Database Management System

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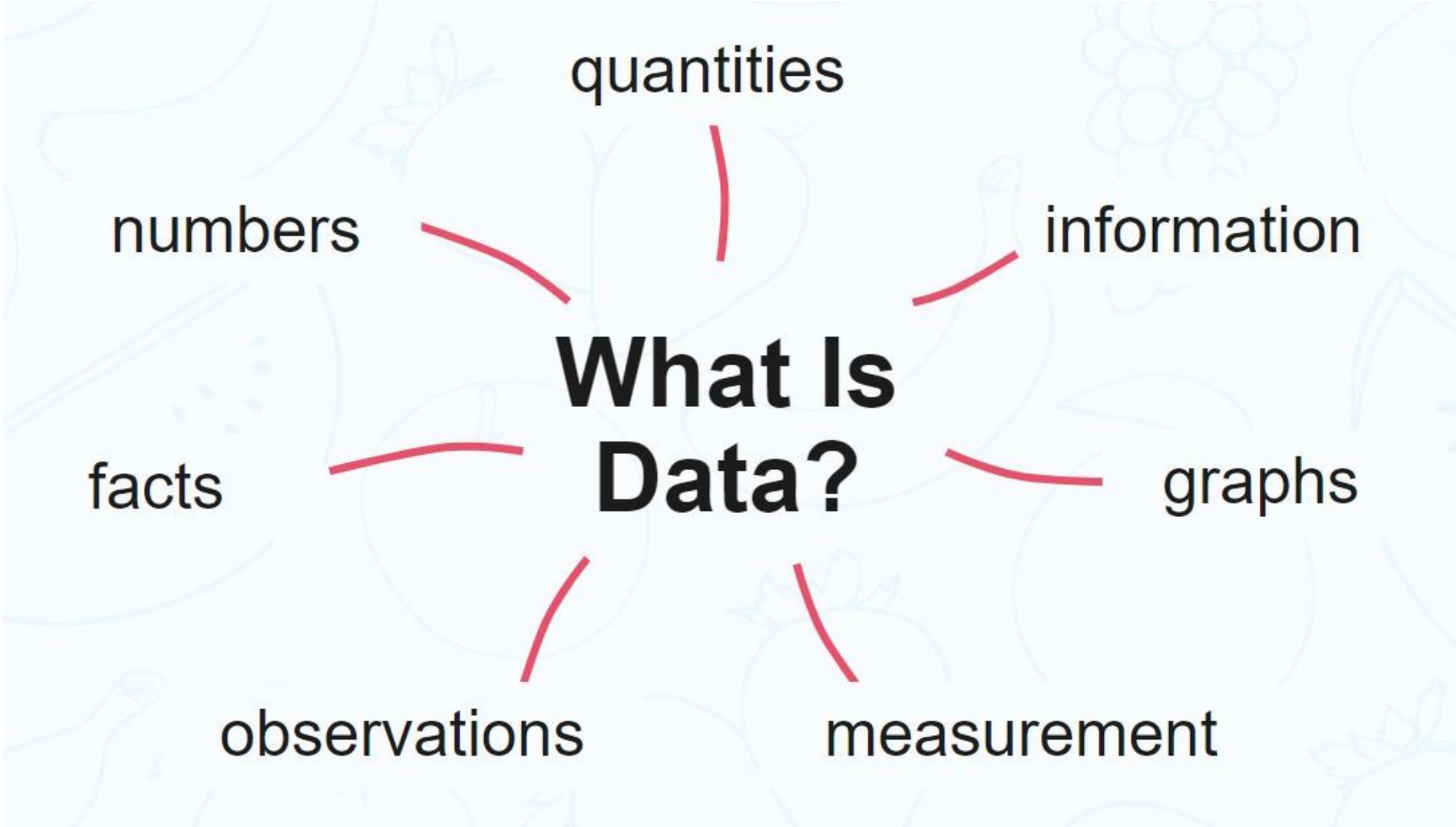
What is Data?


quantities
numbers
information
What Is Data?
facts
graphs
observations
measurement

What is Data?

- Data is a collection of a distinct small unit of information. It can be used in a variety of forms like text, numbers, media, bytes, etc. it can be stored in pieces of paper or electronic memory, etc.
- Word 'Data' is originated from the word 'datum' that means 'single piece of information.' It is plural of the word datum.
- In computing, Data is information that can be translated into a form for efficient movement and processing. Data is interchangeable.

What is Database?

- A database is an organized collection of data, so that it can be easily accessed and managed.
- You can organize data into tables, rows, columns, and index it to make it easier to find relevant information.
- Database handlers create a database in such a way that only one set of software program provides access of data to all the users.
- The main purpose of the database is to operate a large amount of information by storing, retrieving, and managing data.

What is Database Management System?

- A database management system (DBMS) is system software for creating and managing databases.
- A DBMS makes it possible for end users to create, protect, read, update and delete data in a database.
- The most prevalent type of data management platform, the DBMS essentially serves as an interface between databases and users or application programs, ensuring that data is consistently organized and remains easily accessible.

