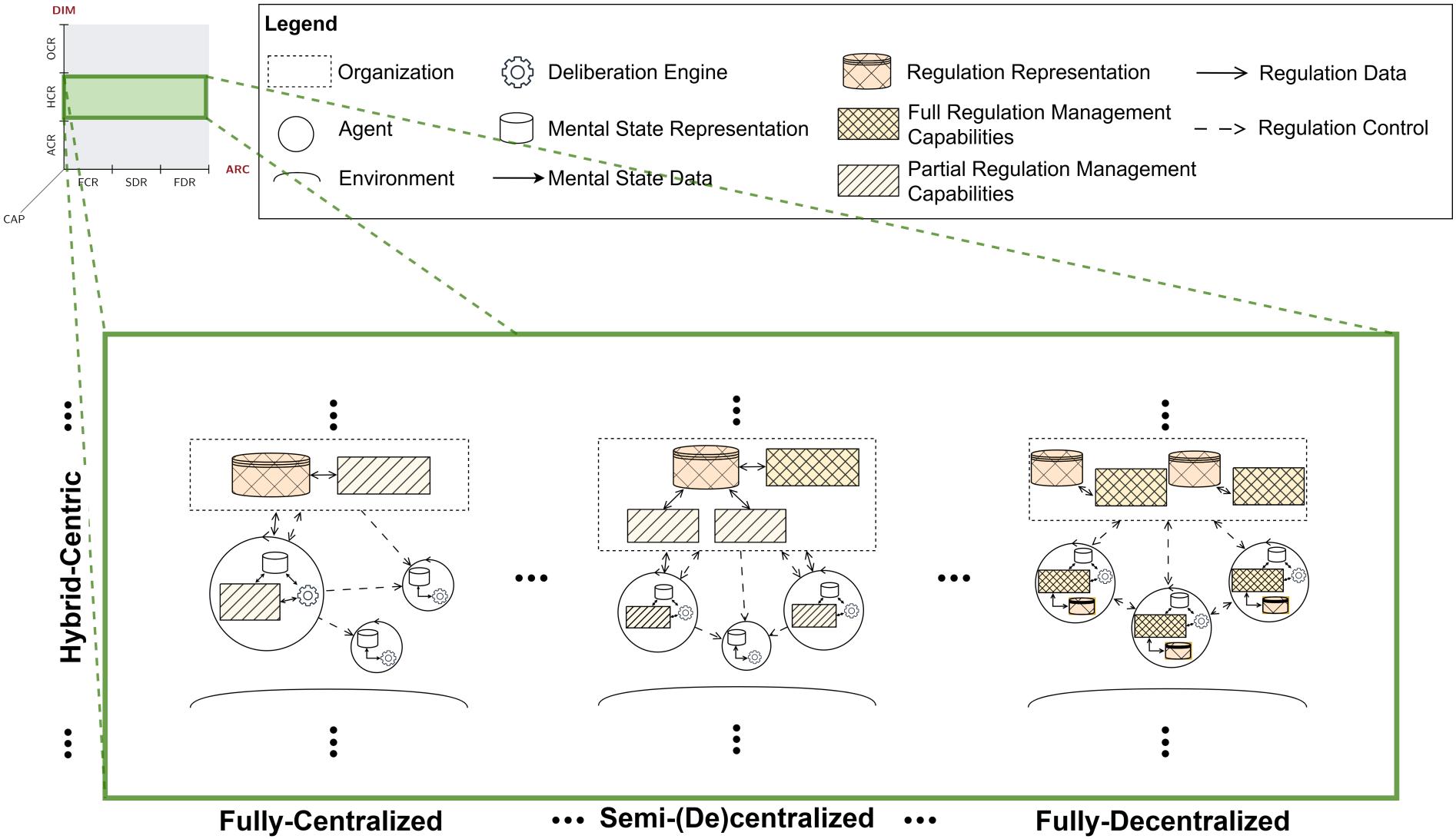

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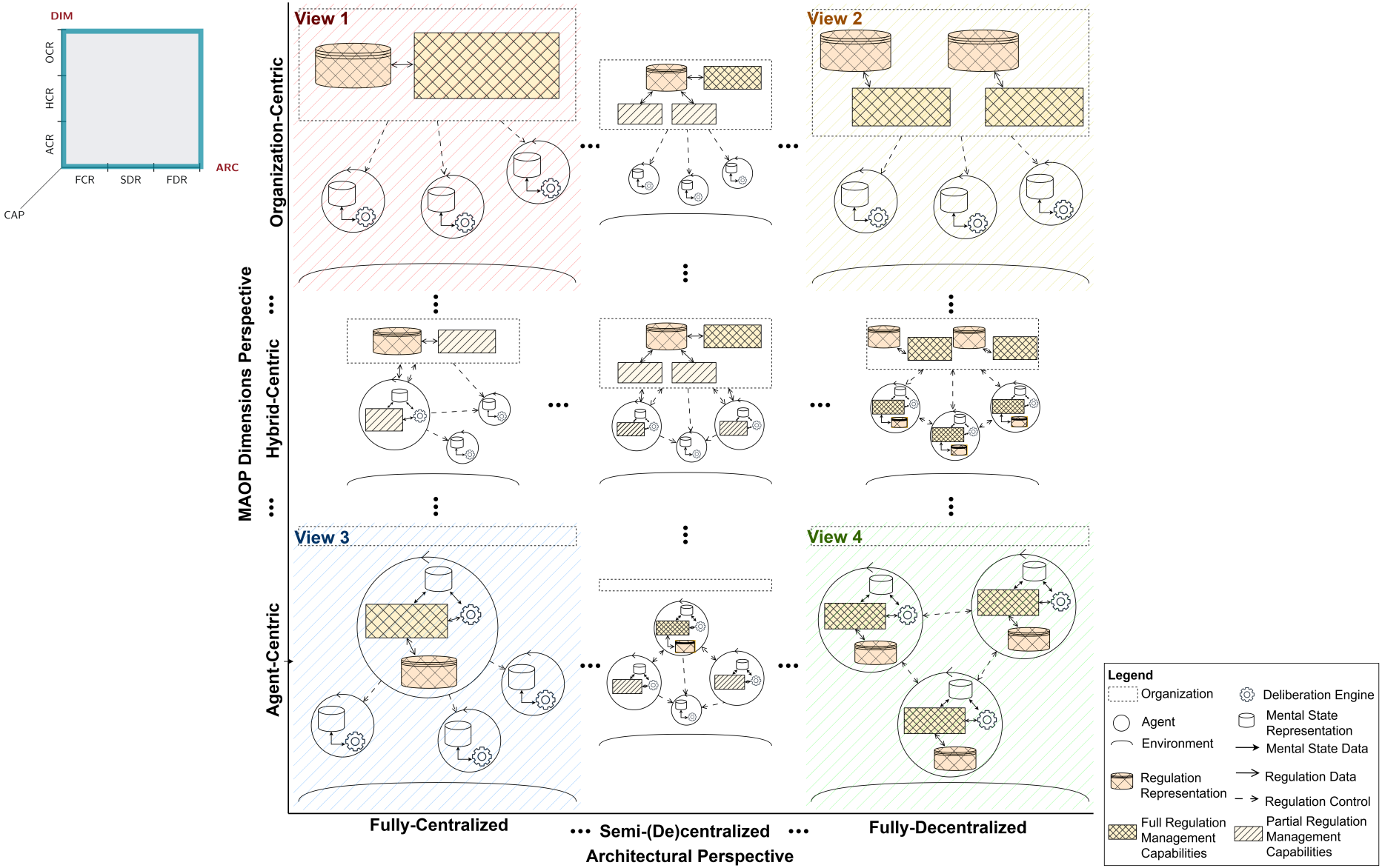

