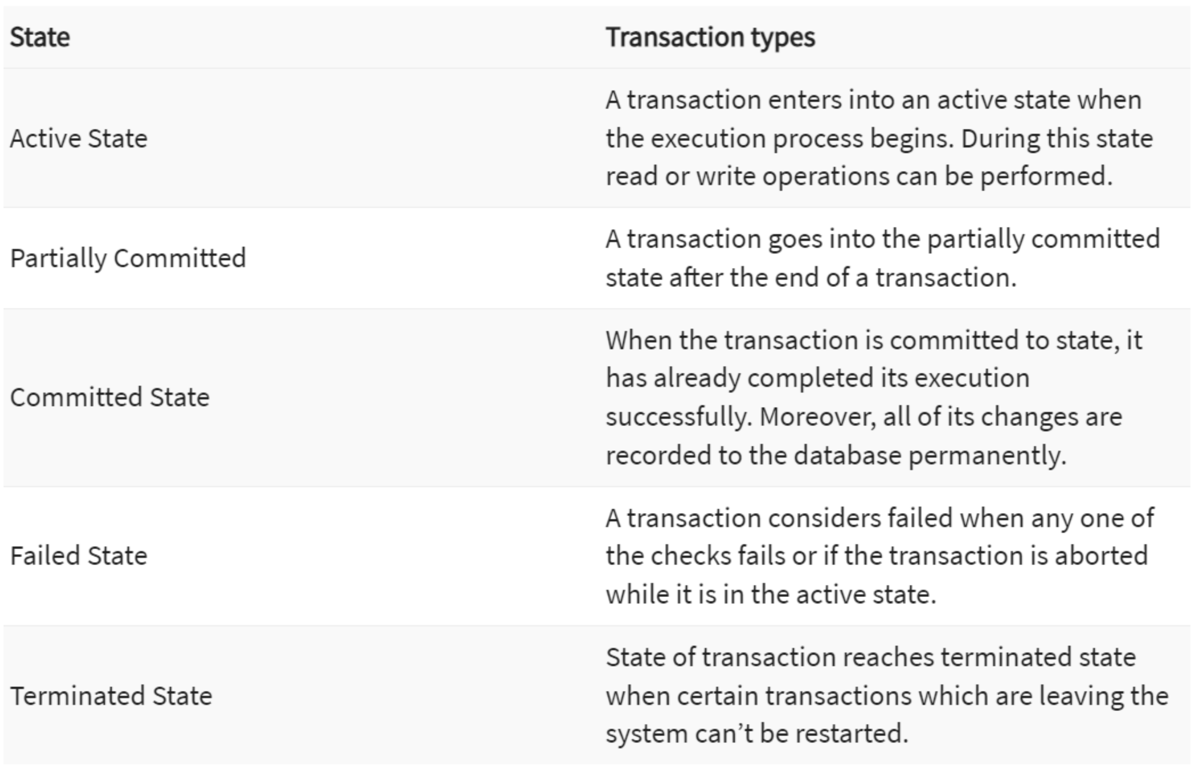
TOPIC 2: CONCURRENCY USING TRANSACTIONS

DATABASE TRANSACTION

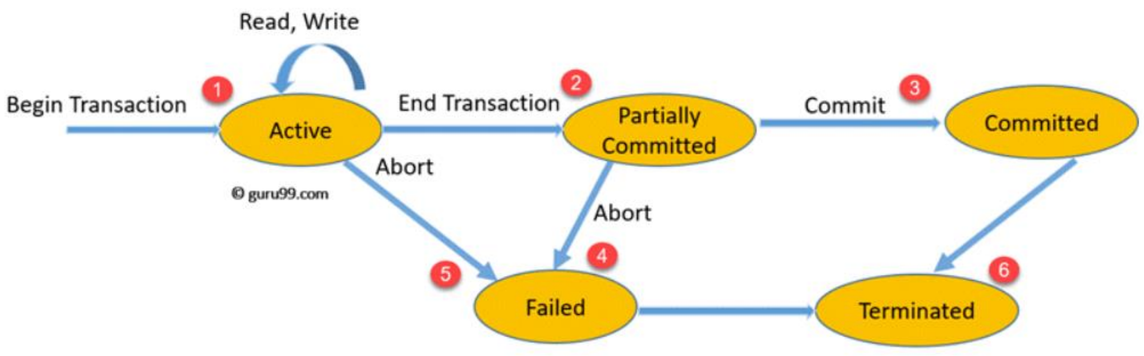
- A Database Transaction is a logical unit of processing in a DBMS that entails one or more database access operations.
- In a nutshell, database transactions represent real-world events of any enterprise.

A transaction is a program unit whose execution may or may not change the contents of a database.

