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Serializability

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❖ Serializability

Serializable schedule:

- concurrent schedule for $T_1 .. T_n$ with final state S
- S is also a final state of a possible serial schedule for $T_1 .. T_n$

Abstracting this needs a notion of schedule equivalence.

Two common formulations of serializability:

- conflict serializibility (read/write operations occur in the "right" order)
- view serializibility (read operations *see* the correct version of data)

❖ Conflict Serializability

Consider two transactions T_1 and T_2 acting on data item X.

Possible orders for read/write operations by T_1 and T_2:

T_1 first	**T_2 first**	Equiv?
$R_1(X)\ R_2(X)$	$R_2(X)\ R_1(X)$	yes
$R_1(X)\ W_2(X)$	$W_2(X)\ R_1(X)$	no
$W_1(X)\ R_2(X)$	$R_2(X)\ W_1(X)$	no
$W_1(X)\ W_2(X)$	$W_2(X)\ W_1(X)$	no

If T_1 and T_2 act on different data items, result is always equivalent.

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❖ Conflict Serializability (cont)

Two transactions have a potential conflict if

- they perform operations on the same data item
- at least one of the operations is a write operation

In such cases, the order of operations affects the result.

If no conflict, can swap order without affecting the result.

If we can transform a schedule

- by swapping the order of non-conflicting operations
- such that the result is a serial schedule

then we say that the schedule is conflict serializible.

❖ Conflict Serializability (cont)

Example: transform a concurrent schedule to serial schedule

```
T1: R(A) W(A)       R(B)       W(B)
T2:           R(A)       W(A)       R(B) W(B)
swap
T1: R(A) W(A) R(B)             W(B)
T2:                R(A) W(A)       R(B) W(B)
swap
T1: R(A) W(A) R(B)       W(B)
T2:                R(A)       W(A) R(B) W(B)
swap
T1: R(A) W(A) R(B) W(B)
T2:                      R(A) W(A) R(B) W(B)
```

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❖ Conflict Serializability (cont)

Checking for conflict-serializability:

- show that ordering in concurrent schedule
- cannot be achieved in any serial schedule

Method for doing this:

- build a precedence-graph
- nodes represent transactions
- arcs represent order of action on shared data
- arc from $T_1 \rightarrow T_2$ means T_1 acts on X before T_2
- a cycle indicates *not* conflict-serializable.

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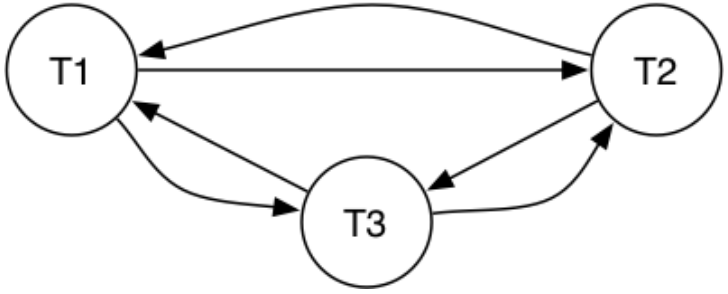
❖ Conflict Serializability Example

Example schedule which is not conflict serializable:

```
T1: R(X)           R(Y) W(X)      W(Y)
T2:          R(X)           W(X)
T3:     R(X)                          W(X)
attempted swaps
T1:          R(X) W(X)          R(Y) W(Y)
T2:     R(X)           W(X)
T3: R(X)                    W(X)
```

Precendence graph for the above schedule:



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❖ View Serializability

View Serializability is

- an alternative formulation of serializability
- that is less conservative than conflict serializability (CS)
  (some safe schedules that are view serializable are not conflict serializable)

As with CS, it is based on a notion of schedule equivalence

- a schedule is "safe" if *view equivalent* to a serial schedule

The idea: if, across the two schedules ...

- they read the same version of a shared object
- they write the same final version of an object

then they are view equivalent

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❖ View Serializability (cont)

Two schedules S and S' on T_1 .. T_n are view equivalent iff

- for each shared data item X
  - if, in S, T_j reads the initial value of X,
    then, in S', T_j also reads the initial value of X
  - if, in S, T_j reads X written by T_k,
    then, in S' T_j also reads the value of X written by T_k in S'
  - if, in S, T_j performs the final write of X,
    then, in S', T_j also performs the final write of X

To check serializibilty of S ...

- find a serial schedule that is *view equivalent* to S
- from among the $n!$ possible serial schedules

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❖ View Serializability Example

Example: consider the following concurrent schedule

```
T1: R(A) W(A)       R(B)       W(B)
T2:           R(A)       W(A)       R(B) W(B)
```

If view serializable, the read/write behaviour must be like one of

1.
```
T1: R(A) W(A) R(B) W(B)
T2:                    R(A) W(A) R(B) W(B)
```

2.
```
T1:                    R(A) W(A) R(B) W(B)
T2: R(A) W(A) R(B) W(B)
```

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❖ View Serializability Example (cont)

Reminder of concurrent schedule

```
T1: R(A) W(A)       R(B)       W(B)
T2:           R(A)       W(A)       R(B) W(B)
```

In the concurrent schedule

- A: T1 reads initial, T2 reads T1's write, T2 writes final
- B: T1 reads initial, T2 reads T1's write, T2 writes final

In T1;T2

- A: T1 reads initial, T2 reads T1's write, T2 writes final
- B: T1 reads initial, T2 reads T1's write, T2 writes final

So, concurrent schedule is view equivalent to T1;T2

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