

# Self-Adjustable Autonomy in Multi-Agent Systems

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## Introduction

Multiagent systems provide a new approach to conceptual modeling for problem solving. However, they present several complex problems for conceptual modeling. These problems have been well defined in (Gasser 1990):

- How does the conceptual model express the relationships among parts of the system?
- What mechanisms of abstraction, specialization and composition account for lower- and higher-order collection of parts and behaviors?

These questions have led to a wide variety of research disciplines. To make concrete these various research disciplines, several distributed architectures have been proposed. However, the use of these distributed architectures requires a very complex parametrization. This complexity is the result of the type of problem resolution which is founded on negotiation. Negotiation is one of the most important concept of the proposed architectures. The main characteristic of negotiation is its incompatibility with efficiency.

The aim of our proposal is to introduce an adaptive multiagent model. We focus our work on the organization of agent groups, on the way that a multiagent system adapts its structure in order to produce emergence of groups. Such system leads the way its organizational process at various granularity levels. We call this system an *adaptive system*.

This paper is concerned with the extension of an operational agent architecture (called DIMA) to model adaptive multiagent systems. It first describes this architecture. Then it describes the proposed multiagent model.

## DIMA: An agent architecture

DIMA is a modular and generic architecture which owns the main properties of an agent (Wooldridge & Jennings 1995), it realizes the extension of the single behavior of an active object into a set of behaviors (Guessoum & Dojat 1996). DIMA (see Figure 1) relies on a first layer made up of interactive modules which represent the different concurrent agent behaviors such as communicating, reasoning and perceiving. They provide the agents

with some properties described in (Wooldridge & Jennings 1995) such as autonomy, reactivity and sociability. To manage the different behaviors, DIMA provides

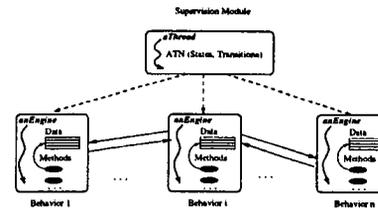


Figure 1: The DIMA agent architecture

a higher level supervision module which can be seen as the agent meta-behavior. This latter represents the agent pro-activity.

## Various Kinds of Organizations

DIMA and very other similar architectures (see for example TouringMachine (Ferguson 1992)) provide the designer with several categories of organizations:

- The reactive systems where each environment event is considered as a stimulus which activates a correspondent action. There is a causal relationship between the external events and the actions.
- The perceptive systems where the events are considered as complex facts. The system builds a symbolic internal representation of its environment. This representation is used to reason on new and unknown events.

Another important but unusual category is the *adaptive systems*. An adaptive system is active for and on itself, with its own organization. It is situated in an environment that it evaluates. It has an action structure and an organization that give a semantics to the situatedness compartment. The system knows that it is different from its environment, it has an organization and an identity that it controls according to its projects (which it defines) and a representation of its environment.

Most existing architectures are well suitable to develop the two first categories of organization (reactive

and perceptive) but they can not be easily extended to develop the last category (adaptive systems). In the following section, we propose a new multiagent model to develop adaptive systems.

## An Adaptive DIMA Architecture

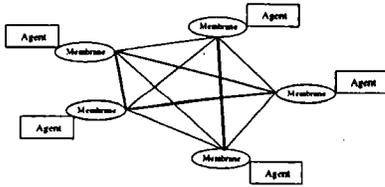


Figure 2: An adaptive multi-agent system structure. The width of lines reflects the weight of the relation between the related agents

An adaptive multiagent system (SMA) is a set of agents which form a net (for example, as defined with the previous version of DIMA) and a set of social membranes (see Figure 2). Membranes can be real or virtual and adapt dynamically the organization to the environment requests. The environment has an active role in the resolution. It is not a simplified simulation of the real environment.

In such systems, the interaction with the world may be performed by a reciprocal adaptation, without exchanging information. We call this process the *operational enclosure*.

Each multi-agent system is a set of agents which form a net as defined with the previous version of DIMA and a set of social membranes (see Figure 2). The environment has therefore an active role in the resolution. It is not a simplified simulation of the real environment but an active entity which a structure and a behavior.

### Agents and Membranes

Each agent is provided with a social membrane that allows him to share some social resources with the other agents of the system and more precisely its group(s). This membrane is a limit to the organizational transformations of the various components of the adaptive system. It makes transformations by committing the operational enclosure and transmits the action to the external universe. Each agent membrane represents therefore the agent social commitment and the potential deployment. Each modification of this membrane, which can be the result of the organization modification, affects the agent state and reciprocally. It defines the main features of the agent organization and acts on the latter. The evolution of these membranes are one of the main causes of the agent reproduction. The set of membranes of the multi-agent system defines an oriented graph. The dynamic of this graph defines the organization modification. Each membrane represents a node of the graph and the arc represents the dependence between two membranes. Only the arc with a

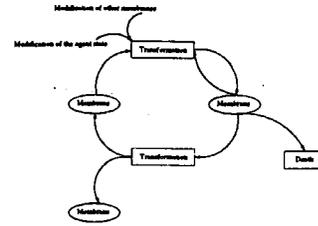


Figure 3: The temporal evolution of a membrane

weight which is over a given threshold are retained. Each related component of the whole graph forms a group.

## Conclusion

Each developed multiagent system is defined as a set of agent and if necessary an environment which is a set of passive objects. These agents can exchange data and knowledge by the communication. Moreover, commitments are represented as the individual agent knowledge and facts. The problem solution is the result of the aggregated set of actions of the individual agents. So, the solution is functional, it does not emerge from the agent organizations. To integrate social commitments, various systems proposed agent models and self-descriptions to embed socially-based conceptual models of commitments. So, the problem resolution is based on negotiation and the solution quality is fully constrained by the self-description model. Agents need therefore to exchange a very wide quantity of knowledge and facts to resolve the problem.

To resolve this problem, we proposed a new multiagent model which incorporates social and organizational reconfigurations, and it does not treat the individual agents as the only unit of analysis. Rather, the organization representation would be the unit of analysis and commitments would be the relations between the organization units.

We are currently implementing the proposed adaptive multiagent model as an extension of DIMA with the validation on real-life applications.

## References

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