What DBMS do?

- The DBMS manages the data; the database engine allows data to be accessed, locked and modified; and the database schema defines the database's logical structure.
- These three foundational elements help provide concurrency, security, data integrity and uniform data administration procedures.
- The DBMS supports many typical database administration tasks, including change management, performance monitoring and tuning, security, and backup and recovery.
- Most database management systems are also responsible for automated rollbacks and restarts as well as logging and auditing of activity in databases and the applications that access them.

What DBMS do?

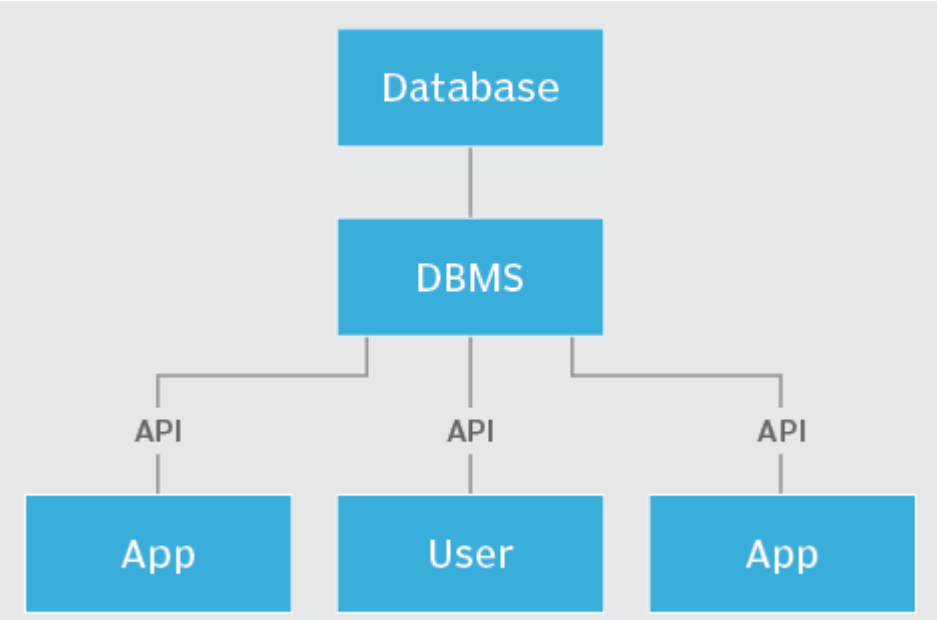
- The DBMS provides a centralized view of data that can be accessed by multiple users from multiple locations in a controlled manner.
- A DBMS can limit what data end users see and how they view the data, providing many views of a single database schema.
- End users and software programs are free from having to understand where the data is physically located or on what type of storage medium it resides because the DBMS handles all requests.

What DBMS do?

- The DBMS can offer both logical and physical data independence to protect users and applications from having to know where data is stored or from being concerned about changes to the physical structure of data.
- So long as programs use the application programming interface (API) for the database that the DBMS provides, developers won't have to modify programs just because changes have been made to the database.

DBMS Components

- A DBMS is a sophisticated piece of system software consisting of multiple integrated components that deliver a consistent, managed environment for creating, accessing and modifying data in databases



Storage Engine

- This basic element of a DBMS is used to store data. The DBMS must interface with a file system at the operating system (OS) level to store data.
- It can use additional components to store data or interface with the actual data at the file system level.

Metadata Catlog

- Sometimes called a system catalog or database dictionary, a metadata catalog functions as a repository for all the database objects that have been created.
- When databases and other objects are created, the DBMS automatically registers information about them in the metadata catalog.
- The DBMS uses this catalog to verify user requests for data, and users can query the catalog for information about the database structures that exist in the DBMS.
- The metadata catalog can include information about database objects, schemas, programs, security, performance, communication and other environmental details about the databases it manages.

Database access language

- The DBMS also must provide an API to access the data, typically in the form of a database access language to access and modify data but may also be used to create database objects and secure and authorize access to the data.
- SQL is an example of a database access language and encompasses several sets of commands, including Data Control Language for authorizing data access, Data Definition Language for defining database structures and Data Manipulation Language for reading and modifying data.

DBMS Components

- Optimization engine.
  - A DBMS may also provide an optimization engine, which is used to parse database access language requests and turn them into actionable commands for accessing and modifying data.
- Query processor.
  - After a query is optimized, the DBMS must provide a means for running the query and returning the results.

DBMS Components

- Lock manager.
  - This crucial component of the DBMS manages concurrent access to the same data. Locks are required to ensure multiple users aren't trying to modify the same data simultaneously.
- Log manager.
  - The DBMS records all changes made to data managed by the DBMS. The record of changes is known as the log, and the log manager component of the DBMS is used to ensure that log records are made efficiently and accurately.
  - The DBMS uses the log manager during shutdown and startup to ensure data integrity, and it interfaces with database utilities to create backups and run recoveries.

