**APPLIED PROBLEMS OF MATHEMATICS AND MECHANICS**

**Agil A. ALIYEV**

# TWO PHASE LOCKING PROTOCOL IN DISTRIBUTED DATABASES

**Abstract**

In this paper we consider two-phase locking protocol in distributed databases, which ensures integrity of the system. Assertion about overhead of two-phase locking protocol is proved.

**Introduction.** Informatization of society becomes one of the major characteristics of our nowadays. There is no area of human activity, which is not connected with processes of receiving and information processing. Information process – is process, in result of which realized receiving, passing, transformation and using of information. Resources of information processing most often are personal computers, which connected via local and global network. Computer network – totality of computers and terminals, connected via channels of connection in whole system, which satisfy distributed information processing requests.

Distributed information processing – is elaboration of data, implemented on independent computers, but connected to each other, which represent distributed system.

Distributed systems (DS) [1] represent a set of sites, which are territorially remote from each other, integrated with data transmission system and interacting via messaging. Such systems provide the distributed data processing, in which application process (program or user) can access to information from one site to another. The final target on DS creation is the integration of informational and computational resources, and also communication accessories, office equipment and etc. of the whole region and as well as of the world for opportunely submission of possibility of their consumption regardless on a geographical location of the users.

Main requirements for modern DS is high reliability, remote access to information resources, protection of data from non-sanction access, maximal use of informational-computing resources of system, remote and without delay access to system, prostate of user contact with system and openness of architecture, i.e. possibility of enlargement and development [5].

For example, the DS can be a distributed database (DDB), which is a set of logically related data in different sites, and flow of application processes - global transactions, which can simultaneously use several databases as a unit.

Ease grafting of computational capabilities, increased fault tolerance, facility of an approximation of data on their users – the main advantages of the DDB. At the same time, use of DDB needs for ensuring such specific requirements for functioning, such as maintenance of integrity and not conflicting of DDB. The important functions of DDB are the concurrent control on application processes and ensuring of fault tolerance, i.e. capacities of the system correctly to execute basic functions (algorithms) irrespective on failures in an equipment or program errors. It is obvious, that both these functions are need to be researched and developed in close interrelation.

**Principles of transaction processing.** Transaction- is indivisible (in point of view influence on Distributed Database Management Systems), set of operations manipulating over data. Each transaction transforms system form one consistent state to another. [4]

However, at parallel execution of some transactions, contents of DDB may be in contradictory. That's why Transaction Management System (TMS), which is main component of DDB, must to manage parallel execution of transactions such that, so as to keep integrity of DDB.

There are different models of transactions, which can be classified by virtue of different characteristics, including a transactional structure, parallelism inside transaction, duration and etc. Mostly intend traditional transactions, which characterized by four classical properties: Atomicity, Consistency, Isolation, Durability - ACID. Sometimes traditional transactions named as ACID-transactions[2]. The above mentioned properties imply the following.

1. (A) Atomicity. Transaction is executed be principle "all or nothing", i.e. either transaction executed in whole and transform DS from one consistent state to other, or if one of transaction's action is unrealizable, then DS return to initial position, which was before transaction execution (transaction rollbacks).

2. (C) Consistency. The property of the consistency guarantees, that in accordance with the execution of transactions DDB passes from one consistent state into other – the transaction does not violate a mutually consistency on data.

3. (I) Isolation. The property isolation means, that the transactions, which are concurrent for a database access, physically operated sequentially, isolated from each other, but for the users it looks as if they are executed in parallel.

4. (D) Durability. The property of durability is treated as follows: if the transaction is successfully completed, then those modifications in data, which were made by it, can not be lost at any circumstances (even in case of consequent errors).

At parallel execution of transaction must be ensured serializability of transaction. Serializability of parallel transactions means that, result of its parallel execution must be the same, as if transactions executed sequentially. Difficulty consist in that, what if not undertake special measures, then data changed by one user may be changed by transaction of another user earlier than finished transaction of first user. In result, in end of transaction, first user will not see results of own work.

**Two-phase locking protocol.** In order to ensure serializability of parallel executed transactions elaborated different methods of concurrency control. One of these methods is locking method. There are different forms of locking method. In this paper we consider one of forms of locking method, namely two-phase locking method. Structure of transaction and method of managing, which satisfy principle of two phase locking, is significant that process of transaction execution can be divided into two periods: period of gradation and degradation. In first period transaction locks all necessary resources and in this period number of resources seized by transaction monotonically increase. In second period all locked resources simultaneously unlocked.

