Database Management Systems

Introduction to DBMS

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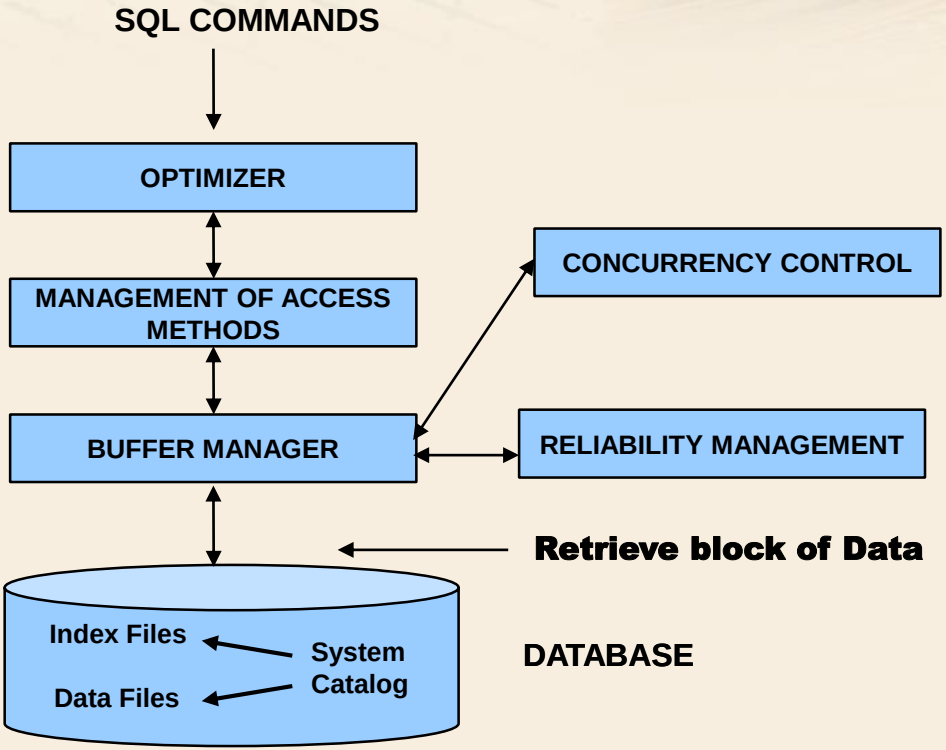
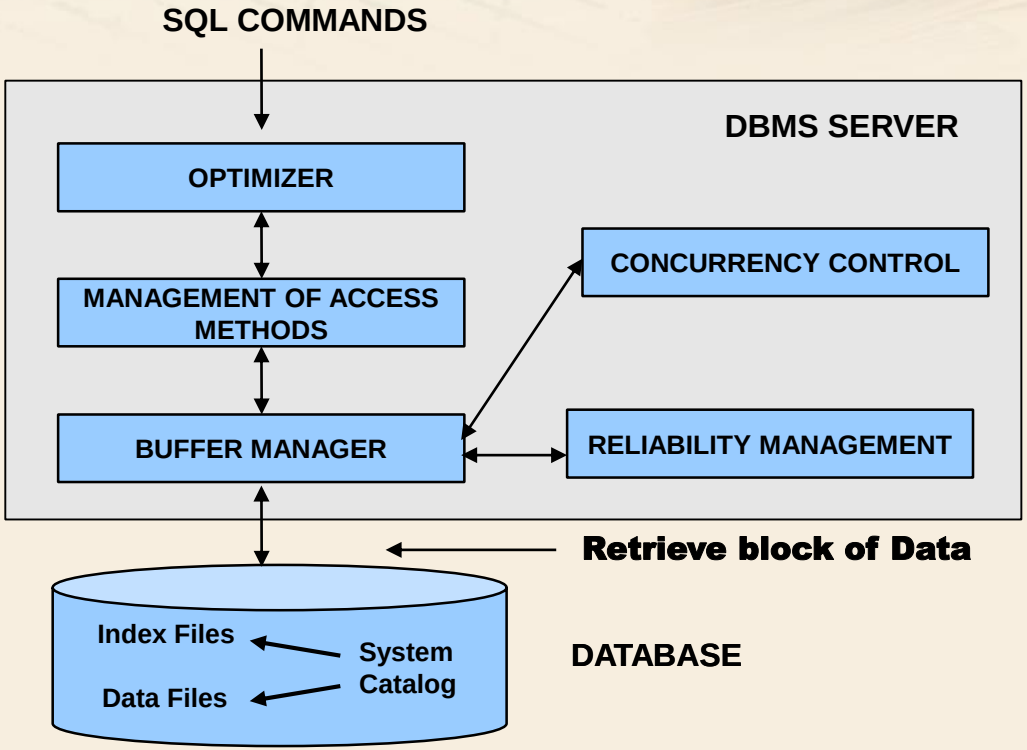
- Data Base Management System (DBMS)
  - A software package designed to store and manage databases
- We are interested in internal mechanisms of a DBMS providing services to applications
  - Useful for making the right design choices
    - System configuration
    - Physical design of applications
  - Some services are becoming available also in operating systems

