Triggers and Transactions

Database Programmability

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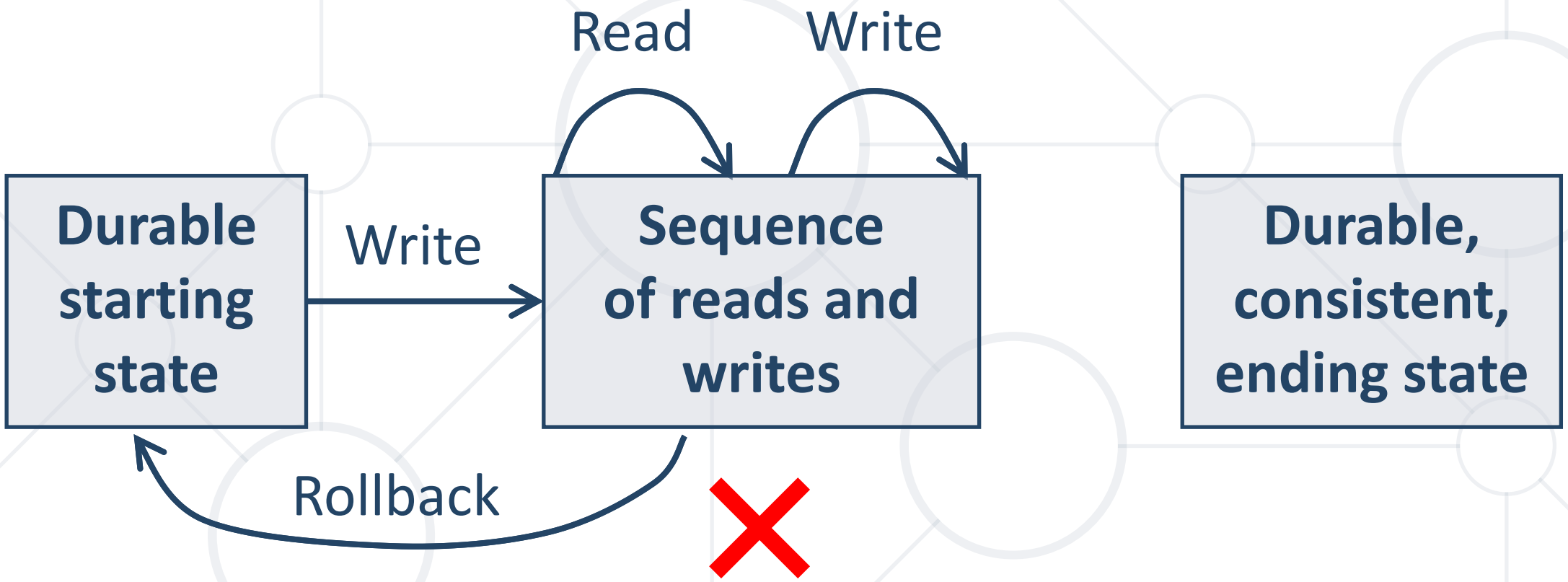
Transactions

Definition, Usage, ACID Model

Transactions

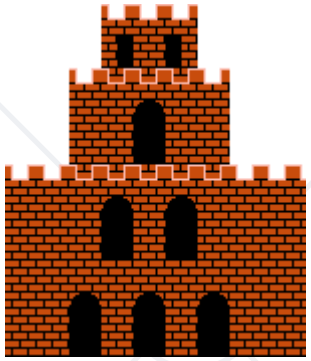
- A **Transaction** is a **sequence of actions** (**database operations**) **executed as a whole**:
  - Either **all** of them **complete successfully** or **none** of them **do**
- Examples:
  - A bank transfer from one account into another (**withdrawal + deposit**)
  - If either the **withdrawal or** the **deposit fails** the **whole operation is cancelled**

Transactions: Lifecycle (Rollback)



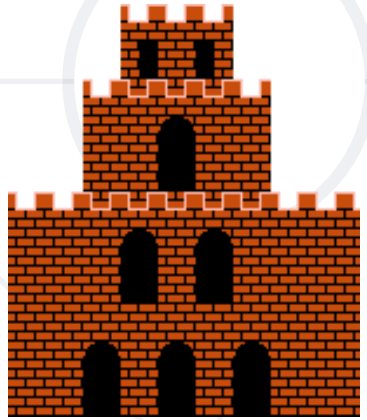
Transactions: Lifecycle (Commit)

Checkpoints in Games



Castle 1-2

DIE



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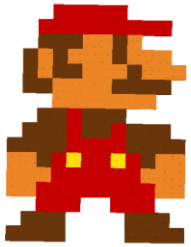


Mario

SURVIVE

What Are Transactions?

