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Engineering open environments with electronic institutions

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Abstract

Nowadays, with the expansion of Internet, there is a need of methodologies and software tools to ease the development of applications where distributed homogeneous entities can participate. Multiagent systems, and electronic institutions in particular, can play a main role in the development of this type of systems. Electronic institutions define the rules of the game in agent societies, by fixing what agents are permitted and forbidden to do and under what circumstances. The goal of this paper is to present EIDE, an integrated development environment for supporting the engineering of multiagent systems as electronic institutions.

Keywords: Multiagent system; Agent-oriented software engineering

1. Introduction

The promises and functionality that the proposals of open systems anticipated in the 1980s (e.g. (Hewitt, 1986) are now ever more pertinent for system development given the pervasiveness of IT and the added accessibility brought about by the World Wide Web. However, the challenges of building open systems are still considerable, not only because of the inherent complexity involved in having adequate interoperation of heterogeneous, independent, distributed, autonomous components, but also because of the significant difficulties of deployment and adoption of the amalgamated systems.

We have been developing a technology to address these challenges.

We do not claim to be dealing with open systems in their full complexity, but rather addressing a restricted—albeit significant enough—type of openness: that present in interactions that involve autonomous, independent entities that are willing to conform to a common, explicit, set of interaction conventions. We will call these *a-open systems*.[1]

For that type of open systems we have been engineering an artifact that focuses in the interactions and their compliance. We call it *Electronic Institutions* (EIs).

The idea behind EIs is to mirror the roles traditional institutions play in the establishment of "the rules of the game"—a set of conventions that articulate agents' interactions—but in our case applied to agents (humans or software entities) that interact through messages whose (socially relevant) effects are known to interacting parties. The essential roles EIs play are both descriptive and prescriptive: the institution makes the conventions explicit to participants, and it warrants their compliance.[2]

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[1]Openness is limited by the *adscription* to the conventions.

[2]In terms of Simon's engineering design abstractions, EIs are the—social—interface layer between the problem space the participating systems deal with, on one side, and the internal decision or functional intricacies of the various participating systems, on the other.

EIs, as artifacts, involve a conceptual framework to describe agent interactions as well as an engineering framework to specify and deploy actual interaction environments. In this paper we look into the EI artifact from a methodological perspective: we discuss the notions that underlie the conceptual framework and show how the system development process can be carried out with the ad hoc software tools we have developed. We have been developing the EI artifact for some time and advocating that open multiagent systems (MAS) can be properly designed and implemented with it, as witnessed by some of the group's publications (Noriega, 1997; Esteva et al., 2001; Rodríguez-Aguilar, 2001; Esteva, 2003). Our experiences in the deployment of applications as EIs, e.g. (Rodríguez-Aguilar et al., 1997; Cuní et al., 2004) make us confident of the validity of this approach.

In what follows, in fact, we will look into EIs as a framework for developing MAS. We do so for two reasons, first because a-open systems can be viewed as a type of MAS, where the entities that interoperate in the open system are simply thought of as agents. Secondly, because, in that light, some recent methodologies and conceptual proposals for MAS engineering are then relevant for a-open systems. Our approach, as we shall show, has things in common with some of those methodologies and conceptual proposals, however, we believe that it contributes to the engineering of this type of MAS through three salient distinctive features:

(1) It is socially centred, and neutral with respect to the participating agents internals and the application domain of their interactions.
(2) It has a uniform conceptual framework to manage components and interactions that prevails through the different views (high-level specification, implementation, monitoring, etc.) of a given system.
(3) It has an interaction-centred methodology that is embedded in a suit of software tools that support the system development cycle from specification to deployment.

In this paper we will illustrate how the EI framework can be used to engineer full-fledged a-open MAS. In Section 2 we discuss the ideas that constitute the conceptual EI framework and in Section 3 the tools we have developed to operationalise our methodology. In Section 4 we sketch an actual EI-based system that we developed using the EI artifact.

2. Electronic institutions

We mentioned, following North (1990), that traditional institutions can be viewed as "a set of artificial restrictions that articulate agent interactions". Analogously, when looking at computer-mediated interactions we think of EIs as a regulated virtual environment where the relevant interactions among participating entities take place.

This crude picture may become sharper by describing the theoretical components that operationalise it. We start by making some operational assumptions explicit:

(1) Participating entities are agents. In the accepted sense of being persistent, identifiable, communication-capable software or humans, capable of adopting commitments.
(2) Interactions are repetitive.
(3) All interactions are speech acts. That is, any and every interaction is—or is tagged by—a message that has some effect on the shared environment where agents interact.
(4) Only illocutions uttered by participating agents have effect on the shared environment.

All these are rather innocent assumptions whose basic purpose is to facilitate the definition of a regulated environment. Assumption 1 is simply a convenient use of terminology that turns EIs into a sort of MAS without loss of content either way. Assumptions 2–4, is what we have called the "dialogical stance" by which we conceive interactions as repetitive dialogues. This dialogical stance is mostly a conventional device that brings dialogical notions—and performatives—into our framework, it allows for a convenient intuitive descriptions of many EI features such as *scenes* and *performative structure* but it burdens other—like *scene transitions*—with some artificiality. Assumptions 3 and 4 are needed to operationalise the normative character of the interaction environment.

We may now get into clarifying what we mean by "relevant interactions in a regulated environment". In order to do that we will discuss the three constituent elements of our theory for EIs. Firstly, the *dialogical framework* that allows us to express the syntactic aspects of EIs, and the ontology of a particular EI. Then the two other elements that allow us to express the prescriptive aspects of EIs and, in particular, what the social effects of the speech acts are intended to be.

2.1. Dialogical framework

A traditional institution, say an auction house, restricts and gives meaning to interactions participants engage in, and sees to it that the consequences of any interaction that takes place within the institution actually happen. In an auction house, for example, if a good is being offered, the only action buyers can take is to rise their hand, indicating they take the bid; any other action is meaningless or inadmissible (and interpreted as a silent "no" to the bid). If a buyer wins a bid, the