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Perspectives on Regulation Adaptation in Multi-Agent Systems:
from Agent to Organization Centric and Beyond

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Introduction

In **multi-agent systems** (MAS), agents' autonomy may lead the system into undesirable states

Regulations can be integrated into MAS to govern agents behaviors aligned with system goals

Motivation

Due to changing contexts (e.g., exogenous shock, persistent problem), regulations should be **adapted** to remain effective

→ **different perspectives** exist for regulation adaptation
(e.g., agent-centric vs. organization-centric)

Objectives

Illustrate how **regulation adaptation** can be managed in MAS

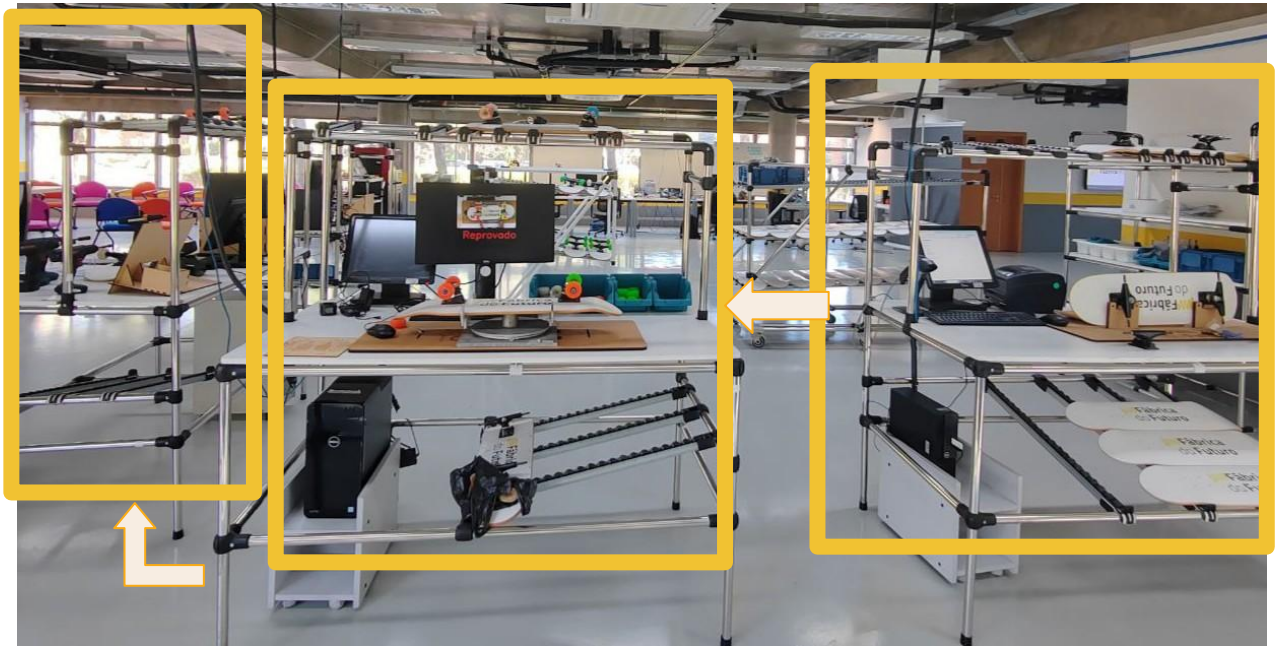
Analyze the **multiple perspectives** on regulation adaptation in MAS

Case Study: The Skateboard Assembly Line

Objective: Assembly custom skateboards according to the orders placed by customers

3 workstations:

- TrunkWS
- WheelWS
- TorqueWS



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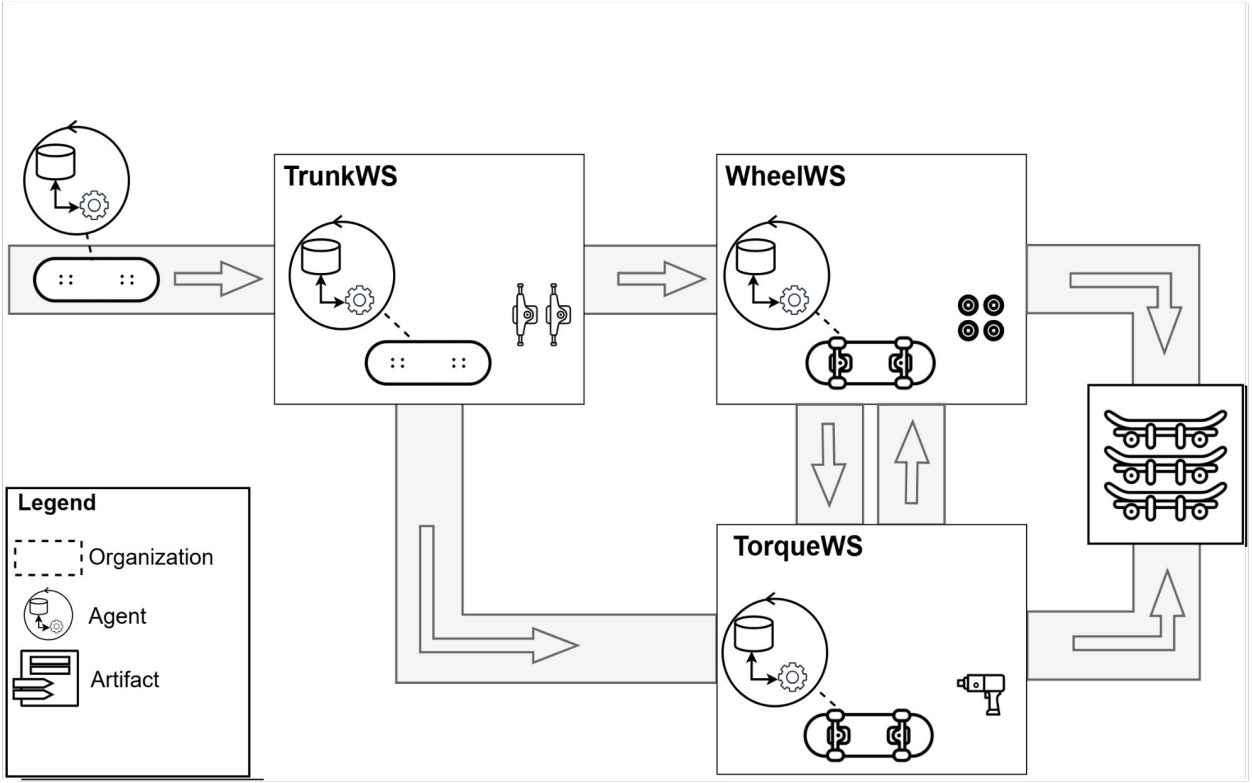
Multi-Agent Oriented Programming (MAOP) Design