DBMS Components

- Data utilities.
  - A DBMS also provides a set of utilities for managing and controlling database activities.
  - Examples of database utilities include reorganization, runstats, backup and copy, recover, integrity check, load data, unload data and repair database.

DBMS Features

- It uses a digital repository established on a server to store and manage the information.
- It can provide a clear and logical view of the process that manipulates data.
- DBMS contains automatic backup and recovery procedures.
- It contains ACID properties which maintain data in a healthy state in case of failure.
- It can reduce the complex relationship between data.
- It is used to support manipulation and processing of data.
- It is used to provide security of data.
- It can view the database from different viewpoints according to the requirements of the user.

DBMS Advantanges

- Controls database redundancy: It can control data redundancy because it stores all the data in one single database file and that recorded data is placed in the database.
- Data sharing: In DBMS, the authorized users of an organization can share the data among multiple users.
- Easily Maintenance: It can be easily maintainable due to the centralized nature of the database system.
- Reduce time: It reduces development time and maintenance need.
- Backup: It provides backup and recovery subsystems which create automatic backup of data from hardware and software failures and restores the data if required.
- Multiple user interface: It provides different types of user interfaces like graphical user interfaces, application program interfaces

DBMS Disadvantanges

- Cost of Hardware and Software: It requires a high speed of data processor and large memory size to run DBMS software.
- Size: It occupies a large space of disks and large memory to run them efficiently.
- Complexity: Database system creates additional complexity and requirements.
- Higher impact of failure: Failure is highly impacted the database because in most of the organization, all the data stored in a single database and if the database is damaged due to electric failure or database corruption then the data may be lost forever.

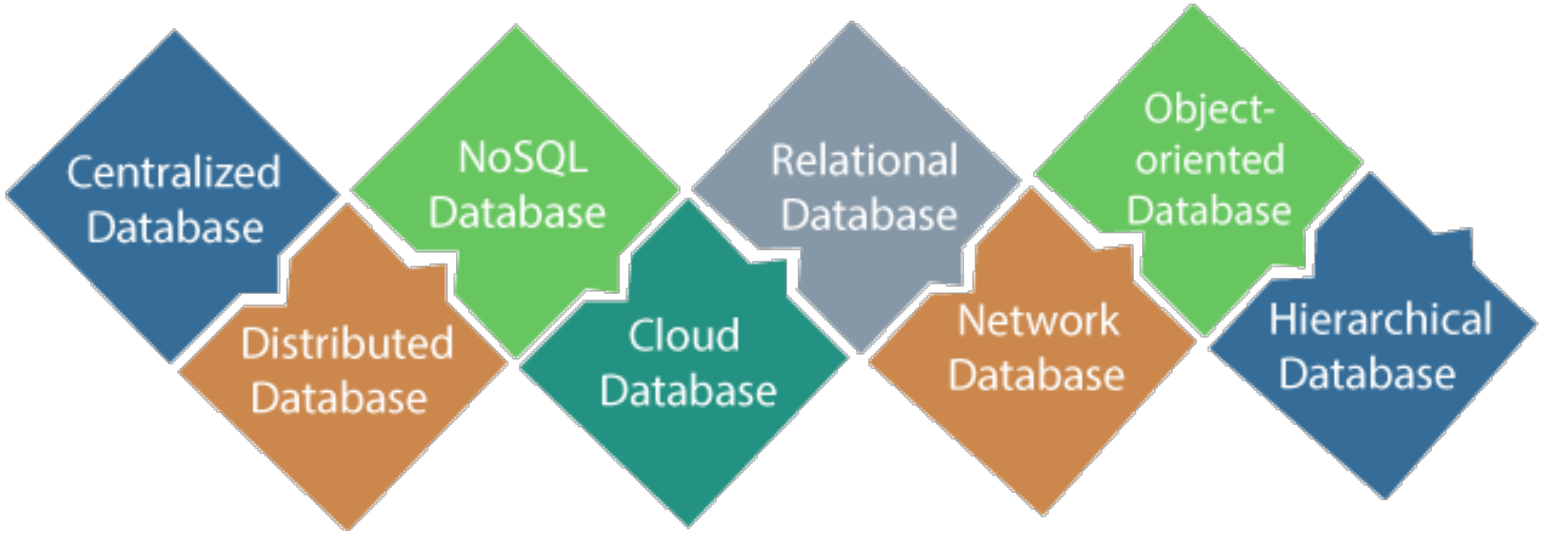
DBMS Terminologies

- Database – A database is a collection of tables, with related data.
- Table – A table is a matrix with data. A table in a database looks like a simple spreadsheet.
- Column – One column (data element) contains data of one and the same kind, for example the column postcode.
- Row – A row (= tuple, entry or record) is a group of related data, for example the data of one subscription.
- Redundancy – Storing data twice, redundantly to make the system faster.

DBMS Terminologies

- Primary Key – A primary key is unique. A key value can not occur twice in one table. With a key, you can only find one row.
- Foreign Key – A foreign key is the linking pin between two tables.
- Compound Key – A compound key (composite key) is a key that consists of multiple columns, because one column is not sufficiently unique.
- Index – An index in a database resembles an index at the back of a book.
- Referential Integrity – Referential Integrity makes sure that a foreign key value always points to an existing row.

