Combining Event-and State-based Norms (Extended Abstract)

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ABSTRACT

Institutions offer a mechanism to regulate the behaviour of agents without the need for these agents to internalise the norms of the system. Current formalisms can be divided in two groups depending on whether norms are expressed on the state of the normative structure or the events that bring about normative change. This paper argues that for complex systems both types are needed.

To this extend, we introduce ESI, a formal model for institutions incorporating the concepts for both event- and state-based normative modelling. We demonstrate our approach with a simplified legal case-study.

Categories and Subject Descriptors

I.2.11 [**Distributed Artificial Intelligence**]: Multiagent systems; I.2.4 [**Knowledge Representation Formalisms and Methods**]: Relation systems; B.5.2 [**Design Aids**]: Verification

General Terms

Design, Theory, Verification

Keywords

Institutions, Norms, Event-based Norms, State-based Norms

1. INTRODUCTION

The concept of institutions – typically also called normative frameworks or organisations [1, 3] – has become firmly embedded in the agent community as a necessary tool to limit the essential autonomy of agents in a flexible way. They have two basic tasks: (i) To indicate permissible and non-permissible agent behaviour and the consequences of undesired behaviour (violation of the norms), and (ii) To specify how the group dynamics affect the state of the system. In both the physical and the virtual world — and the emerging combination of the two — institutions serve the purpose of minimizing disruptive behaviour and supporting the achievement of the goals for which the institution was designed without the requirement for for agents to internalise the norms.

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In literature a variety of institutional formalisms exist. These formalisms can be divided into two groups: The first group including for example OpeRA and $\mathcal{M}$OISE$^+$ [3, 6] takes an organisational approach and expresses high-level norms concerning a state of the system/organisation. The second group consisting of for example InstAL, ISLANDER, OCEAN [1, 4, 5], expresses norms at the level of the actions of the participants.

We believe, while this separation works well for relatively simple settings, both approaches are needed for modelling more complex scenarios.

A designer might be able to express one type of norms via a combination of the other type, using using such "translations" places a lot of responsibility in the hands of the designer as (s)he has to ensure that the translations are adequate and no unintended artefacts are generated. Furthermore, we believe that for complex systems this translation is not always possible. Therefore, we present in this paper a formalism that combines both types of norms.

Although there have been a few attempts to capture elements of both event- and state-based perspective in some normative descriptions, so far, to our knowledge, there is no institutional/organisational framework available providing the means to model both low- and high-level norms and their corresponding concepts at the same time.

This paper presents the fundamentals of the ESI framework which fills this gap and allows to model both: state- and event-based norms in one framework. ESI takes its inspiration from models of both above mentioned groups, with in particular InstAL and OpeRA.

2. THE ESI MODEL: SYNTAX

When we think of event-based norms, we want to be able to express that an event is permitted, not permitted, prohibited, empowered (its actions have a normative effect), obliged to (not) occur.

In state-based systems such as OpeRA, typically agents are divided based on the role/task they have to fulfil. Instead of individually assigning permissions or power to agents, these are often based on roles. Besides roles, when considering state-based norms, we want to be able to specify that the system as a whole needs to reach a certain state or needs to avoid it. This is specified using landmarks. For agents to successfully traverse their state space, the system provides a scene mechanism that guides the system from one scene to the next, and from one landmark to be achieved to the following one. At each completion of a landmark or a scene, the normative capabilities of the system and its participants can change (e.g. a new obligation is initiated, a new scene has to be completed, a particular role's permission to perform a certain action is revoked)

In ESI we combine these capabilities into a single formal model. This gives a 10-tuple: $\langle \mathcal{A}, \mathcal{J}, \mathcal{E}, \mathcal{F}, \mathcal{C}, \mathcal{G}, \mathcal{LA}, \mathcal{LC}, \mathcal{SC}, \Delta \rangle$.

