Introduction to Databases

Database Foundations

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Outline

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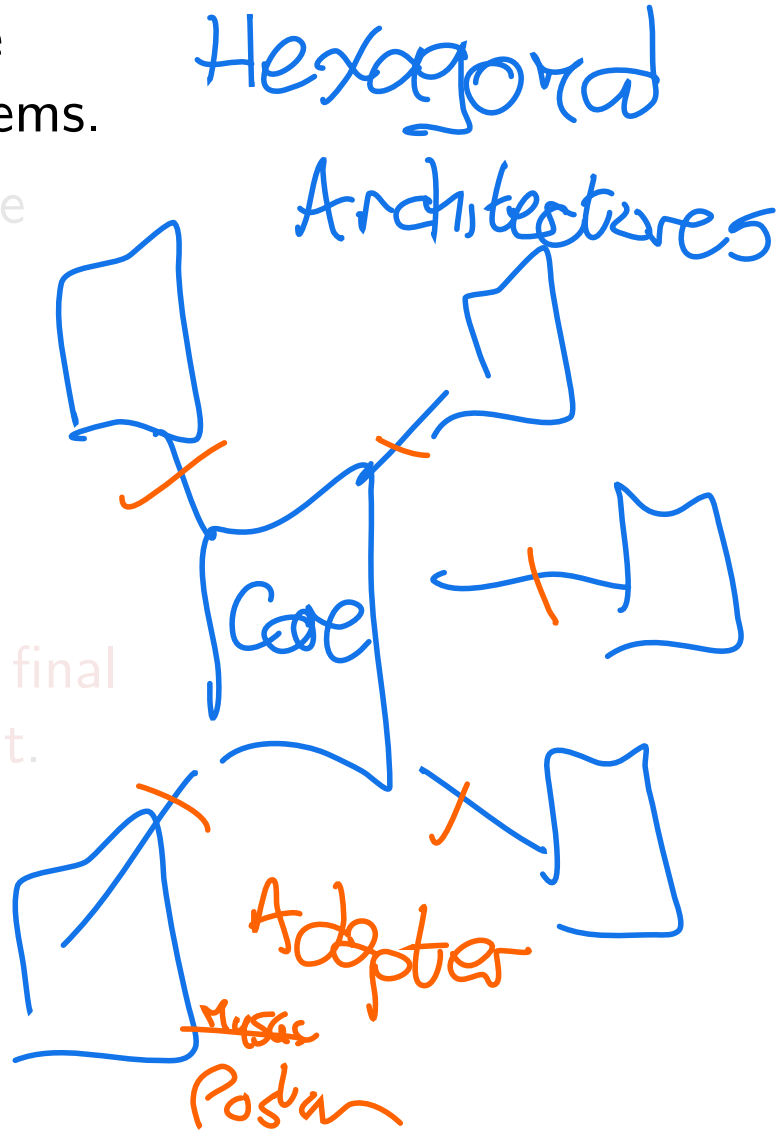
Modular Software Components

- **Software Components** are the building blocks of software systems.
- **Modular Software** is a software design technique that emphasizes separating the functionality of a program into independent, interchangeable **modules**.
- **Software Applications** are the final product of software development.
- **Software Development** is the process of creating software applications.



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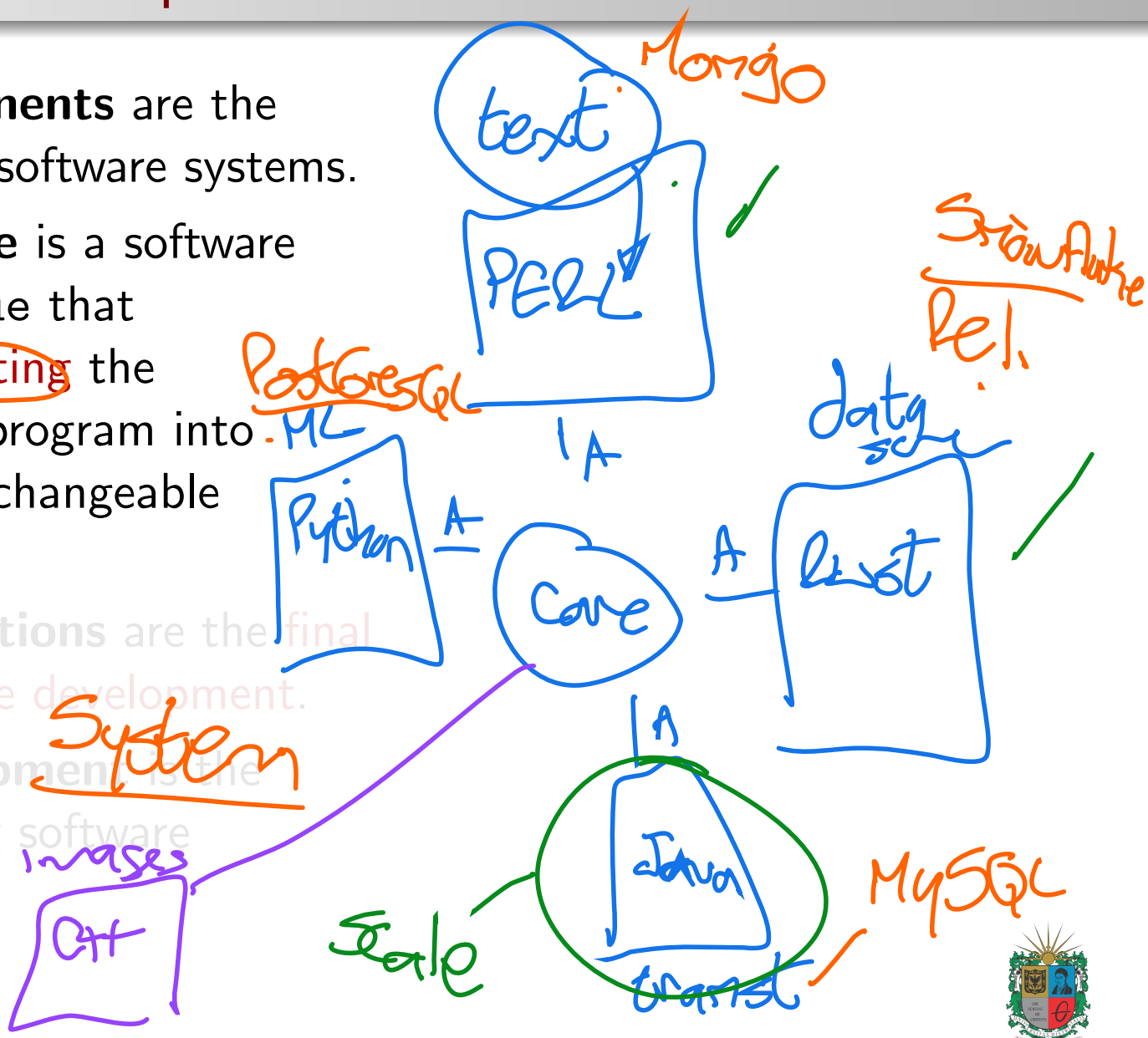

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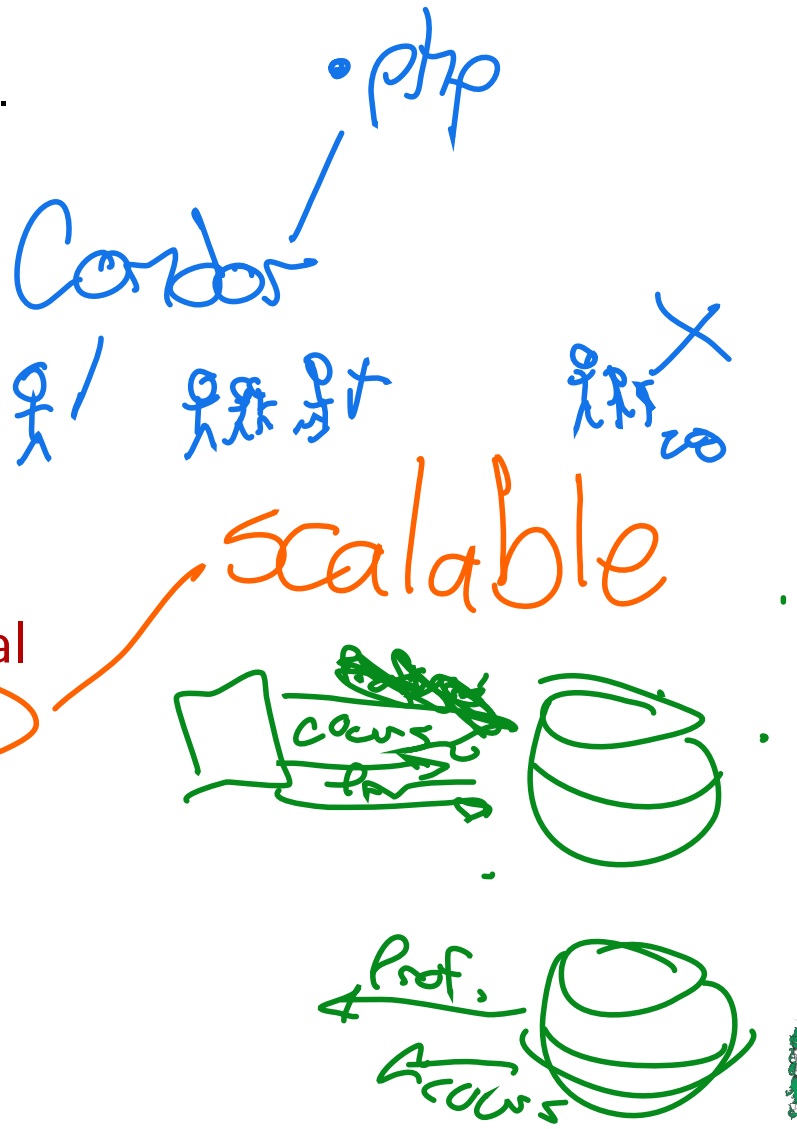

