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MAS Architectures Standardization

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Abstract

The dynamic nature of agent distribution motivates research by groups working on the standardization of dynamic collaborative multi-agent systems. Some of these groups are the Foundation for Intelligent Physical Agents (FIPA), the Object Management Group (OMG), the Knowledge-able Agent-oriented System (KAoS), and the General Magic group.

MAS Architectures Review

The design of computer programs as multi-agent systems presents a useful software engineering paradigm where systems are described as individual problem-solving agents pursuing high-level goals. Although having such an abstraction seems promising, its widespread adoption among system designers has not materialized yet. One reason is that MAS development is a technically difficult task. Efforts are challenged not only by known distributed programming issues, but also by the complexities associated with supporting agent collaboration.

If the agent-oriented paradigm is to succeed, systematic methodologies will be required for specifying and structuring applications as multi-agent systems. Once these methodologies are agreed upon, it will only be a matter of time until commercial MAS development toolkits emerge, and agent technology becomes accessible to a wide variety of software developers.

MAS Architectures Standardization

Although agent research started more than two decades ago, few efforts have been directed toward a definition of an acceptable MAS architecture. It is possible that one of the reasons for such an absence of consensus might be the common misconception in research circles that MAS architectures and frameworks need to be designed from first principles to match project requirements [39]. Although this approach might prove time efficient for individual projects, it certainly creates incompatible systems that are difficult to reuse from project to project. Therefore, one might expect that the widespread adoption of MAS technology will only begin after the formalization and standardization of architectures, mechanisms, and protocols supporting distributed interoperation of agents [35].

Recently, several independent industrial and research groups started to pursue the standardization of multi-agent technology. Prominent efforts, such as those of the Object Manager Group (OMG), the Foundation for Physical Agents (FIPA), the Knowledge-able Agent-oriented System (KAoS) group, and the General Magic group are briefly described below.

OMG's Model

The OMG group proposes a reference model as a guideline for the development of agent technologies [35]. This model outlines the characteristics of an agent environment composed of agents (i.e., components) and agencies (i.e., places) as entities that collaborate using general patterns and policies of interaction. Under this model, agents are characterized by their capabilities (e.g., inferencing, planning, and so on), type of interactions (e.g., synchronous, asynchronous), and mobility (e.g., static, movable with or without state). Agencies, on the other hand, support concurrent agent execution, security and agent mobility, among others.

FIPA's Model

The Foundation for Intelligent Physical Agents (FIPA) is a multi-disciplinary group pursuing the standardization of agent technology. This organization has made available a series of specifications to direct the development of multi-agent systems. Of particular importance are their Agent Management [12] and Agent Communication Language [13] specifications. FIPA's approach to MAS development is based on a "minimal framework for the management of agents in an open environment." This framework is described using a reference model (which specifies the normative environment within which agents exist and operate), and an agent platform (which specifies an infrastructure for the deployment and interaction of agents).

KAoS' Model

Another important standardization effort is pursued by researchers of the Knowledge-able Agent-oriented System [3] architecture. This system, which is also known as KAoS, is described as "an open distributed architecture for software agents." The KAoS architecture describes agent implementations (starting from the notion of a simple generic agent, to role-oriented agents such as mediators and matchmakers), and elaborates on the interactive dynamics of agent-to-agent messaging communication by using conversation policies.

General Magic's Model

General Magic is a commercial endeavor researching mobile agent technology for electronic commerce. Conceptually, this technology models a MAS as an electronic marketplace that lets providers and consumers of goods and services find one another and transact business. This marketplace is modeled as a network of computers supporting a collection of places that offer services to mobile agents. Mobile agents, which are entities that reside in one particular place at a time, have the following capabilities [36]:

- they can **travel**, to move from one place to another
- they can **meet** other agents, which allows them to call one another agent's procedures
- they can create **connections**, to allow an agent to communicate with another agent in a different place
- they have **authority**, which indicates the real-world individual or organization that the agent represents
- they have **permits** to indicate the capabilities of agents

Conclusions

The multi-agent system paradigm promises to be a valuable software engineering abstraction for the development of computer systems. In addition, the wide adoption of the Internet as an open environment and the increasing popularity of machine-independent programming languages, such as Java, make the widespread adoption of multi-agent technology a feasible goal.

Consequently, it might pay off to invest some time to read and understand key concepts on this area. Most serious readings about agents are compilations of research papers previously published in specialized conferences and workshops. The technical nature of these articles makes it difficult for the uninitiated reader to coherently integrate the information presented to form a high-level framework. Therefore, the motivation for this article was to provide readers with a global perspective on the research literature on multi-agent systems.

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