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SPADES
A System for Parallel-Agent, Discrete-Event Simulation

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■ Simulations are an excellent tool for studying AI. However, the simulation technology in use by, and designed for, the AI community often fails to take advantage of much of the work in the larger simulation community to produce stable, repeatable, and efficient simulations. I present SPADES (SYSTEM FOR PARALLEL-AGENT DISCRETE-EVENT SIMULATION) as a simulation substrate for the AI community. SPADES focuses on the agent as a fundamental simulation component. The "thinking time" of an agent is tracked and reflected in the results of the agents' actions. SPADES supports and manages the distribution of agents across machines while it is robust to variations in network performance and machine load. SPADES is not tied to any particular simulation and is a powerful new tool for creating simulations for the study of AI.

Main System Features

Simulations are an excellent tool for studying AI. They can allow the systematic modification of parameters of the environment, execute the large number of trials often required for machine learning, and facilitate the interaction of agents created by different research groups. On the one hand, many general simulation environments do not address the special concerns of the AI community, such as the computation time of the agent being an integral part of its behavior. On the other hand, many simulators created in the AI community fail to take advantage of the vast work in the simulation community for designing stable, repeatable, and efficient simulations.

This article discusses SPADES, the system for parallel-agent discrete-event simulation.[1] The system is designed to support simulations for the AI community without being tied to any particular simulated world. SPADES provides support for simulations with agents running in parallel across multiple machines and for the tracking of the computation time used by these agents. By taking advantage of work in discrete-event simulation, the middleware eases the design of a simulation by taking care of many of the system details required to handle distribution in an efficient and reproducible way.

Some primary features of the system are the following:

First is agent-based execution, including explicit support for modeling latencies in sensation, thinking, and acting. Agents are explicit, fundamental components of the system. The use of the word *agent* here refers to a software entity that has an explicit sense-think-act cycle interaction with the world. These components can overlap in time, and SPADES explicitly allows for this overlap.

Second, agents can be distributed among multiple machines. Distribution across machines can increase the pace of the simulation.

Third, the result of the simulation is unaffected by network delays or load variations among the machines. The efficiency of the simulation can be affected by these factors, but the results of the simulation are not. This is in sharp contrast to the SOCCER SERVER, the current simulator for the RoboCup simulation league (Noda et al. 1998).

Fourth, the architecture for the agents is unconstrained and does not require that the agents be written in a particular programming language. Unlike other systems that track the

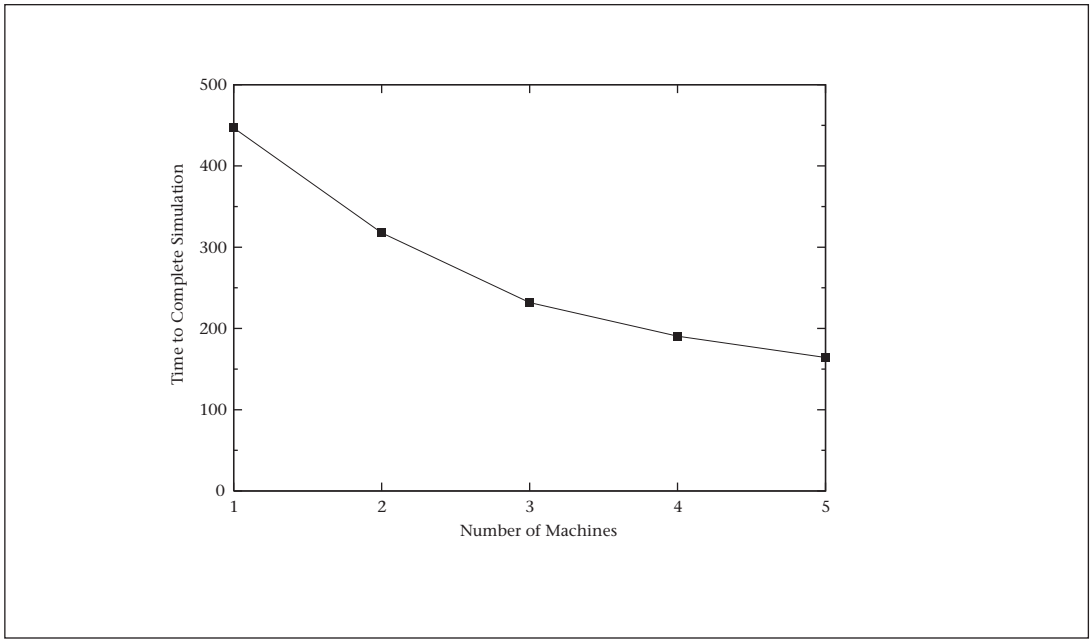

Figure 1. Running Time for 90 Seconds of Simulation Time with 22 Agents.

computation time used by agents (such as MESS [Anderson 1995], the only requirement on the agents is that they run as their own process on the machine.

Fifth, the agents' actions do not have to be synchronized in the domain. Unlike traditional turn-taking games or the discrete-action model embodied in the current SOCCER SERVER, agent actions do not have to occur all at once in a single round.

Experimental Results

To compare the efficiency of SPADES with the current SOCCER SERVER (Noda et al. 1998), a simulation was set up with parameters similar to the SOCCER SERVER. Agent sensations were sent approximately every 100 millisecond of simulated time, and 22 agents were used. The computation time requirements were set to be similar to the CHAMELEONS01 team (Carpenter et al. 2002). The simulation was run for 90 seconds of simulation time. For the SOCCER SERVER running on a single 1-gigahertz machine, this simulation would take 270 seconds. Figure 1 shows the time taken for the simulation on a heterogeneous set of machines ranging from 200 to 450 megahertz. SPADES exhibits higher efficiency and significant parallel speedups.

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Note

1. SPADES is released under the GNU Lesser General Public License. Source code and documentation are available at spades-sim.sourceforge.net/.

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