Types of Databases



Centralized Database

- It is the type of database that stores data at a centralized database system.
- It comforts the users to access the stored data from different locations through several applications.
- These applications contain the authentication process to let users access data securely.
- An example of a Centralized database can be Central Library that carries a central database of each library in a college/university.

Distributed Database

- Unlike a centralized database system, in distributed systems, data is distributed among different database systems of an organization.
- These database systems are connected via communication links. Such links help the end-users to access the data easily.
- Examples of the Distributed database are Apache Cassandra, HBase, Ignite, etc.

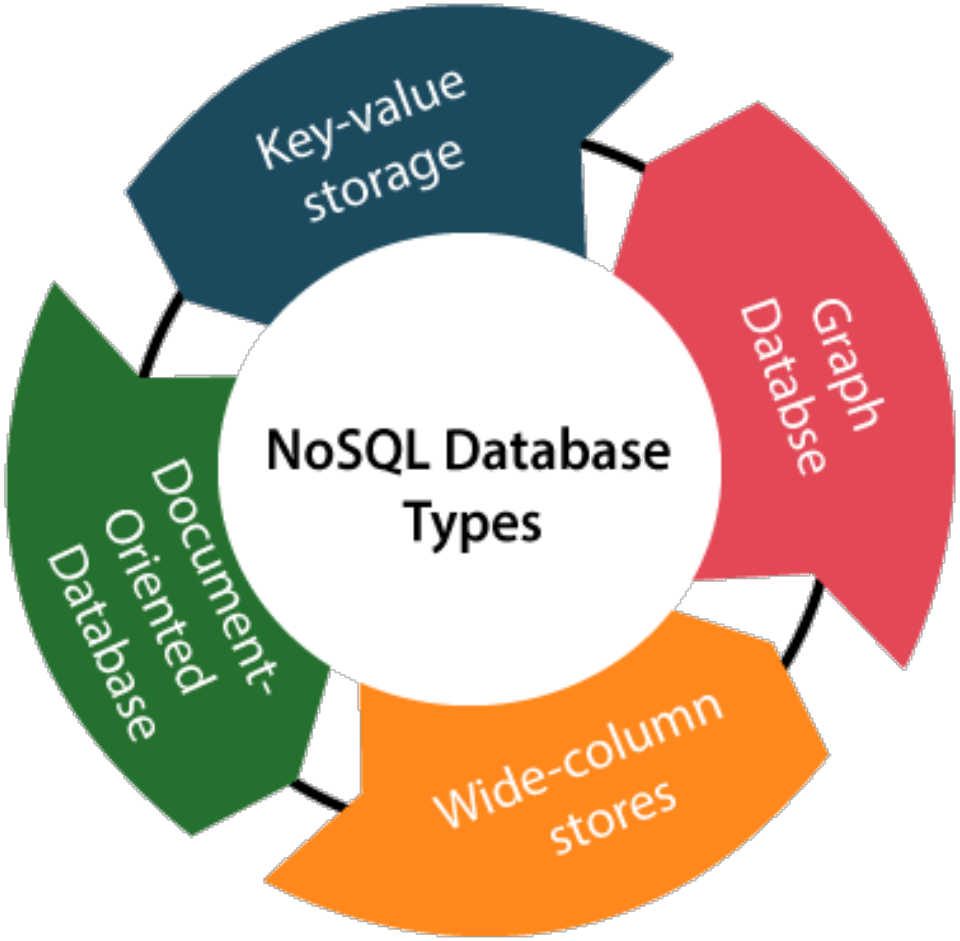
Relational Database

- This database is based on the relational data model, which stores data in the form of rows(tuple) and columns(attributes), and together forms a table(relation).
- A relational database uses SQL for storing, manipulating, as well as maintaining the data. E.F. Codd invented the database in 1970.
- Each table in the database carries a key that makes the data unique from others.
- Examples of Relational databases are MySQL, Microsoft SQL Server, Oracle, etc.

NoSQL Database

- Non-SQL/Not Only SQL is a type of database that is used for storing a wide range of data sets.
- It is not a relational database as it stores data not only in tabular form but in several different ways.
- It came into existence when the demand for building modern applications increased. Thus, NoSQL presented a wide variety of database technologies in response to the demands.
- We can further divide a NoSQL database into the following four types

NoSQL Database



Cloud Database

- A type of database where data is stored in a virtual environment and executes over the cloud computing platform.
- It provides users with various cloud computing services (SaaS, PaaS, IaaS, etc.) for accessing the database. There are numerous cloud platforms, but the best options are:
  - Amazon Web Services(AWS)
  - Microsoft Azure
  - Kamatera
  - PhonixNAP
  - ScienceSoft
  - Google Cloud SQL, etc

Object Oriented Database

- The type of database that uses the object-based data model approach for storing data in the database system.
- The data is represented and stored as objects which are similar to the objects used in the object-oriented programming language.

