Multi-Agent System: An Introduction to Distributed Artificial Intelligence

Jacques Ferber
Harlow: Addison Wesley Longman
1999
Paper: ISBN 0-201-36048-9

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This edition is a translation of the book formerly published in French in 1995 (*Les systèmes multi-agents: Vers une intelligence collective*, Inter Editions, Paris.) Even now, it is still the main reference for the French research community in multi-agent systems (MAS). The book is intended to be both a state of the art text and an introduction for people who are interested in capturing the main ideas of MAS. It deals mainly with the theoretical background, antecedents and applications. I will present a summary of the main ideas and the points that the author highlights as novel features arising from the multi-agent approach to computer science. When some details are very well developed in the book, I will just refer to them, since they are mainly useful for people who actually want to apply the techniques.

The book begins with a long introduction that sketches the historical origins of MAS research (mainly stating that Decentralised Artificial Intelligence is a complement to Artificial Intelligence and Artificial Life). Ferber gives a minimal definition of an agent and of an MAS, so that all branches of multi-agent research can accept it

> An agent can be a physical or virtual entity that can act, perceive its environment (in a partial way) and communicate with others, is autonomous and has skills to achieve its goals and tendencies. It is in a multi-agent system (MAS) that contains an environment, objects and agents (the agents being the only ones to act), relations between all the entities, a set of operations that can be performed by the entities and the changes of the universe in time and due to these actions.

When the book was first published, there were some debates about which kind of MAS should be built. A classical opposition was drawn between reactive and cognitive agents: cognitive agents are those that can form plans for their behaviours, whereas reactive agents are those that just have reflexes. Ferber tries to show how both approaches can converge in the end, while emphasising different aspects: one kind of research focuses on the building of individual intelligences whose communication is organised, whereas the other imagines very simple entities whose co-ordination emerges in time without the agents being conscious of it. In fact, a huge number of different schools of MAS persist, all coming from different theoretical backgrounds. These include the American DAI school (Lesser, Gasser, Sycara), the Rational Agents branch (Rao and Georgeff, Shoham, Castelfranchi), the branch focusing on Speech Acts (Finin), on Petri nets (Estraillier), the Reactive Agents branch (Brooks, Steels, Drogoul, Ferber, Demazeau) and those focusing on learning (Weiss and Sen). These researches, although having different points of view, are very complementary, and each have their own applications.

The main application of multi-agent systems at the moment can be listed as follows:

- **Problem Solving**: As an alternative to centralised problem solving, either because problems are themselves distributed, or because the distribution of problem solving between different agents reveals itself to be more efficient way to organise the problem solving - it can be flexible and allow failures in the system - or because, in some cases, it is the only way to solve the problem.
- **Multi-Agent Simulation**: Simulation is widely used to enhance knowledge in biology or in social science and MAS gives us the possibility to make artificial universes that are small laboratories for the testing of theories about local behaviours. Examples include *Simdelta* (Cambier and Bousquet) and in *SimPop* (Bura).
- **Construction of Synthetic Worlds**: These artificial universes can be used to describe specific interaction mechanisms and analyse their impact at a global level in the system. The entities that are represented are usually called animats, since they are mainly inspired by animal behaviours (hunting, searching or gathering habits). The aim of this research is to have societies of agents that are very flexible and can adapt even in cases of individual failure. (For example, when robots are sent on an expedition and they are required to be very independent from the instructions they could receive.)
- **Collective Robotics**: Defining the robots as a MAS where each subsystem has a specific goal and deals with that goal only. Once all the small tasks are accomplished the big task is too. MAS approaches can also be used in the co-ordination of

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