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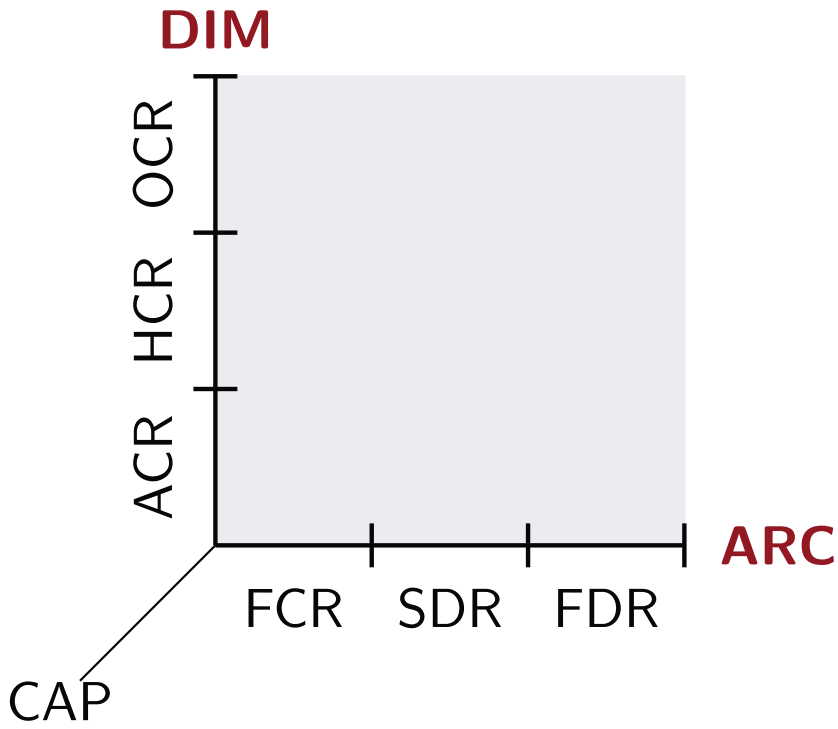
Analysis of Frameworks

