A Regulation Adaptation Model for Multi-Agent Systems

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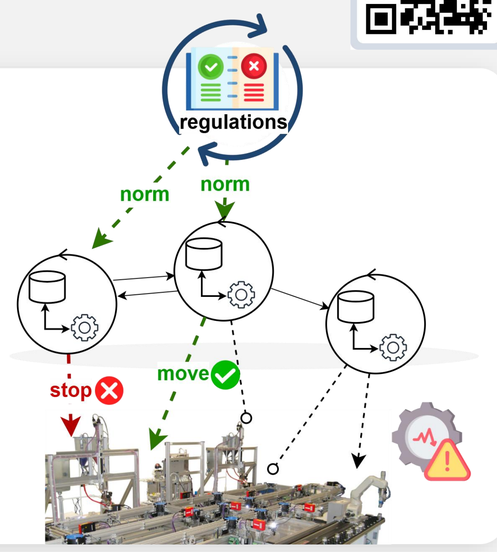
Paper

I. Motivation & Objective

The autonomous behaviors of agents can lead the Multi-Agent System (MAS) to undesirable states
→ **Regulations** can be used in the normative MAS to guide agents towards the overall objectives, while maintaining agents' autonomy

In open and dynamic environments (e.g., industry), the ability of the agents in the MAS to **adapt** regulations at runtime becomes crucial

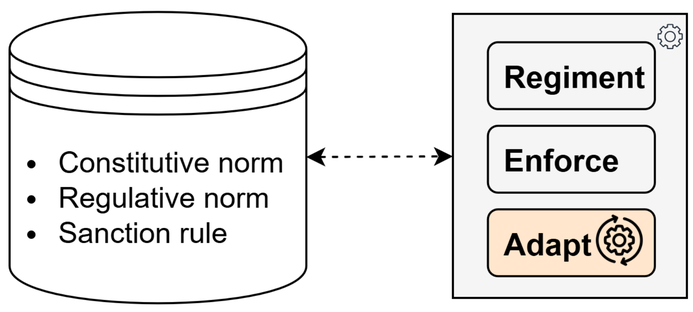
Objective: Design a *regulation adaptation model* for normative MAS



II. Core Elements of Regulation Management

Regulation Representation

Regulation Capability



III. Core Elements of Regulation Adaptation

Regulation Adaptation Representation

detect-fact *design-fact* *execute-fact*

Regulation Adaptation Capability

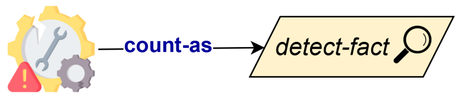
Detect **Design** **Execute**

IV. Regulation Adaptation Process

Use the same regulation management concepts and engine for enabling regulation adaptation