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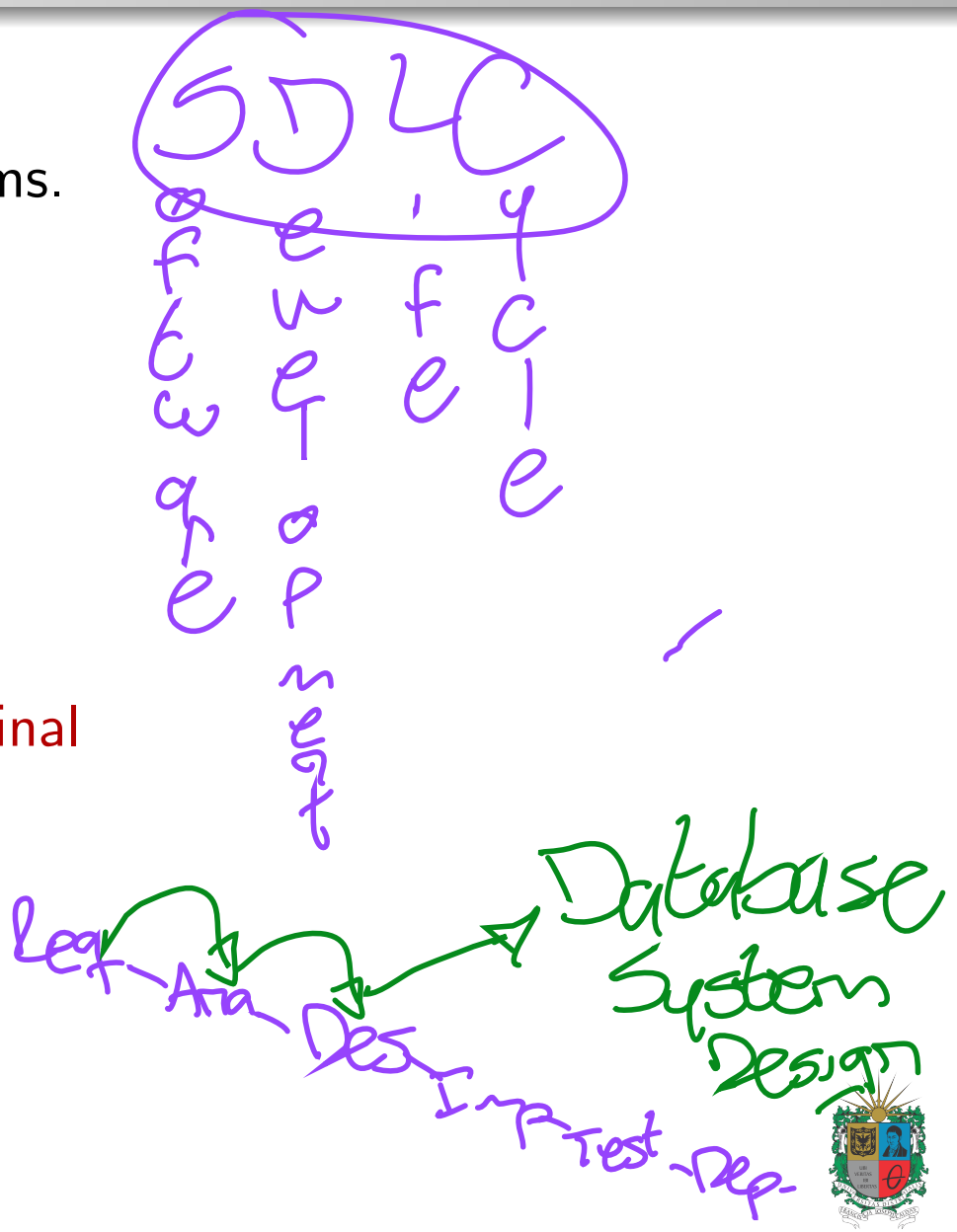
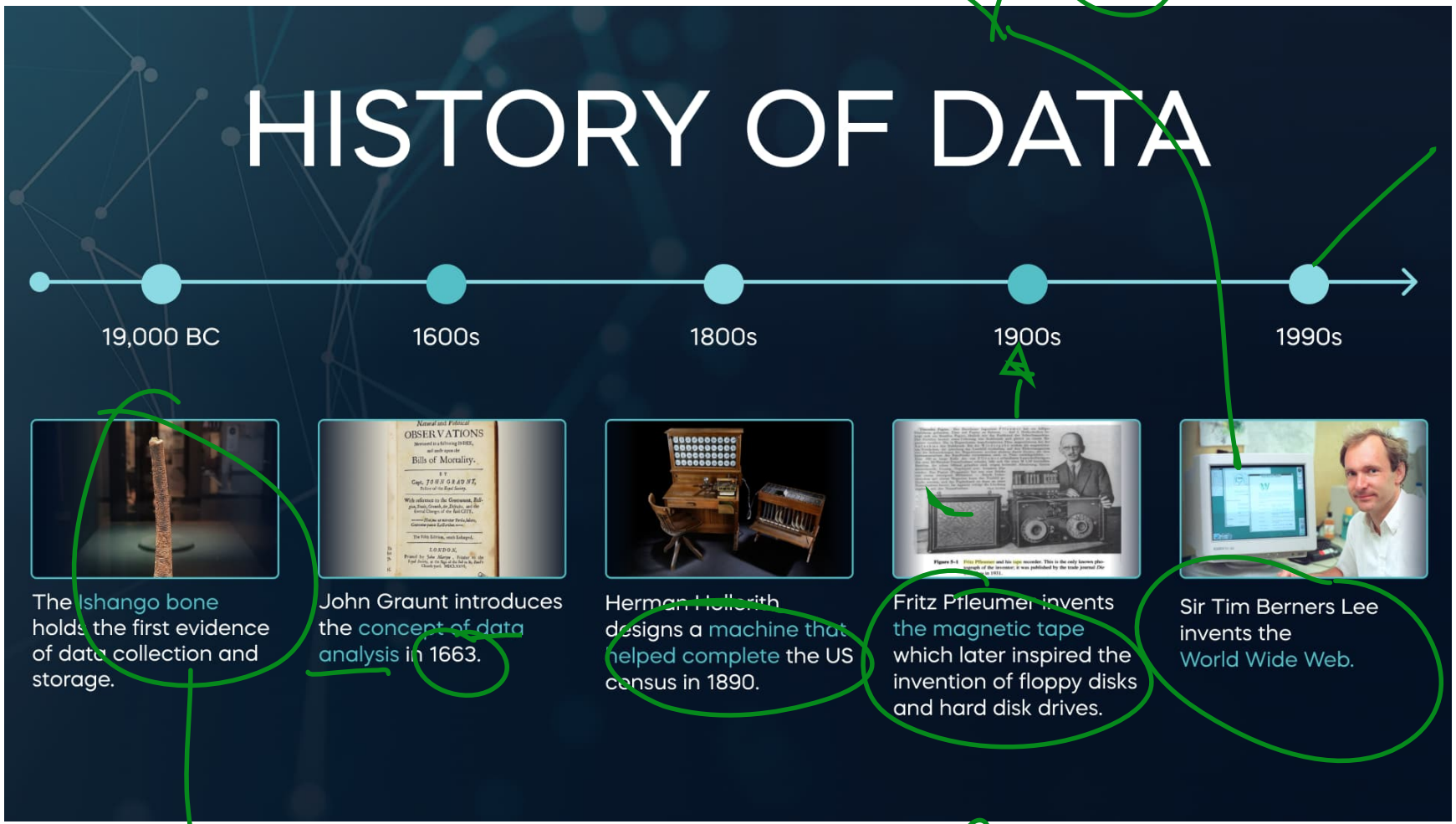
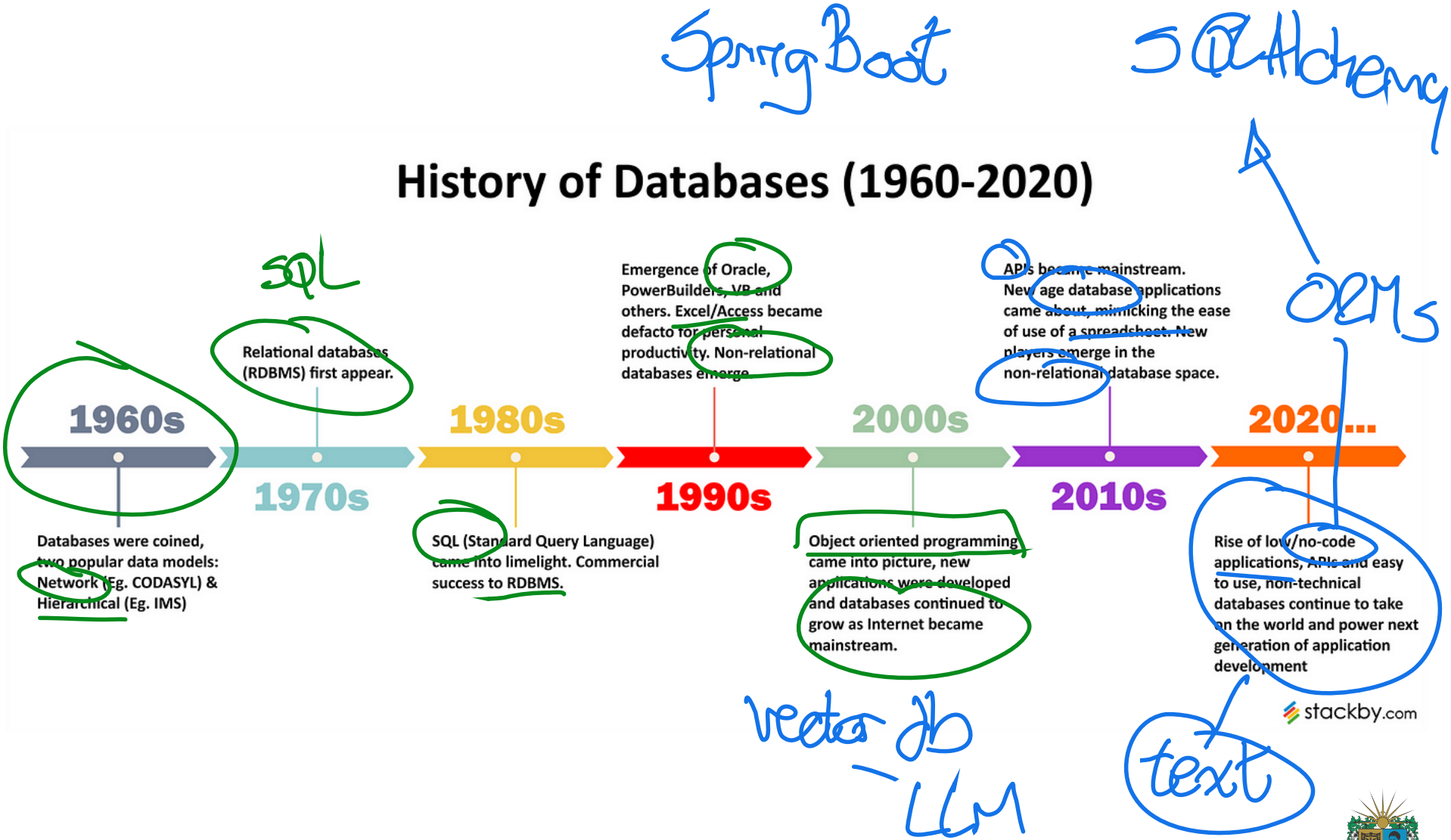


