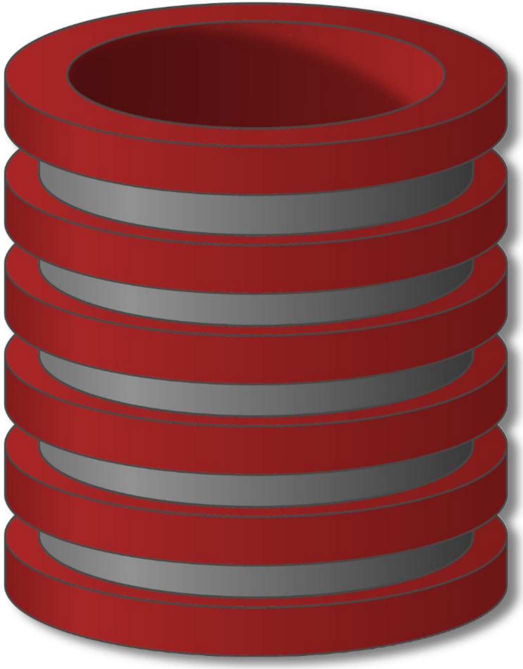


Transactions

Isolation Levels

Jennifer Widom

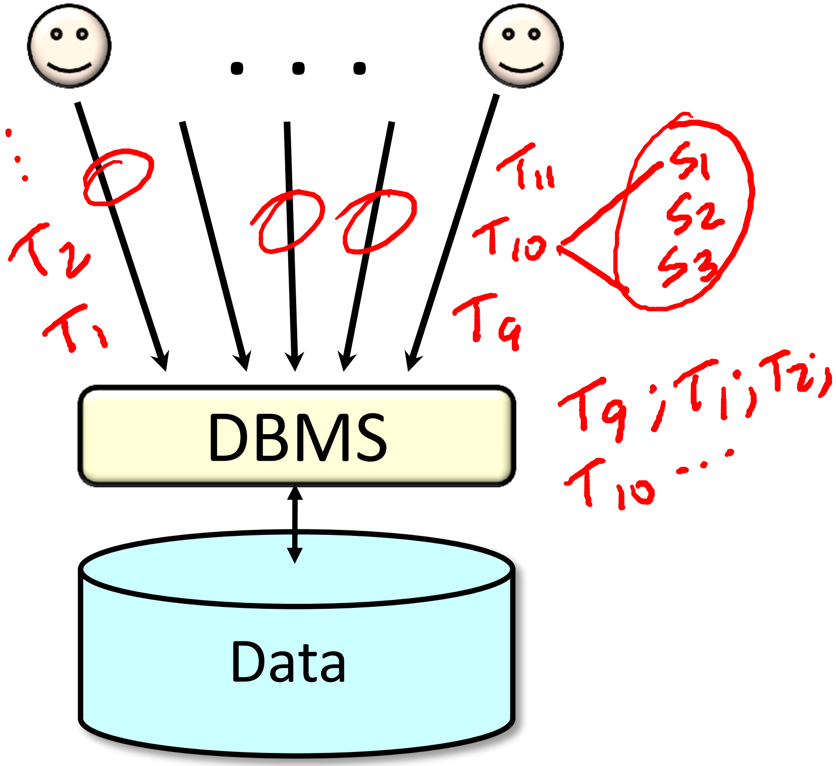
Solution for both concurrency and failures

