University of Central Florida
CGS 2545
Database Concepts

DEPARTMENT OF ELECTRICAL ENGINEERING & COMPUTER SCIENCE
COMPUTER SCIENCE DIVISION

Concurrency Control

- In a multiprogramming environment where multiple transactions can be executed simultaneously, it is highly important to control the concurrency of transactions.
- We have concurrency control protocols to ensure atomicity, isolation, and serializability of concurrent transactions.
- Concurrency control protocols can be broadly divided into two categories
  - Lock based protocols
  - Time stamp based protocols

Concurrency Control

- Lock-based Protocols
  - Database systems equipped with lock-based protocols use a mechanism by which any transaction cannot read or write data until it acquires an appropriate lock on it.
  - Locks are of two kinds
    - Binary Locks
    - Shared/exclusive

Concurrency Control

- Lock-based Protocols
  - **Binary Locks**
    - A lock on a data item can be in two states; it is either locked or unlocked.
  - **Shared/exclusive**
    - This type of locking mechanism differentiates the locks based on their uses.
    - If a lock is acquired on a data item to perform a write operation, it is an exclusive lock.
    - Allowing more than one transaction to write on the same data item would lead the database into an inconsistent state.
    - Read locks are shared because no data value is being changed.

Concurrency Control

- Lock-based Protocols
  - There are four types of lock protocols available
    - Simplistic Lock Protocol
    - Pre-claiming Lock Protocol
    - Two-Phase Locking 2PL
    - Strict Two-Phase Locking

Concurrency Control

- Lock-based Protocols
  - Simplistic Lock Protocol
    - Simplistic lock-based protocols allow transactions to obtain a lock on every object before a 'write' operation is performed.
    - Transactions may unlock the data item after completing the ‘write’ operation.

Concurrency Control

- Lock-based Protocols
  - Pre-claiming Lock Protocol
    - Pre-claiming protocols evaluate their operations and create a list of data items on which they need locks.
    - Before initiating an execution, the transaction requests the system for all the locks it needs beforehand.
    - If all the locks are granted, the transaction executes and releases all the locks when all its operations are over.
    - If all the locks are not granted, the transaction rolls back and waits until all the locks are granted.

Concurrency Control

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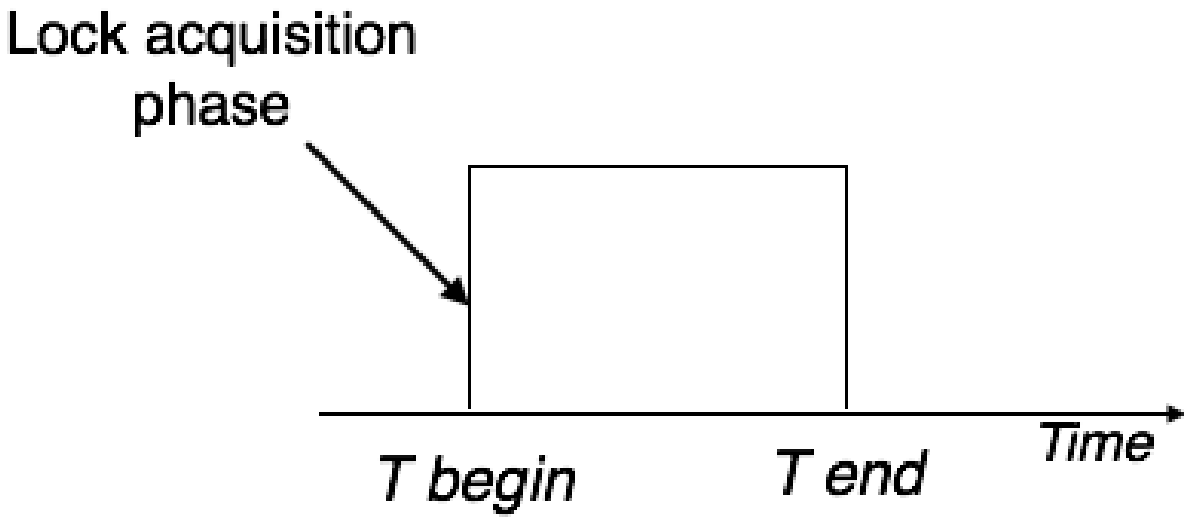
Concurrency Control

