An Agent-Centric Perspective on Norm Enforcement and Sanctions

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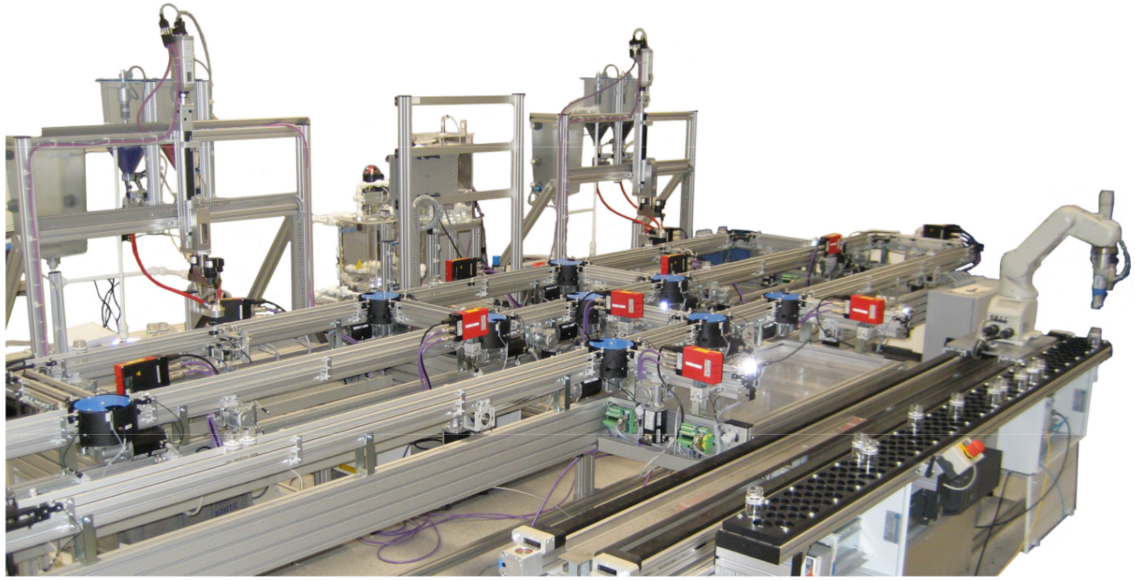
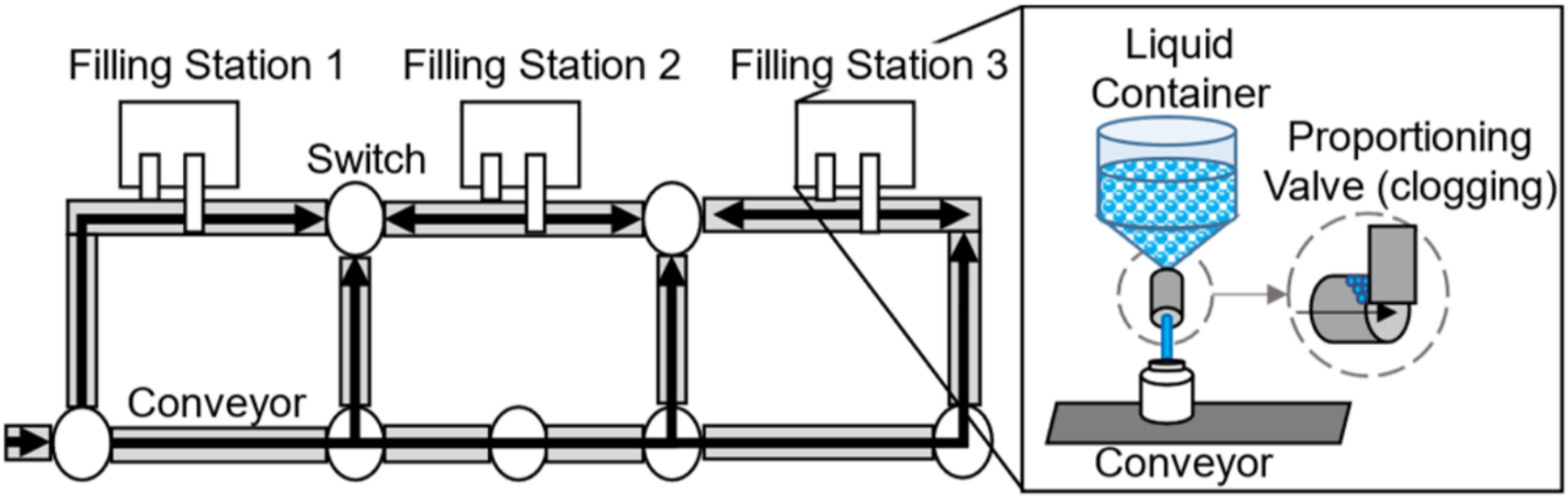
WOA 2024, July 9, 2024

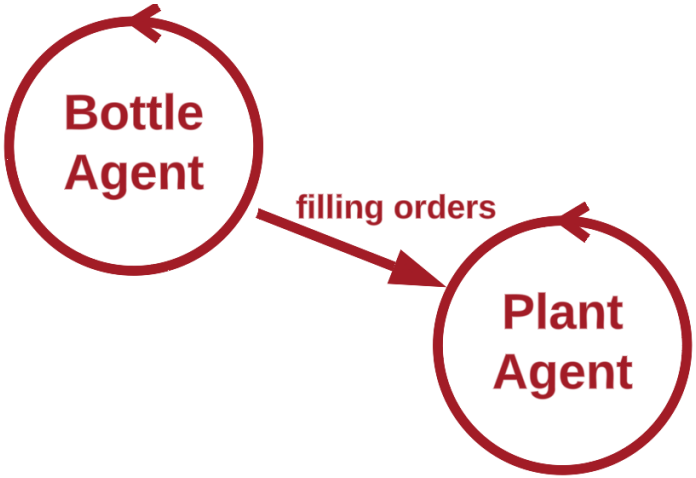
Next in Line...

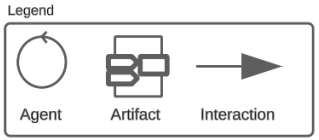
Case Study: Laboratory Plant *myJoghurt*

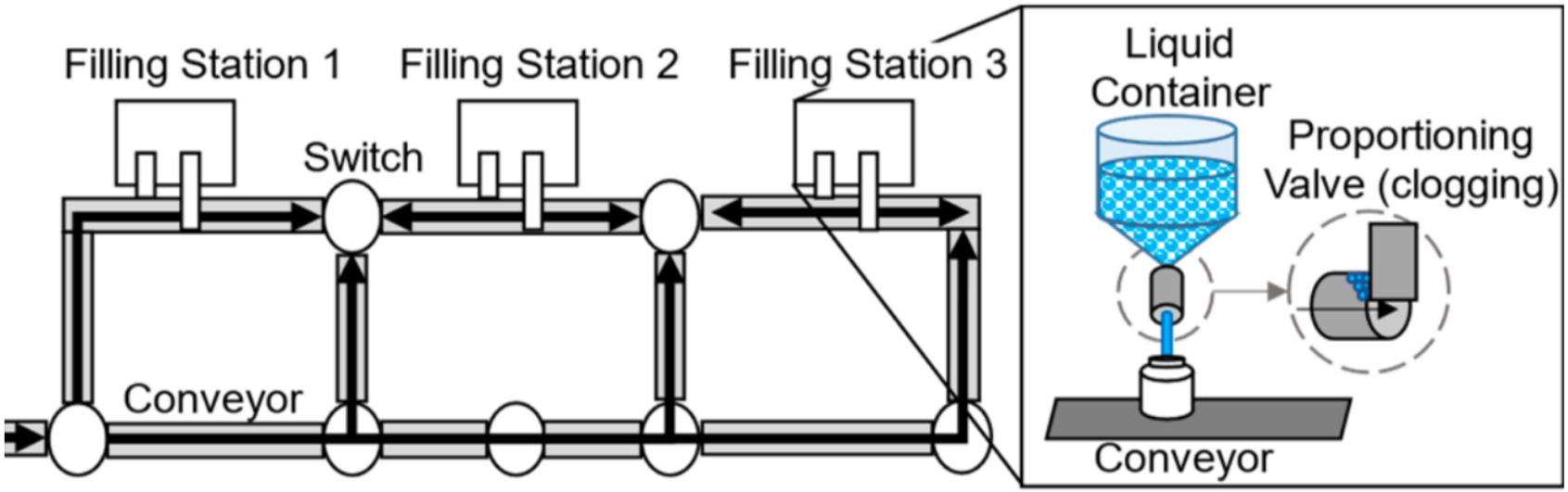




Case Study: A MAOP Design & Programming







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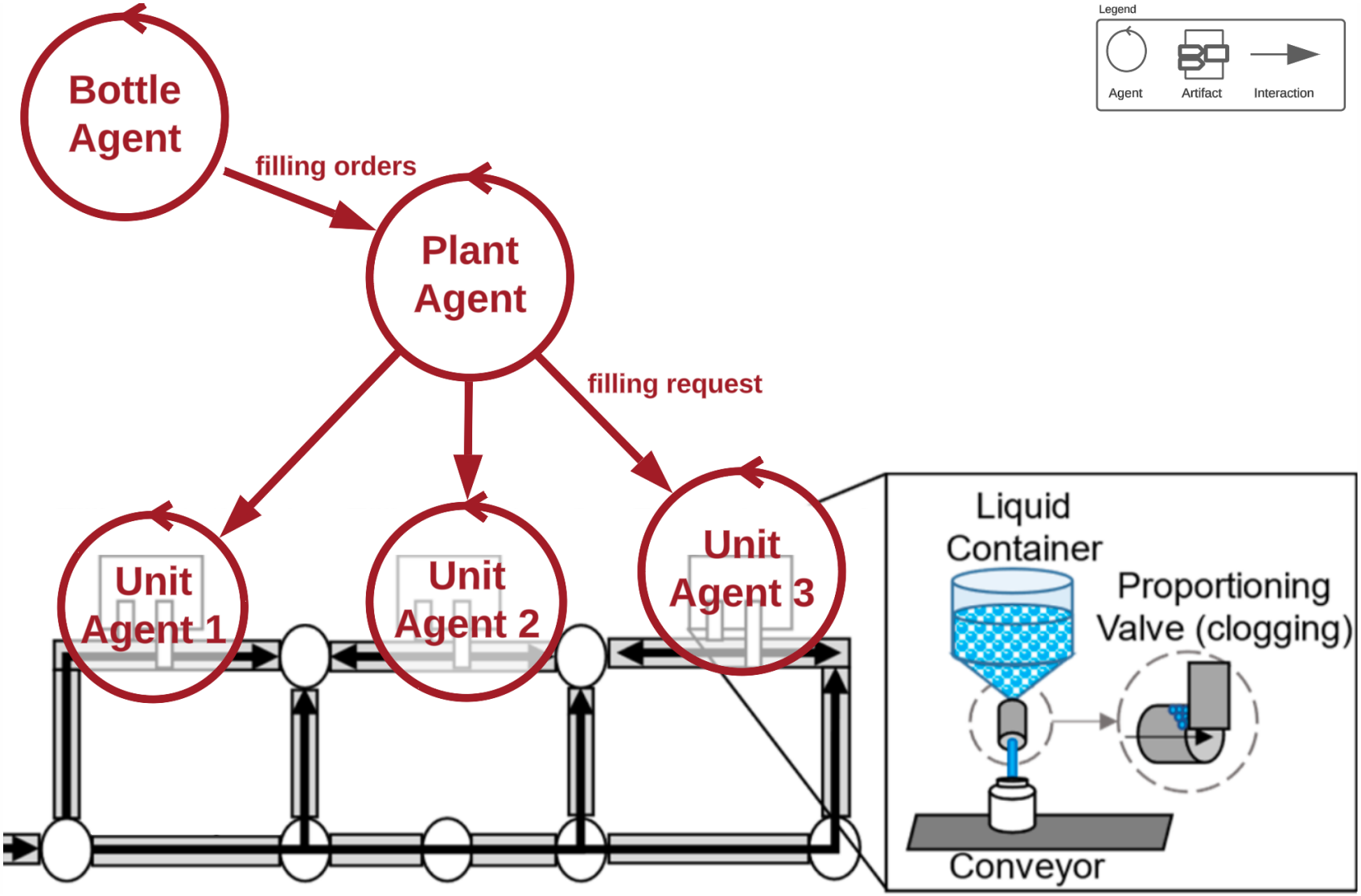

