

Chapter 14

A System Approach to Describing, Analysing and Control of the Behaviour of Agents in MAS

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ABSTRACT

The Petri nets (PN)-based analytical approach to describing both the single agent behaviour as well as the cooperation of several agents in MAS (multi agent systems) is presented. PN yield the possibility to express the agent behaviour and cooperation by means of the vector state equation in the form of linear discrete system. Hence, the modular approach to the creation of the MAS model can be successfully used too. Three different interconnections of modules (agents, interfaces, environment) expressed by PN subnets are introduced. The approach makes possible to use methods of linear algebra. Moreover, it can be successfully used at the system analysis (e.g. the reachability of states), at testing the system properties, and even at the system control synthesis.

INTRODUCTION

If it is possible to believe in different encyclopaedias, Aristotle (384-322 B.C.E.) is considered to be the author of the sentence: “The whole is more than the sum of its parts”. Indeed, usually it is true that people working together often can accomplish tasks that could not be done working separately. Nowadays, this idea is evolved in science especially in modelling, analysing, management and control of complex systems as well as in the theory of multi

agent systems (MAS). Especially, the synergy of subsystems in complex systems (as well as agents in MAS) and the emergent behaviour of the complex system and/or MAS in the whole are in the centre of interest at present research in different branches of science. To realize these ideas, actual methods of cybernetics along with those of system theory (Takahara and Mesarovic, 2004) are utilized arm in arm. System theory represents (Bale, 1995) a framework at description and analysing any group of objects that work in concert to produce some result. It studies complex systems in nature, society, and science. With respect to the fact that system

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theory is interdisciplinary field of science, the system approach can be used also for modelling and analyzing MAS of different kinds – software agents, social agents, different kinds of material agents e.g. robots, devices in manufacturing systems (like machine tools, automatically guided vehicles), etc. Inventing or contriving the idea of management, or explanation and formulating it mentally have its origin in system theory. Namely, the nature of management may be conceptualised (Charlton and Andras, 2003) from a perspective of systems theory as the process by which an organisation generates a global representation of its own processes. In other words, management depends upon modelling. Modelling allows management to perform its distinctive information-processing activities such as monitoring, evaluation, prediction and control. The purposes to which these activities are directed, define the function of management. This function is a product of the interaction between a management system and its environment. This is a consequence of the simple fact that management systems will tend to adapt in order to survive and grow (in whatever specific context in environments). For a human organization (such as a company or enterprise, hotel, hospital and so on) the environment can include different aspects – e.g. physical (like climate, location, etc.), organisational (depending on law, politics, etc.) and others. Here, management systems are a form of social organizational system. To manage and/or control complex systems and MAS in general, the cybernetics aspect is very important too. Namely, cybernetics study feedback and derived concepts such as communication and control in living organisms, machines and organizations. Hence, methods of cybernetics can be widely utilized in order to study cooperative interactions among subsystems of complex systems as well as among agents in MAS. In this chapter the principles of both system theory and cybernetics are put to use. The abstract systems based on Petri nets (PN) and digraphs are used at mathematical modelling the subsystems and/

or elementary agents and groups of them as well as at analysing their behaviour. The methods of cybernetics are used here at control synthesis by means of simultaneous utilizing the straight-lined and backward development of system dynamics. The strong connection between system theory and cybernetics is illustrated on several examples from technical area. The agent based approach can also model (to a certain extent) environment as one of the cooperating agents. This can be exploited especially in management systems. The management aspect of the system theory is illustrated by an example of the negotiation process of two companies.

Agents are (Fonseca *et al.*, 2001) persistent (software, but not only software) entities that can perceive, reason, and act in their environment and communicate with other agents. MAS are usually apprehended as a composition of collaborative agents working in shared environment. In such a way the agents together perform a more complex functionality. Communication among the agent in MAS enables the agents to exchange information. Consequently, the agents can coordinate their actions and cooperate with each other. The agent behaviour has a character of discrete event system (the system driven by occurrence of discrete events). Namely, such a system persists in a given state (e.g. a kind of activity) till then when an occurrence of a discrete event forced it to change the state into another one (e.g. to finish or abort the previous activity and to start another one). The agent behaviour involves both internal and external attributes. While the external attributes are (Demazeau, 2003) that the agent (i) evolves in an environment; (ii) is able to perceive this environment; (iii) is able to act in this environment; (iv) is able to communicate with other agents; (v) exhibits an autonomous behaviour, the internal attributes of the agent are that it encompasses some local control in some of its perception, communication, knowledge acquisition, reasoning, decision, execution, and action processes. The internal attributes character-

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