Data Management of Triple Quorum Replication (TQR) for Data Grid

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ABSTRACT

Grid computing is essentially distributed computing over wide-area networks that often involve large scale resource sharing among collaborations of individuals or institutes. Computational Grids address computationally intensive applications that deal with complex and time consuming computational problems on relatively small data sets, whereas Data Grids address data intensive applications that deal with the evaluation and mining of large amounts of data in the terabyte and petabyte range. By having large number of data in a complex computing structure such as grid requires a good data management protocol. In this paper, Triple Quorum Replication (TQR) protocol was introduces for grid environment and compares its results of data availability with Enhanced Diagonal Replication 2D Mesh (EDR2M). A simulation of Triple Quorum protocol is developed using Java and results has proven that the TQR has higher data availability compare to EDR2M.

Keywords: Data Grid, Quorum Replication, Simulation.

I INTRODUCTION

Data Grids have been adopted as the platform for scientific communities that need to share, access, transport, process and manage large data collections distributed worldwide. Grid computing is one such paradigm that proposes aggregating geographically-distributed, heterogeneous computing, storage and network resources to form Grids that provide unified, secure and pervasive access to the combined capabilities of the aforementioned resources (Venugopal et al., 2005). Data Grids are Grids where the access to distributed data resources and their management are treated as first class entities along with processing operations. Data Grids, therefore primarily deal with providing services and infrastructure for distributed data-intensive applications. The fundamental features of Data Grids are provision of a secure, high-performance transfer protocol for transferring large data sets and a scalable replication mechanism for ensuring distribution of data on-demand.

Replication is a useful technique for distributed database systems where reliability is important. Rather than keeping one copy of important data at a single site, multiple copies of the same data can be maintained at different sites. Replication increases the data's availability: if one copy is temporarily inaccessible, then the transaction can be continued using a different copy. Replication also increases the data's reliability: if one copy is accidentally destroyed, it can be reconstructed from the other copies. Replication involves creating and maintaining duplicates of a database on different computers, typically servers, to enhance services. Replication categorizes the manner in which copies of data are created and maintained in the network (Venugopal et al., 2005). Replication has twin objectives: one, to increase performance by reducing latency and the other, to provide reliability by creating multiple backup copies of data. In a Data Grid, data is mostly replicated on the basis of the locality of requests especially based on community-driven hierarchical model. Replication can also be distinguished on the basis of whether there is a primary copy, changes of which causes updates to other replicas.

Triple-quorum (T-Quorum) replication is a replication algorithm designed to support Internet edge services. This model attempts to improve service availability and latency by allowing clients to access the closest available edge servers rather than a centralized server. By exploiting object-specific workload characteristics Triple-quorum replication combines volume leases and quorum based techniques to achieve excellent availability, response time, and consistency the references to each object. Triple-quorum protocol is to process

reads and writes in three different quorum systems, input quorum system (IQS) and output quorum system (OQS). This protocol uses a cache invalidation strategy to synchronize the state of objects replicated in IQS nodes and cached in *OQS* nodes.

This paper is organized as follows: Section II discussed on the related work which is the EDR2M. Section III explained the proposed protocol which is the Triple Quorum Replication (TQR) Protocol. Section IV discussed on the simulation design and implementations. Section V is discussing on the results and last, Section VI is concluding this paper.

II RELATED WORKS

A. Replica Control Protocol

Many distributed database and grid maintain multiple replicas of some critical data to increase the availability of the replicated data and to reduce read access times. Managing multiple replicas of the same data presents however a special challenge as site failures and network partitions are likely to occasion inconsistent updates. Special replication control protocol shave been devised to avoid this occurrence and guarantee that a consistent view of the replicated data is always presented to their users. An ideal replication control protocol should satisfy two criteria (Paris, 1994): First, it should not require more than two replicas to provide a satisfactory data availability. Second, it should provide inexpensive reads.

Replica Management Service (RMS) called Reptor is a logical single entry point for the user to the replica management system (Stockinger et al., 2003) such as at Figure 1. It is similar functions as Replica Control Protocol. It encapsulates the underlying systems and services and provides a uniform interface to the user. Users of the RMS may be application programmers that require access to certain files, as well as high level Grid tools such as scheduling agents, which use the RMS to acquire information for their resource optimization task and file transfer execution.

