Data Engineering 101: DATABASES

Shwetank Singh
GritSetGrow - GSGLearn.com

DATABASE MANAGEMENT SYSTEM (DBMS) EXPLANATION

A software system that uses a standard method to store and organize data.

EXAMPLE

MySQL, PostgreSQL

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STORAGE ENGINE

EXPLANATION

A component of DBMS responsible for storing, retrieving, and managing data in memory and on

EXAMPLE

InnoDB, RocksDB

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MEMORY-BASED DBMS

EXPLANATION

Databases that store data primarily in memory, using disk for recovery and logging.

EXAMPLE

Redis

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DISK-BASED DBMS

EXPLANATION

Databases that hold most of the data on disk, using memory for caching and temporary storage.

EXAMPLE

PostgreSQL

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DURABILITY IN MEMORY-BASED STORES EXPLANATION

Ensuring data persistence in memory-based DBMS by maintaining backups on disk.

EXAMPLE

Redis with AOF persistence

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ROW-ORIENTED DBMS

EXPLANATION

Databases that store data in rows, optimized for OLTP workloads.

EXAMPLE

MySQL, PostgreSQL

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COLUMN-ORIENTED DBMS

EXPLANATION

Databases that store data in columns, optimized for OLAP workloads.

EXAMPLE

Apache Cassandra, HBase

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DATA FILES

EXPLANATION

Files that store data records in DBMS.

EXAMPLE

MySQL's .ibd files

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INDEX FILES

EXPLANATION

Files that store metadata to locate records in data files efficiently.

EXAMPLE

MySQL's .frm files

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PRIMARY INDEX

EXPLANATION

An index that determines the primary key for accessing data records.

EXAMPLE

Primary key in a MySQL table

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SECONDARY INDEX

EXPLANATION

An index that facilitates access by keys other than the primary one.

EXAMPLE

Index on a non-primary key column

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HEAP FILES

EXPLANATION

Data files where records are stored in no particular order.

EXAMPLE

MySQL MyISAM storage engine

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HASHED FILES

EXPLANATION

Data files where records are stored based on a hash value of the key.

EXAMPLE

Hash index in PostgreSQL

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INDEX-ORGANIZED TABLES (IOT)

EXPLANATION

Tables where data records are stored in the index itself.

EXAMPLE

Oracle IOT

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CLUSTERING

EXPLANATION

Storing data records in index order to improve query performance.

EXAMPLE

Clustered index in SQL Server

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NON-CLUSTERING

EXPLANATION

Storing data records without following the index order.

EXAMPLE

Non-clustered index in SQL Server

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BUFFERING

EXPLANATION

Collecting a certain amount of data in memory before writing it to disk.

EXAMPLE

Write buffer in RocksDB

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IMMUTABILITY

EXPLANATION

Using immutable files for storing data, preventing modifications.

EXAMPLE

Write-once logs in Apache Kafka

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GritSetGrow - GSGLearn.com

ORDERING

EXPLANATION

Storing values in a specific order to optimize access patterns.

EXAMPLE

Sorted strings in LSM trees

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B-TREES

EXPLANATION

A balanced tree data structure that maintains sorted data and allows searches, sequential access, insertions, and deletions.

EXAMPLE

B-Tree indexes in MySQL

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B-TREE VARIANTS

EXPLANATION

Different implementations of B-Trees to optimize for specific use cases.

EXAMPLE

B+ Trees, B Trees*

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LOG-STRUCTURED STORAGE

EXPLANATION

A storage model that logs all changes sequentially to optimize write performance.

EXAMPLE

LSM trees in Cassandra

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LSM TREES

EXPLANATION

A type of log-structured storage optimized for write-heavy workloads.

EXAMPLE

LevelDB, RocksDB

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SORTED STRING TABLES (SSTABLES) EXPLANATION

Immutable data files used in LSM trees, containing sorted key-value pairs.

EXAMPLE

SSTables in Cassandra

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BLOOM FILTERS

EXPLANATION

A space-efficient probabilistic data structure used to test whether an element is in a set.

EXAMPLE

Bloom filters in Cassandra

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SKIPLIST

EXPLANATION

A data structure that allows fast search within an ordered sequence of elements.

EXAMPLE

Skiplist in Redis

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BUFFER MANAGER

EXPLANATION

A component that manages data caching in memory.

EXAMPLE

Buffer cache in PostgreSQL

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RECOVERY MANAGER

EXPLANATION

A component responsible for restoring the system state after failures.