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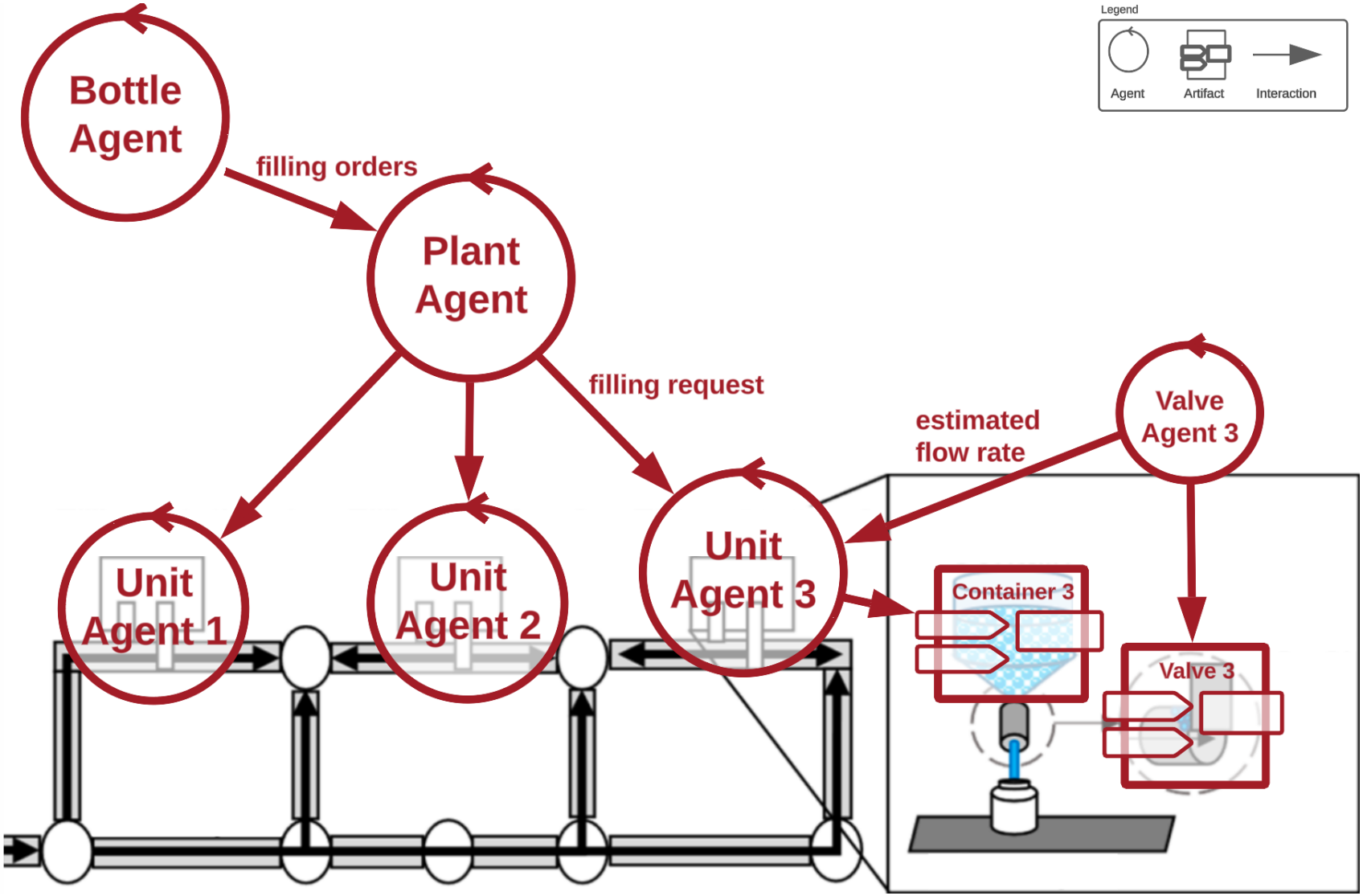

Problems and Objective

Problems:

- the system is *dynamic* and complex (e.g., duration and degree of the clogging are *non-deterministic*, and *hardly measurable*)
- lots of manual interventions are required in a *hard-coded* solution

Problems and Objective

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The objective is:

- to allow flexibility and **adaptation** in decision-making by autonomous agents
- while monitoring and **controlling** their behavior at runtime

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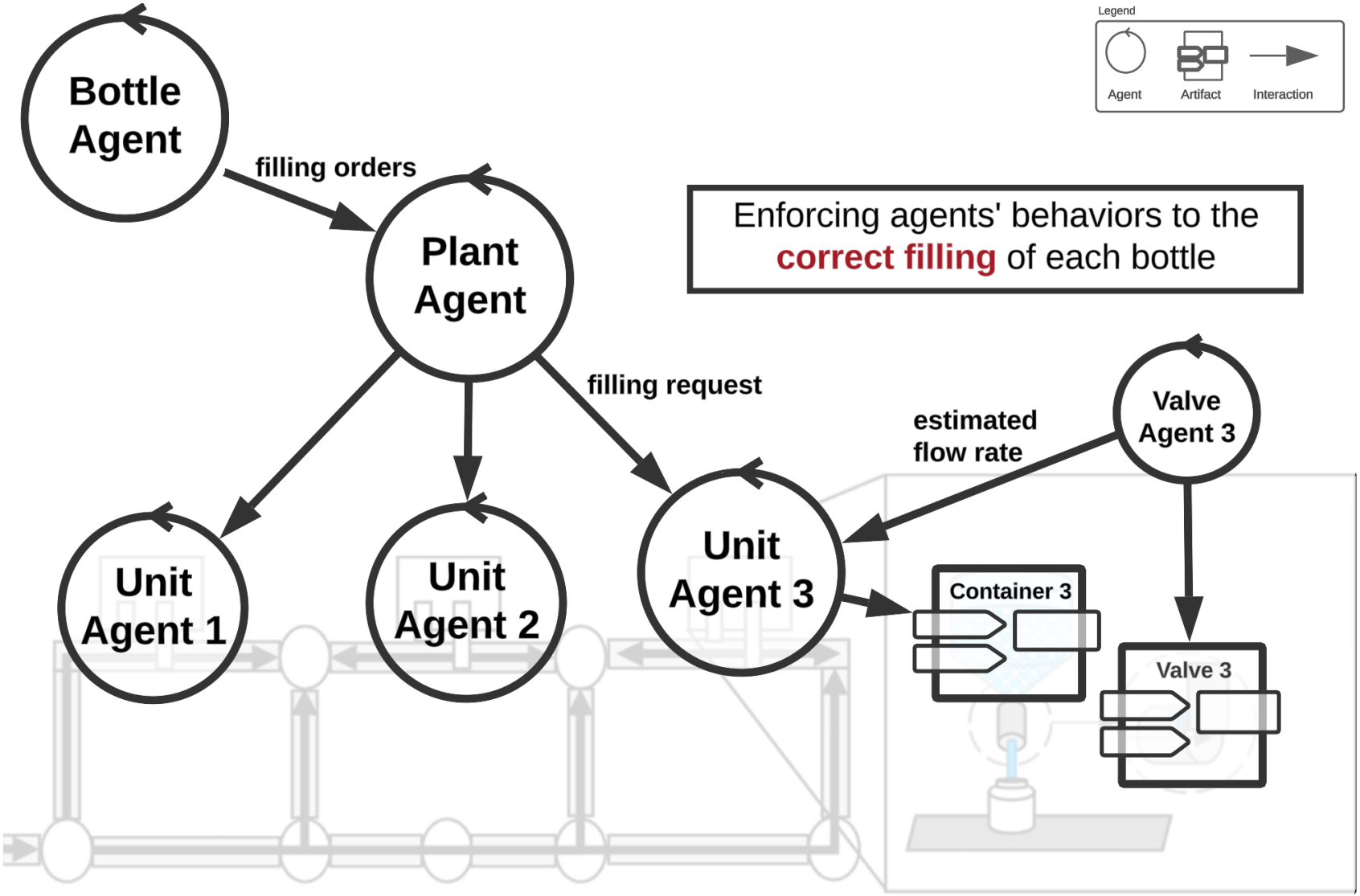
→ A solution is to have **self-regulation**!

Case Study: How can we regulate the system?



