Concurrency Control

Chapter 17

Lock Management

- Lock and unlock requests are handled by the lock manager
- Lock table entry:
  - Transactions currently holding a lock
  - Type of lock held (shared or exclusive)
  - Pointer to queue of lock requests
- Locking and unlocking have to be atomic operations
- Lock upgrade: transaction that holds a shared lock can be upgraded to hold an exclusive lock

Example

T1: S(A) R(A) S(B) R(B)

T2: X(B) W(B) X(C) W(C)

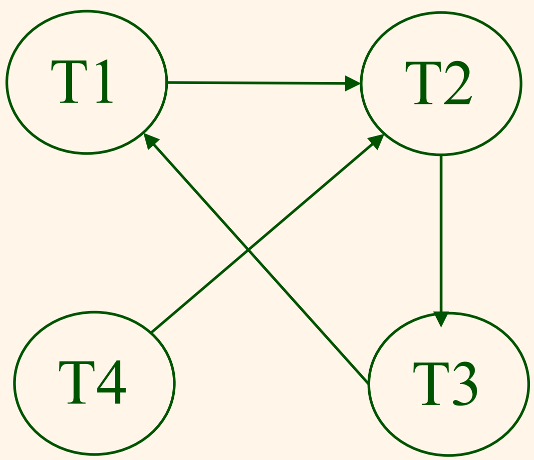
T3: S(C) R(C) X(A) W(A)

T4: X(B) W(B)

Lock table:

Object	X	S	Queue
A		T1	T3
B	T2		T1, T4
C		T3	T2

Waits-for Graph:



Deadlocks

- Deadlock: Cycle of transactions waiting for locks to be released by each other.
- Two ways of dealing with deadlocks:
  - Deadlock prevention
  - Deadlock detection

Deadlock Prevention

- Assign priorities based on timestamps. Assume Ti wants a lock that Tj holds. Two policies are possible:
  - Wait-Die: It Ti has higher priority, Ti waits for Tj; otherwise Ti aborts
  - Wound-wait: If Ti has higher priority, Tj aborts; otherwise Ti waits
- If a transaction re-starts, make sure it has its original timestamp

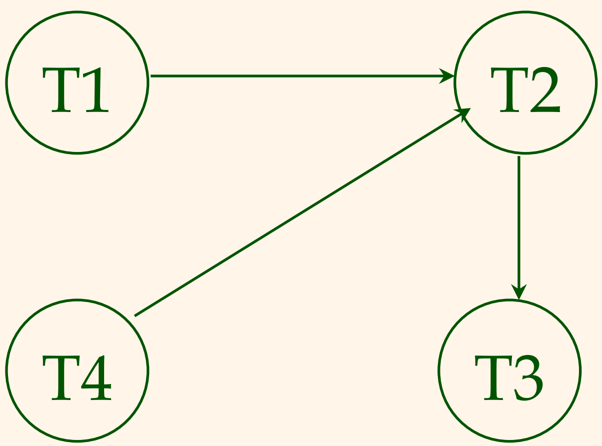
Deadlock Detection

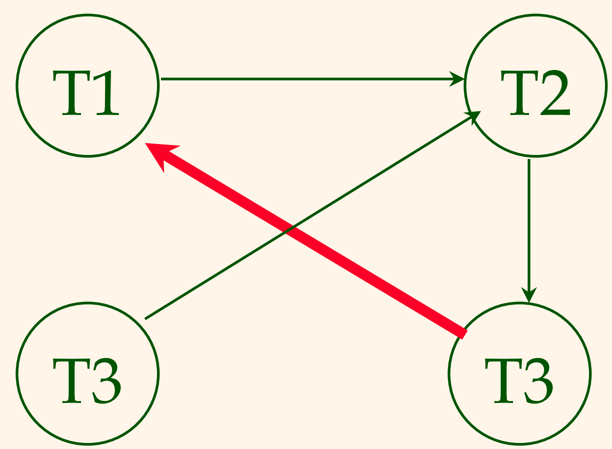
- Create a waits-for graph:
  - Nodes are transactions
  - There is an edge from Ti to Tj if Ti is waiting for Tj to release a lock
- Periodically check for cycles in the waits-for graph

