Governing Government: A Framework for Multi-tier Institution Specification and Reasoning

(Doctoral Consortium)

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ABSTRACT

A key challenge of institutions is how to guide their governing into being desirable. This is important from the perspective of an agent governed by an institution to maintain specific rights, and of cross-institutional policies that require institutions' regulations to be coordinated (e.g. national legislations with supranational policy). This research addresses this problem by developing a framework for the specification and automated reasoning of institution governing institutions, in a hierarchical structure called multi-tier institutions, and automated revision of institutions for compliance. This automates guiding institutional designers towards desirable institutional specifications respecting autonomy and subsidiarity.

Categories and Subject Descriptors

[**Knowledge representation and reasoning**]: Logic programming and answer set programming

General Terms

Legal Aspects; Verification

Keywords

Normative Systems; Institutions; Higher-order Norms

1. INTRODUCTION

The automated specification of norms and institutions, has long been used to guide agents in multi-agent systems (MAS) towards desirable, coordinated and collaborative behaviour (see [1] for a review). This is crucial, since agents' inherent autonomy means there are no guarantees over their behaviour [10]. However, due to the autonomy of their designers, from some perspectives institutions are also liable to imposing undesirable norms.

For an agent being governed, their positive and negative rights are dictated by the norms institution(s) impose on themselves and others. In the wider-context of multi-institution systems, achieving cross-institutional goals requires coordinating institutions' regulations. This creates a problem of how to *guide* institutional design towards a desirable outcome, where institutional designers' autonomy makes *regimentation* impossible, which would in any case vi-

olate the principle of subsidiarity (what can be done at the local level, should be).

This research addresses this problem with a framework for representing and reasoning about multi-tier institutions where institutions govern other institutions. A multi-tier institution is composed from a tier-1 institution that governs and monitors an MAS with norms, a tier-2 institution that governs and monitors the norms the tier-1 institution imposes, and so on. The proposal consists of a formal framework precisely describing the representation and reasoning of multi-tier institutions, and a corresponding computational framework in Answer-Set Programming (ASP) [5] (see [7] for a preliminary version, implemented for a prototype crowdsourced mobile sensing system [6]).

This research is applied to crowdsensing systems, where human users are crowdsourced into providing environmental data [3]. This involves providing human users with a mobile sensing app, and guiding users' behaviour with an explicitly represented institution, such as a contract. The framework developed benefits this application area from two perspectives. First, by allowing users to define institutions to govern offered contracts, and the automated rejection and/or revision of contracts that would violate the rights they wish to maintain. Secondly, it supports composing a kind of crowdsensing system of crowdsensing systems. This is by crafting an over-arching 2nd-tier institution that guides the design of multiple 1st-tier institutions each governing different sets of users using different types of apps and providing wide-ranging types of data.

2. OBJECTIVES

This research aims to meet the following functional requirements. **R1**: the specification and reasoning about institutions governing institutions in a multi-tier structure. Decomposed into representing and reasoning about: **R1.1** conditional and temporal (higher-order) norms **R1.2** ideal and sub-ideal regulations, and **R1.3** automated monitoring of institutions. **R2**: an automated system for revising institutions to be compliant with other institutions. Decomposed into: **R2.1** Searches for all possible revisions for rectifying an example of non-compliance **R2.2** suggests revisions that adhere to the original design of the institution as much as possible.

Another objective is to evaluate the resulting framework. Firstly, through formalising multiple case-studies in the application domain [5–7]. Secondly, by producing a computational framework in ASP corresponding to the formal framework to demonstrate the proposal's feasibility. Finally, in the future by simulating an abstract form of multi-tier governance. This is to see to what extent it benefits the agents being governed (where institutions are used to govern the contracts agents might engage in), and the coordination
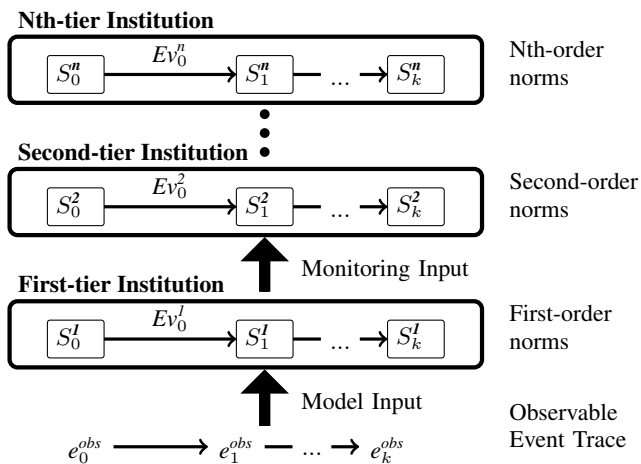
Nth-tier Institution

Figure 1: A Multi-tier Institution

of institutions to meet wider-reaching goals (where over-arching institutions are used to govern a multi-institution system).