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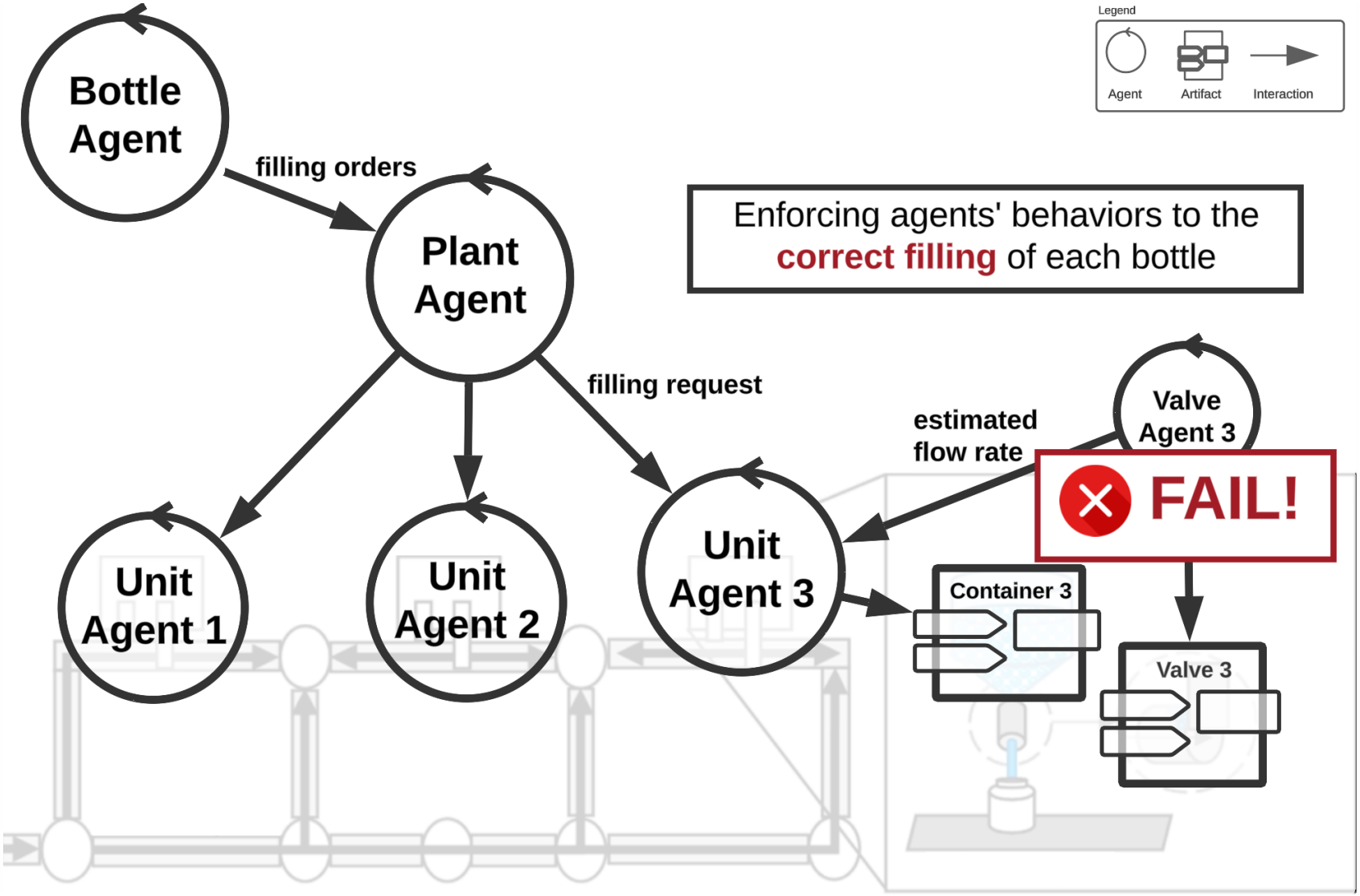

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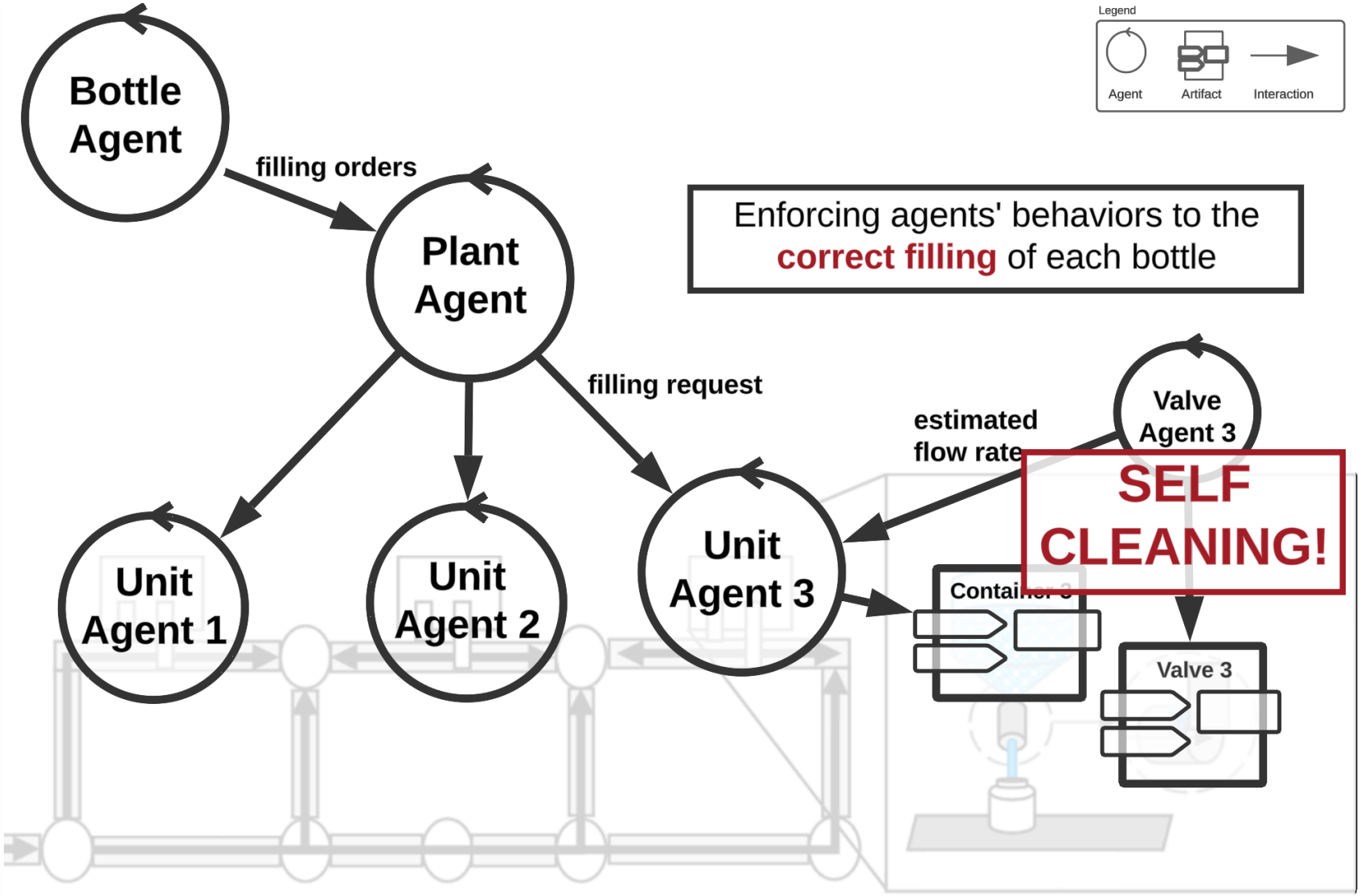

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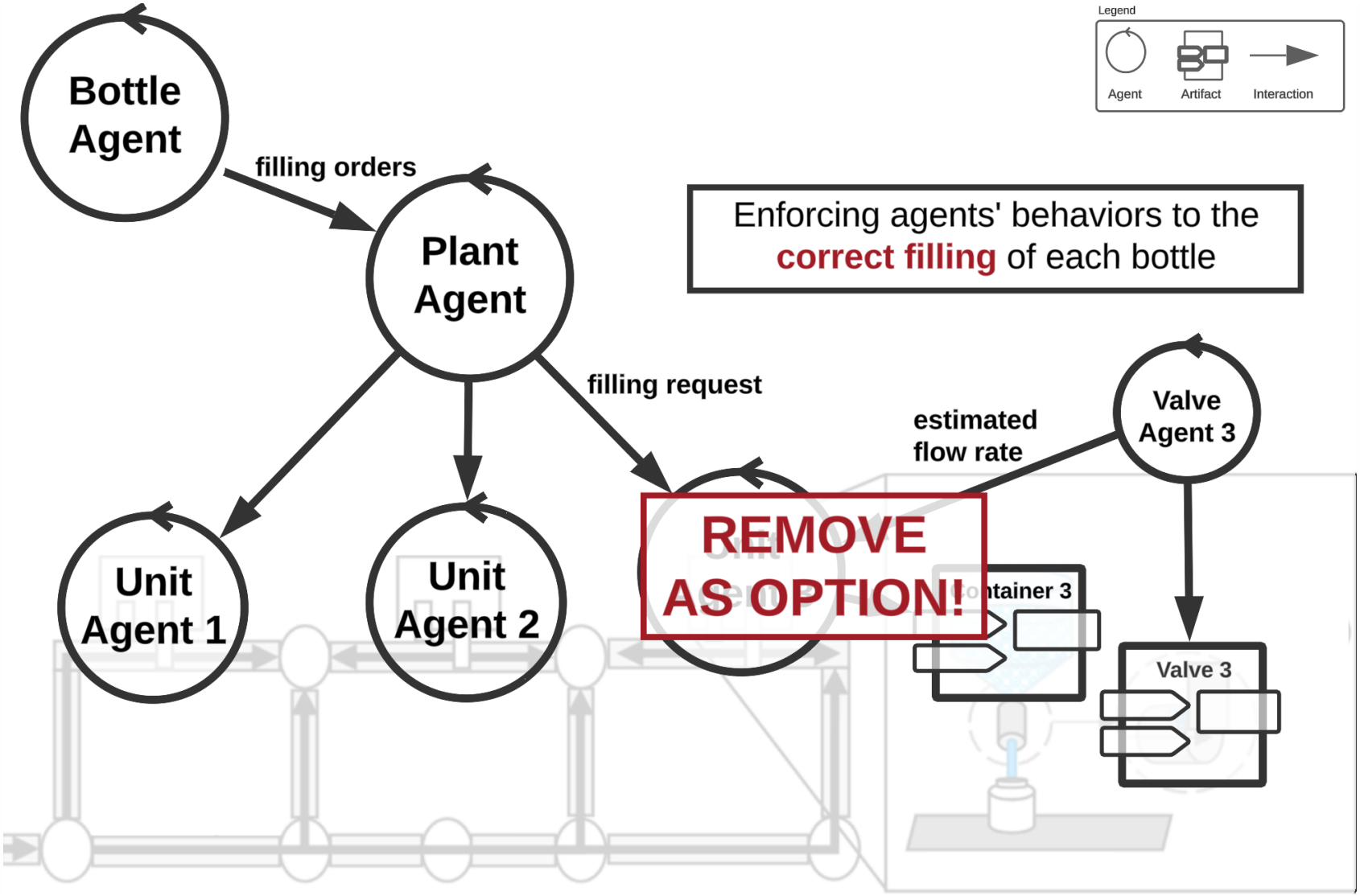


Next in Line...

Research Questions

Our objective is to maintain a balance between agents' autonomy and system regulation.

