

# EXPLOITING THE ENVIRONMENT FOR COORDINATING AGENT INTENTIONS

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## Abstract

One interesting family of MAS applications is characterized (1) by their large scale in terms of number of agents and physical distribution, (2) by their very dynamic nature and (3) by their complex functional and non-functional requirements. This family includes a.o. manufacturing control, traffic control and web service coordination. For this family, the complexity of the software for the individual agents using traditional BDI-approaches is overwhelming. In this paper, we present an innovative approach to BDI which alleviates agent complexity through “delegate MASs”, which use the environment and its resources to obtain BDI functionality. Delegate MASs consist of light-weight agents, which are issued either by resources for building and maintaining information on the environment, or by task agents in order to explore the options on behalf of the agents and to coordinate their intentions. We describe the approach, and validate it in a case study of manufacturing control. The evaluation in this case study shows the feasibility of the approach in coping with the large scale of the application and shows that the approach elegantly achieves flexibility in highly dynamic environments. This paper is a two-page discussion introducing a more extensive paper, accepted for publication in the E4MAS 2006 postproceedings .

## 1 Introduction

BDI agents have internal representations of their beliefs, desires and intentions. A challenging aspect of the applications addressed in this paper is that the community of agents has to account for the internal states of other agents in an n-n fashion (multiple agents affect multiple agents in non-trivial manners). Explicit and comprehensive information exchange through direct interaction amongst the agents leads to information and communication overload, especially if planning into the (near) future is required.

The research in this paper uses the environment as a medium to account for this: the agents delegate to the environment parts and aspects of the representation of their beliefs and their intentions. This results in a normalization in which information and knowledge is represented only once throughout the multi-agent system, and in which the representations benefit from the knowledge of multiple sources.

By locating (part of) their beliefs in the environment, agents avoid exposure to specific and dynamic properties of the world-of-interest. The delegate MAS is a mechanism, which guarantees computational efficiency, for the agents to consult this decentralized and shared world model. Dynamism is handled by evaporate-refresh mechanisms.

By propagating their intentions in the environment, agents introduce into the beliefs (world model) of the affected agents, including themselves, the implications and consequences of their intentions. Moreover, these intentions are transformed during this process into knowledge and information that reflects not only what the originating agent knows but merges this with the knowledge in the environment and even of affected agents. The propagation by means of a delegate MAS again guarantees computational efficiency.

The remainder of this short introduction to the more extensive paper discusses the illustration in multi-agent manufacturing control.

## 2 Delegate MAS for Manufacturing Control

The development and application of a delegate MAS has been pioneered for manufacturing control. Figure 1 shows a simple case (for more information, see: [www.mech.kuleuven.be/benchmarking](http://www.mech.kuleuven.be/benchmarking)). The manufacturing system comprises four workstations, a rail-based transporter and a warehouse. The GANTT-charts at the workstations are part of the externalized – delegated to the environment – beliefs and intentions. They are short-term forecasts of the resource utilization, which have been constructed based on intentions that were propagated by task agents.

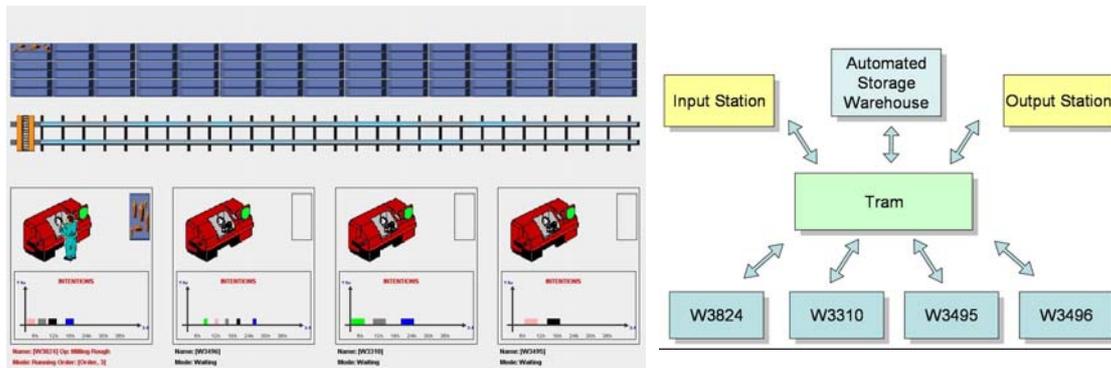


Figure 1: The sample manufacturing system and the corresponding graph in the MAS environment.

Figure 2 shows how the lightweight ant agents of the delegate MAS travel along the graph in the MAS environment. During their travel these agents query the local experts about expected behavior and book time slots on the resources corresponding to the intentions of the agent that created them. Figure 2 also shows how exploring ant agents use the environment as part of the beliefs of the agent that created them. They observe and analyze the decentralized and shared world model to discover possible and attractive ways to execute manufacturing tasks.

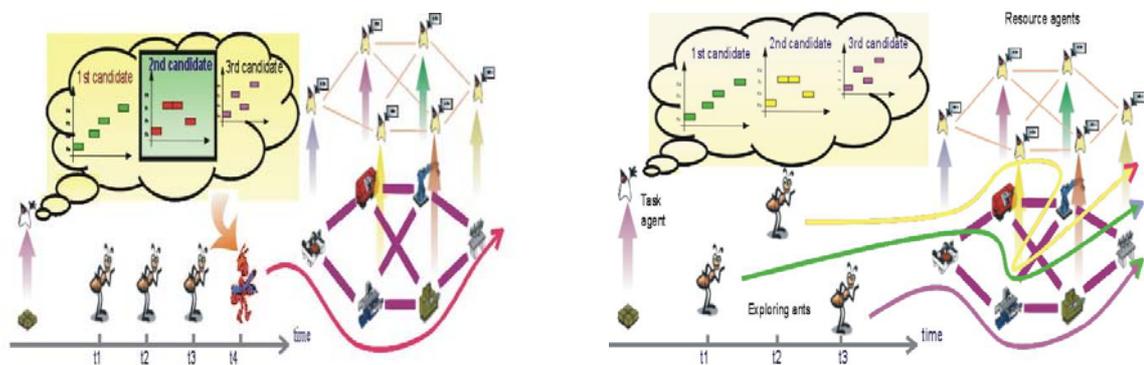


Figure 2: The delegate MAS propagating intentions and exploring for solutions respectively.

By repeating the exploration and intention propagation activities unremittingly, the delegate MAS observes the changes and disturbances in the system with a minor delay. This allows the control system to handle the dynamics. Delegation ensures that the ant agents in a delegate MAS benefit from the local self-knowledge of the environment entities and corresponding agents. This permits the MAS to handle heterogeneity, which is a real challenge in manufacturing, very well.

## Acknowledgements

This paper presents work funded by the Research Fund of the K.U.Leuven (Concerted Research Action on Autonomic Computing for Distributed Production Systems).