



Institut Mines-Télécom

SELF-ADAPTIVE REGULATION MECHANISMS FOR A TRUSTWORTHY AND SUSTAINABLE INDUSTRY OF THE FUTURE

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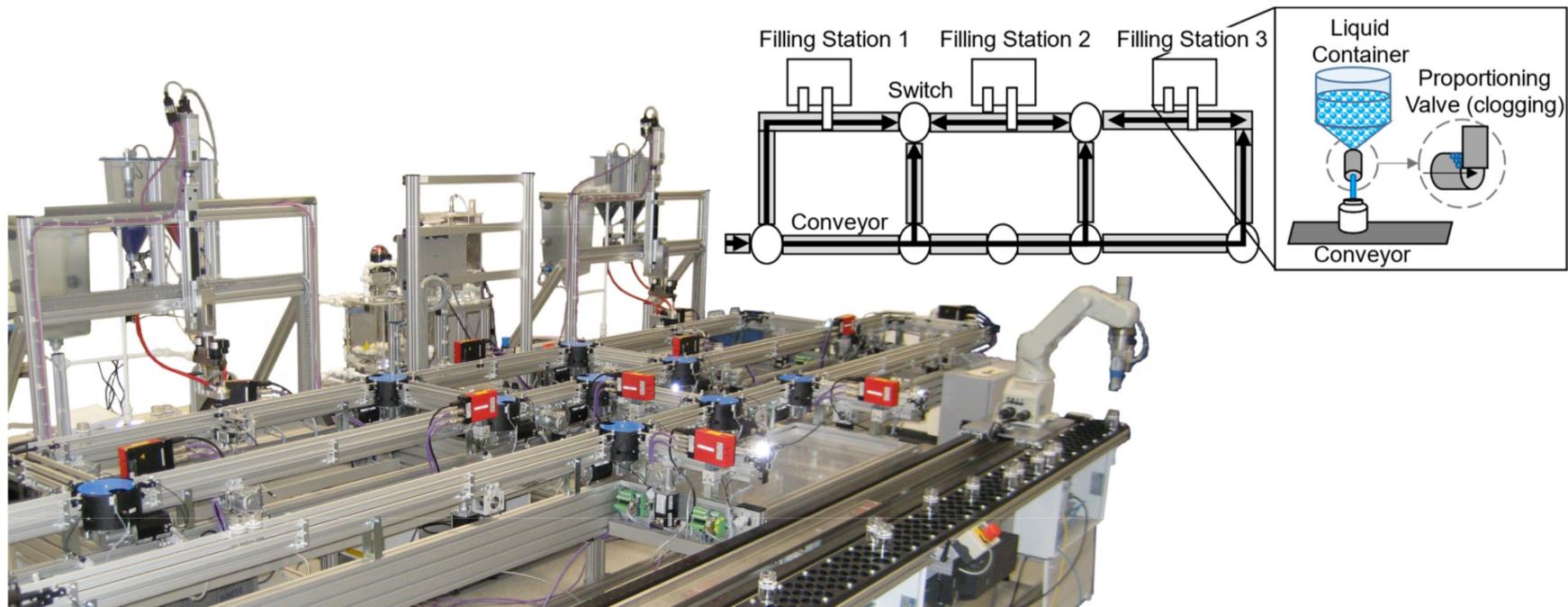
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Case Study: Laboratory Plant *MyJoghurt*