History of Data



History of DataBases



Applications

- Are software based on **layers** of abstraction and modularity lets implement different database strategies.
- Database Systems are fundamental for **data management**.
- Data analysis, data mining, data visualization, and data interpretation are **applications** of **database systems**.

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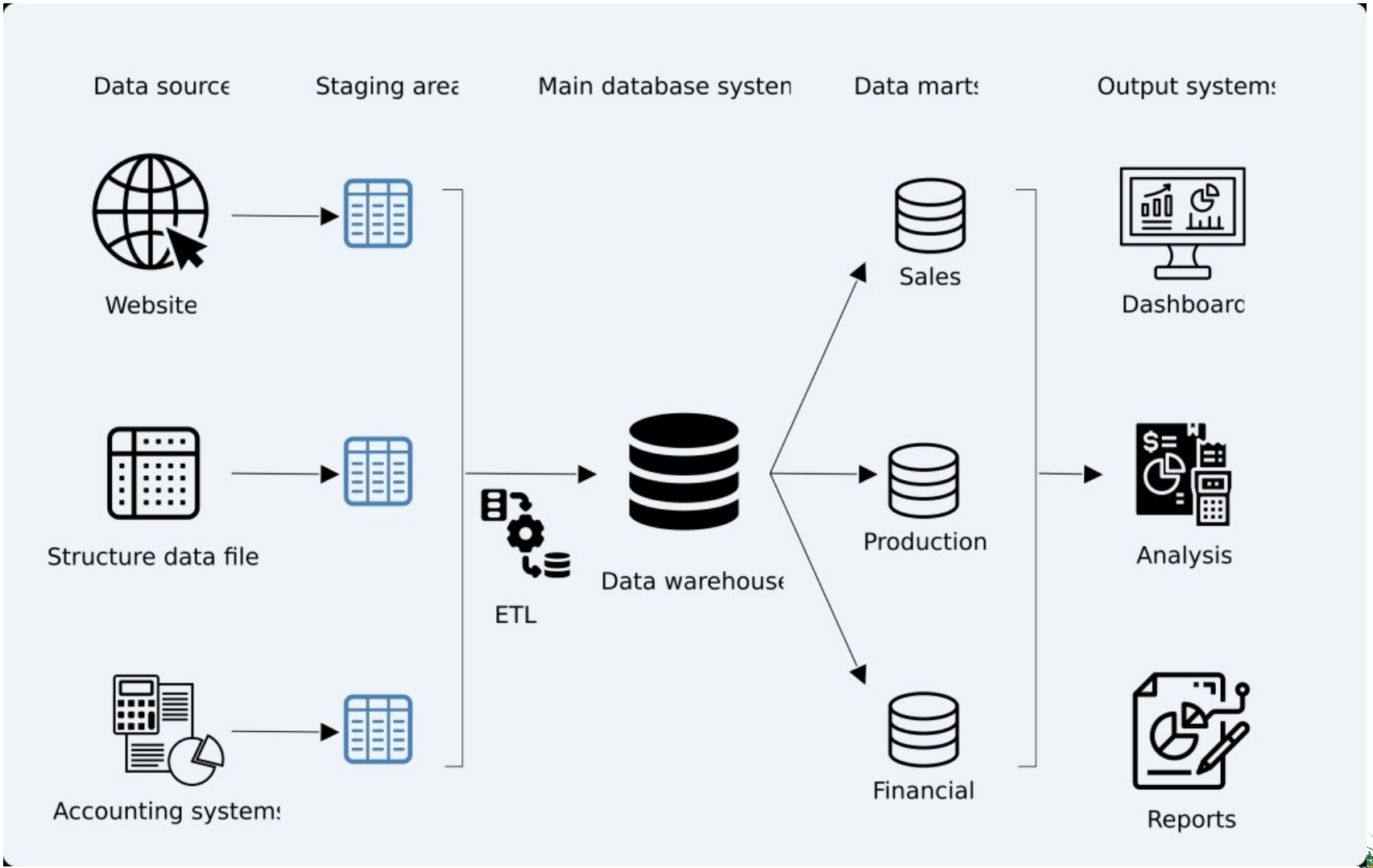
Case of Study: DataBase System



Outline

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From Data to Information

- Data: is a set of **values** of **qualitative** or **quantitative** variables.
- Data Management: is the process of **collecting**, **storing**, **processing**, and **analyzing** data.
- Data Analysis: is a process of **inspecting**, **cleansing**, **transforming**, and **modeling** data with the goal of **discovering** useful **information**, informing **conclusions**, and supporting **decision-making**.

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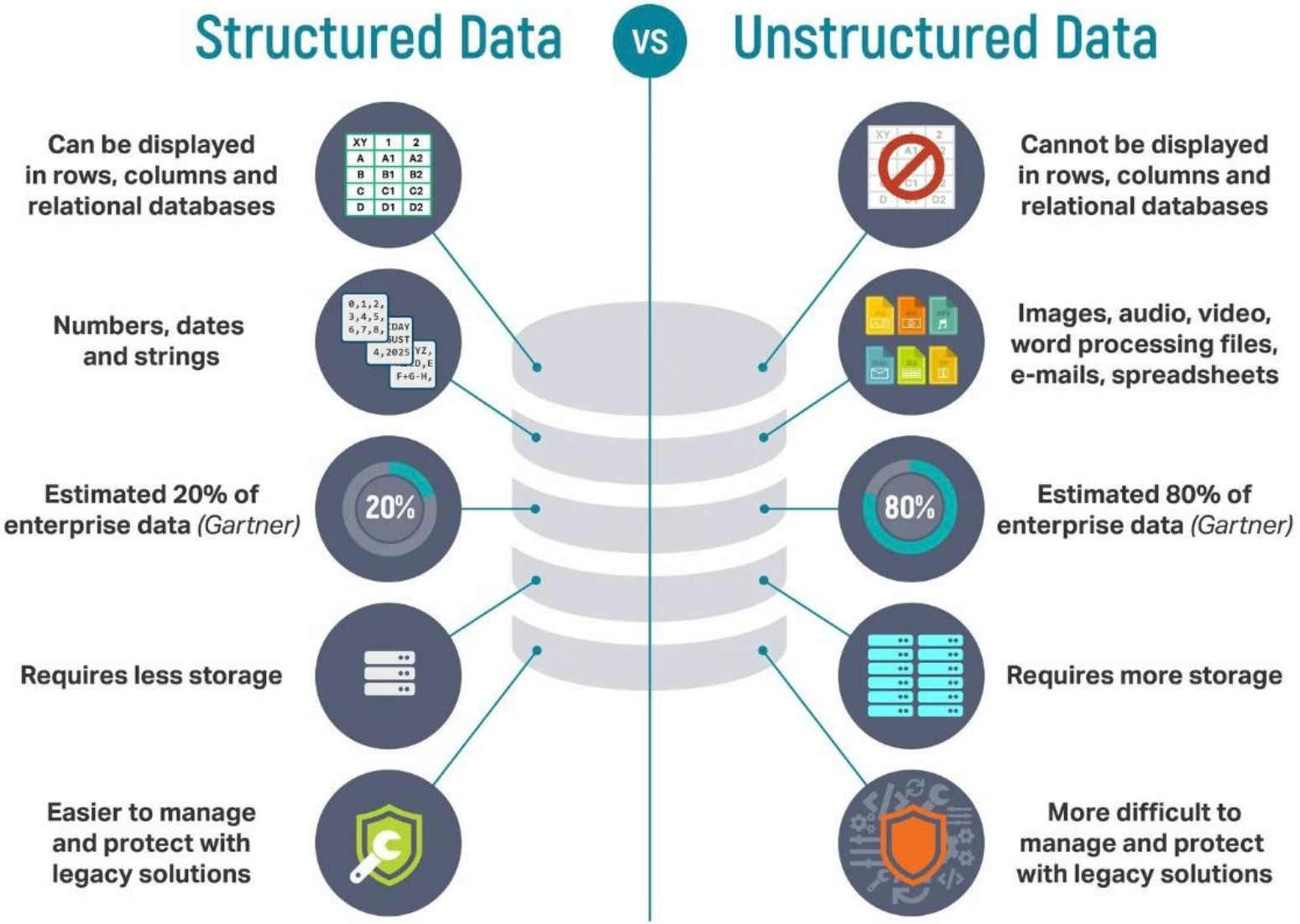
Structured and Unstructured Data



