Runtime Revision of Norms and Sanctions based on Agent Preferences

Davide Dell'Anna, Mehdi Dastani, Fabiano Dalpiaz

Department of Information and Computing Sciences, Utrecht University, The Netherlands

D.DellAnna@uu.nl, M.M.Dastani@uu.nl, F.Dalpiaz@uu.nl

Universiteit Utrecht

Context

In a normative MAS, the enforced norms may be inadequate to fullfill the system objectives.

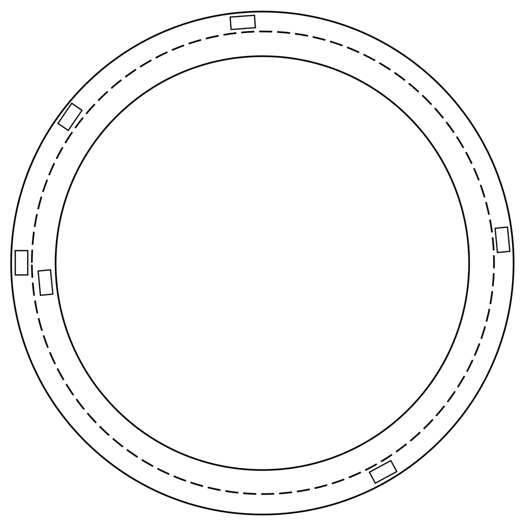
Example: Ring Road

Objective: avoid traffic jams.

Norm: cars' speed $\leq$ 50km/h.

Context: road density 30 cars/km.

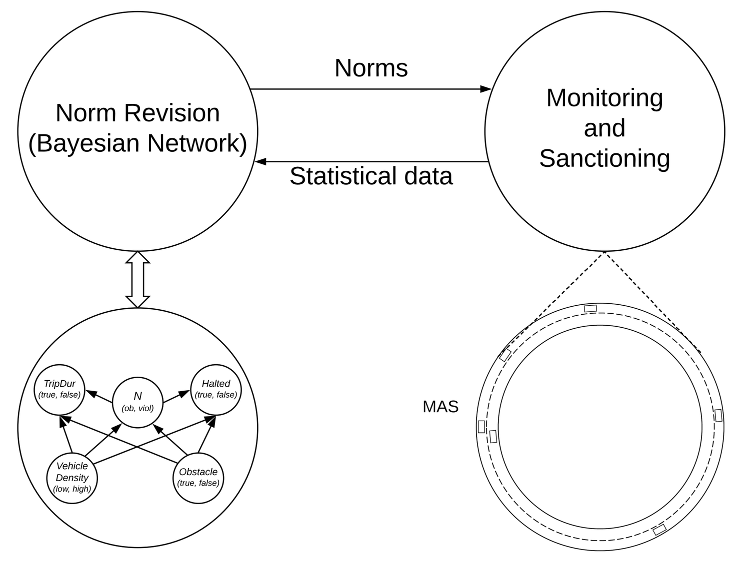
Norm obeyed + **interactions** and **local decisions** of cars, following their **preferences** $\rightarrow$ objective is not achieved.



Research Question

How to effectively **revise the sanction** of a norm so to ensure the fulfillment of the system objectives?

Norm-based Supervision of MAS

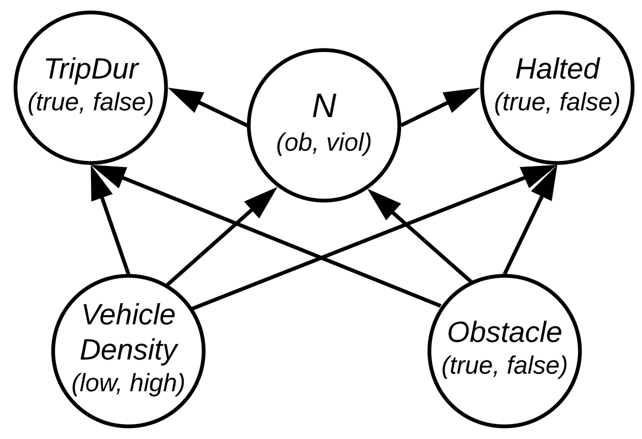


MAS supervision mechanism

- Continuously monitors the execution of a MAS
- Evaluates the norm enforcement in terms of the overall objectives
- Intervenes by revising the norms

