Chapter VI

Consistency of Replicated Datasets in Grid Computing

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ABSTRACT

Data replication is a well-known technique used in distributed systems in order to improve fault tolerance and make data access faster. Several copies of a dataset are created and placed at different nodes, so that users can access the replica closest to them, and at the same time the data access load is distributed among the replicas. In today’s Grid middleware solutions, data management services allow users to replicate datasets (i.e., flat files or databases) among storage elements within a Grid, but replicas are often considered read-only because of the absence of mechanisms able to propagate updates and enforce replica consistency. In this entry we analyze the replica consistency problem and provide hints for the development of a Replica Consistency Service, highlighting the main issues and pros and cons of several approaches.

INTRODUCTION

Replica consistency is the property exhibited by a set of data items, such as files or databases located at different nodes of a Grid, that contain the same information; when these data items are modifiable, all of them should be updated (or synchronized) so that consistency is maintained. Replica consistency is a very well studied research topic and has its roots in distributed systems as well as in
Simply put, data consistency makes sure that different data copies are synchronized, i.e., have the same values.

In Grid computing, data replication is done at different levels of granularity than in traditional, distributed relational database management systems. In particular, Grids often replicate entire files rather than database objects. Furthermore, data synchronization and therefore consistency has to be managed by “external” services which often do not provide a unique interface for reading and writing data based on traditional database transactions. In the rest of this article we concentrate on the specific issues of Data Grids. However, before we go into the details of replica consistency in Grids, let us first review typical data replication components and services that are commonly used in Grid computing.

A Data Grid typically offers a Replica Management Service (RMS), a middleware component that creates replicas of files (rather than relational databases) on request by applications or possibly in a transparent way to optimize data access. This service uses a Replica Catalogue (RC) to keep track of the replicas. The RMS may also rely on a Replica Optimization Service (ROS) to select dynamically the best replicas to be accessed by a given application.

Such file replication tools must then implement policies concerning the following major issues:

- *When and where to create or remove replicas?* A replication service should perform dynamic replication (Ranganathan, 2001), that is the automatic creation and removal of replicas based on different system parameters and/or user needs.

- *Data location and cataloguing.* Replicas can be created and removed in the course of time: they are created somewhere when needed and they must be deleted when they are no longer used. How does a user or application, or the RMS itself know where a replica is, at a certain point in time? To this
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