We use the unified view as a reference grid to analyze the existing frameworks on regulation management in MAS



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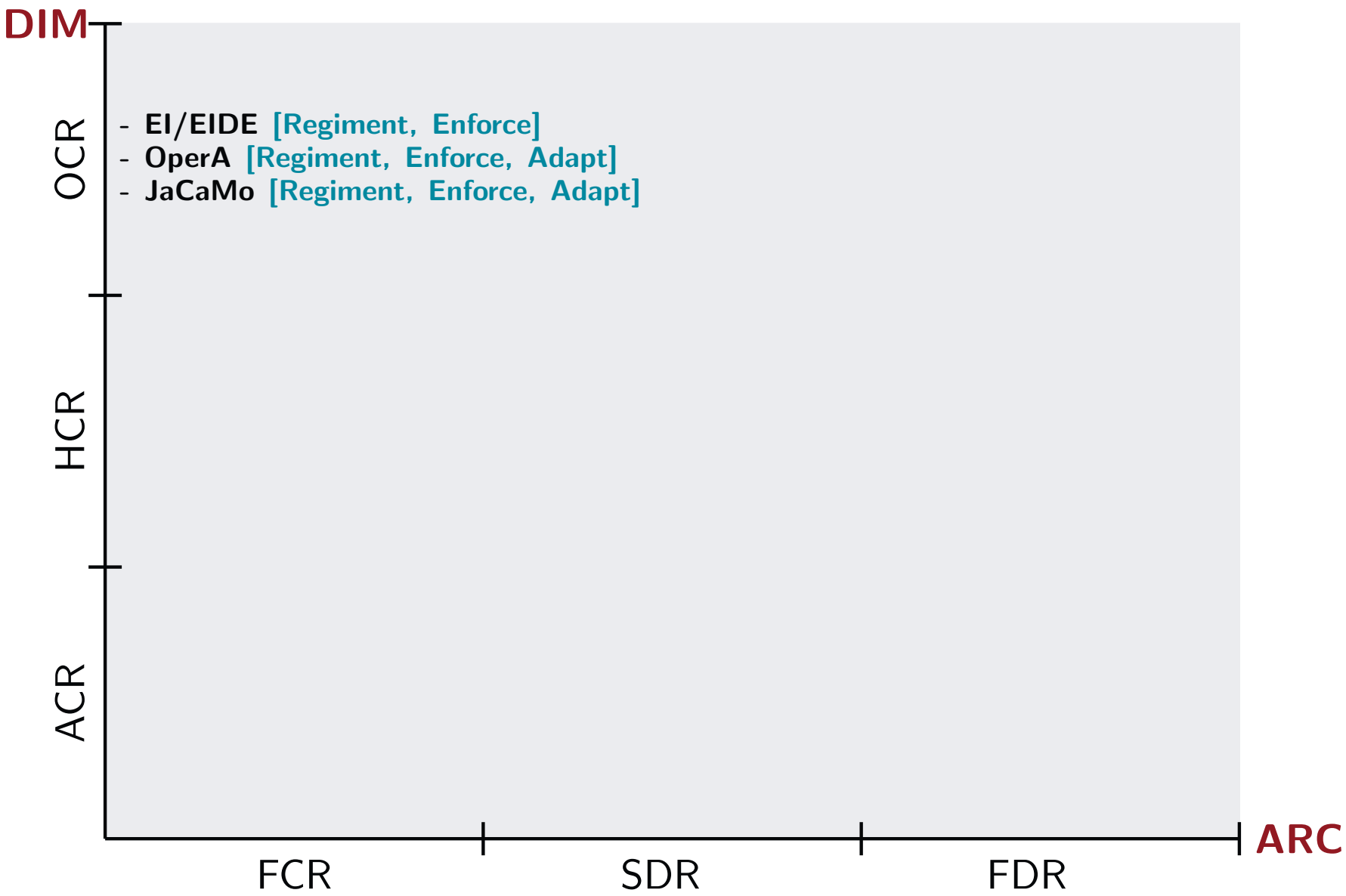

