OPERAS for Space: Formal Modelling of Autonomous Spacecrafts

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Abstract

We present OPERAS, a formal method that facilitates the development of biologically inspired multi-agent systems exhibiting emergent behaviour through self-organisation. We describe how a particular version of this method, namely $OPERAS_{XC}$, could employ and integrate the most prominent characteristics of finite state machines and biological computation systems, such as X-machines and P Systems respectively. We apply this method to formally model a system reported by NASA, which consists of autonomous spacecrafts in a mission for exploring asteroids.

1 Introduction

Throughout the past years, there has been an increasing interest towards biological and biologically inspired systems, particularly with the intent to create software systems that model the behaviour of their biological counterparts (ants, termites, bees, flocks of birds, tumours etc). The motivation behind the development of such software systems varies. In our discipline, the understanding of how nature deals with various problematic situations has inspired problem solving techniques that are applicable to a wide range of situations. Swarm Intelligence and Ant Colony Optimisation techniques have been successfully applied to robotics [Dorigo et al., 2004] and DNA computing [Paun et al., 1998]. Other unconventional, biology inspired computational models [Gheorghe, 2005] can solve NP-complete problems.

These systems can be directly mapped to multi-agent systems (MAS) by considering each entity as an agent. The overall system's behaviour is merely the result of the agents' individual actions, their interactions among them and the environment. This also points to self-organisation and how collective behavioural patterns emerge as a consequence of individuals' local interactions in the lack of knowledge of the entire environment or global control.

The more complex a MAS is, the more difficult to ensure correctness at the modelling level. Correctness implies that all desired properties are verified at the end of the