Performance of Update Propagation Techniques for Data Grid

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Abstract

Data replication is a well known technique used to reduce accesses latency, improve availability, and performance in a distributed computing environment. An asynchronous replication is a commonly agreed solution for the consistency of replicas problem. Direct mail Update propagation is widely used in many replica management frameworks for replica consistency, however it suffers from high overhead at the master replica. we presents a new update propagation protocol called Update Propagation Grid (UPG) to implement load balancing and more reliable system. We model the direct-mail scheme and UPG by a multi-class network queuing model and study its performance with different system load. The analytical solution shows that the UPG better performance than direct mail protocol.

I. Introduction

Scientific research community such as European Organization for Nuclear Research (CERN) and High Energy Physics (HEP) produce petabytes of data per year. Data will be used by thousands of physicists and distributed around the world for processing. As a specialization and the extension of the computational grid, the Data Grid is the solution for the above problem. Essentially, the data grid is an infrastructure that manages large scale data files and provides computational resources in distributed systems. In data grid environment, the primary goal of data replication is to reduce access latency, increase fault tolerance and performance of the systems.

A Grid is an organized collection of nodes in a wide area network which contribute various computation, storage data, and application. In Grid high numbers of users are distributed in a wide area environment, moreover this environment is a dynamic and heterogeneous environment. As in most distributed environments [1] Data Grid has used replication to reduce access latency, improve data locality, increase fault tolerance and performance for distributed applications.

Data management is one of the current issues, where data transparency, consistency, fault tolerance, automatic management, and the performance are the user parameters in grid environment [2]. Data management techniques must scale up while addressing autonomy, dynamicity and heterogeneity of the data resource. Replication introduces the problem of maintaining consistency among the replicas when the file allowed to be updated. The update information should be propagated to all replicas to guarantee correct read of the remote replicas. The update propagation with a single master scenario is a common technique for asynchronous replication. The basic idea of a single master replication is that for each data item or file there exist one master copy and all other replicas are secondary replicas. The user updates only pass to the master replica, which does the updates and then propagates the changes in form of update information to all secondary replicas. The secondary sites receive the update information and apply the modification to its home replica.

A few studies have been done to maintain replica consistency in Data Grid [3, 4, 5, 6, and 8]. Most of the current techniques use a direct-mail as propagation schemes, in which the master site propagates the update message to all replica sites. Sending the update information from the master replica to other replicas may have high processing site cost on the master site, and may tight up the master site for a long time. And the site may not be able to process the incoming requests successfully.

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We proposed new asynchronous replication protocol called Update Propagation Grid (UPG) to maintain replica consistency in data grid [9]. In UPG the updates reach all on-line secondary replicas using a propagation technique based on nodes organized into a logical structure network in the form of grid structure. In this paper we present an analytical model of UPG and Direct mail. We model the single master site as a multi-class network queuing model. We show that the master site may process assigned requests successfully as long as the arrival rate of requests has not reached saturated value furthermore, the saturated value of UPG is higher that of direct mail.

The rest of this paper is organized as follows: in section 2 we give an explanation of direct mail and UPG propagation protocols. In section 3 the multi-class network queuing model is presented. Section 4 discusses the result of the performance evaluation in term of response time and resource utilization. Section The conclusion and future works presented in section 5.

II. THE PROPAGATION TECHNIQUES

The techniques proposed in [3, 4, 5, 6, 7] to maintain replica consistency in Data Grid used a direct-mail as propagation schemes, in which the master site propagates the update message to all replica sites. A direct mail process is shown in figure 1.

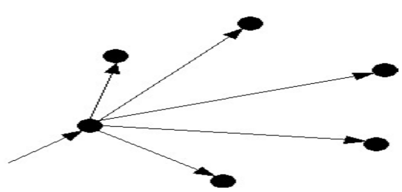


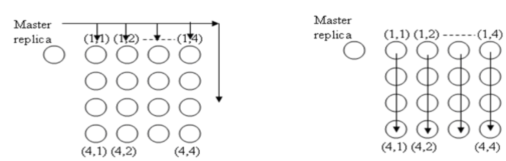
Figure 1. **Propagation of update message using a direct mail**

The direct mail protocol can propagate the update information; however the overhead of the master site linearly increases as the number of replica holder's increase. Sending the update information from the master replica to other replicas may have high processing site cost on the master site, and may tight up the master site for a long time especially when dealing with large size update information. Moreover the site may not be able to process the incoming requests successfully. Thus, this method cannot work well in a system with a very large number of replica holders.

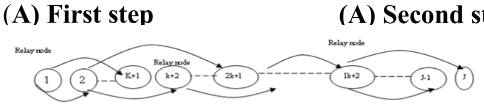
In order to achieve load balancing and increase system performance we proposed new update propagation technique called Update Propagation Grid (UPG) to maintain replica consistency in data grid. The propose protocol is fulfils the characteristic of grid environment. In UPG the updates reach all on line secondary replicas using a propagation technique based on nodes organized into a logical structure network in the form of grid structure.