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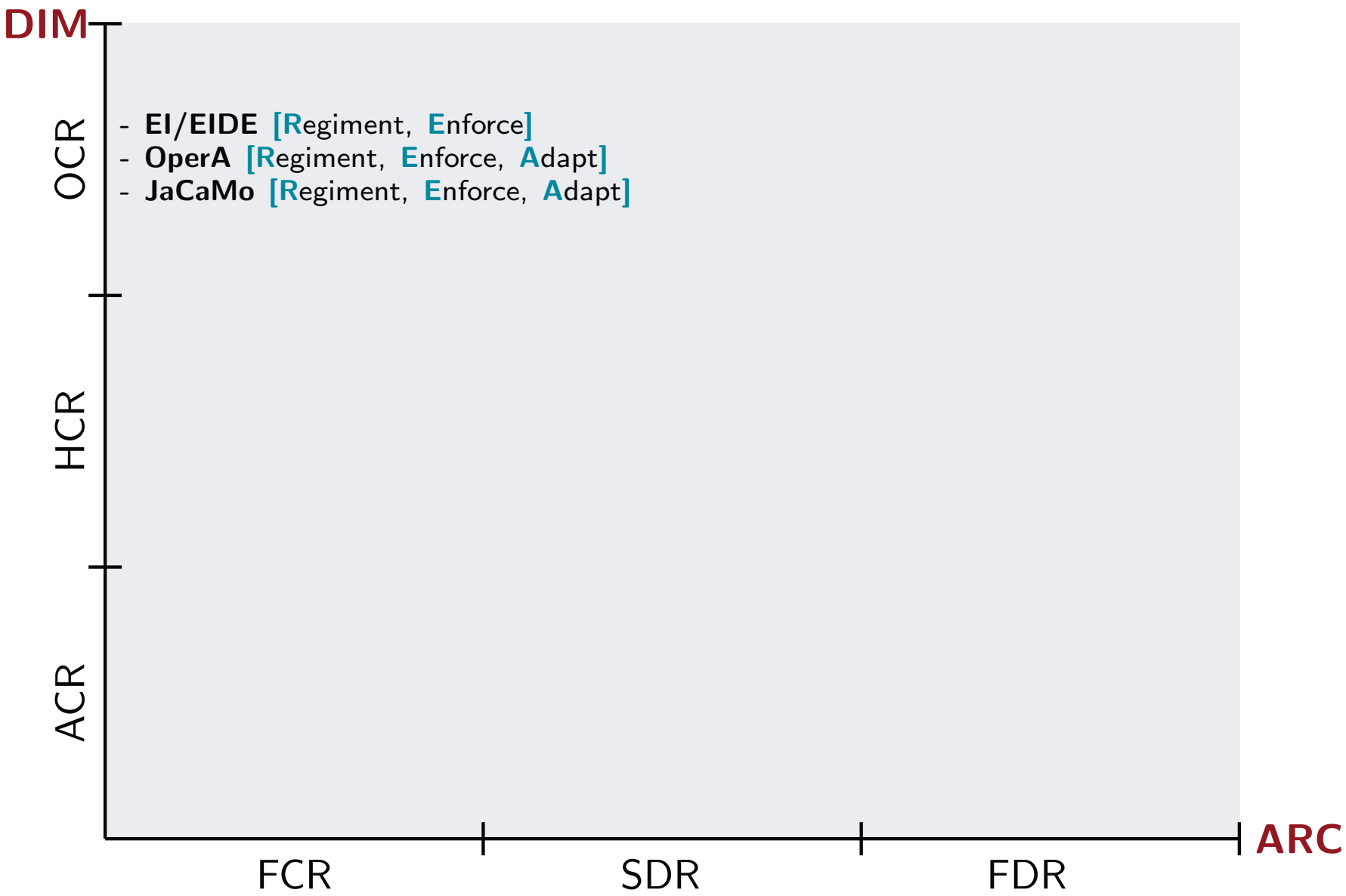