Agent Dimension

SkHandler Agents

responsible to handle the skateboard SID according to the order



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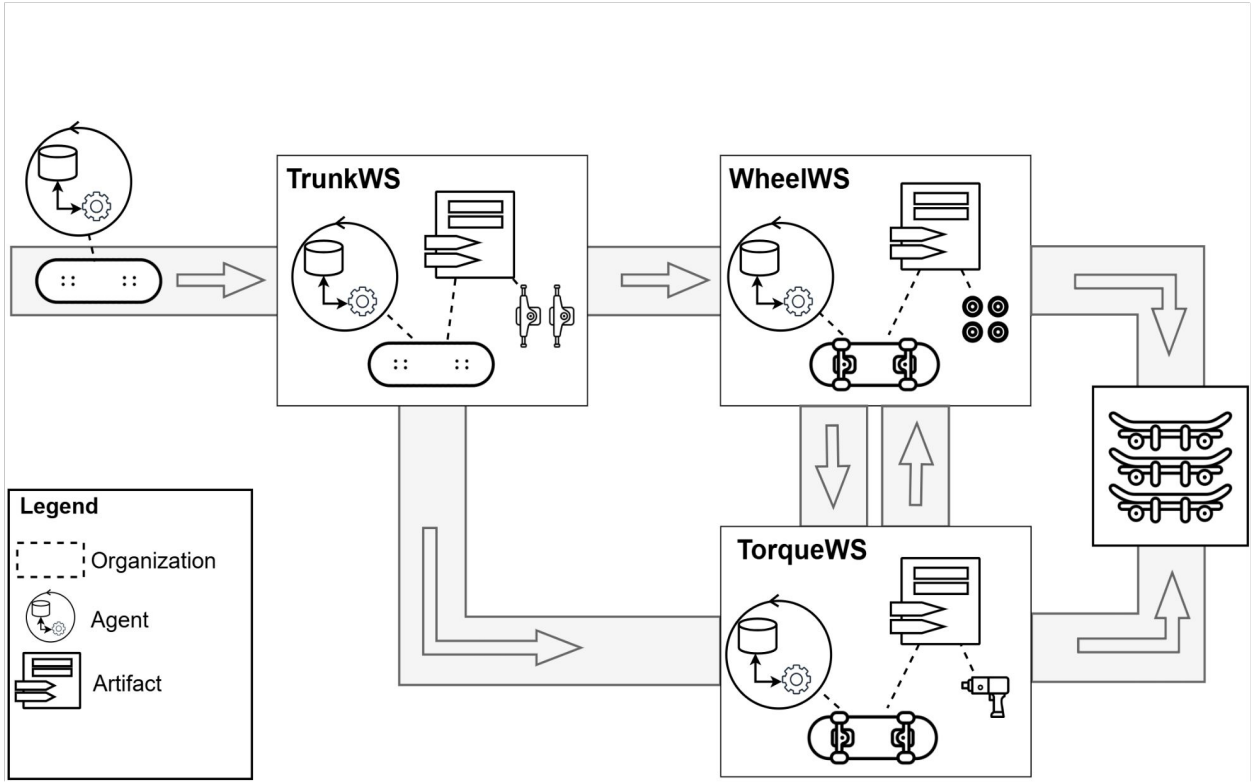
Multi-Agent Oriented Programming (MAOP) Design