ROLLBACK

STATE 1

Queries

COMMIT

STATE 2

Transactions Syntax

```
CREATE PROC usp_Withdraw (@withdrawAmount DECIMAL(18,2), @accountId INT)
AS
BEGIN TRANSACTION
UPDATE Accounts SET Balance = Balance - @withdrawAmount
WHERE AccountId = @accountId
IF @@ROWCOUNT <> 1 -- Didn't affect exactly one row
BEGIN
   ROLLBACK
   RAISERROR('Invalid account!', 16, 1);
   RETURN
END
COMMIT
```

Start Transaction

Withdraw Money

Undo Changes

Raise Error

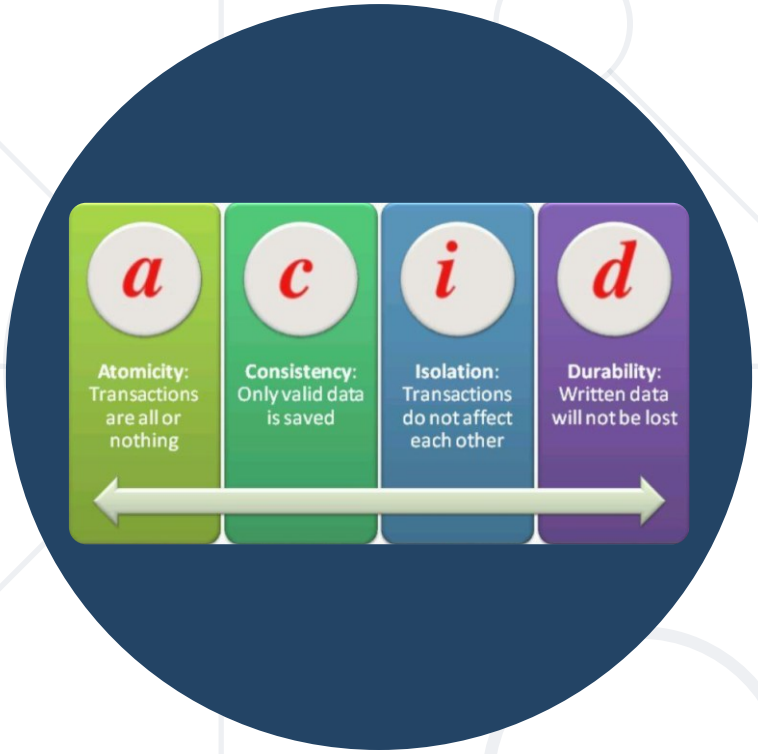
Save Changes

Transactions Behavior

- **Transactions** guarantee the **consistency** and the **integrity** of the **database**
  - All **changes** in a transaction **are temporary**
  - Changes are **persisted** when a **COMMIT** is **executed**
  - At any time, **all changes** can be **canceled** by **ROLLBACK**
- All **changes** are **persisted at once**
  - As long as **COMMIT** is called

Transactions: What Can Go Wrong?

- Some actions **fail to complete**
  - The application **software** or database **server crashes**
  - The user **cancels the action** while it's **in progress**
- **Interference** from another **transaction**
  - What happens if several transfers run for the same account at the same time?