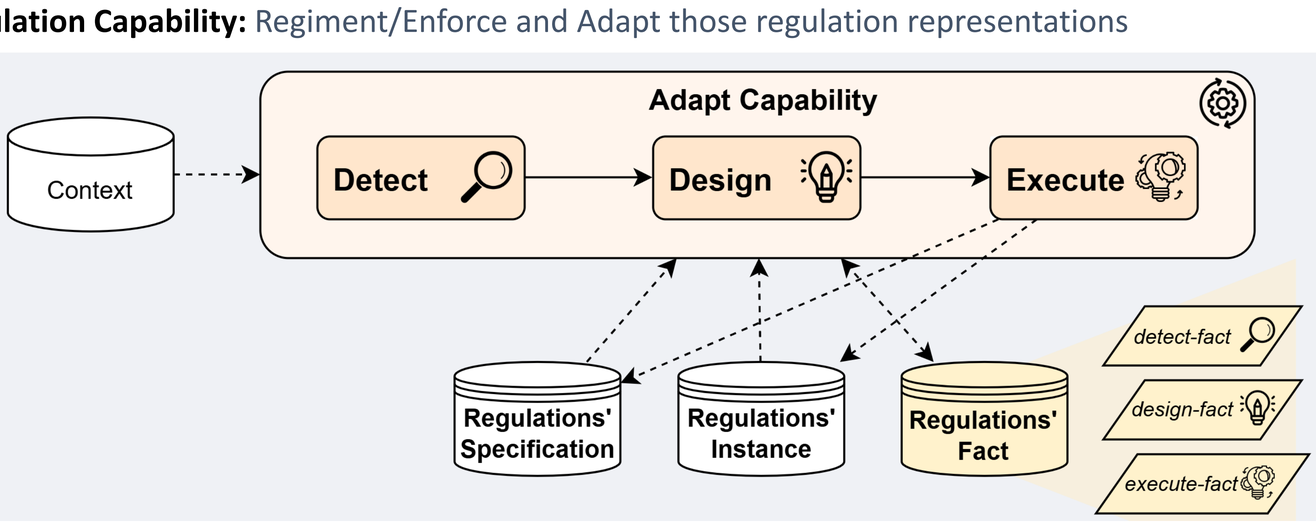
→ **Regulation Representation:**

Constitutive norms



Regulative norms

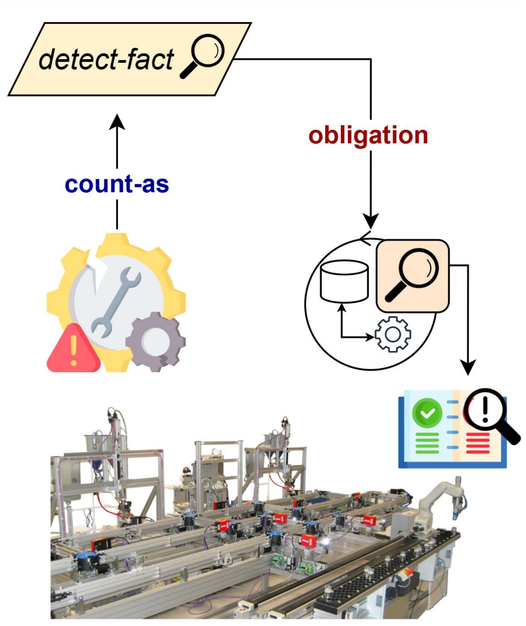
→ **Regulation Capability:** Regiment/Enforce and Adapt those regulation representations



Example

When a *failure* occurs, it **counts-as** a *detect-fact.*

This creates an **obligation** for *alice* to achieve the *detect-goal.*

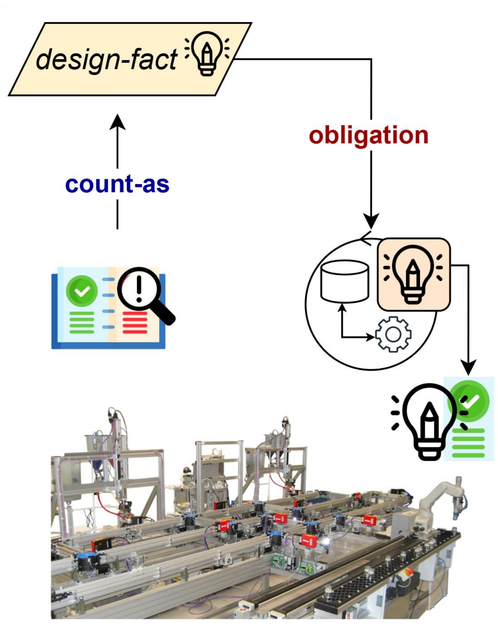


failure **count-as** *detect-fact*

detect-fact → **obligation**(alice, detect-goal)

When a regulation is *detected* to adapt, it **counts-as** a *design-fact.*

This creates an **obligation** for *bob* to achieve the *design-goal.*

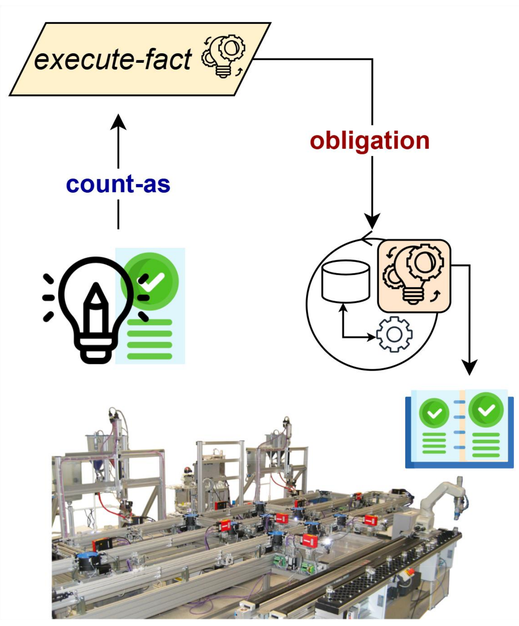


detected **count-as** *design-fact*

design-fact → **obligation**(bob, design-goal)

