CS 564: Database Management Systems

Lecture 31: Concurrency control

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4/10/2024

Module B4 Transactions

Concurrency control

Optimistic concurrency control

Logging

ARIES recovery

Outline

Transaction basics

ACID properties

Two-phase locking (2PL)

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Transaction basics

ACID properties

Two-phase locking (2PL)

Basic Concept: **Transaction**

Transaction: A sequence of many actions considered to be one atomic unit of work

- Action: read, scan, update, insert, delete, etc.
- Special action: **begin**, **commit**, **abort**
- Central building block of a database

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- Action: read, scan, update, insert, delete, etc.
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```
BEGIN TRANSACTION ;
      UPDATE account
        SET balance = balance – 1000
        WHERE account_no = 1;
      UPDATE account
        SET balance = balance + 1000
        WHERE account_no = 2;
COMMIT ;
```

Use cases

- Transfer money between accounts
- Purchase a group of products online
- Book flight tickets

Outline

Transaction basics

ACID properties

- Atomicity
- Consistency
- Isolation (serializability)
- Durability

Two-phase locking (2PL)

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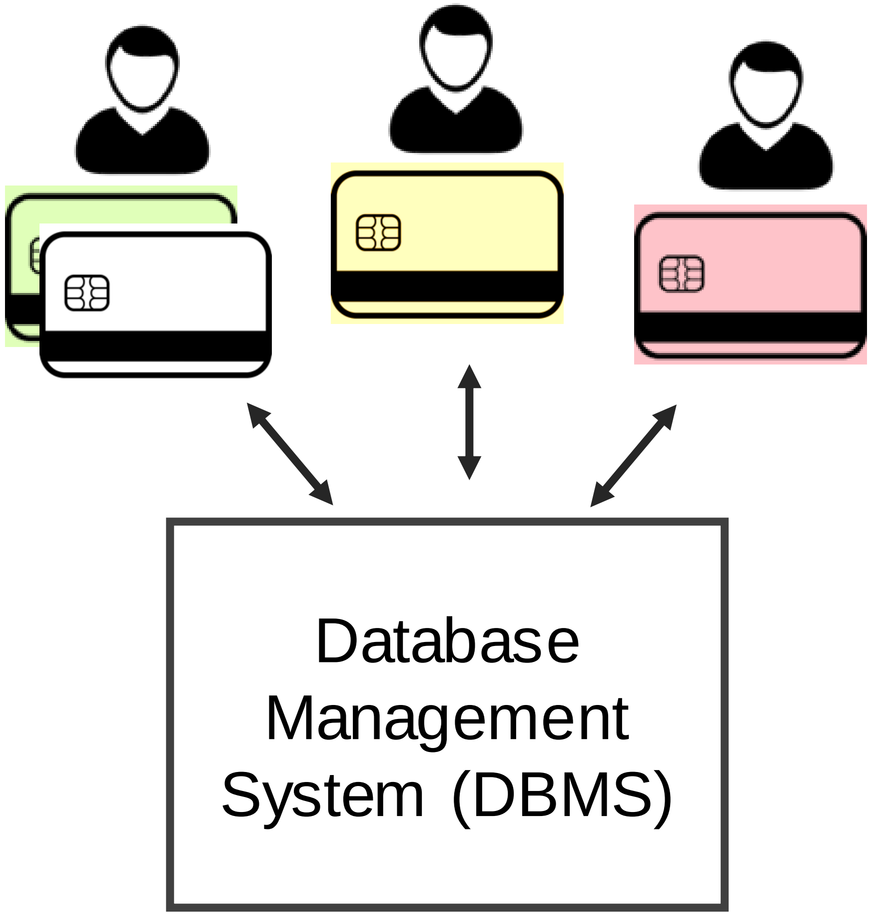
- **Consistency**: a database in a consistent state will remain in a consistent state after the transaction
- **Isolation**: the execution of one transaction is isolated from other (possibly interleaved) transactions
- **Durability**: once a transaction commits, its effects must persist

A Naïve Implementation of Transactions



