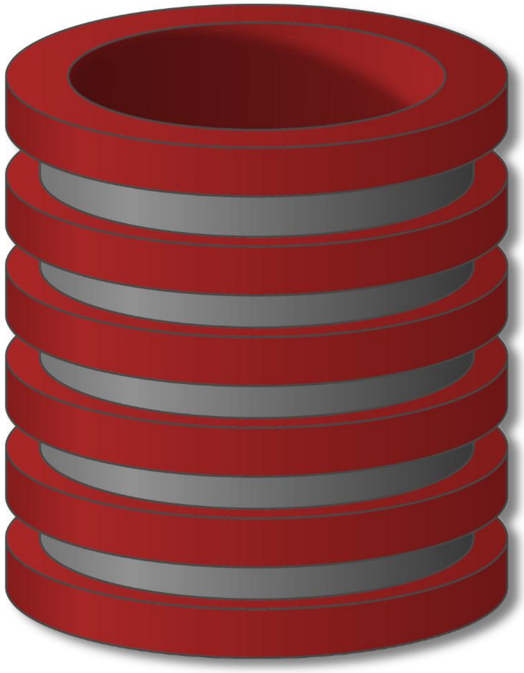


Transactions

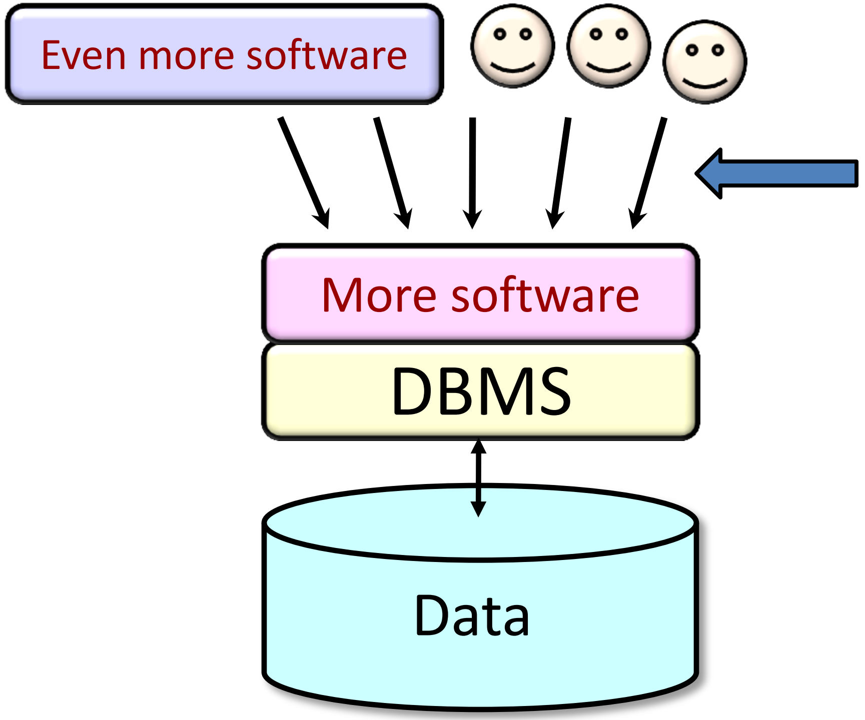
Introduction

Jennifer Widom

Motivated by two independent requirements

- Concurrent database access
- Resilience to system failures

Concurrent Database Access



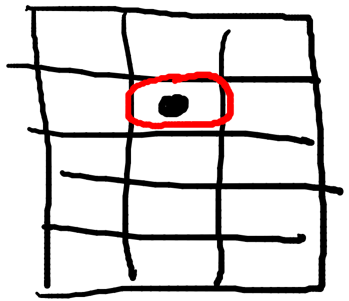
Select... ✓
Update... ✓
Create Table... ✓
Drop Index... ✓
Help... ✓
Delete... ✓