Environment Dimension

TrunkArt for installing the trunk

WheelArt for assembly the wheels

Torque Art for torque the trunk



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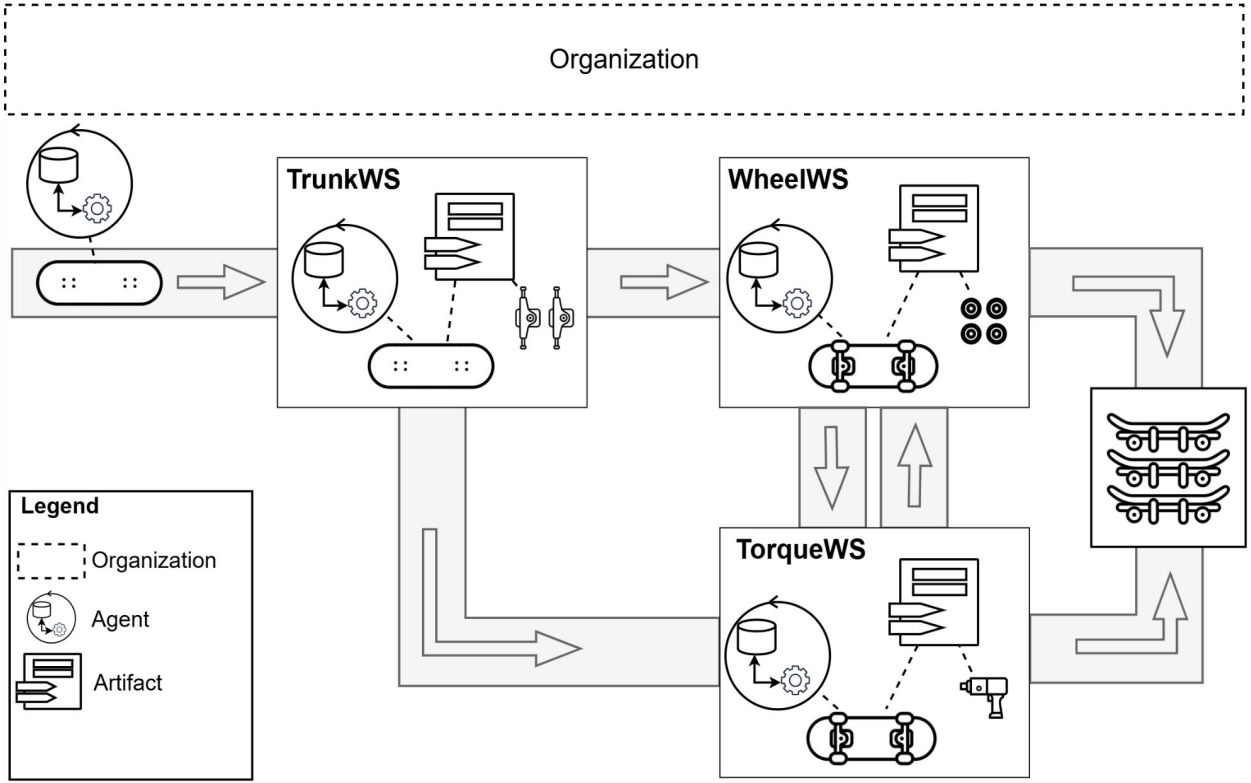
Multi-Agent Oriented Programming (MAOP) Design

Organization Dimension

defines the roles and responsibilities of agents

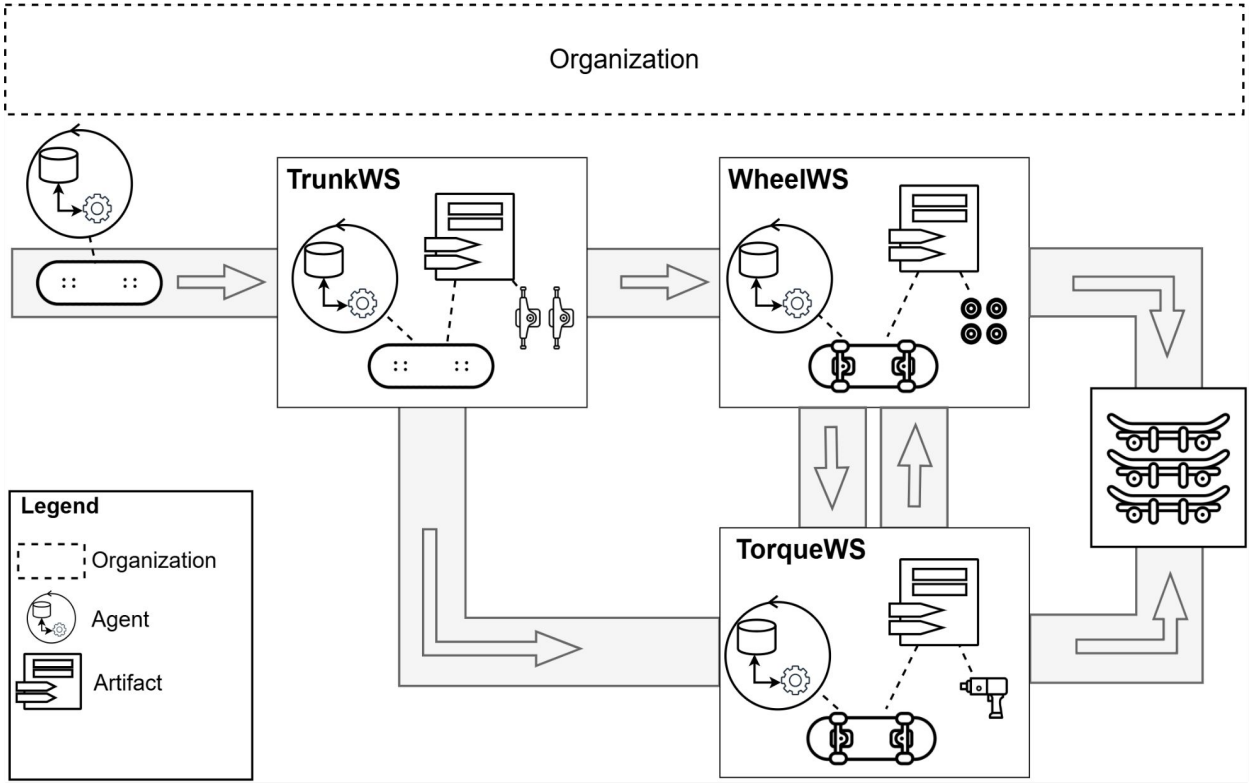


Pynadath, D. V., Tambe, M., Chauvat, N., and Cavedon, L. (1999). Toward team-oriented programming. In Jennings, N. R. and Lespérance, Y., editors, Intelligent Agents VI, Agent Theories, Architectures, and Languages (ATAL), Proceedings, volume 1757 of Lecture Notes in Computer Science, pages 233–247. Springer.