Tables, Columns and Rows

- **Table** is a collection of related data held in a structured format within a database.
- **Column** is a set of data values of a particular simple type, one for each row of the table.
- **Row** is a set of data values of a particular relationship, one for each column of the table.

Primary and Foreign Keys

- **Primary Key** is a unique identifier for a record in a data set.
- **Foreign Key** is a column or group of columns in a table that links to a primary key in another table.

Key-Value Data Structures

- **Key-Value Data Structures** are a type of data structure that can map keys to values.
- **Key** is a unique identifier for a record in a data fragment. **Value** is the data that is associated with the key.

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CRUD Operations

- CRUD is an acronym for **Create**, **Read**, **Update**, and **Delete**.
- Create is the process of **adding** new **records** to a **data set**.
- Read is the process of **retrieving records** from a **data set**.
- Update is the process of **modifying records** in a **data set**.
- Delete is the process of **removing records** from a **data set**.

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DataBase Classification

- DataBase is a collection of **data** that is **organized** so that it can be **easily accessed**, **managed**, and **updated**.
- Relational DataBase is a type of **database** that stores and provides access to **data points** that are **related** to one another.
- NoSQL DataBase is a type of **database** that provides a mechanism for **storage** and **retrieval** of **data** that is **modeled** in **means** other than the **tabular relations** used in **relational databases**.

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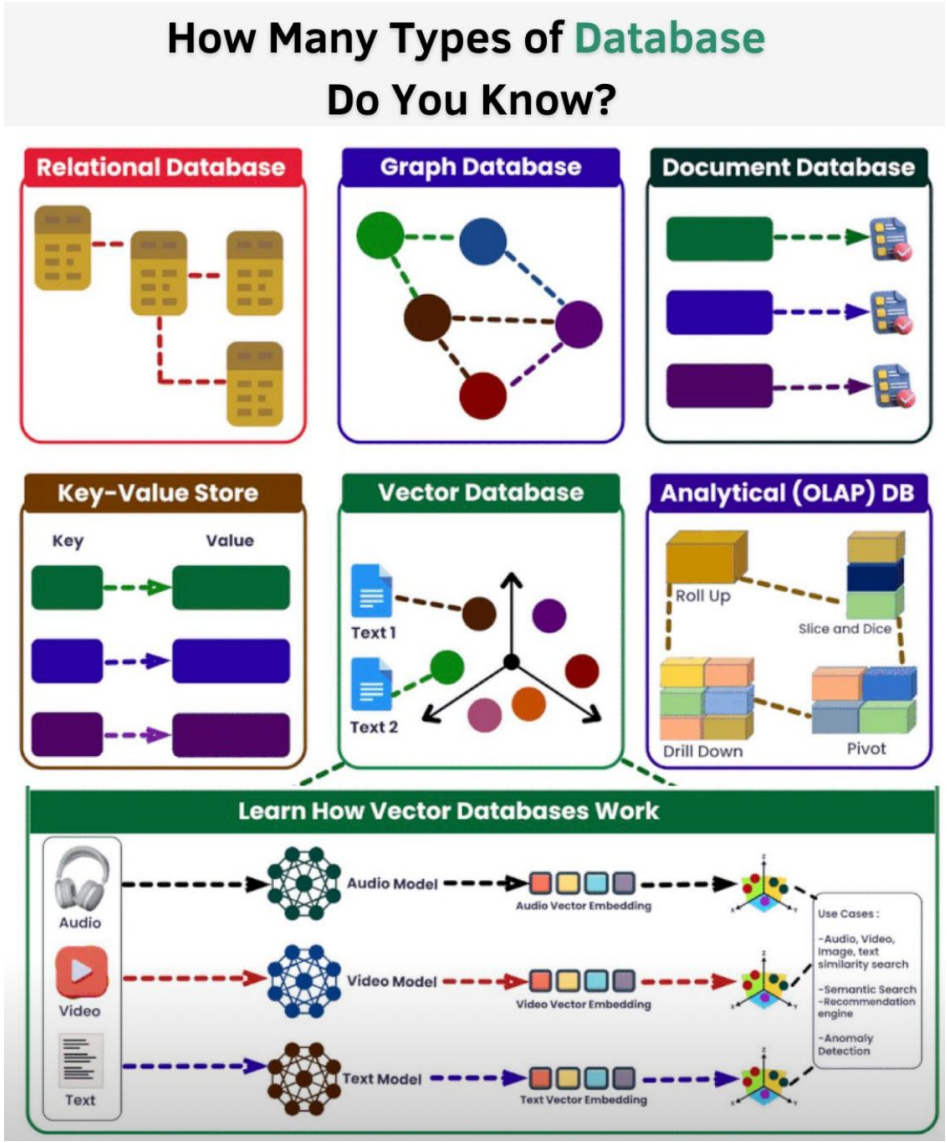
Types of Database



DataBases Models

DataBases Models are the way to organize and store data in a database.

There are some common models:

- Hierarchical
- Network
- Relational
- Object-Oriented
- Document-Based
- Graph-Based
- ...

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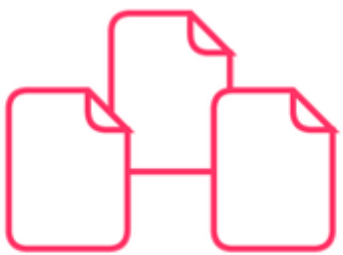
Semi-Structured Data



Unstructured	Semi-structured	Structured
PDFs, JPEGs, MP3, Movies, ...	CSV, JSON, XML, MongoDB, ...	Oracle, MSSQL, MySQL, DB2, ...

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Relational Model

- The **relational model** is the most common and widely used model today.
- It is based on the concept of relations. A **relation** is a table with rows and columns.
- The relational model is based on the concept of **keys**, which leads to *strong relationships* in `structured data`.
- It also incorporates the concepts of integrity constraints and **normalization**.

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Hierarchical Model

- The **hierarchical model** organizes data in a tree-like structure.
- It is based on the concept of parent-child relationships, meaning **one-to-many** relationships.
- An example of a hierarchical model is the `XML format`.

