Database Technology

Topic 9: Transaction Processing

Topic 10: Concurrency Control

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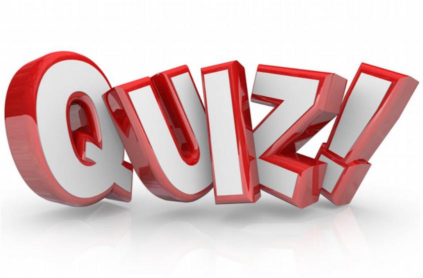
ACID Properties

- Consider a transaction with several update operations where one of them violates an integrity constraint; the other ones are correct
- A DBMS might do the following:
  - return an error message for the incorrect operation,
  - successfully execute the other operations (which is possible because they are all correct), and
  - commit the transaction
- By doing so, the system fails to guarantee the ACID properties!
- Which property in particular would be violated in this case?

  1. **A**tomicity
  2. **C**onsistency preservation
  3. **I**solation
  4. **D**urability



- Assume a DBMS that only supports one transaction at a time
  - i.e., if there are multiple transactions, they may simply have to queue up before they are considered by the system
- Which of the ACID properties would be guaranteed *trivially* by this system?

1. **A**tomicity
2. **C**onsistency preservation
3. **I**solation
4. **D**urability

Concurrency Control

Basic Concepts

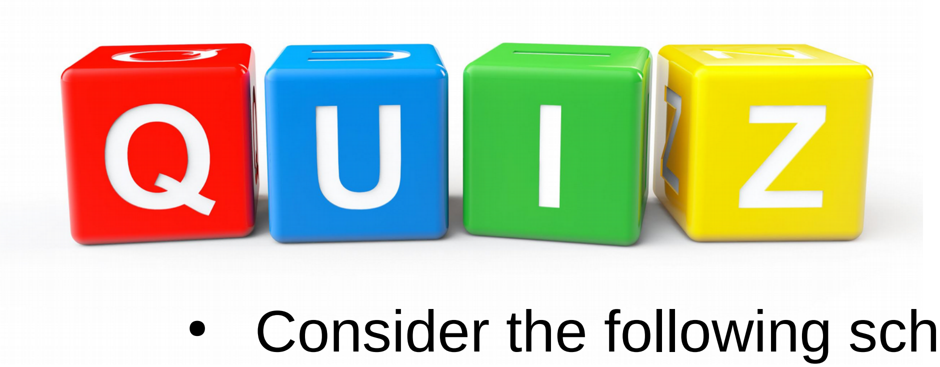
- Remember that *schedules* may contain operations from multiple transactions
- How many operations from each transaction can be in one such schedule?
  1. only one
  2. at most 64 if we assume a 64-bit computer architecture
  3. all of them
  4. all of them but they must all come directly after one another (i.e., without operations from other transactions in between)

- Which of the following types of schedules is guaranteed to produce a state of the database that is correct?
  (assuming all transactions in such schedules have the consistency preservation property)

1. serial schedules
2. serializable schedules with operations from only one transaction
3. all serializable schedules
4. all of the above

Concurrency Control

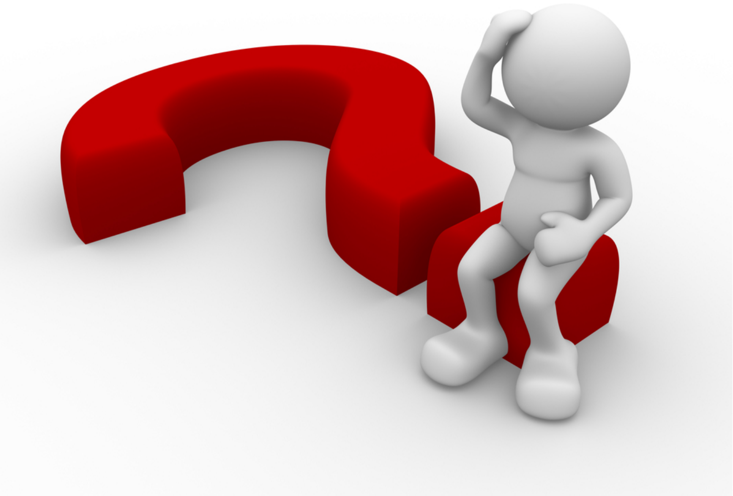
Conflict Equivalence



- Consider the following schedule

S_1: b_1, $r_1(X)$, b_2, $r_2(Y)$, $w_1(X)$, b_3, $w_2(Y)$, e_2, $r_1(Y)$, $r_3(X)$, e_3, $w_1(Y)$, e_1

- How many pairs of conflicting operations are in this schedule?
  1. only *one*
  2. *three*
  3. *four*
  4. *six*



- Consider the following two schedules

S_1: $b_1, r_1(X), b_2, r_2(Y), w_1(X), b_3, w_2(Y), e_2, r_1(Y), r_3(X), e_3, w_1(Y), e_1$

S_2: $b_2, r_2(Y), b_1, r_1(X), w_1(X), b_3, w_2(Y), e_2, r_3(X), r_1(Y), e_3, w_1(Y), e_1$

- Are these two schedules conflict equivalent?
  1. yes
  2. no
  3. that’s a trick question because only operations can be conflict equivalent
  4. sorry, I don’t know

Concurrency Control

Serializability

- Consider the following schedule

S_1: $b_1, r_1(X), b_2, r_2(Y), w_1(X), b_3, w_2(Y), e_2, r_1(Y), r_3(X), e_3, w_1(Y), e_1$