Concurrent Access: Attribute-level Inconsistency

S1
```
Update College Set enrollment = enrollment + 1000
Where cName = 'Stanford'
```

concurrent with …

S2
```
Update College Set enrollment = enrollment + 1500
Where cName = 'Stanford'
```



get ; modify ; put ✓

15,000 + 2500 = 17,500

+ 1000

+ 1500

Concurrent Access: Tuple-level Inconsistency

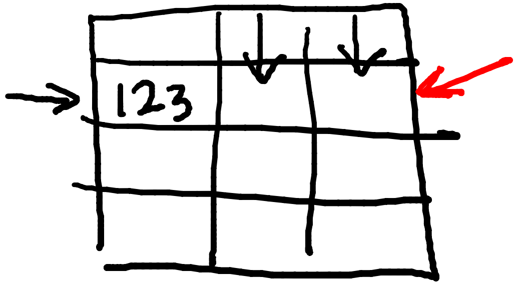
S1

```
Update Apply Set major = 'CS' Where sID = 123
```

concurrent with …

S2

```
Update Apply Set decision = 'Y' Where sID = 123
```



get; modify; put

both changes

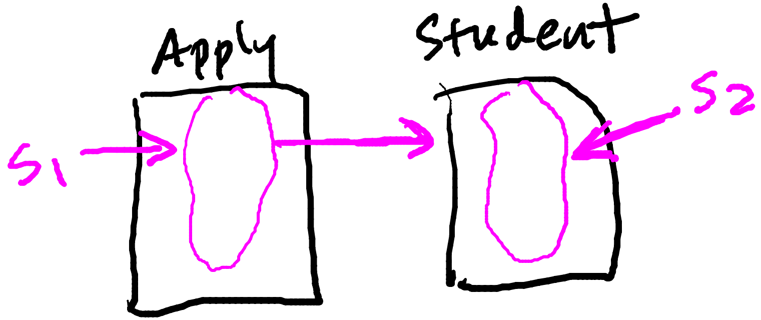
one of the two changes

Concurrent Access: Table-level Inconsistency

S1
```
Update Apply Set decision = 'Y'
Where sID In (Select sID From Student Where GPA > 3.9)
```

concurrent with …

S2
```
Update Student Set GPA = (1.1) * GPA Where sizeHS > 2500
```



Concurrent Access: Multi-statement inconsistency

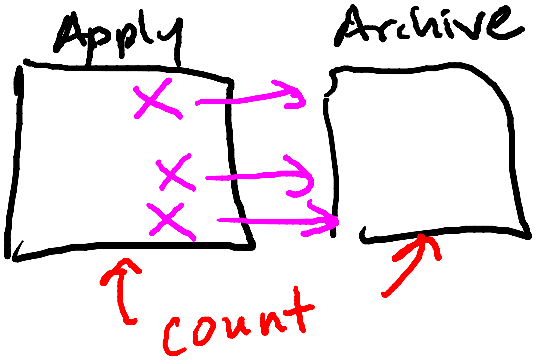
C1

```
Insert Into Archive
  Select * From Apply Where decision = 'N';
Delete From Apply Where decision = 'N';
```