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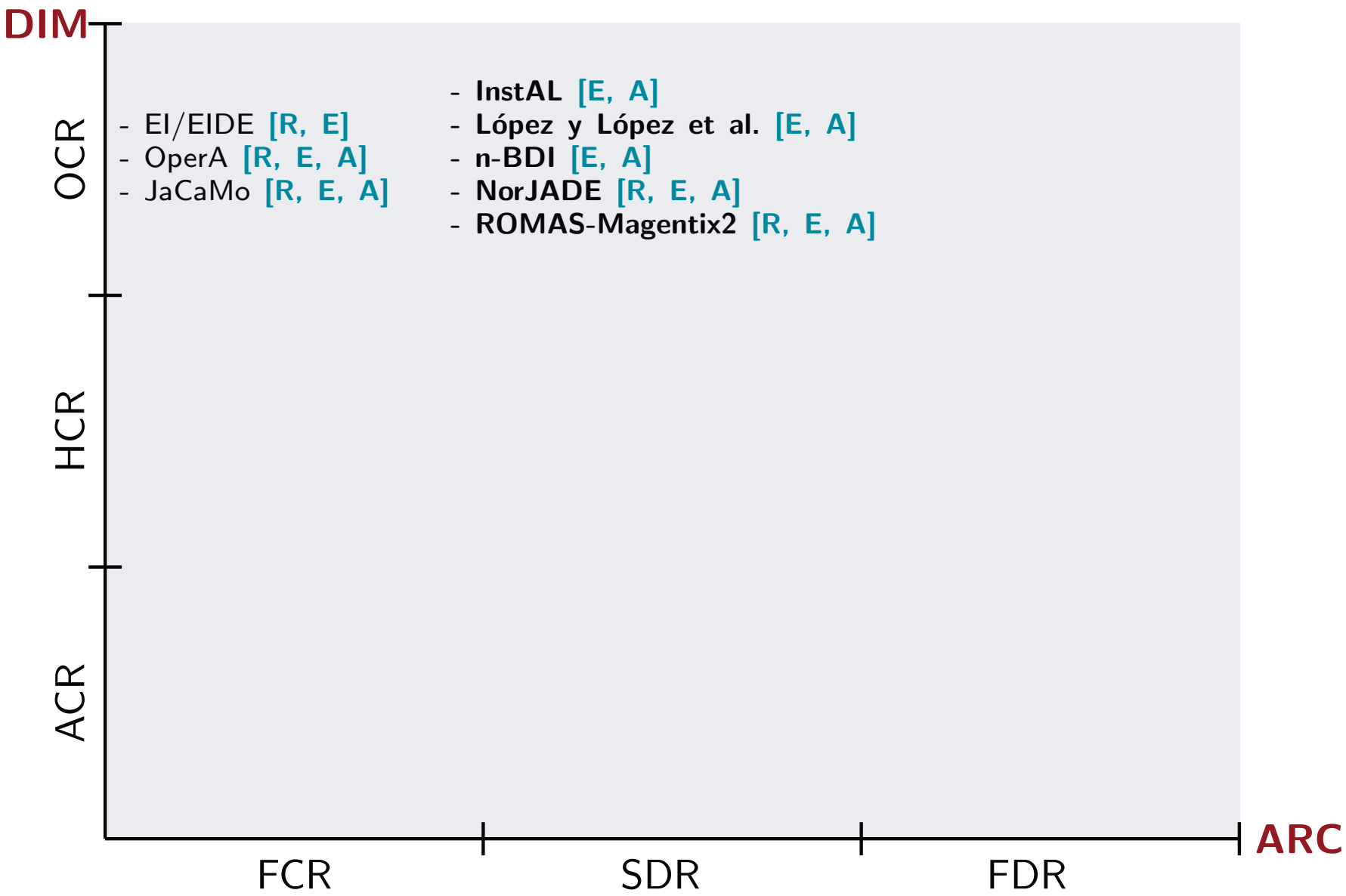

