No cascading-rollbacks!

Overview over this video

Last video: Recoverable schedules

- I.e. if we follow those, we can avoid breaking durability (because of cascading rollbacks)

This video: Cascadeless schedules

- I.e. if we follow those, we can avoid cascading rollbacks!

Recoverable schedules still cascades

A recoverable schedule:

S_4: $w_1(X)$; $w_1(Y)$; $w_2(X)$; $r_2(Y)$; $w_2(Y)$; c_1; c_2

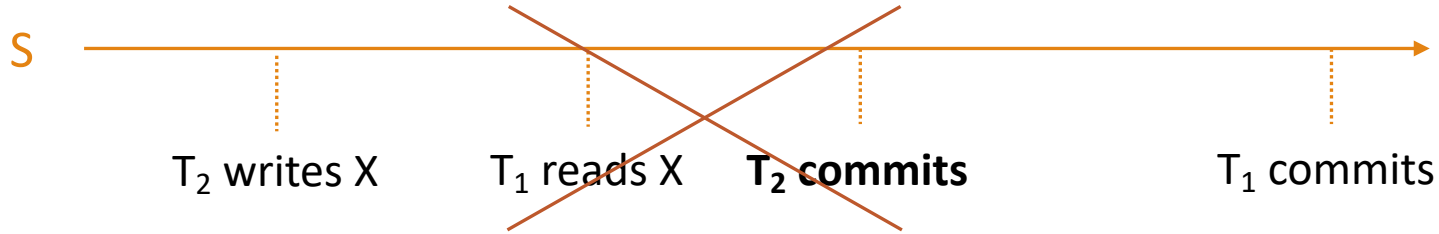
Suppose T_1 needs to be rolled back here

T_1 rolls back → T_2 has to be rolled back

Cascadeless Schedules

A schedule is **cascadeless** if each transaction in it reads only values that were written by transactions that have already committed.

No reading of “dirty data”.
No cascading rollbacks.



Cascadeless Schedules

A schedule is **cascadeless** if each transaction in it reads only values that were written by transactions that have already committed.

No reading of “dirty data”.
No cascading rollbacks.

As for recoverable schedules:
Log records have to reach disk in the right order.

Example

The schedules S_1-S_4 in previous video are **not cascadeless**:

reads uncommitted data from T_1

S_1: $w_2(X)$; $w_1(Y)$; $w_1(X)$; $r_2(Y)$; $w_2(Y)$; c_1; c_2

S_2: $w_1(X)$; $w_1(Y)$; $w_2(X)$; $r_2(Y)$; $w_2(Y)$; c_2; c_1

S_3: $w_2(X)$; $w_1(Y)$; $w_1(X)$; $r_2(Y)$; $w_2(Y)$; c_2; c_1

S_4: $w_1(X)$; $w_1(Y)$; $w_2(X)$; $r_2(Y)$; $w_2(Y)$; c_1; c_2

This variant of S_1 is **cascadeless**:

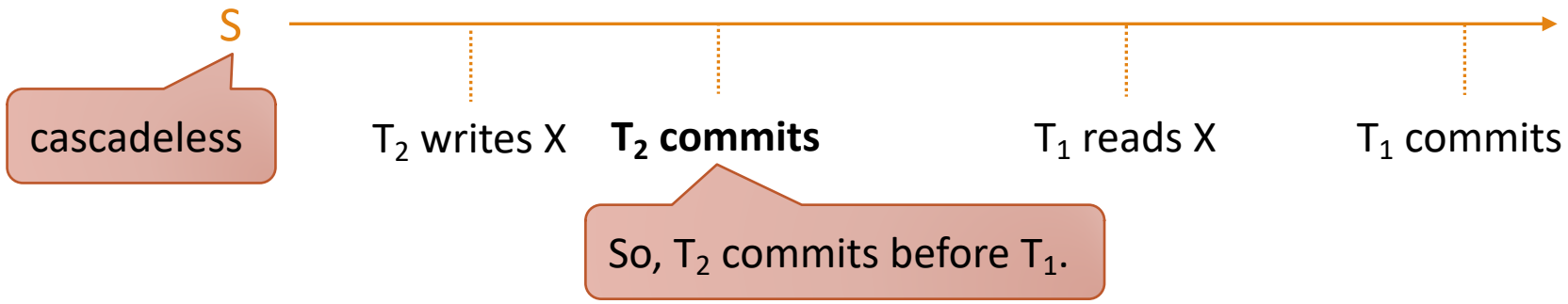
S_5: $w_2(X)$; $w_1(Y)$; $w_1(X)$; c_1; $r_2(Y)$; $w_2(Y)$; c_2

