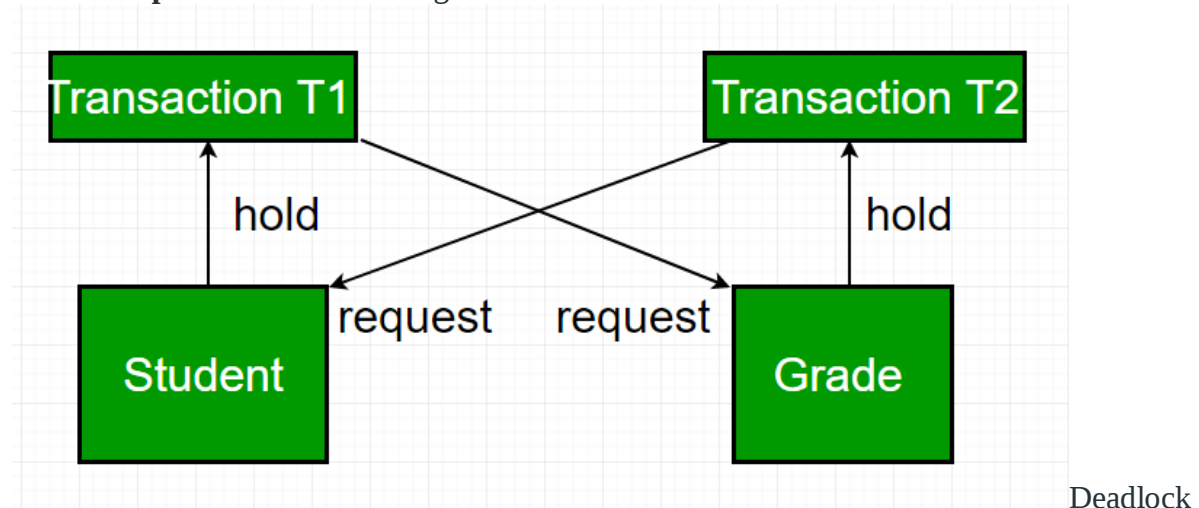


Deadlock in DBMS

A deadlock occurs in a multi-user database environment when two or more transactions block each other indefinitely by each holding a resource the other needs. This results in a cycle of dependencies (circular wait) where no transaction can proceed.

For Example: Consider the image below



in DBMS

In the above image, we can see that:

- T1 locks Resource "Student" and needs Resource "Grade"
- T2 locks Resource "Grade" and needs Resource "Student"
- T1 waits for T2, T2 waits for T1, hence resulting in a deadlock

Necessary Conditions of Deadlock

For a deadlock to occur, all four of these conditions must be true:

- **Mutual Exclusion:** Only one transaction can hold a particular resource at a time.
- **Hold and Wait:** The Transactions holding resources may request additional resources held by others.
- **No Preemption:** The Resources cannot be forcibly taken from the transaction holding them.
- **Circular Wait:** A cycle of transactions exists where each transaction is waiting for the resource held by the next transaction in the cycle.

Why Deadlocks Are a Problem?

- Transactions are stuck indefinitely.
- System throughput decreases as transactions remain blocked.
- Resources are held unnecessarily, preventing other operations.
- Can lead to performance bottlenecks or even system-wide standstill if not handled.

Real-Life Example

Transaction T1:

- Locks rows in Students
- Wants to update rows in Grades

Transaction T2:

- Locks rows in Grades
- Wants to update rows in Students

Both wait on each other and this results in **deadlock**, and all database activity comes to a standstill.

How to Handle Deadlocks

There are some approaches and by ensuring them, we can handle deadlocks. They are discussed below:

1. Deadlock Avoidance

Plan transactions in a way that prevents deadlock from occurring.

Methods:

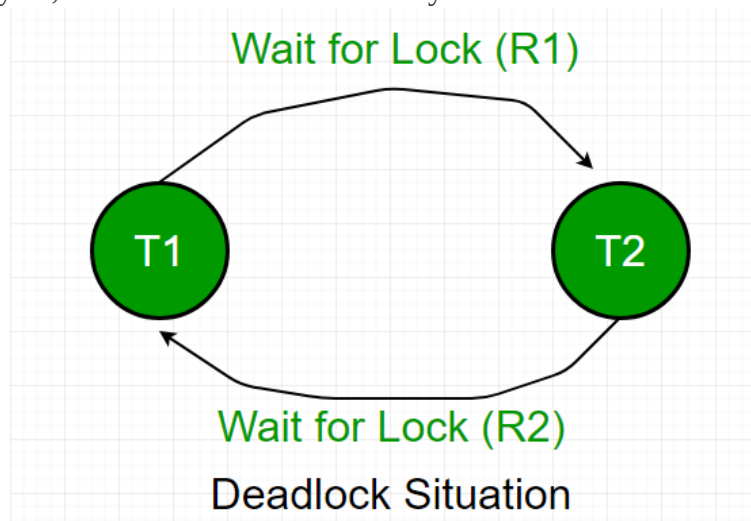
- Access resources in the same order. For e.g., always access Students first, then Grades
- Use row-level locking and READ COMMITTED isolation level. It reduces chances, but doesn't eliminate deadlocks completely

2. Deadlock Detection

If a transaction waits too long, the DBMS checks if it's part of a deadlock.

Method: Wait-For Graph

- Nodes: Transactions
- Edges: Waiting relationships
- If there's a cycle, a deadlock exists. It's mostly suitable for small to medium databases



3. Deadlock Prevention

For a large database, the deadlock prevention method is suitable. A deadlock can be prevented if the resources are allocated in such a way that a deadlock never occurs. The DBMS analyzes the operations whether they can create a deadlock situation or not. If they do, that transaction is never allowed to be executed.

Deadlock prevention mechanism proposes two schemes:

1. Wait-Die Scheme (Non-preemptive)

- Older transactions are allowed to wait.
- Younger transactions are killed (aborted and restarted) if they request a resource held by an older one

For example:

- Consider two transaction- T1 = 10 and T2 = 20
- If T1 (older) wants a resource held by T2 → T1 waits
- If T2 (younger) wants a resource held by T1 → T2 dies and restarts

Prevents deadlock by not allowing a younger transaction to wait and form a wait cycle.

2. Wound-Wait Scheme (Preemptive)

- Older transactions are aggressive (preemptive) and can force younger ones to abort.
- Younger transactions must wait if they want a resource held by an older one.

For example:

- Consider two transaction- T1 = 10 and T2 = 20

- If T1 (older) wants a resource held by T2 → T2 is killed, T1 proceeds.
 - If T2 (younger) wants a resource held by T1 → T2 waits
- Prevents deadlock by not allowing younger transactions to block older ones.

Wait - Die	Wound -Wait
It is based on a non-preemptive technique.	It is based on a preemptive technique.
In this, older transactions must wait for the younger one to release its data items.	In this, older transactions never wait for younger transactions.
The number of aborts and rollbacks is higher in these techniques.	In this, the number of aborts and rollback is lesser.

The following table lists the differences between Wait-Die and Wound-Wait scheme prevention schemes:

Applications Affected by Deadlock

1. **Delayed Transactions:** blocked indefinitely
2. **Lost Transactions:** may get aborted or rolled back
3. **Reduced Concurrency:** fewer simultaneous operations
4. **Increased Resource Usage:** idle but locked resources
5. **Poor User Experience:** slow response or system freeze