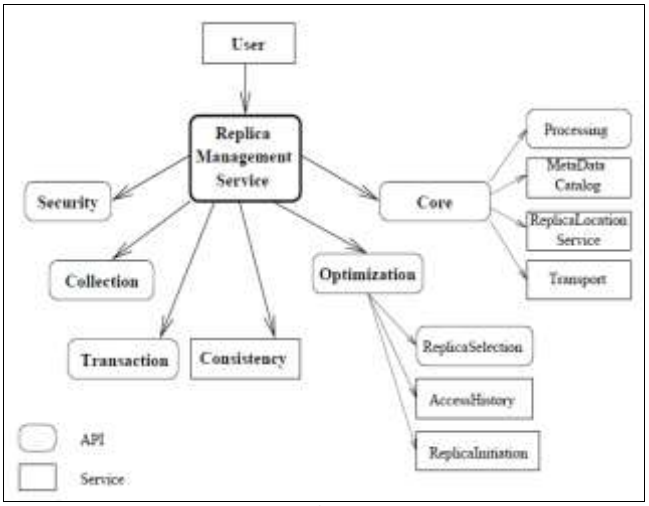

Figure 1: The main components of a Replica Management System

B. Enhanced Diagonal Data Replication using 2D Mesh Protocol (EDR2M)

EDR2M was introduced by (Rohaya Latip, 2008). It is formed by identifying number of quorums needed in the network. Each quorum must intersect with each other. As illustrated in Figure 2. To compute the number of quorum, EDR2M introduced Eq. (1) which to calculate the number of quorums needed in N size of network where n is the number of row or columns. The total number of quorums, q_R for the whole network, N is $q*q$ where q is the number of quorum in a row or columns as shown in Eq. (1).

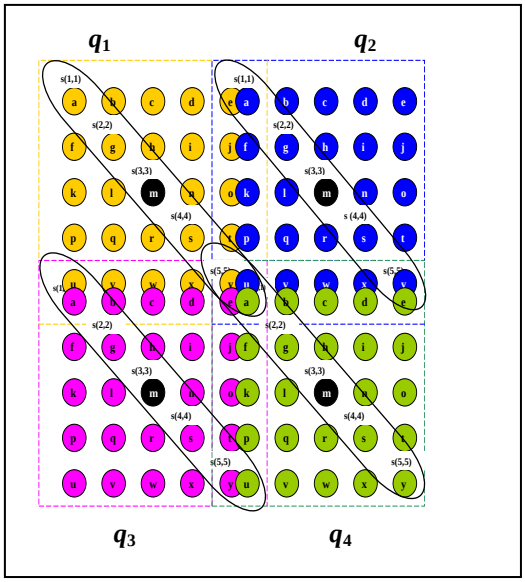

Figure 2: EDR2M intersection of Quorums

$$q = \left\lfloor \sqrt{n} - \frac{n}{10} \right\rfloor$$

$$q_R = q^2 \quad (1)$$

To calculate the availability, all copies are assumed to have the same probability *p* of availability. Refer Eq. (2).

$$A_{EDR2M} = \sum_{i=q_R}^{n} \binom{n}{i} p^i (1-p)^{n-i} \quad (2)$$

This replica control protocol is in Mesh structure. Therefore the number of quorum is doubled for each group of quorum since it required two quorums to intersect. This has increased the communication cost to maintain its data availability. Due to this limitation, Triple Quorum Replication (TQR) was introduced.

III THE PROTOCOL

Triple Quorum Replication (TQR) protocol is structuring the quorum into three group of quorum that intersect as illustrated in Figure 3. The number of nodes in each quorum depends on the domain but if no priority and domain was given for the groups, the nodes are group based on Eq. (1) to determine the number of nodes in each quorum.

