CS315: Principles of Database Systems
Schedules

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Tue, Fri 1530-1700 at CS101

Schedule

- A schedule is a chronological sequence of instructions from concurrent transactions
- If a transaction appears in a schedule, *all* instructions of the transaction must appear in the schedule
- Order of instructions within a transaction must be maintained in the schedule
- A transaction finishing successfully will have *commit* as the last instruction
- A transaction not finishing successfully will have *abort* as the last instruction
- Commit and abort statements may be omitted if obvious

Example

- T1 transfers 50 from A to B and then T2 transfers 10% of A to B
- A serial schedule:
  $r_1(A); A := A - 50; w_1(A); r_1(B); B := B + 50; w_1(B);$
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Serializability

- Each transaction preserves database consistency
- Hence, a serial schedule also does that
- A schedule is serializable if it is *equivalent* to a serial schedule
- There are different forms of equivalence giving rise to notions of
    - Conflict serializability
    - View serializability
- Operations other than *read* and *write* are ignored

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  - View serializability
- Operations other than *read* and *write* are ignored
- Instruction I_i of transaction T_i conflicts with I_j of T_j if and only if they access the same data item and at least one of them is a write
- Intuitively, a conflict enforces a logical temporal order of the instructions
- Consequently, if two instructions do not conflict, they can be interchanged

Conflict serializability

- A schedule S is conflict equivalent to another schedule S' if it can be transformed to S' by a series of swaps of *non-conflicting* instructions
- A schedule S is conflict serializable if it is conflict equivalent to a serial schedule
- A serial schedule is conflict serializable, but not vice versa
- If a schedule is conflict serializable, it is correct in the sense that it preserves database consistency

Example

- $S : r_1(a) w_1(a) r_2(a) w_2(a) r_1(b) w_1(b) r_2(b) w_2(b)$

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  is conflict serializable as it is conflict equivalent to the serial schedule
  $T_1T_2 : r_1(a)w_1(a)r_1(b)w_1(b)r_2(a)w_2(a)r_2(b)w_2(b)$
  - It is not required to be conflict equivalent to T_2T_1 as well
- $r_1(a)w_2(a)w_1(a)$

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  is *not* conflict serializable as it is not conflict equivalent to either of the two serial schedules T_1T_2 and T_2T_1

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- Two schedules are view equivalent if the reads in them get the same "view", i.e., they read the value produced by the same write operation
- Formally, two schedules S and S' are view equivalent if
  1. For each data item x, if a transaction T reads the initial value of x in S, it reads the same initial value of x in S' as well
  2. For each data item x, if a transaction T writes the final value of x in S, it writes the final value of a in S' as well
  3. If transaction T_i reads the value of data item x produced by write by transaction T_j in S, it must read the value written by T_j in S' as well
- A schedule S is view serializable if it is view equivalent to a serial schedule

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  is *not* view serializable as it is not view equivalent to either of the two serial schedules $T_1 T_2$ and $T_2 T_1$

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- Every view serializable schedule that is not conflict serializable must have blind writes

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- Conflict and view serializable schedules are restrictive in the sense that they aim to guarantee database consistency without analyzing the result
- A schedule S is result equivalent to a schedule S' if it produces the same result as S'
- Consider
  $r_1(A); A := A - 50; w_1(A); r_2(B); B := B - 10; w_2(B);$
  $r_1(B); B := B + 50; w_1(B); r_2(A); A := A + 10; w_2(A);$
- It produces the same result as the serial schedule
  $r_1(A); A := A - 50; w_1(A); r_1(B); B := B + 50; w_1(B);$
  $r_2(B); B := B - 10; w_2(B); r_2(A); A := A + 10; w_2(A);$
  but is not conflict or view serializable
- Determining such equivalence requires *semantic* analysis of operations other than read and write

Testing for serializability

- Create a precedence graph for the schedule
- Directed graph where each transaction is a vertex
- An edge from transaction T_i to T_j exists if
  - $w_i(x)$ precedes $r_j(x)$, or
  - $r_i(x)$ precedes $w_j(x)$, or
  - $w_i(x)$ precedes $w_j(x)$
- A schedule is conflict serializable if and only if its precedence graph is *acyclic*
- *Depth-first search* can detect cycles in $O(n + m)$ time
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- *Depth-first search* can detect cycles in $O(n + m)$ time
- *Topological sorting* produces an equivalent serial order
- Testing for view serializability is *NP-complete*
- Practical algorithms
  - Catches all non view serializable schedules
  - But can miss a view serializable schedule

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- Consider $r_1(a)w_1(a)r_2(a)r_1(b)$
- If T_2 commits just after $r_2(a)$, i.e., if the schedule is $r_1(a)w_1(a)r_2(a)c_2r_1(b)a_1$, then it is *not* recoverable
  - If T_1 crashes, then $w_1(a)$ is undone, but T_2 has already read a wrong value of a and committed

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  - If T_1 crashes, then $w_1(a)$ is undone, but T_2 has already read a wrong value of a and committed
- Therefore, to make it recoverable, the schedule should be $r_1(a)w_1(a)r_2(a)r_1(b)c_1c_2$
  - If T_1 aborts, T_2 can also abort

Cascading rollbacks

- In recoverable schedules, a single transaction failure may lead to a series of rollbacks
- This is called cascading rollbacks or cascading aborts
- Consider $r_1(a)w_1(a)r_2(a)w_2(a)r_3(a)r_1(b)a_1c_2c_3$
- It is recoverable
- However, if T_1 fails, T_2 and T_3 must abort as well
- Not preferable as lot of work is undone

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- Every cascadeless schedule is recoverable, but not vice versa

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