DBMS Architecture



DBMS Architecture



DBMS Components

- Optimizer
  - It selects the appropriate execution strategy for accessing data to answer queries
  - It receives in input a SQL instruction (DML)
  - It executes lexical, syntactic, and semantic parsing and detects (some) errors
  - It transforms the query in an internal representation (based on relational algebra)
  - It selects the "right" strategy for accessing data
- This component guarantees the *data independence* property in the relational model

DBMS Components

- Access Method Manager
  - It performs physical access to data
  - It implements the strategy selected by the optimizer

DBMS Components

- Buffer Manager
  - It manages page transfer from disk to main memory and vice versa
  - It manages the main memory portion that is pre-allocated to the DBMS
    - e.g., Oracle SGA
- The memory block pre-allocated to the DBMS is *shared* among many applications

DBMS Components

- Concurrency Control
  - It manages concurrent access to data
    - Important for write operations
  - It guarantees that applications do not interfere with each other, thus yielding consistency problems

DBMS Components

- Reliability Manager
  - It guarantees correctness of the database content when the system crashes
  - It guarantees atomic execution of a transaction (sequence of operations)
  - It exploits auxiliary structures (log files) to recover the correct database state after a failure

Transaction

- A *transaction* is a logical unit of work performed by an application
  - It is a sequence of one or more SQL instructions, performing read and write operations on the database
- It is characterized by
  - Correctness
  - Reliability
  - Isolation

Transaction example: Bank Tranfer

- The following transaction moves 100 euro from account xxx to account yyy

```
UPDATE ACCOUNTS
SET Balance = Balance - 100
WHERE Account_Number = xxx

UPDATE ACCOUNTS
SET Balance = Balance + 100
WHERE Account_Number = yyy
```

Transaction delimiters

- Transaction start
  - Typically implicit
  - First SQL instruction
    - At the beginning of a program
    - After the end of the former transaction
- Transaction end
  - COMMIT: correct end of a transaction
  - ROLLBACK: end with error
    - The database state goes back to the state at the beginning of the transaction

Transaction end

- 99.9% of transactions commit
- Remaining transactions rollback
  - Rollback is required by the transaction (suicide)
  - Rollback is required by the system (murder)

Transaction properties

- ACID properties of transactions
  - **A**tomicity
  - **C**onsistency
  - **I**solation
  - **D**urability

Atomicity

- A transaction cannot be divided in smaller units
  - It is *not* possible to leave the database in a intermediate state of execution
- Guaranteed by
  - *Undo.* The system undoes all the work performed by the transaction up to the current point
    - It is used for rollback
  - *Redo.* The system redoes all work performed by committed transactions
    - It is used to guarantee transaction commit in presence of failure

Consistency

- A transaction execution should not violate integrity constraints on a database
  - Enforced by defining integrity constraints in the database schema (Create table, ….)
    - Primary key
    - Referential Integrity (Foreign key)
    - Domain Constraints
    - …
  - When a violation is detected, the system may
    - Rollback the transaction
    - Automatically correct the violation

Isolation

- The execution of a transaction is *independent* of the concurrent execution of other transactions
  - Enforced by the Concurrency Control block of the DBMS

Durability

- The effect of a committed transaction *is not lost* in presence of failures
  - It guarantees the reliability of the DBMS
  - Enforced by the Reliability Manager block of the DBMS