Note: S_5 is **not serialisable**.

reads committed data from T_1

Cascadeless Schedules: Properties

Cascadeless schedules are **recoverable**:

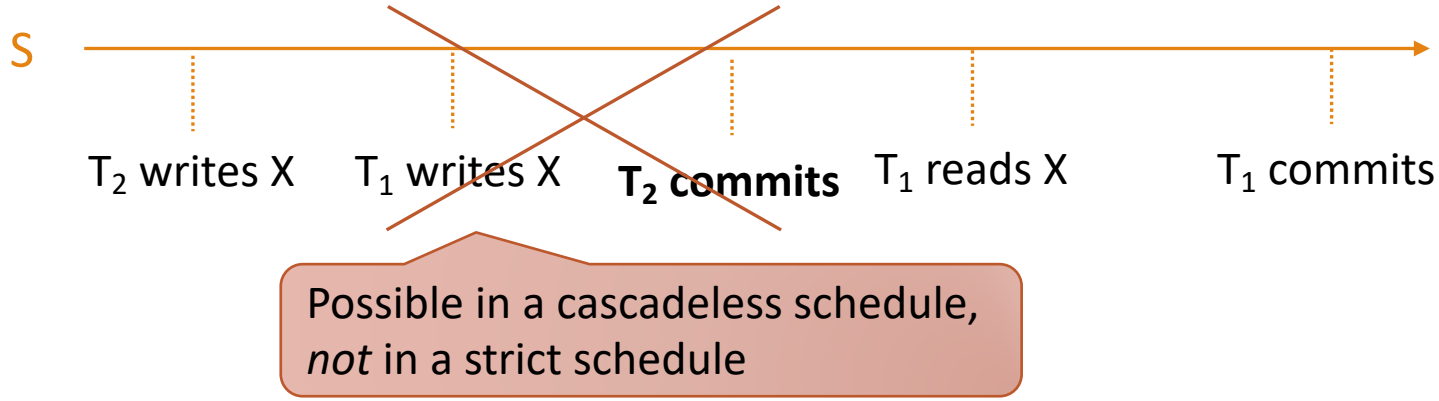


Cascadeless schedules are in general **not serialisable**.
(recall example on previous slide)

Can We Have Both?
No Cascading Aborts & Serialisability?

Strict Schedules

A schedule is **strict** if each transaction in it reads and writes only values that were written by transactions that have already committed.



Strict Schedules

A schedule is **strict** if each transaction in it reads and writes only values that were written by transactions that have already committed.

Of course, log records have to reach disk in order.

Strict Two-Phase Locking (Strict 2PL)

Most popular variant of two-phase locking (2PL)

Enforces both:

- Conflict-serialisability
- Strict schedules

Strict locking condition
(in addition to 2PL condition):

- with simple locking: **any lock**
- with shared/exclusive locks: **just exclusive locks**

A transaction T **must not release any lock (that allows T to write data)** until:

- T has committed or aborted, and
- the commit/abort log record has been written to disk.