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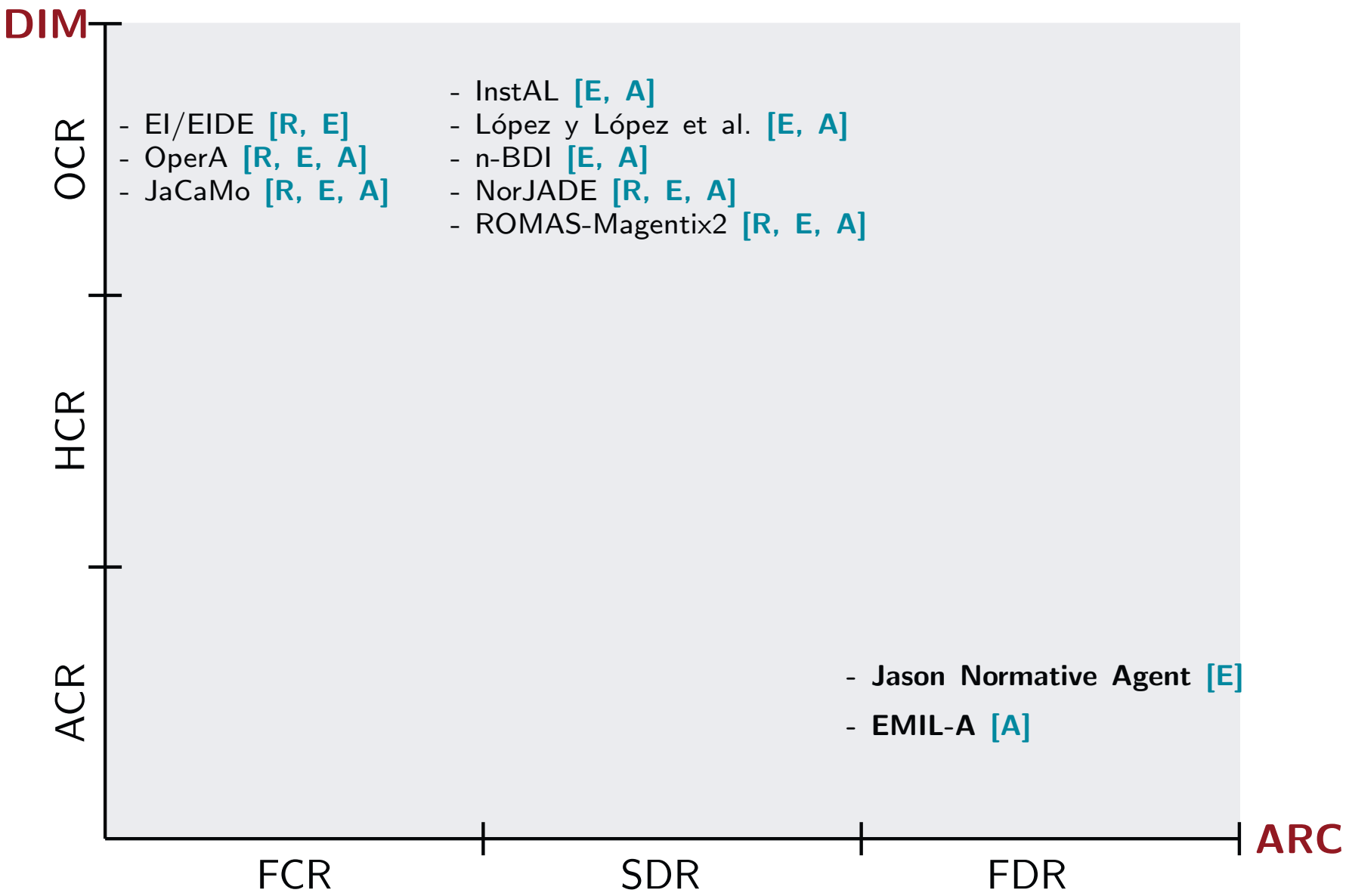

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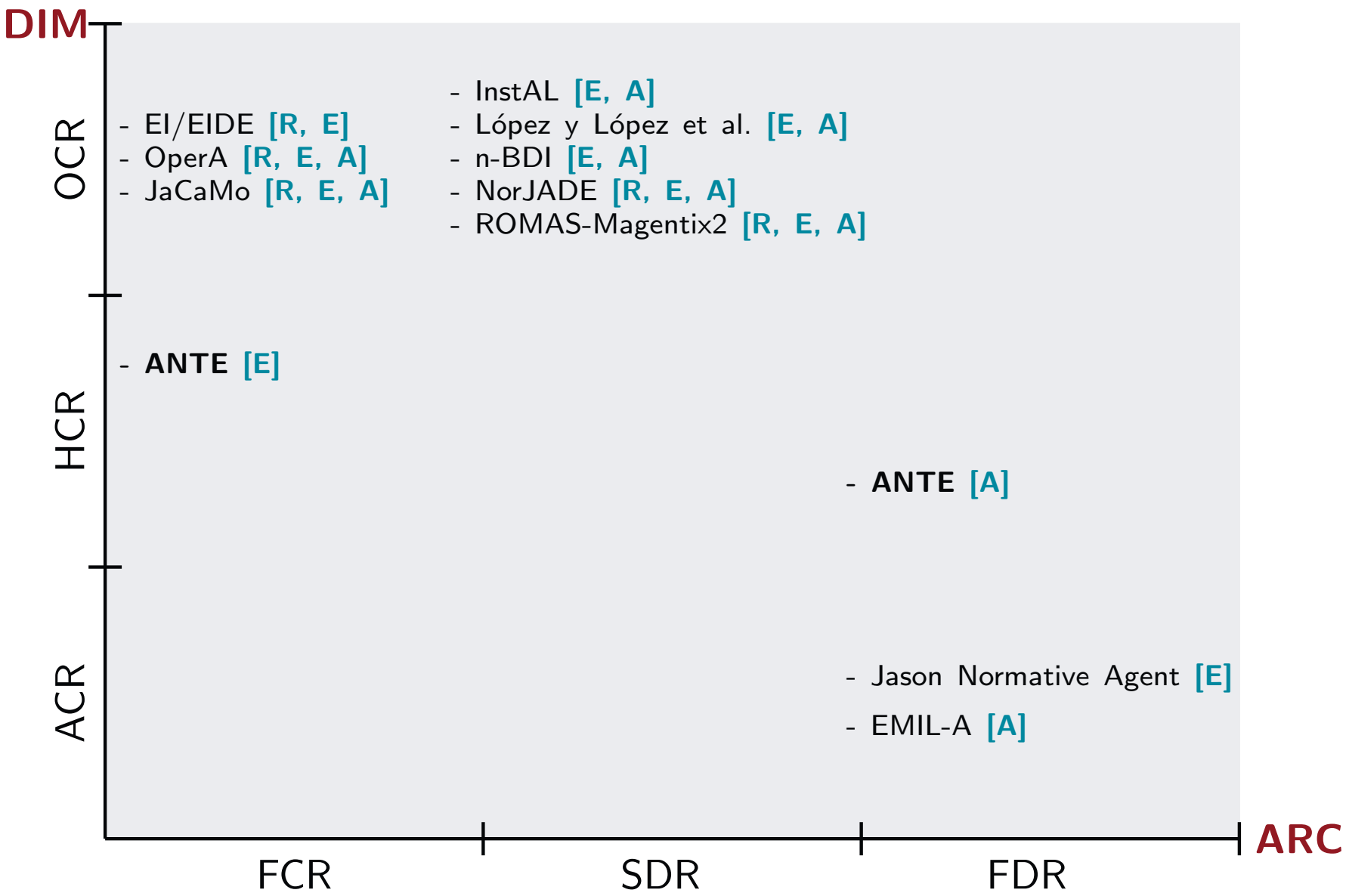