When a regulation is *designed*, it **counts-as** an *execute-fact.*

This creates an **obligation** for *carlos* to achieve the *execute-goal.*



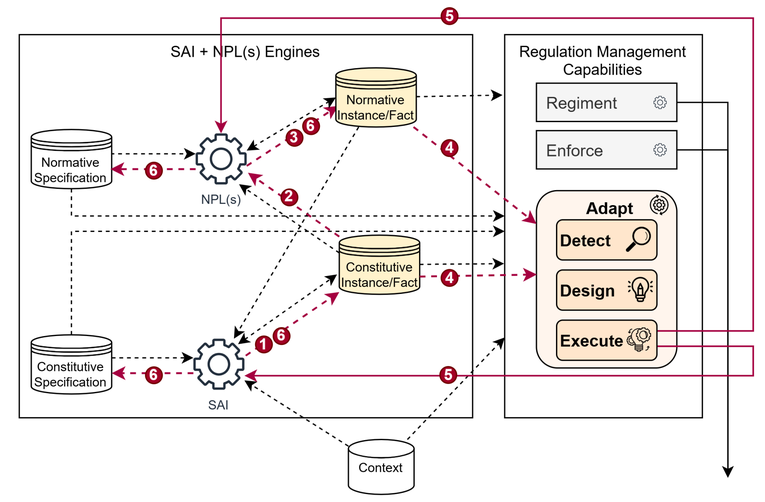
designed **count-as** *execute-fact*

execute-fact → **obligation**(carlos, execute-goal)

V. Prototype Implementation

Regulation Engines

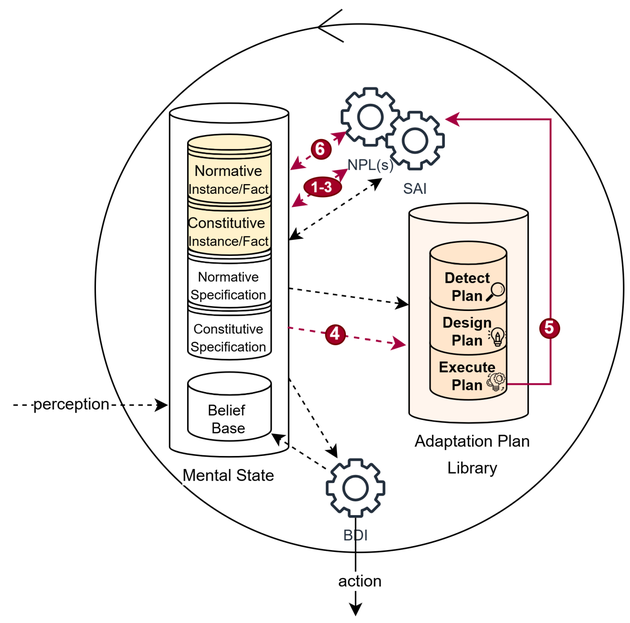
- Situated Artificial Institutions **SAI** [2] for programming constitutive norms
- Normative Programming Language **NPL(s)** [3] for programming regulative norms and sanction rules



1. SAI creates the adaptation facts according to the specification and the context information
2. The adaptation facts are used by NPL(s)
3. NPL(s) creates the normative instance and facts (e.g., obligation) according to the specification and the context information
4. These normative facts trigger the adaptation capability
5. The execute sub-capability applies the adaptation by actions such as create, modify, or remove regulations in SAI or NPL(s) engines
6. SAI or NPL(s) applies the adaptation in the respective constitutive or normative specification or instance

Agent-Centric Regulation Adaptation

BDI agent architecture in JaCaMo [1] integrated with SAI and NPL(s) engines and the adaptation capability



Regulation Representation → Agent's beliefs
Regulation Capability → Agent's plans

VI. Conclusions and Perspectives

Regulations can be used to represent and govern agents in the *regulation adaptation process*

→ If the system provides representations of the *process* and *architecture* (e.g., agent-centric or organization-centric), then these regulation management aspects can be adapted

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[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.
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