Norm Bayesian Network

- Two objectives nodes **O**
- One norm node N
- Two context nodes **C**



Norms and Agents Preferences

Norm: $N = (p, s)$, with $p \in L$ set of propositional atoms, and $s \in \mathbb{N}$.
Agent's Preference: $Pref(a) = (C, \succeq)$, with $C = \{(p_i, b_i) \mid 1 \leq i \leq k \;\&\; b_i \in \mathbb{N}\}$ and $\succeq$ partial order on C.
Preferences characterize **agent's type**.

Example: $N = (speed\_50, 1)$. Two types of agents: *T1* and *T2*
T1: $(speed\_100, 0) \succeq$ **$(speed\_50, 0)$** $\succeq (speed\_100, 1) \succeq (speed\_50, 1)$
T2: $(speed\_100, 0) \succeq$ **$(speed\_100, 1)$** $\succeq (speed\_50, 0) \succeq (speed\_50, 1)$
T1 **has no reason to violate** N, *T2* **has reason to violate** N.

Sanction Revision Strategies

SYNERGY

Positive synergy between N and **O** iff $P(\mathbf{O}_{true} | N_{ob}) \geq P(\mathbf{O}_{true} | N_{viol})$.

- If positive synergy $\rightarrow$ reduce violations of N
- Otherwise $\rightarrow$ increase violations of N

New sanction: the closest s expected to increase (reduce) $P(N_{viol} | \mathbf{c})$.

SENSITIVITY

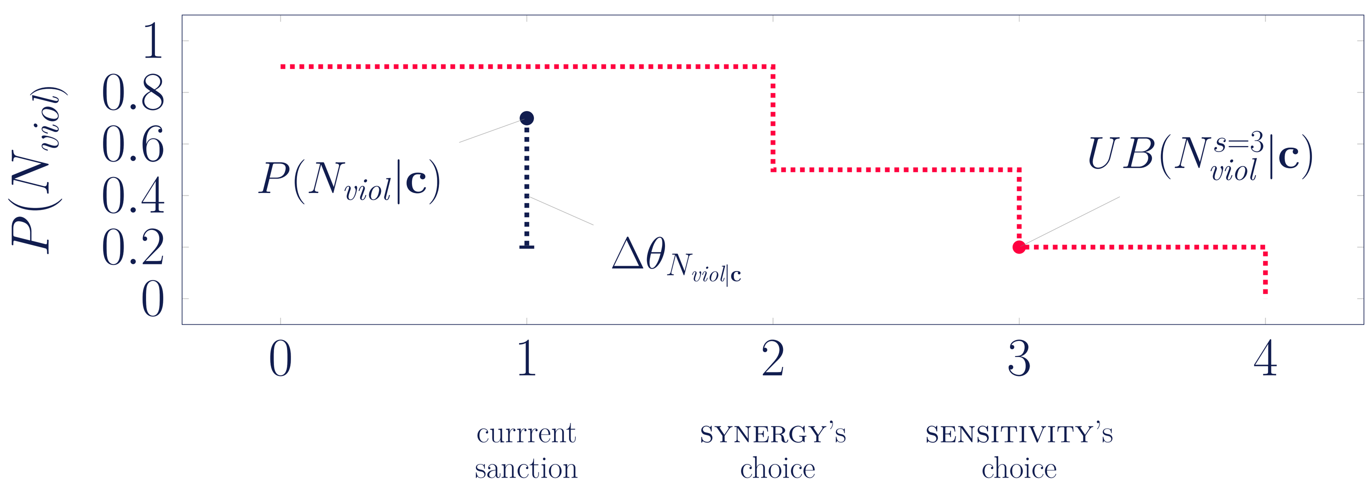
Required revision strength $\Delta\theta_{N_{viol|\mathbf{c}}}$ in context **c**: required change in $P(N_{viol} | \mathbf{c})$ so that $P(\mathbf{O}_{true} | \mathbf{c}) \geq \tau$