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) **Isolation**



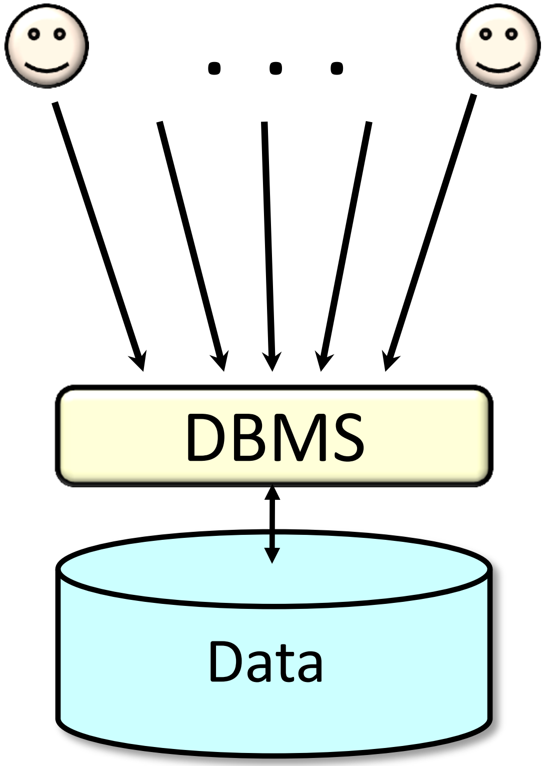
Serializability

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

⇒ Overhead

⇒ Reduction in concurrency

(ACID Properties) **Isolation**



Weaker "Isolation Levels"

weak
↓
strong

Read Uncommitted

Read Committed

Repeatable Read

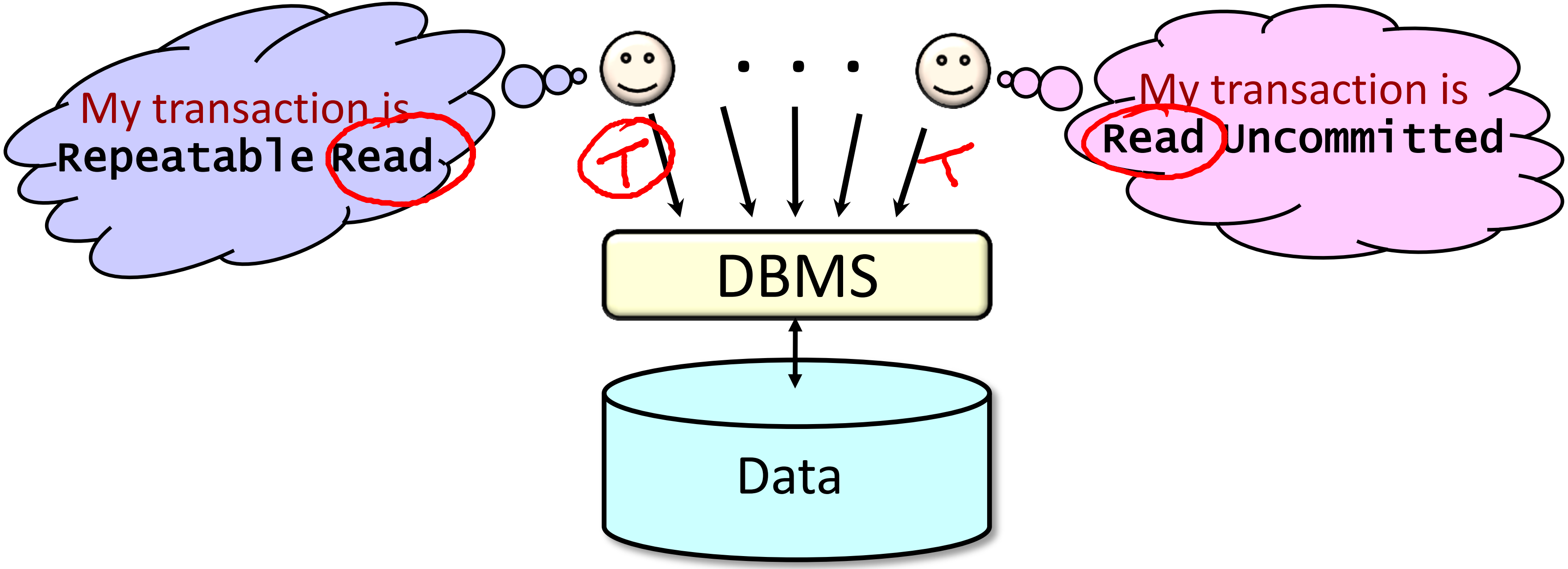
Serializable

↓ Overhead ↑ Concurrency

↓ **Consistency Guarantees**

Isolation Levels

- Per transaction
- "In the eye of the beholder"



