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Environments for Multi-Agent Systems

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Preface

The modern field of multiagent systems has developed from two main lines of earlier research.

Its practitioners generally regard it as a form of artificial intelligence (AI). Some of its earliest work was reported in a series of workshops in the US dating from 1980, revealingly entitled, "Distributed Artificial Intelligence," and pioneers often quoted a statement attributed to Nils Nilsson that "all AI is distributed." The locus of classical AI was what happens in the head of a single agent, and much MAS research reflects this heritage with its emphasis on detailed modeling of the mental state and processes of individual agents. From this perspective, intelligence is ultimately the purview of a single mind, though it can be amplified by appropriate interactions with other minds. These interactions are typically mediated by structured protocols of various sorts, modeled on human conversational behavior.

But the modern field of MAS was not born of a single parent. A few researchers have persistently advocated ideas from the field of artificial life (ALife). These scientists were impressed by the complex adaptive behaviors of communities of animals (often extremely simple animals, such as insects or even microorganisms). The computational models on which they drew were often created by biologists who used them not to solve practical engineering problems but to test their hypotheses about the mechanisms used by natural systems. In the artificial life model, intelligence need not reside in a single agent, but emerges at the level of the community from the nonlinear interactions among agents. Because the individual agents are often subcognitive, their interactions cannot be modeled by protocols that presume linguistic competence. The French biologist Grassé observed that these interactions are typically achieved indirectly, through modifications of a shared environment [1].

All interaction among agents of any sort requires an environment. For an AI agent whose interactions with other agents are based on speech act theory, the environment consists of a computer network that can convey messages from one agent's outbox to another agent's inbox. For an ALife agent, the environment is whatever the agent's sensors sense and whatever its effectors try to manipulate.

In most cases, AI agents (and their designers) can take the environment for granted. Error-correcting protocols ensure that messages once sent will arrive in due course. Message latency may lead to synchronization issues among agents, but these issues can be discussed entirely at the level of the agents themselves, without reasoning about the environment. As a result, the environment fades into the background, and becomes invisible.

Not so for ALife agents. Simon observed long ago that the complex behavior of an ant wandering along the ground is best explained not by what goes on inside the ant, but by what happens outside, in the structure of the ground over which the ant moves [2]. When a termite interacts with other termites by depositing

and sensing pheromones, the absorption and evaporation of the pheromone by the environment plays a critical role in the emergent structure of the colony's behavior. There are no error-correcting protocols to ensure that an agent who tries to push a rock from one place to another will in fact be able to realize that objective. From the ALife perspective, the environment is an active participant in agent dynamics, a first-class member of the overall system.

One happy result of the confluence of AI and ALife in MAS is the emergence of hybrid agents that draw on the best of both earlier traditions. This volume, and the workshop of which it is the archival record, is evidence of that hybridization. The agents described in these papers are not artificial ants constructed to test a biologist's theories about insect behavior, but components of systems engineered to fly airplanes, or analyze sensor data, or produce plausible human-like behavior in a video game. Like AI agents, many of them have cognitive, symbolic internal structures. Like ALife agents, all of them interact explicitly and deliberately with the environment through which they coordinate their behaviors.

The notion of the environment in MAS is still young, but the number of papers contributed to this volume suggests the potential of this concept for engineered systems, and their breadth sketches the broad framework of what a mature discipline of environments for multiagent systems might resemble. The entire life cycle of environmental engineering is represented here: conceptual models and languages for the design and specification of environments, simulation environments that admit environments as first-class objects, analysis of the role played by an explicit environment in agent coordination, and examples of full applications that exploit the power of an active environment. The introductory survey pulls these themes together to offer an integrated overview of this emerging discipline.

This volume shows the wide range of exploration typical of a nascent discipline as pioneers discover the best ways to frame problems and approach solutions. It will enable other researchers to take build on this body of initial exploration, and should form the foundation for a fruitful new set of tools and methods for developing multiagent systems.

[1] Grassé, P.P.: La Reconstruction du Nid et les Coordinations Interindividuelles chez Bellicositermes Natalensis et Cubitermes sp. La theórie de la Stigmergie: Essai d'Interpreétation du Comportement des Termites Constructeurs. Insectes Sociaux 6 (1959) 41-84
[2] Simon, H.A.: The Sciences of the Artificial. Cambridge, MA, MIT Press (1969)

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http://www.cs.kuleuven.ac.be/∼distrinet/events/e4mas/

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