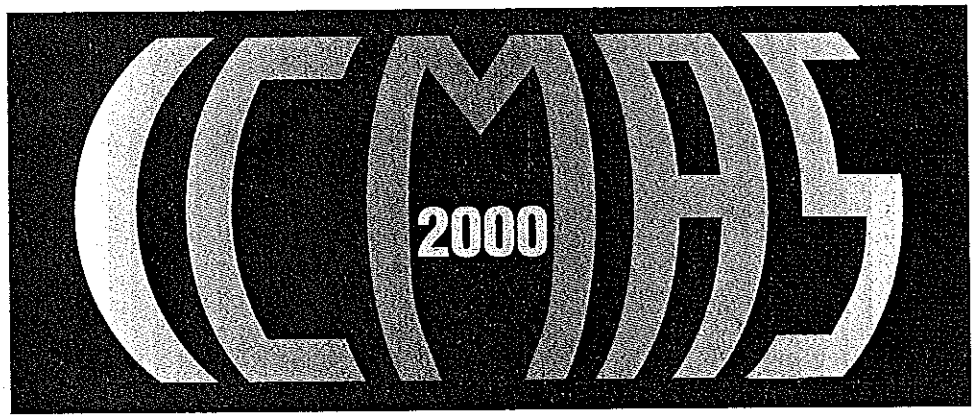

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Institutionalising Open Multi-Agent Systems

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Abstract

In this paper we argue that open agent organisations can be effectively designed and implemented as institutionalised electronic organisations (electronic institutions) *composed of a vast amount of heterogeneous (human and software) agents playing different roles and interacting by means of illocutions. Here we present the principal components that define an electronic institution.*

1. Introduction

Human organisations define the roles and responsibilities for organisational participants, who are expected to bring those into action depending on the task and environmental demands. Early work in DAI identified the advantages of organisational structuring as one of the main issues in order to cope with the complexity of designing DAI systems [2, 3, 6].

Recently there is a growing interest in incorporating organisational components into multi-agent systems. For instance, in [7] we find a methodology for agent-oriented design and analysis founded on the view of a system as a computational organisation consisting of various interacting roles.

We advocate for a methodological approach to build open multi agent systems based on the specification of the components of an electronic institution. In the next section we outline them. We focus on macro-level (societal) aspects of agents, not in their micro-level (internal) aspects. An extended description of the ideas presented can be seen in [1]

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2. Electronic Institutions. Fundamental Concepts

Our specification will be based on a purposely devised language enabled to produce graphical specifications of infrastructures for electronic institutions. Such specification language will serve to produce a sound and unambiguous specifications of the *rules* of an electronic institution. The infrastructure of electronic institutions will be automatically generated from the specifications in this language after a validation process. We have used the ideas presented here for developing an electronic auction house as can be seen in [4].

The core notions of our vision of electronic institution include:

- *Agents and Roles.* Agents are the players in an electronic institution, interacting by the exchange of illocutions, whereas roles are defined as standardised patterns of behaviour. The identification and regulation of roles is considered as part of the formalisation process of any organisation [5]. Any agent within an electronic institution is required to adopt some role(s). As dialogic actions are associated to roles, an agent adopting a given role is allowed to perform the actions associated to that role. A major advantage of using roles is that they can be updated without having to update the actions for every agent on an individual basis.

- *Dialogic framework.* The context or framework of interaction amongst agents of an institution, such as the objects of the world and the language employed for communicating, are fixed. In a dialogic institution, agents interact through illocutions. Institutions establish the acceptable illocutions by defining the ontology (vocabulary) —the common language to represent the "world"— and the common language for communication and knowledge representation. All of these contextual features are bundled together in what we call

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dialogic framework. By sharing a dialogic framework, we enable heterogeneous agents to exchange knowledge with other agents. Thus a dialogic framework must be regarded as a necessary ingredient to specify scenes, as shown below.

- *Scene.* Interactions between agents are articulated through agent group meetings, which we call *scenes*, with a well-defined communication protocol. More precisely, a scene defines a generic pattern of conversation protocol between roles. Any agent participating in the scene has to play one of its roles. A scene is specified as a graph where the nodes represent the conversation states and arcs are labelled with the expressions of the communication language that make the scene state evolve. Because we aim at modelling multi-agent conversations whose set of participants may dynamically vary, scenes will allow that agents either join in or leave at some particular moments during an ongoing conversation. For this purpose, we differentiate for each role the sets of access and exit states. A minimum and maximum number of agents per role are needed for the correct evolution of a scene. These values must be satisfied when agents join in or leave the scene.

- *Performative structure.* Scenes can be connected, composing a network of scenes which captures the relationships among them. Thus, while a scene models a particular multi-agent dialogic activity, more complex activities can be specified by establishing relationships among scenes. The performative structure allows to express, causal dependency between scenes, synchronisation of agents before join in or start scenes, parallelism, choice points and to establish the role flow policy among scenes. The specification of a peformative structure contains a description of how the agents depending on the role they are playing can legally move from scene to scene. Apart from the roles, the movements of the agents can be restricted depending on their past actions. There are constraints that agents must satisfy in order to move between scenes. A performative structure is to contain the multiple, simultaneous ongoing activities, represented by scenes. Agents within a performative structure may participate in different scenes at the same time with different roles. An agent participating in the execution of a performative structure devotes its time to jointly start new scene executions, to enter active scenes, to leave active scenes to possibly enter other scenes and finally to abandon the performative structure, that is, to abandon the institution.

- *Normative Rules.* Agent actions in the context of a scene may have consequences that either limit or enlarge its subsequent acting possibilities out of the scope of the scene. On the one hand, some actions introduce subsequent acting commitments that have to be interpreted as acting obligations. On the other hand, some actions within a scene have consequences on the paths that an agent can follow in the performative structure because they change the satisfaction or dissatisfaction of the constraints for moving between scenes. For instance, a buyer winning a bidding round in an auction house is obliged to go to the settlements office to pay for the good. He will not be allowed to leave the market until he pays. In other words, until he pays he will not satisfy the constraints for leaving the auction house.

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