Example 1

2PL transaction

Not strict 2PL

Transaction T
lock(X)
read_item(X)
X := X + 100
write_item(X)
lock(Y)
unlock(X)
read_item(Y)
Y := Y + 100
write_item(Y)
unlock(Y)
commit

For undo logging, we assume that **commit**…

1. Writes all log records to disk
2. Writes all modified database items to disk
3. Writes the commit record to disk

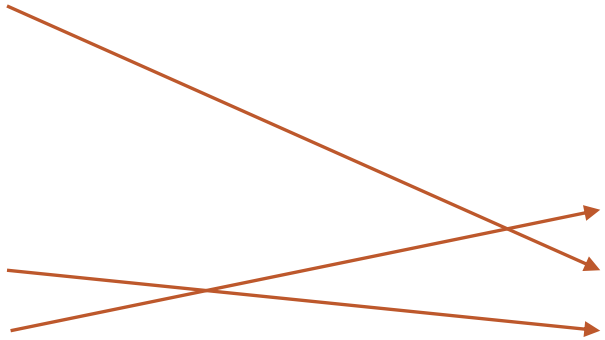
Example 2

2PL transaction

Transaction T
lock(X)
read_item(X)
X := X + 100
write_item(X)
lock(Y)
unlock(X)
read_item(Y)
Y := Y + 100
write_item(Y)
unlock(Y)
commit

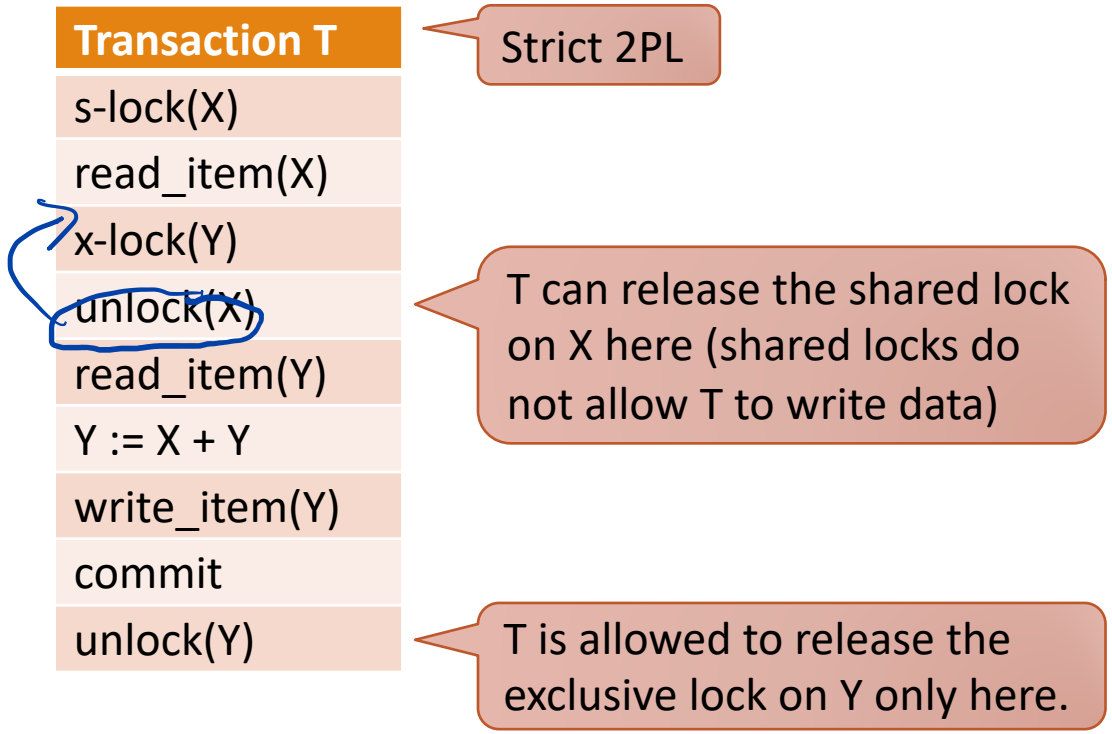
Strict 2PL transaction

New transaction T’
lock(X)
read_item(X)
X := X + 100
write_item(X)
lock(Y)
read_item(Y)
Y := Y + 100
write_item(Y)
commit
unlock(X)
unlock(Y)



