

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



Shwetank Singh
GritSetGrow - GSGLearn.com



STORAGE ENGINE

EXPLANATION

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

EXAMPLE

InnoDB, RocksDB



Shwetank Singh
GritSetGrow - GSGLearn.com



MEMORY-BASED DBMS

EXPLANATION

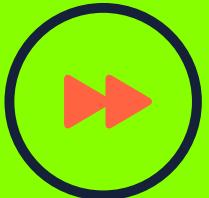
Databases that store data primarily in memory, using disk for recovery and logging.

EXAMPLE

Redis



Shwetank Singh
GritSetGrow - GSGLearn.com



DISK-BASED DBMS

EXPLANATION

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

EXAMPLE

PostgreSQL



Shwetank Singh
GritSetGrow - GSGLearn.com



DURABILITY IN MEMORY-BASED STORES

EXPLANATION

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

EXAMPLE

Redis with AOF persistence



Shwetank Singh
GritSetGrow - GSGLearn.com



ROW-ORIENTED DBMS

EXPLANATION

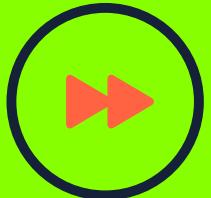
Databases that store data in rows, optimized for OLTP workloads.

EXAMPLE

MySQL, PostgreSQL



Shwetank Singh
GritSetGrow - GSGLearn.com



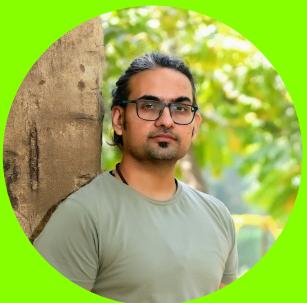
COLUMN-ORIENTED DBMS

EXPLANATION

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

EXAMPLE

Apache Cassandra, HBase



Shwetank Singh
GritSetGrow - GSGLearn.com



DATA FILES

EXPLANATION

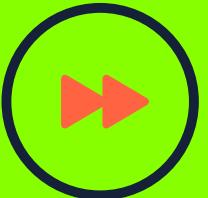
Files that store data records in DBMS.

EXAMPLE

MySQL's .ibd files



Shwetank Singh
GritSetGrow - GSGLearn.com



INDEX FILES

EXPLANATION

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

EXAMPLE

MySQL's .frm files



Shwetank Singh
GritSetGrow - GSGLearn.com



PRIMARY INDEX

EXPLANATION

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

EXAMPLE

Primary key in a MySQL table



Shwetank Singh
GritSetGrow - GSGLearn.com



SECONDARY INDEX

EXPLANATION

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

EXAMPLE

Index on a non-primary key column



Shwetank Singh
GritSetGrow - GSGLearn.com



HEAP FILES

EXPLANATION

Data files where records are stored in no particular order.

EXAMPLE

MySQL MyISAM storage engine



Shwetank Singh
GritSetGrow - GSGLearn.com



HASHED FILES

EXPLANATION

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

EXAMPLE

Hash index in PostgreSQL



Shwetank Singh
GritSetGrow - GSGLearn.com



INDEX-ORGANIZED TABLES (IOT)

EXPLANATION

Tables where data records are stored in the index itself.

EXAMPLE

Oracle IOT



Shwetank Singh
GritSetGrow - GSGLearn.com



CLUSTERING

EXPLANATION

*Storing data records in index order
to improve query performance.*

EXAMPLE

Clustered index in SQL Server



Shwetank Singh
GritSetGrow - GSGLearn.com



NON-CLUSTERING

EXPLANATION

Storing data records without following the index order.

EXAMPLE

Non-clustered index in SQL Server



Shwetank Singh
GritSetGrow - GSGLearn.com



BUFFERING

EXPLANATION

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

EXAMPLE

Write buffer in RocksDB



Shwetank Singh
GritSetGrow - GSGLearn.com



IMMUTABILITY

EXPLANATION

Using immutable files for storing data, preventing modifications.

EXAMPLE

Write-once logs in Apache Kafka



Shwetank Singh
GritSetGrow - GSGLearn.com



ORDERING

EXPLANATION

Storing values in a specific order to optimize access patterns.