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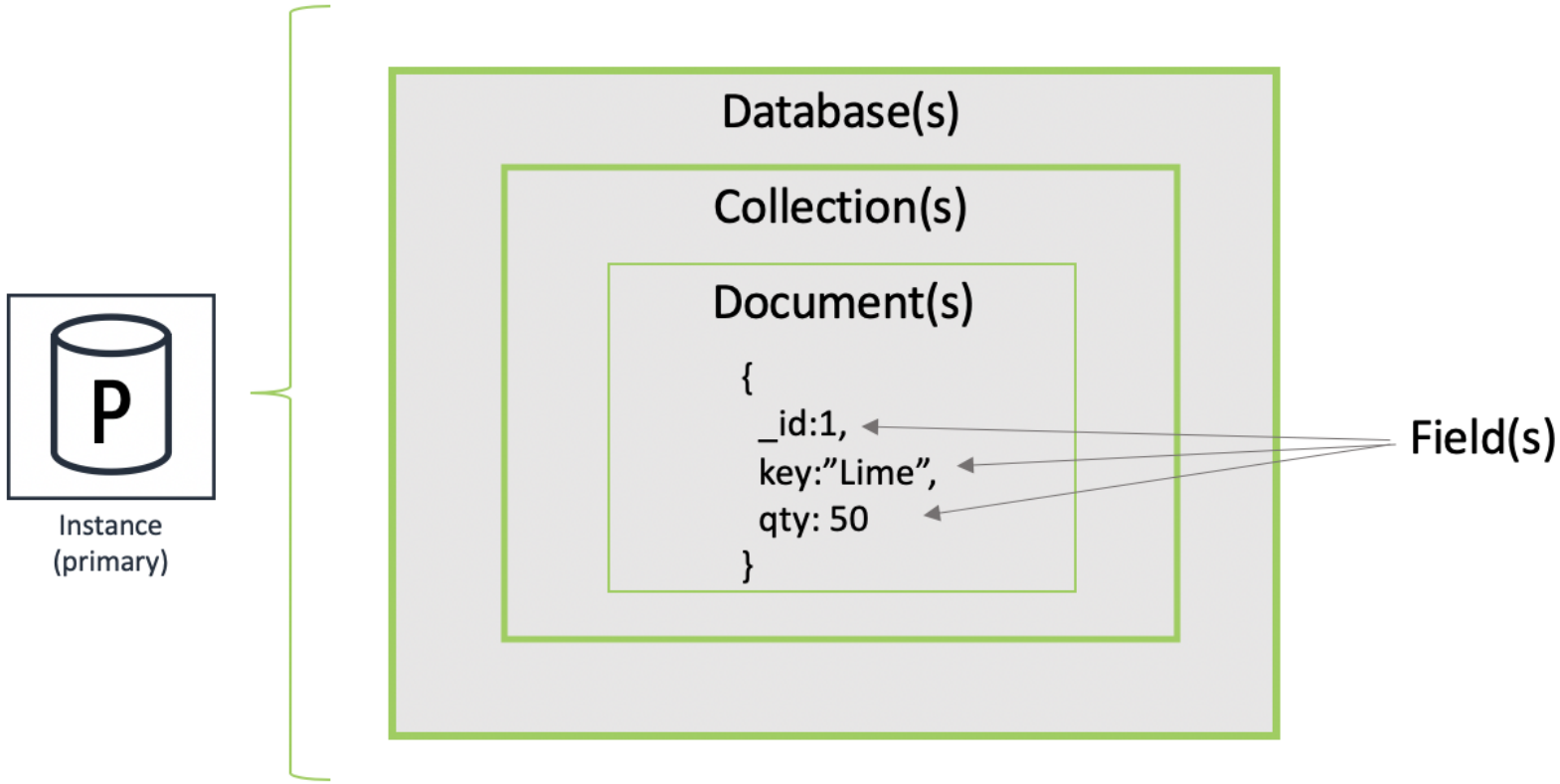
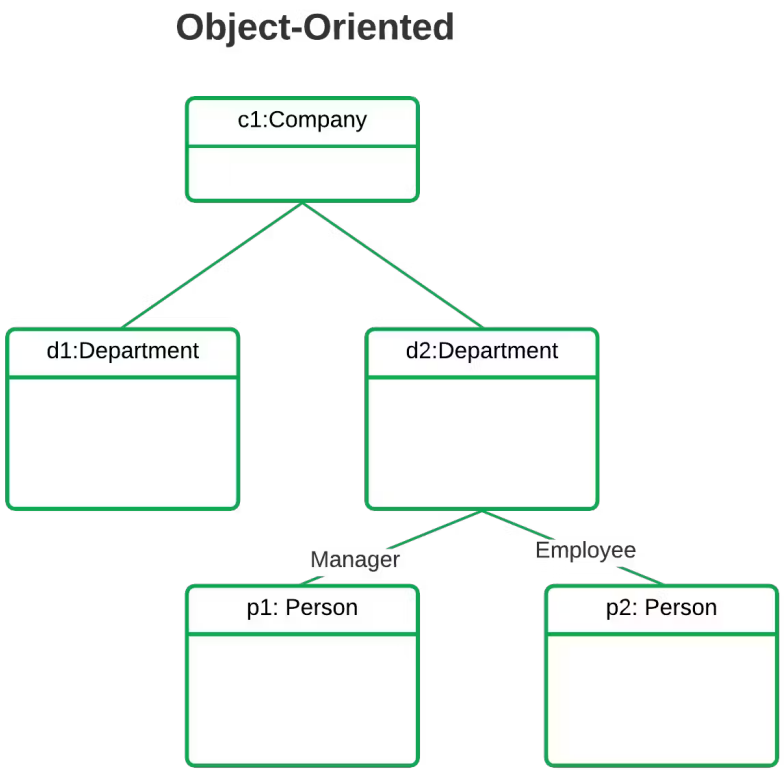
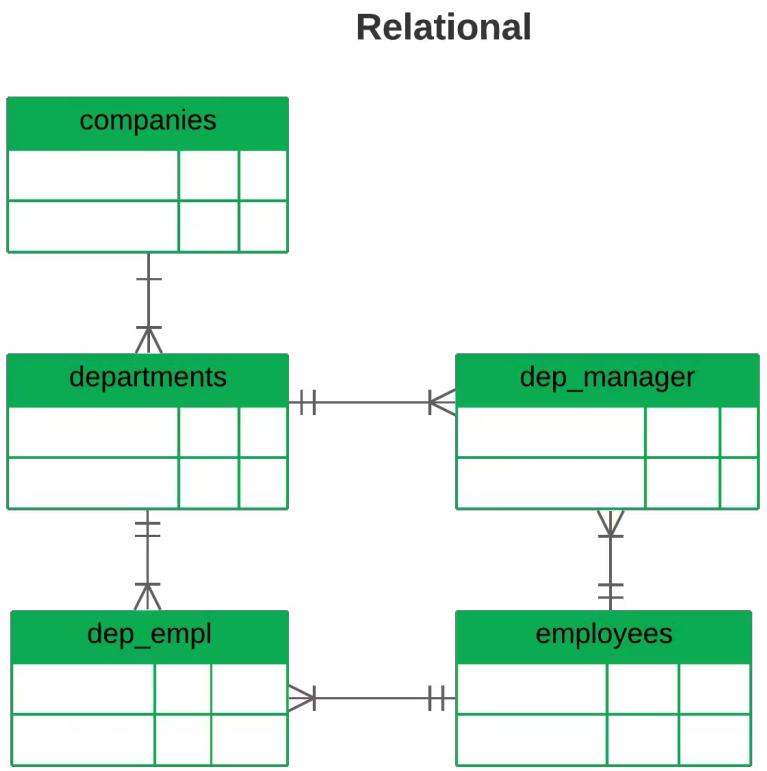
Document-Based Model

