

Transactions

Properties

Solution for both concurrency and failures

Transactions

A transaction is a sequence of one or more SQL operations treated as a unit

- Transactions appear to run in isolation
- If the system fails, each transaction's changes are reflected either entirely or not at all

ACID Properties

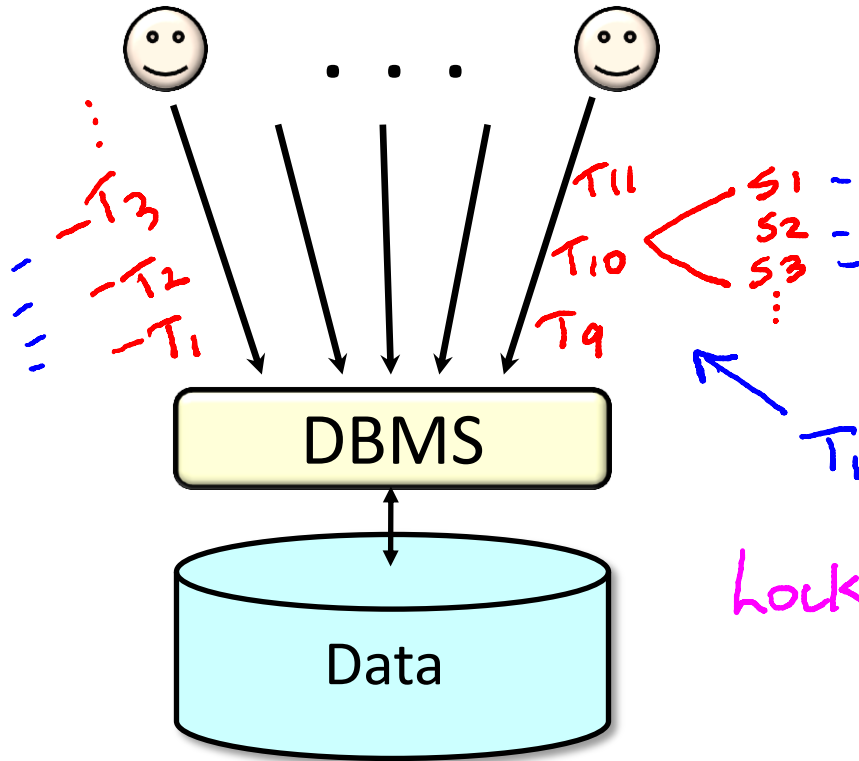
③ **A**tomicity

④ **C**onsistency

① **I**solation

② **D**urability

(ACID Properties) Isolation



→ Serializability

Operations may be interleaved, but execution must be equivalent to *some* sequential (serial) order of all transactions

locking.

Concurrent Access: Attribute-level Inconsistency

T_1 Update college Set enrollment = enrollment + 1000
where cName = 'Stanford'

concurrent with ...

T_2 Update college Set enrollment = enrollment + 1500
where cName = 'Stanford'

$T_1 ; T_2$ 15,000 \rightarrow 17,500
 $T_2 ; T_1$

Concurrent Access: Tuple-level Inconsistency

T_1 Update Apply Set major = 'CS' where SID = 123

concurrent with ...

T_2 Update Apply Set decision = 'Y' where SID = 123

$T_1; T_2$

$T_2; T_1$

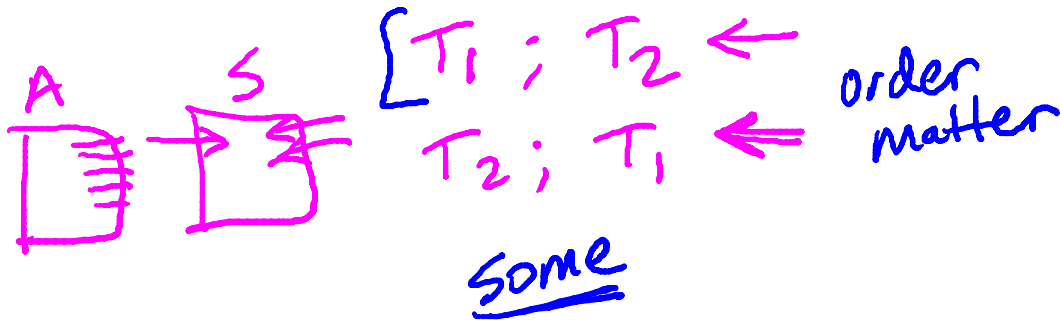
both changes

Concurrent Access: Table-level Inconsistency

T_1 Update Apply Set decision = 'Y'
 where SID In (Select SID From Student Where GPA > 3.9)

concurrent with ...