EXAMPLE

Sorted strings in LSM trees



Shwetank Singh
GritSetGrow - GSGLearn.com



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



Shwetank Singh
GritSetGrow - GSGLearn.com



B-TREE VARIANTS

EXPLANATION

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

EXAMPLE

B+ Trees, B Trees*



Shwetank Singh
GritSetGrow - GSGLearn.com



LOG-STRUCTURED STORAGE

EXPLANATION

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

EXAMPLE

LSM trees in Cassandra



Shwetank Singh
[GritSetGrow - GSGLearn.com](http://GritSetGrow.com)



LSM TREES

EXPLANATION

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

EXAMPLE

LevelDB, RocksDB



Shwetank Singh
[GritSetGrow - GSGLearn.com](http://GritSetGrow.com)



SORTED STRING TABLES (SSTABLES)

EXPLANATION

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

EXAMPLE

SSTables in Cassandra



Shwetank Singh
GritSetGrow - GSGLearn.com



BLOOM FILTERS

EXPLANATION

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

EXAMPLE

Bloom filters in Cassandra



Shwetank Singh
GritSetGrow - GSGLearn.com



SKIPLIST

EXPLANATION

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

EXAMPLE

SkipList in Redis



Shwetank Singh
GritSetGrow - GSGLearn.com



BUFFER MANAGER

EXPLANATION

A component that manages data caching in memory.

EXAMPLE

Buffer cache in PostgreSQL



Shwetank Singh
GritSetGrow - GSGLearn.com



RECOVERY MANAGER EXPLANATION

A component responsible for restoring the system state after failures.

EXAMPLE

WAL in PostgreSQL



Shwetank Singh
GritSetGrow - GSGLearn.com



CONCURRENCY CONTROL

EXPLANATION

Mechanisms to ensure correct results for concurrent operations.

EXAMPLE

MVCC in PostgreSQL



Shwetank Singh
GritSetGrow - GSGLearn.com



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



Shwetank Singh
GritSetGrow - GSGLearn.com



OPTIMISTIC CONCURRENCY CONTROL EXPLANATION

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

EXAMPLE

OCC in Oracle



Shwetank Singh
GritSetGrow - GSGLearn.com



PESSIMISTIC CONCURRENCY CONTROL EXPLANATION

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

EXAMPLE

Lock-based transactions in MySQL



Shwetank Singh
GritSetGrow - GSGLearn.com



LOCK-BASED CONCURRENCY CONTROL EXPLANATION

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

EXAMPLE

Two-phase locking in SQL Server



Shwetank Singh
GritSetGrow - GSGLearn.com



MULTIVERSION CONCURRENCY CONTROL (MVCC) EXPLANATION

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

EXAMPLE

MVCC in PostgreSQL



Shwetank Singh
GritSetGrow - GSGLearn.com



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



Shwetank Singh
GritSetGrow - GSGLearn.com



THREE-PHASE COMMIT (3PC)

EXPLANATION

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

EXAMPLE

3PC in distributed databases



Shwetank Singh
GritSetGrow - GSGLearn.com



PAXOS

EXPLANATION

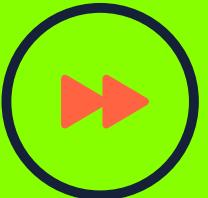
A consensus algorithm to achieve agreement among distributed systems.

EXAMPLE

Used in Google Spanner



Shwetank Singh
GritSetGrow - GSGLearn.com



RAFT

EXPLANATION

A consensus algorithm designed for managing replicated logs.

EXAMPLE

Used in etcd, Consul



Shwetank Singh
GritSetGrow - GSGLearn.com



BYZANTINE FAULT TOLERANCE (BFT)

EXPLANATION

A property of systems that can tolerate Byzantine faults.

EXAMPLE

PBFT algorithm



Shwetank Singh
GritSetGrow - GSGLearn.com



LOG STACKING

EXPLANATION

Organizing multiple logs for efficiency and reliability.

