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Explain ACID properties for database with propar example

The ACID properties ensure that database transactions are processed reliably. ACID stands for Atomicity, Consistency, Isolation, and Durability. Let's break down each property with an example.

1. Atomicity

Definition:
A transaction is an atomic unit of work that either completes entirely or does not happen at all. There are no partial transactions.

Example:
Consider a bank transfer where $100 is transferred from Alice's account to Bob's account. This transaction involves two operations:

- Debit $100 from Alice's account.
- Credit $100 to Bob's account.

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Atomicity ensures that either both operations are completed successfully, or neither is. If the debit operation is successful but the credit operation fails, the transaction will be rolled back, and Alice's account will remain unchanged.

2. Consistency

Definition:
A transaction brings the database from one valid state to another, maintaining database invariants.

Example:
Suppose a rule in the database ensures that the total balance of Alice's and Bob's accounts should always be $1000. Before the transaction, Alice has $700, and Bob has $300. After transferring $100 from Alice to Bob, Alice should have $600, and Bob should have $400. Consistency ensures this rule is maintained before and after the transaction.

3. Isolation

Definition:
Transactions are executed in isolation from one another. Intermediate states are not visible to other transactions.

Example:
Assume two transactions occur simultaneously:

- Transaction 1: Transfer $100 from Alice to Bob.
- Transaction 2: Transfer $50 from Bob to Charlie.

Isolation ensures that Transaction 1 does not see the intermediate state of Transaction 2, and vice versa. Both transactions should result as if they were executed sequentially, not affecting each other's partial results.

4. Durability

Definition:
Once a transaction is committed, it remains so, even in the event of a system failure.

Example:
After successfully transferring $100 from Alice to Bob, a system crash occurs. Durability guarantees that when the system recovers, change (the updated balances) will still be present in the database. The transfer will not be undone or lost.

Summary with Example

Consider the entire process of transferring $100 from Alice's account to Bob's account:

1. **Atomicity:** Both debit and credit operations must complete together. If either fails, the transaction is rolled back.
2. **Consistency:** The total balance before and after the transaction should be the same, adhering to any rules or constraints in the database.

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3. **Isolation:** If another transaction is transferring money at the same time, it should not see any intermediate state of this transaction.
4. **Durability:** Once the transaction completes and is committed, the changes remain even if the database crashes.

These properties ensure reliable and predictable transaction processing, which is crucial for maintaining data integrity and consistency in database systems.