T_2 Update Student Set GPA = (1.1) * GPA Where sizeHS > 2500



Concurrent Access: Multi-statement inconsistency

Insert Into Archive

T1

Select * From Apply where decision = 'N';

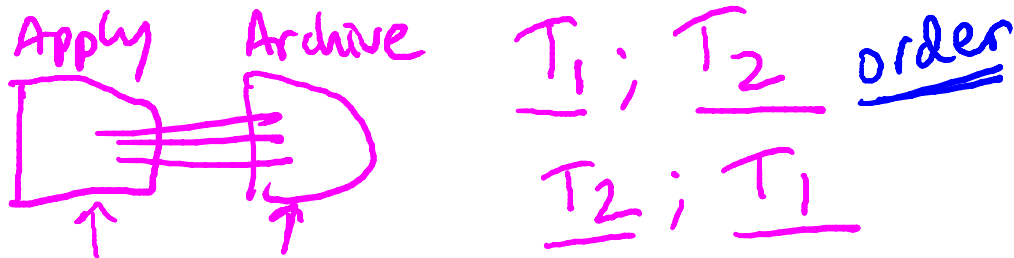
Delete From Apply where decision = 'N';

concurrent with ...

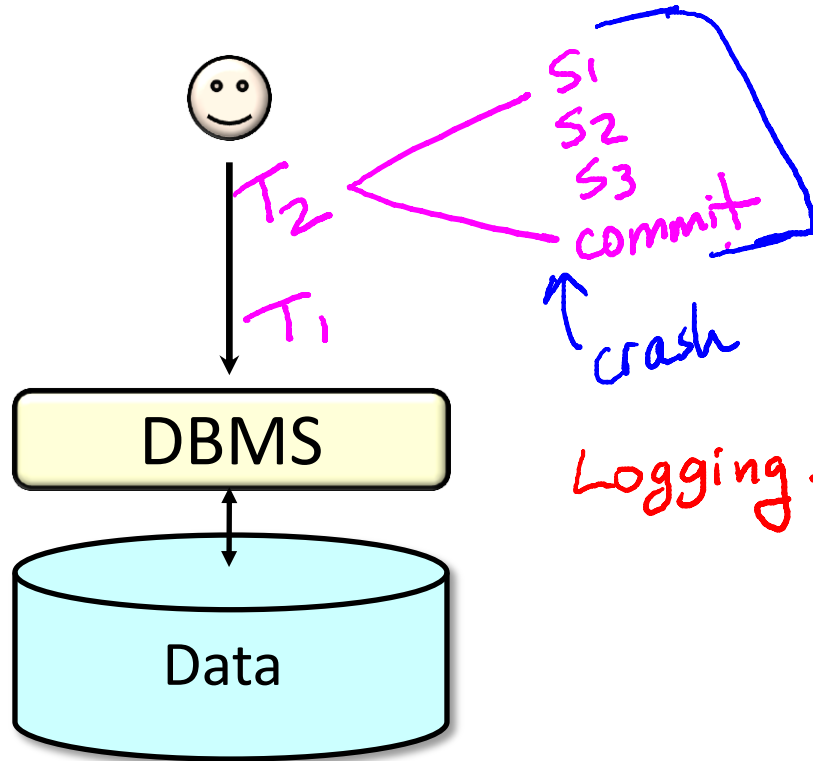
Select Count(*) From Apply;

T2

Select Count(*) From Archive;

