

# An Efficient Heuristic Search in a Large Multi-Agent System\*

Cheng-Gang Bian, Wen Cao, Gunnar Hartvigsen

Department of Computer Science  
 Institute of Mathematical and Physical Sciences  
 University of Tromsø, N-9037 Tromsø, Norway  
 bian@stud.cs.uit.no, cao@cs.uit.no, gunnar@cs.uit.no

We are investigating the cooperative behavior of intelligent agents in a large group. A cooperative intelligent agent is a user's personal consultant that can take care of problems the user got, and solve them either by itself or via cooperation. We have proposed a *twin-base* (cooperator-base  $\oplus$  task-base) agent modeling technique for individual agents to monitor activities of the others in order to achieve efficient cooperation in a small agent group (Cao, Bian, & Hartvigsen 1996) (Cao, Bian, & Hartvigsen 1997a). While the group grows in size and complexity, an activity-oriented hierarchical organization structure, *club-community-society*, has been studied (Cao, Bian, & Hartvigsen 1997b). In this organization, each agent shows its activities to the outside world, and these activities are symbolic categories for the *twin-base* guided heuristic searches in peer locating processes.

ance and dual roles of cooperation traders (cooperative agents and virtual group managers). Generally, a heuristic search uses knowledge about the problem to guide the search process. For example, to locate a peer agent in a large multi-agent system, a *best-first* heuristic search will traverse the path (B1-B2-B3-B4-B5-B6) to locate the target  $\oplus$  (Figure 1). With the *twin-base* technique, individual agents and their traders have knowledge about all members in their cooperative groups. As such, upon receiving a task beyond its capabilities, an agent first tries to locate peers directly from its *twin-base*; if not, it invokes a heuristic search by having *twin-base* as the intelligent guide. In this sense, when an agent needs help from peer agents in another club which belongs to different communities, the agent first consults its club trader (A1). Since the club trader can not find peers in its *twin-base*, it passes the request to community trader for further consulting (A2). The community trader retrieves a club trader where peers might be situated, and this club trader is requested to return the address of peer agent  $\oplus$  to the original asker via related traders (A3). As we can see (Figure 1), this heuristic search saves nearly 50% search cost of a normal *best-first* heuristic search.

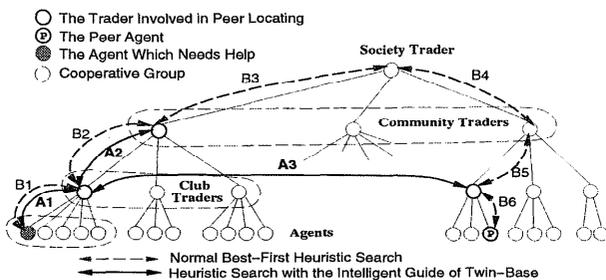


Figure 1: Two Different Heuristic Searches

Experimental results have shown that the *twin-base* agent modeling approach achieves efficient cooperation in a small agent group (Cao, Bian, & Hartvigsen 1997a). By organizing agents into an activity-oriented hierarchical structure, we argue that agents perform efficient heuristic searches because of the *twin-base* guid-

\*This work is partly supported by the Research Council of Norway (Grant no. 112577/431).

Copyright © 1997, American Association for Artificial Intelligence (www.aaai.org). All rights reserved.

## References

Cao, W.; Bian, C. G.; and Hartvigsen, G. 1996. Cooperator-Base  $\oplus$  Task-Base for Agent Modeling: the Virtual Secretary Approach. In *Proceedings of Agent Modeling Workshop, AAAI'96*. AAAI Press.

Cao, W.; Bian, C. G.; and Hartvigsen, G. 1997a. Achieving Efficient Cooperation in a Multi-Agent System: the Twin-Base Modeling. In *Proceedings of Cooperative Information Agents, CIA'97*. Lecture Notes in Artificial Intelligence 1202, Springer.

Cao, W.; Bian, C. G.; and Hartvigsen, G. 1997b. An Organizational Approach to Efficient Cooperation in An Agent Society. In *poster Proceedings of MAA-MAW'97*. Forthcoming.