NaïveDB

- Admit one transaction T
- Execute T to completion
- Flush T's writes to disk
- Commit T

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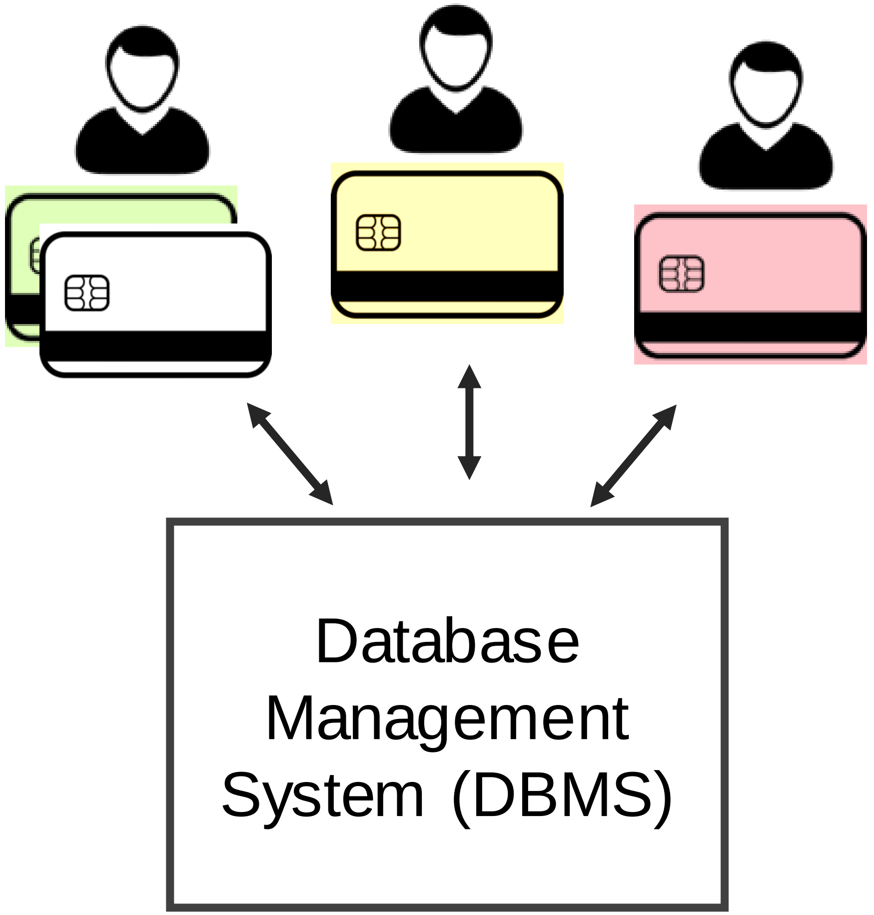

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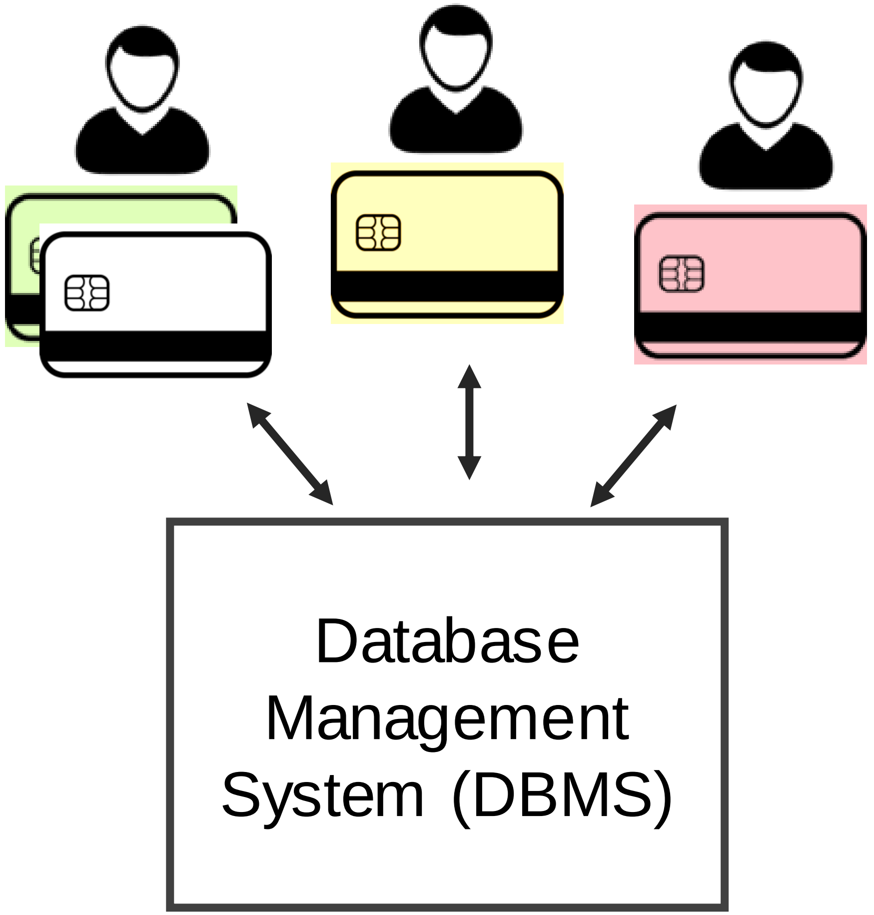

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Disadvantage of NaiveDB?

Performance!

Online Transaction Processing (OLTP)

NaïveDB
- Admit one transaction T
- Execute T to completion
- Flush T's writes to disk
- Commit T

Performance goal of OLTP DBMS: **Logically equivalent to NaïveDB** and yet achieve **better performance**

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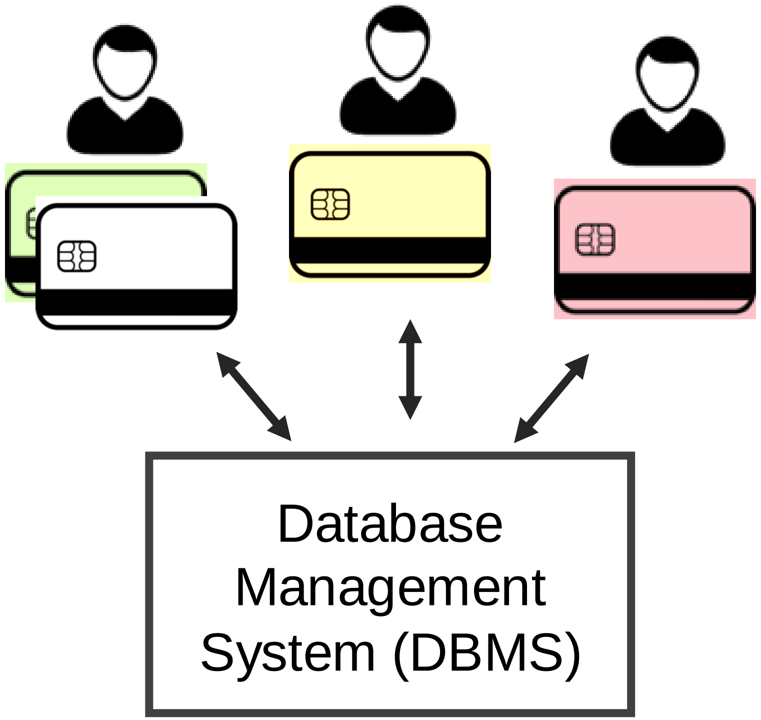
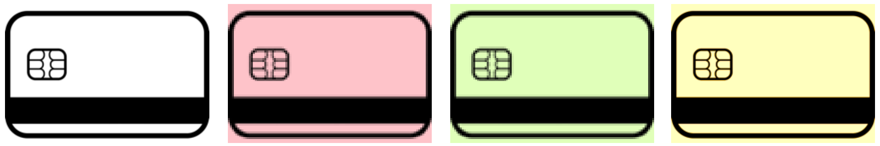


Serializable execution



ACID – Isolation Example

Initailly
checking.balance = 1000