Multi-Agent Oriented Programming (MAOP) Design

Interaction Dimension

direct and indirect interactions among all dimensions

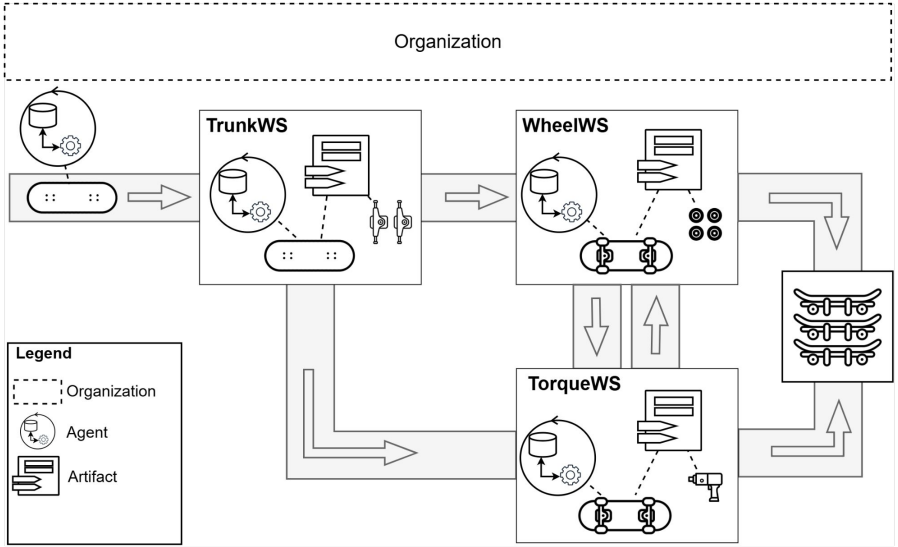


Huhns, M. N. (2001). Interaction-oriented programming. In Ciancarini, P. and Wooldridge, M. J., editors, Agent-Oriented Software Engineering, First International Workshop, AOSE 2000, Limerick, Ireland, June 10, 2000, Revised Papers, volume 1957 of Lecture Notes in Computer Science, pages 29–44. Springer.

Regulation Management

Regulation representation

- constitutive norms
- **regulative norms**
- sanction rules

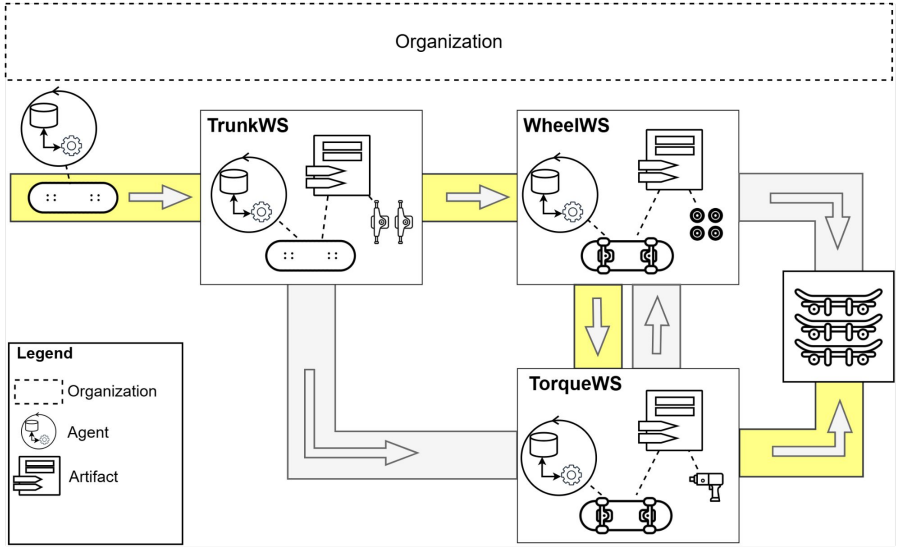


Id	Condition	Consequence
R1	order_received(SID) ∧ ¬trunk_installed(SID)	**Obligation**(SkHandler, trunk_installed(SID))
R2	trunk_installed(SID) ∧ ¬wheel_assembled(SID)	**Obligation**(SkHandler, wheel_assembled(SID))
R3	wheel_assembled(SID) ∧ ¬trunk_torqued(SID)	**Obligation**(SkHandler, trunk_torqued(SID))

Regulation Management

Regulation management capability

- **regiment**
- **enforce**
- adapt



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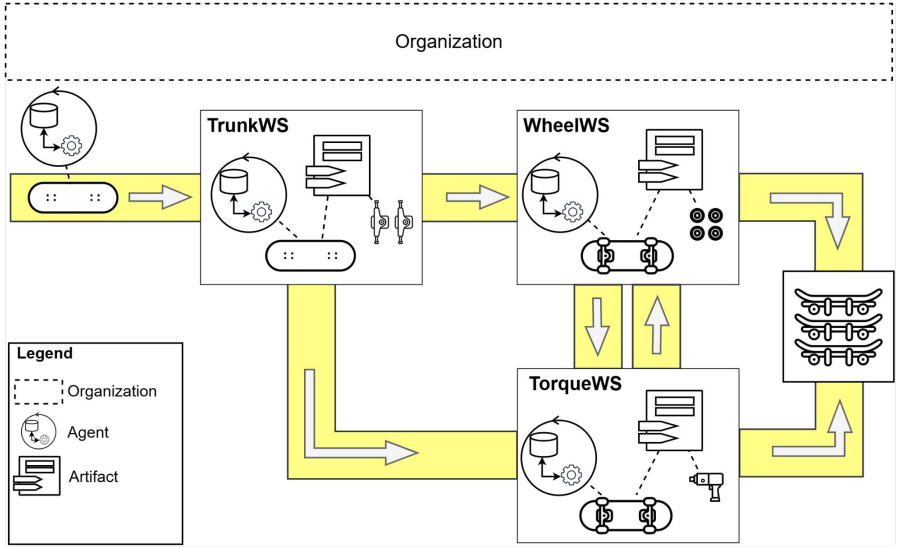
Regulation Management