Research Questions

1. How to express agent's expected behaviors and enforced behaviors?
2. How to enforce agents' expected behaviors?

State of the Art

1. How to express agent's expected behaviors and enforced behaviors?

Language	Expected behaviors	Enforced behaviors
NPL, 2011	**obligations, permissions, prohibitions**	-
NoA, 2002	obligations, permissions, prohibitions	-
N-2APL, 2012	obligations and prohibitions	**sanction**

Extend NPL to NPL(s) with sanctions as a first-class abstraction

State of the Art

2. How to enforce agents' expected behaviors?

Agent Architecture	Enforcement Mechanism
López y López et al., 2006	use secondary norms
n-BDI, 2014	always sanctions
AORTA, 2015	trigger another norm or plan
Normative MDP, 2010	inflict a cost for the violation
EMIL-I-A, 2007	**adaptive sanction**

Embed NPL(s) engine into a BDI normative agent architecture to enable agents to enforce their or the other agents' behavior

Proposed Approach

- Extend NPL to NPL(s) with sanctions as a first-class abstraction
- Embed NPL(s) engine into a BDI normative agent architecture to enable agents to enforce their or the other agents' behavior

Next in Line...

NPL

```
norm <id>
   : <when>
  -> obligation(<who>, <while>, <what>, <deadline>).
```

Example

```
norm n2
    : level(V,X,L) & .my_name(U)
    -> obligation(U, n2, update_factors(V,X,L),
        deviation_factor(X, "negative", _)).
```

NPL(s) - Sanction Rule

```
norm <id>
   : <when>
  -> obligation(<who>, <while>, <what>, <deadline>)
     [if fulfilled: <sanction-rule>*]
     [if unfulfilled: <sanction-rule>*]
     [if inactive: <sanction-rule>*]
  .
```

Example

```
norm n2
    : level(V,X,L) & .my_name(U)
    -> obligation(U, n2, update_factors(V,X,L),
        deviation_factor(X, "negative", _))
    if unfulfilled: s1(V,X), s2(V,X).
```

NPL(s) - Sanction

```
sanction-rule <id>(<args>)
    : <condition>
   -> sanction(<agent>, <description>).
```

Example (Self Cleaning)

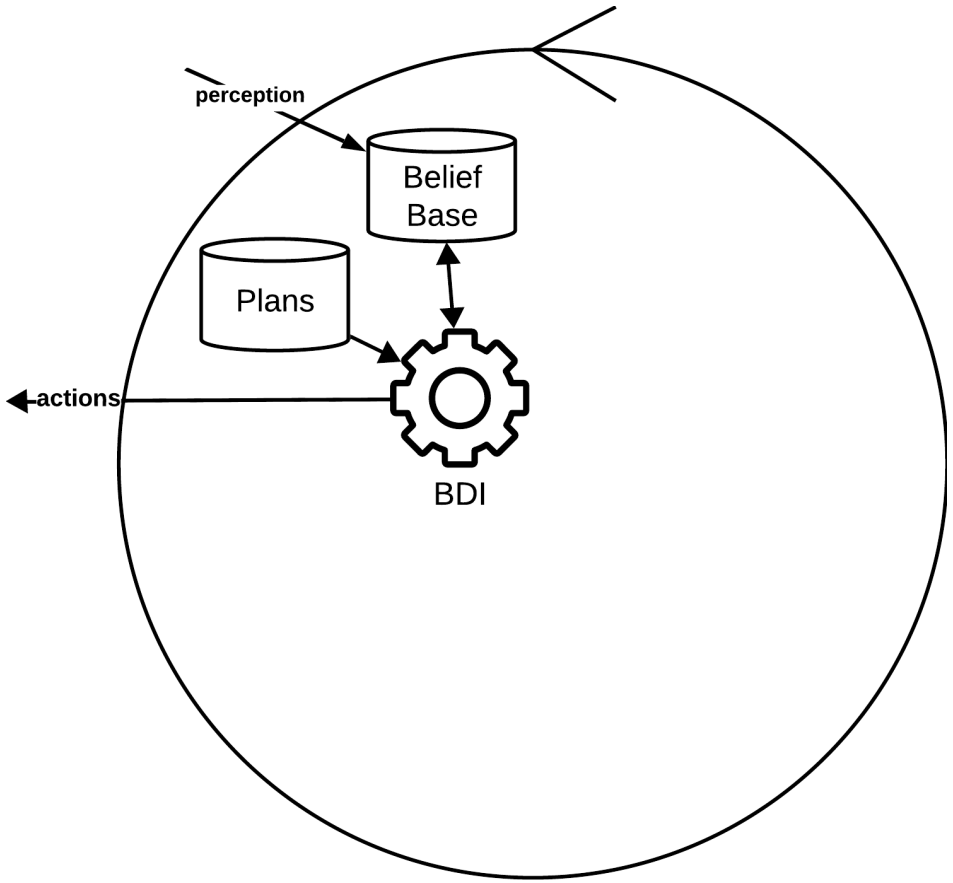
```
sanction-rule s2(V,X)
    : learning_factor(V,X,_,_,_,C) & threshold(_,T) & C>=T
    -> sanction(V, self_cleaning(X)).
```

Id	Sanctioner	Target	Sanction	Condition
S2	unit	valve	Activate the **self-cleaning** procedure	The violation occurs three consecutive times

Next in Line...

Normative Agent Architecture

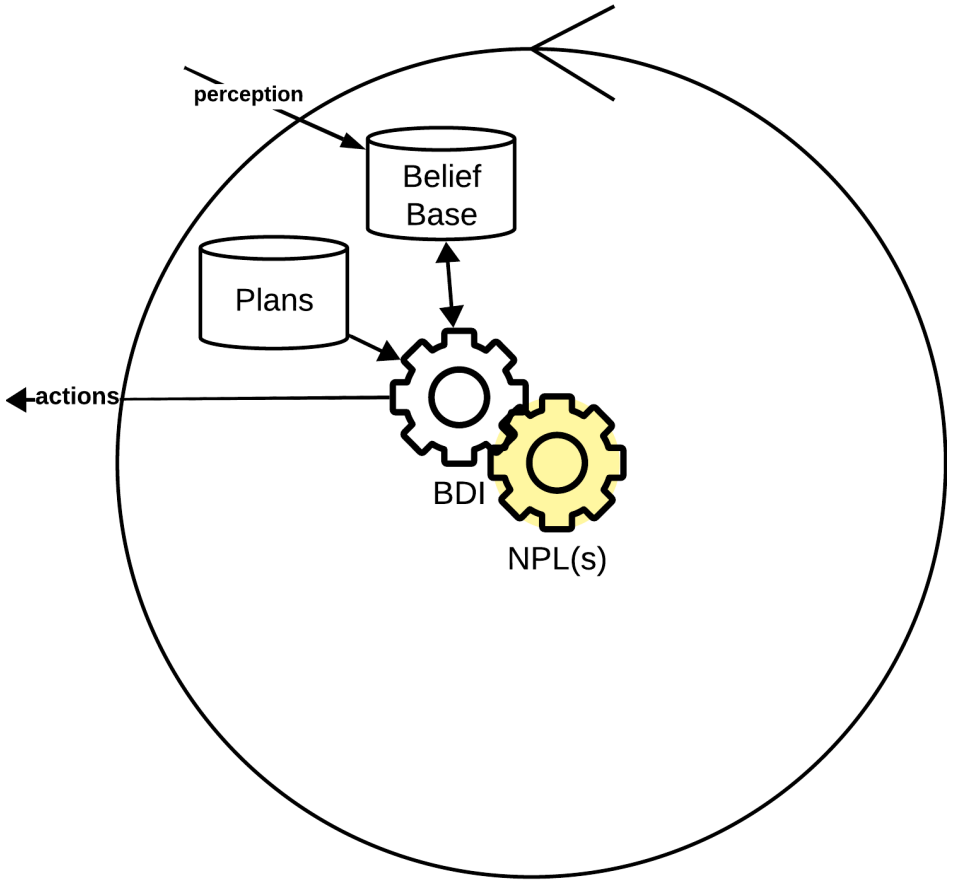
BDI JaCaMo agent architecture



Normative Agent Architecture

We extend the BDI JaCaMo agent architecture by integrating:

- **NPL(s) Engine**



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We extend the BDI JaCaMo agent architecture by integrating:

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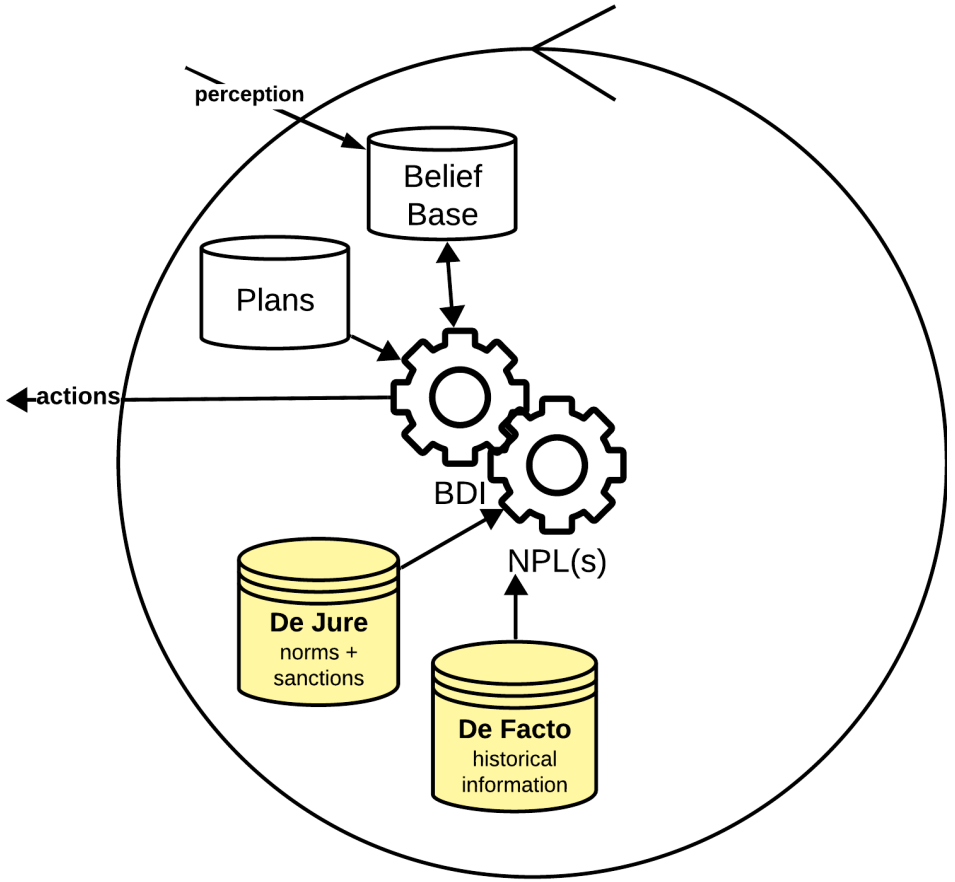
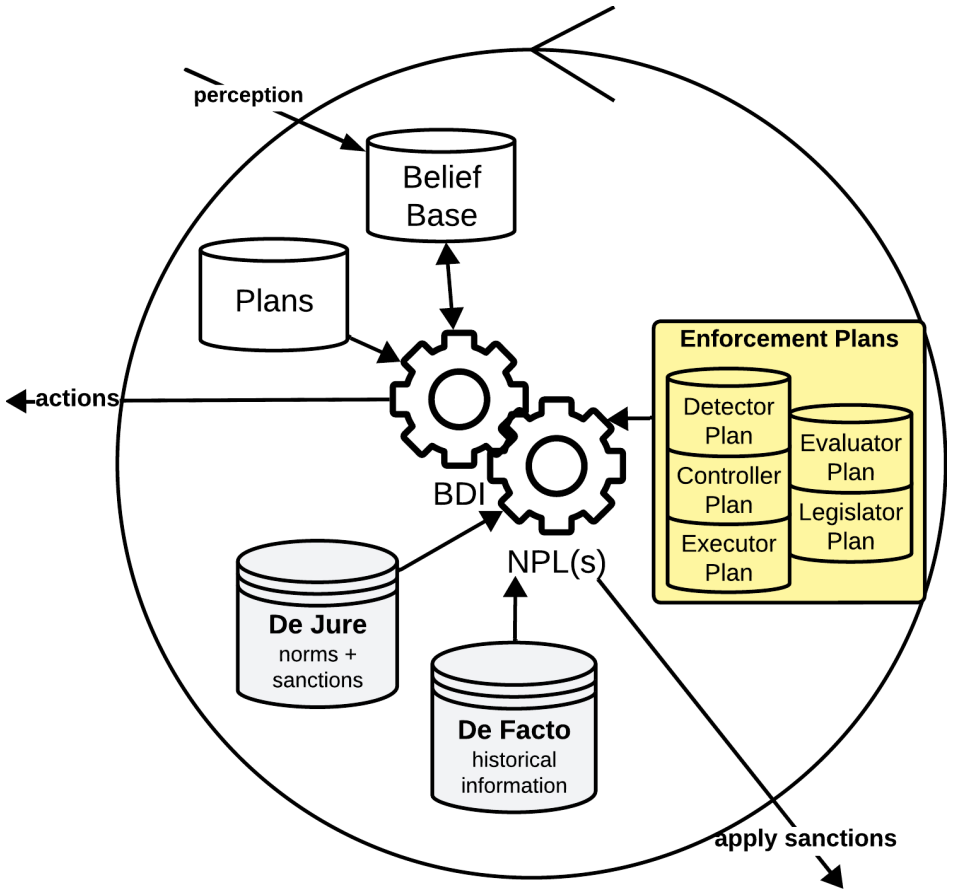
- **De Jure**
- **De Facto**

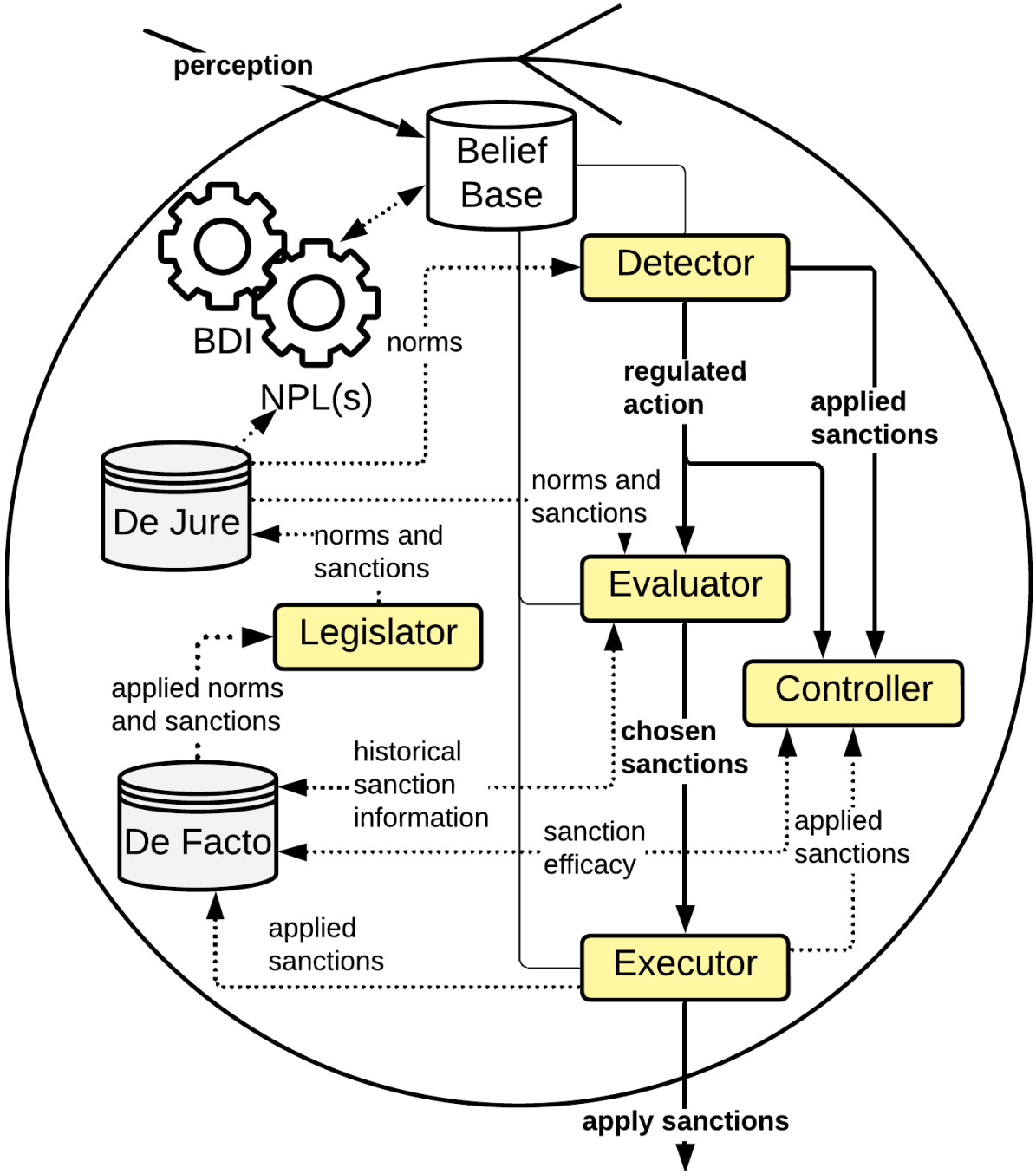


Normative Agent Architecture

We extend the BDI JaCaMo agent architecture by integrating:

- **NPL(s) Engine**
- **De Jure**
- **De Facto**
- **Enforcement Plans**:
  - Detector
  - Evaluator
  - Executor
  - Controller
  - Legislator