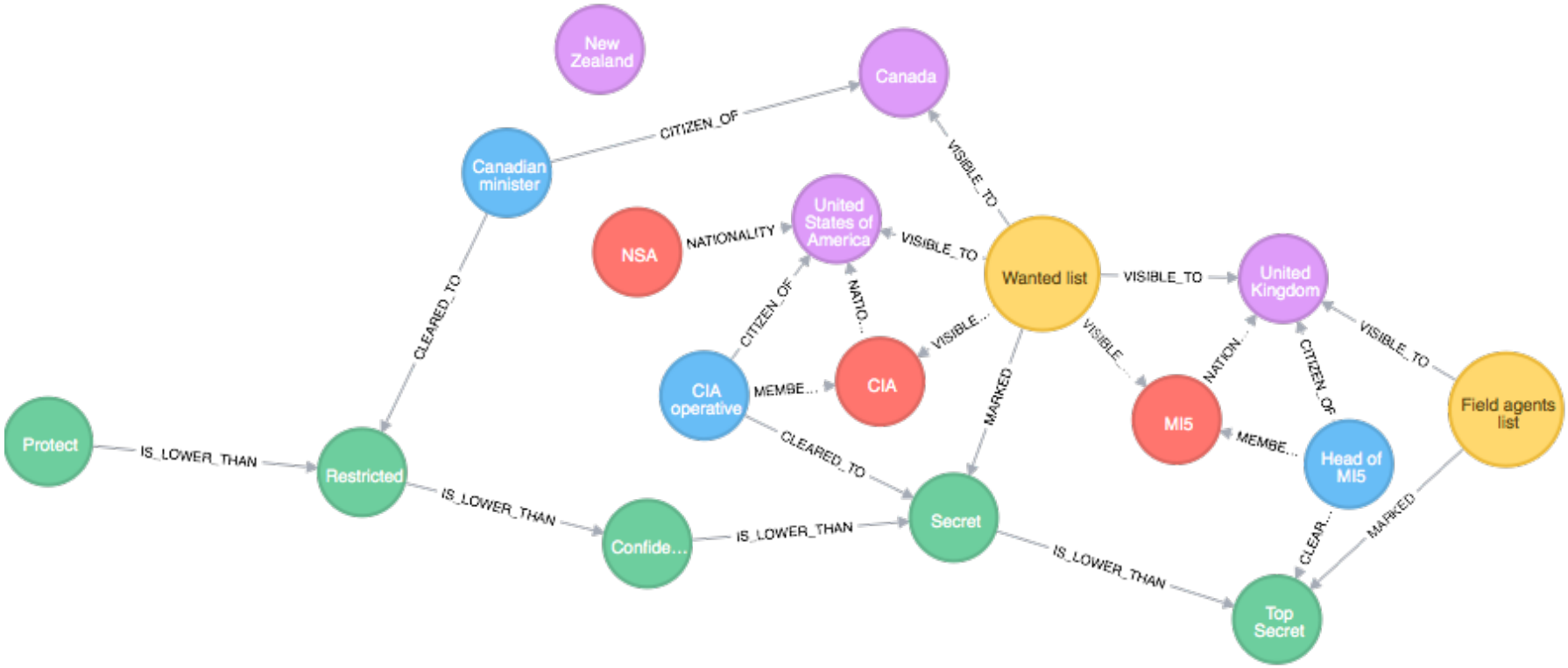


Object-Oriented Model

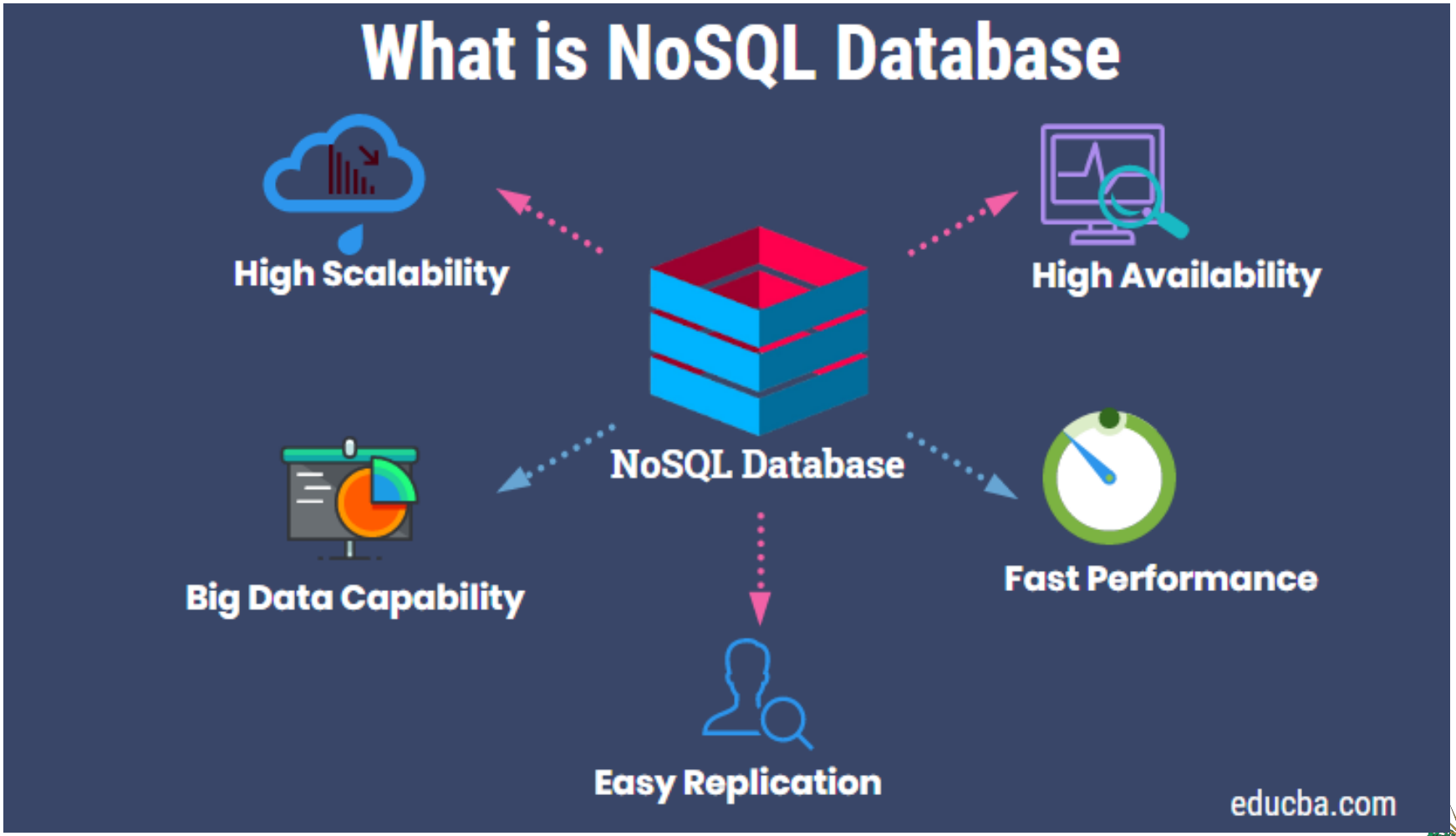




Graph-Based Model



NoSQL Model


What is NoSQL Database
High Scalability
High Availability
NoSQL Database
Big Data Capability
Fast Performance
Easy Replication
educba.com

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Database Design Foundations

- In the context of **databases**, designing a database is the process of producing a **detailed** data model.
- This **data model** encompasses all the required logical and physical design **decisions**, as well as physical storage parameters, to generate a design in a *data definition language* that can subsequently be used to create the database.
- A fully attributed data model contains detailed attributes for **each entity**.
- **Relational data models** avoid redundancy and inconsistency by ensuring that data is **normalized**.

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Set Theory in Databases

- The **set theory** is a branch of mathematical logic that studies sets, which are collections of objects.
- The **set theory** is applied in databases to define the relational model and the relational algebra.
- The **relational model** is a mathematical model of data for large shared data banks and it has a **solid theoretical foundation**.
- The **relational algebra** is a procedural query language, which takes relations as input and produces relations as output.

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Normalization in Databases

- **Normalization** is the process of organizing the columns (attributes) and tables (relations) of a relational database to **minimize data redundancy**.
- **Normalization** involves decomposing a table into **smaller tables** and defining relationships between them.
- The objective is to **isolate data** so that additions, deletions, and modifications of a field can be made in just **one table** and then **propagated** through the rest of the database using the defined relationships.

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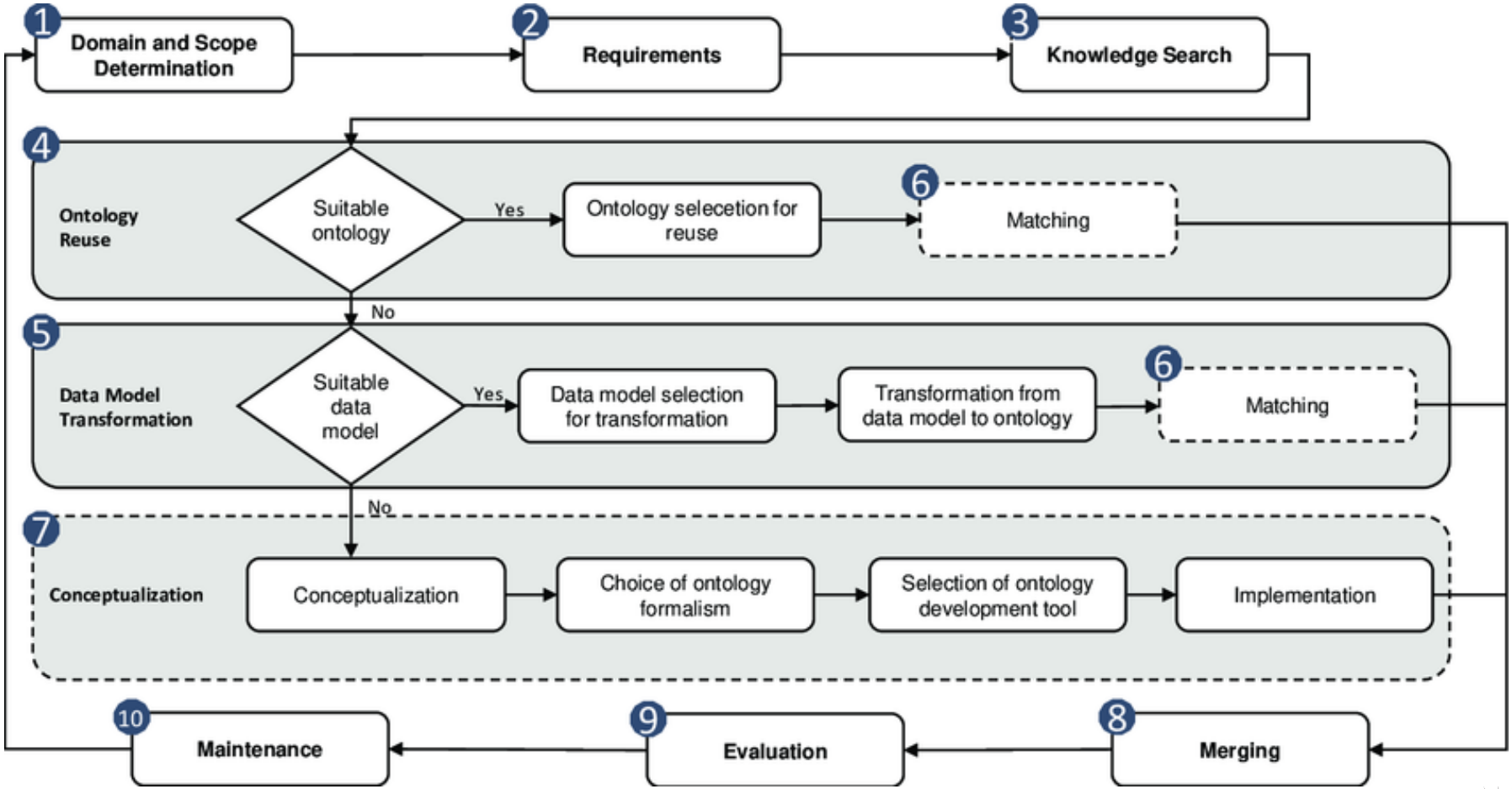
Normal Levels

1. **First normal form (1NF)**: The table is a two-dimensional table with rows and columns. Each column contains **atomic values**, and there are no repeating groups or arrays.
2. **Second normal form (2NF)**: The table is in first normal form and all the non-key attributes are fully functionally dependent on the primary key.
3. **Third normal form (3NF)**: The table is in second normal form and all the non-key attributes are non-transitively dependent on the primary key.
4. **Fourth normal form (4NF)**: The table is in third normal form and there are no multi-valued dependencies.