EXAMPLE

WAL in PostgreSQL

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CONCURRENCY CONTROL

EXPLANATION

Mechanisms to ensure correct results for concurrent operations.

EXAMPLE

MVCC in PostgreSQL

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TRANSACTION ISOLATION

EXPLANATION

The degree to which the operations in one transaction are isolated from those in other transactions.

EXAMPLE

Serializable, Read Committed isolation levels

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OPTIMISTIC CONCURRENCY CONTROL

EXPLANATION

A method where transactions execute without locking resources and check for conflicts before commit.

EXAMPLE

OCC in Oracle

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PESSIMISTIC CONCURRENCY CONTROL

EXPLANATION

A method where transactions lock resources before accessing them to prevent conflicts.

EXAMPLE

Lock-based transactions in MySQL

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LOCK-BASED CONCURRENCY CONTROL

EXPLANATION

A method that uses locks to manage concurrent access to data.

EXAMPLE

Two-phase locking in SQL Server

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MULTIVERSION CONCURRENCY CONTROL (MVCC)

EXPLANATION

A concurrency control method that keeps multiple versions of data to increase transaction isolation.

EXAMPLE

MVCC in PostgreSQL

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TWO-PHASE COMMIT (2PC)

EXPLANATION

A protocol to ensure all participants in a distributed transaction agree to commit or abort.

EXAMPLE

2PC in distributed databases

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THREE-PHASE COMMIT (3PC)

EXPLANATION

An extension of 2PC to reduce the chances of blocking in case of failures.

EXAMPLE

3PC in distributed databases

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PAXOS

EXPLANATION

A consensus algorithm to achieve agreement among distributed systems.

EXAMPLE

Used in Google Spanner

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RAFT

EXPLANATION

A consensus algorithm designed for managing replicated logs.

EXAMPLE

Used in etcd, Consul

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BYZANTINE FAULT TOLERANCE (BFT)

EXPLANATION

A property of systems that can tolerate Byzantine faults.

EXAMPLE

PBFT algorithm

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LOG STACKING

EXPLANATION

Organizing multiple logs for efficiency and reliability.

EXAMPLE

LLAMA in distributed systems

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FLASH TRANSLATION LAYER (FTL) EXPLANATION

A layer that manages flash memory operations, translating logical block addresses to physical addresses.

EXAMPLE

FTL in SSDs

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CONSISTENT HASHING

EXPLANATION

A technique to distribute data across multiple nodes to minimize reorganization when nodes are added or removed.

EXAMPLE

Used in DynamoDB

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DISTRIBUTED SYSTEMS ABSTRACTIONS

EXPLANATION

Concepts to simplify the design and implementation of distributed systems.

EXAMPLE

CAP theorem

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LEADER ELECTION

EXPLANATION

Algorithms to elect a leader in a distributed system to coordinate tasks.

EXAMPLE

Bully algorithm

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FAILURE DETECTION

EXPLANATION

Mechanisms to identify failures in distributed systems.

EXAMPLE

Heartbeats and pings

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GOSSIP PROTOCOL

EXPLANATION

A communication protocol to spread information in distributed systems.

EXAMPLE

Gossip protocol in Cassandra

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ANTI-ENTROPY

EXPLANATION

Techniques to reconcile differences between replicas in distributed systems.

EXAMPLE

Merkle trees

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DIGEST READS

EXPLANATION

A method to check data consistency by comparing digests of data.

EXAMPLE

Digest reads in Cassandra

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HINTED HANDOFF

EXPLANATION

A technique to handle temporary failures in distributed systems by storing write operations for later replay.

EXAMPLE

Hinted handoff in Cassandra

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MERKLE TREES

EXPLANATION

A tree structure for efficient data verification and synchronization.

EXAMPLE

Used in Git and Cassandra

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OVERLAY NETWORKS

EXPLANATION

Networks built on top of another network to provide additional features.

EXAMPLE

Virtual networks in cloud services

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ATOMIC BROADCAST

EXPLANATION

Ensuring messages are delivered in the same order across all nodes in a distributed system.

EXAMPLE

ZAB in ZooKeeper

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VIRTUAL SYNCHRONY

EXPLANATION

A model to ensure consistent group membership and message delivery order.

EXAMPLE

Used in ISIS2 library

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TWO GENERALS' PROBLEM

EXPLANATION

A thought experiment illustrating the challenges of coordination in distributed systems.