Deadlock Detection (Continued)

Example:

T1:	S(A), R(A),		S(B)				
T2:		X(B),W(B)			X(C)		
T3:				S(C), R(C)			X(A)
T4:						X(B)	





Optimistic CC

- Locking is a conservative approach in which conflicts are prevented. Disadvantages:
  - Lock management overhead.
  - Deadlock detection/resolution.
  - Lock contention for heavily used objects.
- If conflicts are rare, we might be able to gain concurrency by not locking, and instead checking for conflicts before Xacts commit.

Optimistic CC Model

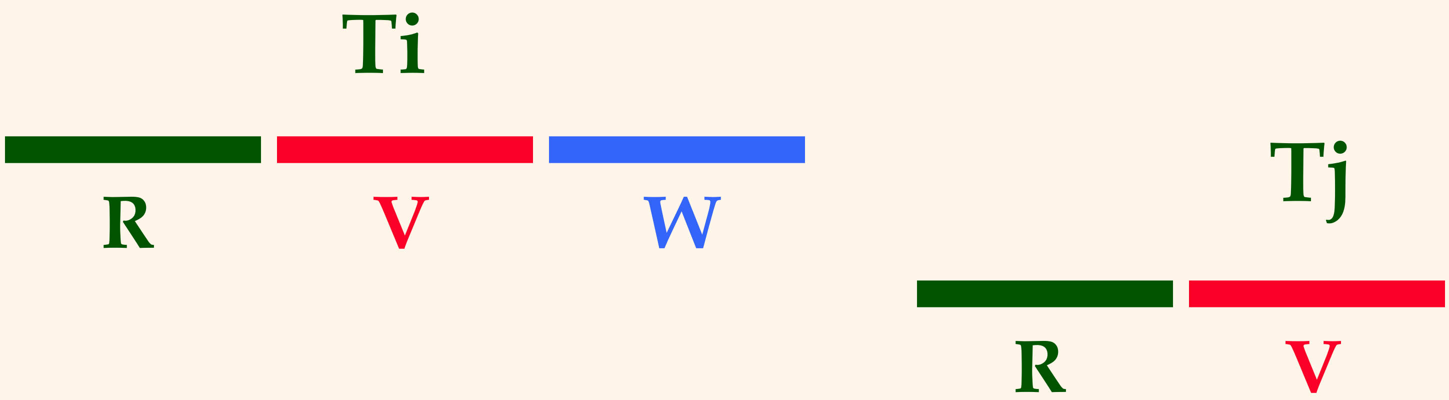
- Xacts have three phases:
  - READ: Xacts read from the database, but make changes to private copies of objects.
  - VALIDATE: Check for conflicts.
  - WRITE: Make local copies of changes public.

Validation

- Test conditions that are sufficient to ensure that no conflict occurred.
- Each Xact is assigned a numeric id.
  - Just use a **timestamp**.
- Xact ids assigned at end of READ phase, just before validation begins.
- ReadSet(Ti): Set of objects read by Xact Ti.
- WriteSet(Ti): Set of objects modified by Ti.