concurrent with …

C2

```
Select Count(*) From Apply;
Select Count(*) From Archive;
```



Concurrency Goal

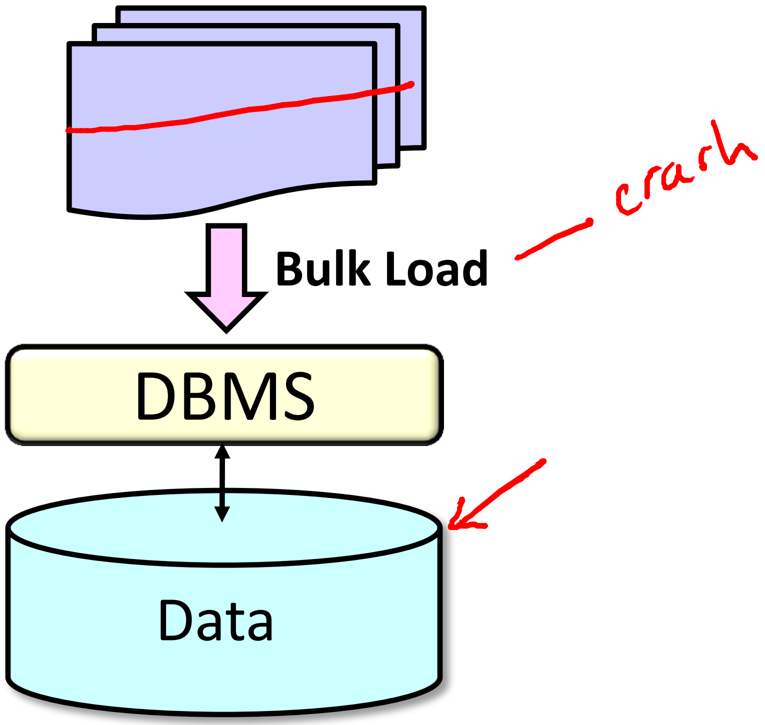
Execute *sequence of SQL statements* so they appear to be running in isolation

✱ Simple solution: execute them in isolation

But want to enable concurrency whenever safe to do so

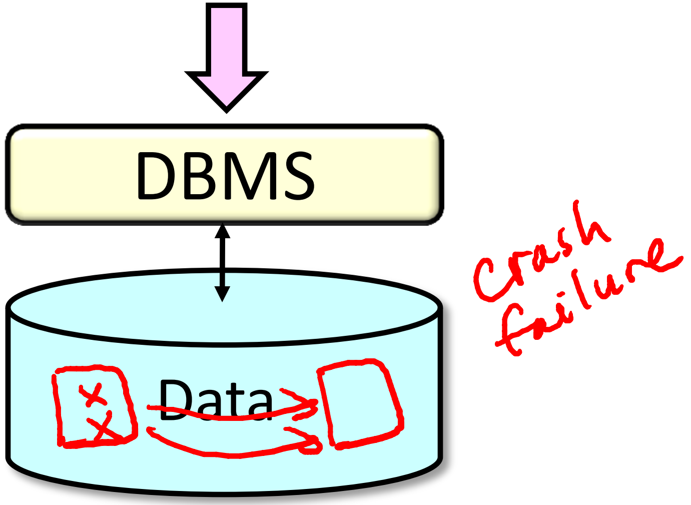
Multiprocessor
Multithreaded
Asynchronous I/O