Dirty Reads

“Dirty” data item: written by an uncommitted transaction

T_1

```
Update College Set enrollment = enrollment + 1000
Where cName = ‘Stanford’
```

" dirty "

commit

concurrent with …

T_2

```
Select Avg(enrollment) From College
```

commit

Dirty Reads

"Dirty" data item: written by an uncommitted transaction

T1

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

concurrent with …

T2

```
Select GPA From Student Where sID = 123
```

concurrent with …

T3

```
Update Student Set sizeHS = 2600 Where sID = 234
```

sizeHS

Isolation Level Read Uncommitted

- A transaction may perform dirty reads

T_1

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

concurrent with …

T_2

```
Select Avg(GPA) From Student
```

$T_1 ; T_2$

$T_2 ; T_1$

Isolation Level **Read Uncommitted**

- A transaction may perform dirty reads

serializable

T1
```
Update Student Set GPA = (1.1) * GPA Where sizeHS > 2500
```

concurrent with …

T2
```
Set Transaction Isolation Level Read Uncommitted;
Select Avg(GPA) From Student;
```

$T_1 ; T_2$ $T_2 ; T_1$

Isolation Level Read Committed

- A transaction may *not* perform dirty reads

Still does not guarantee global serializability

T1

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

concurrent with …

T2

```
Set Transaction Isolation Level Read Committed;
Select Avg(GPA) From Student;
Select Max(GPA) From Student;
```

T1 ; T2   T2 ; T1

Isolation Level **Repeatable Read**

- A transaction may not perform dirty reads ✓ ✓
- An item read multiple times cannot change value ✓ ✓

Still does not guarantee global serializability

T_1

```
Update Student Set GPA = (1.1) * GPA;
Update Student Set sizeHS = 1500 Where sID = 123;
```

concurrent with …

T_2

```
Set Transaction Isolation Level Repeatable Read;
Select Avg(GPA) From Student;
Select Avg(sizeHS) From Student;
```

$T_1 ; T_2$ $T_2 ; T_1$

Isolation Level **Repeatable Read**

- A transaction may not perform dirty reads ✓
- An item read multiple times cannot change value ✓

  But a relation *can* change: “phantom” tuples

T1

```
Insert Into Student [ 100 new tuples ]
```

phantom

concurrent with …

T2

```
Set Transaction Isolation Level Repeatable Read;
Select Avg(GPA) From Student;
Select Max(GPA) From Student;
```

Avg

Isolation Level **Repeatable Read**

- A transaction may not perform dirty reads
- An item read multiple times cannot change value

  But a relation *can* change: "phantom" tuples

```
Delete From Student [ 100 tuples ]
```

concurrent with …

```
Set Transaction Isolation Level Repeatable Read;
Select Avg(GPA) From Student;
Select Max(GPA) From Student;
```

Read Only transactions

- Helps system optimize performance
- Independent of isolation level

```
Set Transaction Read Only;
Set Transaction Isolation Level Repeatable Read;
Select Avg(GPA) From Student;
Select Max(GPA) From Student;
```

Isolation Levels: Summary

weak

	dirty reads	nonrepeatable reads	phantoms
Read Uncommitted	Y	Y	Y
Read Committed	N	Y	Y
Repeatable Read	N	N	Y
Serializable	N	N	N

strong

Isolation Levels: Summary

- Standard default: `Serializable`
- Weaker isolation levels
  - Increased concurrency + decreased overhead = increased performance
  - Weaker consistency guarantees
  - Some systems have default `Repeatable Read`
- Isolation level per transaction and "eye of the beholder"
  - Each transaction's reads must conform to its isolation level