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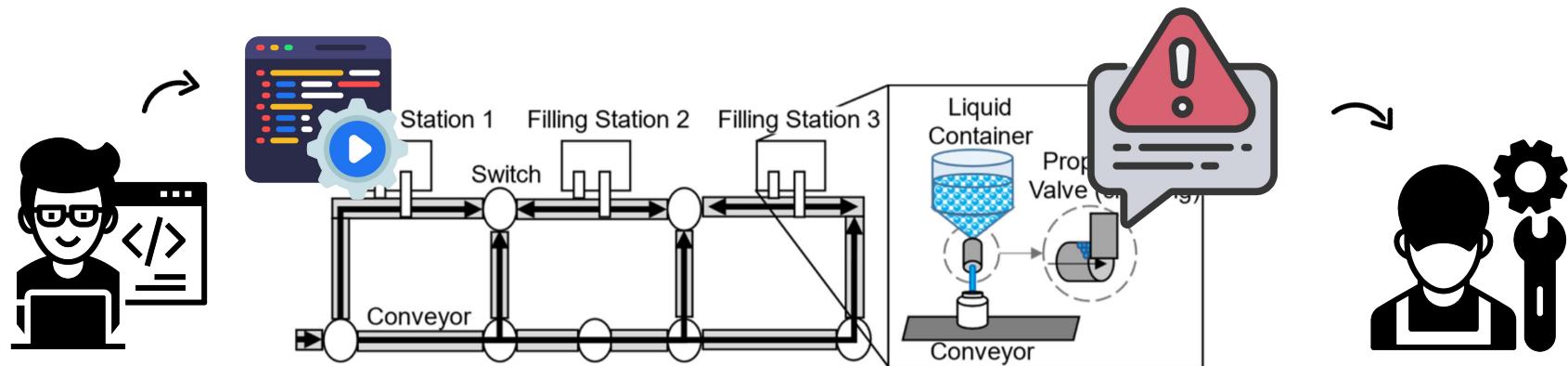


Land, K., Nardin, L., Vogel-Heuser, B.: Increasing robustness of agents' decision-making in production automation using sanctioning.
In: 2023 IEEE 21st International Conference on Industrial Informatics (INDIN). pp. 1–6 (2023)

Current Main Limitations

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- ▶ Redesign the system to respond to *different situations and constraints*
- ▶ Manual interventions to recover from *unexpected events*



R1. Resilience: the system avoids and recovers from unexpected events

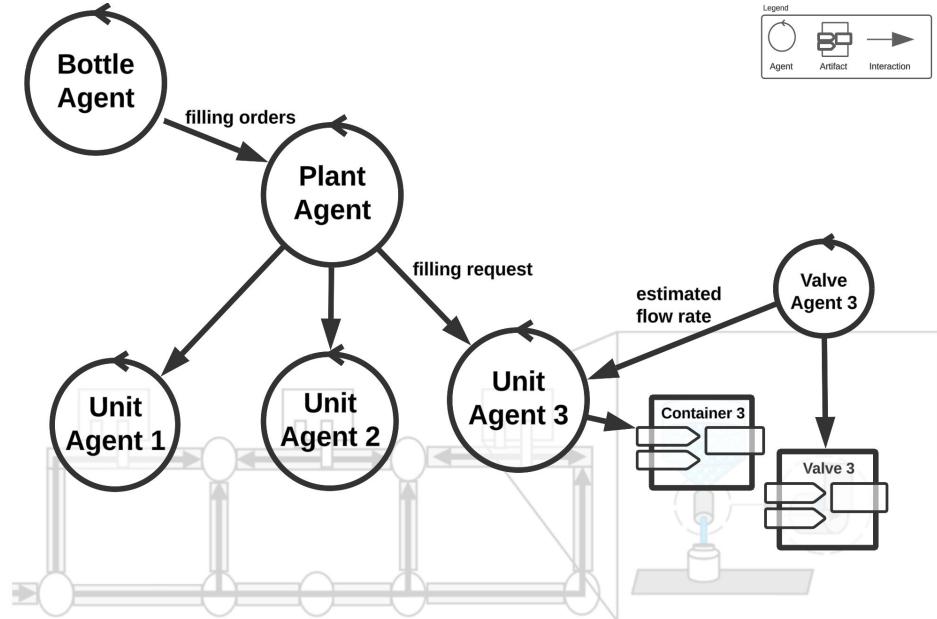
R2. Flexibility: the system adapts to different situations