STATES OF DATABASE TRANSACTIONS



State	Transaction types
Active State	A transaction enters into an active state when the execution process begins. During this state read or write operations can be performed.
Partially Committed	A transaction goes into the partially committed state after the end of a transaction.
Committed State	When the transaction is committed to state, it has already completed its execution successfully. Moreover, all of its changes are recorded to the database permanently.
Failed State	A transaction considers failed when any one of the checks fails or if the transaction is aborted while it is in the active state.
Terminated State	State of transaction reaches terminated state when certain transactions which are leaving the system can't be restarted.

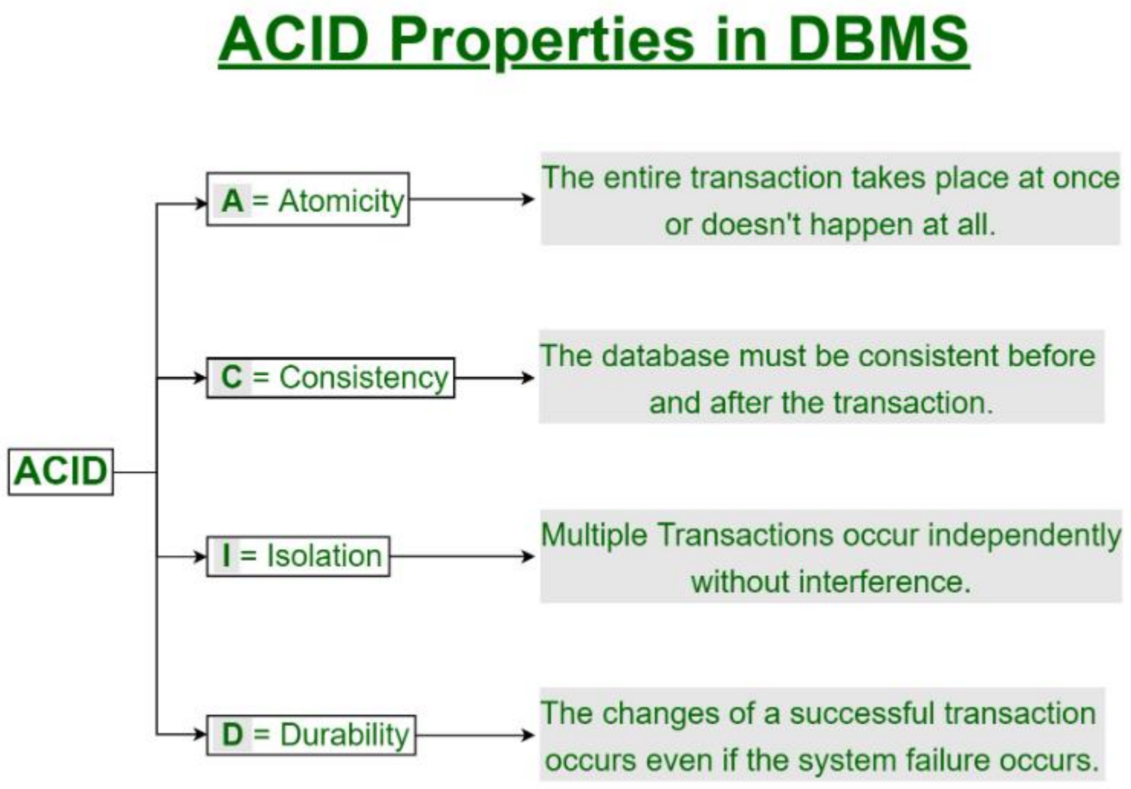


States of database transactions

1. Once a transaction states execution, it becomes active. It can issue READ or WRITE operations.
2. Once the READ and WRITE operations are complete, the transactions become partially committed state.
3. Next, some recovery protocols need to ensure that a system failure will not result in an inability to record changes in the transaction permanently. If this check succeeds, the transaction commits and enters the committed state.
4. If the check is a fail, the transaction goes to the Failed state.
5. If the transaction is aborted while it's in the active state, it goes to the failed state. The transaction should be rolled back to undo the effect of its write operations on the database.
6. The terminated state refers to the transaction leaving the system.

ACID PROPERTIES

- A transaction is a single logical unit of work that accesses and possibly modifies the contents of a database.
- Transactions access data using read-and-write operations.
- In order to maintain consistency in a database, certain properties are followed before and after the transaction.
- These are called ACID properties.