Given N replica of the data set, UPG are logically organized the N sites in the form of two-dimensional grid structure (see Figure2). UPG consists of 16 replica sites the sites are organized in the form of 4×4 grids. Each site has one master replica and the other sites are secondary replicas see Figure 2(A). The UPG can be easily extended and restructured by adding as well as deleting the replica from a given site.

The update propagation process is shown in Figure 2. The master replica site sends the update information to the first site in each column see Figure 2(A). The first site in each column propagates the update information to other sites in its respective column in parallel with other first sites, (see Figure 2(B). Figure 2(c) gives details of the other round in each column.



(A) First step **(A) Second step**



(C) Detail of the second step

Figure 2. In a UPG update scenario.

III. ANALYTICAL MODEL

The grid resources, including computing facilities, data storage and network bandwidth, are consumed by the jobs or requests [8]. Two types of requests are usually considered for data grid: read and update requests. The read request involves the processing at the selected site that includes accessing computing elements and the storage element. On the other hand, for the update request, the propagation process and the communication overhead are additional attributes that have to be taken into consideration, besides accessing those elements.

The model is based on Separable Queuing Networks [10] Figure 3 shows the model that is used to represent the master site in DataGrid. The model was design to be as simple as possible while still displaying the principle characteristics of the DataGrid system. Storage element, computing element and network are modeled as a single queue with a single server which is served as a FIFO manner.

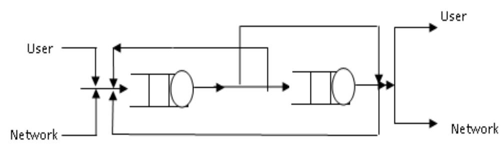


Figure 3. The network queuing model

A. Model Parameter

The model parameters and there description is given in Table1.

TABLE I. . QUEUING MODEL PARAMETER

K	Number of servers centers
C	Number of class
λ	Arrival rate of the requests to the system
λ_C	Arrival rate of request of class C.
$S_{c,k}$	Average service time of the class C at the service center k.
$V_{c,k}$.	Number of visit of the class C to the service center k
P	Probability of assigning request to the master site.
$R_{c,k}$	Average response time of class C requests at the service center k
R_c	Average response time of class c request at all service centers.
$U_{c,k}$	Average utilization of class C request at the service center k
U_k	Average utilization of all classes of service at the service center k.

B. Job Classes

In update propagation process we can find five class of jobs, these jobs and there notation is given in Table 2.

TABLE II. TABLE 2. JOB CLASSES

Class	Description
J	Class of job operation in the processing phase
U	Class of Update operation in the processing phase
P_Default	Class of processing the default part of propagation algorithm
P_Conditional	Class of processing the conditional part of the propagation overhead.
P_C	Class of operation in to processing the message in the communication phase

IV. MODEL RESOLUTION

A. Analysis of the result

The resolution of the model is given as follows: The job response time will be:

$$R^I_{Job} = \frac{D^{Job\_Proces}_{com\_Elemnt\_I}}{1 - U_{Com\_Element\_I}(\lambda)} + \frac{D^{Job\_Proces}_{storage\_Elemnt\_I}}{1 - U_{Storage\_Element\_I}(\lambda)} \qquad 1$$

And the update response time will be:

$$R^I_{Update} = \frac{D^{Update_{Proces}}_{com_{Elemnt_I}}}{1 - U_{Com_{Element_I}}(\lambda)} + \frac{D^{Update_{Proces}}_{storage_{Elemnt_I}}}{1 - U_{Storage_{Element_I}}(\lambda)} \qquad 2$$

Therefore $U_{c,k} = \lambda_c \times V_{c,k} \times S_{c,k}$ 3

$$U_{Storage\_Elemnt} = U_{J,storage\_Elemnt} + U_{U,storage\_Elemnt} \qquad 4$$

$and\ for\ the\ computing\ elemnt\ will\ be$

$$U_{Com\_Element} = U_{J,Com\_Element} + U_{U,Com\_Elemnt} + \qquad 5$$

The utilization for the computing element will be

In this section we evaluate the performance matrices we will use Mean Value Analysis (MVA).

B. Processing Capacity

A system is said to have sufficient capacity to process a given offered load λ if it is capable of doing so when subjected to the workload over a long period of time. The throughput indicate the maximum arrival rate of incoming request that the system can handle successfully and it may be computed using force the utilization law

$$U_{c,k} = \lambda_c \times V_{c,k} \times S_{c,k} \qquad 6$$

A master site K may accommodates increased arrival rate as long as it has unused capacity (utilization less than one). The master site becomes saturated when its utilization reaches one. The system throughput bound is the smallest arrival rate λsat at which the system saturated and is not be able to process subsequent request successfully. The intersystem saturates when any of the service centers become saturated. To compare the UPG with the direct mail we consider a system for which the parameters are given in table 3.