Regulation management capability

- regiment
- enforce
- **adapt**



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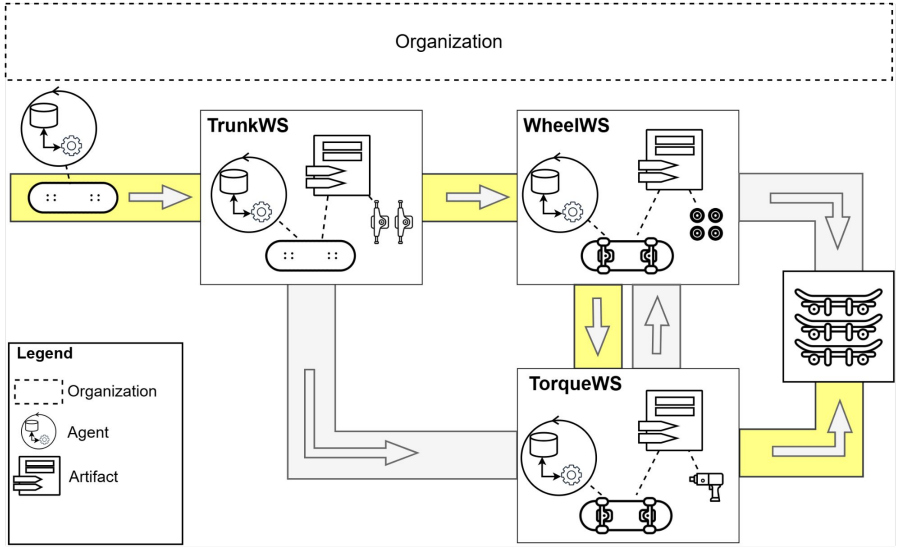
Regulation Adaptation

Adapt capability

- detect
- design
- execute



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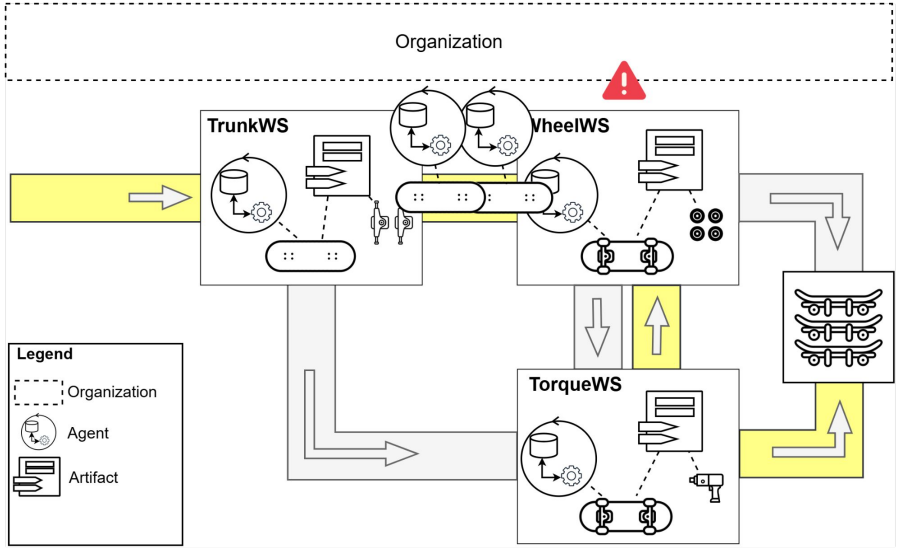
Yan, E., Nardin, L. G., Boissier, O., and Sichman, J. S. (2025). A Regulation Adaptation Model for Multi-Agent Systems. In 28th European Conference on Artificial Intelligence (Accepted)

Regulation Adaptation

Adapt capability

- **detect**
- design
- execute



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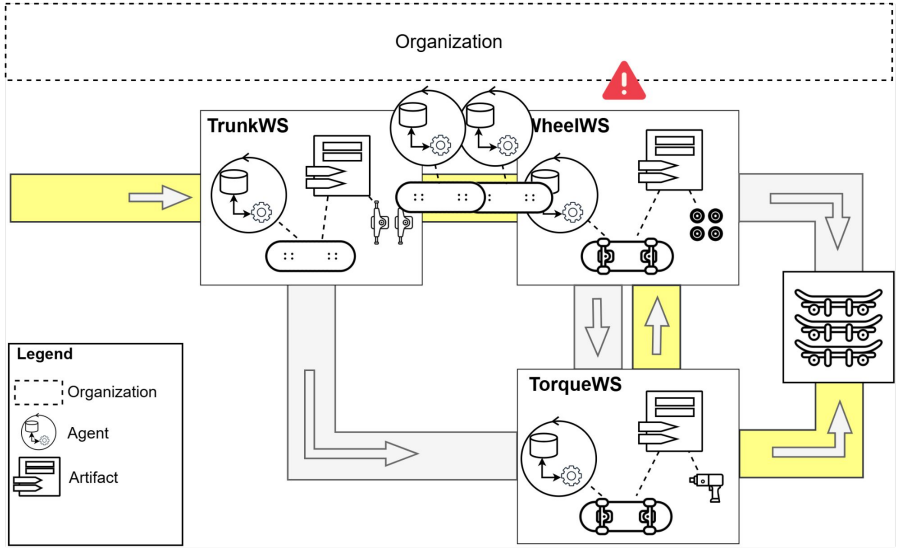
Regulation Adaptation