3. FRAMEWORK

Figure 1 provides a schematic overview of the framework, fully described in [5], and overviewed in this section. The starting point of the framework's design was to see to what extent existing techniques in AI can be used to model multi-tier institutions. The InstAL framework [2] was found to already meet a number of preliminary requirements (reasoning about institutions governing MAS) and thus was built upon to produce a framework for multi-tier institutional representation and reasoning.

The formalisation of multi-tier institutions is inspired by mutitier governance in the social world (also known as vertical and multi-level governance [9]) and described as follows. At tier-1 an institution is specified that governs an MAS with first-order norms (norms about non-normative events and states). A second-tier institution governs the first-tier with second-order norms (obliging and prohibiting the norms of the first-tier institution). That is, each tier-i institution governs the tier below by imposing ith-order norms.

Given a multi-tier specification, the framework produces a model for a given sequence of events, user or computer generated, that can occur in an MAS. The model consists of an event-state sequence for each institution (see Figure 1), where each state describes the institutional facts (e.g. an agent is at a location) and norms (e.g. an agent is obliged to reveal their location) that hold for that institution. States are transitioned between by events, both those occurring in the MAS from the input sequence within the institution (e.g. a norm has been violated). This means, when an institution imposes higher-order norms that are violated by the imposition of norms by the institution below, a higher-order norm violation event occurs. Thus, the produced model of a multi-tier institution also reveals the compliance of institutions for a given sequence of events.

When non-compliance is revealed, a multi-tier model is used used as input for an existing Abductive Learning via Inductive Logic Programming (ILP) based automated norm-revision system [8]. This takes the institutional specifications and converts them into a form from which revisions for compliance can be learned. There are many possible revisions for compliance, the ILP-based system searches for the ones with the minimum cost (in this case, the number of changes to institutional rules). The suggested revisions can then be passed on to institutional designers as guidance for compliance.

4. FUTURE WORK

The research conducted has focused on the governing of institutions by other institutions with multi-tier specification, and automated monitoring and revision, to meet requirements **R1-2**. However, there are other aspects of hierarchical governance structures that are beneficial.

This leads us to identifying further functional requirements to be met with frameworks that modularly work together with the framework for multi-tier governance. The third requirement, **R3** is for automated specification and reasoning about institutions at different levels of abstraction, both formally (as in [4]) and computationally. This means, at higher-levels of authority more abstract aims should be expressible which lower-levels of authority can meet in a wide number of ways. The fourth requirement **R4**, is to produce a framework for the representation and reasoning about what to do when an institution is non-compliant (e.g. what punishments to enforce based on an institution's sub-ideality).

Acknowledgments

REFERENCES

[1] G. Andrighetto, G. Governatori, P. Noriega, and L. van der Torre. Normative Multi-Agent Systems. *Dagstuhl Follow-Ups*, 4, 2013.

[2] O. Cliffe, M. De Vos, and J. Padget. Answer set programming for representing and reasoning about virtual institutions. *Computational Logic in Multi-Agent Systems*, 4371:60–79, 2006.

[3] R. Ganti, F. Ye, and H. Lei. Mobile crowdsensing: current state and future challenges. *IEEE Communications Magazine*, 49(11):32–39, Nov. 2011.

[4] D. Grossi and F. Dignum. From abstract to concrete norms in agent institutions. In *Formal Approaches to Agent-Based Systems*, pages 12–29, 2005.

[5] T. C. King, T. Li, M. D. Vos, V. Dignum, C. M. Jonker, J. Padget, and M. B. V. Riemsdijk. A Framework for Institutions Governing Institutions. In *Proceedings of the 14th International Conference on Autonomous Agents and Multiagent Systems (AAMAS 2015)*, 2015.

[6] T. C. King, Q. Liu, G. Polevoy, M. de Weerdt, V. Dignum, M. B. van Riemsdijk, and M. Warnier. Request Driven Social Sensing (Demonstration). In A. Lomuscio, P. Scerri, A. Bazzan, and M. Huhns, editors, *Proceedings of the 13th International Conference on Autonomous Agents and Multiagent Systems (AAMAS 2014)*, Paris, France, 2014.

[7] T. C. King, M. B. V. Riemsdijk, V. Dignum, and C. M. Jonker. Supporting Request Acceptance with Use Policies. In *COIN @ AAMAS 2014 Pre-proceedings*, 2014.

[8] T. Li, T. Balke, M. De Vos, J. Padget, and K. Satoh. A model-based approach to the automatic revision of secondary legislation. In *Proceedings of the Fourteenth International Conference on Artificial Intelligence and Law*, pages 202–206. ACM, 2013.

[9] H. Liesbet and M. Gary. Unraveling the central state, but how? Types of multi-level governance. *American political science review*, 97(02):233 – 243, 2003.

[10] M. Wooldridge. *An Introduction to Multi-Agent Systems*. Wiley, 2002.

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[1]http://shine.tudelft.nl/