Lock Based Concurrency Control Protocol in DBMS

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In a Database Management System (DBMS), lock-based concurrency control (BCC**)** is a method used to manage how multiple transactions access the same data. This protocol ensures data consistency and integrity when multiple users interact with the database simultaneously.
This method uses locks to manage access to data, ensuring transactions don't clash and everything runs smoothly when multiple transactions happen at the same time. In this article, we'll take a closer look at how the Lock-Based Protocol works.

What is a Lock?

A lock is a variable associated with a data item that indicates whether it is currently in use or available for other operations. Locks are essential for managing access to data during concurrent transactions. When one transaction is accessing or modifying a data item, a lock ensures that other transactions cannot interfere with it, maintaining data integrity and preventing conflicts. This process, known as locking, is a widely used method to ensure smooth and consistent operation in database systems.

Lock Based Protocols

Lock-Based Protocols in DBMS ensure that a transaction cannot read or write data until it gets the necessary lock. Here's how they work:

- These protocols prevent concurrency issues by allowing only one transaction to access a specific data item at a time.
- Locks help multiple transactions work together smoothly by managing access to the database items.
- Locking is a common method used to maintain the serializability of transactions.
- A transaction must acquire a read lock or write lock on a data item before performing any read or write operations on it.

Types of Lock

1. **Shared Lock (S):** Shared Lock is also known as Read-only lock. As the name suggests it can be shared between transactions because while holding this lock the transaction does not have the permission to update data on the data item. S-lock is requested using lock-S instruction.
2. **Exclusive Lock (X):** Data item can be both read as well as written. This is Exclusive and cannot be held simultaneously on the same data item. X-lock is requested using lock-X instruction.

Read more about Types of Locks.

Rules of Locking

The basic rules for Locking are given below :

Read Lock (or) Shared Lock(S)

❖ If a Transaction has a Read lock on a data item, it can read the item but not update it.

❖ If a transaction has a Read lock on the data item, other transaction can obtain Read Lock on the data item but no Write Locks.

❖ So, the Read Lock is also called a Shared Lock.

Write Lock (or) Exclusive Lock (X)

❖ If a transaction has a write Lock on a data item, it can both read and update the data item.

❖ If a transaction has a write Lock on the data item, then other transactions cannot obtain either a Read lock or write lock on the data item.

❖ So, the Write Lock is also known as Exclusive Lock.

Lock Compatibility Matrix

- A transaction can acquire a lock on a data item only if the requested lock is compatible with existing locks held by other transactions.

- **Shared Locks (S):** Multiple transactions can hold shared locks on the same data item simultaneously.
- **Exclusive Lock (X):** If a transaction holds an exclusive lock on a data item, no other transaction can hold any type of lock on that item.
- If a requested lock is not compatible, the requesting transaction must wait until all incompatible locks are released by other transactions.
- Once the incompatible locks are released, the requested lock is granted.

Concurrency Control Protocols

Concurrency Control Protocols are the methods used to manage multiple transactions happening at the same time. They ensure that transactions are executed safely without interfering with each other, maintaining the accuracy and consistency of the database.

These protocols prevent issues like data conflicts, lost updates or inconsistent data by controlling how transactions access and modify data.

Types of Lock-Based Protocols

1. Simplistic Lock Protocol

It is the simplest method for locking data during a transaction. Simple lock-based protocols enable all transactions to obtain a lock on the data before inserting, deleting, or updating it. It will unlock the data item once the transaction is completed.

Example:

Consider a database with a single data item X = 10.

Transactions:

- **T1**: Wants to read and update X.
- **T2**: Wants to read X.

Steps:

1. T1 requests an exclusive lock on X to update its value. The lock is granted.
   - T1 reads X = 10 and updates it to X = 20.
2. T2 requests a shared lock on X to read its value. Since T1 is holding an exclusive lock, T2 must wait.
3. T1 completes its operation and releases the lock.
4. T2 now gets the shared lock and reads the updated value X = 20.

This example shows how simplistic lock protocols handle concurrency but do not prevent problems like deadlocks or limits concurrency.

2. Pre-Claiming Lock Protocol

The Pre-Claiming Lock Protocol evaluates a transaction to identify all the data items that require locks. Before the transaction begins, it requests the database management system to grant locks on all necessary data elements. If all the requested locks are successfully acquired, the transaction proceeds. Once the transaction is completed, all locks are released. However, if any of the locks are unavailable, the transaction rolls back and waits until all required locks are granted before restarting.

Example:

Consider two transactions T1 and T2 and two data items, X and Y:

1. Transaction T1 declares that it needs:
   - A write lock on X.
   - A read lock on Y.

   Since both locks are available, the system grants them. T1 starts execution:
   - It updates X.
   - It reads the value of Y.
2. While T1 is executing, Transaction T2 declares that it needs:
   - A read lock on X.

   However, since T1 already holds a write lock on X, T2's request is denied. T2 must wait until T1 completes its operations and releases the locks.

3. Once T1 finishes, it releases the locks on X and Y. The system now grants the read lock on X to T2, allowing it to proceed.

This method is simple but may lead to inefficiency in systems with a high number of transactions.

