>>

Transaction Schedules

- Transaction Schedules
- Serial Schedules
- Concurrent Schedules
- Example Update Anomaly

^ >>

❖ Transaction Schedules

When reasoning about transactions, we consider only

- **READ** - transfer data item from database to memory
- **WRITE** - transfer data item from memory to database
- **BEGIN** - start a transaction
- **COMMIT** - successfully complete a transaction
- **ABORT** - fail a transaction and unwind effects

All other operations are ignored (e.g. addition, testing, ...)

- take place in the memory space of one transaction
- have no affect on other transactions

<< ^ >>

❖ Transaction Schedules (cont)

Relating SQL to database reads/writes ...

- **SELECT** produces **READ** operations on the database
- **INSERT** produces **WRITE** operations
- **UPDATE**, **DELETE** produce both **READ** + **WRITE** operations

Assume: each operation involves one database item (e.g. one tuple)

Notation: items denoted **X**, **Y**, etc; operations denoted **R**, **W**, **C**, **A**

Thus, we see notation like: **R(X)**, **R(Y)**, **W(X)**, **W(Y)**, etc.

Notes:

- items with same name in different transactions refer to a shared item
- typically don't use explicit **BEGIN** or **COMMIT** or **ABORT**

<< ^ >>

❖ Transaction Schedules (cont)

Showing SQL→Schedule, using bank transfer example

```
get balance in source account
get balance in destination account
if (source balance sufficient):
   update source by subtracting amount transferred
   update destination by adding amount transferred
```

If X = source account, Y = destination account, can be summarized as

```
R(X)  R(Y)  W(X)  W(Y)
```

Note: we treat the **`update`**s simply as writes ...

- assume **`UPDATE`** = **`R;W`**, and **`R;W`** is atomic, so overall effect is just **`W`**

❖ Transaction Schedules (cont)

When multiple transactions run in parallel

- each transaction runs its own operations in a well-defined order
- but operations from different transactions interleave differently

Possible execution orders for operations of two transactions

```
-- no concurrency
T1: R(X) W(X) R(Y) W(Y)
T2:                    R(X) W(X) R(Y) W(Y)

-- with concurrent execution
T1: R(X)      W(X)      R(Y)      W(Y)
T2:      R(X)      W(X)      R(Y)      W(Y)
```

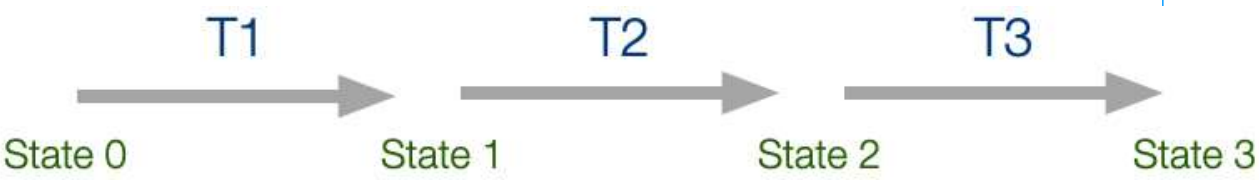
<< ^ >>

❖ Transaction Schedules (cont)

Executing a single correct transaction ...

- maps the DB from a consistent state to another consistent state

Similarly, executing transactions sequentially ...



Abribtrary interleaving of operations can cause anomalies, so that ...

- two consistency-preserving transactions, running concurrently
- produce a final state which is not consistent

<< ^ >>

❖ Serial Schedules

Serial execution: **T1** then **T2** or **T2** then **T1**

```
T1: R(X) W(X) R(Y) W(Y)
T2:                    R(X) W(X)
```

or

```
T1:                    R(X) W(X) R(Y) W(Y)
T2: R(X) W(X)
```

Serial execution guarantees a consistent final state if

- the initial state of the database is consistent
- **T1** and **T2** are consistency-preserving

<< ^ >>

❖ Concurrent Schedules

Concurrent schedules interleave **T1**,**T2**,... operations

Some concurrent schedules are ok, e.g.

```
T1: R(X) W(X)       R(Y)       W(Y)
T2:           R(X)       W(X)
```

Other concurrent schedules cause anomalies, e.g.

```
T1: R(X)       W(X)       R(Y) W(Y)
T2:      R(X)       W(X)
```

Want the system to ensure that only valid schedules occur.

<< ^

❖ Example Update Anomaly

Two concurrent transfers from same source account:

- T1 transfers $200 X→Y, T2 transfers $100 X→Y
- inital values: X=500, Y=100; final values: X=200, Y=400

T1	T2	X_{T1}	X_{T2}	X_{db}	Y_{T1}	Y_{T2}	Y_{db}
R(X)		500		500			100
X-200		300					
	R(X)		500				
W(X)		300		300			
	X-100		400				
	W(X)		400	400			
	R(Y)					100	
R(Y)					100		
Y+200					300		
W(Y)					300		300
	Y+100					200	
	W(Y)					200	200

Produced: 16 Nov 2020