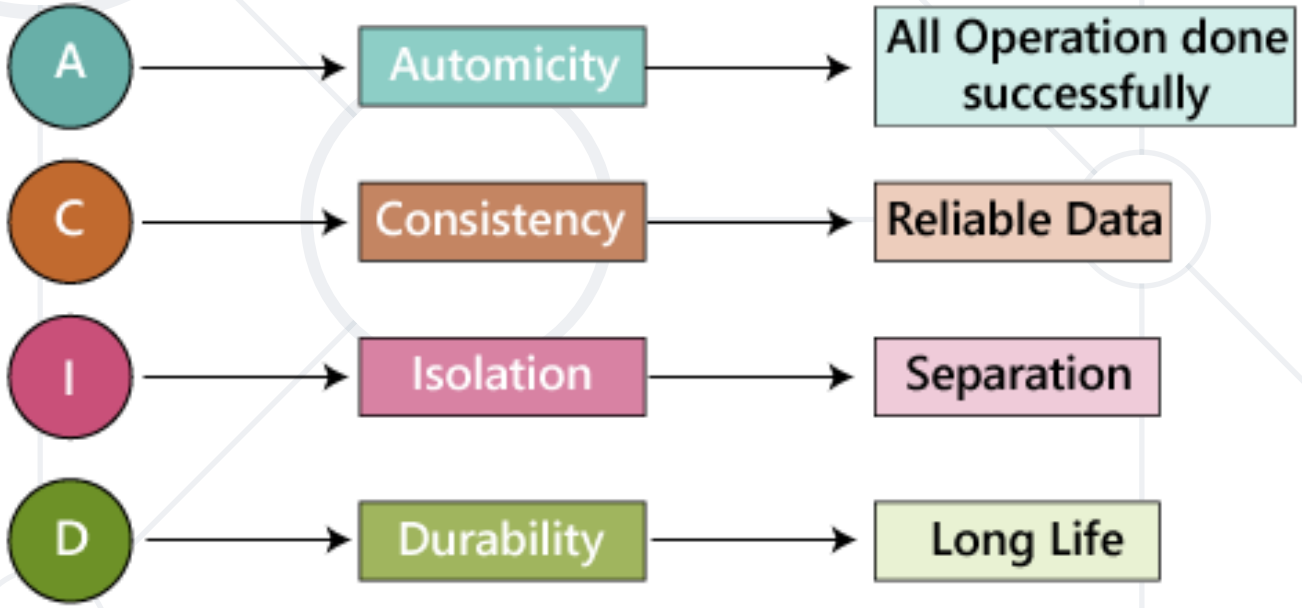


ACID Models

Solving Problems Before They Arise

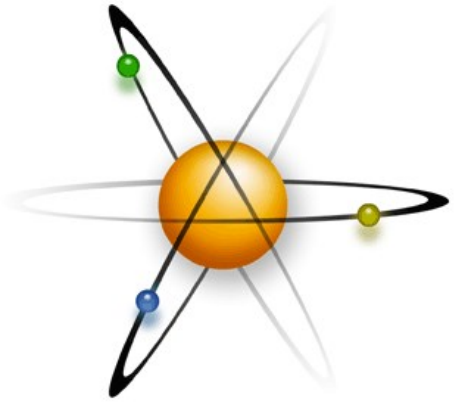
Transaction Properties

- Modern DBMS servers have **built-in transaction support**
  - Implement "**ACID**" **transactions**
  - MS SQL Server, Oracle, MySQL, PostgreSQL, etc.
- **ACID** means:
  - **Atomicity**
  - **Consistency**
  - **Isolation**
  - **Durability**



Atomicity

- **Atomicity** means that:
  - **Transactions** execute as a **whole**
  - DBMS guarantees that **either all** of the operations are performed **or none** of them



- Example: Transferring funds between bank accounts
  - Either withdraw + deposit both succeed, or none of them do
  - In case of failure, the database stays unchanged

Consistency

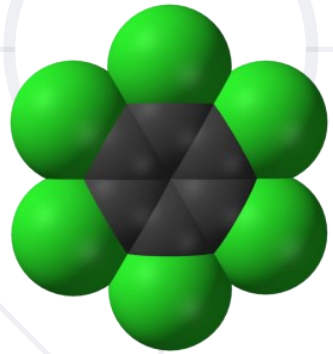
- **Consistency** means that:
  - The database has a legal state in both the **transaction's beginning** and **its end**
  - Only **valid data** will be **written** to the DB
  - Transaction **cannot break the rules** of the database
    - Primary keys, foreign keys, check constraints, data types…
- Consistency example:
  - Transaction **cannot end with a duplicate primary key** in a table

Isolation

- **Isolation** means that:
  - **Multiple transactions** running at the same time **do not impact each other's execution**
  - Transactions **don’t see** other transactions’ **uncommitted changes**
  - Isolation level defines how deep transactions **isolate from one another**
- Isolation example:
  - If two or more people try to buy the last copy of a product, only one of them will succeed

Durability

- **Durability** means that:
  - If a transaction is **committed** it becomes **persistent**
    - **Cannot** be **lost** or **undone**
  - Ensured by the use of **database transaction logs**



- Durability example:
  - After funds are transferred and committed, the power supply at the DB server is lost
  - Transaction stays persistent (**no data is lost**)

Triggers

Automatically executed SQL code in response to event

What Are Triggers?