perception
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Detector
BDI
NPL(s)
norms
regulated action
applied sanctions
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chosen sanctions
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De Facto
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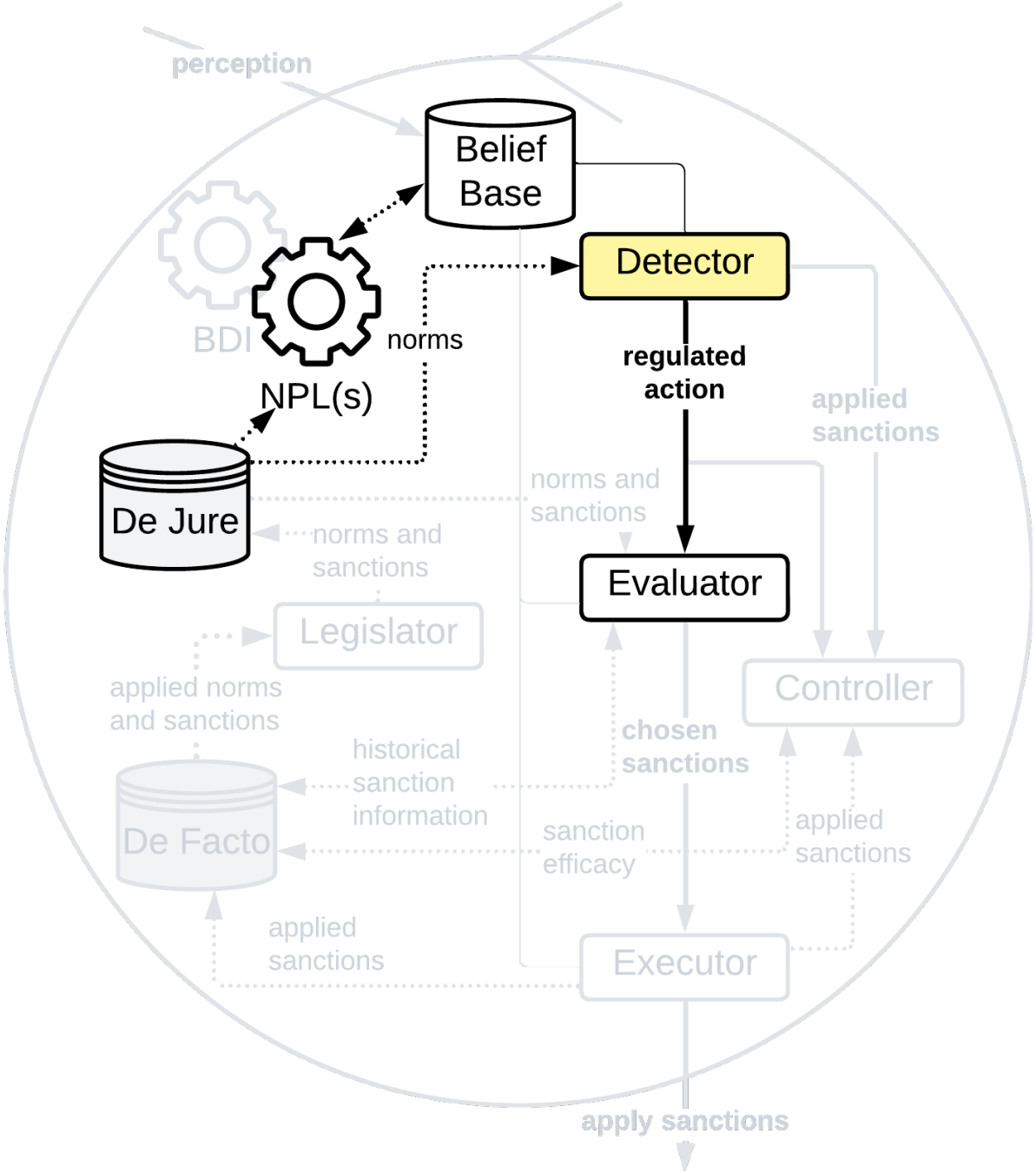
Executor
apply sanctions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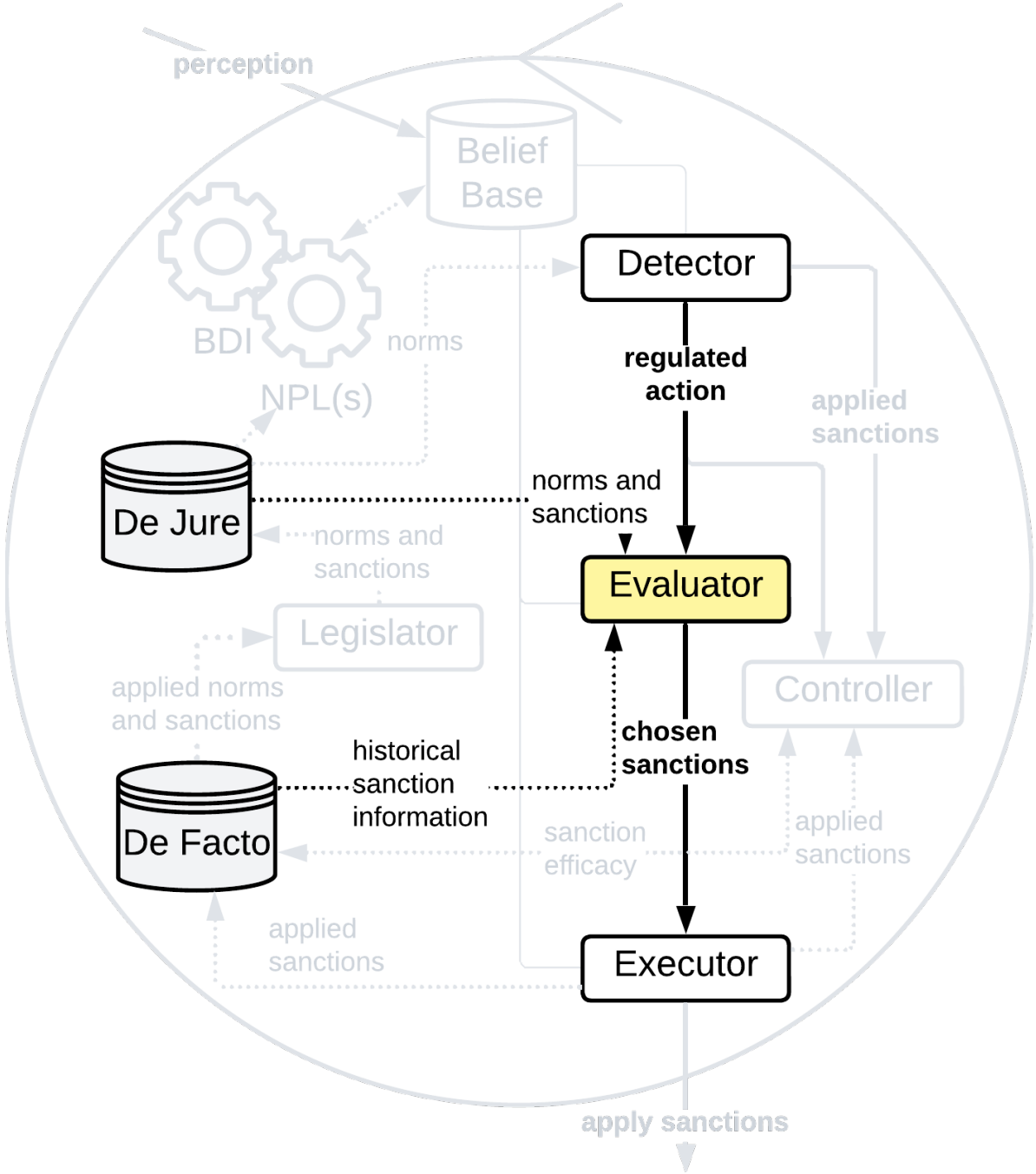