$$P(\mathbf{O}_{true} | \mathbf{c}) + \frac{\delta P(\mathbf{O}_{true} | \mathbf{c})}{\delta \theta_{N_{viol|\mathbf{c}}}} \cdot \Delta\theta_{N_{viol|\mathbf{c}}} \geq \tau$$

New sanction: the closest s s.t. $UB(N'_{viol} | \mathbf{c}) - P(N_{viol} | \mathbf{c}) \approx \Delta\theta_{N_{viol|\mathbf{c}}}$.

Example

$N = (speed\_50, 1)$. Positive synergy between N and **O** in **c**.
SYNERGY: reduce $P(N_{viol}) \rightarrow$ new sanction: 2
SENSITIVITY: reduce $P(N_{viol})$ of $\Delta\theta_{N_{viol|\mathbf{c}}} = -0.5 \rightarrow$ new sanction: 3

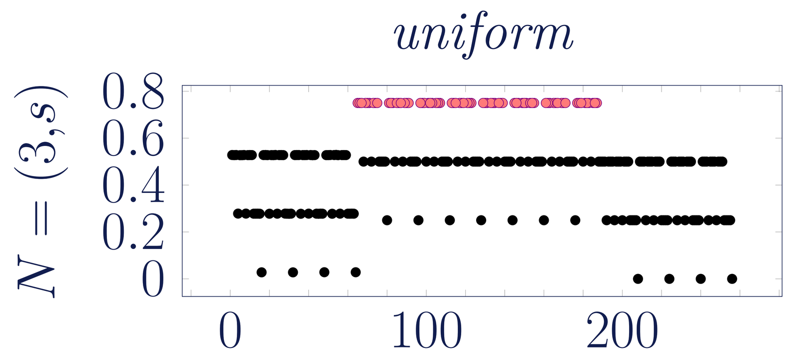


Revision Strategies as Hill Climbing Neighborhood Heuristics: Steps to Converge

Six scenarios of the Ring Road with **SUMO Traffic Simulator**: 2 norms and 3 distributions of agents.
Goal: to determine an **optimal sanction** $s \in \{0, 1, 2, 3\}$ for each of 4 execution contexts. $\rightarrow$ 256 possibile configurations for each scenario.
Average number of steps required to find an optimal configuration ($P(\mathbf{O}_{true}) \geq \tau$):