Hierarchical Database

- It is the type of database that stores data in the form of parent-children relationship nodes. Here, it organizes data in a tree-like structure.
- Data get stored in the form of records that are connected via links.
- Each child record in the tree will contain only one parent. On the other hand, each parent record can have multiple child records.

What is SQL?

- SQL is the standard language for dealing with Relational Databases.
- SQL can be used to insert, search, update, and delete database records. SQL can do lots of other operations, including optimizing and maintenance of databases.
- SQL Full Form
  - SQL stands for Structured Query language, pronounced as “S-Q-L” or sometimes as “See-Quel”… Relational databases like MySQL Database, Oracle, MS SQL Server, Sybase, etc. use ANSI SQL.

What is SQL used for?

- Here are important reasons for using SQL
  - It helps users to access data in the RDBMS system.
  - It helps you to describe the data.
  - It allows you to define the data in a database and manipulate that specific data.
  - With the help of SQL, you can create and drop databases and tables.
  - SQL offers you to use the function in a database, create a view, and stored procedure.
  - You can set permissions on tables, procedures, and views.

MySQL

- MySQL is released under an open-source license. So you have nothing to pay to use it.
- MySQL is a very powerful program in its own right. It handles a large subset of the functionality of the most expensive and powerful database packages.
- MySQL uses a standard form of the well-known SQL data language.
- MySQL works on many operating systems and with many languages including Python, PHP, PERL, C, C++, JAVA, etc.
- MySQL works very quickly and works well even with large data sets.

MySQL

- MySQL works very quickly and works well even with large data sets.
- MySQL is very friendly to PHP, the most appreciated language for web development.
- MySQL supports large databases, up to 50 million rows or more in a table. The default file size limit for a table is 4GB, but you can increase this (if your operating system can handle it) to a theoretical limit of 8 million terabytes (TB).
- MySQL is customizable. The open-source GPL license allows programmers to modify the MySQL software to fit their own specific environments.

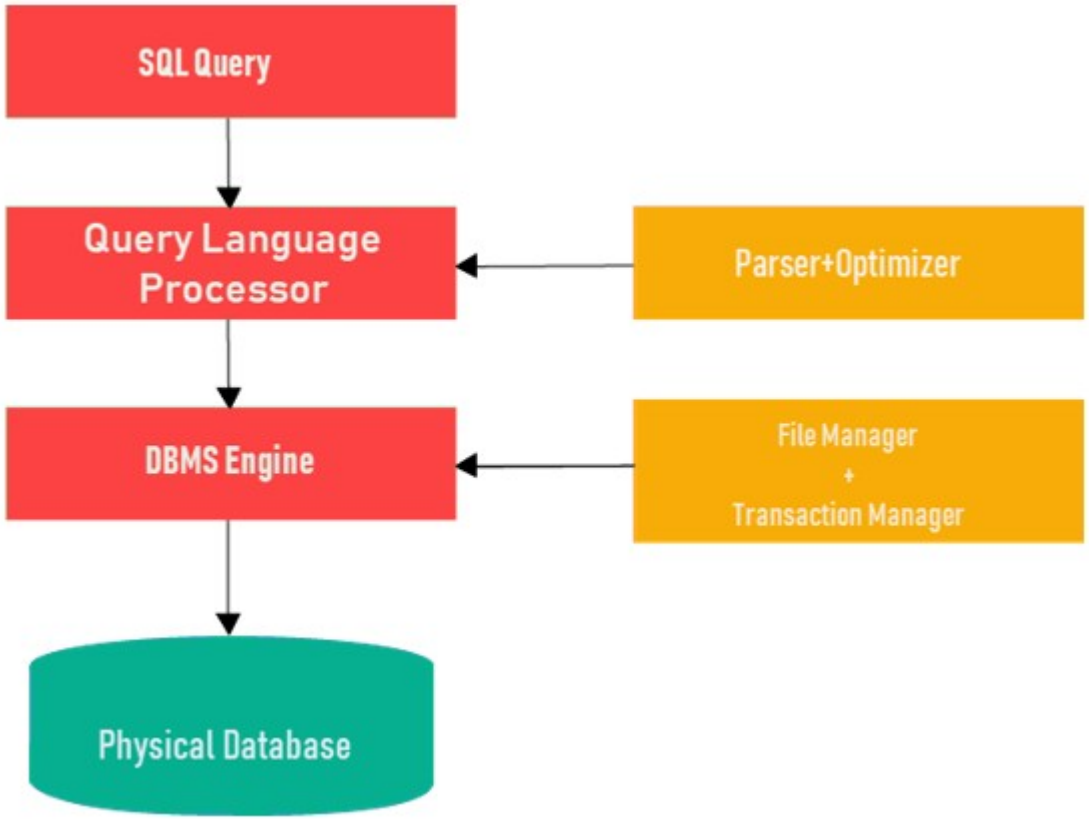
Types of SQL Statements

- Here are five types of widely used SQL queries.
  - Data Definition Language (DDL)
  - Data Manipulation Language (DML)
  - Data Control Language (DCL)
  - Transaction Control Language (TCL)
  - Data Query Language (DQL)