The first element ($\mathcal{A}$) of the tuple identifies the participants of the institution. Next come the available roles ($\mathcal{J}$). Like InstAL, we distinguish two types of events ($\mathcal{E}$): exogenous ones for the actions of the participants that the institution recognises and the institutional events that place the exogenous event within context. The group also contains the violation events. ESI admits a variety of fluents ($\mathcal{F}$): we have domain fluents that represent the information about the world and normative fluents which include permission, power, obligation, role assignment, landmark and scene fluents. The first three of those are event fluents, indicating with is allowed, recognised and obliged to happen or not to happen. Role assignment indicates what role a certain agent is assigned. Landmark and scene fluent indicate which landmarks and scenes have been reached/accomplished. Each (recognised) event can change the state provided the change is specified by the consequence relation ($\mathcal{C}$). The $\mathcal{G}$ function "interprets" the exogenous events in the context of the institution. To deal with landmarks we have two functions. $\mathcal{LA}$ indicates the conditions on the state to achieve a landmark. $\mathcal{LC}$ determines the consequences of reaching a landmark. Scene transition is organised by $\mathcal{SC}$. When a landmarks or scene is completed, this function determines a new scene and or landmark to achieve, which is encoded as an obligation. Finally we have a set of fluents, Δ, that determine the initial state of the institution.

3. SEMANTICS

The state of the ESI framework changes as the consequence of single exogenous event. The ESI semantics for this process has three phases. The first phase is responsible for determining which fluents need to be initiated and terminated as a directed consequence of the occurrence of the exogenous event or one of its institutional counter-parts. This provides us with an intermediate state from which we can derive which landmarks were achieved (second phase). The third phase uses the newly achieved landmarks and occurred events to determine scene progression. Furthermore, it applies the effects of the landmarks and scenes and deals with state-based obligations.

Given a state δ, an exogenous event e_{ex} executed by an agent a, new state is obtained via $\mathrm{TR}(\delta, e_{ex}.a)$.

From a semantics point of view, we are not just interested in one state transition. We would to be able to examine the change of an institution over a period of time. This can we expressed as a sequence of exogenous events. An ordered trace is defined as a sequence of exogenous events and the executing agents $\langle [e_0, a_o], [e_1, a_1], \ldots, [e_n, a_n] \rangle$ with $e_i \in \mathcal{E}_{ex}, a_i \in \mathcal{A}, 0 \leq i \leq n$. Its evaluation starting is the sequence $\langle \delta_0 = \emptyset, \delta_1, \ldots \delta_{n+1} \rangle$ such that:

$$\delta_{i+1} = \begin{cases} \mathrm{TR}(\Delta^*, e_i.a_i) & \texttt{live} \in \delta_i \\ \delta_i & \text{otherwise} \end{cases}$$

with `live` indicating that the institution has been initialised.

4. RELATED AND FUTURE WORK

In this paper we presented ESI, a formal model for normative systems that combines state- and event-based norms.

While to our knowledge there is no other general institutional framework incorporating both event- and state-based concepts, few papers exist that point out the importance of combining event- and state-based views and include some of the concepts. One of these papers is [8]. Rather then looking at the normative specifications, the authors take the view of agents and combine information about acceptable methods of achieving a normative system goal/state. The work is strongly example-driven – the authors develop a framework to reason about delegation. In contrast to ESI their approach cannot be applied in normative systems in general.

In the NoA architecture [7] address the issue of reasoning about both event- and state-based norms from an agent's perspective. They present the concept of responsibility which can be understood both in terms of states as well as events. In contrast to our work, Kollingbaum et al.'s approach is from an agent's perspective and as such does not consider normative concepts such as roles, scenes or landmarks, which are however important when designing an institution. [2] follows a similar approach such as Kollingbaum et al., however instead of focusing on responsibility, they use the (conditional) commitments to translate events as well as states.

Looking at the future work, we plan to extend the formal model to be able to account for hierarchies of roles in order to ease the modelling of organizational structures. Furthermore we plan to develop one or more computational models for ESI. Following in the foot-steps of InstAL, we could opt for an answer set programming approach. We believe the mapping would be relatively straightforward.

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