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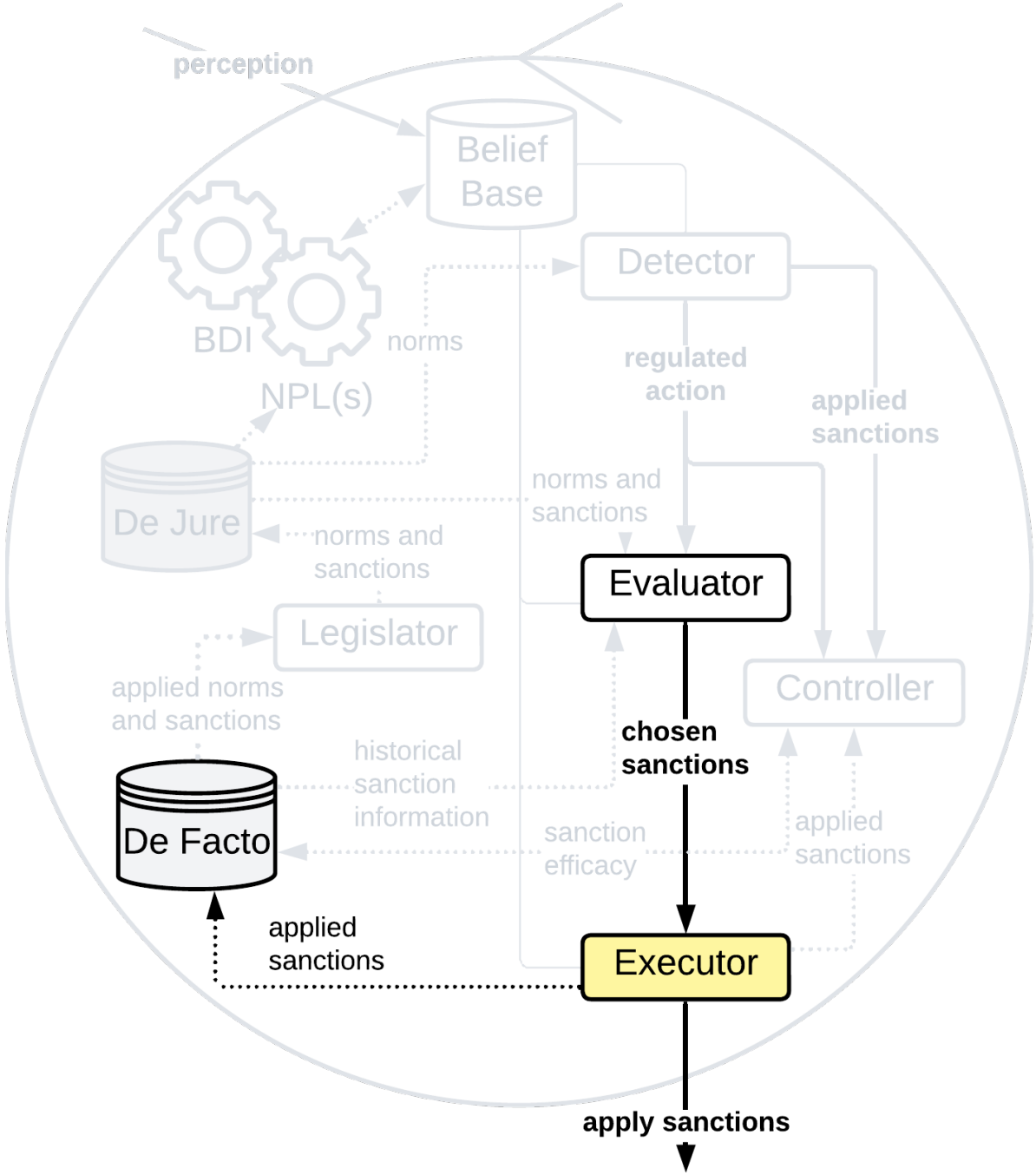
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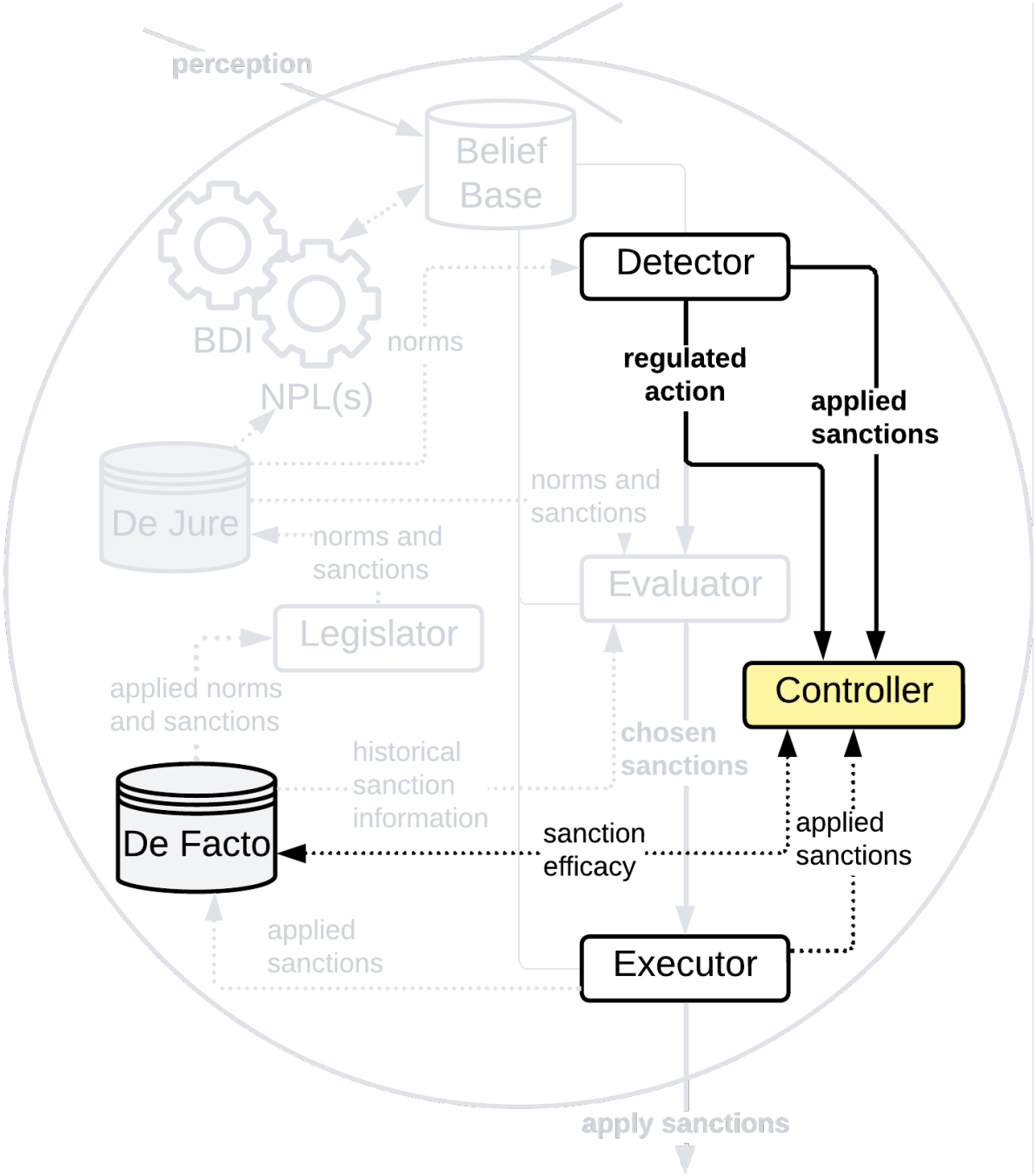
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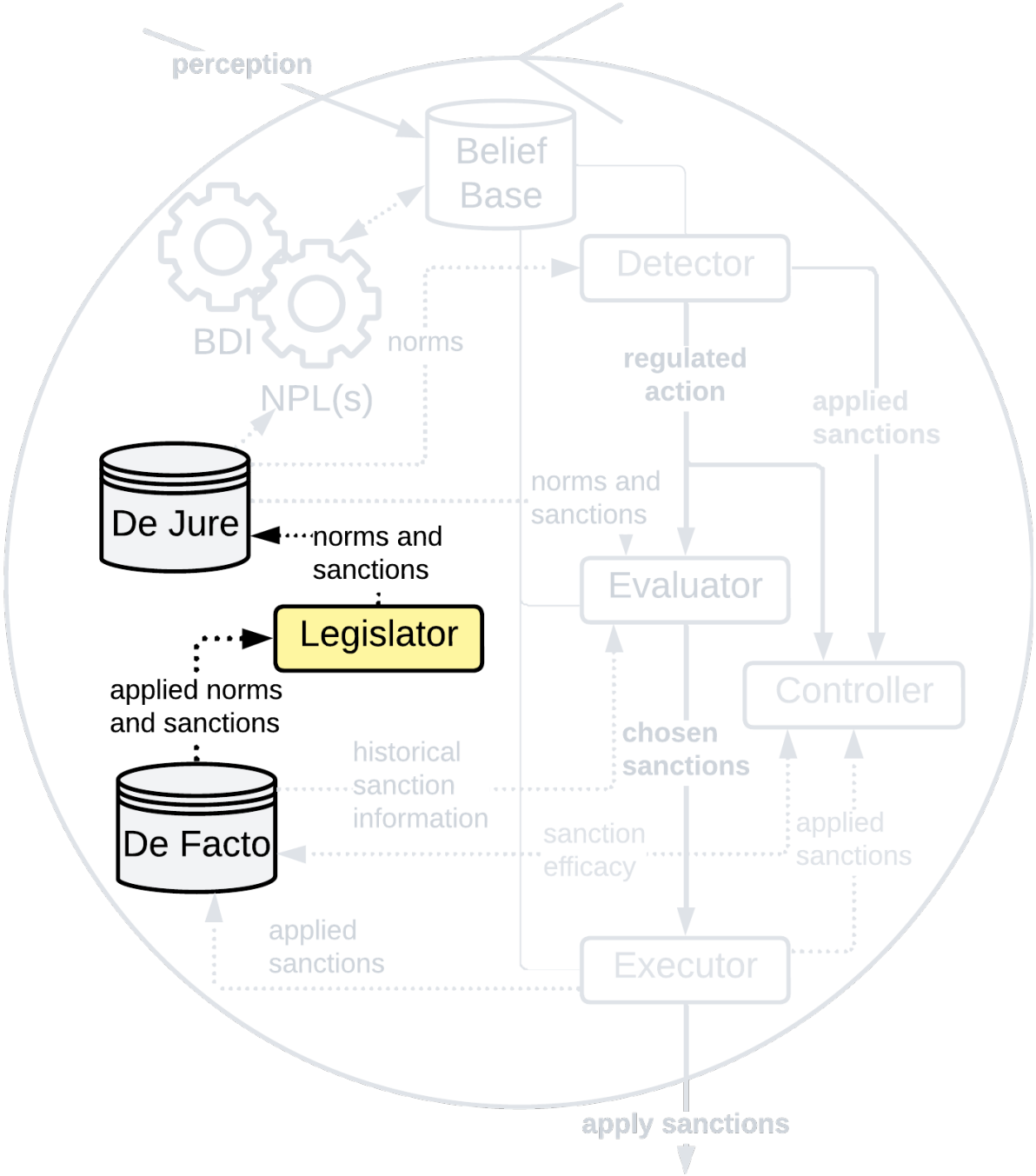
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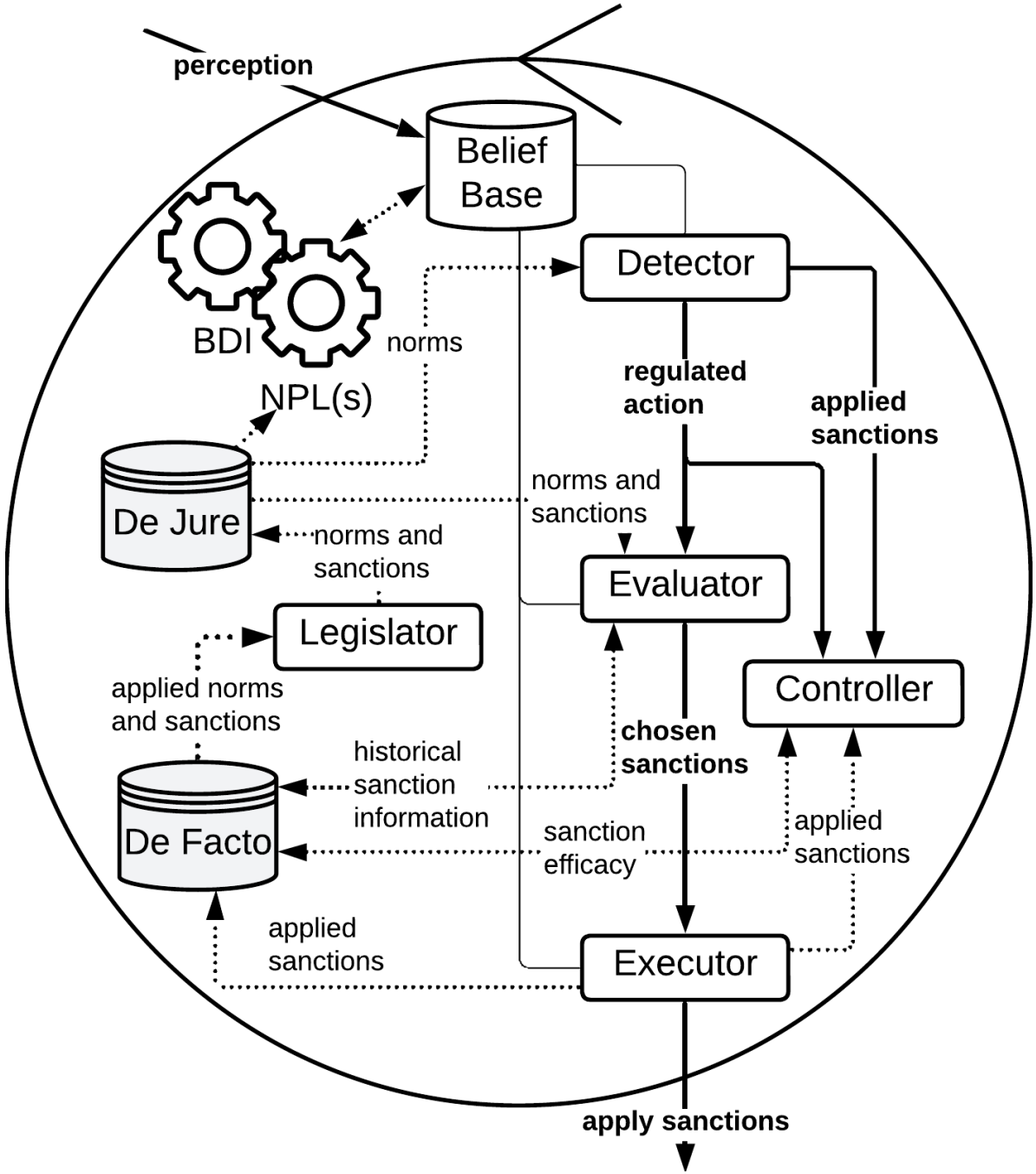
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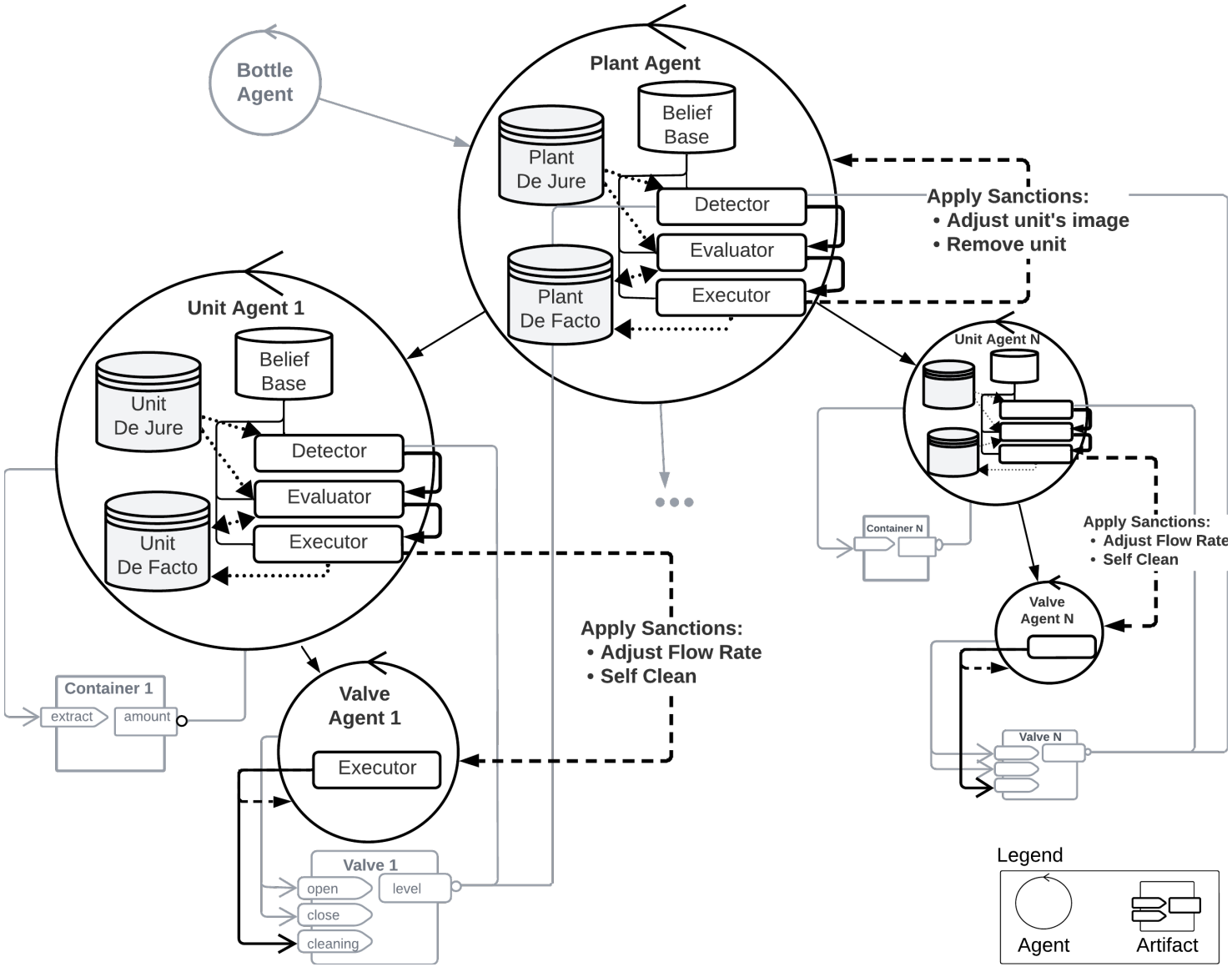
myJoghurt Case Study: Norm and Sanctions