EXAMPLE

LLAMA in distributed systems



Shwetank Singh
[GritSetGrow - GSGLearn.com](http://GritSetGrow.com)



FLASH TRANSLATION LAYER (FTL)

EXPLANATION

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

EXAMPLE

FTL in SSDs



Shwetank Singh
GritSetGrow - GSGLearn.com



CONSISTENT HASHING EXPLANATION

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

EXAMPLE

Used in DynamoDB



Shwetank Singh
GritSetGrow - GSGLearn.com



DISTRIBUTED SYSTEMS ABSTRACTIONS EXPLANATION

Concepts to simplify the design and implementation of distributed systems.

EXAMPLE

CAP theorem



Shwetank Singh
GritSetGrow - GSGLearn.com



LEADER ELECTION

EXPLANATION

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

EXAMPLE

Bully algorithm



Shwetank Singh
GritSetGrow - GSGLearn.com



FAILURE DETECTION

EXPLANATION

Mechanisms to identify failures in distributed systems.

EXAMPLE

Heartbeats and pings



Shwetank Singh
GritSetGrow - GSGLearn.com



GOSSIP PROTOCOL

EXPLANATION

A communication protocol to spread information in distributed systems.

EXAMPLE

Gossip protocol in Cassandra



Shwetank Singh
GritSetGrow - GSGLearn.com



ANTI-ENTROPY EXPLANATION

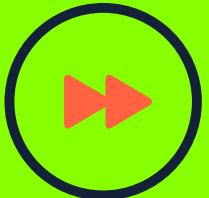
*Techniques to reconcile differences
between replicas in distributed
systems.*

EXAMPLE

Merkle trees



Shwetank Singh
GritSetGrow - GSGLearn.com



DIGEST READS

EXPLANATION

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

EXAMPLE

Digest reads in Cassandra



Shwetank Singh
GritSetGrow - GSGLearn.com



HINTED HANDOFF

EXPLANATION

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

EXAMPLE

Hinted handoff in Cassandra



Shwetank Singh
GritSetGrow - GSGLearn.com



MERKLE TREES

EXPLANATION

A tree structure for efficient data verification and synchronization.

EXAMPLE

Used in Git and Cassandra



Shwetank Singh
GritSetGrow - GSGLearn.com



OVERLAY NETWORKS

EXPLANATION

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

EXAMPLE

Virtual networks in cloud services



Shwetank Singh
GritSetGrow - GSGLearn.com



ATOMIC BROADCAST

EXPLANATION

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

EXAMPLE

ZAB in ZooKeeper



Shwetank Singh
[GritSetGrow - GSGLearn.com](http://GritSetGrow.com)



VIRTUAL SYNCHRONY EXPLANATION

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

EXAMPLE

Used in ISIS2 library



Shwetank Singh
GritSetGrow - GSGLearn.com



TWO GENERALS' PROBLEM EXPLANATION

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

EXAMPLE

Problem statement in distributed computing



Shwetank Singh
GritSetGrow - GSGLearn.com



FLP IMPOSSIBILITY

EXPLANATION

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

EXAMPLE

FLP result in distributed systems



Shwetank Singh
GritSetGrow - GSGLearn.com



SYSTEM SYNCHRONY

EXPLANATION

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

EXAMPLE

*Synchronous, asynchronous
systems*



Shwetank Singh
GritSetGrow - GSGLearn.com



FAILURE MODELS

EXPLANATION

Different ways to categorize and handle failures in distributed systems.

EXAMPLE

*Crash faults, omission faults,
Byzantine faults*



Shwetank Singh
GritSetGrow - GSGLearn.com



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



Shwetank Singh
GritSetGrow - GSGLearn.com



EVENTUAL CONSISTENCY EXPLANATION

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

EXAMPLE

Eventual consistency in DynamoDB



Shwetank Singh
GritSetGrow - GSGLearn.com



STRONG CONSISTENCY

EXPLANATION

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

EXAMPLE

Linearizability



Shwetank Singh
GritSetGrow - GSGLearn.com



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



Shwetank Singh
GritSetGrow - GSGLearn.com



LINEARIZABILITY

EXPLANATION

A strong consistency model where operations appear to occur instantaneously.