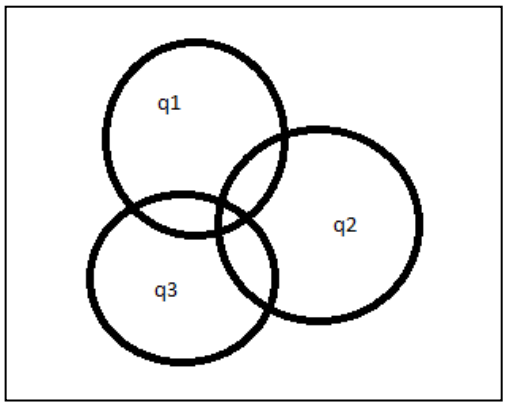

Figure 3: TQR where 3 quorums are intersect

By introducing this protocol, the data availability increase and maintained but the communication cost has reduced.

IV SIMULATION DESIGN AND IMPLEMENTATION

The TQR is simulated in Java. There are some assumptions made in this paper which is also based on paper (Rohaya Latip, 2008).

i. All nodes and sites are active.

ii. The quorum for read and write operations are the same since read and write operation execute at the same quorum.

iii. Number of nodes (*n)* in each quorum ranges from 25 to 361.

iv. Read availability and write availability for triple-quorum is same therefore we named it data availability.

The input variable for availability is the probability (*p*) that a copy is accessible. The value of *p* is from 0.1 to 0.9.
The output variable is read availability and writes availability (system availability). The simulation identifies which database is the nearest primary database from the requested node which is selected randomly. Random selection of requested node is implemented because all nodes are assumed to have the same priority.

V RESULTS AND DISCUSSIONS

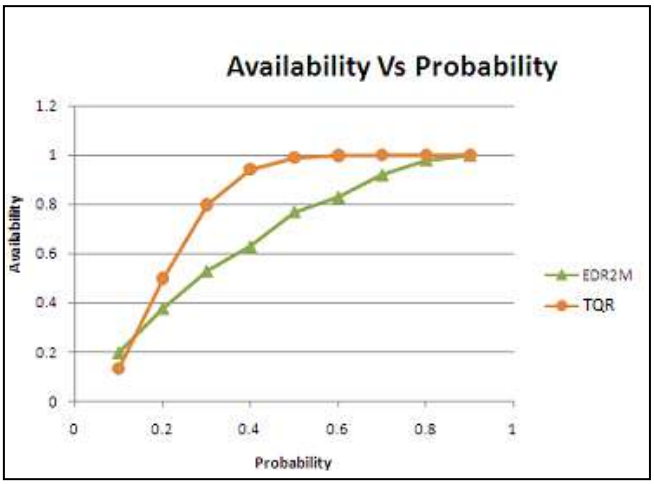

Figure 4: Data availability results

By using the same equation which is Eq. (2) the data availability is obtained. Figure 4 shows that the TQR has the highest data availability compared to EDR2M. Results show that the average of data availability for EDR2M is 6.3 and for Triple Quorum the average of availability is 0.82 which is 18.80% higher.

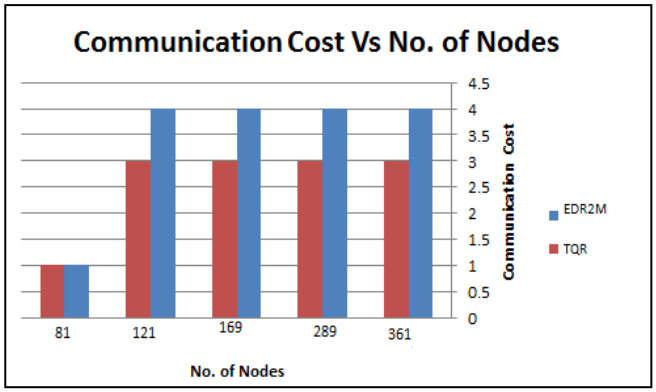

Figure 5: Communication cost results

Figure 5 shows the communication cost results where the communication cost for EDR2M will consistently be four when the number of nodes increase whereas for TQR the communication cost will be three (3) consistently when the network become larger until the network size is 361 nodes.

VI CONCLUSION

This paper has achieved its objective by proofing that the data availability is increasing and communication cost is reduced by reducing the quorum size. TQR has increase its efficiency to 18.80% more than EDR2M protocol for data availability TQR also has reduce the communication cost compare to EDR2M. For future work, when the network size grows larger such as in grid environment, the primary database to be access will be further apart based on the previous protocol. Therefore this has decrease the performance of data availability. For future work another protocol for replicating the data at another tier is going to be investigated.

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