```
If checking.balance > 100

    bal = checking.balance

    bal = bal - 100

    checking.balance = bal
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bal = 900

```
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```
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```
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3
```
    checking = 900
```

```
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ACID – Isolation Example

Not Serializable!

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Is the following execution serializable?

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Serializability – Example

Is the following execution serializable?

T1.read(X) T2.write(X) T2.read(Y) T1.read(Y) C1 C2 ✓

T1.write(X) T2.read(X) C1 C2 ✓

T1.read(X) T2.read(Y) T1.write(Y) T2.write(X) C1 C2 ✗

T1.write(X) T2.read(X) A1 C2 ✗

T1.read(X) T2.read(X) T2.write(X) T1.write(X) C1 C2 ✗

Outline

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Two-phase locking (2PL)

- Shared and exclusive lock
- Strict 2PL
- Deadlock

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- A lock is in either **Shared** (for read) or **Exclusive** (for write) mode

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Use **fine-grained locks** (e.g., page granularity) to improve concurrency

– A lock is in either **Shared** (for read) or **Exclusive** (for write) mode

Transaction T1	Transaction T2
SH-lock(A) Unlock(A)	
	EX-lock(A) Unlock(A)
SH-lock(A) Unlock(A)	

Locking by itself does not guarantee serializability

Two-Phase Locking (2PL)

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Two-phase locking (2PL) ensures serializability

- **Growing phase**: acquire but do not release locks
- **Shrinking phases**: release but do not acquire locks

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Two-phase locking (2PL) ensures serializability

- **Growing phase**: acquire but do not release locks
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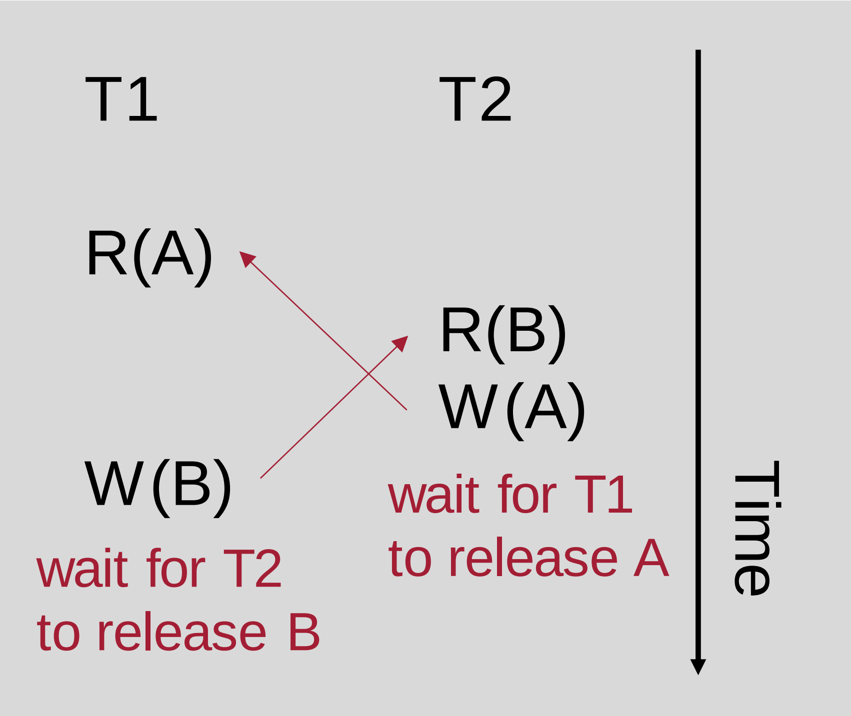
Strict 2PL (S2PL): release locks only after a transaction commits or aborts

Deadlock in 2PL

Deadlock is a significant challenge in 2PL



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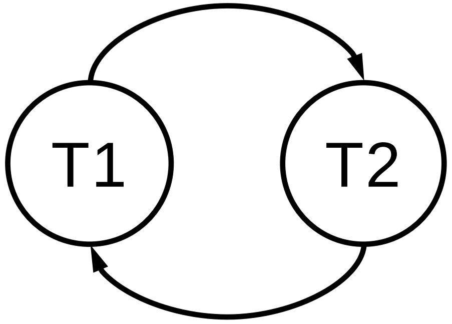
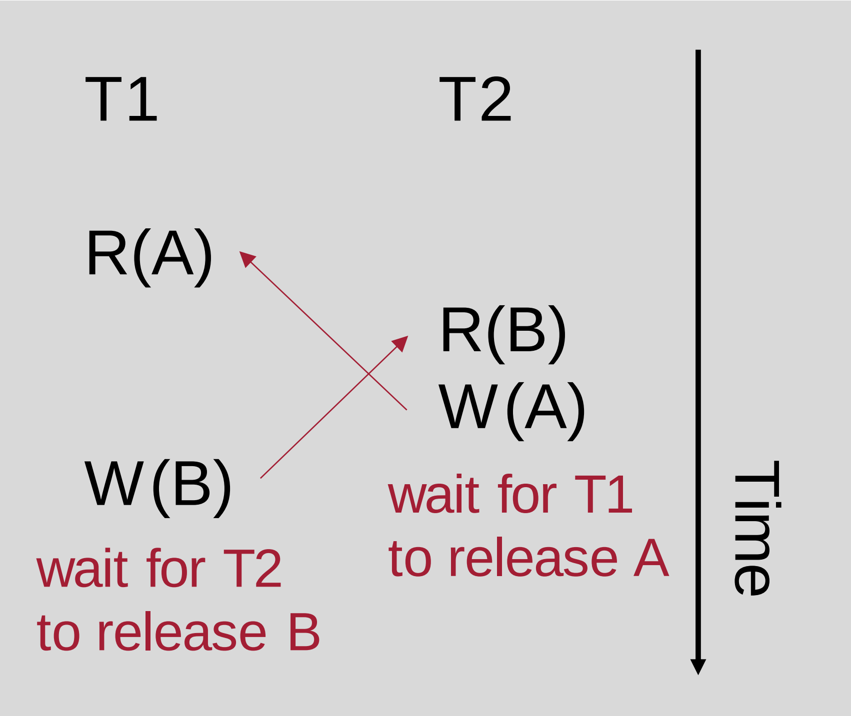


