Chapter XVI
Evaluating a Bio-Inspired Approach for the Design of a Grid Information System: The SO-Grid Portal

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ABSTRACT

This chapter proposes a bio-inspired approach for the construction of a self-organizing Grid information system. A dissemination protocol exploits the activity of ant-inspired mobile agents to replicate and reorganize metadata information on the basis of the characteristics of the related Grid resources. Resource reorganization emerges from simple operations of a large number of agents, in a "swarm intelligence" fashion. Moreover, a discovery protocol allows Grid clients to locate useful resources on the Grid through a semi-informed approach. This chapter also describes the SO-Grid Portal, a simulation portal through which registered users can simulate and analyze the ant-based protocols. This portal can be used by researchers to perform "parameter sweep" studies, as it allows for the graphical comparison of results obtained in previous sessions. We believe that the deployment of the SO-Grid portal, along with the definition and discussion of the protocols presented in this chapter, can foster the understanding and use of swarm intelligence, multi-agent and bio-inspired paradigms in the field of distributed computing.

INTRODUCTION

To support the design and execution of complex applications, modern distributed systems must provide enhanced services such as the retrieval and access to content, the creation and management of content, and the placement of content at appropriate locations. In a Grid, these services are offered by a pillar component of Grid frameworks, the *information system*. This chapter discusses a novel approach for the construction of a Grid information system which allows for an efficient management and discovery of information. The approach, proposed in (Forestiero et al., 2005) in its basic version, exploits the features of (1) epidemic mechanisms tailored to the dissemination of information in distributed systems (Peterson et al., 1997, Eugster & al., 2004) and (2) self organizing systems in which "swarm intelligence" emerges from the behavior of a large number of agents which interact with the environment (Bonabeau & al., 1999, Dasgupta, 2004).

The proposed ARMAP protocol (*Ant-based Replication and MApping Protocol*) disseminates Grid resource *descriptors* (i.e., metadata documents) in a controlled way, by spatially mapping these descriptors according to their semantic classification, so to achieve a logical reorganization of resources. A resource descriptor can be composed of a syntactical description of a Grid service (e.g. a Web Services Description Language - WSDL - document) and/or a semantic description of the capabilities of the service.

Descriptor reorganization results from pick and drop operations performed by a large number of agents. Each ARMAP agent travels the Grid through P2P interconnections among Grid hosts, and uses simple probability functions to decide whether or not to *pick* descriptors from or *drop* descriptors into the current Grid host. This approach is inspired by the activity of some species of ants and termites that cluster and map items within their environment (Bonabeau & al., 1999).

Furthermore, a self-organization approach based on ants' pheromone (Van Dyke & al., 2005) enables each agent to regulate its activity, i.e. its operation *mode*, only on the basis of local information. Indeed, each agent initially works in the *copy* mode: it can generate new descriptors and disseminate them on the Grid. However, when it realizes from its own past activity that a sufficient number of replicas have been generated, it switches to the *move* mode: it only moves descriptors from one host to another without generating new replicas. This switch is performed when the level of a pheromone variable, which depends on agent's activity, exceeds a given threshold.

The ARMAP protocol can effectively be used to build a Grid information system in which (1) resource descriptors are properly replicated and (2) the overall entropy is reduced. A balance between these two features is achieved by regulating the pheromone threshold, i.e., by shortening or extending the time interval in which agents operate under the *copy* mode.

A semi-informed discovery protocol exploits the logical resource organization achieved by ARMAP. Indeed, whenever a large number of descriptors of a specific class are accumulated in a restricted region of the Grid, it becomes convenient to drive query messages (issued by users to locate descriptors of this class) towards this region, in order to maximize the number of discovered descriptors and minimize the response time. While this chapter focuses on enhancements and performance of the ARMAP protocol, the discovery protocol, namely ARDIP (*Ant-Based Resource Discovery Protocol*) is here shortly discussed, whereas an extensive analysis can be found in (Forestiero & al., 2007).

This chapter also introduces the SO-Grid (*Self Organizing Grid*) portal, a Web portal which gives remote users access to an event-based simulator written in Java. This portal, available at the URL *http://so-grid.icar.cnr.it*, allows for the experimental reproduction of simulation results and can be used by researchers to perform "parameter