3.ACID Properties

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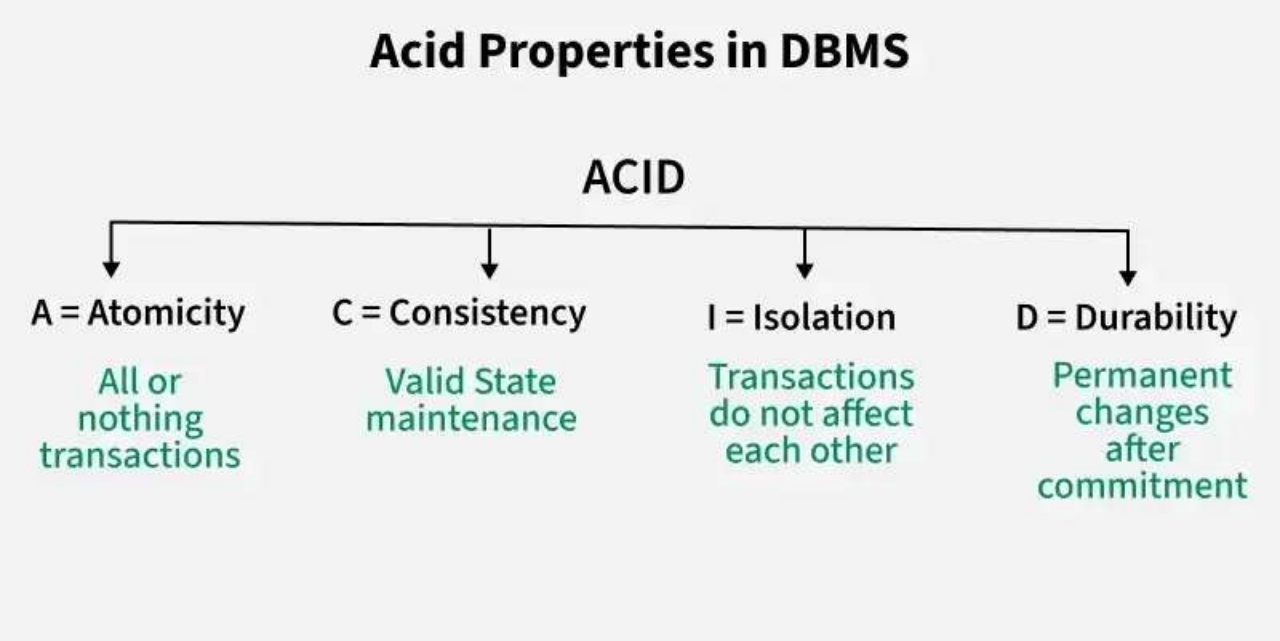
ACID Properties in DBMS
ACID is an acronym for Atomicity, Consistency, Isolation, and Durability. These four properties ensure that database transactions are processed reliably, even in cases of errors, crashes, or power failures.



1. Atomicity
Atomicity means a transaction is **all-or-nothing**.
Either *every* operation in the transaction is completed successfully, or **none** of them are applied.
Key points:

- If any step fails → the entire transaction is **rolled back**.
- If all steps succeed → the transaction is **committed**.

Example:
Transferring money between two accounts:

- Debit Account A
- Credit Account B

If crediting fails, the debit must be undone.
2. Consistency
Consistency in transactions means that the database must remain in a valid state before and after a transaction.

- A valid state follows all defined rules, constraints, and relationships (like primary keys, foreign keys, etc.).
- If a transaction violates any of these rules, it is rolled back to prevent corrupt or invalid data.
- If a transaction deducts money from one account but doesn't add it to another (in a transfer), it violates consistency.

3. Isolation
Isolation ensures that transactions run independently without affecting each other. Changes made by one transaction are not visible to others until they are committed.
It ensures that the result of concurrent transactions is the same as if they were run one after another, preventing issues like:

- **Dirty reads:** reading uncommitted data
- **Non-repeatable reads:** data changes between two reads
- **Phantom reads:** new rows appear during a transaction

4. Durability:
Durability ensures that once a transaction is committed, its changes are permanently saved, even if the system fails. The data is stored in non-volatile memory, so the database can recover to its last committed state without losing data.
Example: After successfully transferring money from Account A to Account B, the changes are stored on disk. Even if there is a crash immediately after the commit, the transfer details will still be intact when the system recovers, ensuring durability.

How ACID Properties Impact DBMS Design and Operation

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.

1. Data Integrity and Consistency

ACID properties safeguard the data integrity of a DBMS by ensuring that transactions either complete successfully or leave no trace if interrupted. They prevent partial updates from corrupting the data and ensure that the database transitions only between valid states.

2. Concurrency Control

ACID properties provide a solid framework for managing concurrent transactions. Isolation ensures that transactions do not interfere with each other, preventing data anomalies such as lost updates, temporary inconsistency, and uncommitted data.

3. Recovery and Fault Tolerance

Durability ensures that even if a system crashes, the database can recover to a consistent state. Thanks to the Atomicity and Durability properties, if a transaction fails midway, the database remains in a consistent state.

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

Critical Use Cases for ACID in Databases

In modern applications, ensuring the reliability and consistency of data is crucial. ACID properties are fundamental in sectors like:

- **Banking**: Transactions involving money transfers, deposits, or withdrawals must maintain strict consistency and durability to prevent errors and fraud.
- **E-commerce**: Ensuring that inventory counts, orders, and customer details are handled correctly and consistently, even during high traffic, requires ACID compliance.
- **Healthcare**: Patient records, test results, and prescriptions must adhere to strict consistency, integrity, and security standards.