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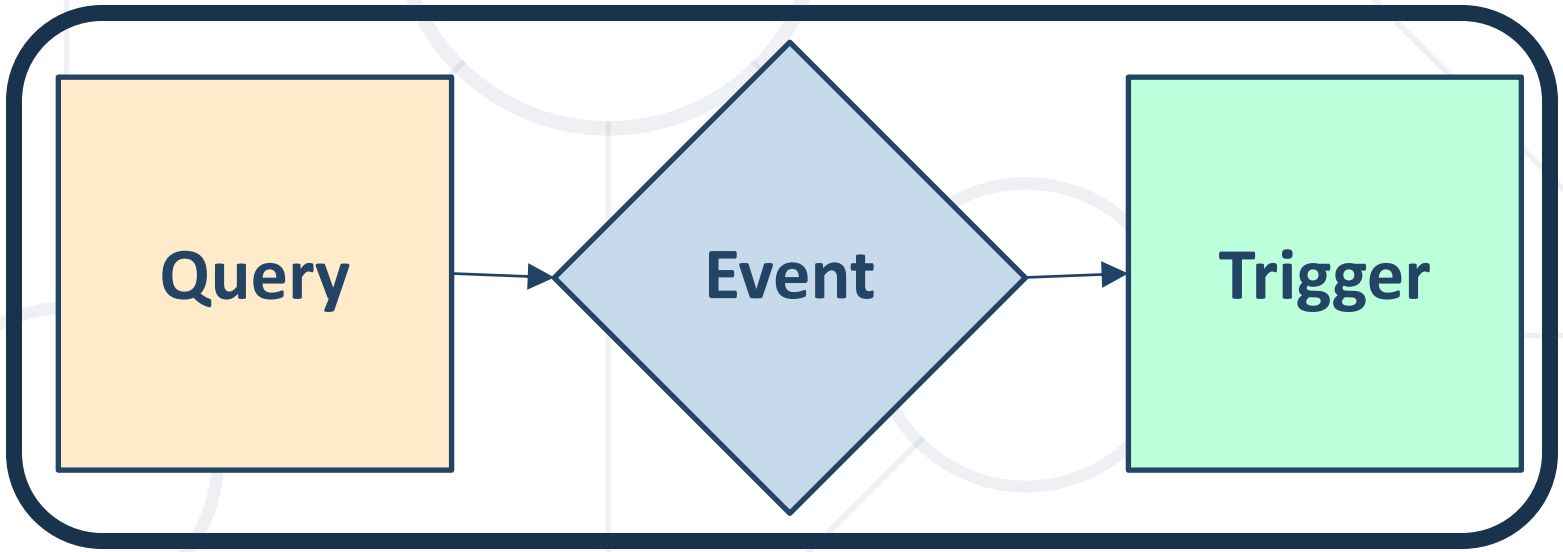
- **Triggers** are very much like **stored procedures**
  - Called **in case of a specific event**
- We do **not call** triggers **explicitly**
  - **Triggers are attached to a table**
  - Triggers are fired **when a certain SQL statement is executed** against the contents of the table
  - Syntax:
    - **AFTER INSERT/UPDATE/DELETE**
    - **INSTEAD OF INSERT/UPDATE/DELETE**

