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Managing Educational Resource - Student Information Systems Using BVAGQ Fragmented Database Replication Model

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Abstract

Significant and urgent solutions are required in order to manage educational resource efficient and effective. Data replication is one of the key components to manage the huge of resources in data grid architecture as it enhances data access and reliability. Replication provides user with fast, local access to shared data, and increased availability of applications because alternate data access options exist. In this paper, we present on how to manage fragmented database replication and transaction for educational resources-Student Information System (SIS) by using Binary Vote Assignment on Grid Quorum (BVAGQ) fragmented database replication model. Furthermore, fragmentation in distributed database is very useful in terms of usage, reliability and efficiency. In particular, BVAGQ able to partition the database into disjoint fragments. The result shows that managing replication and transaction through proposed BVAGQ able to preserve data availability and consistency. It also increases the degrees of parallelism. This is because by using fragmentation, replication and transaction can be divided into several subqueries that operate on the fragments.

Keywords: Replication algorithm, fragmentation, BVAGQ, Student Information System.

1. Introduction

Significant and urgent solutions are required in order to manage educational resource efficient and effective. Data replication is one of the key components to manage the huge of resources in data grid architecture as it enhances data access and reliability. Replication is the process of copying and maintaining database objects in multiple databases that make up a distributed database system [1]. It is broadly installed in disaster tolerance systems to replicate data from the primary system to the remote backup system dynamically [2]. Replication provides user with fast, local access to shared data, and protects availability of applications because alternate data access options exist. In this paper, we manage fragmented database replication and transaction management for Student Information System using a new proposed algorithm called Binary Vote Assignment on Grid Quorum. This technique will combine replication and fragmentation. Fragmentation in distributed database is very useful in terms of usage, reliability and efficiency. BVAGQ partition the database into disjoint fragments. If data items are located at the site where they used most frequently, locality of reference is high. In fragmentations, similarly, reliability and

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availability are low. So, combining fragmentation with replication, performance should be good. Even if one site becomes unavailable, users can continue to query or even update the remaining fragments.

There are several replication protocols to manage huge resources of data include Read-One-Write-All Monitoring Synchronization Transaction System (ROWA-MSTS) Protocol [3]. In ROWA-MSTS techniques, replicas consistencies is guaranteed by the consistency of execution on one replica, but the client replicas are only updated when obtain all quorum, thus the response time quite low. Besides ROWA-MSTS, Neighbour Replication on Grid (NRG) [4,5] is also one of the replication protocols. NRG daemon manages replication and transactions in order to preserve data consistency and maintain data availability in distributed system. NRG daemon guarantees data consistency and obey serializability through the synchronize replication. In addition, the other replication techniques are Hierarchical Replication Scheme (HRS) and Branch Replication Scheme (BRS) [6]. Replication in HRS starts when a transaction initiates at first site and all the data will be replicate into other site. All sites will have all the same data while BRS replicas are created as close as possible to the clients that request the data files. Using this technique, the growing of the replica tree is driven by client needs. Its goals are to increase the scalability, performance, and fault tolerance. The other protocol is Binary Vote Assignment on Data Grid (BVADG) [7] where a data will replicate to the neighbouring sites from its primary site. Four sites on the corners of the grid have only two adjacent sites, and other sites on the boundaries have only three neighbours.