Common SQL Commands

- CREATE – defines the database structure schema
- INSERT – inserts data into the row of a table
- UPDATE – updates data in a database
- DELETE – removes one or more rows from a table
- SELECT – selects the attribute based on the condition described by the WHERE clause
- DROP – removes tables and databases

SQL Process


SQL Query
Query Language Processor
Parser+Optimizer
DBMS Engine
File Manager
+
Transaction Manager
Physical Database

NoSQL

- A NoSQL (originally referring to "non-SQL" or "non-relational") database provides a mechanism for storage and retrieval of data that is modeled in means other than the tabular relations used in relational databases.
- Such databases have existed since the late 1960s, but the name "NoSQL" was only coined in the early 21st century, triggered by the needs of Web 2.0 companies.
- NoSQL databases are increasingly used in big data and real-time web applications.
- NoSQL systems are also sometimes called "Not only SQL" to emphasize that they may support SQL-like query languages or sit alongside SQL databases in polyglot-persistent architectures

NoSQL

- Motivations for this approach include: simplicity of design, simpler "horizontal" scaling to clusters of machines (which is a problem for relational databases), finer control over availability and limiting the object-relational impedance mismatch.
- The data structures used by NoSQL databases (e.g. key–value pair, wide column, graph, or document) are different from those used by default in relational databases, making some operations faster in NoSQL.
- The particular suitability of a given NoSQL database depends on the problem it must solve. Sometimes the data structures used by NoSQL databases are also viewed as "more flexible" than relational database tables.

NoSQL – Types

- Wide column: Azure Cosmos DB, Accumulo, Cassandra, Scylla, HBase.
- Document: Azure Cosmos DB, Apache CouchDB, ArangoDB, BaseX, Clusterpoint, Couchbase, eXist-db, IBM Domino, MarkLogic, MongoDB, OrientDB, Qizx, RethinkDB
- Key–value: Azure Cosmos DB, Aerospike, Apache Ignite, ArangoDB, Berkeley DB, Couchbase, Dynamo, FoundationDB, InfinityDB, MemcacheDB, MUMPS, Oracle NoSQL Database, OrientDB, Redis, Riak, SciDB, SDBM/Flat File dbm, ZooKeeper
- Graph: Azure Cosmos DB, AllegroGraph, ArangoDB, InfiniteGraph, Apache Giraph, MarkLogic, Neo4J, OrientDB, Virtuoso