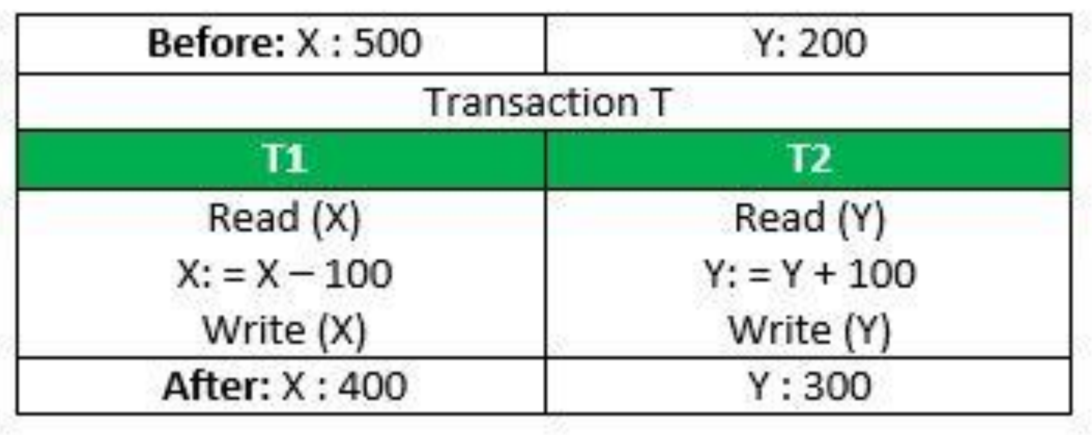


ACID Properties in DBMS
ACID
A = Atomicity
The entire transaction takes place at once or doesn't happen at all.
C = Consistency
The database must be consistent before and after the transaction.
I = Isolation
Multiple Transactions occur independently without interference.
D = Durability
The changes of a successful transaction occurs even if the system failure occurs.

ACID properties

Atomicity

- By this, we mean that the entire transaction occurs at once or doesn't happen at all. There is no midway i.e. transactions do not occur partially. Each transaction is considered as one unit and either run to completion or is not executed at all.
- It involves the following two operations.
—Abort: If a transaction aborts, changes made to the database are not visible.
—Commit: If a transaction commits, changes made are visible.
Atomicity is also known as the 'All or nothing rule'.



Before: X : 500	Y: 200
Transaction T	
T1	**T2**
Read (X) X: = X – 100 Write (X)	Read (Y) Y: = Y + 100 Write (Y)
After: X : 400	Y : 300

If the transaction fails after completion of T1 but before completion of T2.(say, after write(X) but before write(Y)), then the amount has been deducted from X but not added to Y. This results in an inconsistent database state. Therefore, the transaction must be executed in its entirety in order to ensure the correctness of the database state.

Consistency

- This means that integrity constraints must be maintained so that the database is consistent before and after the transaction. It refers to the correctness of a database. Referring to the example above,
- The total amount before and after the transaction must be maintained.

Total before T occurs = 500 + 200 = 700.

Total after T occurs = 400 + 300 = 700.

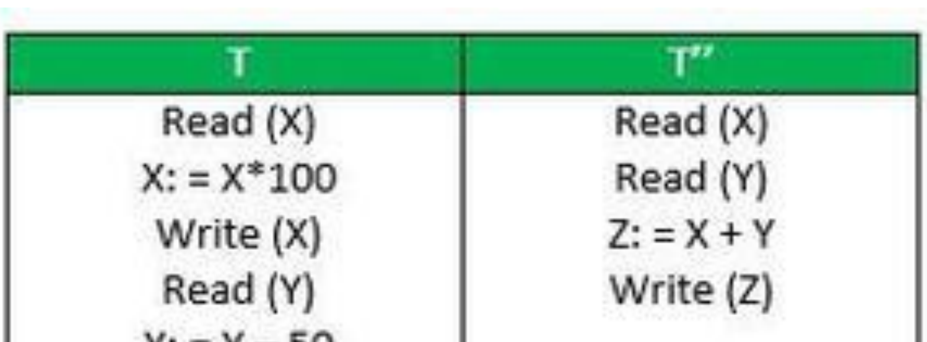
Therefore, the database is consistent. Inconsistency occurs in case T1 completes but T2 fails. As a result, T is incomplete.

Isolation

- This property ensures that multiple transactions can occur concurrently without leading to the inconsistency of the database state.
- Transactions occur independently without interference.
- Changes occurring in a particular transaction will not be visible to any other transaction until that particular change in that transaction is written to memory or has been committed.
- This property ensures that the execution of transactions concurrently will result in a state that is equivalent to a state achieved these were executed serially in some order.

Let X= 500, Y = 500.

Consider two transactions T and T".



T	T"
Read (X) X: = X*100 Write (X) Read (Y) Y: = Y − 50 Write(Y)	Read (X) Read (Y) Z: = X + Y Write (Z)

Durability

- This property ensures that once the transaction has completed execution, the updates and modifications to the database are stored in and written to disk and they persist even if a system failure occurs.
- These updates now become permanent and are stored in non-volatile memory. The effects of the transaction, thus, are never lost.