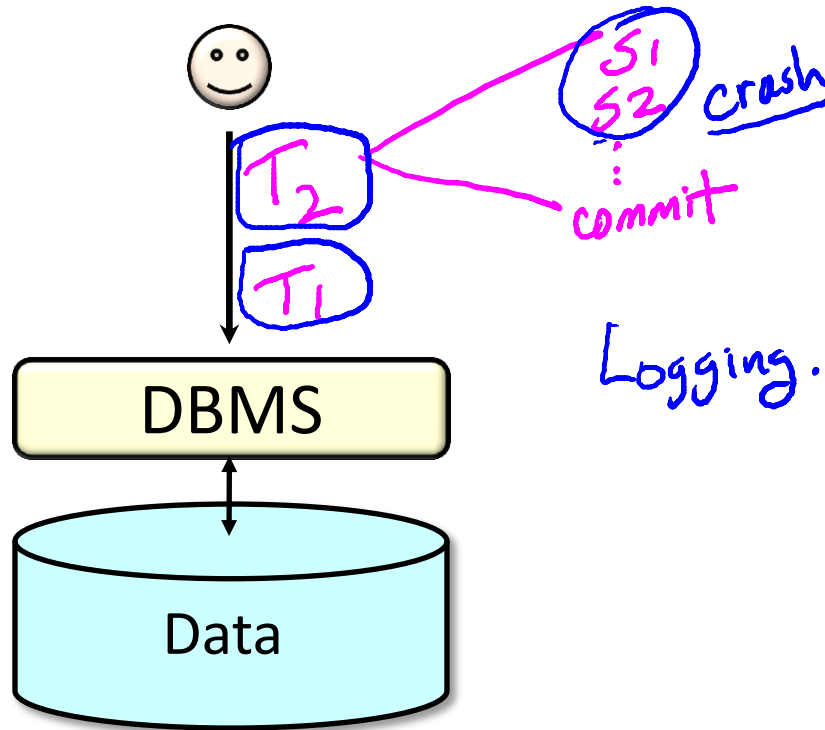


(ACID Properties) **Durability**



If system crashes
after transaction commits,
all effects of transaction
remain in database

(ACID Properties) **Atomicity**



Each transaction is
“all-or-nothing,”
never left half done

Transaction Rollback (= Abort) ☆

- Undoes partial effects of transaction
- Can be system- or client-initiated

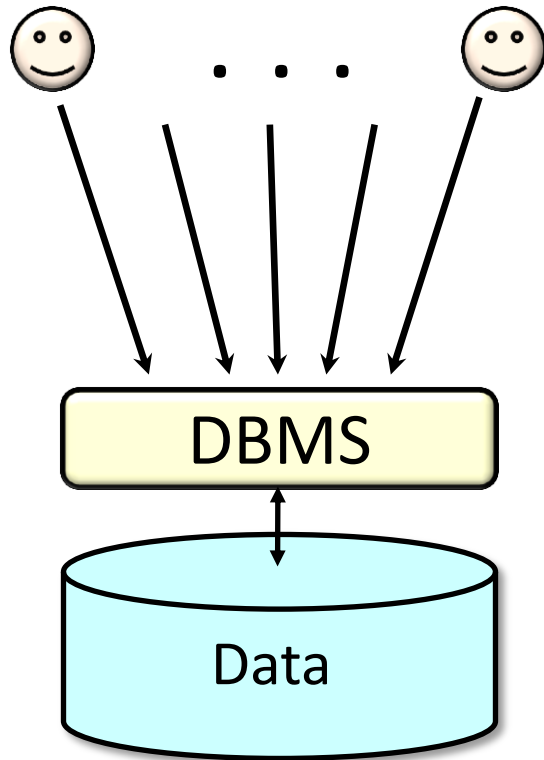
☆ Each transaction is “all-or-nothing,” never left half done

```
Begin Transaction;
<get input from user>
SQL commands based on input
<confirm results with user>
If ans='ok' Then Commit; Else Rollback;
```

vars
delivering
cash

☹ Locking

(ACID Properties) Consistency



Each client, each transaction:

- Can assume all constraints hold when transaction begins
- Must guarantee all constraints hold when transaction ends

Serializability \Rightarrow constraints always hold

T_1 T_2 T_3
↑ ↑ ↑ ↑

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✓ **C**onsistency

✓ **I**solation 

✓ **D**urability