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# Managing Fragmented Database Replication for Mygrants Using Binary Vote Assignment on Cloud Quorum

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**Keywords**:Data replication, Cloud Computing, replication algorithm, fragmentation, BVACQ, quorum, MyGRANTS.

**Abstract.** Replication in distributed database is the process of copying and maintaining database objects in multiple databases that make up a distributed database system. In this paper, we will manage fragmented database replication and transaction management for Malaysian Greater Research Network (MyGRANTS) using a new proposed algorithm called Binary Vote Assignment on Cloud Quorum (BVACQ). This technique will combine replication and fragmentation. Fragmentation in distributed database is very useful in terms of usage, efficiency, parallelism and also for security. This strategy will partition the database into disjoint fragments. The result shows that managing replication and transaction through proposed BVACQ able to preserve data 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.

## Introduction

Database replication is the frequent electronic copying data from a database in one computer or server to a database in another so that all users share the same level of information [1]. This process helps to improve reliability, fault-tolerance, or accessibility of data [2].

However, research problems arise, how are mechanisms done in order to maintain the availability and consistency of the data in the event of disaster? How large the storage needed to store all the replicated data? How about the communication cost for the data replication? Existing data replication technique such as Read-One-Write-All (ROWA) applied all-data-to-all-sites protocol. Ergo, the storage and communication cost for ROWA technique is very high.

We will propose a new replication technique namely Binary Vote Assignment on Cloud Quorum (BVACQ) which is based from BVAG [2] technique to manage replication in Cloud environment with example case using Malaysian Greater Research Network (MyGRANTS) database.

MyGRANTS is sets of systems and tools to help researchers, nurture collegiality amongst researcher and to help develop a critical mass of researches by offering a conducive research ecosystem. Among of the MyGRANTS objectives are to manage the operation of research management at universities level and to optimize the available research grants. MyGRANTS systems need huge storage since it will store the database of all the researchers around Malaysia. Therefore, it is important to choose the right method to handle the data storage and replication. Otherwise, it will increase the communication cost and time taken for the transaction to complete.

In order to minimize the storage and the communication cost used for data replication, BVACQ will combine fragmentation with the replication. Fragmentation in distributed database is very useful in terms of usage, efficiency, parallelism and also for security[3]. This strategy will 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 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 [3].

## Literature Review

**Data Replication.** In managing replica placement strategy in Cloud, there are three fundamental questions that must be answered which are when should the replicas be created? Which files should be replicated? And where the replicas should be placed? Different replication strategies have been developed to overcome the problems that have been mentioned [4,5,6]. In replicated systems, synchronization is one of the issues that need to be concerned. Synchronization schemes can be classified as synchronous or asynchronous [7]. Asynchronous replication updates replication using separate transaction which can cause inconsistencies. However, synchronous replication will guarantee data consistency since it works based on quorum to execute the operations [8]. This will ensure that all the copies in any site are the same and consistent. Nevertheless, synchronous replication requires vast amounts of storage capacity [9].

**Database Fragmentation Concept.** Fragmentation is when 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 [10]. In data distribution, it is better to work with subsets of relations as the unit of distribution [10]. The other benefit from fragmentation is the efficiency. Data is stored close to where it is most frequently used and for data that is not needed, it is not stored. There are two main types of fragmentation which are horizontal and vertical [10]. Horizontal fragments are subsets of tuples and vertical fragments are subsets of attributes.

## System Model

The following notations are described:

a) $V$ is a transaction.
b) $S$ is a relation in the database.
c) $T$ is a tuple in fragmented $S$.
d) $x$ is an instant in $T$ which will be modified by the element of $V$.
e) $y$ is an instant in $T$ which will not be modified by the element of $V$.
f) $S_1$ is a vertical fragmented relation with instant $x$ derived from $S$.
g) $S_2$ is a vertical fragmented relation without instant $x$ derived from $S_1$.
h) $P_k$ is a primary key.
i) $P_{k,x}$ is a primary key and data $x$.
j) $P_{k,y}$ is a primary with data $y$, where $y \neq x$
k) $S_{1_{(Pk,x)}}$ and $S_{1_{(Pk,y)}}$ are a horizontal fragmentation relation derived from $S_1$.
l) $\eta$ and $\psi$ are groups for the transaction $V$.
m) $\lambda = \eta$ or $\psi$ where it represents different group for the transaction $V$ (before and until get quorum).
n) $V_\eta$ is a set of transactions that comes before $V_\psi$, while $V_\psi$ is a set of transactions that comes after $V_\eta$.
o) $D$ is a union of all data objects managed by all transactions V of BVAFD.
p) Target set = {1, 0, -1} is a result of transaction $V$ (see Table 3.1).
q) BVAFD transaction elements $V_\eta = \{V_{\eta_{x,qr}} \mid r=1,2,...,k\}$ where $V_{\eta_{x,qr}}$ is a queued element of $V_\eta$ transaction.
r) BVAFD transaction elements $V_\psi = \{V_{\psi_{x,qr}} \mid r=1,2,...,k\}$ where $V_{\psi_{x,qr}}$ is a queued element of $V_\psi$transaction.
s) BVAFD transaction elements $V_\lambda = \{V_{\lambda_{x,qr}} \mid r=1,2,...,k\}$ where $V_{\lambda_{x,qr}}$ is a queued element either in different set of transactions $V_\eta$ or $V_\psi$.
t) $wV_{\lambda_{x,qr}}$ is write counter for the transaction.
u) $\hat{V}_{\lambda_{x,qr}}$ is a transaction that is transformed from $V_{\lambda_{x,qr}}$.

v) $V_{\mu_{x,q_1}}$ represents the transaction feedback from a neighbour site. $V_{\mu_{x,q_1}}$ exists if either $V_{\lambda_{x,q_r}}$ or $\hat{V}_{\lambda_{x,q_r}}$ exists.