Adapt capability

- detect
- **design**
- execute



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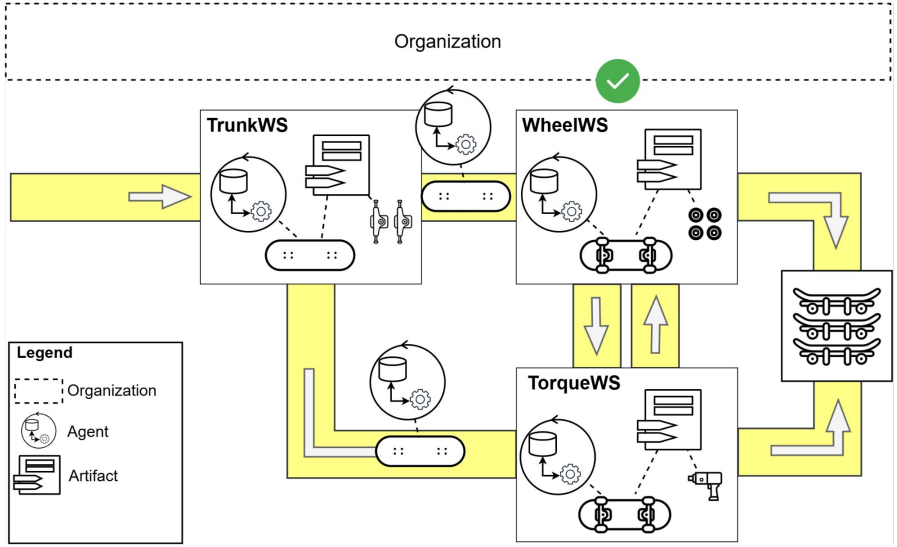
Regulation Adaptation

Adapt capability

- detect
- design
- **execute**



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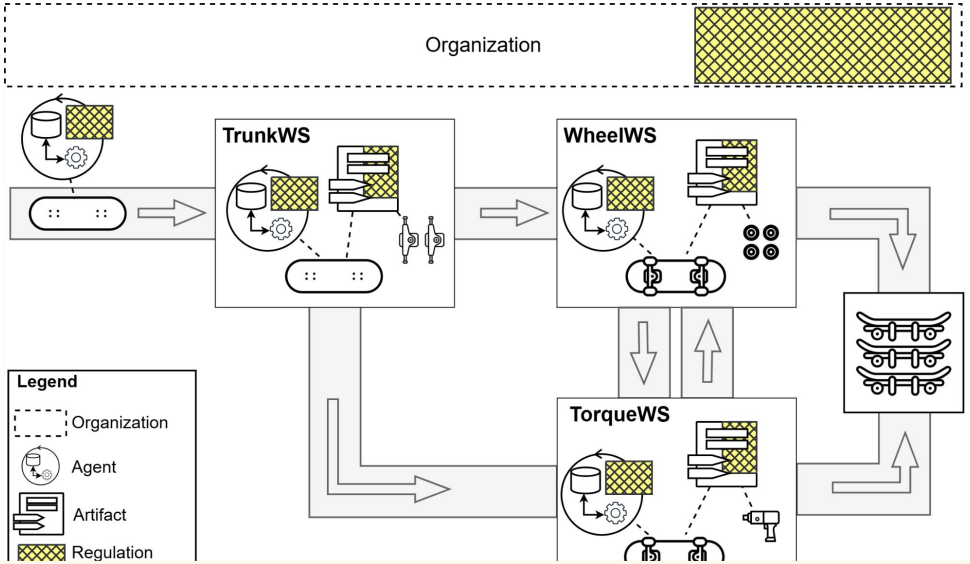
MAOP Dimensions Perspective on Regulation Adaptation

Regulation adaptation can be realized with **abstractions** and **mechanisms** of the MAOP dimensions , originating:

- agent-centric
- environment-centric
- interaction-centric
- organization-centric
- hybrid-centric

regulation adaptation



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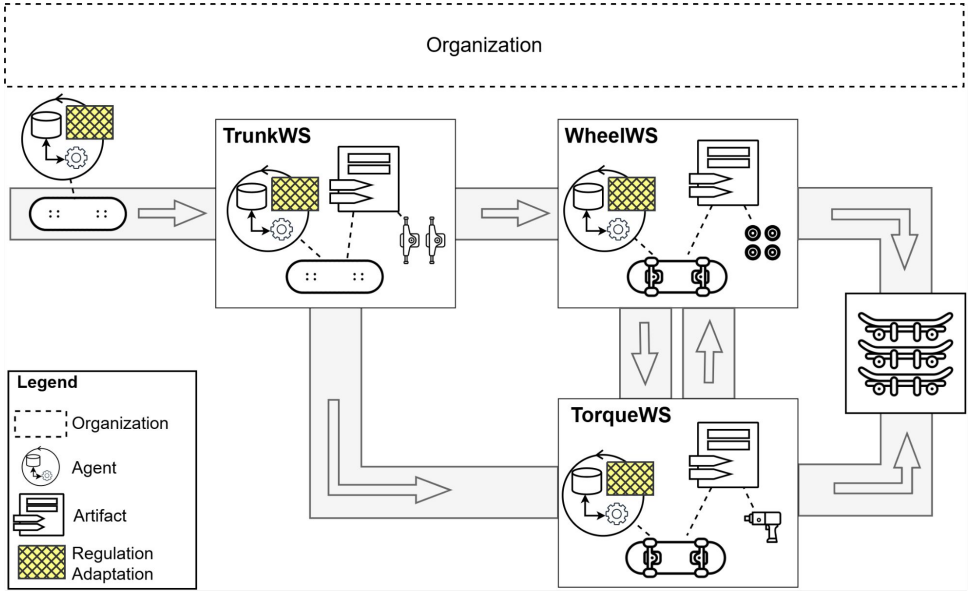
Agent-Centric Regulation Adaptation

- Regulation representation
- Adapt capability (detect, design, execute)

} **Agent Dimension**
(e.g., beliefs, plans, goals)