EXAMPLE

Linearizability in databases



Shwetank Singh
GritSetGrow - GSGLearn.com



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



Shwetank Singh
GritSetGrow - GSGLearn.com



CRDTS (CONFLICT-FREE REPLICATED DATA TYPES)

EXPLANATION

Data structures designed to ensure strong eventual consistency.

EXAMPLE

CRDTs in distributed systems



Shwetank Singh
GritSetGrow - GSGLearn.com



HARVEST AND YIELD

EXPLANATION

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

EXAMPLE

Used in database design



Shwetank Singh
GritSetGrow - GSGLearn.com



DISTRIBUTED TRANSACTIONS

EXPLANATION

Transactions that span multiple nodes or databases.

EXAMPLE

Two-phase commit, three-phase commit



Shwetank Singh
GritSetGrow - GSGLearn.com



COORDINATION AVOIDANCE

EXPLANATION

Techniques to reduce the need for coordination in distributed transactions.

EXAMPLE

Coordination-free algorithms



Shwetank Singh
GritSetGrow - GSGLearn.com



WITNESS REPLICAS

EXPLANATION

Lightweight replicas used to improve availability and consistency.

EXAMPLE

Witness nodes in database clusters



Shwetank Singh
GritSetGrow - GSGLearn.com



CONSISTENCY MODELS

EXPLANATION

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

EXAMPLE

Strong, eventual, causal consistency



Shwetank Singh
GritSetGrow - GSGLearn.com



DATA SHARDING

EXPLANATION

Splitting data across multiple databases to improve performance and scalability.

EXAMPLE

Sharding in MongoDB



Shwetank Singh
GritSetGrow - GSGLearn.com



READ REPAIR

EXPLANATION

A technique to ensure data consistency during read operations.

EXAMPLE

Read repair in Cassandra



Shwetank Singh
GritSetGrow - GSGLearn.com



STATE CONSISTENCY EXPLANATION

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

EXAMPLE

Consistent state in distributed databases



Shwetank Singh
GritSetGrow - GSGLearn.com



PROCESSING

EXPLANATION

The execution of tasks in a distributed system.

EXAMPLE

Distributed processing frameworks



Shwetank Singh
GritSetGrow - GSGLearn.com



CLOCKS AND TIME

EXPLANATION

The role of clocks and time synchronization in distributed systems.

EXAMPLE

NTP, logical clocks



Shwetank Singh
GritSetGrow - GSGLearn.com



CASCADING FAILURES

EXPLANATION

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

EXAMPLE

Handling cascading failures in distributed systems



Shwetank Singh
GritSetGrow - GSGLearn.com



HYBRID GOSSIP

EXPLANATION

Combining gossip protocols with other communication methods.

EXAMPLE

Hybrid gossip in distributed systems



Shwetank Singh
[GritSetGrow - GSGLearn.com](http://GritSetGrow.com)



PARTIAL VIEWS

EXPLANATION

Maintaining a partial view of the network to improve scalability.

EXAMPLE

Partial views in peer-to-peer networks



Shwetank Singh
GritSetGrow - GSGLearn.com



LOCAL AND REMOTE EXECUTION EXPLANATION

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

EXAMPLE

Remote procedure calls (RPCs)



Shwetank Singh
GritSetGrow - GSGLearn.com



NETWORK PARTITIONS EXPLANATION

Splitting the network into disjoint segments, affecting system availability.

EXAMPLE

Handling network partitions in distributed systems



Shwetank Singh
GritSetGrow - GSGLearn.com



TRANSPARENT HANDLING OF FAILURES EXPLANATION

*Designing systems to handle
failures without user intervention.*

EXAMPLE

Failover mechanisms in databases



Shwetank Singh
GritSetGrow - GSGLearn.com



REVERSING FAILURE DETECTION PROBLEM STATEMENT

EXPLANATION

Techniques to ensure accurate failure detection in distributed systems.

EXAMPLE

Failure detection algorithms



Shwetank Singh
GritSetGrow - GSGLearn.com