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

x) $\left\lceil \frac{n}{2} \right\rceil$ is the greatest integer function (i.e., $n$=9, $\left\lceil \frac{9}{2} \right\rceil = 5$ ).

In BVACG, all sites are logically organized in the form of two-dimensional grid structure. That means, if a BVACQ involves of twenty-five sites, it will logically organize in the form of 5 × 5 grid. Every site has a primary data file. A site is either operational or failed and the state of either it is operational or failed of each site is statistically independent to the others. When a site is operational, the copy at the site is available; otherwise it is unavailable (Deris et al., 2003). A site X is a neighbour to site Y, if X is logically adjacent to Y (Deris et al., 2003). A data from its primary site will replicate to the neighbouring sites.

## Experimental Result

To make it clearer on how we manage the transaction using BVACQ, here we present the example case by applying data from MyGRANTS database. For this experiment, only Application module has been considered since it is the most critical data that need to be updated synchronously. A cluster with 5 replication servers connected to each other as shown in Fig. 1.

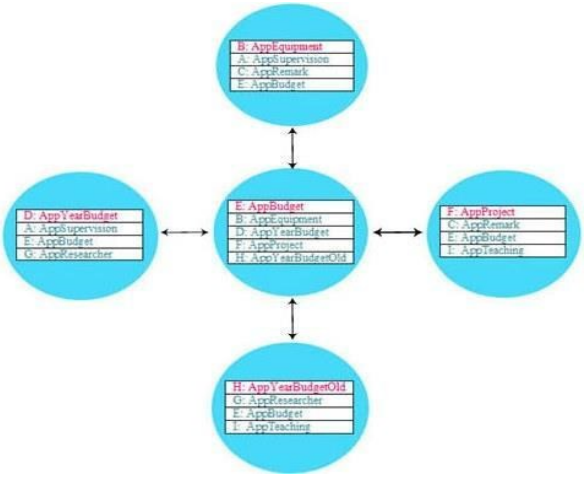


Fig. 1 Three replication servers connected to each.

For the experiment, case that has been tested is when a set of transaction, $V_n$ request to update instant x from relation AppBudget at site E. The details of experiment result are shown in Fig. 2.

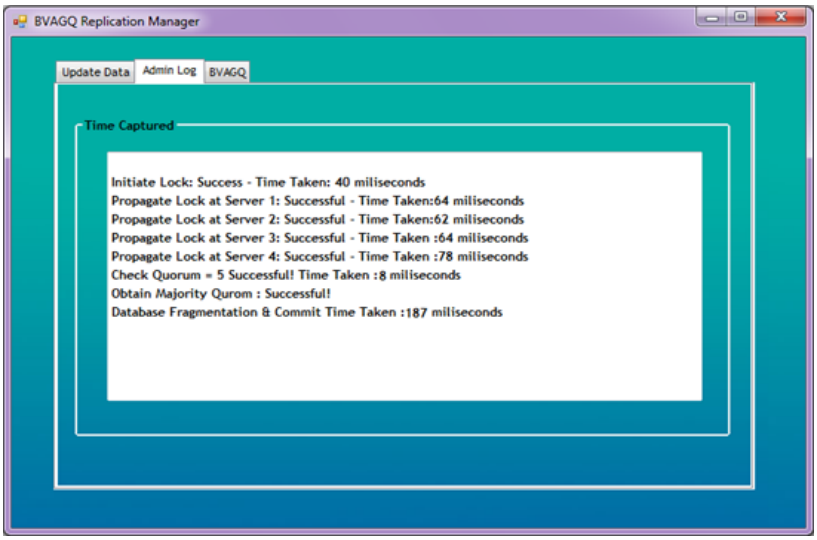


Fig. 2 Time taken for the first experiment

Fig. 2 shows the executing time for the first experiment. It is shown that the time taken to initiate lock is 40 milliseconds (ms), propagate lock to server 1 is 64 ms, propagate lock to server 2 is 62 milliseconds, propagate lock to server 3 is 64 milliseconds and propagate lock to server 4 is 78 milliseconds. Time taken to check quorum is 8 ms. Lastly, time taken to fragment the database and commit the transaction is 187 ms.

## Conclusion

In order to preserve data consistency and reliability of the systems, managing transactions is very important. With the aim of managing fragmented database replication and transaction management in Cloud Computing, we design a new model called Binary Vote Assignment on Cloud Quorum. From the experiment result, we can say that managing replication and transaction through proposed BVACQ able to preserve data consistency. It also increases the degrees of parallelism because by using fragmentation, replication and transaction can be divided into several subqueries that operate on the fragments.

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