COS 425:
Database and Information
Management Systems

Transactions
and
Concurrency Control

1

Transactions

- Unit of update/change
  - Viewed as indivisible
  - Database can be inconsistent during transaction
    - Add to relations with mutual foreign keys
    - Constraints on values
      - Debit of bank savings + credit of bank checking
  - Commit transaction/ Abort transaction
    - Aborts by User
    - Aborts by Error

2

Concurrency

- Must be able to execute multiple transactions on DB together
  - Multiple users
    - Reservations, billing, banking, …
  - Long transactions
    - Reports, analysis, …
- Interleave transactions
- Each committed transaction must leave DB in consistent state
- Each aborted transaction must leave DB in state as if it never happened

3

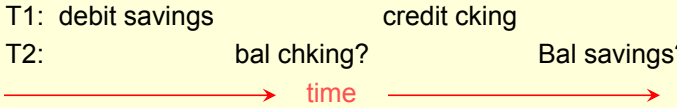
Modeling transactions

- Only reads and writes to DB tables relevant
- Consider actions READ, WRITE, COMMIT, ABORT
- How interleave these actions correctly?
  - Actions of different transactions can interact
- Around these actions a transaction does local computation: not affect DB
- Next time: crash recovery
  - make sure DB in consistent state w.r.t transactions after crash

4

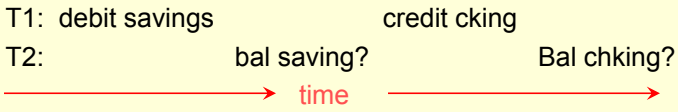
Example

Transaction T1: debit savings; credit checking
Transaction T2: get savings bal.; get checking bal.



BAD

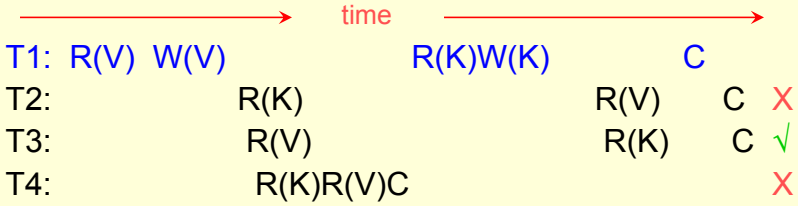
Transaction T1: debit savings; credit checking
Transaction T3: get savings bal.; get checking bal.



GOOD

5

Read/Write diagrams



R(object): read the DB object
W(object): write the DB object
C: transaction commits
V represents savings account
K represents checking account

6

Equivalence of schedules

Two schedule are equivalent if:

- For any starting state of the DB for both schedules
- The effect of executing the 1st schedule is identical to the effect of executing the 2nd schedule

Effect refers to the state of the DB as well as other results (e.g. a nasty letter that you are overdrawn)

7

Serializability

- Serial schedule: schedule for a set of transactions that does not interleave actions of different transactions
- A schedule is serializable if it is equivalent to some serial schedule for the same set of transactions

8

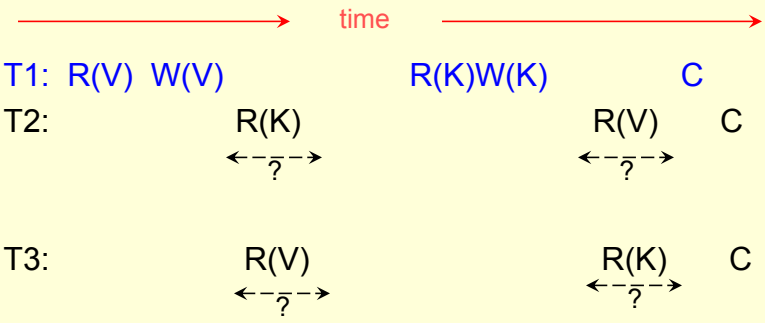
Conflict Serializable

- Conflicting actions by different transactions
  - Read and write to same DB object
  - Two writes to the same DB object
- Only non-conflicting actions
  - Two reads to the same DB object

A schedule is conflict serializable if the non-conflicting actions of the schedule can be reordered to get a serial schedule
  - Strong condition!

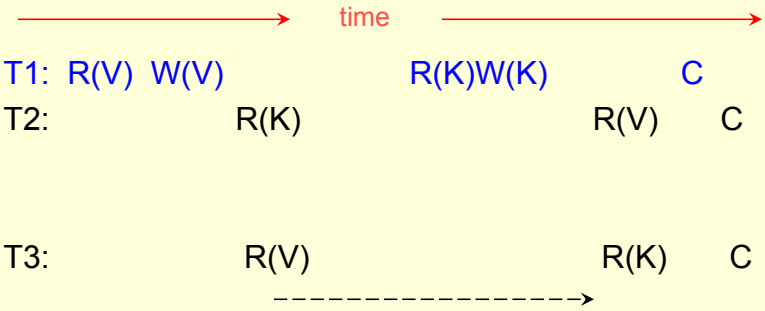
9

Our Examples



10

Our Examples

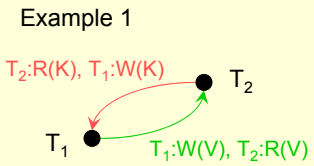


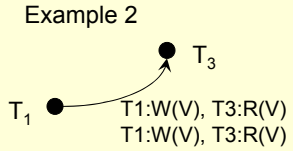
11

Precedence Graph

- Each node represents a transaction T_i
- Edge from T_i to T_j if some action of T_i precedes and conflicts with an action of T_j

THEOREM: A schedule is conflict serializable if and only if the precedence graph for the schedule is acyclic





12

Locking

- Locks maintained by transaction manager
- Transaction requests lock
- Manager grants/denies lock
- Lock types:
  - Shared: need to have before read object
  - Exclusive: need to have before write object
- Object locked?
  - Different levels granularity
    - Tables and indexes
    - expense

13

Locking protocols

- Strict 2-phase locking:
  - Transaction requests lock at any time before action
  - Transaction releases locks when commits
- 2-phase locking (not strict)
  - Transaction requests lock at any time before action
  - Transaction releases locks at any time, BUT cannot request additional locks once released ***any*** lock
    - Can release before commit but must have all locks ever need when release 1st
- Strict 2-phase locking satisfies 2-phase locking constraints

14

Theorem

- 2 phase locking (2PL) allows only schedule with acyclic precedents graph

=>

- 2 phase locking allows only conflict serializable schedules

- Corollary: Strict 2-phase locking allows only conflict serializable schedules

15