Resilience to System Failures

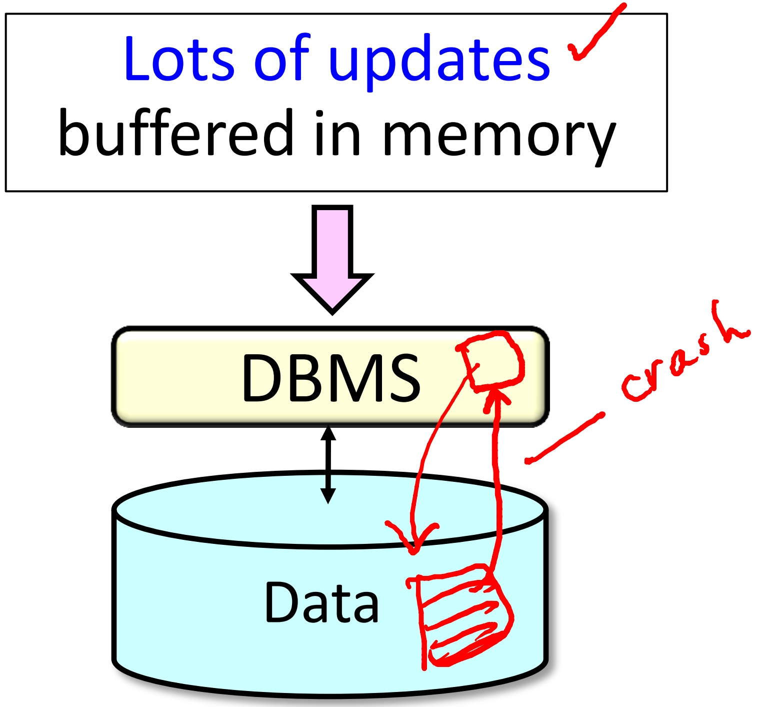


Resilience to System Failures

```
Insert Into Archive
   Select * From Apply Where decision = 'N';
Delete From Apply Where decision = 'N';
```

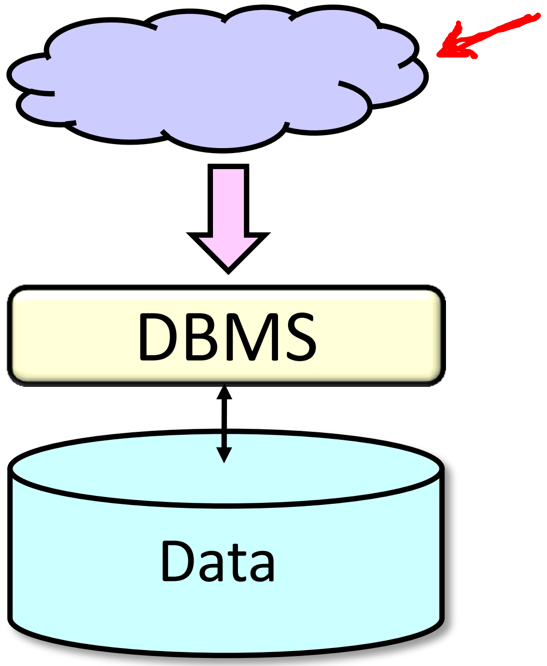


Resilience to System Failures



System-Failure Goal

Guarantee all-or-nothing execution, regardless of failures



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

Solution for both concurrency and failures

Transactions

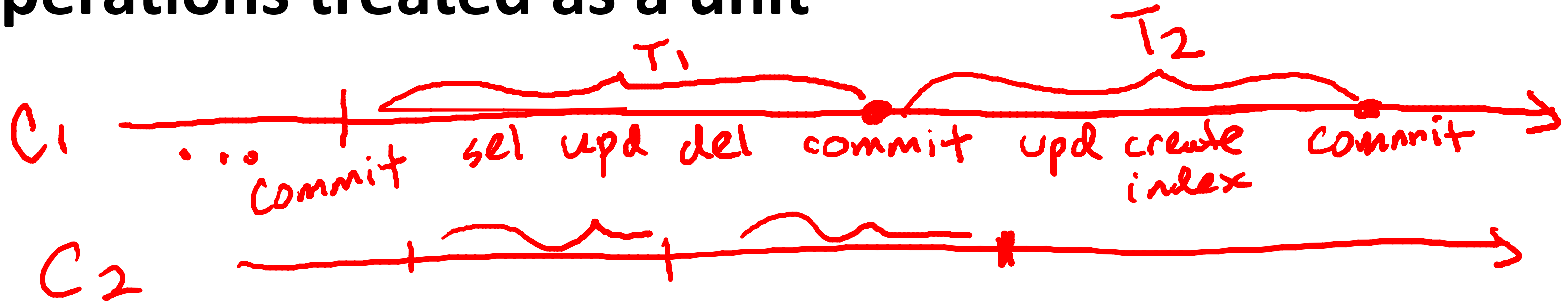
A transaction is a sequence of one or more SQL operations treated as a unit. SQL standard:

- Transaction begins automatically on first SQL statement
- On "`commit`" transaction ends and new one begins
- Current transaction ends on session termination
- "`Autocommit`" turns each statement into transaction

Solution for both concurrency and failures

Transactions

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


T1
T2
C1
... commit
sel
upd
del
commit
upd
create index
commit
C2