ADAM: A Multi-Agent System for Autonomous Database Administration and Maintenance

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ABSTRACT

In today's world, databases and database systems have become an essential component of everyday life, so much so that a life without DBMSs has become inconceivable. This article focuses on relational database management systems in particular, and proposes a novel and innovative multi-agent system that would autonomously and rationally administer and maintain databases. The proposed multi-agent system tool, ADAM, is in the form of a self-administering wrapper around database systems, and it addresses and offers a solution to the problem of overburdened and expensive DBAs with the objective of making databases a cost-effective option for small/medium-sized organizations. An implementation of the agent-based system to proactively or reactively identify and resolve a small subset of DBA tasks is discussed, and the GAIA methodology is used to outline the detailed analysis and design of the same. Role models describing the responsibilities, permissions, activities, and protocols of the candidate agents, and interaction models representing the links between the roles, are explained. The Coordinated Intelligent Rational agent model is used to describe the agent architecture, and a brief description of the functionalities, responsibilities, and components of each agent in the ADAM multi-agent system is presented. Finally, a prototype system implementation using JADE 2.5 and Oracle 8.1.7 is presented as evidence of the feasibility of the proposed agent-based solution for the autonomous administration and maintenance of relational databases.

Keywords: database maintenance; database management systems; multi-agent systems; relational databases; software agents

INTRODUCTION

One of the most significant aspects of the computer revolution has been the concept of a database: the storage of information in such a way as to enhance our ability to use it (Argonne National Laboratory, 1988). Today, databases play a critical role in almost all areas...
where computers are used (Elmasri & Navathe, 2000).

Databases are growing rapidly in scale and complexity. With the cost of both hardware and software decreasing rapidly due to technological advancements, the cost of ownership for database applications is increasingly dominated by the cost of people who manage them. Skilled database administrators (DBAs) are becoming rarer and more expensive (Lightstone, Kwan, Storm, & Wu, 2002a; Lightstone, Lohman, & Zilio, 2002b). As a result, the need for self-managing, self-administering, and self-maintaining databases is on the rise.

The key focus of research in the field of databases currently is on making databases intelligent enough to maintain and tune themselves for optimum performance. The objectives of this research is to make databases and the various advantages they offer available to small/medium-sized organizations without forcing the organizations to incur the huge costs associated with people required to manage the databases, and to help beleaguered DBAs of large (in size or in number) databases by easing some of the burden of database administration off their shoulders.

This article proposes one such system whose goal is to make databases self-managing. Agent technology is used as the motivation behind the proposed system design in an attempt to replace human DBAs with intelligent software agents for some of the more mundane DBA activities, thereby easing the workload on DBAs and reducing the cost of operation associated with database management systems. The multi-agent system (MAS) for autonomous database administration proposed in this article builds on the features of proactivity, autonomy, interaction, collaboration, and negotiation, and comprises numerous intelligent agents that would automatically schedule and run maintenance and administrative tasks on databases. The agents should proactively monitor the database and autonomously resolve issues, such as abnormal growth of objects or tablespaces, which could result in errors if left unattended. They should interact and collaborate with other agents in the system for services such as backup or recovery of objects or the databases, and they should negotiate the terms and conditions of the services depending on time availability and cost requirements. Thus, the ADAM MAS aims at ensuring that the health of the database is monitored and managed efficiently and autonomously.

The organization of this article is as follows. A preliminary specification (a subset of the tasks that are part of a DBA’s workload) of the Autonomous Database Administration and Maintenance (ADAM) multi-agent system to aid with relational database administration is presented in the following section. We then describe the methodology and procedures adopted to analyze and design the proposed multi-agent system, and illustrate the implementation specifics of ADAM with detailed descriptions of the responsibilities and capabilities of each agent along with their respective activity diagrams. Some of the sample results obtained from the initial prototype of ADAM are presented, and a case is presented for the validation, in a chiefly academic environment, of these sample results.
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