✔ fast and localized

✗ inconsistency

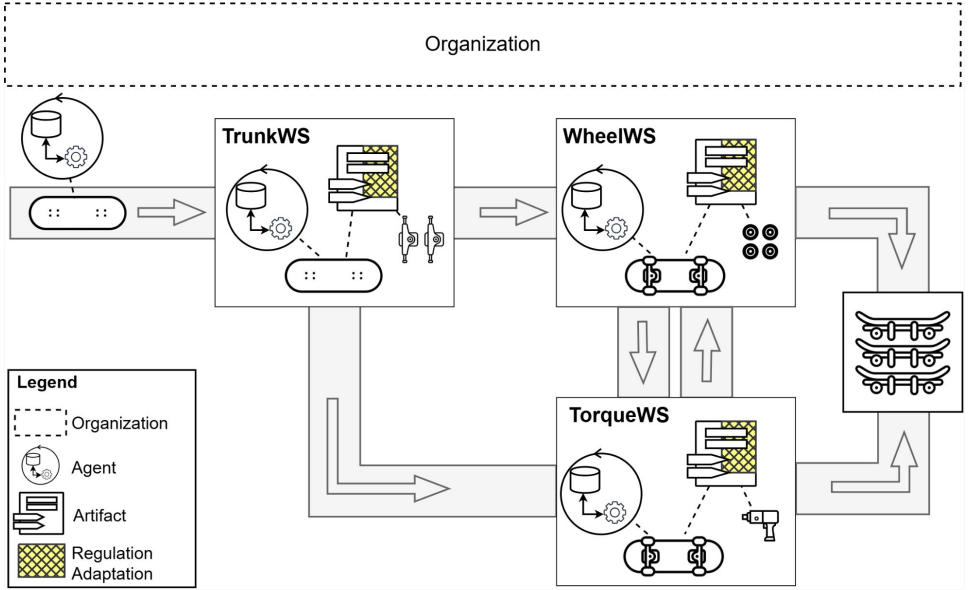


Environment-Centric Regulation Adaptation

- Regulation representation
- Adapt capability (detect, design, execute)

} **Environment Dimension**
(e.g., properties, operations)

✔ embedded and automated
✗ no decision

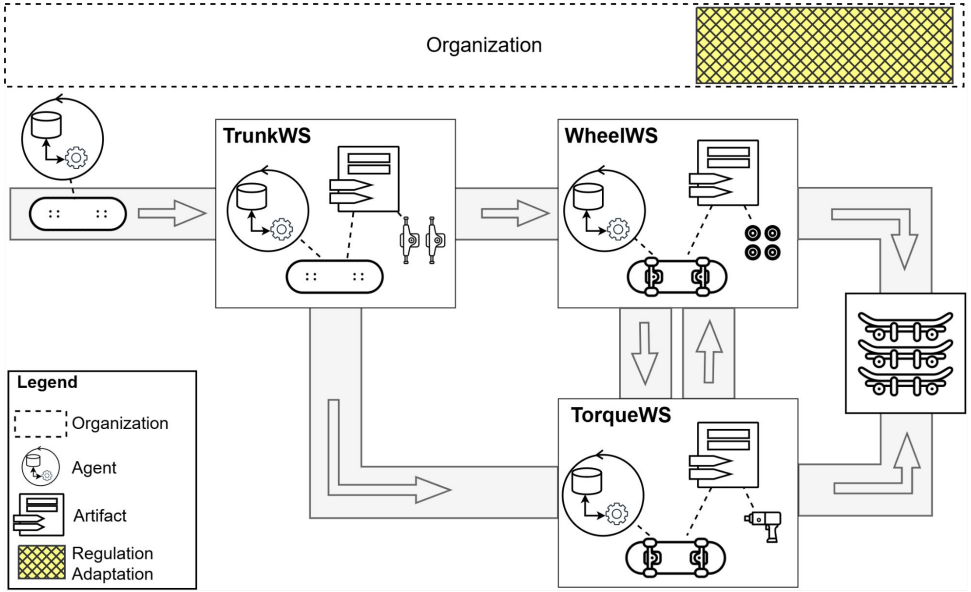


Organization-Centric Regulation Adaptation

- Regulation representation
- Adapt capability (detect, design, execute)

} **Organization Dimension**
(e.g., norms, roles, groups)

✔ global coordination
✗ lacks flexibility



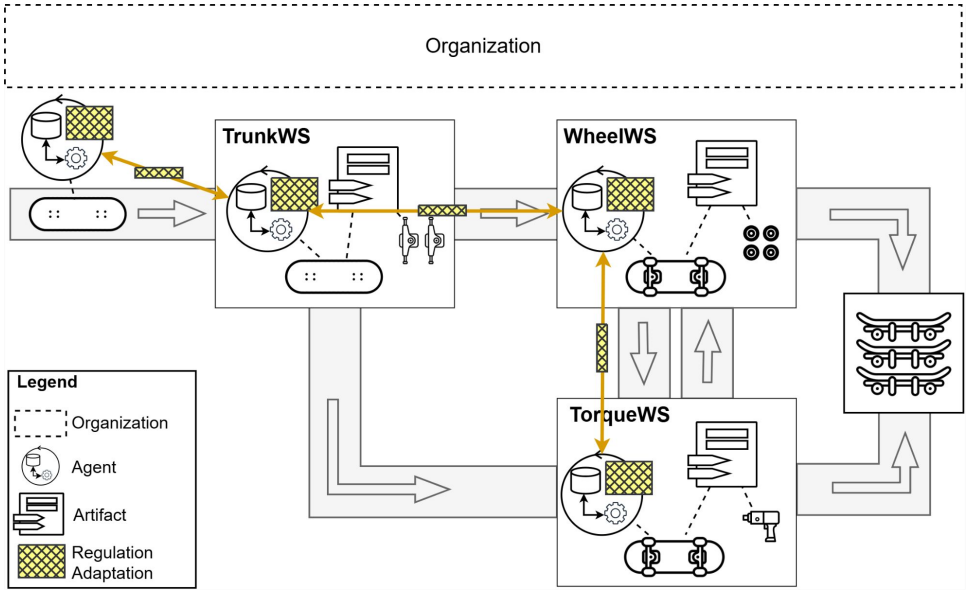
Hybrid Agent- and Interaction-Centric Regulation Adaptation