- Lock-based Protocols
  - Pre-claiming Lock Protocol

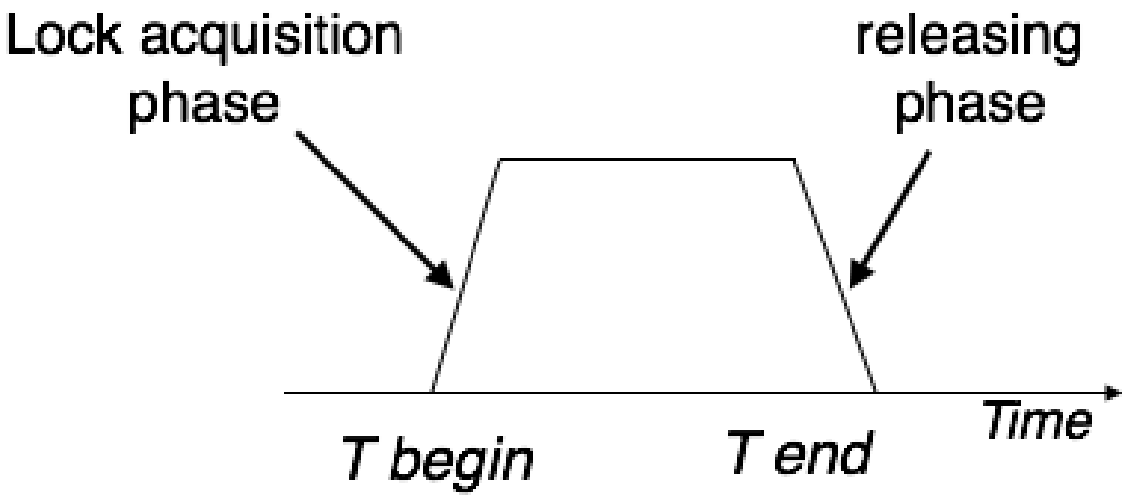


Concurrency Control

- Lock-based Protocols
  - Two-Phase Locking 2PL
    - This locking protocol divides the execution phase of a transaction into three parts.
    - In the first part, when the transaction starts executing, it seeks permission for the locks it requires.
    - The second part is where the transaction acquires all the locks.
    - As soon as the transaction releases its first lock, the third phase starts. In this phase, the transaction cannot demand any new locks; it only releases the acquired locks.

Concurrency Control

- Lock-based Protocols
  - Two-Phase Locking 2PL



Concurrency Control

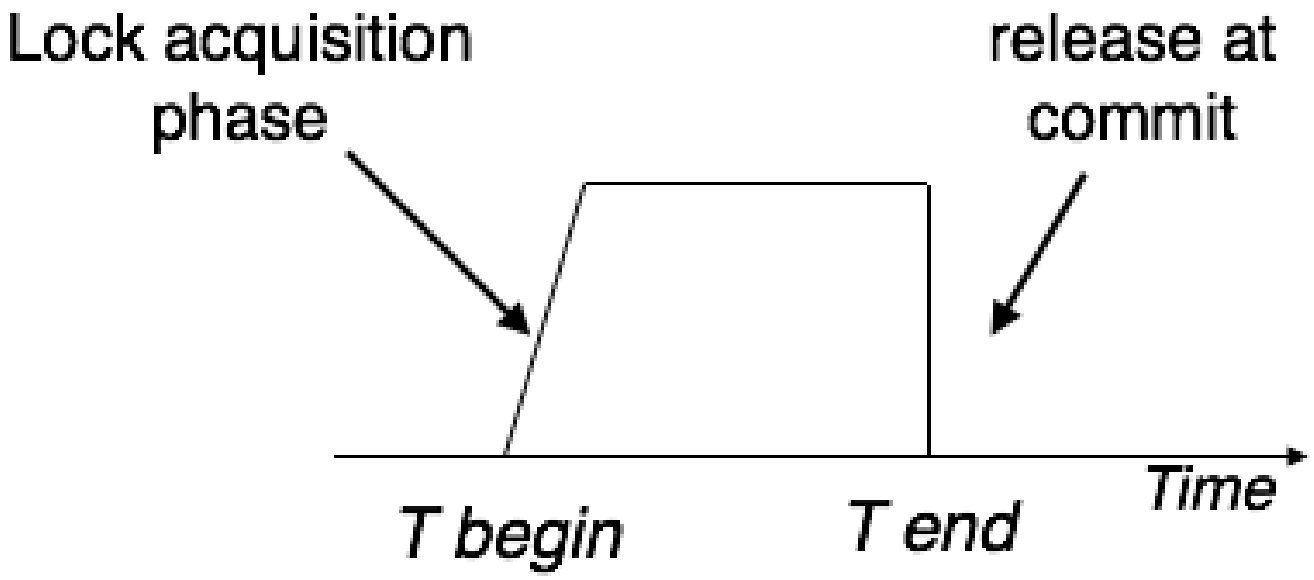
- Lock-based Protocols
  - Two-Phase Locking 2PL
    - Two-phase locking has two phases, one is **growing**, where all the locks are being acquired by the transaction; and the second phase is shrinking, where the locks held by the transaction are being released.
    - To claim an exclusive (write) lock, a transaction must first acquire a shared (read) lock and then upgrade it to an exclusive lock.