Locks released only after fully committed, and all log records written to disk

Example With Shared/Exclusive Locks

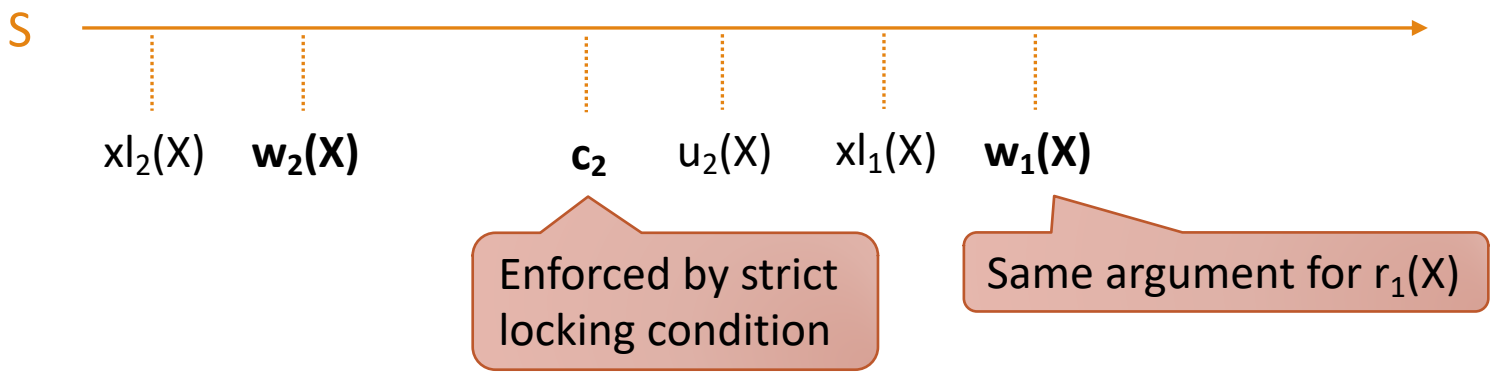


Strict Two-Phase Locking *Enforces* Conflict-Serialisable & Strict Schedules

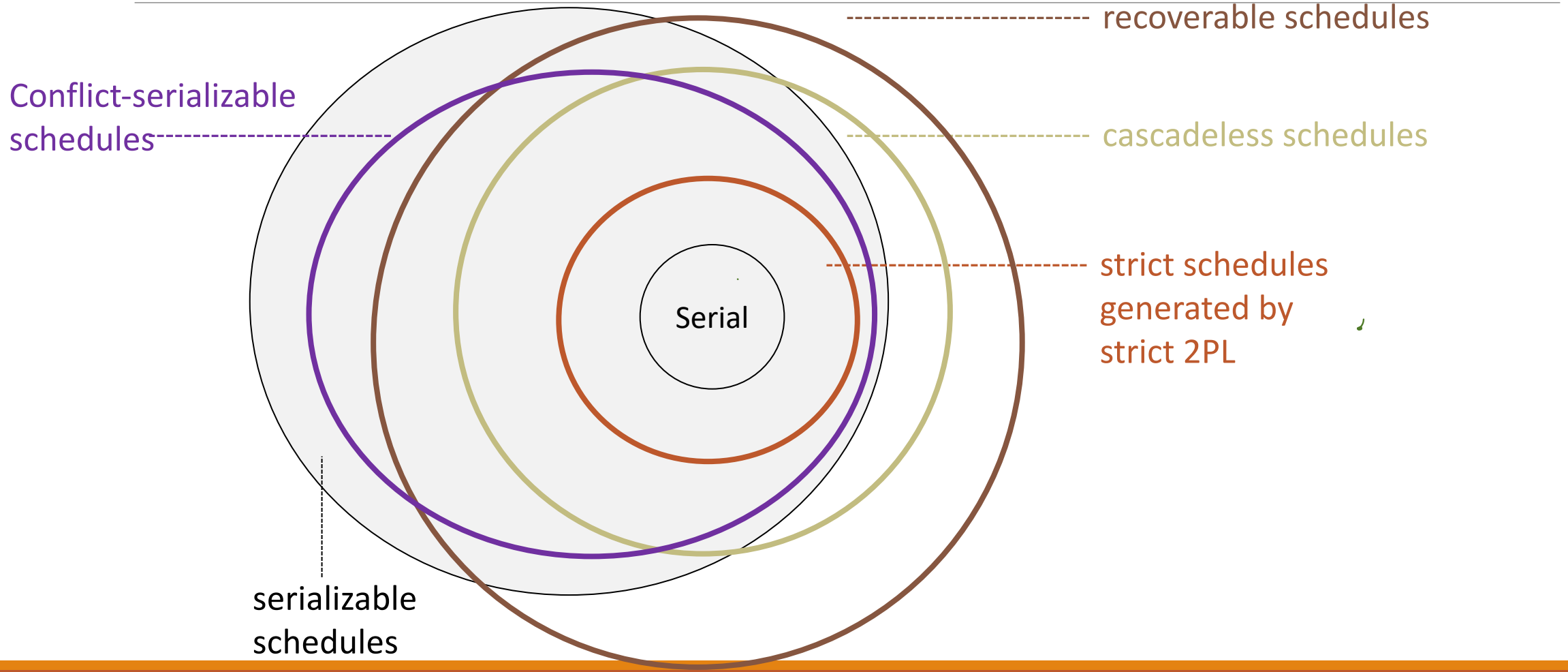
If S is a schedule consisting of strict 2PL transactions:

- S is conflict-serialisable.
- S is strict.

Strictness:



How the Types of Schedules are Related



Examples for serializable schedules

1. example: $w_2(X); w_1(X); w_1(Y); w_2(Y); r_3(Y); w_3(X); c_3; c_2; c_1$
   - This is serializable, but not conflict-serializable or recoverable
2. example: $w_1(X); w_1(Y); w_2(X); w_2(Y); r_3(Y); w_3(X); c_3; c_2; c_1$
   - This is conflict-serializable, but not recoverable
3. example: $w_2(X); w_1(X); w_1(Y); w_2(Y); r_3(Y); w_3(X); c_2; c_3; c_1$
   - This is recoverable and serializable, but not conflict-serializable nor cascadeless
4. example: $w_1(X); w_1(Y); w_2(X); w_2(Y); r_3(Y); w_3(X); c_2; c_3; c_1$
   - This is recoverable and conflict-serializable, but not cascadeless
5: example: $w_2(X); w_1(X); w_1(Y); w_2(Y); c_2; r_3(Y); w_3(X); c_3; c_1$
   - This is cascadeless and serializable, but not conflict-serializable
6: example: $w_1(X); w_1(Y); w_2(X); w_2(Y); c_2; r_3(Y); w_3(X); c_3; c_1$

Conflict-serializable and cascadeless but not strict

Still… Risk of Deadlocks

T_1
lock(X)
read_item(X)
X := X + 100
write_item(X)
lock(Y)
read_item(Y)
Y := Y + 100
write_item(Y)
commit
unlock(X)
unlock(Y)

T_2
lock(Y)
read_item(Y)
Y := Y + 100
write_item(Y)
lock(X)
read_item(X)
X := X + 100
write_item(X)
commit
unlock(X)
unlock(Y)

$l_1(X); r_1(X); w_1(X); l_2(Y); r_2(Y); w_2(Y);$?

T_2's request for lock on X denied

T_1's request for lock on Y denied

Strict 2PL and Deadlocks

Strict 2PL yields **conflict-serialisable**, **strict schedules**

Problem: **deadlocks**

T_1	T_2
lock(X)	lock(Y)
read_item(X)	read_item(Y)
X := X + 100	Y := Y + 100
write_item(X)	write_item(Y)
lock(Y)	**lock(X)**
…	…

$l_1(X); r_1(X); w_1(X);$
$l_2(Y); r_2(Y); w_2(Y);$?

Roll back (and restart) one of the transactions

Two approaches for deadlock prevention:

- **Detect deadlocks & fix them**
- **Enforce deadlock-free schedules**

Not based on (strict) 2PL

Summary

Cascadeless schedules are a more restrictive form of schedules

- You can only read things that are already committed

Instead of implementing that, we use Strict

- You can only read or overwrite things that are already committed

We then finally use Strict 2PL

- Like 2PL, but where you can only unlock (locks that could write) after commit