Performance Analysis of Distribution-based and Replication-based Model for High Performance Grid Information Service

Cheng-Hao Quan, Hie-Cheol Kim, Kang-Woo Lee*, Yong-Doo Lee
Dept. of Computer and Communication, Daegu University
E-mail : ch@lactt.taegu.ac.kr

Abstract

As the entities participating Grid become larger, performance requirement for the LDAP-based GIS(Grid Information Service) goes beyond that provided by a stand-alone single LDAP server. This entails the exploration of distributed LDAP systems. This paper presents the performance evaluation respectively for a distribution-based and a replication-based LDAP model. The analysis is based on an analytic performance model for each distributed system which is obtained by applying the M/M/1 queuing model. The performance evaluation made to these analytic models reveals that the distribution-based and the replication-based model show a significant tradeoff in their performance with respect to the system size as well as the amount of system load.

I. Introduction

Recently, the Grid has actively explored for practical deployment both in research and commercial sectors. The Grid computing is a form of distributed computing that involves coordinating and sharing computing, application, data, storage, or network resources across dynamic and geographically dispersed organizations[1]. For example, about 40 gigabytes of data is pulled down daily in the SETI@home project, by the telescope, and is sent to 3 million volunteers's computers all over the world to be analyzed. It would normally cost millions of dollars to achieve that type of computing power on one or even two supercomputers.

GIS(Grid Information Service) is an imporrant component in Grid systems and providing fundamental mechanisms for discovery and monitoring, and thus for planning and adapting application behavior[2]. Globus project is a leader project of the Grid and it is developing fundamental technologies needed to build Grid systems. The Globus uses LDAP(Lightweight Directory Access Protocol) in its MDS(Meta Directory Service) that act as the GIS[3,4].

As the number of resources and users in an LDAP-based GIS system increases, the LDAP system becomes insufficient to handle the loads. Further, any LDAP system read intensive operation has inherent defect when used for Grid environment with the write intensive operations. Most of previous works focused on analysis of performance for read intensive environments rather than write intensive Grid environments[5,6,7]. As mentioned above, it is needed to design a new LDAP system suited for Grid environments.

In this paper, we present performance analysis of LDAP systems in Grid environments based on an analytic model respectively for distribution-based and replication-based model. First, we have developed an analytic model respectively for the distribution-based and replication-based model. And then, tradeoff between distribution-based and replication-based model. The goal of this research is to suggest the direction of the design of the high performance LDAP systems for Grid environments.

The reset of this paper is organized as follows. In section 2, we first describe the concept of distribution-based and replication-based, and develop an analytic models. In section 3, we present result of analysis. Finally, we summarized our result providing some conclusions and future works in section 4.

II. Analytic model

To improve the performance of an LDAP system,

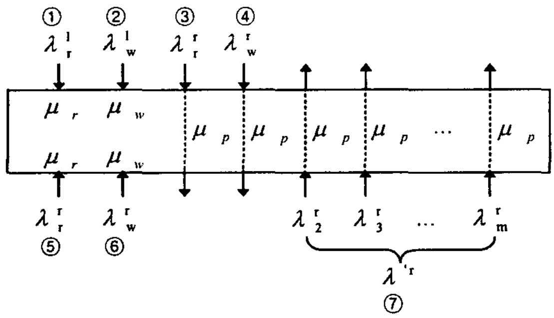
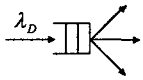


Figure 1. Distribution-based model



$$P_r^s \cdot \mu_r, \quad P_r^s = P_r \cdot \frac{\lambda}{\lambda_D}$$

$$P_w^s \cdot \mu_w, \quad P_w^s = P_w \cdot \frac{\lambda}{\lambda_D}$$

$$P_p^s \cdot \mu_p, \quad P_p^s = (P^r + \sum_{i=2}^{m}(i-1) \cdot P_i^r \cdot P^r) \cdot \frac{\lambda}{\lambda_D}$$

Figure 2. Service rate for distribution-based model

its distributed implementation is essential. In terms of the allocation of directory data, the design space of a distributed LDAP system spans from a distribution-based model to replication-based model. A distribution-based model is to partition the data into many pieces and each of them is allocated to a server. Referrals are used to link those partitions. A replication-based model is to store the whole copy of the data on each server participating the target distributed system.

Given an LDAP directory, both the distribution-based and the replication-based model generally enhance the average response time due to additional their computing power. Compared with a stand alone LDAP system, a distribution-based and replication-based system entail negative impact respectively on read accesses and write accesses. The response time of a read access should become worse in a distribution-based model because of multiple sequential queries for a single access. On the other hand, the performance of a write access would become worse in a replication-based system due to the update of the replication in the other servers. Due the tradeoff, it is not clear to which one shows better performance.

