SIMBA: An Approach for Real-Time Multi-agent Systems

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Abstract. The use of the agent/multi-agent system paradigm has increased sharply as an important field of research within the Artificial Intelligence area. In recent times, the application of this paradigm seems appropriate for solving complex problems which require intelligence and bounded response times. This paper presents SIMBA : an architecture based on ARTIS agents as its main component for the development of real-time multi-agent systems. The ARTIS agent architecture guarantees an agent response that satisfies all its critical temporal restrictions in a real-time environment. The main feature of SIMBA systems is their applicability for complex, distributed, real-time domains. The architecture allows the communication among agents taking into account their hard temporal restrictions.
In order to show the use of systems of this kind, the paper describes the design of a multi-agent system for the distributed intelligent control of a residential building.

Keywords: agents, multi-agent systems, real-time AI.

1 Introduction

Over the last few years, the application of the agent / multi-agent paradigm in real-time environments arises from the required capacities of new real-time systems. This paradigm attempts to incorporate flexibility and distribution in new real-time designs. A *Real-Time System (RTS)* is a system in which the correctness of the system depends not only on the logical result of computation, but also on the time at which the results are produced [15]. It is well-known that a RTS is formed by a set of tasks characterised by a deadline, a period, a worst-case execution time and an assigned priority. A *deadline* defines the greatest time interval in which the system can provide a response. If the response is obtained after this time, it will probably not be useful. Researchers differentiate between two types of RTS. The first, called *Hard Real-Time System*, is a RTS where the execution of a task after its deadline is completely useless. Systems of this kind are critical systems and if timing responses are not satisfied, this will result in severe consequences. The second, called *Soft Real-Time System*, is characterised by the fact that the execution of a task after its deadline only decreases the

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quality of the task result [16]. Different techniques are needed for hard and soft RTS.

On the other hand, a multi-agent system which involves several agents that collaborate towards the achievement of a joint objective is viewed as a team of agents. Most proposed teamwork structures [10] [3] rely on agents in a multi-agent system to negotiate and/or contract with each other in order to initiate team plans. However, in dynamic, real-time domains with limited communication, complex negotiation protocols may take up too much time. Therefore, these protocols are not suitable for time-bounded problems.

Our work has been focused in time critical environments in which the full system can be controlled by autonomous agents that need communication to improve the system goal. This focus motivates the introduction of Social Real-Time Domains. In such domains, agents need to act autonomously while still working towards a common system goal. Time-critical environments require real-time response and, therefore, they eliminate the possibility of excessive communication among agents.

According to these concepts, it is possible to define a *Real-Time Agent* as an agent with temporal restrictions. These restrictions may be hard, soft or both. A real-time agent should guarantee its temporal restrictions and, concurrently, it should try to accomplish its goals. Finally, if a real-time agent is included as a component of a multi-agent system, this system can be considered as a *Real-Time Multi-Agent System*. It is important to highlight that the agent may have its interactions bounded. This modification will affect all the communication processes in the multi-agent system.

An architecture for a real-time multi-agent system is presented in this paper. The proposal is called SIMBA (Multi-Agent System Based on ARTIS) and it constitutes a significant extension of the ARTIS agent architecture approach for real-time environments [2]. SIMBA can be seen as a set of ARTIS agents and their interactions. This proposal increases the applicability of the ARTIS agent architecture for problems where a multi-agent approach is more suitable than a centralised one.

The rest of the paper is structured as follows: section 2 focuses on the features of social real-time domains. Section 3 presents an overview of the SIMBA architecture for real-time environments and its main component, the ARTIS agent. Section 4 goes into the communicative aspects of this type of agents. In section 5, an intelligent building management system is described as an example. Finally, some conclusions are mentioned in section 6.

2 Social Real-Time Domains

We define a social real-time domain as a domain with the following characteristics:

– There is a team of autonomous agents $\mathcal{A}$ that collaborate to achieve a common long-term goal $\mathcal{G}$.