2. Multi-Agent Systems

2.1 Introduction

The interest for multi-agent systems (MASs) has grown increasingly in the last years. These systems are beginning to be used in a great variety of applications such as air traffic control, process control, manufacturing, electronic commerce, patient monitoring, or games. This appeal is due to the fact that multi-agent systems present very attractive means of more naturally understanding, designing and implementing several classes of complex distributed and concurrent software. This growing attention to multi-agent technology has been even more accentuated with the increase of internet computing, which integrates an underlying infrastructure presenting a space organization in which autonomous agents roam and interact with one another.

Nevertheless, as a consequence of their popularity, the terms "*autonomous agents*" and "*multi-agent systems*" are often misused. It is indeed not rare to find software described in these terms, although it is not necessarily correlated with multi-agent technology. Therefore, we have to clarify what autonomous agents and multi-agent systems really are, how they can be modeled, designed and implemented.

This chapter is organized as follows. In sections 2.2 and 2.3, we present what are autonomous agents and multi-agent systems. On this basis, we discuss in section 2.4 MAS modeling by proposing an explicit integration of the interaction setup of a MAS and by sustaining a distinction between subjective and objective coordination. Then, section 2.5 exposes our target class of systems. Finally section 2.6 discusses how practical MASs can be built and concludes by maintaining the use of coordination models and languages for the design and the implementation of MASs.

2.2 What Is an Autonomous Agent?

The debate on what constitutes an autonomous agent is still under way. As a large range of agent types exist, it is obvious that a lot of descriptions have been proposed, without, however, reaching a commonly accepted definition. This section nevertheless sketches the fundamental characteristics of

M. Schumacher: Objective Coordination in MAS Engineering, LNAI 2039, pp. 9–32, 2001.

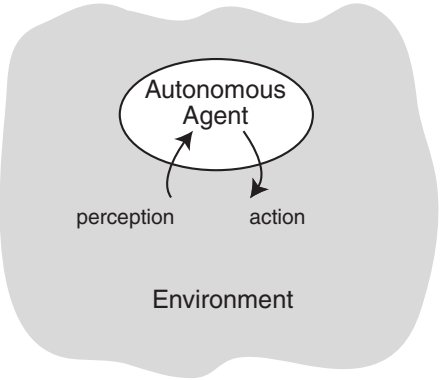

Fig. 2.1. An autonomous agent and its environment.

what most research understands with an autonomous agent by presenting the definition we adhere to and by discussing a wide-spread definition.

2.2.1 Definitions

Wishing to avoid the formulation of a new definition and being conscious of the difficulty of the task due to the wide variety of existing agent paradigms (see for instance [Mae95]. [HR95]. [BT96]. [JSW98]), this section proposes to adopt a proposal of Franklin and Graesser [FG96].

After having analyzed several agent proposals, Franklin and Graesser give a definition, which is similar to that of Beer [Bee95]. They explain the essence of an autonomous agent as follows:

> *An autonomous agent is a system situated within and a part of an environment that senses that environment and acts on it, over time, in pursuit of its own agenda and so as to effect what it senses in the future.*

This definition is further explained:

> *Each agent is situated in, and is part of some environment. Each senses its environment and acts autonomously upon it. No other entity is required to feed its input, or to interpret and use its output. Each acts in pursuit of it's own agenda. (...) Each acts so that its current actions may effect its later sensing, that is its actions effect its environment. Finally, each acts continually over some period of time.*

This definition shows that the notion of *situatedness* within an environment is an essential concept: the agent can sense its surrounding (receive sensory input) and act upon it so as to change it. Furthermore, the response