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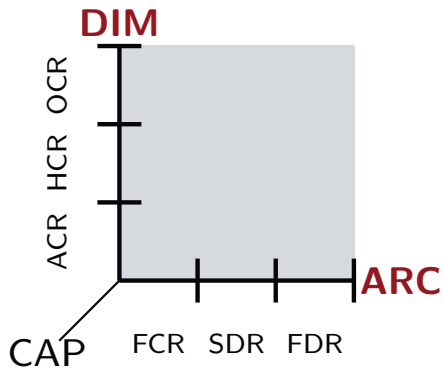
- identify possible design options *(e.g., to support choosing regulation management for a particular system)*
- explore opportunities and challenges *(e.g., hybrid-centric regulation management and adaptation on the regulation management system)*



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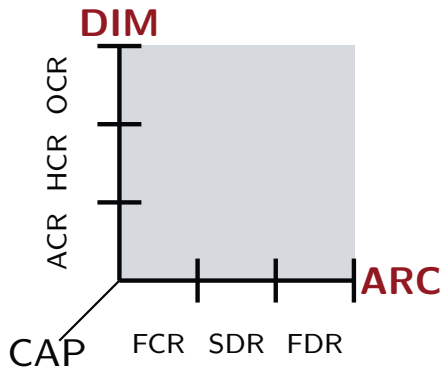


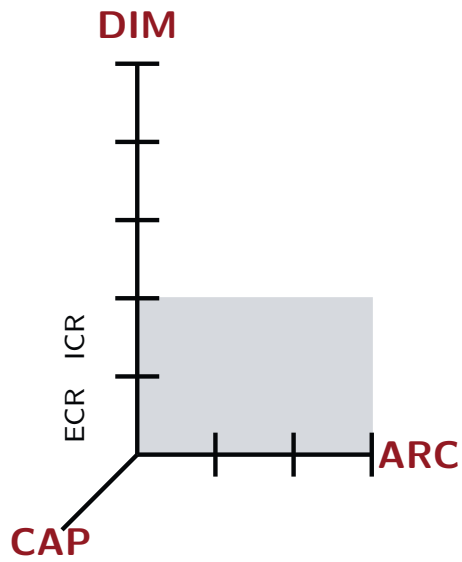
Future Work

On the unified view:

- complete the unified view on regulation management *(i.e., including the environment-centric and interaction-centric perspectives and their hybrid combinations)*
- evaluate formally the benefits and limitations of the design options

Practically:

- investigate the *adapt capability* in the Jason normative agent and integrate it into a *hybrid-centric* regulation with JaCaMo
- investigate the *adaptation of the regulation management system* in JaCaMo



