Modeling Institutions in Socio-Ecosystems

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Abstract

In socio-ecosystems, human activities are structured in time and space by interactions between different regulatory systems with different collective goals. These regulatory systems are modeled by institutions and organizations, and the regulatory mechanisms by norms applied to agents in Multi-Agent Systems (MAS). However, little is said about sharing resources, space and time. In particular, temporal and spatial expressivity is often limited in MAS for institutions and norms. This research proposes an institutional MAS model capable of representing multiple institutions and norms in the socio-ecosystem, in order to account for the multiplicity of interactions through agents, resources, space and time. We propose an extension of Descriptive Logic for the description of institutions and norms, and use Allen's algebra and the RCC8 to represent time and space. The resulting model allows us to know the norms applicable to an agent located socially, spatially and temporally.

1 Introduction

The socio-ecosystem encompasses a wide variety of constituent elements such as fauna, flora, humans, lakes, etc. The interactions between these elements are multiple and take place in time and space. The regulation systems of these interactions are diversified and are modeled by institutions in MAS, defining the norms applying to the agents. These regulative norms describe the desired behaviors of agents in a MAS [Dignum et al., 2004]. While the literature on institutional MAS focuses mainly on the structure of norms and their applications, the interactions between different institutions have been little explored. Similarly, the temporal parameter in norms has been little studied, and the spatial parameter has not yet been formalized in norms. This research proposes a model of institutional MAS adapted to socio-ecosystems, through an extension of the Description Logic (DL) designed to express norms in institutions and especially their interactions through resources, time and space. The proposed norm model takes into account space-time conditions. This model allows to describe an institutional MAS through a dedicated language, and to observe

the norms applicable to an agent according to its roles in the system, and its spatial and temporal coordinates. In the following section, we will describe our contribution: the model of institution and norm, then we will explain limits and values of the research, before concluding.

2 The Contribution

2.1 The Model of Institution and Organization

First, we chose the Interval Algebra [Allen, 1983] to represent time, and the Region Connection Calculus RCC8 [Randell et al., 1992] for the space. Reality is represented by a discourse domain containing computer objects to represent resources, regions, intervals and actions. Then we build on the definition of an institution in [Fornara et al., 2004] which describes an institution by the composition of an ontology and a set of norms. We propose that an institution is a set of words or concepts, typed by meta-concepts in terms of what they are talking about, by a set of norms, and assertions to define the concepts and associate them with the domain of discourse. Assuming that a context consists of an ontology of meta-concepts, atomic concepts, and assertions [Grossi et al., 2005a], the institution is thus a context to which we add the regulative norms. It is possible to inherit or import characteristics between institutions. The difference between institution and organization is based on the one described by [Fornara et al., 2013]. It considers the institution as a virtual entity that describes the norms and an ontology, and the organization describes who has to do it through the institutional roles that individuals take on, their goals and resources, as a physical entity. We propose that an organization represents a physical entity that implements the institution (e.g., The organization Antanambao implements the village institution). All the norms of the institution are applicable in the organization, but the organization can also have its proper norms. An organization that implements an institution must map the concepts of the institution to the objects of the discourse domain by the "count-as" relation which defines a constitutive norm [Grossi et al., 2005b] characterizing the organization. We then proposed an extension of DL to describe institutions and norms in the socio-ecosystem. This extension of the DL is characterized by the introduction of the meta-concept to type the concepts (e.g.

Monday is a concept whose metaconcept is time), the functions on a temporal or spatial concept to build others (e.g. before Monday), specific temporal and spatial relations inspired by interval algebra and RCC8 spatial algebra, the notion of action on a set of concepts set as parameters (e.g. the action cultivating must have a concept of plant as parameter), and the mapping of a concept to the objects of the discourse domain via the constitutive norm by the count-as relation (e.g. Paul counts as a farmer). Currently we are writing an article on this model of institution.

