Lecture 18-19:
Concurrency Control

Wednesday, February 22, 2006
and
Friday, February 24, 2006

Announcements

- Homework 4 is posted
- Mon, 2/27: Guest Lecture *Indexes*
  Prof. Magda Balazinska (CSE, UW)
- Wed, 3/1: Guest Lecture *DB Administration*
  Shankar Pal, (Microsoft, SQL Server group)

Outline

- Concurrency control by timestamps 18.8
- Concurrency control by validation 18.9

Timestamps

Every transaction receives a unique timestamp TS(T)

Could be:

- The system’s clock
- A unique counter, incremented by the scheduler

Timestaps

Main invariant:

> The timestamp order defines
> the searialization order of the transaction

Timestamps

Associate to each element X:

- RT(X) = the highest timestamp of any transaction that read X
- WT(X) = the highest timestamp of any transaction that wrote X
- C(X) = the commit bit: says if the transaction with highest timestamp that wrote X commited

These are associated to each page X in the buffer pool

Main Idea

For any two conflicting actions, ensure that their order is the serialized order:

In each of these cases

- $w_U(X) \ldots r_T(X)$
- $r_U(X) \ldots w_T(X)$
- $w_U(X) \ldots w_T(X)$

Check that TS(U) < TS(T)

Read too late ?

Write too late ?

No problem (WHY ??)

When T wants to read X, $r_T(X)$, how do we know U, and TS(U) ?

Details

Read too late:

- T wants to read X, and TS(T) < WT(X)

START(T) … START(U) … $w_U(X) \ldots r_T(X)$

Need to rollback T !

Details

Write too late:

- T wants to write X, and
  WT(X) < TS(T) < RT(X)

START(T) … START(U) … r_U(X) . . . w_T(X)

Need to rollback T !

Why do we check WT(X) < TS(T) ????

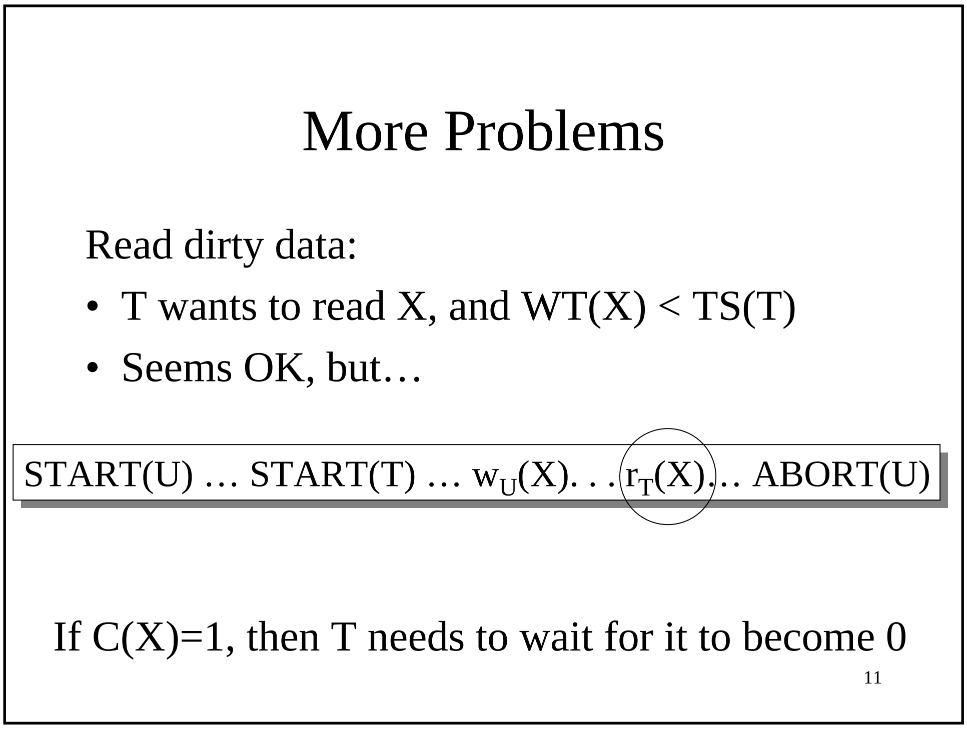
Details

Write too late, but we can still handle it:

- T wants to write X, and
  TS(T) < RT(X) but WT(X) > TS(T)

START(T) … START(V) … w_V(X) . . . w_T(X)

Don’t write X at all !
(but see later…)



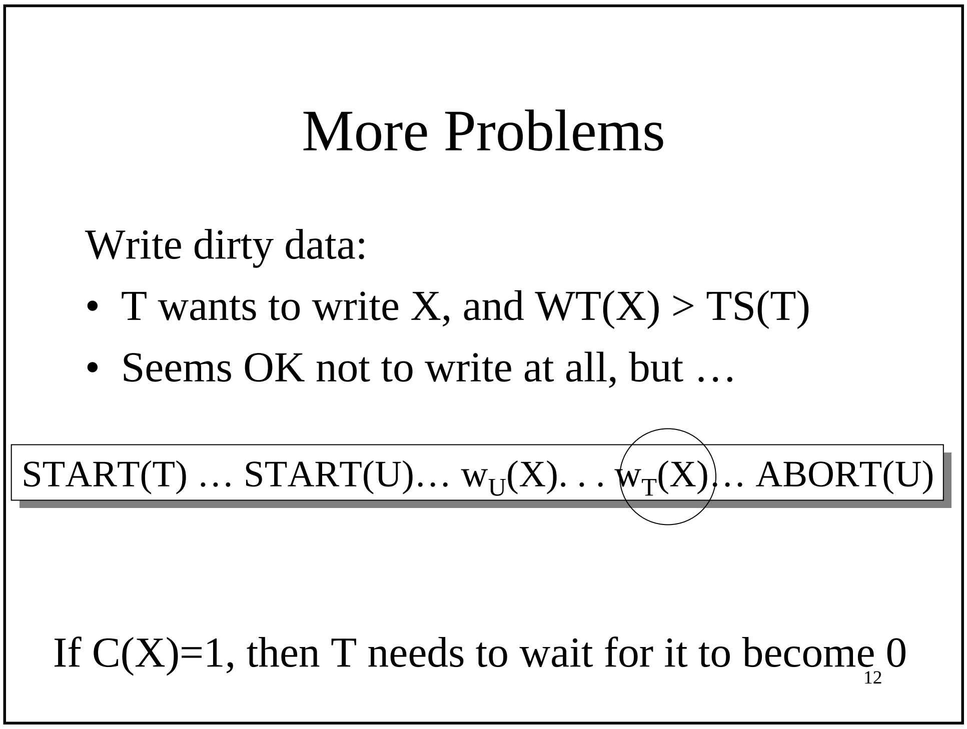
More Problems

Read dirty data:

- T wants to read X, and WT(X) < TS(T)
- Seems OK, but…

START(U) … START(T) … w_U(X). . . r_T(X)… ABORT(U)

If C(X)=1, then T needs to wait for it to become 0



More Problems

Write dirty data:

- T wants to write X, and WT(X) > TS(T)
- Seems OK not to write at all, but …

START(T) … START(U)… w_U(X). . . w_T(X)… ABORT(U)

If C(X)=1, then T needs to wait for it to become 0

Timestamp-based Scheduling

When a transaction T requests r(X) or w(X), the scheduler examines RT(X), WT(X), C(X), and decides one of:

- To grant the request, or
- To rollback T (and restart with later timestamp)
- To delay T until C(X) = 0

Timestamp-based Scheduling

RULES:

- There are 4 long rules in the textbook, on page 974
- You should be able to understand them, or even derive them yourself, based on the previous slides
- Make sure you understand them !