Waits-for graph



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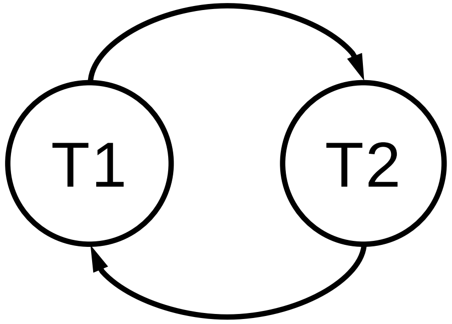
A cycle in the waits-for graph -> **Deadlock**!



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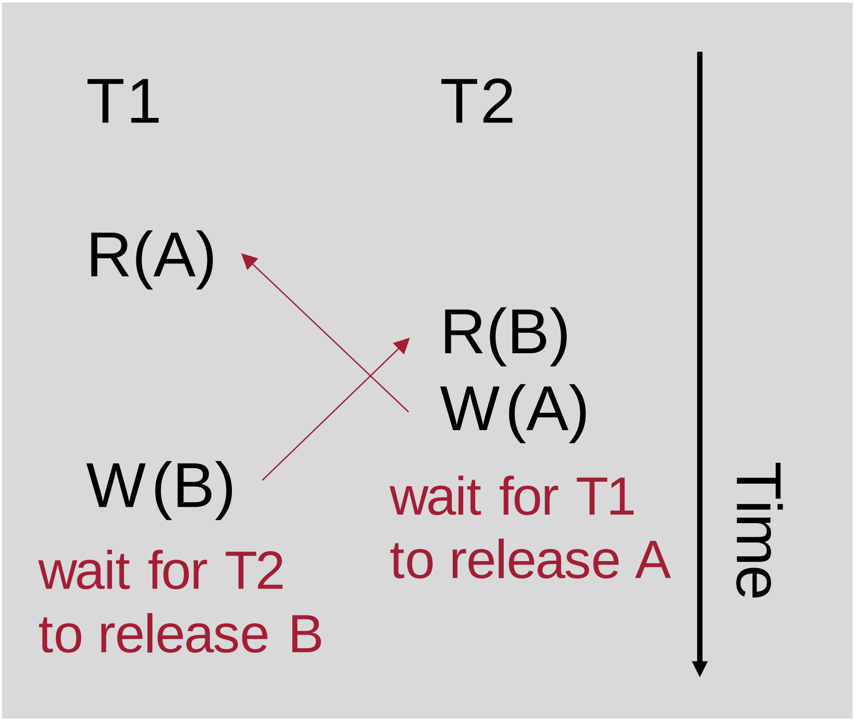

Deadlock Detection and Prevention

Deadlock detection: Once a cycle is detected, abort one transaction to break the cycle

- DBMS maintains the **waits-for graph**

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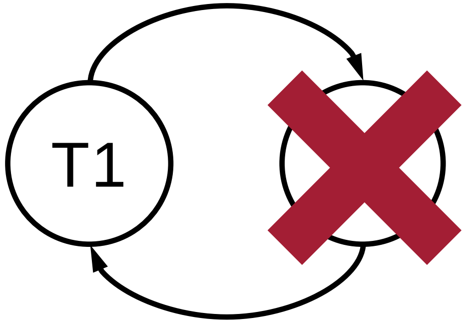