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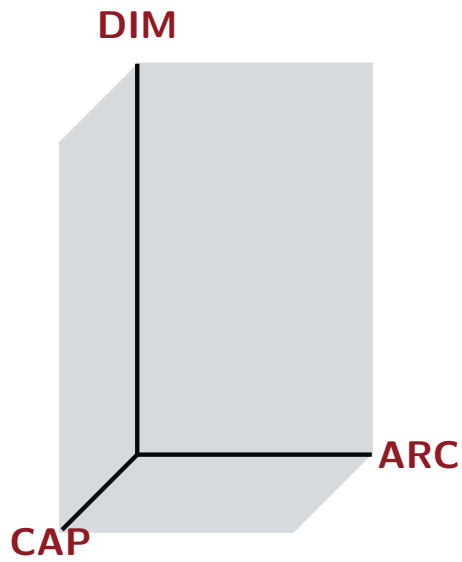

Future Work

On the unified view:

- complete the unified view on regulation management *(i.e., including the environment-centric and interaction-centric perspectives and their hybrid combinations)*
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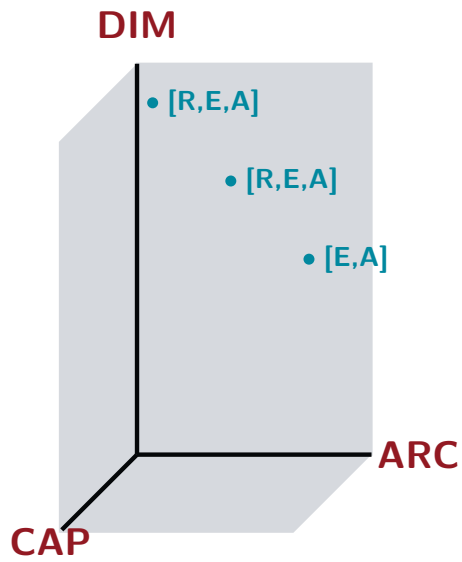

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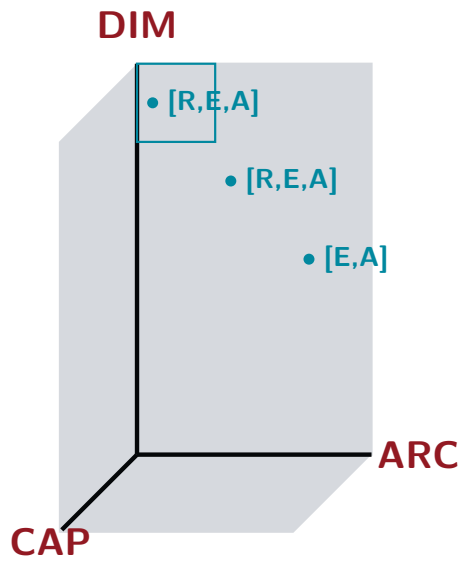

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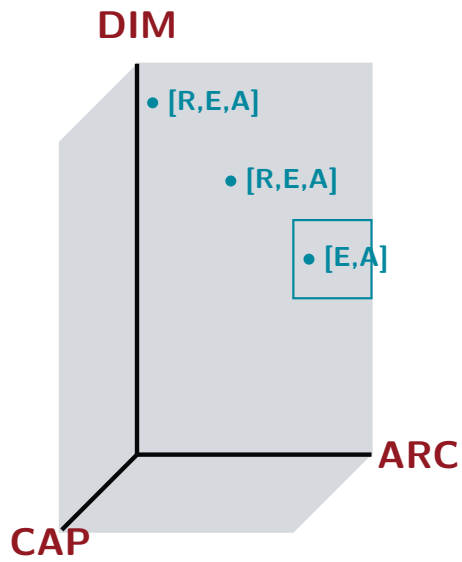

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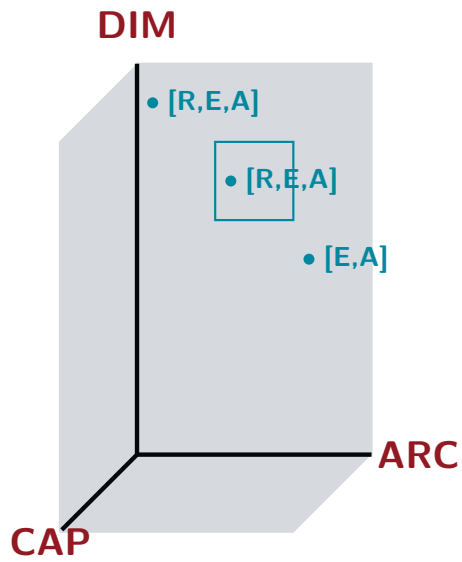

Thank you for your attention!

For further information:

Elena Yan, Luis G. Nardin, Olivier Boissier, Jaime S. Sichman.
A Unified View on Regulation Management in Multi-Agent Systems.
International Workshop on Coordination, Organizations, Institutions, Norms and Ethics for Governance of Multi-Agent Systems (COINE 2025), May 2025.

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