- Regulation representation
- Adapt capability
  - detect → agent
  - design → agent
  - execute → agent/interaction

} Agent and Interaction Dimensions

✔ flexibility and alignment

✗ overhead



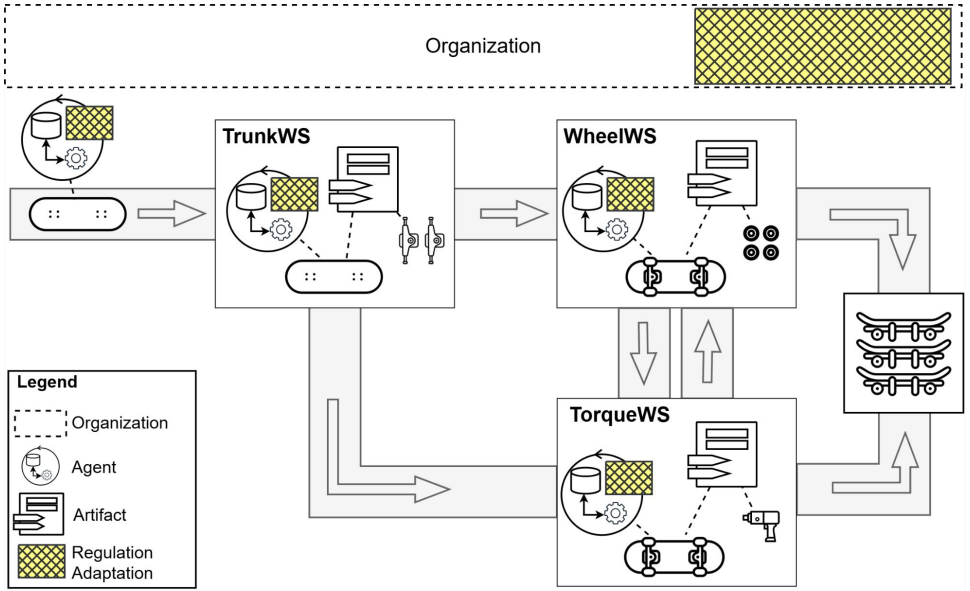
Hybrid Agent- and Organization-Centric Regulation Adaptation

- Regulation representation
- Adapt capability
  - detect → agent
  - design → agent
  - execute → agent/organization

} Agent and Organization Dimensions

✔ balance global and local adaptation

✗ complexity



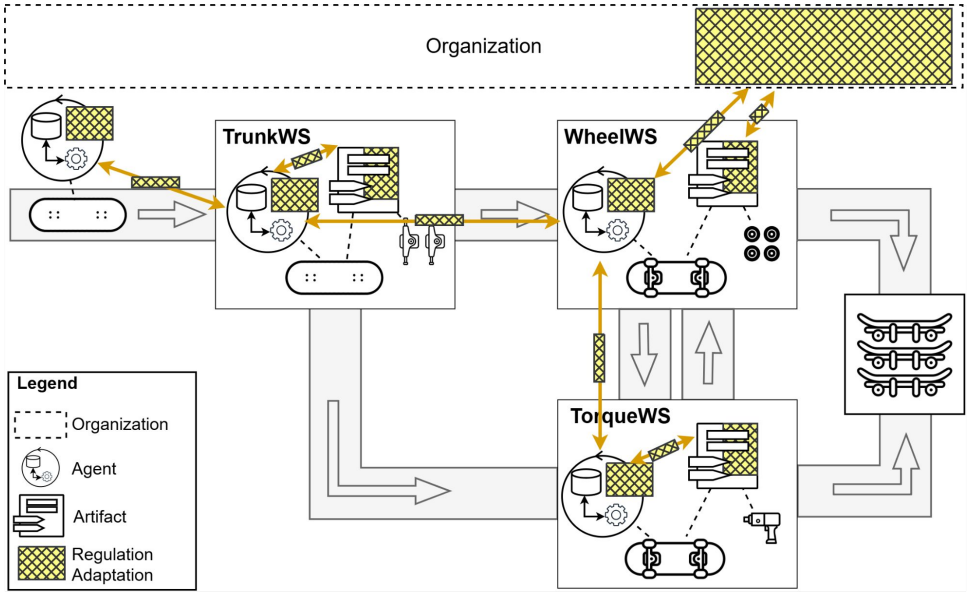
Hybrid Agent-, Environment-, Interaction- and Organization-Centric Regulation Adaptation

- Regulation representation
- Adapt capability
  - detect → environment
  - design → agent
  - execute → agent/interaction/ organization

Agent/Environment/Interaction/Organization Dimensions

✔ balance global, local, automated, and alignment

✗ complexity



Conclusion and Future Work

Perspectives on Regulation Adaptation		
agent-centric	✔ fast and localized	✗ inconsistency
environment-centric	✔ embedded and automated	✗ no decision
interaction-centric	✔ coordination and alignment	✗ overhead
organization-centric	✔ global coordination	✗ inflexible
hybrid-centric	✔ combines benefits of multiple perspectives	✗ complexity

Future work: adaptation of the regulation architecture, by switching from one perspective to another

Thank you for your attention!

Perspectives on Regulation Adaptation in Multi-Agent Systems: from Agent to Organization Centric and Beyond

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