EXAMPLE

Problem statement in distributed computing

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FLP IMPOSSIBILITY

EXPLANATION

A theorem stating that consensus is impossible in an asynchronous system with one faulty process.

EXAMPLE

FLP result in distributed systems

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SYSTEM SYNCHRONY

EXPLANATION

The assumption about the bounds on message delays and clock drifts in a distributed system.

EXAMPLE

Synchronous, asynchronous systems

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FAILURE MODELS

EXPLANATION

Different ways to categorize and handle failures in distributed systems.

EXAMPLE

Crash faults, omission faults, Byzantine faults

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CAP THEOREM

EXPLANATION

The principle that a distributed system can only guarantee two out of three: Consistency, Availability, Partition tolerance.

EXAMPLE

CAP trade-offs in NoSQL databases

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EVENTUAL CONSISTENCY

EXPLANATION

A consistency model where updates will propagate to all nodes eventually.

EXAMPLE

Eventual consistency in DynamoDB

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STRONG CONSISTENCY

EXPLANATION

A consistency model ensuring immediate visibility of updates to all nodes.

EXAMPLE

Linearizability

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CAUSAL CONSISTENCY

EXPLANATION

A consistency model ensuring that operations that are causally related are seen in the correct order.

EXAMPLE

Causal consistency in distributed systems

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LINEARIZABILITY

EXPLANATION

A strong consistency model where operations appear to occur instantaneously.

EXAMPLE

Linearizability in databases

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SEQUENTIAL CONSISTENCY

EXPLANATION

A consistency model where the results of operations are the same as if they were executed in some sequential order.

EXAMPLE

Sequential consistency in memory models

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CRDTs (Conflict-free Replicated Data Types)

Explanation

Data structures designed to ensure strong eventual consistency.

Example

CRDTs in distributed systems

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HARVEST AND YIELD

EXPLANATION

A model to understand the trade-offs between availability and consistency.

EXAMPLE

Used in database design

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DISTRIBUTED TRANSACTIONS

EXPLANATION

Transactions that span multiple nodes or databases.

EXAMPLE

Two-phase commit, three-phase commit

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COORDINATION AVOIDANCE

EXPLANATION

Techniques to reduce the need for coordination in distributed transactions.

EXAMPLE

Coordination-free algorithms

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WITNESS REPLICAS

EXPLANATION

Lightweight replicas used to improve availability and consistency.

EXAMPLE

Witness nodes in database clusters

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CONSISTENCY MODELS

EXPLANATION

The guarantees provided by a database system regarding the visibility and ordering of updates.

EXAMPLE

Strong, eventual, causal consistency

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DATA SHARDING

EXPLANATION

Splitting data across multiple databases to improve performance and scalability.

EXAMPLE

Sharding in MongoDB

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READ REPAIR

EXPLANATION

A technique to ensure data consistency during read operations.

EXAMPLE

Read repair in Cassandra

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STATE CONSISTENCY

EXPLANATION

Ensuring all nodes in a distributed system have the same state.

EXAMPLE

Consistent state in distributed databases

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PROCESSING

EXPLANATION

The execution of tasks in a distributed system.

EXAMPLE

Distributed processing frameworks

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CLOCKS AND TIME

EXPLANATION

The role of clocks and time synchronization in distributed systems.

EXAMPLE

NTP, logical clocks

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CASCADING FAILURES

EXPLANATION

A failure in one part of the system triggering failures in other parts.

EXAMPLE

Handling cascading failures in distributed systems

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HYBRID GOSSIP

EXPLANATION

Combining gossip protocols with other communication methods.

EXAMPLE

Hybrid gossip in distributed systems

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PARTIAL VIEWS

EXPLANATION

Maintaining a partial view of the network to improve scalability.

EXAMPLE

Partial views in peer-to-peer networks

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LOCAL AND REMOTE EXECUTION

EXPLANATION

Executing tasks on local or remote nodes in a distributed system.

EXAMPLE

Remote procedure calls (RPCs)

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NETWORK PARTITIONS

EXPLANATION

Splitting the network into disjoint segments, affecting system availability.

EXAMPLE

Handling network partitions in distributed systems

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TRANSPARENT HANDLING OF FAILURES

EXPLANATION

Designing systems to handle failures without user intervention.

EXAMPLE

Failover mechanisms in databases

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REVERSING FAILURE DETECTION PROBLEM STATEMENT

EXPLANATION

Techniques to ensure accurate failure detection in distributed systems.

EXAMPLE

Failure detection algorithms

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