Modelling Dynamically Organised Colonies of Bio-Entities

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Abstract. The dynamic nature of biological systems' structure, and the continuous evolution of their components require new modelling approaches. In this paper it will be investigated how these systems composed of many dynamic components can be formally modelled as well as how their configurations can be altered, thus affecting the communication between parts. We use two different formal methods, communicating X-machines and population P systems, both with dynamic structures. It will be shown that new modelling approaches are required in order to capture the complex and dynamic nature of these systems.

1 Introduction

Biological systems are modelled in different ways depending on the aim of the model. There are models trying to exhibit the general behaviour of the system based mainly on continuous approaches. In this way a generic description of the system's behaviour is defined in terms of mathematical functions evolving in time. Another perspective is based on individual components interacting toward achieving certain goals. In this latter case an emergent property of the system, not obvious from the components' behaviour, is mostly envisaged. For example the behaviours of the social insects are directed towards the benefit of the colony as a whole, and this is done through self-organisation and specialisation. Local interactions with other insects, and with the environment produce solutions to problems that colonies face. No one insect in the colony can give a picture of the whole environment, but information can be learnt through interaction. Bees, for example, can determine how busy a colony is when they bring nectar to hive. Instead of passing all this onto one bee (who will distribute it), small portions of nectar will be passed onto many bees. The bee can determine how busy the hive is by calculating how long it has to wait to pass nectar onto another bee [11].

This perspective on modelling biological systems is investigated in this paper and mainly relies on describing components as agents. An agent is a fairly