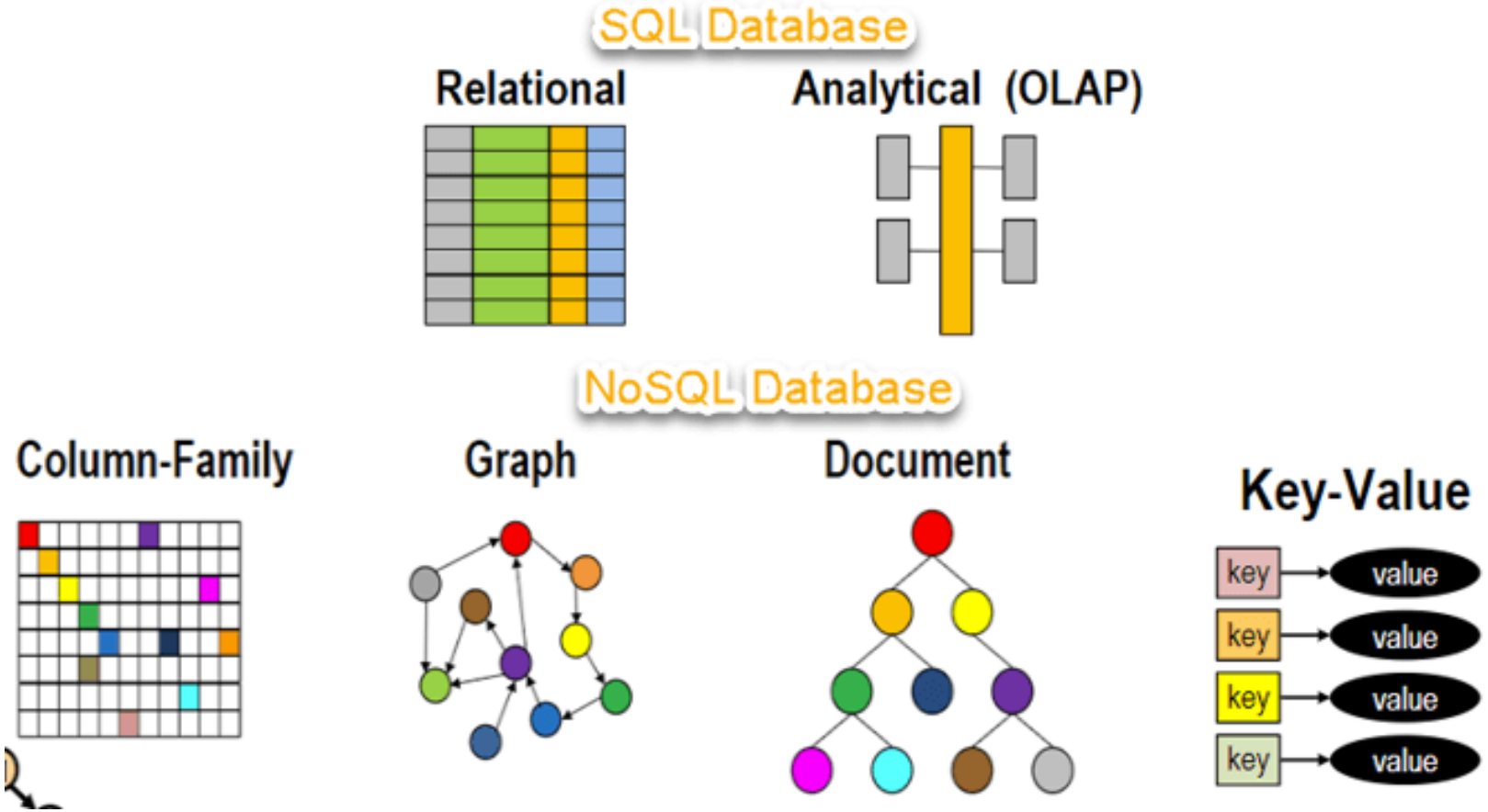
Database as a Service – SQL

- Amazon Aurora, MySQL based service
- Amazon Relational Database Service
- Clustrix Database as a Service
- Crunchy Bridge, PostgreSQL as a Service.
- EnterpriseDB Postgres Plus Cloud Database
- Google Cloud SQL
- Heroku PostgreSQL as a Service (shared and dedicated database options)
- MariaDB SkySQL
- Microsoft Azure SQL Database (MS SQL)
- Oracle Database Cloud Service
- Snowflake Cloud Data Warehouse
- Xeround Cloud Database* – MySQL front-end (*service no longer available)

Database as a Service – NoSQL

- Amazon DynamoDB
- Amazon SimpleDB
- Azure Cosmos DB
- Cloudant Data Layer (CouchDB)
- EnterpriseDB Postgres Plus Cloud Database
- Google Cloud Bigtable
- Google Cloud Datastore
- MongoDB Database as a Service (several options)
- RavenDB Cloud Database as a Service
- Oracle NoSQL Database Cloud Service
- Amazon DocumentDB

Database Types



Comparison

SQL	NOSQL
Relational Database management system	Distributed Database management system
Vertically Scalable	Horizontally Scalable
Fixed or predifined Schema	Dynamic Schema
Not suitable for hierarchical data storage	Best suitable for hierarchical data storage
Can be used for complex queries	Not good for complex queries

Why NoSQL?

- NoSQL databases are used in nearly every industry.
- Use cases range from the highly critical (e.g., storing financial data and healthcare records) to the more fun and frivolous (e.g., storing IoT readings from a smart kitty litter box).

Why NoSQL?

- Support large numbers of concurrent users (tens of thousands, perhaps millions)
- Deliver highly responsive experiences to a globally distributed base of users
- Be always available – no downtime
- Handle semi- and unstructured data
- Rapidly adapt to changing requirements with frequent updates and new features

When NoSQL?

- When deciding which database to use, decision-makers typically find one or more of the following factors lead them to selecting a NoSQL database:
  - Fast-paced Agile development
  - Storage of structured and semi-structured data
  - Huge volumes of data
  - Requirements for scale-out architecture
  - Modern application paradigms like microservices and real-time streaming

Misconcepts

- Over the years, many misconceptions about NoSQL databases have spread throughout the developer community. Two of the most common misconceptions:
  - Relationship data is best suited for relational databases.
  - NoSQL databases don't support ACID transactions.

Misconcepts

- A common misconception is that NoSQL databases or non-relational databases don’t store relationship data well. NoSQL databases can store relationship data — they just store it differently than relational databases do.
- In fact, when compared with relational databases, many find modeling relationship data in NoSQL databases to be easier than in relational databases, because related data doesn’t have to be split between tables.
- NoSQL data models allow related data to be nested within a single data structure.