READING ASSIGNMENT: 18.8.4

Multiversion Timestamp

- When transaction T requests r(X)
  but WT(X) > TS(T),
  then T must rollback
- Idea: keep multiple versions of X:
  X_t, X_{t-1}, X_{t-2}, . . .

$$\boxed{TS(X_t) > TS(X_{t-1}) > TS(X_{t-2}) > . . .}$$

- Let T read an older version, with appropriate timestamp

Details

- When $w_T(X)$ occurs create a new version, denoted X_t where t = TS(T)
- When $r_T(X)$ occurs, find a version X_t such that t < TS(T) and t is the largest such
- $WT(X_t)$ = t and it never chanes
- $RD(X_t)$ must also be maintained, to reject certain writes (why ?)
- When can we delete X_t: if we have a later version X_{t1} and all active transactions T have TS(T) > t1

Tradeoffs

- Locks:
  - Great when there are many conflicts
  - Poor when there are few conflicts
- Timestamps
  - Poor when there are many conflicts (rollbacks)
  - Great when there are few conflicts

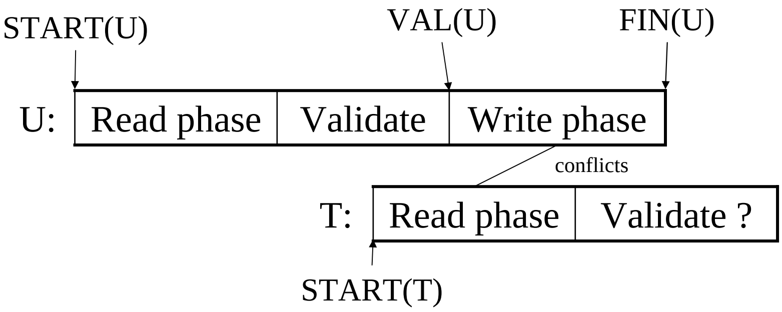
- Compromise
  - READ ONLY transactions → timestamps
  - READ/WRITE transactions → locks

Concurrency Control by Validation

- Each transaction T defines a *read set* RS(T) and a *write set* WS(T)
- Each transaction proceeds in three phases:
  - Read all elements in RS(T). Time = START(T)
  - Validate (may need to rollback). Time = VAL(T)
  - Write all elements in WS(T). Time = FIN(T)

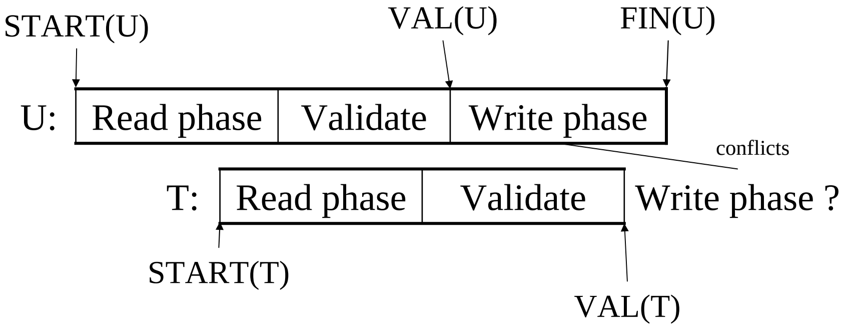
Main invariant: the serialization order is VAL(T)

Avoid $r_T(X)$ - $w_U(X)$ Conflicts



IF RS(T) ∩ WS(U) and FIN(U) > START(T)
(U has validated and U has not finished before T begun)
Then ROLLBACK(T)

Avoid $w_T(X)$ - $w_U(X)$ Conflicts



IF WS(T) ∩ WS(U) and FIN(U) > VAL(T)
(U has validated and U has not finished before T validates)
Then ROLLBACK(T)

Final comments

- Locks and timestamps: SQL Server, DB2
- Validation: Oracle

(more or less)