The norms refer to the correct filling of each bottle.

Sanctioner	**Target**	**Sanction**	**Pre-condition**
unit	valve	**Adjust** the estimated **flow rate**	The image is below a threshold
unit	valve	Activate the **self-cleaning** procedure	The violation occurs three consecutive times
plant	unit	**Adjust** the unit agent's **image**	The image is below a threshold
plant	unit	**Remove as an option** for subsequent filling orders	The violation occurs five consecutive times

myJoghurt Case Study: MAS Architecture



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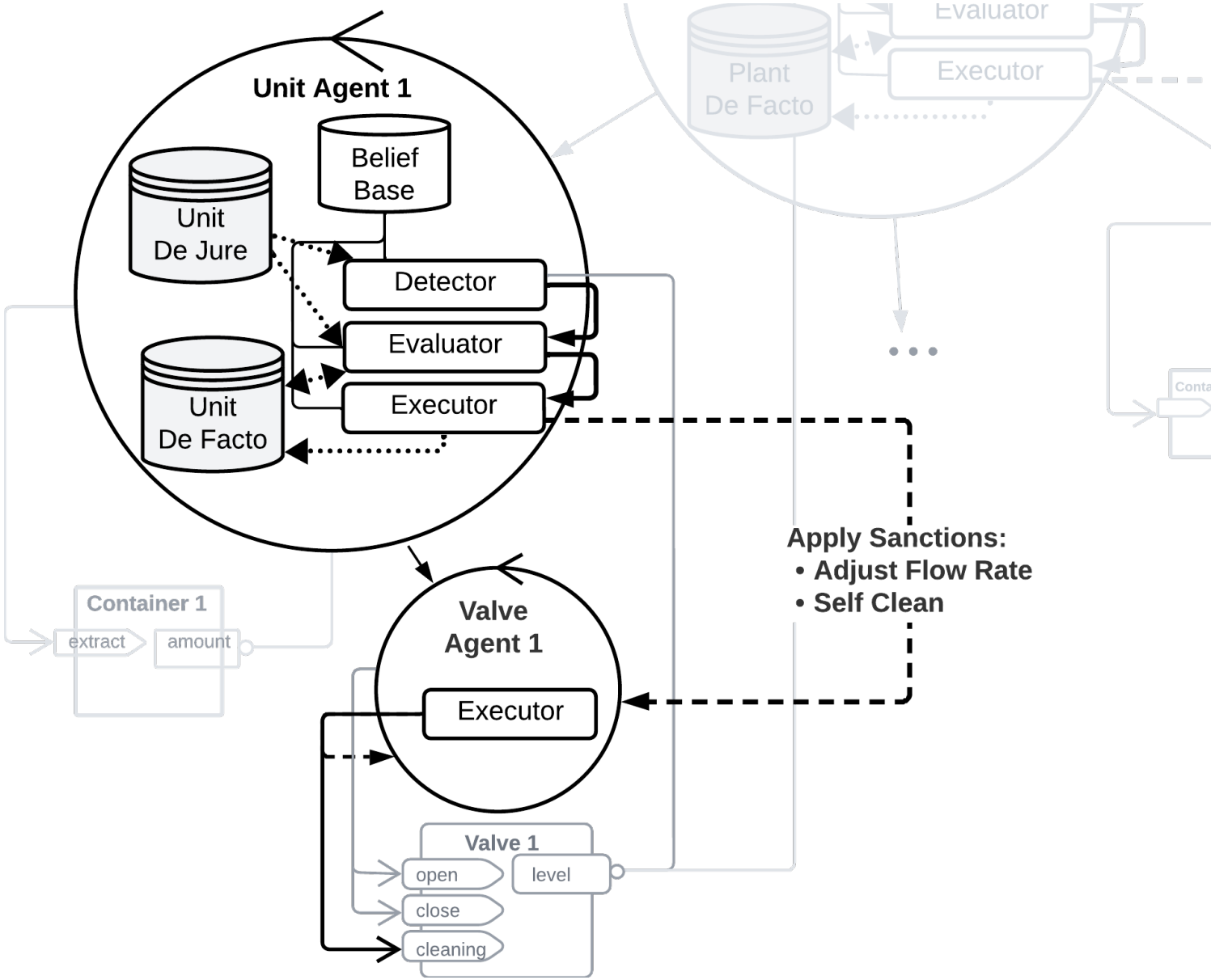

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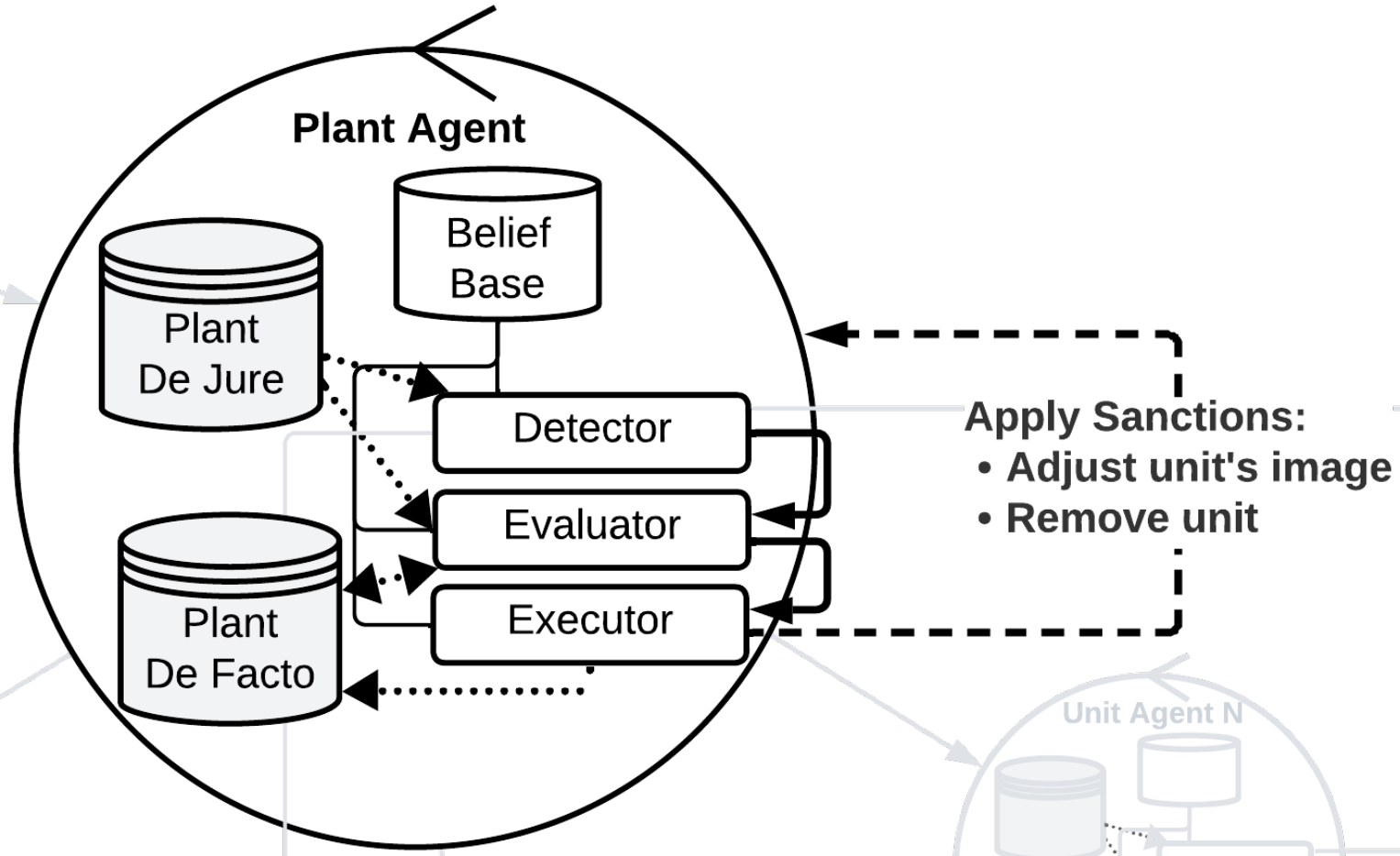

Next in Line...

Conclusions

1. **How to express agent's expected behaviors and enforced behaviors?**

   NPL(s) with the explicit representation of norms and sanctions

2. **How to enforce agents' expected behaviors?**

   Normative agent architecture with a comprehensible and flexible module on norm enforcement and sanctions

$\rightarrow$ Illustrate in an *industrial case study*

Future Work

- Consider the distinction between types of obligations and adapt the sanctioning efficacy
- Connect the sanctioning process directly to the environment with the approach developed in SAI [6]
- Explore accountability [3] and explainability [14] of the normative functioning

Thank you for your attention!

For further information:

Elena Yan, Luis G. Nardin, Jomi F. Hübner, and Olivier Boissier.
An Agent-Centric Perspective on Norm Enforcement and Sanctions.
International Workshop on Coordination, Organizations, Institutions, Norms and Ethics for Governance of Multi-Agent Systems, May 2024, Auckland, New Zealand.
`https://arxiv.org/abs/2403.15128`.

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DE MODÉLISATION ET D'OPTIMISATION DES SYSTÈMES

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WOA 2024, July 9, 2024

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