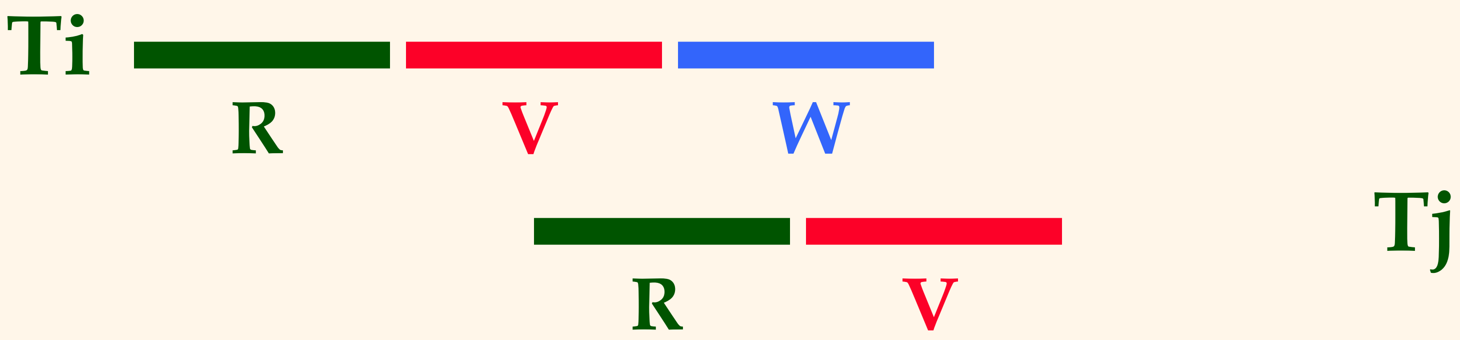
Test 1

- For all i and j such that Ti < Tj, check that Ti completes before Tj begins.



Test 2

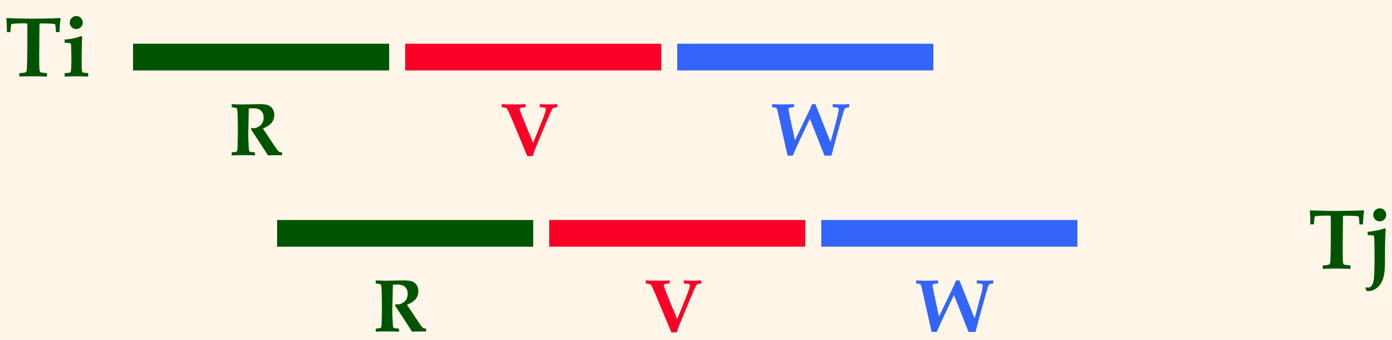
- For all i and j such that Ti < Tj, check that:
  - Ti completes before Tj begins its Write phase +
  - WriteSet(Ti) $\cap$ ReadSet(Tj) is empty.



Does Tj read dirty data? Does Ti overwrite Tj's writes?

Test 3

- For all i and j such that Ti < Tj, check that:
  - Ti completes Read phase before Tj does **+**
  - WriteSet(Ti) $\cap$ ReadSet(Tj) is empty **+**
  - WriteSet(Ti) $\cap$ WriteSet(Tj) is empty.



Does Tj read dirty data? Does Ti overwrite Tj's writes?

Summary

- There are several lock-based concurrency control schemes (Strict 2PL, 2PL). Conflicts between transactions can be detected in the dependency graph
- The lock manager keeps track of the locks issued. Deadlocks can either be prevented or detected.

Summary (Contd.)

- Multiple granularity locking reduces the overhead involved in setting locks for nested collections of objects (e.g., a file of pages); should not be confused with tree index locking!
- Optimistic CC aims to minimize CC overheads in an ``optimistic'' environment where reads are common and writes are rare.
- Optimistic CC has its own overheads however; most real systems use locking.
- SQL-92 provides different isolation levels that control the degree of concurrency