2. Related Work

2.1. Database Fragmentation

Fragmentation in a single database needs to be divided into two or more pieces such that the combination of the pieces yields the original database without any loss of information. Each resulting piece is known as a database fragment [8]. There are two main types of fragmentation which are horizontal and vertical. Horizontal fragments are subsets of tuples and vertical fragments are subsets of attributes. In addition, horizontal fragmentation groups together the tuples in a relation that are deployed by the important transactions. A horizontal fragment is produced by specifying a predicate that performs a restriction on the tuples in the relation. It is defined using the Selection operation of the relational algebra. Given a relation *R*, a horizontal fragment is defined as $\sigma_p (R)$, where *p* is a predicate based on one or more attributes of the relation. Horizontal fragmentation is most effective if locality of reference can be established by using site-based attributes for fragmentation. It improves response time, availability and concurrency of transactions [8]. Vertical fragmentation groups together the attributes in a relation that are used jointly by the important transactions [9]. A vertical fragment is defined using the Projection operation of the relational algebra. Given a relation R, a vertical fragmentation is defined as $\Pi a_1,...,a_n (R)$, where $a_1,...,a_n$ are attributes of the relation *R*. Vertical fragmentation involves dividing the attributes of a relation into groups and then projecting the relation over each group. The attributes must not have any overlapping across the groups with the exception of primary key attributes or tuple ID. Substantial when fragments can be formed such that query or update transactions for a relation at a site are largely localized to the fragment at that site is the benefit of vertical fragmentation. It comes generally with side-effects and requires a detailed analysis for establishing its benefit.

2.2. Existing Work on Fragmentation

This research focuses on the problem of selecting a fragmentation pattern horizontally in the relational data warehouses based on an approach that uses the algorithm of ant colonies [10]. The problems of selection of these optimization techniques are known NP-complete [11]. To solve these problems, researchers have considered using the approximate methods or metaheuristics which are capable of finding near-optimal solution in a finite time.

The collective intelligence of artificial ants in solving combinatorial optimization problems NP-Complete is a very promising activity. In this research, they have modelled the problem of selecting a horizontal fragmentation scheme that be supported by the approach based on ant colonies while defining the input variables which are the unfragmented data warehouse, the query load frequently used and the maximum number of fragments required by the administrator of the data warehouse (ADW).

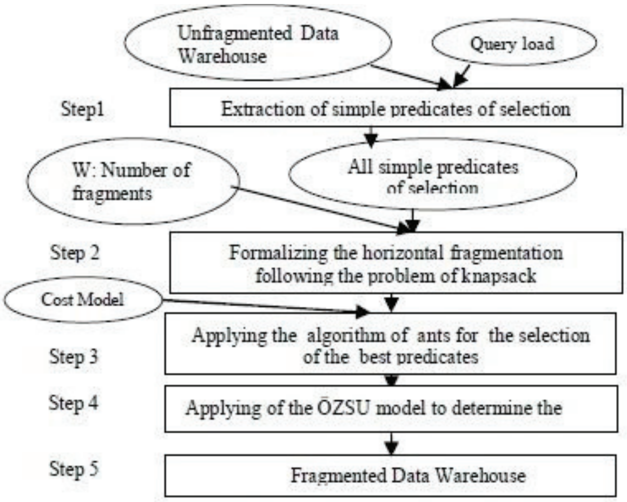

Figure 1: General architecture of our solution [9]

Based on Figure 1, Step 1 shows the highlights the entries in support of requests from which we extract all the simple predicates in the load of queries. In Step 2, *W* represents the number of fragments required by the Administrator of the Data Warehouse which represents a hypothetical element very important in the approach. For Step 3, according to *W*, the load of queries and their execution costs expressed in number of Input/output, the ants will select the best predicates grouped possibly in subsets of predicates of the same attribute. The subsets of selected predicates are those used according to the ÖZSU model, for the partitioning of the data warehouse which is showed in Step 4. A final partitioning scheme will be deducted in Step 5.

3. BVAGQ Fragmentation Database Model

In this section, we proposed the Binary Vote Assignment Grid Quorum (BVAGQ) by considering the distributed database fragmentation. The following notations are defined:

a) V is a transaction.
b) S is relation in database.
c) S_i is vertical fragmented relation derived from S, where i = 1,2,...,n.
d) P_k is a primary key
e) x is an instant in T which will be modified by element of V.
f) T is a tuple in fragmented S.
g) ${}^{Si}{}_{Pkxx}$ is a horizontal fragmentation relation derived from S_i.
h) P_i is an attribute in S where i = 1,2,...,n.
i) $M_{i,j}$ is an instant in relation S where i and j = 1,2,...,n.
j) i represent a row in S.
k) j represent a column in S.
l) η and ψ are groups for the transaction V.
m) $\gamma = \alpha$ or β where it represents different group for the transaction V (before and until get quorum).
n) V_η is a set of transactions that comes before V_ψ, while V_ψ is a set of transactions that comes after V_η.
o) D is the union of all data objects managed by all transactions V of BVAG.
p) Target set = {-1, 0, 1} is the result of transaction V; where -1 represents unknown status, 0 represents no failure and 1 represents accessing failure.
q) BVAG transaction elements $V_\eta = \{V_{\eta x,qr} | r=1,2,...,k\}$ where $V_{\eta x,qr}$ is a queued element of V_η transaction.