3. Two-phase locking (2PL)

A transaction is said to follow the Two-Phase Locking protocol if Locking and Unlocking can be done in two phases :

- **Growing Phase:** New locks on data items may be acquired but none can be released.
- **Shrinking Phase:** Existing locks may be released but no new locks can be acquired.

For more detail refer the article Two-phase locking (2PL).

4. Strict Two-Phase Locking Protocol

Strict Two-Phase Locking requires that in addition to the 2-PL all Exclusive(X) locks held by the transaction be released until after the Transaction Commits.

For more details refer the article Strict Two-Phase Locking Protocol.

Problem With Simple Locking

Consider the Partial Schedule:

S.No	T_1	T_2
1	lock-X(B)	
2	read(B)	
3	B:=B-50	
4	write(B)	
5		lock-S(A)
6		read(A)
7		lock-S(B)
8	lock-X(A)	
9	……	……

1. Deadlock

In the given execution scenario, T1 holds an exclusive lock on B, while T2 holds a shared lock on A. At Statement 7, T2 requests a lock on B, and at Statement 8, T1 requests a lock on A. This situation creates a deadlock, as both transactions are waiting for resources held by the other, preventing either from proceeding with their execution.

2. Starvation

Starvation is also possible if concurrency control manager is badly designed. For example: A transaction may be waiting for an X-lock on an item, while a sequence of other transactions request and are granted

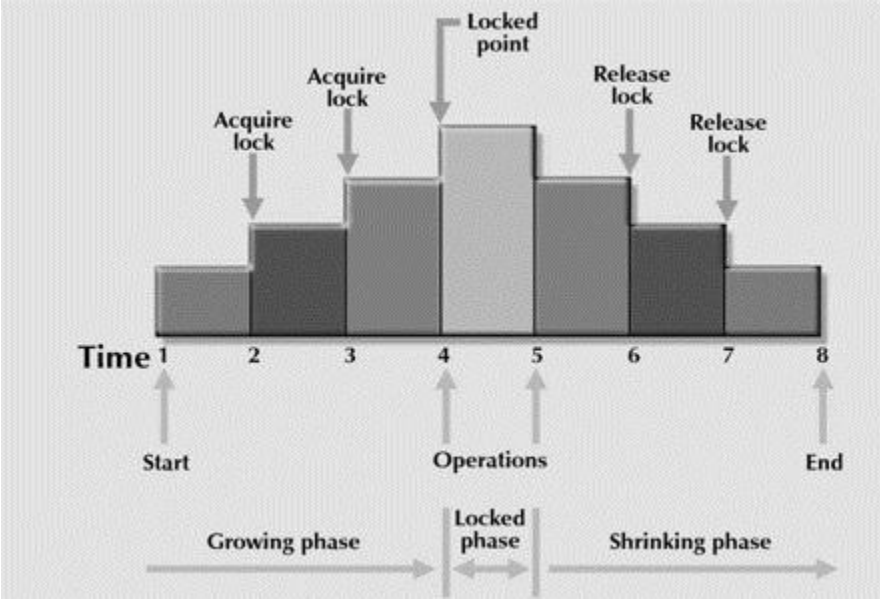
an S-lock on the same item. This may be avoided if the concurrency control manager is properly designed.

2PL locking protocol

Every **transaction** will lock and unlock the data item in two different phases.

- **Growing Phase** − All the locks are issued in this phase. No locks are released, after all changes to data-items are committed and then the second phase (shrinking phase) starts.
- **Shrinking phase** − No locks are issued in this phase, all the changes to data-items are noted (stored) and then locks are released.

The 2PL locking protocol is represented diagrammatically as follows −



In the growing phase transaction reaches a point where all the locks it may need has been acquired. This point is called LOCK POINT.

After the lock point has been reached, the transaction enters a shrinking phase.

Types

Two phase locking is of two types −

Strict two phase locking protocol

A transaction can release a shared lock after the lock point, but it cannot release any exclusive lock until the transaction commits. This protocol creates a cascade less schedule.
Cascading schedule: In this schedule one transaction is dependent on another transaction. So if one has to rollback then the other has to rollback.

Rigorous two phase locking protocol

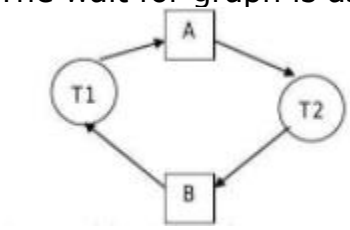
A transaction cannot release any lock either shared or exclusive until it commits.
The 2PL protocol guarantees serializability, but cannot guarantee that deadlock will not happen.

Example

Let T1 and T2 are two transactions.
T1=A+B and T2=B+A

T1	T2
Lock-X(A)	Lock-X(B)
Read A;	Read B;
Lock-X(B)	Lock-X(A)

Here,
Lock-X(B) : Cannot execute Lock-X(B) since B is locked by T2.
Lock-X(A) : Cannot execute Lock-X(A) since A is locked by T1.
In the above situation T1 waits for B and T2 waits for A. The waiting time never ends. Both the transaction cannot proceed further at least any one releases the lock voluntarily. This situation is called deadlock.
The wait for graph is as follows –



Wait for graph: It is used in the deadlock detection method, creating a node for each transaction, creating an edge Ti to Tj, if Ti is waiting to lock an item locked by Tj. A cycle in WFG indicates a deadlock has occurred. WFG is created at regular intervals.