2.2 The Model of Norm

We chose the norm model in ADICO [Crawford and Ostrom, 1995] which encompasses the main constituent elements of a norm. We then formalized the expression of the normative condition by proposing a meta-model of conditions capable of accounting for actions, facts, time, and space, for a broader expressiveness of norms in the socio-ecosystem [Raharivelo and Müller, 2018]. It becomes possible to formalize a norm expression of the form: "In the area exteriorly connected to the lake and after winter, it is forbidden to a farmer to cultivate rice" in an institution "village". Let's consider an agent A which belongs to the organization "village of Antanambao" implementing "village", and situated in the interval "now" and at the region "here". This norm is applicable for A if A counts as a farmer for the organization, if "now" is included in "after winter", and if "here" is contained in "exteriorly connected to the lake". Thus, for any agent with a role in the system, located temporally and spatially, it is possible to find all the norms applicable to it after checking the conditions for each norm of each organization in which it belongs.

3 The Remaining Work, the Limits and the Values of the Work

Currently, our MAS institutional model is fully designed. We are finalizing the implementation of the dedicated language for describing an institution based on this model, using Model Driven Engineering, and we still have to model the case of forest management in Madagascar as a concrete example. Note that an institution is designed to describe norms; our institution model considers only the concepts used to express norms. Similarly, the organization considers only the objects used in the norms. The purpose of the research is limited to consulting all the norms applicable to an agent according to his social, temporal and spatial positions, despite the contradictions that may exist between these norms. The particularity of this model lies in its capacity to represent the sharing of resources between different institutions, and the formalization of factual, actional, temporal and spatial normative conditions. The model makes it possible to evaluate the impact of interactions in the system through the observation of applicable norms.

4 Conclusion

In this paper, we have proposed an institutional MAS model capable of representing the socio-ecosystem through a mul-

tiplicity of institutions and organizations described in DL. Norms are structured in the institution and their application is at the organizational level. An institution consists mainly of regulative norms, formulated according to concepts typed by meta-concepts, and possibly using assertions. Agents act in organizations, and an organization must implement an institution and define the correspondence between the concepts and the objects of the domain of discourse through constitutive norms, in order to determine the norms applicable to each agent. This model allows to formalize the multiplicity of discourses on the same objects and to obtain the norms applicable to an agent located socially, spatially and temporally. The list of these norms applicable to an agent can be taken into account when an agent makes a decision.

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References

[Allen, 1983] James F. Allen: Maintaining knowledge about temporal intervals. *Commun ACM* 26: 832–843, 1983.

[Crawford and Ostrom, 1995] Sue E.S. Crawford and Elinor Ostrom : A grammar of institutions. *Am Polit Sci Rev* 89: 582–600, 1995.

[Dignum et al., 2004] Virginia Dignum, Javier Vázquez-Salceda and Frank Dignum : *Omni: Introducing social structure, norms and ontologies into agent organizations*. Springer, pp181–198, 2004.

[Fornara et al., 2004] Nicoletta Fornara, Francesco Viganò and Marco Colombetti : *Agent communication and institutional reality*. Springer, pp1–17, 2004.

[Fornara et al., 2013] Nicoletta Fornara, Henrique L. Cardoso, Pablo Noriega, Eugénio Oliveira, Charalampos Tampitsikas and Michael I. Schumacher : Modelling agent institutions. In: *Agreement technologies*. Springer, pp277–307, 2013.

[Grossi et al., 2005a] Davide Grossi, Frank Dignum and John-Jules Ch. Meyer : *Contextual terminologies*. Springer, pp284–302, 2005.

[Grossi et al., 2005b] Davide Grossi, John-Jules Ch. Meyer and Frank Dignum: *Modal logic investigations in the semantics of counts-as*. ACM, pp1–9, 2005.

[Raharivelo and Müller, 2018] Sitraka O. Raharivelo and Jean-Pierre Müller: Un modèle de norme intégrant les conditions spatio-temporelles. In: *Distribution et Décentralisation - Vingt-sixièmes journées francophones sur les systèmes multi-agents, JFSMA 2018, Métabief, France, 10-12 Octobre 2018*. pp117–126, 2018.

[Randell et al., 1992] David A. Randell, Zhan Cui and Anthony G.Cohn : A spatial logic based on regions and connection. *KR* 92: 165–176, 1992.