Chapter 2.9
Engineering Adaptive Multi–Agent Systems:
The ADELFE Methodology

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ABSTRACT

This chapter introduces the ADELFE methodology, an agent-oriented methodology dedicated to the design of systems that are complex, open, and not well-specified. The need for its development is justified by the theoretical background given in the first section, which also gives an overview of the concepts on which multi-agent systems developed with ADELFE are based. A methodology is composed of a process, a notation, and tools. Tools are presented in the second section and the process in the third one, using an information system case study to better visualize how to apply this process. The last part of the chapter assesses strengths and limitations of ADELFE. We note that its main strength is also its main limitation—it is a specialized methodology, especially suited to the development of software with emergent functionalities.

INTRODUCTION

Usually, classical design of computational systems requires some important initial knowledge in the

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sense that the exact purposes of the system and every interaction to which it may be confronted in the future have to be known. However, at the same time, today's problems are becoming more and more complex (e.g., information searching on the Internet, mobile robots moving in the real world). Indeed, systems that are able to deal with such problems are also becoming open and complex; they are immersed in a dynamical environment; they are often incompletely specified and, especially, an a priori known algorithm does not exist to find a solution. Classical approaches then become inadequate and a new way to tackle such problems is necessary.

Our research work, for several years now, has essentially focused on these kinds of systems and has led us to propose *Adaptive Multi-Agent Systems* (AMAS) as an answer (Camps, Gleizes, & Glize, 1998; Capera, Georgé, Gleizes & Glize, 2003; Gleizes, Georgé & Glize, 2000; Piquemal-Baluard, Camps, Gleizes, & Glize, 1996). These systems are composed of agents that permanently try to maintain cooperative interactions with others. We have built, with success, several systems based on the use of adaptive agents in different areas. To ease and promote this kind of programming, we then developed the ADELFE methodology, the aim of which is to help and guide designers when developing AMAS.

The remainder of this section briefly presents the foundation of adaptive multi-agent systems and then explains how to implement adaptation in such systems. After that, the main characteristics of ADELFE, as well as the context of its presentation, are given.

Theoretical Background: Adaptive Multi-Agent Systems

In a general way, when conceiving a system, a designer wants it to realize the right function; the system must be "functionally adequate." But openness and dynamics are sources of unex-

pected events and an open system plunged into a dynamic environment has to be able to adapt to these changes, to self-organize. If every component of a system is endowed with the capability to locally rearrange its interactions with others, this ability of self-organization at the lowest level permits changes in the global function without coding this modification at the upper level of the system. Self-organization is a means to make the system adapt but also to overcome complexity. If a system is complex and its algorithm unknown, it is impossible to code its global function. This function has then to emerge at the macro level (the system level) from the interactions at the micro level (component level). Moreover, this global function cannot be known at the component level, and a component just needs some local criteria to rearrange its interactions. A proven theorem on functional adequacy says that "For any functionally adequate system in a given environment, there is a system having a cooperative internal medium which realizes an equivalent function" (Camps, Gleizes, & Glize, 1998, p. 8). In other words, it is sufficient to build a system whose components have a cooperative attitude to make it realize an expected function. Cooperation is the local criterion that enables a component to find the right place within the organization and that ensures that the system taken as a whole is functionally adequate.

Highly relevant to our work in the agent domain, this theory has been mapped onto multi-agent systems[1] giving rise to what we call Adaptive Multi-Agent Systems (AMAS).

Implementation of Self-Organization: Cooperative Agents

Any agent in an AMAS follows a specific lifecycle that consists of three steps:

- The agent gets perceptions from its environment;

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