Ontologies

- An **ontology** is a formal naming and definition of the types, properties, and interrelationships of the **entities** that really or fundamentally exist for a particular domain of discourse.
- **Ontologies** are used in databases to define the schema of the database.
- The **schema** of a database is a formal definition of the structure of the database: the `types of data` that are stored, the `relationships` between the data, and the `constraints` on the data.

Ontology Workflow



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Definitions

- **Entity**: A thing or object in the real world that is distinguishable from other objects.
- **Attribute**: A property or characteristic of an entity.
- **Relationship**: An association between entities.
- **Cardinality**: The number of instances of an entity that can be associated with another entity.
- **Degree**: The number of entities that participate in a relationship.

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Entity-Relation Model

- The **Entity-Relation Model** is a graphical representation of the entities and their relationships in a database.
- The **Entity-Relation Model** is used to design the schema of a database and to communicate the design to stakeholders.
- Following a process based on a **ontology** it is easy to define the entities, attributes, and relationships of the database.

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Step 1. Define Components

Step 2. Define Entities

Step 3. Define Attributes per Entity

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Step 4. Define Relationships

Step 5. Define Relationships Types

Step 6. First Entity-Relationship Model Draw

Step 7. Split Many-to-Many Relationships

Step 8. Second Entity-Relationship Model Draw

Step 9. Get Data-Structure Entity-Relationship Model

Step 10. Define Constraints and Properties of Data

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What is a DBMS?

- A **Database Management System** (DBMS) is a software system that uses a standard method to store and organize data.
- A **DBMS** is a software system that allows users to define, create, maintain, and control access to the database.
- A **DBMS** is a software package designed to manipulate, retrieve, and manage data in a database.

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Pros & Cons of DBMS

- **Pros**:
  - **Data Independence**: Data is stored independently of the applications that use it.
  - **Data Integrity**: Data is consistent and accurate.
  - **Data Security**: Data is protected from unauthorized access.
  - **Data Recovery**: Data can be recovered in case of failure.
- **Cons**:
  - **Complexity**: DBMS are complex systems.
  - **Cost**: DBMS are expensive for bigger data volumes.
  - **Performance**: DBMS can be slow.

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GUI Assistants

- A **Graphical User Interface** (`GUI`) is a type of user interface that allows users to interact with electronic devices using graphical icons and visual indicators.
- `GUIs` are easier to use than `Command Line Interfaces` (CLI) because they allow users to interact with the system using visual elements such as windows, buttons, and menus.
- `GUIs` are more intuitive and user-friendly than `CLIs`, which makes them ideal for users who are not familiar with the system.

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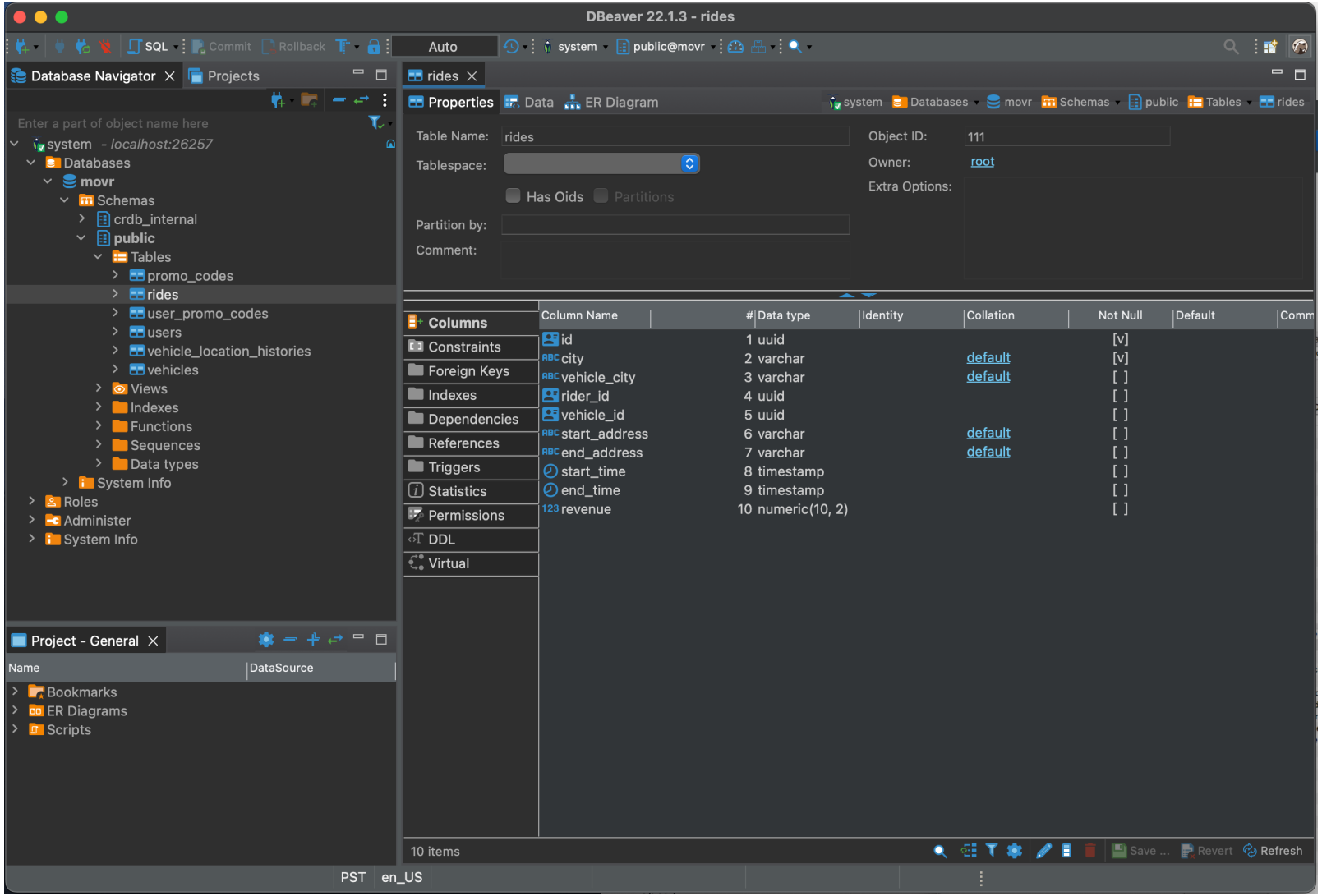
Case of Study: DBeaver



Command Line

- A **Command Line Interface** (`CLI`) is a type of user interface that allows users to interact with electronic devices using text-based commands.
- `CLIs` are more powerful and flexible than `GUIs` because they allow users to perform complex tasks using simple commands.
- `CLIs` are more efficient than `GUIs` because they do not require users to navigate through menus and windows to perform tasks.

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Case of Study: MariaDB CLI

```
arnel@arnel.com [~]# mysql -u arnel_test2 -p
Enter password:
Welcome to the MariaDB monitor.  Commands end with ; or \g.
Your MariaDB connection id is 8643
Server version: 10.1.25-MariaDB MariaDB Server

Copyright (c) 2000, 2017, Oracle, MariaDB Corporation Ab and others.

Type 'help;' or '\h' for help. Type '\c' to clear the current input statement.

MariaDB [(none)]> show databases;
+--------------------+
| Database           |
+--------------------+
| arnel_test1        |
| arnel_test2        |
| information_schema |
+--------------------+
3 rows in set (0.00 sec)

MariaDB [(none)]> use arnel_test1
Reading table information for completion of table and column names
You can turn off this feature to get a quicker startup with -A

Database changed
MariaDB [arnel_test1]>
```

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Why use an agnostic tool?

- An **agnostic tool** is a tool that is not tied to a specific technology or platform.
- **Agnostic tools** are useful because they allow users to work with multiple databases without having to learn different tools.
- **Agnostic tools** are also useful because they allow users to work with multiple databases without having to switch between different tools.

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Outline

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What is the Cloud Computing?

- **Cloud computing** is the delivery of computing services over the internet.
- **Cloud computing** allows users to access computing resources such as servers, storage, and databases **on demand**.

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What is On-Premises Computing?

- **On-premises computing** is the traditional way of accessing computing resources.
- **On-premises computing** requires users to purchase and maintain their own computing resources such as servers, storage, and databases.

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Pros & Cons of Cloud Computing

- **Pros**:
  - **Cost-Effective**: Cloud computing is a cost-effective way to access computing resources.
  - **Scalable**: Cloud computing is a scalable way to access computing resources.
  - **Flexible**: Cloud computing is a flexible way to access computing resources.
- **Cons**:
  - **Security**: Cloud computing can be less secure than on-premises computing.
  - **Performance**: Cloud computing can be slower than on-premises computing.
  - **Reliability**: Cloud computing can be less reliable than on-premises computing.

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SaaS Vs. IaaS Vs. PaaS

- **Software as a Service** (*SaaS*) is a software distribution model in which a third-party provider hosts applications and makes them available to customers over the internet.
- **Infrastructure as a Service** (*IaaS*) is a cloud computing model that provides virtualized computing resources over the internet.
- **Platform as a Service** (*PaaS*) is a cloud computing model that provides a platform for developers to build, deploy, and manage applications over the internet.