$N = (3, s)$

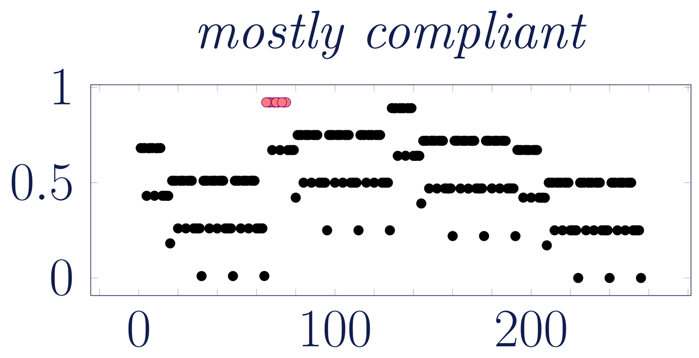
uniform



uninformed:	66.07 ± 41.91
SYNERGY:	15.80 ± 25.91
SENSITIVITY:	**1.67 ± 1.29**

~98% GAIN

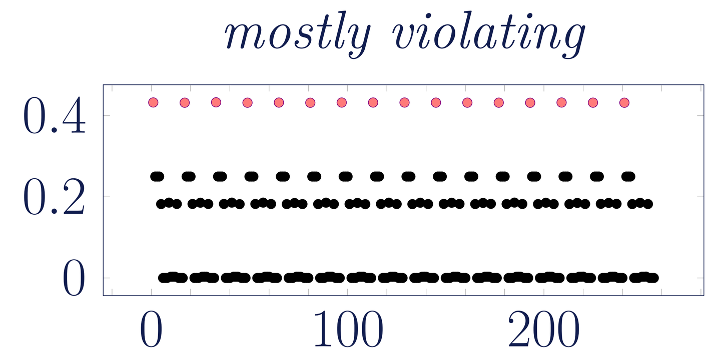
mostly compliant



uninformed:	102.17 ± 30.67
SYNERGY:	50.00 ± 25.74
SENSITIVITY:	14.13 ± 22.73

~86% GAIN

mostly violating

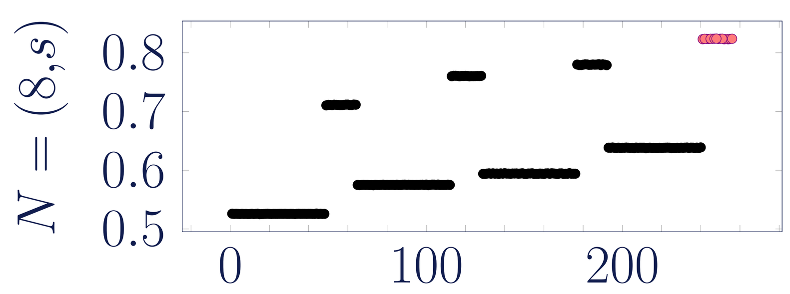


uninformed:	97.94 ± 33.49
SYNERGY:	11.96 ± 4.19
SENSITIVITY:	**3.97 ± 2.48**

~96% GAIN

$N = (8, s)$

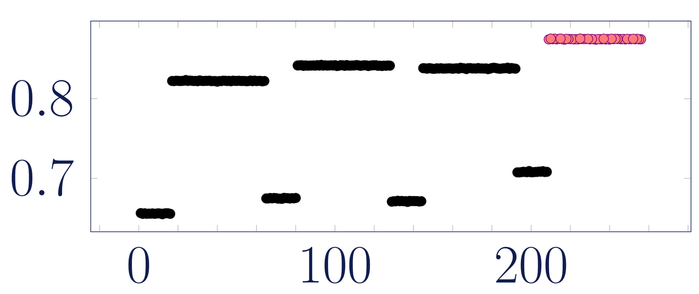
uniform



uninformed:	109.98 ± 42.62
SYNERGY:	**3.04 ± 1.68**
SENSITIVITY:	**2.25 ± 1.26**

~98% GAIN

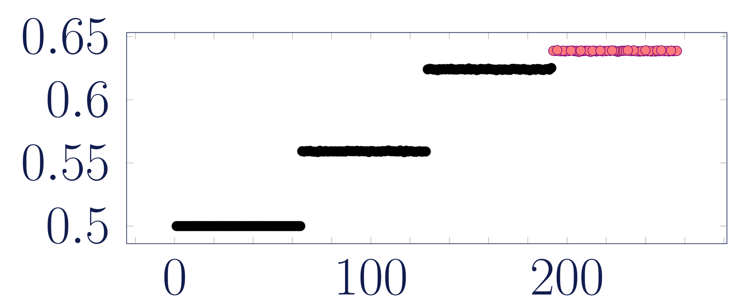
mostly compliant



uninformed:	103.87 ± 66.18
SYNERGY:	**1.25 ± 0.83**
SENSITIVITY:	**1.81 ± 1.26**

~98% GAIN

mostly violating



uninformed:	74.29 ± 44.60
SYNERGY:	6.32 ± 4.27
SENSITIVITY:	6.02 ± 3.98

~92% GAIN

Current and Future Work

- Multiple norms
- More complex norms representation
- Revision strategies for norm's proposition
- Runtime norm-based mechanism design