Chapter V
Providing Quantitative Scalability Improvement of Consistency Control for Large-Scale, Replication-Based Grid Systems

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ABSTRACT

Consistency control is important in replication-based-Grid systems because it provides QoS guarantee. However, conventional consistency control mechanisms incur high communication overhead and are ill suited for large-scale dynamic Grid systems. In this chapter, the authors propose CVRetrieval (Consistency View Retrieval) to provide quantitative scalability improvement of consistency control for large-scale, replication-based Grid systems. Based on the observation that not all participants are equally active or engaged in distributed online collaboration, CVRetrieval differentiates the notions of consistency maintenance and consistency retrieval. Here, consistency maintenance implies a protocol that periodically communicates with all participants to maintain a certain consistency level; and consistency retrieval means that passive participants explicitly request consistent views from the system when the need arises in stead of joining the expensive consistency maintenance protocol all the time.
The rationale is that it is much more cost-effective to satisfy a passive participant's need on-demand. The evaluation of CVRetrieval is done in two parts. First, by analyzing its scalability and the result shows that CVRetrieval can greatly reduce communication cost and hence make consistency control more scalable. Second, a prototype of CVRetrieval is deployed on the Planet-Lab test-bed and the results show that the active participants experience a short response time at expense of the passive participants that may encounter a longer response time.

INTRODUCTION

A popular strategy to improve the availability of shared data in large-scale Grid systems is to replicate data on geographically dispersed nodes. In this way, participants can fetch the data from a nearby copy with improved availability and response time. After retrieving a copy to the local node, the local copy becomes a new replica of the data and can be used to serve other nodes' need. In this type of replication-based systems, it is important to guarantee the consistency among participants' copies of the same data to make collaboration meaningful. In that sense, improved consistency among participants can improve participants' perceived Quality of Service (QoS) of the application.

There are two obstacles facing the design of a highly scalable consistency control mechanism for large-scale, replication-based Grid systems. First, large-scale Grid systems have a large number of nodes that are often geographically dispersed globally. Due to the network congestions and the inability to control remote nodes, maintaining even a relaxed consistency in such systems involves formidable communication and management cost.

Second, large-scale Grid systems are often dynamic. I.e., nodes could join or leave the system at their will. With such dynamism, both the group of replicas and that of the nodes are interested in getting a replica keeps changing. Thus, any static—in the sense that the protocol fixed with certain replicas—is not suitable.

Current consistency maintenance mechanisms rely either on applying the same protocol on all participants or is based on the assumption that the replica group does not change. The former scheme is not scalable in large-scale Grid systems because it induces high communication overhead in the presence of a large number of participants (Cetintemel 2003). The dynamic nature of large-scale Grid systems means the latter scheme is not suitable as well.

In this paper, we propose a new low-overhead, hence more scalable, consistency control architecture to address this limitation, thus improving the QoS from the consistency control's point of view. This architecture is consistency retrieval. We also present the design, implementation, and evaluation of Consistent View Retrieval (CVRetrieval), a system that supports the consistency retrieval functionalities.

Consistency Retrieval vs. Consistency Maintenance

Consistency retrieval is in contrary to the notion of consistency maintenance. In this paper, consistency maintenance refers to the enforcement of consistency through communication among all the participants. The maintenance cost grows with the number of participants. In a truly large system, the consistency maintenance cost can be formidable.

Consistency retrieval reduces maintenance cost by reducing the number of participants that a consistency maintenance module needs to include. This approach is both doable and preferable in practice.