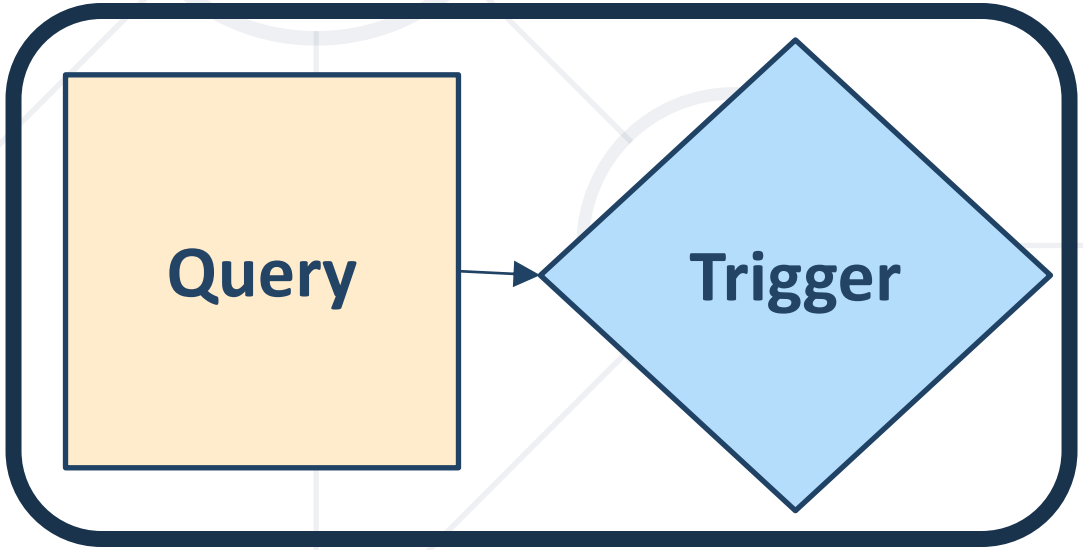
After Trigger

- **AFTER Trigger** is executed **right after an event is fired**



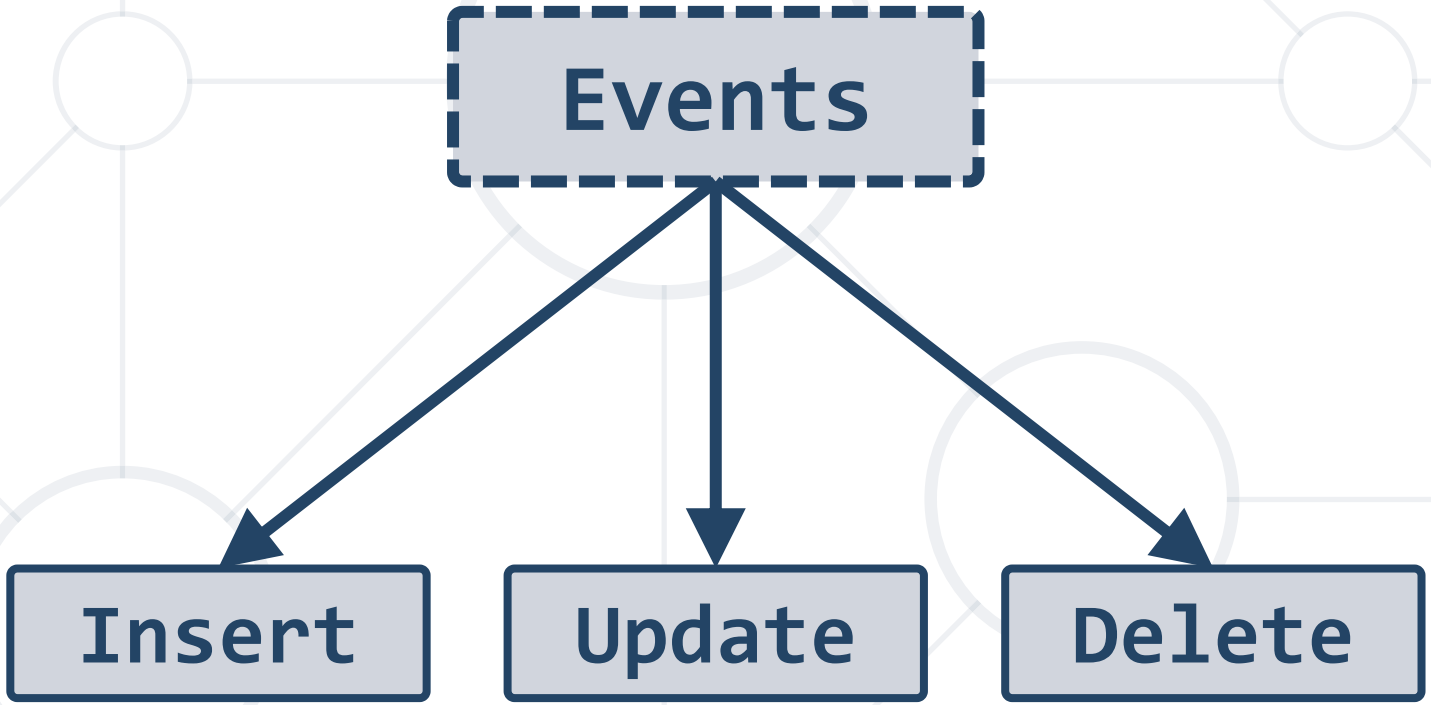
Instead of Trigger

- **INSTEAD OF** Trigger completely replaces an event action from happening
  - You can apply totally different logic



