A Distributed Agent-based Approach to Stabilization of Global Resource Utilization[1]

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September 23, 2009

Complex, intelligent, distributed systems in dynamic environments need to adapt continually. Central management of such systems is not often an option: distributed management is required. The full paper version addresses distributed management of resource utilization. Resources are managed by software agents. Software agents are capable of reasoning with and about (1) their own knowledge at any given time, (2) knowledge they receive from other agents and (3) knowledge they acquire from interaction with their environment, with respect to their goals. They act accordingly, adapting to change as required. Note that adaptivity has been recognized as a means to handle arising complexity of knowledge and interactions [10].

Virtual organizations of agents define communication structures between agents, e.g., hierarchical organizations [3], between and within which agents can choose to cooperate and coordinate their actions, or compete. Dynamic organized hierarchies can be used to support adaptive, aggregate, nonlinear behavior, as a means to reduce complexity. Coordination in unstructured environments entails distributed search and distributed scheduling [9, 4].

The paper that this abstract discusses, proposes a fully decentralized agent-based approach to global stabilization of resource utilization, based on local coordination. The core question addressed is:

To which extent can global stabilization in resource utilization be acquired by local coordination of resource utilization using software agents to manage resources?

The approach is threefold and can be outlined as follows:

1. Agents are members of a hierarchical virtual organization, structuring agent interactions and aggregation of agent resource requirements.
2. A simple agent knowledge model is assumed on the basis of which resource requests are generated.
3. Agents can make local adaptive decisions on the basis of information they receive from the agents to which they are linked.

The problem and the proposed solution are illustrated in the context of the electricity domain. In this context, global stabilization is acquired in the energy consumption of an electricity network. In particular, this work focuses on minimizing the oscillations of thermostatic controlled appliances. These devices, (e.g. refrigerators, air conditioners, water heaters) consume 25% of the total energy supply in the USA [6], thus management of these devices can have a significant effect on the stabilization of global resource consumption. Software agents can autonomously negotiate their resource requirements and configuration [2].

Based on the above application domain, a network of interconnected software agents representing thermostatic devices has been designed, developed and implemented/simulated. Agents interact and use local knowledge on the basis of which they make local adaptive decisions towards stabilizing the global consumption. Two different algorithm variations have been examined: (i) one that aims to achieve minimum oscillations in each and every aggregation round and, (ii) one that reverses oscillations with respect to a

[1]The full version [8] of this paper appeared in the Proceedings of International Conference of Complex Intelligent and Software Intensive Systems (CISIS'09).

previous aggregation round (to acquire the opposite deviation values), resulting in global stabilization over a series of aggregation rounds. Experiments reveal that the consecutive adaptive aggregations and decision-makings in every level over the virtual organization enables the system to keep the deviations of the global plan significantly lower (36.54%-78.71%) compared to a system with greedy agents. It also converges a new aggregate plan to a reversed version of a previous global plan effectively (correlation coefficient approaches -1).

Summarizing, the full paper version describes a method of global stabilization of resource utilization, by local coordination. More specifically, agents provide alternative options, aggregate information, choose utilizations and communicate over a hierarchy. The main contribution of the proposed approach is the following:

Hierarchical local coordination achieves emerging convergence of the global stabilization through local knowledge, local decisions and local interactions by individual software agents.

Acknowledgments

This project is supported by the NLnet Foundation `http://www.nlnet.nl`.

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