r) BVAG transaction elements V_ψ = {$V_{\psi x,qr}$| $r=1,2,...,k$} where $V_{\psi x,qr}$ is a queued element of V_ψ transaction.

s) BVAG transaction elements V_λ = { $V_{\lambda x,qr}$| $r=1,2,...,k$} where $V_{\lambda x,qr}$ is a queued element either in different set of transactions V_η or V_ψ.

t) $\hat{V}_{\lambda x,q1}$ is a transaction that is transformed from $V_{\lambda x,qr}$.

u) $V_{\mu_{x,q_1}}$ represents the transaction feedback from a neighbour site. $V_{\mu_{x,q_1}}$ exists if either $V_{\lambda x,qr}$ or $\hat{V}_{\lambda x,q1}$ exists.

v) Successful transaction at primary site $V_{\lambda x,qr} = 0$ where $V_{\lambda x,qr} \in$ D (i.e., the transaction locked an instant x at primary). Meanwhile, successful transaction at neighbour site $V(\mu_{x,q_1}) = 0$, where $\mu_{x,q_1} \in D$ (i.e., the transaction locked a data x at neighbour).

4. Implementation

To make it clearer on how we manage the transaction using BVAGQ, we present the example case. Each node is connected to one another through an Ethernet switch hub. A cluster with 3 replication servers connected to each as shown in Figure 2.

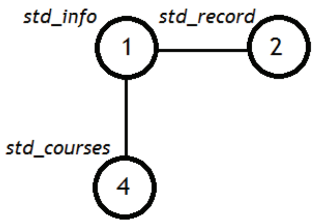

Figure 2: Replication servers

Using BVAGQ techniques, each primary replica copy other database to its neighbour replicas. Client can access other database at any server that has its replica. We assume that primary database *std_info* located in Server 1, primary database *std_record* will be at Server 2 and primary database *std_courses* will be at Server 3. Based on BVAGQ model, *status* for $V_{\lambda_{status}, q_1}$ will be any instant *a, b, c, d, e, f, g, h* and *i.*

If two sets of transactions, V_η and V_ψ initiates to update database *std_info* at replica 1 and 2, first it needs to request to update database *std_info* from primary replica 1 and 2. If $V_{\lambda_{status}, q_1} = 0$, the other transactions in queue will abort. Then, neighbor binary voting assignment is initiated. Transactions in both nodes, V_η and V_ψ will propagate lock. The first transaction that initiated will get the lock and other transactions will be aborted. So now Replica 1 and 2 have a transaction waiting but transactions cannot read or update database *a* at same time.

Primary nodes 1 propagate lock to its neighbor replicas 2 while primary nodes 2 propagate lock to its neighbor replica 4. Primary replica for V_{η_{status}, q_1} propagates lock to its neighbor replicas 2 and 4. Primary replica for V_{ψ_{status}, q_1} propagates lock to its neighbor replicas 1 and 4. The first transaction get majority quorum will be transform to $\hat{V}_{\lambda_{status}, q_1}$. The details of experiment result are shown in Table 1.

