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**COMMIT /** UNIVERSITY OF AMSTERDAM

## **Regulating Complex Adaptive Systems: Towards a Computational Model for Simulating the Effects of Rules**

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Complexity cannot be strictly defined, only situated in between order and disorder. A complex system is presented as a collection of interacting agents, representing components as diverse as people, cells or organizations. Because of the non-linearity of the interactions, the overall system evolution is to a substantial degree unpredictable and uncontrollable.

One of the research topics in the Multi-Agent Systems area is using models that represent social structures, such as a network of organizations that create alliances, to analyze more objectively the emergent behavior of such a regulated open system. In our research, we study the impact of rules that describe the expected behavior of actors in such system. For this, we model both the rules as well as some aspects of the behavior of the agents that are subjected to these rules. In our simulations we model complex networks that consist of many different actors that may represent individuals or organizations, which are related to each other by various types of relationships. Examples may be dependencies on goals, conflicts over resources and various beliefs. Legal rules bind the actors and because they are part of an organizational network (in this research a distributed network) they are bounded by a set of norms, including legal norms, contracts, and agreements. Obviously, actors may comply with the rules or not and being able to notice non-compliance and responding to it adequately is one of the reasons why we are interested in this research topic. The inherent complexity and unpredictability of this social society demand new kinds of coordination mechanism that focus on rapid joint responses and collective actions instead of centralized predictive planning. We present a multi-agent framework intended to explore the emergent behavior of a regulated complex system. Our approach is the result of ongoing investigations after the impact of regulations on social regimes, with the purpose of understanding social complexity as an emergent phenomenon floating on the characteristics of the models of the involved agents. In order to reduce the potentially infinite variance of individuals that are interacting in our real societies, we propose to apply canonical agents as an abstract model of agents. This will allow us to model the domain system with sufficient accuracy while being able to reduce the computational demands of our simulation. Our framework relies on agent-role modeling and simulation as a tool for examination the specific manifestations of emergent behavior. It proceeds along three steps. First, we explore how an institutional perspective can handle in our computational framework. Roles, institutions, and rules become components of the agent architecture. Second, we extend the agent architecture to address the problem of choosing an appropriate plan in an uncertain situation when an agent has to respond to and act upon uncertain, and incomplete information. Third, the resulting scenario representation

is synthesized as agent programs. These scripts correspond to descriptions of agent roles observed in a social setting.

The social intelligence of the agent is distributed to several cognitive modules that form the building blocks of our agent models. The agents are able to reason about the rules they and others are subjected to, using institutional reasoning. The outcomes of that process are coordinated in the agent's decision-making cycle. Our simulation environment allows us to analyze the impact of rules both the behavior of the individual, i.e. canonical, agents as well as the impact of their behavior on the social system they are part of.