Two Phase Locking Protocol

There are two types of Locks available Shared S(a) and Exclusive X(a). Implementing this lock system without any restrictions gives us the **Simple Lock-based protocol** (or ***Binary Locking***), but it has its own disadvantages, they do not guarantee **Serializability**. Schedules may follow the preceding rules but a non-serializable schedule may result.

To guarantee serializability, we must follow some additional protocols *concerning the positioning of locking and unlocking operations* in every transaction. This is where the concept of **Two-Phase Locking(2-PL)** comes into the picture, 2-PL ensures serializability. Now, let's dig deep!

Two Phase Locking

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.

Note: If lock conversion is allowed, then upgrading of lock(from S(a) to X(a)) is allowed in the Growing Phase, and downgrading of lock (from X(a) to S(a)) must be done in the shrinking phase.

Let's see a transaction implementing 2-PL.

	T1	**T2**
1	lock-S(A)	
2		lock-S(A)
3	lock-X(B)	
4	……….	……….
5	Unlock(A)	
6		Lock-X(C)

	T1	**T2**
7	Unlock(B)	
8		Unlock(A)
9		Unlock(C)
10	……….	……….

This is just a skeleton transaction that shows how unlocking and locking work with 2-PL. Note for:

Transaction T1

- The growing Phase is from steps 1-3
- The shrinking Phase is from steps 5-7
- Lock Point at 3

Transaction T2

- The growing Phase is from steps 2-6
- The shrinking Phase is from steps 8-9
- Lock Point at 6

Lock Point

The Point at which the growing phase ends, i.e., when a transaction takes the final lock it needs to carry on its work. Now look at the schedule, you'll surely understand. I have said that 2-PL ensures serializability, but there are still some drawbacks of 2-PL. Let's glance at the drawbacks.

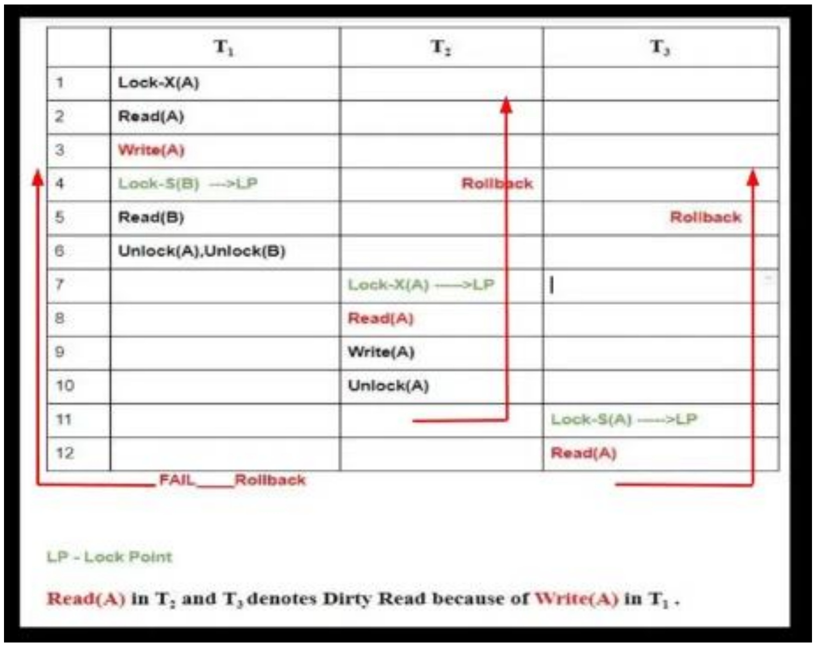
- Cascading Rollback is possible under 2-PL.
- Deadlocks and Starvation are possible.

Cascading Rollbacks in 2-PL

Let's see the following Schedule:

Cascading Roll-Back

Take a moment to analyze the schedule. Yes, you're correct, because of Dirty Read in T2 and T3 in lines 8 and 12 respectively, when T1 failed we have to roll back others also. Hence, Cascading Rollbacks are possible in 2-PL. I have taken skeleton schedules as examples because it's easy to understand when it's kept simple. When explained with real-time transaction problems with many variables, it becomes very complex.



	T_1	T_2	T_3
1	Lock-X(A)		
2	Read(A)		
3	Write(A)		
4	Lock-S(B) --->LP	Rollback	
5	Read(B)		Rollback
6	Unlock(A),Unlock(B)		
7		Lock-X(A) ---->LP	
8		Read(A)	
9		Write(A)	
10		Unlock(A)	
11			Lock-S(A) ---->LP
12			Read(A)

FAIL___Rollback

LP - Lock Point

Read(A) in T_2 and T_3 denotes Dirty Read because of Write(A) in T_1 .

Figure: Cascading Roll-Back

Deadlock in 2-PL

Consider this simple example, it will be easy to understand. Say we have two transactions T1 and T2.

Schedule: Lock-X1(A) Lock-X2(B) Lock-X1(B) Lock-X2(A)

Drawing the precedence graph, you may detect the loop. So Deadlock is also possible in 2-PL.

Two-phase locking may also limit the amount of concurrency that occurs in a schedule because a Transaction may not be able to release an item after it has used it. This may be because of the protocols and other restrictions we may put on the schedule to ensure serializability, deadlock freedom, and other factors. This is the price we have to pay to ensure serializability and other factors, hence it can be considered as a bargain between concurrency and maintaining the ACID properties.

The above-mentioned type of 2-PL is called **Basic 2PL**. To sum it up it ensures Conflict Serializability but **does not** prevent Cascading Rollback and Deadlock. Further, we will study three other types of 2PL, **Strict 2PL**, **Conservative 2PL**, and **Rigorous 2PL**.

Problem with Two-Phase Locking

- It does not insure recoverability which can be solved by strict two-phase locking and rigorous two-phase locking.
- It does not ensure a cascade-less schedule which can be solved by strict two-phase locking and rigorous two-phase locking.
- It may suffer from deadlock which can be solved by conservative two-phase locking.