Some important points:

Property	Responsibility for maintaining properties
Atomicity	Transaction Manager
Consistency	Application programmer
Isolation	Concurrency Control Manager
Durability	Recovery Manager

The ACID properties, in totality, provide a mechanism to ensure the correctness and consistency of a database in a way such that each transaction is a group of operations that acts as a single unit, produces consistent results, acts in isolation from other operations, and updates that it makes are durably stored.

Summary

1. Atomicity: Atomicity ensures that a transaction is treated as a single, indivisible unit of work. Either all the operations within the transaction are completed successfully, or none of them are. If any part of the transaction fails, the entire transaction is rolled back to its original state, ensuring data consistency and integrity.

2. Consistency: Consistency ensures that a transaction takes the database from one consistent state to another consistent state. The database is in a consistent state both before and after the transaction is executed. Constraints, such as unique keys and foreign keys, must be maintained to ensure data consistency.

3. Isolation: Isolation ensures that multiple transactions can execute concurrently without interfering with each other. Each transaction must be isolated from other transactions until it is completed. This isolation prevents dirty reads, non-repeatable reads, and phantom reads.

4. Durability: Durability ensures that once a transaction is committed, its changes are permanent and will survive any subsequent system failures. The transaction’s changes are saved to the database permanently, and even if the system crashes, the changes remain intact and can be recovered.

Overall, ACID properties provide a framework for ensuring data consistency, integrity, and reliability in DBMS. They ensure that transactions are executed in a reliable and consistent manner, even in the presence of system failures, network issues, or other problems. These properties make DBMS a reliable and efficient tool for managing data in modern organizations.

Advantages of ACID Properties in DBMS:

1. Data Consistency: ACID properties ensure that the data remains consistent and accurate after any transaction execution.
2. Data Integrity: ACID properties maintain the integrity of the data by ensuring that any changes to the database are permanent and cannot be lost.
3. Concurrency Control: ACID properties help to manage multiple transactions occurring concurrently by preventing interference between them.
4. Recovery: ACID properties ensure that in case of any failure or crash, the system can recover the data up to the point of failure or crash.

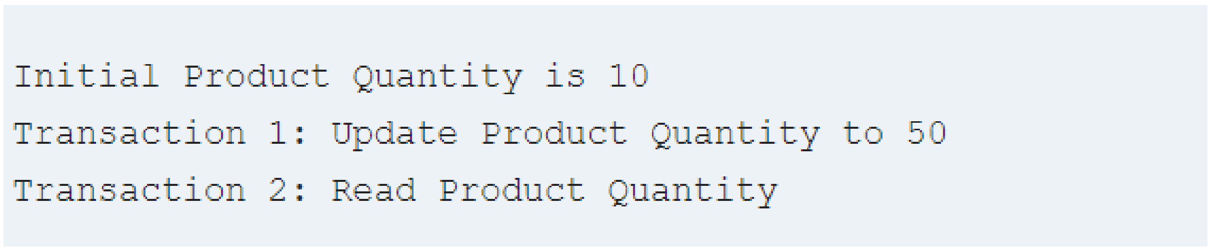
Disadvantages of ACID Properties in DBMS:

1. Performance: The ACID properties can cause a performance overhead in the system, as they require additional processing to ensure data consistency and integrity.
2. Scalability: The ACID properties may cause scalability issues in large distributed systems where multiple transactions occur concurrently.
3. Complexity: Implementing the ACID properties can increase the complexity of the system and require significant expertise and resources. Overall, the advantages of ACID properties in DBMS outweigh the disadvantages. They provide a reliable and consistent approach to data
4. management, ensuring data integrity, accuracy, and reliability. However, in some cases, the overhead of implementing ACID properties can cause performance and scalability issues. Therefore, it’s important to balance the benefits of ACID properties against the specific needs and requirements of the system.

What is a Schedule?

- A Schedule is a process of creating a single group of multiple parallel transactions and executing them one by one.
- It should preserve the order in which the instructions appear in each transaction. If two transactions are executed at the same time, the result of one transaction may affect the output of the other.

Example



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Initial Product Quantity is 10
Transaction 1: Update Product Quantity to 50
Transaction 2: Read Product Quantity
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Parallel execution in a database is inevitable. But, Parallel execution is permitted when there is an equivalence relation amongst the simultaneously executing transactions. This equivalence is of 3 Types.

What is Serializability?

Serializability is the process of searching for a concurrent schedule whose output is equal to a serial schedule where transactions are executed one after the other. Depending on the type of schedule, there are two types of serializability:

- Conflict
- View

REFERENCES

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