Engineering Open Multi-Agent Systems as Electronic Institutions

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Abstract

In this demo we focus on the engineering of open multi-agent systems as electronic institutions. Electronic institutions are a formalism to define the rules which structure agent interactions, establishing what agents are permitted and forbidden to do. We present a set of tools that support the specification, analysis and execution of institutions, as well as the implementation of agents. Our methodology allows for a successive refinement approach to multi-agent systems engineering.

Introduction

Multi-agent systems (MASs, henceforth) are harder to design than centralised systems, and tools and methods to support their development are in urgent need. Specially when we consider open MAS populated by self-interested heterogeneous (human and software) agents representing different parties. Hence, it seems apparent the need for introducing regulatory structures establishing what agents are permitted and forbidden to do. We advocate that such regulatory structures can be defined as *electronic institutions* (or e-institutions for shorter) (Esteva 2003) that shape the environment wherein agents interact by introducing sets of artificial constraints that articulate their interactions. Engineering electronic institutions can be regarded as engineering environments (from totally open to normative) for open agent societies as illustrated in figure 1.

In this demo we present a method and support tools for engineering MAS based on the notion of electronic institutions. Next we detail the steps to be followed when engineering and subsequently executing institutions. Furthermore, in the demo we demonstrate the software tools that support all the steps from the specification of an institution to its final deployment.

In what follows we detail the different steps of our methodology, identifying which tool(s) give(s) support to each one (detailed and illustrated in figure 2):

1. *Electronic institution specification.* Electronic institutions can be graphically specified with the aid of ISLANDER (Esteva, de la Cruz, & Sierra 2002) (Best prototype paper award at the First Joint International Conference on Autonomous Agents and Multiagent Systems AAMAS 2002). It allows for the definition of a common ontology, all the interactions that agents may have, and the consequences of such interactions. The result is a precise description of the kinds and order of messages that the components of the MAS can exchange, along with a collection of norms to regulate agents' actions. The tool permits th graphical specification of some of the components, facilitating the work of institution designers. The specifications obtained using the ISLANDER editor are based on the formalisation of e-institutions presented in (Esteva 2003). Notice that the specification of an e-institution focus on the macro-level (societal) aspects of electronic institutions, instead of the micro-level (internal) aspects of agents.

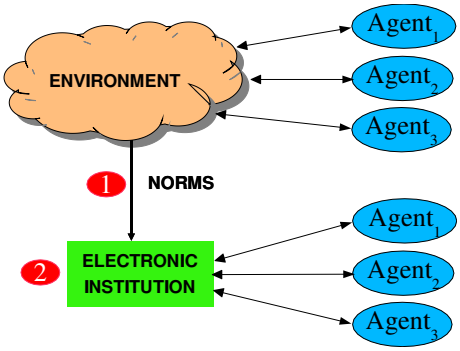

Figure 1: Open systems engineering. A vision

2. *Verification.* Once specified an institution, it should go through a verification process to verify it, before open it to participating agents. This step is twofold. There is a first verification process focusing on static, structural properties of the e-institution specification. A second verification process follows concerned with the expected dynamic properties of the e-institution at work.

   (a) The static verification of e-institutions amounts to checking the structural correctness of specifications. For instance, to check that interaction protocols are correctly specified. This process is also supported by the ISLANDER editor.

   (b) We advocate that the dynamic verification of e-

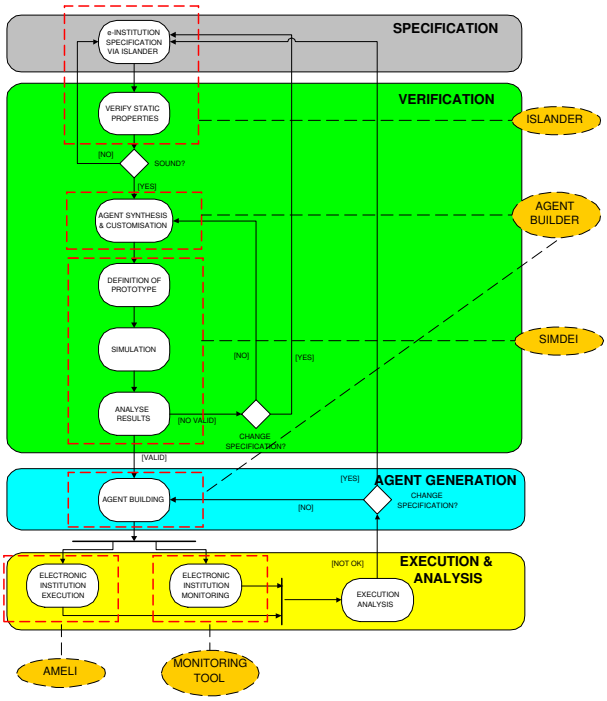

Figure 2: Overview of a Methodology for Engineering MASs

institutions should be done by means of simulation, with the aim of verifying the dynamic properties of the specified institution. This process starts with the definition of different types of agents for the specified institution. In order to facilitate this task we have developed an *agent builder* capable of generating, from a specification, an agent skeleton depending on the roles and interactions in which the agent may participate. In order to completely define an agent, the generated skeleton must be filled up by agent designers with decision making mechanisms. Once agents have been implemented, simulations of the e-institution can be ran using the SIMDEI simulation tool. This simulation tool for electronic institutions has been developed over REPAST (REPAST URL). It permits to run simulations with different populations of agents. The institution designer should analyse the results of the simulation and return to step one, if they differ from the expected ones.

3. *Agent generation.* Once the institution specification is validated, it can be make open for agent participation. At this points agent designers should must implement their agents. We want to remark that we do not impose restrictions on the type of agents which can participate in the institution. Agent designers can choose the language and architecture that is better to fulfil their goals, as well as, the use of any software tool that facilitates their work. However, we believe that it is important to give support to this process, and the agent builder can be used by agent designers in this stage to implement their agents. Nowadays the agent builder permits the development of agents in JAVA in a defined architecture. In next future we plan to extend it to permit to define agents in different languages and architectures.

4. *Execution & Analysis.* An electronic institution define a normative environment that shapes agent interactions. As an institution will be populated at execution time by heterogeneous and self interested agents we can not expect that this agents will behave according to the institutional ruled encoded in the specification. For this purpose, the institution is executed via an infrastructure which facilitates agents interactions while enforcing the institutional rules, the so-called *AMELI* (Esteva *et al.* 2003; 2004). The implemented infrastructure is of general purpose, as it can interpret any ISLANDER specification. Therefore, it must be regarded as domain independent, and it can be used in the deployment of any specified institution without any extra codification. The infrastructure keeps the execution state and uses it, along with the institution specification to validate the actions that agents want to undertake. Hence, the execution of the e-institution starts out by running the infratructure containing the specification. Thereafter, external agent may enter the institution and they can interact with other agents in the institution via the infrastructure. An institution execution can be monitored by a monitoring tool that we have developed. The monitoring tool shows in graphical interface the events occurring during the institution execution. It can be used for debugging the institution execution to detect agents' misbehaviours.

As a summary, we want to point out that in this demo we will show all the steps that lead from the institution specification to its execution and monitoring.

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REPAST URL. http://repast.sourceforge.net/.