There are two models of locking method: monoversion and multiversion [6]. There is only one version of data in monoversion model. But in multiversion model there is more than one version. Read operation returns value of data, usually last. Write operation creates new version of data. The method of two phase locking is developed for both models.

In this paper we consider overhead of two-phase locking protocol for monoversion model of the two-phase locking protocol. There are three types of measures for defining overhead [3]. First one measures the maximal number of protocol steps (locks, unlocks). This measure is most appropriate in a fast and lightly loaded network, where the completion time of a transaction is determined by the longest sequence of steps, regardless of the number of intersite messages required in order to execute it. Since entities can be read or written only while locked, the longest sequence of lock-unlock steps is closely related to the longest sequence of disk accesses. The second measure also deals with parallel execution and quantifies the longest sequence of intersite messages that transaction must send in order to obey the protocol. It is most appropriate in a heavily loaded local-area network with broadcast facility. One message sent from a site can be received by all other site, but contention may delay the placing of the message on the network; the number of times a transaction has to do so determines response time. The third measure quantifies the total number of intersite messages that transaction must send. It determines performance in a heavily loaded wide-area network without the broadcast facility.

Lets determine third measure of overhead of two-phase locking protocol. For that we introduce some denotes:

$X$ - a set of entities;

$2PL$ – two-phase locking protocol;

$2PL(X)$ – the set of transactions that belongs to $2PL$ and reference exactly the set of entities X.

$Mn.2PL(X)$ –message-number overhead;

$n$ – number of sites

$l$ – number of locked steps;

$u$ - number of unlocked steps;

In that way following assertion is true.

**Assertion.** The total number of intersite messages in two-phase locking method not exceeds 2n-2, i.e.:

$$Mn.2PL(X) \leq 2n - 2$$

**Proof.** Let's consider that,

$$T \in 2PL(X).$$

Let, $T$ have $u$ unlock steps of which none succeeds another unlock step, and $l$ lock steps of which none precedes another lock step. It is clear that,

$$n \geq l, l \geq 1.$$

The total number of arcs between these steps is $u \bullet l$, because all locks precede all unlocks. At the most $\min(l,u)$ of these arcs are from a lock to unlock at the same site. Thus there are at least $u \bullet l - \min(u,l)$ intersite arcs from locks to unlocks. Let $z_1, z_2, ..., z_n$be the first unlock steps executed at sites 1,2,. . . ,n respectively. Since only $u$ unlocks do not have an unlock predecessor, $n-u$ of these steps are preceded by an unlock step executed at a different site. Thus, the number of intersite arcs between two unlocks in $T$ is at least $n-u$. Similarly, it can be shown that the number of intersite arcs between two locks is at least $n-l$. Thus the total number of intersite arcs is at least

$$2n - u - l + u \bullet l - \min(u,l)$$

If we will prove that,

$$u + l + \min(l,u) - ul \leq 2,$$

then we will receive

$$2n + u + l + \min(l,u) - ul \leq 2n + 2.$$

Let

$$\varphi(l,u) = u + l + \min(l,u) - ul.$$

Then

$$\varphi(l+1,u+1) = (u+1) + (l+1) + \min(l+1,u+1) - (u+1)(l+1) =$$

$$= u + l + 2 + \min(l+1,u+1) - ul - u - l - 1 =$$

$$= u + l + \min(l+1,u+1) - 1 - ul + (2 - u - l).$$

It is clear that,

$$\min(l+1,u+1) - 1 = \min(l,u)$$

and for any

$$l \geq 1, u \geq 1,$$

take place the following inequality:

$$2 - u - l \leq 0.$$

Using this modifications we get:

$$\varphi(l+1,u+1) = u + l + \min(l+1,u+1) - ul + (2 - u - l) =$$

$$= u + l + \min(l, u) - ul + (2 - u - l) \leq$$
$$\leq u + l + \min(l, u) - ul = \varphi(l, u)$$

i.e. we receive that,

$$\varphi(l + 1, u + 1) \leq \varphi(l, u)$$

This ineqality receives its maximum value at minimal value of

$$(l, u)$$

Now as minimal value

$$l = 1, u = 1,$$

then we receive that,

$$\varphi(1, 1) = 1 + 1 + \min(1, 1) - 1 * 1 = 2$$

**Conclusions.** Thus, in this paper considered locking methods in distributed databases, which ensures integrity of system. Overhead of two-phase locking is considered. Message-number overhead and prove of corresponding assertion are shown.

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**Agil A. Aliyev**
Institute of Information Technology of Azerbaijan National Academy of Sciences.
9, F.Agayev str., AZ1141, Baku, Azerbaijan.
Email: aliev@lan.ab.az

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