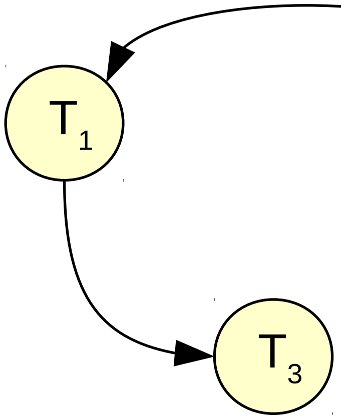
- Is this schedule serializable?
  1. yes
  2. no

- Consider the following schedule

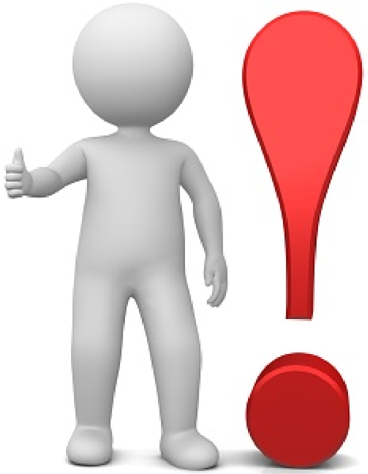
  S_1: b_1, $r_1(X)$, b_2, $r_2(Y)$, $w_1(X)$, b_3, $w_2(Y)$, e_2, $r_1(Y)$, $r_3(X)$, e_3, $w_1(Y)$, e_1

- Is this schedule serializable?

  1. yes
  2. ~~no~~



no directed cycle in the serialization graph



EXERCISE

- Consider the following schedule

  S_1: b_1, $r_1(X)$, b_2, $r_2(Y)$, $w_1(X)$, b_3, $w_2(Y)$, e_2, $r_1(Y)$, $r_3(X)$, e_3, $w_1(Y)$, e_1

- Write down a serial schedule that is conflict equivalent with S_1

EXERCISE

- Consider the following schedule

S_1: b_1, $r_1(X)$, b_2, $r_2(Y)$, $w_1(X)$, b_3, $w_2(Y)$, e_2, $r_1(Y)$, $r_3(X)$, e_3, $w_1(Y)$, e_1

- Write down a serial schedule that is conflict equivalent with S_1

S_3: b_2, $r_2(Y)$, $w_2(Y)$, e_2, b_1, $r_1(X)$, $w_1(X)$, $r_1(Y)$, $w_1(Y)$, e_1, b_3, $r_3(X)$, e_3

EXERCISE

- Consider the following schedule (which is a different one now!)

  S_4: b_1, $r_1(Y)$, b_2, $r_2(Y)$, $w_1(X)$, b_3, $w_2(Y)$, e_2, $r_3(X)$, e_3, $w_1(Y)$, e_1

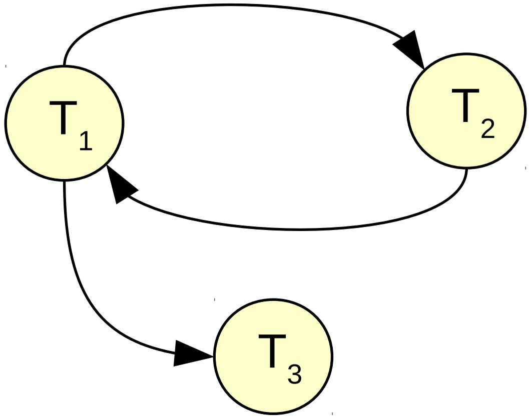
- Is this schedule serializable?
  1. yes
  2. no

- Consider the following schedule

  S_4: b_1, $r_1(Y)$, b_2, $r_2(Y)$, $w_1(X)$, b_3, $w_2(Y)$, e_2, $r_3(X)$, e_3, $w_1(Y)$, e_1

- Is this schedule serializable?

  1. ~~yes~~
  2. no, because its serialization graph contains a cycle



Concurrency Control

Locking

Quiz

- Consider the following situation:
  - transaction TA1 holds exclusive lock on data item D1
  - transaction TA2 holds shared lock on data item D2
  - transaction TA2 is currently waiting for shared lock on D1
- Now, TA1 wants to read data item D2
- Which lock does TA1 need, and will it get this lock immediately?

1. shared lock; can get it immediately
2. shared lock; will have to wait for it
3. exclusive lock; can get it immediately
4. exclusive lock; will have to wait for it

Quiz

- Consider the following transaction (with lock operations):

exclLock(X), r_1(X), w_1(X), unlock(X), exclLock(Y), r_1(Y), w_1(Y), unlock(Y)

- Is this transaction valid in terms of the locks that it needs to hold for the operations that it aims to do?

1. yes
2. no, because it needs to obtain shared locks as well
3. no, because it needs to obtain all locks in the beginning
4. no, because of both of the aforementioned reasons

Quiz

- Consider the following transaction (with lock operations):

exclLock(X), r_1(X), w_1(X), unlock(X), exclLock(Y), r_1(Y), w_1(Y), unlock(Y)

- Does this TA follow the two-phase locking (2PL) protocol?

1. yes
2. no

Exercise

- Consider the following transaction (with lock operations):

exclLock(X), r_1(X), w_1(X), unlock(X), exclLock(Y), r_1(Y), w_1(Y), unlock(Y)

- Modify this TA so that it follows 2PL
  - Option 1:

exclLock(X), r_1(X), w_1(X), exclLock(Y), unlock(X), r_1(Y), w_1(Y), unlock(Y)

  - Option 2:

exclLock(X), exclLock(Y), r_1(X), w_1(X), unlock(X), r_1(Y), w_1(Y), unlock(Y)

  - Option 3:

exclLock(X), r_1(X), exclLock(Y), w_1(X), r_1(Y), unlock(X), w_1(Y), unlock(Y)

  - etc.

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