

**AN AGENT-ORIENTED METHODOLOGY FOR
HYBRID INTELLIGENT SYSTEM CONSTRUCTION**

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CERTIFICATE OF AUTHORSHIP/ORIGINALITY

I certify that the work in this thesis has not previously been submitted for a degree nor has it been submitted as part of requirements for a degree except as fully acknowledged within the text.

I also certify that the thesis has been written by me. Any help that I have received in my research work and the preparation of the thesis itself has been acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

Signature of Candidate

To My Wife Aiyun and Our Lovely Son Kan

Abstract

In recent years, both researchers and practitioners have recognised the advantages of applying the agent-based paradigm to the development of hybrid intelligent systems (HIS). Yet, the number of deployed commercial agent-based hybrid intelligent applications is small. One of the reasons for this is the lack of practical methodologies for agent-based hybrid intelligent applications development.

The aim of this thesis is to overcome this limitation. We have devised an agent-oriented methodology, called MAHIS (standing for *Methodology for constructing Agent-based Hybrid Intelligent Systems*). To avoid building MAHIS from scratch, we have followed the strategy of extending an existing well-known methodology in order to bridge the gap between the existing methodology and agent-based HIS construction. MAHIS has extended the capabilities of MAS-CommonKADS in agent-based HIS development. It is suitable for constructing agent-based HIS, as well as analysing and designing any *open systems* with hierarchical structure. *Open system* in this thesis means that the system allows for dynamic addition or removal of agents at run-time.

MAHIS consists of eight models: *Hybrid Strategy Identification Model*, *Organisation Model*, *Task Model*, *Agent Model*, *Expertise Model*, *Coordination Model*, *Reorganisation Model*, and *Design Model*. These models are grouped into three levels: *conceptualisation*, *analysis*, and *design*. Both the *Hybrid Strategy Identification Model* and *Reorganisation Model* are newly developed models rather than from MAS-CommonKADS. At the same time, some existing models have

been improved accordingly. The *Reorganisation Model* is the key model to support HIS and any *open systems* with hierarchical structure. It consists of *category role*, *group roles*, *virtual organisation role*, and *dynamics rules*. This model describes the hierarchical, dynamic, reusable, and unpredictable characteristics of HIS with *virtual organisation*, *category*, and *group* perspectives. Some previously developed agents can be reused by means of involving them in a new *virtual organisation* dynamically. The output of the *Reorganisation Model* is the specification of the dynamic platform which comprises middle agents and makes all agents and agent groups hierarchical and dynamic.

A dynamic platform PAHIS (*Platform for Agent-based Hybrid Intelligent Systems*) has been developed. PAHIS not only verified the capability of MAHIS in dynamic platform construction, but also can be used as an infrastructure of agent-based HIS. It supports the dynamic addition and removal of group-based agents at run-time. A self-organising ring-based architectural model has been developed to organise middle agents in PAHIS. Moreover, the ring-based architectural model has been evaluated from the viewpoints of complexity, efficiency, extendibility, and availability. The ring-based architectural model is competent in agent-based systems with middle agents.

The verification of MAHIS in HIS construction has been conducted by two successful case studies: "financial investment planning system" and "petroleum reservoir characterisation system". The former has verified MAHIS in constructing agent-based HIS with tight-coupling hybrid strategy. The latter has verified MAHIS in constructing agent-based HIS with loose-coupling hybrid strategy. PAHIS has been employed in these two systems.

The evaluation of MAHIS with the enriched evaluation framework which was originally proposed by Cernuzzi and Rossi has been completed by comparing it with Gaia and MAS-CommonKADS. The *reorganisation attributes* have been added into the evaluation framework. The evaluation results have indicated that MAHIS is preferable over Gaia and MAS-CommonKADS, especially in the construction of agent-based HIS.

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List of the Publications

The following is a list of my research papers published in referred international conference proceedings or journals during my PhD study at University of Technology, Sydney (UTS):

1. Chunsheng Li, Zili Zhang, and Chengqi Zhang, A platform for dynamic organisation of agents in agent-based systems, in *Proceedings of the 2004 IEEE/WIC International Conference on Intelligent Agent Technology*, Beijing, China, 2004, 454-457.
2. Chunsheng Li, Li Liu, and Qingfeng Song, A practical framework for agent-based hybrid intelligent systems, *Asian Journal of Information Technology*, Vol. 3 (2), 2004, 107-114.
3. Chunsheng Li, Dan Cheng, and Chengqi Zhang, A platform to integrate well-log information applications on heterogeneous environments, in *Proceedings of the 2nd International Conference on Information Technology and Applications*, Harbin, China, 2004, 265-270.
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