2-Phase Locking Protocol

Use Locks to Ensure Serializable Schedule.

Problem with Serializability

- Definition: "Equivalent to some serial schedule"
- Calculation of Equivalence takes too long
- Example: 10 transactions in schedule
  - How many serial schedules?
  - 10 x 9 x 8 x ... x 1 = 10! = 3,628,800

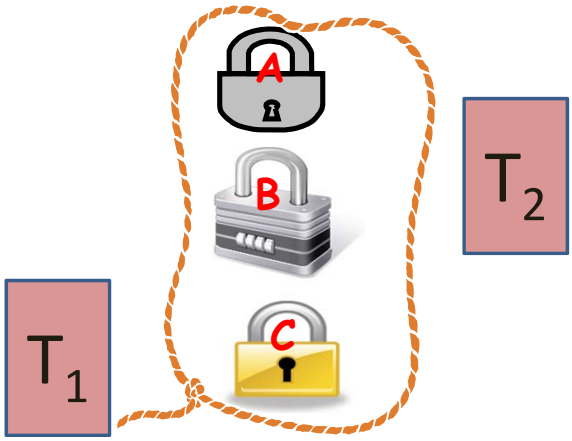
Solution

- Every transaction follows a protocol
  - protocol = rules of behavior
- Protocol guarantees serializable schedule

Basic Idea

- At one point in its life, every transaction holds all the locks it will use.
- So so any other transaction must have got its locks on the conflicting items
  - All before, or
  - All after
- 2 Phases are
  - Growing Phase (acquire locks)
  - Shrinking Phase (give them up)

2 Phase Locking Protocol



- T_1 & T_2 conflict in A,B,C
- Both must get 3 locks to complete.
- If T_1 gets all 3 **now**, T_2 must get them **all before** or **all after**.
- So with respect to **conflict items**, the schedule will be serial.

Growing Phase:

- Can only LOCK items during this Phase.
- May also UPGRADE
- May also Read & Write once items are locked.
- NO UNLOCKING in this phase

- If Transaction is **successful,** it **gets all** its locks.
- If Transaction is **not successful**, it may **deadlock** or **fail** because it cannot get a lock.

Shrinking Phase:

- Can only UNLOCK items during this Phase.
- May also DOWNGRADE
- May still Read & Write items which are still locked.
- Phase begins with FIRST UNLOCK
- NO LOCK after first unlock

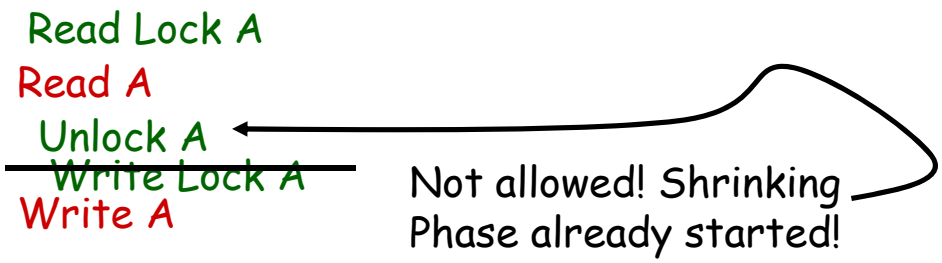
- This Phase cannot fail, but transaction may still fail because of Dirty Read
- If no Dirty Read, transaction will be serial.

Variations

- Several variants of this protocol.
- Will look at the basic one first.

No Upgrade Protocol

- Only read/writelocks. No up/downgrades.
- If transaction reads and writes item, it must start with writelock unless upgrades are allowed.



1st Example of No-Upgrade

TRANSFER

Write lock NumTrans
Write lock Bal_B
Write lock Bal_A
Read NumTrans
Read Bal_B
Write Bal_B
Read Bal_A
Write Bal_A
Write NumTrans
Unlock NumTrans
Unlock Bal_B
Unlock Bal_A

All items are read and written so all locks must be write locks.

This does not allow much interleaving!

2nd Example of No-Upgrade

TRANSFER
Write lock NumTrans
Read NumTrans
Write lock Bal_B
Read Bal_B

Write Bal_B
Write lock Bal_A Unlock Bal_B
Read Bal_A

Write Bal_A
Unlock Bal_A
Write NumTrans
Unlock NumTrans

We will Lock Late and Unlock Early.

After locking A we have all locks so we can Unlock B

2-PHASE LOCKING PROTOCOL

Upgrading Allowed

Rules of Upgrading

- You are allowed to upgrade locks from
  - ReadLocks to WriteLocks
  - during the GROWING PHASE
- and to downgrade them from
  - WriteLocks to ReadLocks
  - during the SHRINKING PHASE.
- Constraint: No one else holds Read Lock.
- Downgrade or Unlock starts Shrinking Phase

Example of Upgradeable Locks

TRANSFER

Read lock NumTrans
Read NumTrans
Read lock Bal_B
Read Bal_B
Upgrade Bal_B
Write Bal_B
Read lock Bal_A
Read Bal_A
Upgrade Bal_A
Write Bal_A
Upgrade NumTrans Unlock Bal_A Unlock Bal_B
Write NumTrans
Unlock NumTrans

We will try to Lock Late and Unlock Early. But there are several ways to do it.