Events

- There are **three different events** that can be applied **within a trigger**:



After Triggers

- Defined by the keyword **FOR**

```
CREATE TRIGGER tr_AddToLogsOnAccountUpdate
ON Accounts FOR UPDATE
AS
  INSERT INTO Logs(AccountId, OldAmount, NewAmount, UpdatedOn)
  SELECT i.Id, d.Balance, i.Balance, GETDATE()
  FROM inserted AS i
  JOIN deleted AS d ON i.Id = d.Id
  WHERE i.Balance != d.Balance
  SELECT * FROM deleted
GO
```

shows the table when trigger is fired

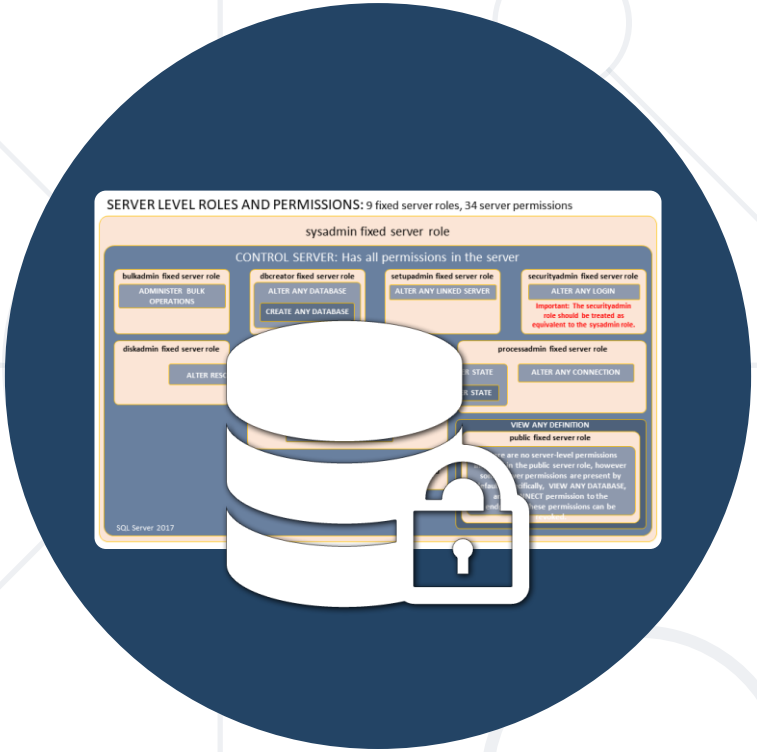
- **deleted** and **inserted** are **logical** (conceptual) **tables**. They hold the old values or new values of the rows

Instead of Triggers

- Defined by using **INSTEAD OF**

```
CREATE OR ALTER TRIGGER tr_SetIsDeletedOnDelete
ON AccountHolders
INSTEAD OF DELETE
AS
  UPDATE AccountHolders SET IsDeleted = 1
    WHERE Id IN (SELECT Id FROM deleted)
GO
```

- `deleted` tables are used with **delete** and **update**
- `inserted` tables, with **insert** and **update**.



Database Security

Fixed Server Roles, Fixed Database Roles

Database Security: SQL Server

- SQL Server has **two layers of database security**:
  - **Fixed Server Roles**
    - sysadmin, bulkadmin, dbcreator, securityadmin
  - **Fixed Database Roles**
    - db_owner, db_securityadmin, db_accessadmin
    - db_backupoperator, db_ddladmin
    - db_datareader/db_datawriter

Custom Roles

- SQL Server lets us create **custom roles**
  - **Collection of privileges** (permissions)
- Fine **control over permissions**
  - Can use **one role for multiple users** (groups)
- Makes **auditing operations easier**

Summary

- **Transactions** give our operations **stability**
  - Operation Integrity
  - Solving the concurrent operation problem
  - The ACID model is implemented in most RDBMS
- **Triggers** apply a given behavior when a condition is hit
  - Gives us temporary **INSERTED** and **DELETED tables**
- **Security** in SQL Server can be finely controlled
  - Using fixed **server roles** and fixed **database roles**
- **Custom roles** control permissions even more finely

Questions?

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