Runtime Revision of Norms and Sanctions based on Agent Preferences

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Normative Multiagent Systems

Norms with sanctions: means to control and influence the behavior of autonomous agents to guarantee the overall objective of the MAS.

Problem: **the dinamicity of a MAS**
unpredictable, weakly controllable
and uncertain environment s.t. the
norm enforcement may become ineffective

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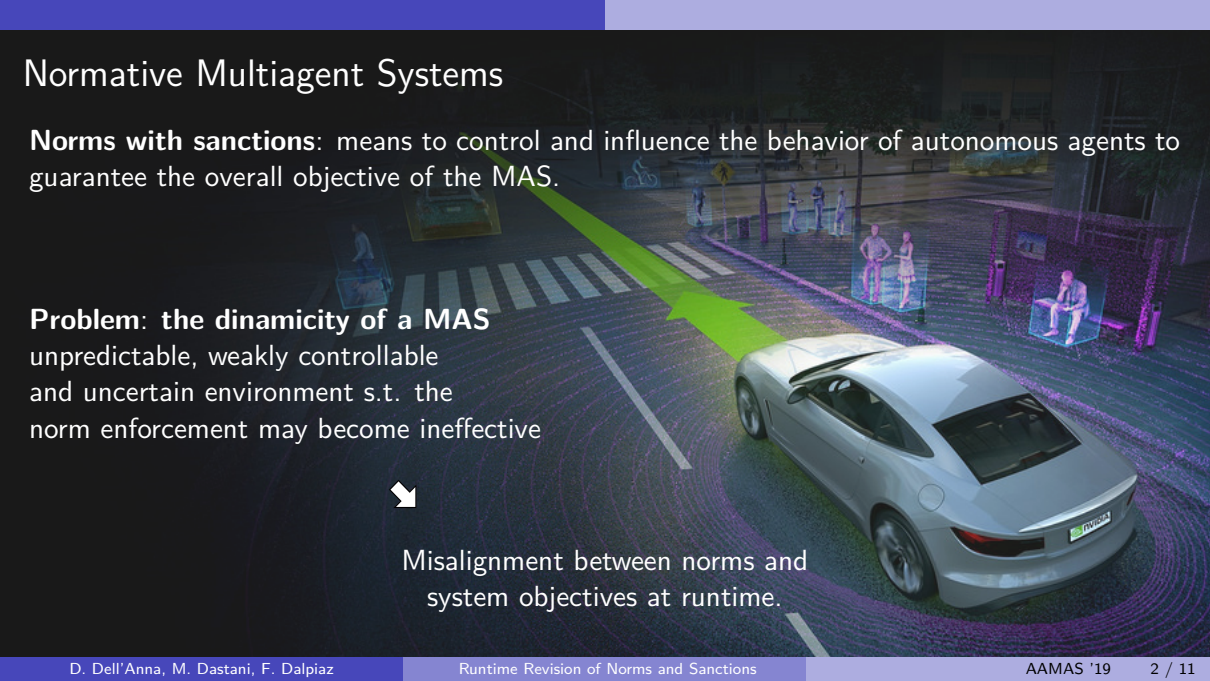
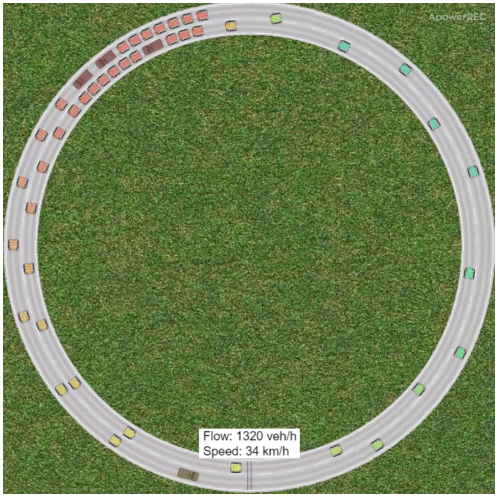
Misalignment between norms and
system objectives at runtime.



