Holons: Autonomous and Cooperative Agents for Industry

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1. INTRODUCTION

Recently, there has been growing interest in the holonic approach to the development of complex industrial and business systems. Motivated by the need to enable these man-made systems to adapt to disturbances while maintaining system stability and efficient use of resources, holonic systems were inspired by Arthur Koestler's early observations of the structure and behavior of living organisms and social organizations [3].

Like multi-agent systems (MAS), holonic systems are composed of self-reliant units that are capable of flexible behavior. More specifically though, a holon can be thought of as a special type of agent that is characteristically autonomous, cooperative and recursive, that populates a system where there is no high-level distinction between hardware and software.

Although both approaches share many basic concepts, research in each area has been conducted independently for the most part. Holonic systems research has primarily focused on intelligent manufacturing systems and has been organized around the international Holonic Manufacturing Systems (HMS) consortium [2]. In contrast, MAS research is much broader in scope, focusing generally on the development of systems in which "data, control, expertise or resources are distributed; agents provide a natural metaphor for delivering system functionality; or a number of legacy systems must be made to interwork" [4]. As a result, various groups and consortia have emerged to tackle research issues in this area such as the AgentLink consortium, the International Foundation for MAS, and the Foundation for Intelligent Physical Agents (FIPA).

This workshop focuses on the close relationship between the concepts of multi-agent and holonic systems. For example, the analogous concepts of the HMS "cooperation domain" (i.e., "a logical space in which holons operate, which provides the context within which holons may locate, contact and interact with each other" [2]) and the FIPA "agent domain" (i.e., "a logical grouping of agents/services defined by membership of a directory maintained by the directory facilitator" [1]) have emerged independently from both the holonic systems and multi-agent systems communities.

The intent of the workshop is to provide an opportunity for researchers to meet and discuss the best holonic approaches as well as identify similarities and differences between holonic and multi-agent systems. In particular, the workshop brings together industrial and academic researchers to report on the latest advances in holonic systems and discuss the major issues in this area. The two main themes of the workshop are: (1) how and why holons differ from agents, and (2) industrial applications of autonomous, cooperative agents (i.e., holons).

2. THE PAPERS

The papers selected for this workshop demonstrate the wide range of research that is currently being conducted on industrial applications of multi-agent and holonic systems. The first paper, "Holonic enterprise as an information ecosystem" by Ulieru et al., provides a general overview of this area. In this paper, the authors discuss the research challenges present at the various levels of a manufacturing enterprise, and then suggest how multi-agent and holonic systems approaches can be applied to realize an enterprise-wide solution.

The next four papers focus on general holonic and agent-based design principles that can be used to develop the holonic enterprise described by Ulieru et al. First, Valckenaers et al. discuss multi-agent coordination and control, and in particular, indirect coordination of multi-agent systems in their paper "Stigmery in holonic systems." Fletcher et al. next look at general holonic systems modeling concepts in "Principles underpinning a unified architecture for holonic manufacturing systems" then extend these principles to the realm of real-time control in "A philosophy for modeling agent-based manufacturing". Finally, in "Organization of social knowledge in multi-agent systems" Marik et al. investigate how social knowledge is maintained in a multi-agent system and propose a knowledge-based model of agents' mutual awareness.

The final four papers describe the application of holonic and agent concepts to specific industrial problems. First, Wada and Okada present a prototype holonic system that uses autonomous and mobile agents to determine resource allocation in a manufacturing test-bed in "Towards holonic manufacturing systems: an autonomous agent approach." Next, Shen proposes a combined genetic algorithm-based search and agent-based negotiation approach for scheduling manufacturing systems in "Integration of agent-based approaches with genetic algorithms for manufacturing scheduling." In "Agent-based dynamic scheduling of surface mount technology production facilities" Rogers and Kan next present their work on the application of an agent-based dynamic scheduling system in the electronics manufacturing industry. Finally, Xu and Norrie describe a modeling approach that is used to handle timeliness issues in real-time manufacturing control systems in "Real-time task control model for holonic systems."

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