R3. Sustainability: the system adapts to sustainability regulations

R4. Trustworthiness: human beings trust and understand the system

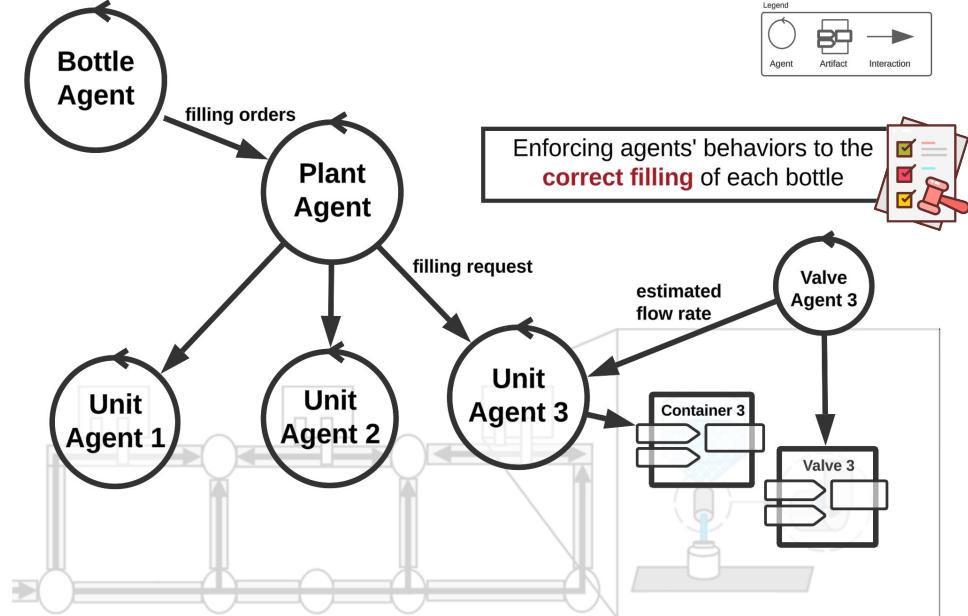
Design for Decentralization: Multi Agent System (MAS)

- ▶ MAS support decentralization and flexibility
- ▶ Agents are autonomous and intelligent entities, able to adapt themselves to dynamic conditions and unexpected events



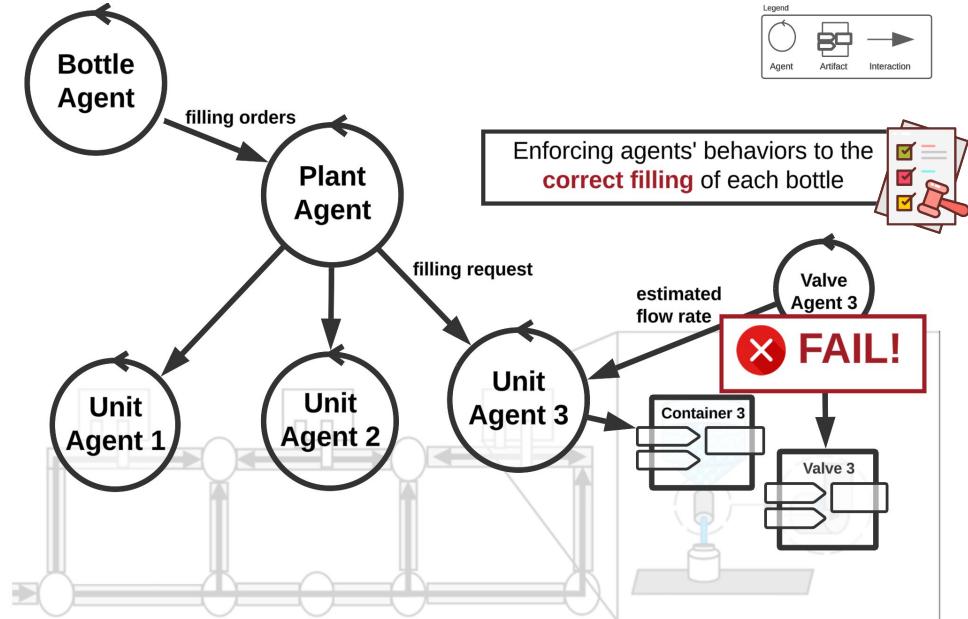
Design for Adaptivity and Sustainability: Regulation Mechanisms