Illustrative Scenario: Ring Road[1]



At Design Time:

If vehicles do not exceed 100km/h → no traffic jams

- System **Objective**: *avoid traffic jams*
- Enforced **Norm**: *vehicles shall not exceed 108km/h*

At Run-Time:

Norm obeyed **BUT** in **context** *30 cars/km* the **interactions** and **local decisions** of vehicles in the shared **environment** cause **traffic jams**

[1] Video taken from http://www.traffic-simulation.de/

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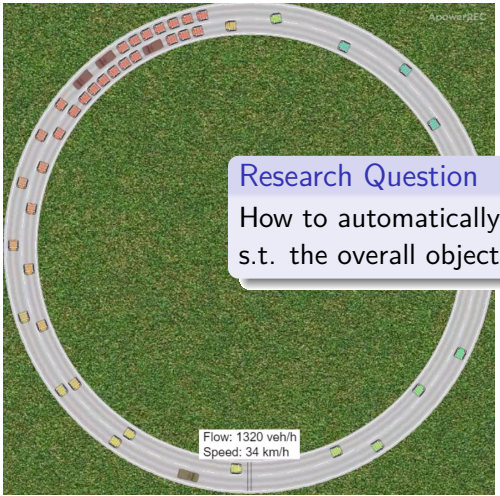

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Research Question

How to automatically revise a norm at runtime, s.t. the overall objectives of a MAS are achieved?

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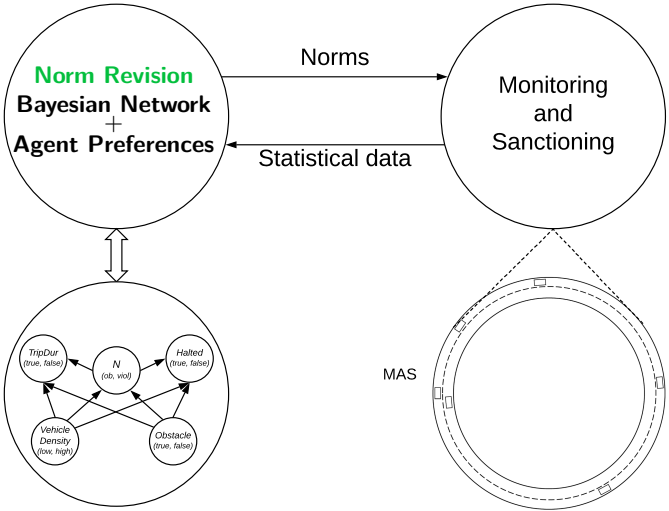
Norms-based MAS Runtime Supervision



Norms and Agents Preferences

Norm N: $(speed\_50, 1)$

Agent type **brave but poor** with **no reason to violate** N:
$(speed\_100, 0) \succeq$ **$(speed\_50, 0)$** $\succeq (speed\_100, 1) \succeq (speed\_50, 1)$

Agent type **brave and rich** with **reason to violate** N:
$(speed\_100, 0) \succeq$ **$(speed\_100, 1)$** $\succeq (speed\_50, 0) \succeq (speed\_50, 1)$

Given a **distribution of types** of agents in the system

↓

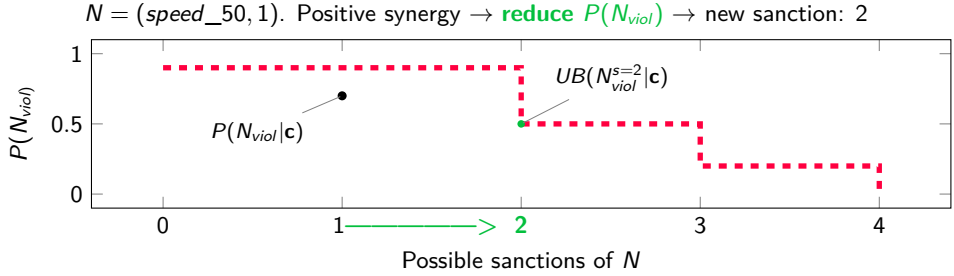
Estimation of **upper bound** of number of **violations**