We first propose a queuing model respectively for the distribution-based and the replication-based model is shown in Figure 1 and 3. These models are more suited for Gird environments; The

Table 1. Parameter description

Parameter	Description
λ^a	arrival rate for system
λ	arrival rate for single node
μ_r	service rate for read
μ_w	service rate for write
μ_p	service rate for referral
μ_{wb}	service rate for write+broadcast
μ_a	service rate for acknowledge
λ_i^r	arrival rate for a request has i referrals
P_i^r	probability of λ_i^r
n	number of node
m	number of referral
P^l	local probability
P^r	remote probability
P_r	read probability
P_w	write probability
P_r^l	local read probability
P_w^l	local write probability
P_r^r	remote read probability
P_w^r	remote write probability

distribution-based model assumes more than one referrals during a access. The replication-based model includes lock-step operations of the data write for maintaining data consistency of write intensive Grid environments.

In our model, we assume that each LDAP server is an M/M/1 system and ignore any communication delay between system node. Parameters used in our model are shown in Table 1.

1. Distribution-based model

As shown in Figure 1, the arrival rate for each node is represented as below:

$$\lambda_D = \lambda_r^l + \lambda_w^l + \lambda_r^r + \lambda_w^r + \lambda_r^r + \lambda_w^r + \lambda'^r \quad (1)$$

Representing the above equation by using probabilities of local and remote request as well as arrival rate from the direct user request results in the following equation.

$$\lambda_D = (\frac{(m-1)}{2}(P^r)^2 + P^r + 1)\lambda \quad (2)$$

As shown in Figure 2, the service rate is represented as follows:

$$\mu_D = P_r^s \cdot \mu_r + P_w^s \cdot \mu_w + P_p^s \cdot \mu_p \quad (3)$$

By representing the equation using system arrival rate(λ_D), equation (3) becomes as below:

$$\mu_D = (P_r \cdot \mu_r + P_w \cdot \mu_w + (\frac{(m-1)}{2}(P^r)^2 + P^r)\mu_p)\frac{\lambda}{\lambda_D} \quad (4)$$

According to equation of M/M/1, the response time of the distribution-based model becomes as

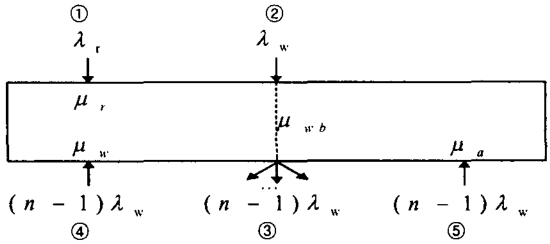


Figure 3. Replication-based model

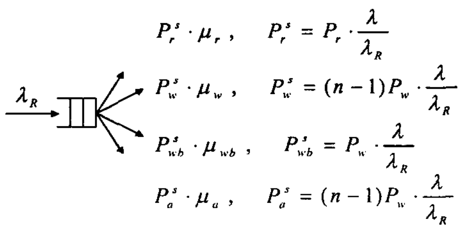


Figure 4. Service rate for replication-based model

follows:

$$RT_D = \frac{m+3}{2}P' \cdot \frac{1}{\mu_D - \lambda_D} \quad (5)$$

2. Replication-based model

In Figure 3, arrival rate for replication-based model expressed as follows:

$$\lambda_R = \lambda_r + \lambda_w + 2(n-1)\lambda_w, \quad n \geq 2 \quad (6)$$

Replacing λr and λ_w with appropriate expressions using λ, the arrival rate is as follows:

$$\lambda_R = (1 + 2(n-1)P_w)\lambda \quad (7)$$

In Figure 4, service rate for data replication is as follows:

$$\mu_R = P_r^s \cdot \mu_r + P_w^s \cdot \mu_w + P_{wb}^s \cdot \mu_{wb} + P_a^s \cdot \mu_a \quad (8)$$

Representing the equation using system arrival rate(λ_R), equation (8) becomes as below:

$$\mu_R = (P_r \cdot \mu_r + (n-1)P_w \cdot \mu_w + P_w \cdot \mu_{wb} + (n-1)P_w \cdot \mu_a)\frac{\lambda}{\lambda_R} \quad (9)$$

According to equation of M/M/1, the response time of the replication-based model becomes as follows:

$$RT_R = \frac{P_r + 3P_w}{\mu_R - \lambda_R} = \frac{1 + 2P_w}{\mu_R - \lambda_R} \quad (10)$$

III. Results of analysis

In order to identify the performance tradeoff between the distribution-based model and the replication-based model, we evaluate the performance of each model under a set of the same system configurations. Table 2 shows the system parameters. The choice of these parameters is based on previous researches so as to reflect realistic system configurations.

Table 2. Parameter values

Parameter	Value	Parameter	Value
μ_r	125	m	n-1
μ_w	60	P^l	1/n
μ_p	125	P^r	n-1/n
μ_{wb}	50	P_r	5%
μ_a	330	P_w	95%

Figure 5 shows a graph which depicts the change of response time with respect to the change of the arrival rate for the distribution-based model. According to the graph, as the number of node *n* becomes larger, both throughput and response time become larger. However, when the arrival rate becomes to about 250 queries per second, which is large enough for saturating the system, the increase of *n* does not affect the maximum throughput. This reflects the fact that the increase of *m* due to the increase of *n* induces severe negative impact against read accesses.