- ▶ Regulate the system to different situations and production environments
- ▶ Ensure the sustainability through **self-adaptive** and **self-regulating** mechanisms for agents



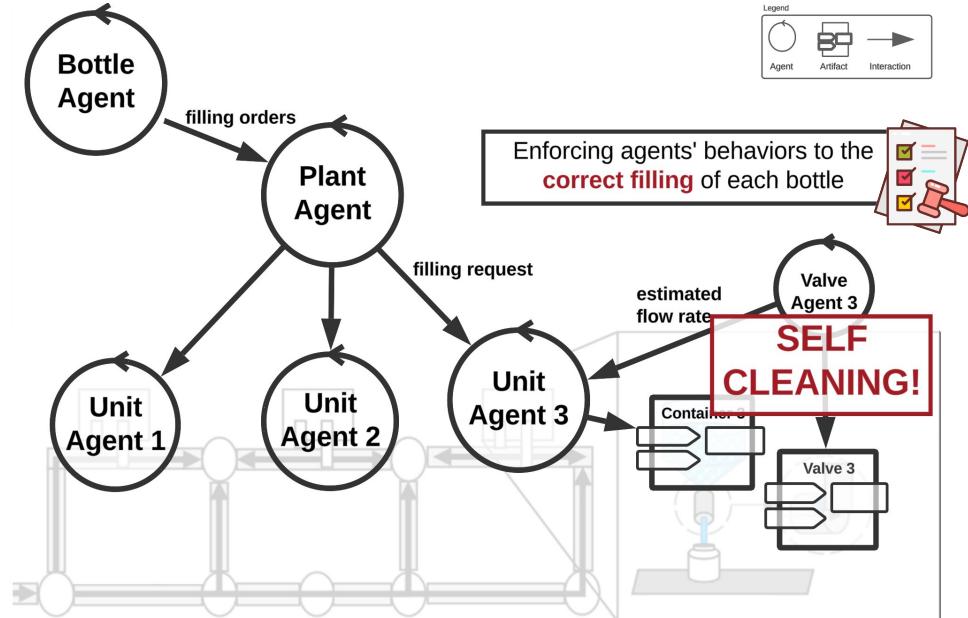
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