

Programming norm-aware multi-agent systems with group norms

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normHACing framework

We explore the ways in which flexible autonomy can be supported using models based on the expression of obligations and prohibitions.

Normative MAS are organized by means of mechanisms to represent, communicate, distribute, detect, create, modify, and enforce norms, and mechanisms to deliberate about norms and detect norm violation and fulfilment.

N-2APL norm-aware agents

Norm-aware agents programmed in N-2APL are able to reason about norms that are in a form of obligations and prohibitions with assigned numerical priorities and corresponding sanctions. Such a coordination mechanism of multi-agent systems allows the autonomy of agents to be dynamically adjusted with the use of norms deployed by the organization.

Implementation of group norms

In this framework agents could be regulated not only with obligations aimed at them individually but also obligations that are issued to a of group agents. Implementation of such an obligation requires the agents to have a plan how to participate in the joint action and to be able to infer what is the sanction going to be depending on the actions of other agents.

N-2APL agents have individual plans to enact their part in a group obligation. Agents also know the maximum and sanction they can incur in case the norm is violated.

When an agents deliberate about which plan to adopt it can take into account either the maximum or the minimum value depending whether agent is optimistic or pessimistic.

Agent is sanctioned with the maximum value in case it was solely responsible for the violation and similarly with the minimum in case when none of the responsible agents did their part.

Location based mixed reality game

This is done in the context of a disaster scenario. The work involves developing a system that links with a version of existing AtomicOrchid and allows the obligations and prohibitions for each agent to be expressed using 2OPL language for describing constraints. A tuple space is used to link these to the AtomicOrchid allowing these to drive the actors within the game. The tuple space contains complete state of the game with its history and also all obligations and prohibitions^[1].



Rules of the game are described as conditional norms with deadlines and sanctions. In the example below is a basic group obligation in 2OPL notation telling pursuers to surround a coin, which was placed by a coordinator.

```
norm(surround_coin(Pursuers),
  ([],
  [pursuers(Pursuers), coin(X,Y,Agent),
  West is X-1,East is X+1,North is Y+1,South is Y-1]),
  obligation(
    Pursuers,
    [at(East,Y,A1),at(West,Y,A2),at(X,North,A3),at(X,South,A4)],
    now+15,
    [reduce_score(Pursuers,300)]
  )
).
```

When a coordinating agent is obliged to coordinate a group of agents it creates individual obligations for agents that are participating in the task. It also specifies a policy by which the agents will be sanctioned in case the obligation is not fulfilled.

In the event of a norm violations sanctions are applied from top to the bottom following the hierarchy. Following the policy that applies to the norm the organisation splits the sanction amongst agents that contributed to the violation.

Hierarchical group norms

```
norm(
  groupCollect,
  ([],
  [coordinator(Agent1), object(A), at(X,Y,A)]
  ),
  obligation([Agent1],[groupCollectObject(A)],now + 120,[reduce(1000)])
)

norm(
  individualCollect,
  ([groupCollect],
  [object(A)]
  ),
  obligation([Agent2,Agent3],[collectObject(A)],now + 120,[split(1000)])
).
```

In the example above is a group norm labelled *groupCollect* which is directed to a coordinator *agent1*, which is obliged to bring about a state *groupCollectObject(A)* in 2 minutes (120 seconds from now) otherwise it will be sanctioned with a loss of 1000 points.

The second norm is an example of an individual norm, which is detached after norm *groupCollect* is detached. It is directed to agents *agent2* and *agent3* who are obliged to bring about state *collectObject(A)* in 2 minutes otherwise they will be sanctioned with a maximum of 1000 penalty points.

[1] Dybalova, D., Testerink, B., Dastani, M., & Logan, B. (2013). A Framework for Programming Norm-Aware Multi-Agent Systems. In International workshop on Coordination, Organizations, Institutions, and Norm in Multi-Agent Systems.