Sanction revision based on norm-objectives synergy

Positive synergy between N and $\mathbf{O}$ in context $\mathbf{c}$

$P(\mathbf{O}_{true}|N_{ob}) \geq P(\mathbf{O}_{true}|N_{viol})$

- if **positive synergy** $\rightarrow$ **reduce violations** of N
- otherwise $\rightarrow$ **increase violations** of N

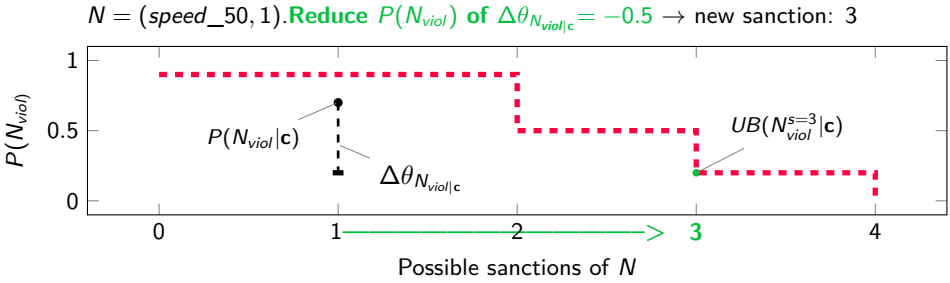


Sanction revision based on sensitivity analysis

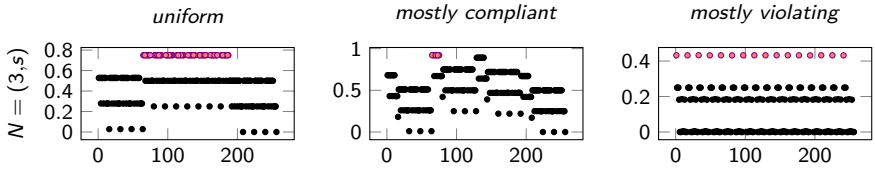
Required revision strength $\Delta\theta_{N_{viol|\mathbf{c}}}$ in context $\mathbf{c}$

The required change in $P(N_{viol}|\mathbf{c})$ to make N effective in $\mathbf{c}$. $P(\mathbf{O}_{true}|\mathbf{c}) + \frac{\delta P(\mathbf{O}_{true}|\mathbf{c})}{\delta \theta_{N_{viol|\mathbf{c}}}} \cdot \Delta\theta_{N_{viol|\mathbf{c}}} \geq \tau$

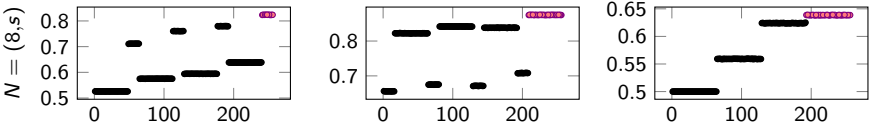
- **change violation probability** of $\Delta\theta_{N_{viol|\mathbf{c}}}$.