TABLE III. SAMPLE OF SYSTEM PARAMETERS

Description	Value
Number of site	1000
Number of instruction to process the job request	50,000,000
Number of instruction to process the Update request	100,000
Number of instruction to process the Default part of the propagation algorithm	4000
Number of instruction to process the Conditional part of the propagation overhead peer destination.	2000
The mean storage time of the job request	50,000,000
Number of instruction needed to send, receive a message	20,000
The power of the processing element	1000
The power of the storage element	1000

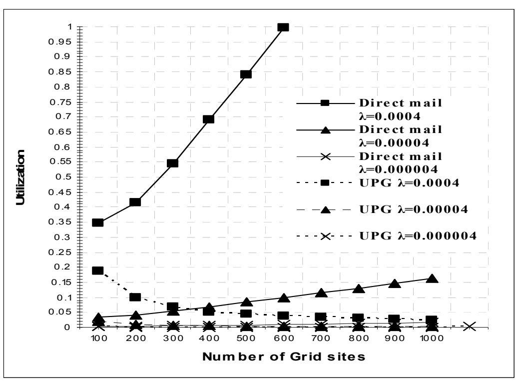


Figure 4. Evaluation of the master site utilization under light load.

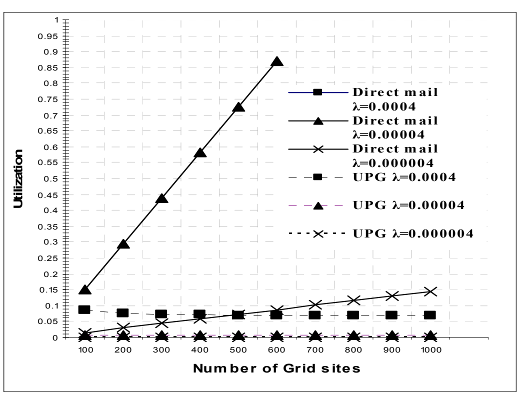


Figure 5. Evaluation of the master site utilization under heavy load.

The utilization of the master site with a light load is shown in figure 4 the Probability of job request is set 0.9, and with a heavy load is shown in figure 5 the Probability of job request is set 0.1. Using direct mail with low update rate the master site will be saturated when the N is grater that 600 while the UPG will not get saturate even with N=1000. And under heavy load the master site will get saturate when λ is equal to 0.0004 even if n=100. The utilization value in the case of direct mail with λ=0.0004 is not appear in figure 5, because it is always greater than 1.

V. CONCLUSION

In this paper, we describe (UPG), an Update Propagation Technique over data grid. . We model the direct-mail scheme and UPG by a multi-class network queuing model and study its performance with different system load. The analytical solution shows that master of UPG have scale up well with high number of replica sites and under heavy load.

REFERENCES

[1] Gray, J. et al. The Dangers of Replication and a Solution. In Proceedings of the 1996 ACM SIGMOD International Conference on Management of Data, pp.173-182.

[2] Esther Pacitti, Patrick Valduriez, Marta Mattoso: Grid Data Management: Open Problems and New Issues. J. Grid Comput. 5(3): 273-281 (2007)

[3] [10]A.Domenici, et al. Replica Consistency in a Data Grid, Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment, 534(1-2): 24-28, November 2004, Elsevier.

[4] [11] J. No, et al. Data Replication Techniques for Data-Intensive Applications. International Conference on Computational Science (4) 2006: 1063-1070.

[5] [12]R. Chang, et al. Adaptable Replica Consistency Service for Data Grids. The Third International Conference on Information Technology: New Generations (ITNG'06) 2006.

[6] [13]Y. Sun, et al. Grid Replication Coherence Protocol. ipdps, p. 232b, 18th International Parallel and Distributed Processing Symposium (IPDPS'04) - Workshop 13, 2004.

[7] [14]A. Domenici, et al: Relaxed Data Consistency with CONStanza. CCGRID 2006: 425-429.

[8] M. Carman, et al, "Towards an Economy-Based Optimisation of File Access and Replication on a Data Grid", In: Intl. Workshop on Agend-based Cluster and Grid Computing., Proc. of the CCGrid2002, pp. 340--345, May 2002.

[9] 1 Mohammed Radi, Ali Mamat, Mustafa Mat Deris, Hamidah Ibrahim, Subramaniam Shamala: Update Propagation Technique for Data Grid. ICCSA (3) 2007: 115-127.

[10] E.D., Lazowska, J. Zahorjan, G.S. Graham, and K.C.Sevcik, “Quantitative System Performance”, Prentice-Hall, Englewood Cliffs, NJ, 1984.