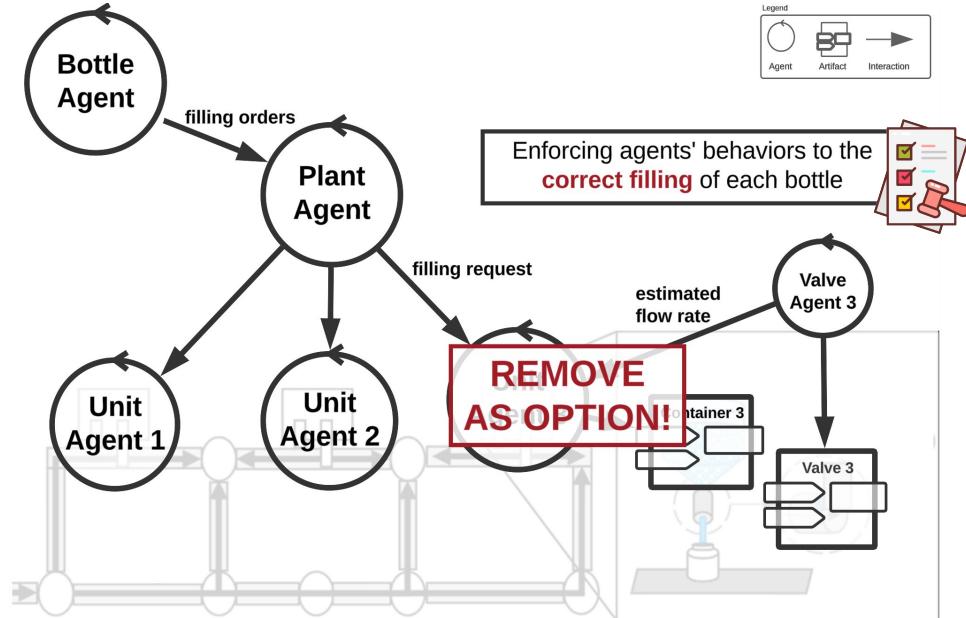
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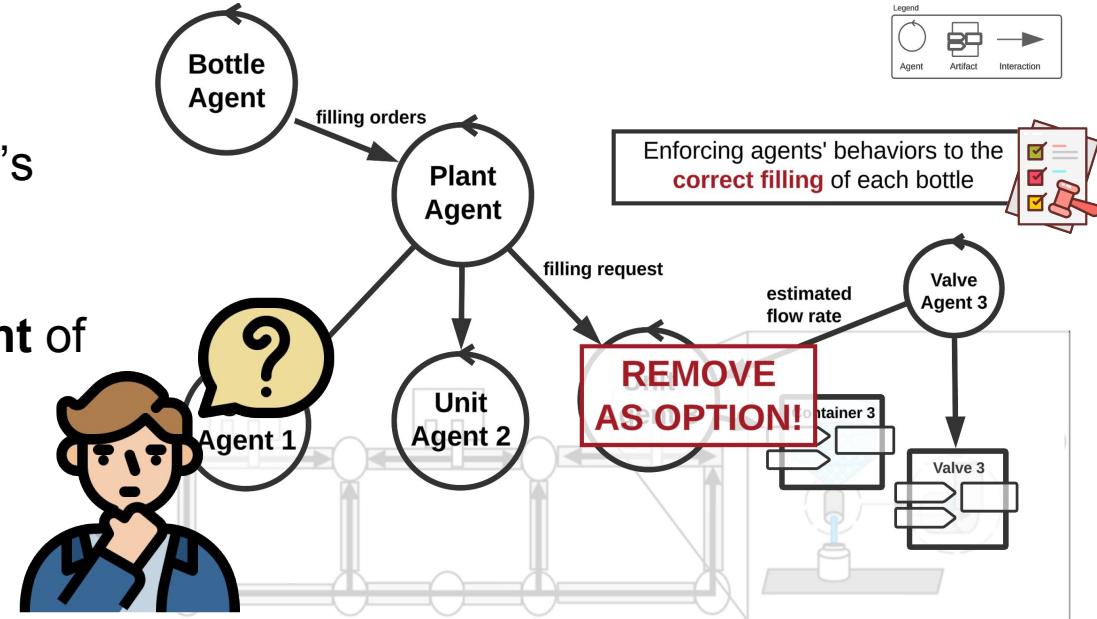
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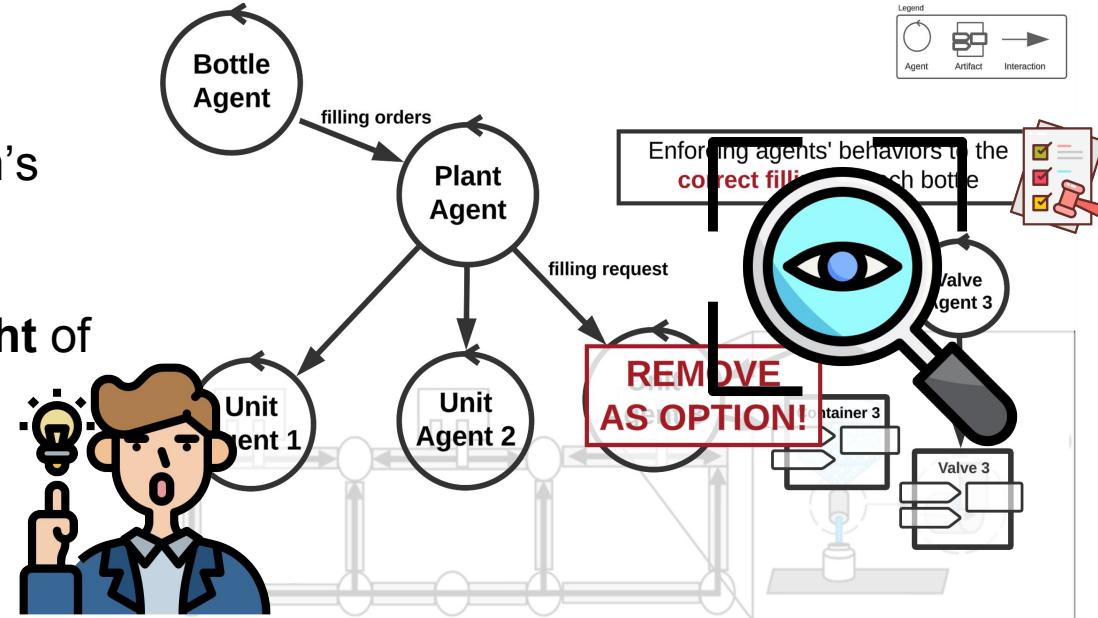
Design for transparency and accountability