Concurrency Control

- Lock-based Protocols
  - Strict Two-Phase Locking
    - The first phase of Strict-2PL is same as 2PL.
    - After acquiring all the locks in the first phase, the transaction continues to execute normally.
    - But in contrast to 2PL, Strict-2PL does not release a lock after using it.
    - Strict-2PL holds all the locks until the commit point and releases all the locks at a time.
    - Strict-2PL does not have cascading abort as 2PL does

Concurrency Control

- Lock-based Protocols
  - Strict Two-Phase Locking



Concurrency Control

- Timestamp-based Protocols
  - The most commonly used concurrency protocol is the timestamp based protocol.
  - This protocol uses either system time or logical counter as a timestamp.
  - Lock-based protocols manage the order between the conflicting pairs among transactions at the time of execution, whereas timestamp-based protocols start working as soon as a transaction is created.

Concurrency Control

- Timestamp-based Protocols
  - Every transaction has a timestamp associated with it, and the ordering is determined by the age of the transaction.
  - A transaction created at 0002 clock time would be older than all other transactions that come after it.
  - For example, any transaction 'y' entering the system at 0004 is two seconds younger and the priority would be given to the older one.

Concurrency Control

- Timestamp-based Protocols
  - In addition, every data item is given the latest read and write-timestamp.
  - This lets the system know when the last ‘read and write’ operation was performed on the data item.

Concurrency Control

- Timestamp Ordering Protocol
  - The timestamp-ordering protocol ensures serializability among transactions in their conflicting read and write operations.
  - This is the responsibility of the protocol system that the conflicting pair of tasks should be executed according to the timestamp values of the transactions.
    - The timestamp of transaction T_i is denoted as $TS(T_i)$
    - Read time-stamp of data-item X is denoted by R-timestamp(X).
    - Write time-stamp of data-item X is denoted by W-timestamp(X).

Concurrency Control

- Timestamp Ordering Protocol
  - Timestamp ordering protocol works as follows

If a transaction Ti issues a read(X) operation –

- If TS(Ti) < W-timestamp(X)
  - Operation rejected.
- If TS(Ti) >= W-timestamp(X)
  - Operation executed.
- All data-item timestamps updated.

If a transaction Ti issues a write(X) operation –

- If TS(Ti) < R-timestamp(X)
  - Operation rejected.
- If TS(Ti) < W-timestamp(X)
  - Operation rejected and Ti rolled back.
- Otherwise, operation executed.

Concurrency Control

- Timestamp Ordering Protocol

Thomas' Write Rule

This rule states if TS(Ti) < W-timestamp(X), then the operation is rejected and T_i is rolled back.

Time-stamp ordering rules can be modified to make the schedule view serializable.

Instead of making T_i rolled back, the 'write' operation itself is ignored.