Figure 6 shows a graph which depicts the change of response time with respect to the change of the arrival rate for the replication-based model. Even though the number of nodes become larger, the throughput and response time do not change much. This reflects the fact that the benefit from the increase of *n* is compensated by the overhead from the broadcast.

Figure 7 and 8 shows the performance of both the distribution-based and the replication-based model. It shows the response time for each model. As shown in Figure 5, when the system is small scale with less than 5 nodes, the distribution-based model is superior to the replication-based model. However, as the number of nodes become larger, the performance shows two different cases. First, the replication-based model is better than the distribution-based model when the system load is light. Second, the distribution-based model is better than the replication-based model when the system load is heavy. Indeed, either when the number of nodes is less than 4 or when the arrival rate is over 90, the distribution-based model shows better

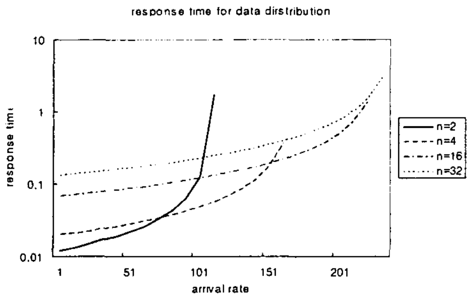


Figure 5. Response time for a distribution-based model

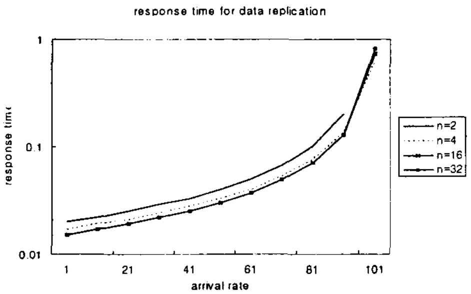


Figure 6. Response time for a replication-based model

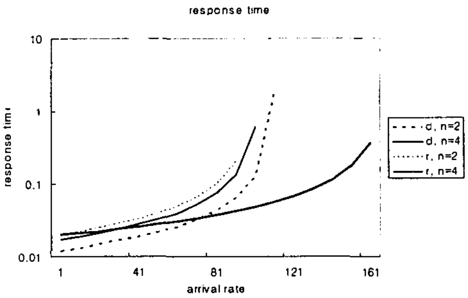


Figure 7. Response time for both model (1)

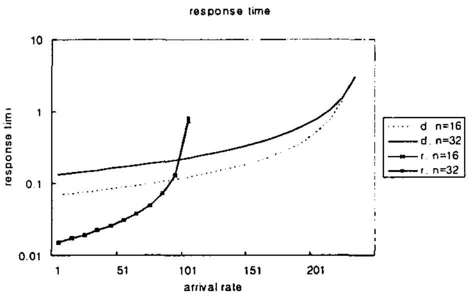


Figure 8. Response time for both model (2)

response time..

IV. Conclusions

This paper presents the performance evaluation respectively for a distribution-based and a replication-based implementation. The analysis is based on an analytic performance model for each distributed system which is obtained by applying the M/M/1 queuing model. According to the evaluation result, either when the number of nodes is less than 4 or when the arrival rate is over 90, the distribution model shows better response time. This reveals that the implementation of distributed LDAP systems should take into account the trade off to get the maximum performance. This point indeed can be of crucial importance for highly distributed LDAP applications such as the GIS of GRIDs.

References

[1] I. Foster, C. Kesselman, S. Tuecke. The Anatomy of the Grid: Enabling scalable virtual organizations. Intl. *Journal of Supercomputing Applications.* (to appear) 2001.

[2] K. Czajkowski, S. Fitzgerald, I. Foster, C. Kesselman. Gird Information Service for Distributed Resource Sharing. *Proc. 10th IEEE International Symposium on High Performance Distributed Computer(HPDC-10),* IEEE Press. 2001.

[3] I. Foster and C. Kesselman. Globus: A Meatacomputing Infrastructure Toolkit. *International Journal of Supercomputing applications.* 11(2):115-128, 1997.

[4] H. Johner, L. Brown, FS. Hinner, W. Reis, J. Westman. Understanding LDAP *IBM.* June, 1998.

[5] W. Smith, A. Waheed, D. meyers, J. Yan. An Evaluation of Alternative Designs for a Grid Information Service. *HPDC 2000,* IEEE Press: 185-192, 2000.

[6] X. Wang, H. Schulzrine, D. Kandlur, D. Verma. Measurement and Analysis of LDAP Performance. *International Conference on Measurement and Modeling of Computer Systems (SIGMETRICS'2000),* Santa Clara, CA, pp. 156--165, Jun. 2000.

[7] YC. Jang, KS Kim, JS. Woo, SS. An. The Replication Mechanism Analysis of OSI(Open System Interconnection) Directory System. *J. ENG. SCI. & TECH.* Vol. 33, pp. 49~61.