- ▶ Ensure transparency and accountability for the system's decisions
- ▶ Enable the human oversight of the system operations



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- ▶ Develop a new generation of autonomous agents incorporating **self-adaptive** and **self-regulation** mechanisms
- ▶ Ensure for a **trustworthy** and **sustainable** industry of the future

- ▶ Proposed **NPL(s)**, a normative programming language to express regulation and enforcement (i.e., norms and sanctions)

```

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

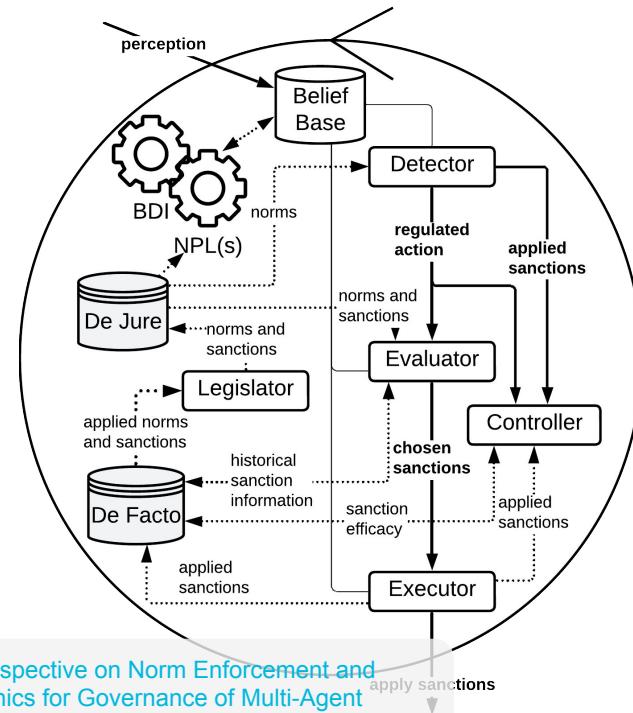
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Elena Yan, Luis G. Nardin, Jomí F. Hübner, and Olivier Boissier. (2024). An Agent-Centric Perspective on Norm Enforcement and Sanctions. International Workshop on Coordination, Organizations, Institutions, Norms and Ethics for Governance of Multi-Agent Systems, <https://arxiv.org/abs/2403.15128>.

What Have We Done?

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- ▶ Proposed a **normative agent architecture** to enable agents to enforce their or other agents' behaviors