Table 1: Experiment Result

Time/Replica	Replica 1	Replica 2	Replica 4
0.1	unlock (*std_info)*	unlock (*std_info)*	unlock (*std_info)*
0.2	Begin transaction	Begin transaction	

0.3	write lock (*std_info*) counter_w(*std_info*)=1	write lock (*std_info*) counter_w(*std_info*)=1	
0.4	wait	wait	
0.5	V_{η_{status}, q_1} propagate lock: 2	V_{ψ_{status}, q_1} propagate lock: 4	
0.6	propagate lock: 2	V_{ψ_{status}, q_1} get lock: 2 counter_w(*std_info*)=2 obtain quorum release lock: 1	
0.7	abort V_{η_{status}, q_1} lock (*std_info*) from 2		
0.8		V_{ψ_{status}, q_1} fragmented into S_2	
0.9		S_2 is fragmented into ${}^{S2}_{Pkxx}$	
0.10		${}^{S2}_{Pkxx}$ divided into T_2 where $T_1 = P_1 = std\_id$ $T_2 = P_6 = status$	
0.11		unlock (*std_info)*	
0.12	Commit $\hat{V}_{\lambda_{status}, q_1}$	Commit $\hat{V}_{\lambda_{status}, q_1}$	Commit $\hat{V}_{\lambda_{status}, q_1}$
0.13	unlock (*std_info)*	unlock (*std_info)*	unlock (*std_info)*

Refer Table 2 to Table 6, relation *S* will be fragmented using vertical fragmentation into S_i. Next, the fragmented relation, S_i will be fragmented again but this time using horizontal fragmentation into ${}^{Si}_{Pkxx}$ leaving only instant for primary key and data that need to be update.

Table 2: Relation *S*

STD_INFO								
STD_ID	STD_NAME	P.O.B	D.O.B	RELIGION	PERMANENTADD	CURRENTADD	NATIONALITY	STATUS
MSC09002	Noriyani Mohd Zain	Machang	08-JUL-85	Muslim	Machang, Kelantan	Kuantan, Pahang	Malaysian	Single
MSC09003	Ainul Azila Che Fauzi	Kota Bharu	21-APR-85	Muslim	Kota Bharu, Kelantan	Kuantan, Pahang	Malaysia	Single
PCC09003	Nawsher Khan	Samar Bagh Dir	30-DEC-79	Muslim	Samar Bagh Dir, Pakistan	Kuantan, Pahang	Pakistan	Married

Relation *S* fragmented into S_1 and S_2 using horizontal fragmentation as shown in Table 3 and Table 4.

$S_1 = \Pi$ *STD_ID, STD_NAME, P.O.B, D.O.B, RELIGION, PERMANENTADD, CURRENTADD, NATIONALITY (S)*

$S_2 = \Pi$ *STD_ID, STATUS (S)*

Table 3: Relation S_1

STD_ID	STD_NAME	P.O.B	D.O.B	RELIGION	PERMANENTADD	CURRENTADD	NATIONALITY
MSC09002	Noriyani Mohd Zain	Machang	08-JUL-85	Muslim	Machang, Kelantan	Kuantan, Pahang	Malaysian
MSC09003	Ainul Azila Che Fauzi	Kota Bharu	21-APR-85	Muslim	Kota Bharu, Kelantan	Kuantan, Pahang	Malaysia
PCC09003	Nawsher Khan	Samar Bagh Dir	30-DEC-79	Muslim	Samar Bagh Dir, Pakistan	Kuantan, Pahang	Pakistan

Table 4: Relation S_2

STD_ID	STATUS
MSC09002	Single
MSC09003	Single
PCC09003	Married

Relation S_2 fragmented using horizontal fragmentation into ${}^{Si}{}_{STDIDxSTATUS}$. After that, we will get the instant that w want to update, along with the primary key.

Table 5: Table ${}^{S1}{}_{STDIDxSTATUS}$

STD_ID	STATUS
MSC09002	Single
PCC09003	Married

$T_1 = P_1 = STD\_ID$

Table 6: Table ${}^{S2}{}_{STDIDxSTATUS}$

STD_ID	STATUS
MSC09003	Single

$T_2 = P_6 = STATUS$

5. Conclusions

In order to preserve data availability and consistency of the systems, managing transactions is very import With the aim of managing fragmented database replication and transaction management, we design a new mo called Binary Vote Assignment on Grid Quorum. From the experiment result, we can say that managing replica and transaction through proposed BVAGQ able to preserve data consistency. It also increases the degree parallelism because by using fragmentation, replication and transaction can be divided into several subqueries operate on the fragments.

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