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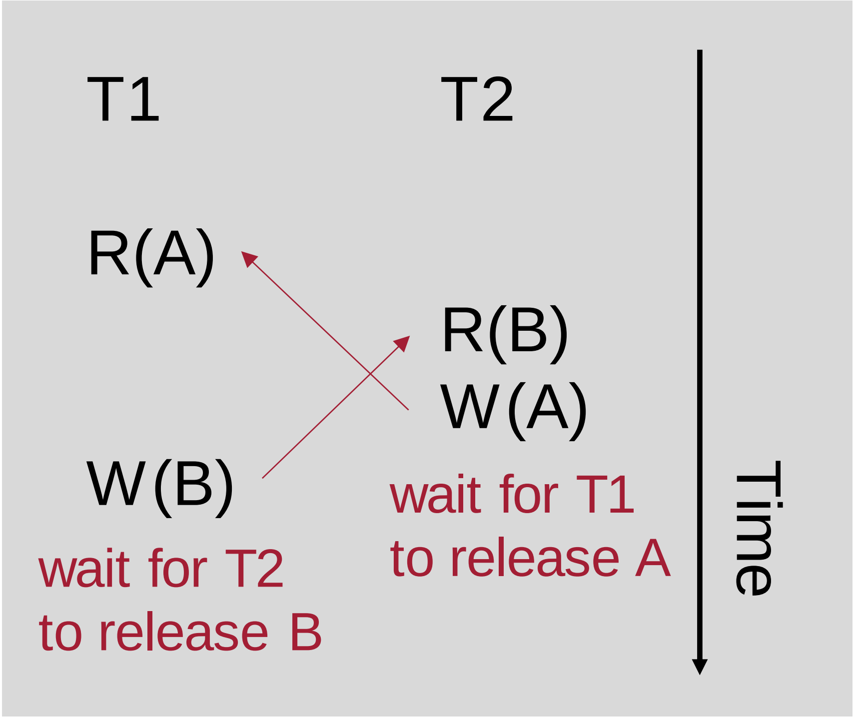


Deadlock Prevention

No-Wait: A transaction self-aborts when encountering a conflict

– No wait -> no deadline

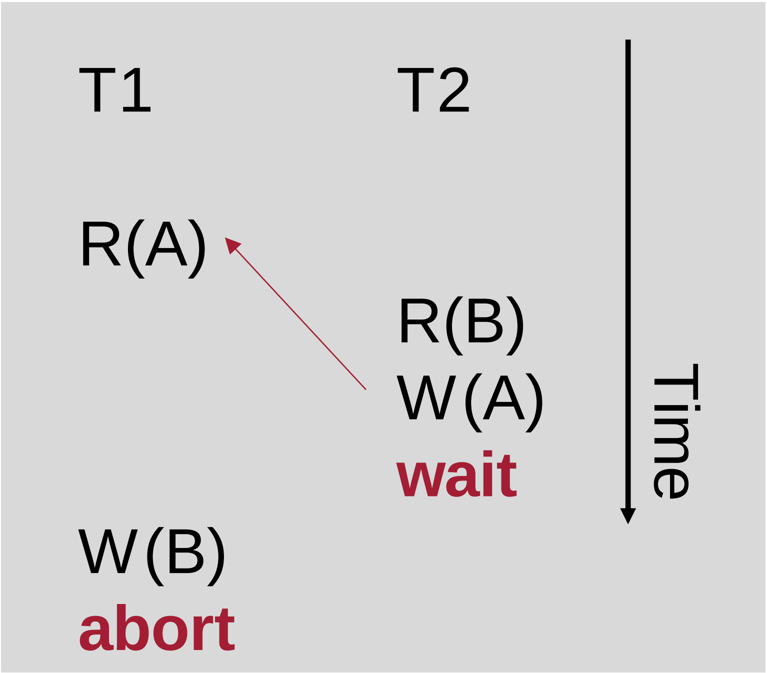
T1	T2
R(A)	
	R(B)
	W(A)
	abort
W(B)	
commit	

Time

Deadlock Prevention

Wait-Die: On a conflict, the requesting transaction **waits** if it has higher priority than the transaction that owns the lock; otherwise the requesting transaction **self-aborts**

- **No deadlock**: wait only from high-priority to low-priority txn
- **No starvation**: highest priority txn will not abort



* Assuming T2 has higher priority

Summary

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- Isolation (serializability)
- Durability

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