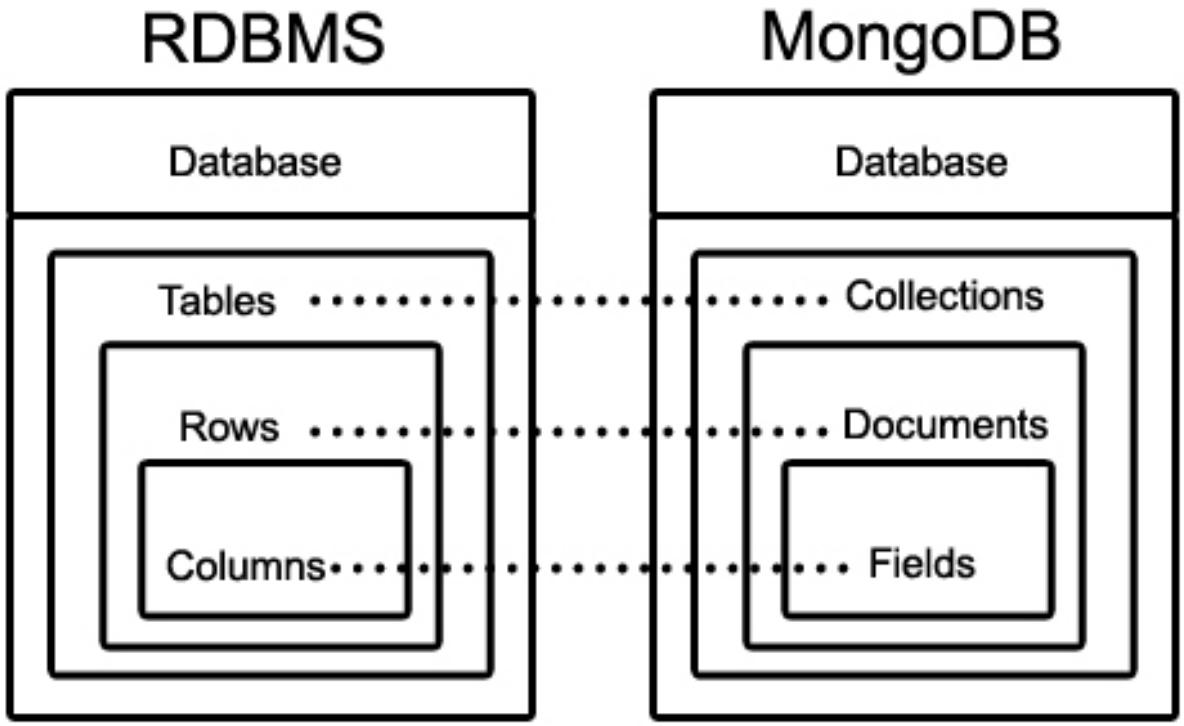
Terminologies

- Database
  - Database is a physical container for collections. Each database gets its own set of files on the file system. A single MongoDB server typically has multiple databases.
- Collection
  - Collection is a group of MongoDB documents. It is the equivalent of an RDBMS table. A collection exists within a single database.
  - Collections do not enforce a schema. Documents within a collection can have different fields. Typically, all documents in a collection are of similar or related purpose.
- Document
  - A document is a set of key-value pairs. Documents have dynamic schema. Dynamic schema means that documents in the same collection do not need to have the same set of fields or structure, and common fields in a collection's documents may hold different types of data.

RDBMS vs. MongoDB

RDBMS	MongoDB
Database	Database
Table	Collection
Tuple/Row	Document
column	Field
Table Join	Embedded Documents
Primary Key	Primary Key (Default key _id provided by MongoDB itself)
Database Server and Client	
mysqld/Oracle	mongod
mysql/sqlplus	mongo

RDBMS vs. MongoDB



Example Document

```
{
   _id: ObjectId(7df78ad8902c)
   title: 'MongoDB Overview',
   description: 'MongoDB is no sql database',
   by: 'MiTU Skillologies',
   url: 'https://www.mitu.co.in',
   tags: ['mongodb', 'database', 'NoSQL'],
   comments: [
      {
         user:'user1',
         message: 'My first comment',
         like: 0
      },
      {
         user:'user2',
         message: 'My second comments',
         dateCreated: new Date(2011,1,25,7,45),
         like: 5
      }
   ]
}
```

Advantages

- Schema less – MongoDB is a document database in which one collection holds different documents. Number of fields, content and size of the document can differ from one document to another.
- Structure of a single object is clear.
- No complex joins.
- Deep query-ability. MongoDB supports dynamic queries on documents using a document-based query language that's nearly as powerful as SQL.
- Ease of scale-out – MongoDB is easy to scale.
- Conversion/mapping of application objects to database objects not needed.
- Uses internal memory for storing the (windowed) working set, enabling faster access of data.

Why to use NoSQL?

- Document Oriented Storage – Data is stored in the form of JSON style documents.
- Index on any attribute
- Replication and high availability
- Auto-Sharding
- Rich queries
- Fast in-place updates
- Professional support by MongoDB

Where to use ?

- Big Data
- Content Management and Delivery
- Mobile and Social Infrastructure
- User Data Management
- Data Hub

MySQL Clients

- MYSQL Client are programs for communicating with the server to manipulate the information in the databases that the server manages.
- Example : mysql is the command line program that acts as a text-based front end for the server.

MySQL Workbench

- MySQL Workbench is a unified visual tool for database architects, developers, and DBAs.
- MySQL Workbench provides data modeling, SQL development, and comprehensive administration tools for server configuration, user administration, backup, and much more.
- MySQL Workbench is available on Windows, Linux and Mac OS X.

MySQL Shell

- The MySQL Shell is an interactive Javascript, Python, or SQL interface supporting development and administration for the MySQL Server and is a component of the MySQL Server.
- You can use the MySQL Shell to perform data queries and updates as well as various administration operations.

Thank you

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