Revision Strategies: Hill Climbing Neighborhood Heuristics



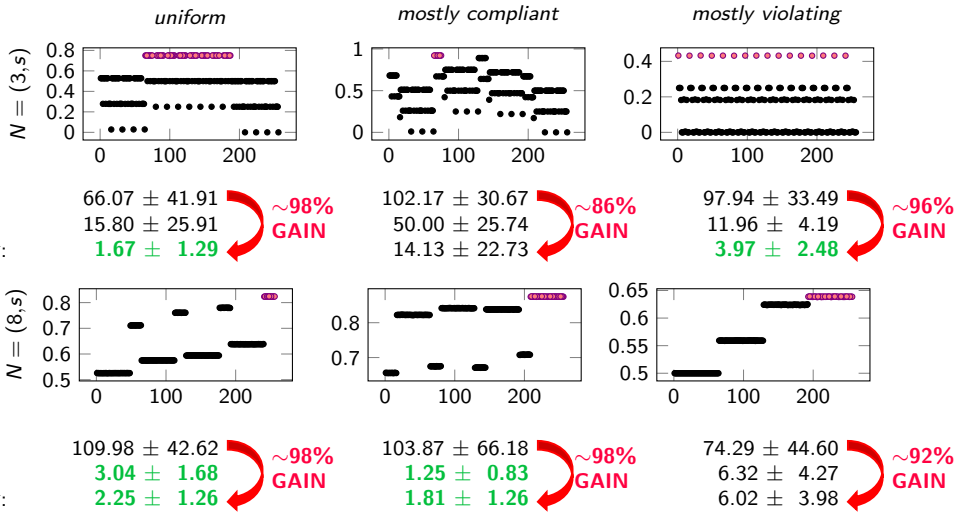
Six Scenarios of the Ring Road with SUMO Simulator



$4^4 = 256$ possible configurations of sanctions for each scenario:

4 possible sanctions in 4 execution contexts (low/high vehicle density, yes/no obstacle).

Results: Few Steps Required to Find Optimal Sanctions



Conclusion and Currrent and Future Work

- **Supervision of NMAS: runtime refinement of design artifacts**
  Agent preferences + runtime MAS behavior $\rightarrow$ effective revision of norms in few steps
- Approach independent from language of norms and objectives
- Easily extensible to support:
  - more complex norm/preferences representations
  - symbolic sanctions
  - multiple norms
  - deviation of agents from prototypical types
  - open MAS

Thank you for your attention.
See you at the poster session!

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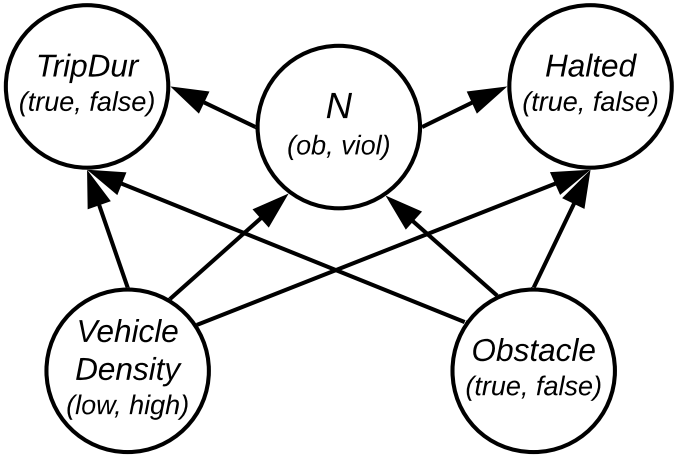
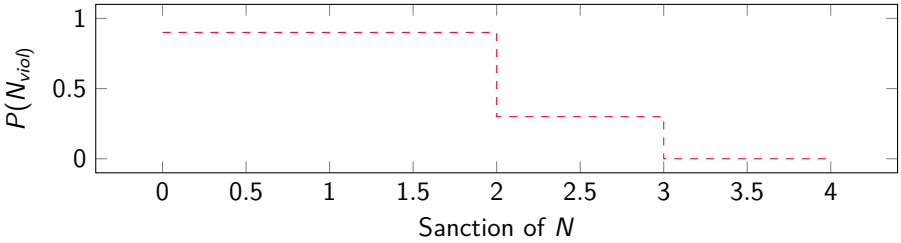
Norm Bayesian Network



Well Defined Norms and Exhibited Norm Violation

N **well defined**: $P(N_{viol})$ always $\leq$ the % agents with reason to violate N.[2]

Upper Bound of $P(N_{viol})$ (example):
Population of agents:
60% type t_1 (max budget to viol N: 2), 30% t_2 (max b. 3), 10% t_3 (max b. 0).



Exhibited norm violation: the actual $P(N_{viol})$ monitored at **runtime**. It is affected by the agents interactions and by the MAS environment.

[2] Assuming no agent performs more actions than others.