Chapter 7

A Collective Can Do Better

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Can we devise simple solutions to complex problems? Is it possible to do so by making use of elemental modules, which when collaborating create emerging intelligence? The answer is yes. No complex mathematical models are required. Nature offers a variety of techniques that lend themselves well to solving complex problems making use of simpler atomic entities. Insects, for instance, as individuals are very simple, but in a collective they are powerful systems able to solve very complex tasks. This chapter describes how the insect world can inspire engineers and computer scientists to devise simple solutions to complex problems. After all the simplest solution is always the best.¹

1 Introduction

Nature demonstrates that complex behaviour can emerge from the interaction of simpler living creatures. Ants, bees, wasps are well known examples of insect species that through cooperation build organised societies. Can this emerging intelligence be reproduced to solve complex problems, usually solved with complex mathematical models? It is possible when simple elemental modules are devised to interact intelligently. Intelligence can indeed emerge either directly through direct communication between modules dedicated to sub-

¹One should not increase, beyond what is necessary, the number of entities required to explain anything, Occam’s Razor, and nature is as simple as it gets.
problems, or indirectly by means of a common space available for all modules to share their experience in order to achieve better performance as a whole system.

Nature offers good examples. Ants and bees in the real world solve difficult problems, not as individuals but as a collective, providing a holistic solution through simple communication and cooperation. In nature communication among insect species occurs through the secretion of chemicals, each one having a different purpose, to convey a different type of message. Individual insects secrete minute quantities of pheromone to exchange information with insects of the same species (Hölldobler and Wilson 1995). Other insects detect the information and join in the effort to accomplish a task, for example finding the shortest path to a food source.

Computer scientists have worked on models of intelligence of varying degree of complexity for decades now. The idea of storing information in a common repository is not uncommon. Initial models of the human mind were mimicked by rule-based systems, where emerging but predictable functionality was built on rules and meta-rules. Learning was added later on, allowing, for instance, for real time generation of rules and meta-rules (Giarratano 1998). In the early 80s blackboard systems were introduced, where knowledge sources operate on data and information stored on the blackboard, a common repository. No direct communication between knowledge sources was allowed only through the blackboard system. Distributed blackboard systems were also devised to create a pervasive layer over an array of processors capable of spawning a large number of processes. A flavour of the 90s was the agent paradigm, introduced to make smaller, modular and more portable individual units, capable of solving specific tasks and collaborating through more or less complex ontologies to solve complex problems.

The common denominator of all techniques presented in the Computer Science and Artificial Intelligence literature are simplicity,