

# ENVIRONMENT AS A FIRST-CLASS ABSTRACTION IN MULTIAGENT SYSTEMS<sup>1</sup>

Danny Weyns <sup>a</sup>                      Andrea Omicini <sup>b</sup>                      James Odell <sup>c</sup>

<sup>a</sup> *Katholieke Universiteit Leuven, Belgium*<sup>2</sup>

<sup>b</sup> *Università di Bologna, Cesena, Italy*

<sup>c</sup> *Intelligent Automation Inc., Ann Arbor, MI, USA*

## Abstract

The current practice in multiagent systems (MAS) typically associates the environment with resources that are external to agents and their communication infrastructure. Advanced uses of the environment include infrastructures for indirect coordination, such as digital pheromones, or support for governed interaction in electronic institutions. Yet, in general, the notion of environment is not well defined. Functionalities of the environment are often dealt with implicitly or in an ad hoc manner. This is not only poor engineering practice, it also hinders engineers to exploit the full potential of the environment in MAS. We put forward the environment as an explicit part of MAS. We give a definition stating that the environment in a MAS is a first-class abstraction with dual roles: (1) the environment provides the surrounding conditions for agents to exist, and (2) the environment provides an exploitable design abstraction for building MAS applications. Considering the environment as a first-class abstraction in MAS opens up new horizons for research and development in MAS.

## Defining the Environment as a First-Class Abstraction in MAS

Based on insights that we have derived from recent research on environments in MAS, we introduce the following definition of the environment:

*The environment is a first-class abstraction that provides the surrounding conditions for agents to exist and that mediates both the interaction among agents and the access to resources.*

First of all, this definition states that the environment is a *first-class abstraction*. This stresses the fact that the environment is a building block in MAS that encapsulates its own clear-cut responsibilities, irrespective of the agents. Second, the environment *provides the surrounding conditions for agents to exist*. This implies that the environment is an essential part of a MAS. The environment is first of all the part of the world with which the agents interact, and in which the effects of the agents will be observed and evaluated. Furthermore, to build a useful system out of individual agents, agents must be able to interact. On their own, agents are just individual loci of control. The environment is the glue that connects agents into a working system. The environment encapsulates and provides access to external entities and resources, and enables agents to interact. Third, the environment *mediates* both the interaction among agents and the access to resources. This states that the environment can be an active entity with specific responsibilities in MAS. The environment provides a medium for sharing information and mediating coordination among agents. As a mediator, the environment enables interaction and it constrains it.

Recognizing the environment as first-class abstraction promotes the environment to a design element that is considered explicitly and can be exploited creatively when building MAS applications. The environment can be assigned a custom set of responsibilities. Engineers can use agents as well as the environment to make a well-considered assignment of responsibilities according to the application requirements at hand. Allocating responsibilities among agents and the environment helps to manage the huge complexity of engineering real-world applications, and improves separation of concerns in MAS.

---

<sup>1</sup>This is an extended abstract of the original paper that is published in *Autonomous Agent Multi-Agent Systems* (2007) 14(1):5-30; DOI 10.1007/s10458-006-0012-0

<sup>2</sup>The first author is supported by the the Research Fund K.U.Leuven.