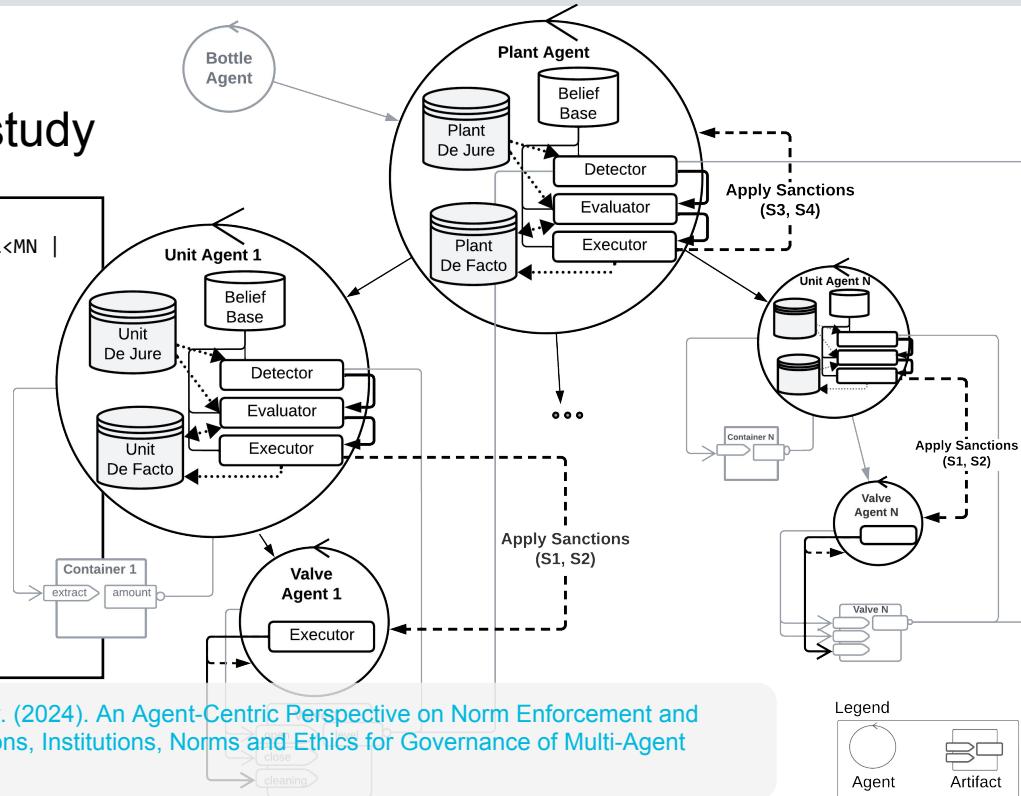
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► Illustrate in an industrial case study

```
norm n1: fill_bottle(LQ, X, MN, MX) & .my_name(U)
  -> obligation(U, n1, fill(LQ,X,MN,MX), level(X,L) & (L<MN | L>MX)).  
  
norm n2: level(V,X,L) & .my_name(U)
  -> obligation(U, n2, update_factors(V,X,L),
deviation_factor(V,X,"negative",_) &
learning_factor(V,X,I,_,_,_) & threshold(T,_) & I<T)
  if unfulfilled: s1(V,X), s2(V,X).  
  
sanction-rule s1(V,X): learning_factor(V,X,_,_,_,C) &
threshold(_,T) & C<T
  -> sanction(V, adjust_flow_rate(X)).  
  
sanction-rule s2(V,X): learning_factor(V,X,_,_,_,C) &
threshold(_,T) & C>=T
  -> sanction(V, self_cleaning(X)).
```



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

What are the Next Steps?

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- ▶ Design for **self-adaptive agents** able to adjust to different situations
- ▶ Incorporate mechanisms that reflect the **dynamics of regulation**
- ▶ Design for **transparency and accountability**
- ▶ Experiment in real industry settings



Thank you for your attention!

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