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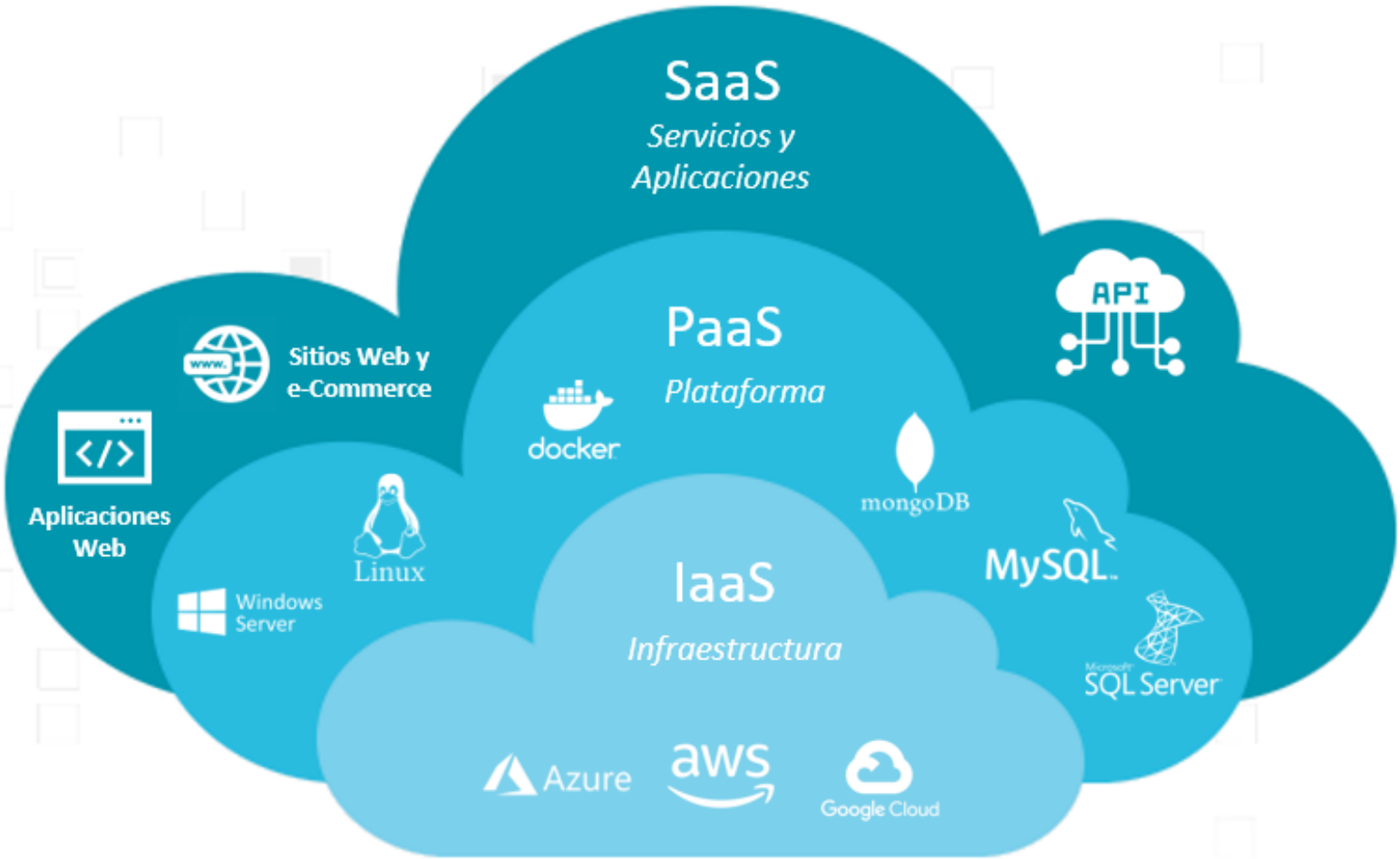
Cloud Levels



DataBases as a Service

Database as a Service (DBaaS) is a cloud computing model that provides database services over the internet.

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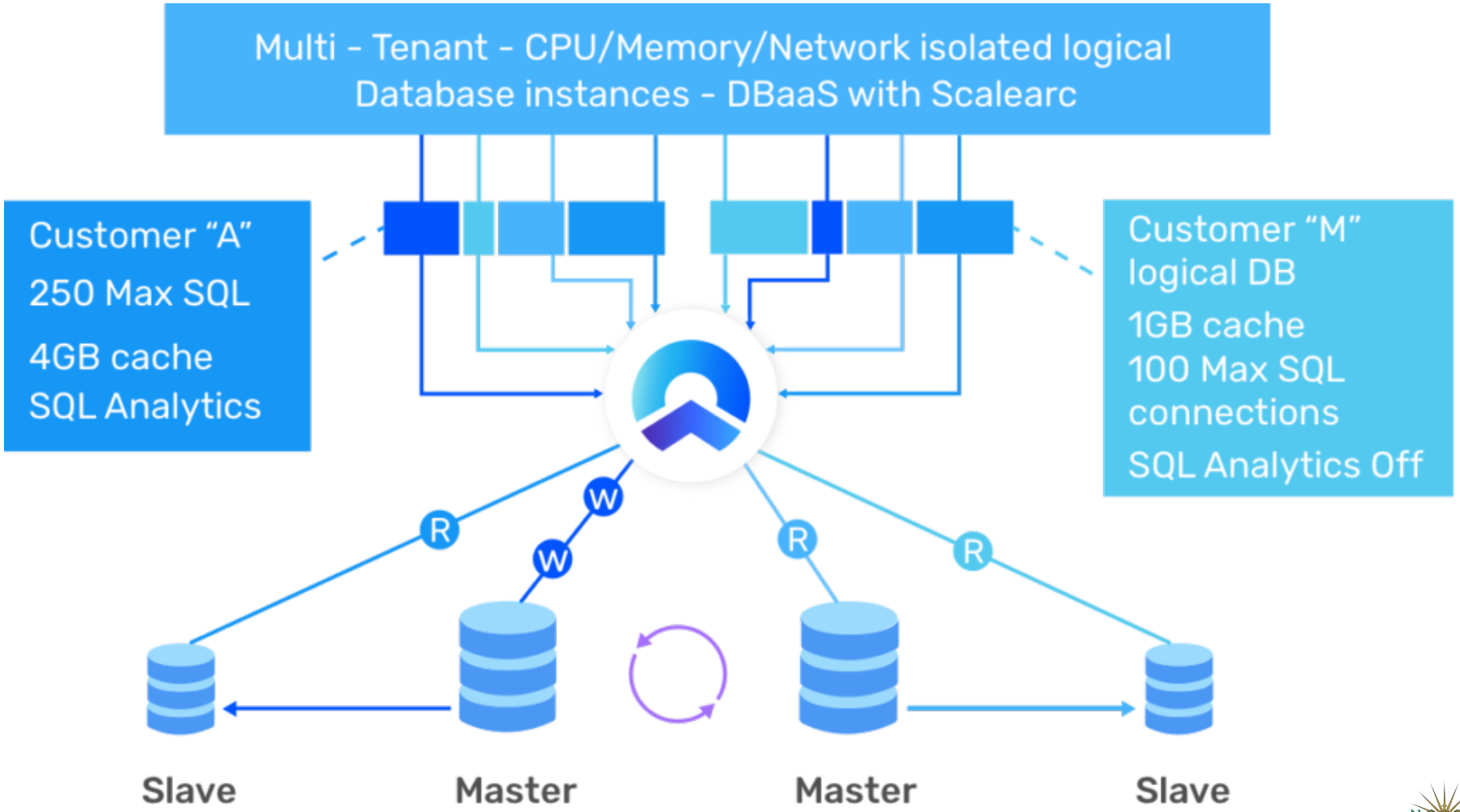
Case of Study: DBaaS Custom for Clients



Localhost

- **Localhost** is a hostname that refers to the local computer that a program is running on.
- **Localhost** is used to access the services that are running on the local computer.
- **Localhost** is used to access the database services that are running on the local computer.
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Monolithic Architecture

- **Monolithic Architecture** is a software architecture in which all the components of the software are combined into a single program.
- **Monolithic Architecture** is a traditional software architecture that was used to build large and complex software systems.
- **Monolithic Architecture** is a simple and easy-to-understand software architecture that is used to build software systems that do not require high scalability and flexibility.

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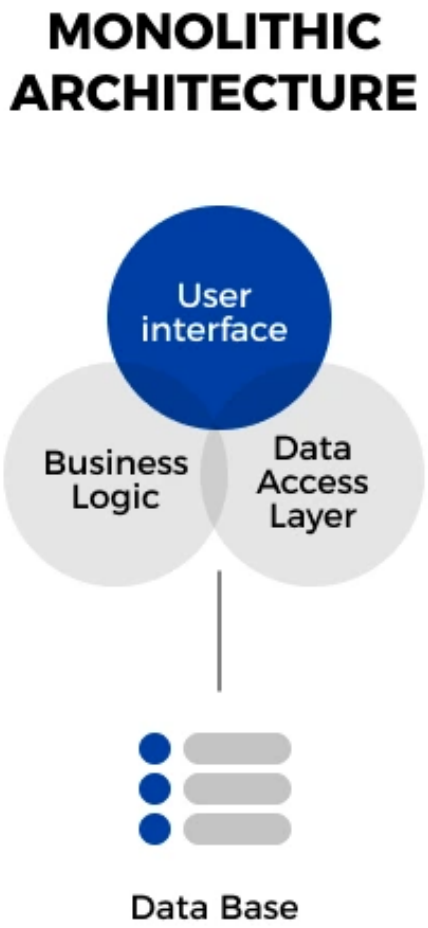
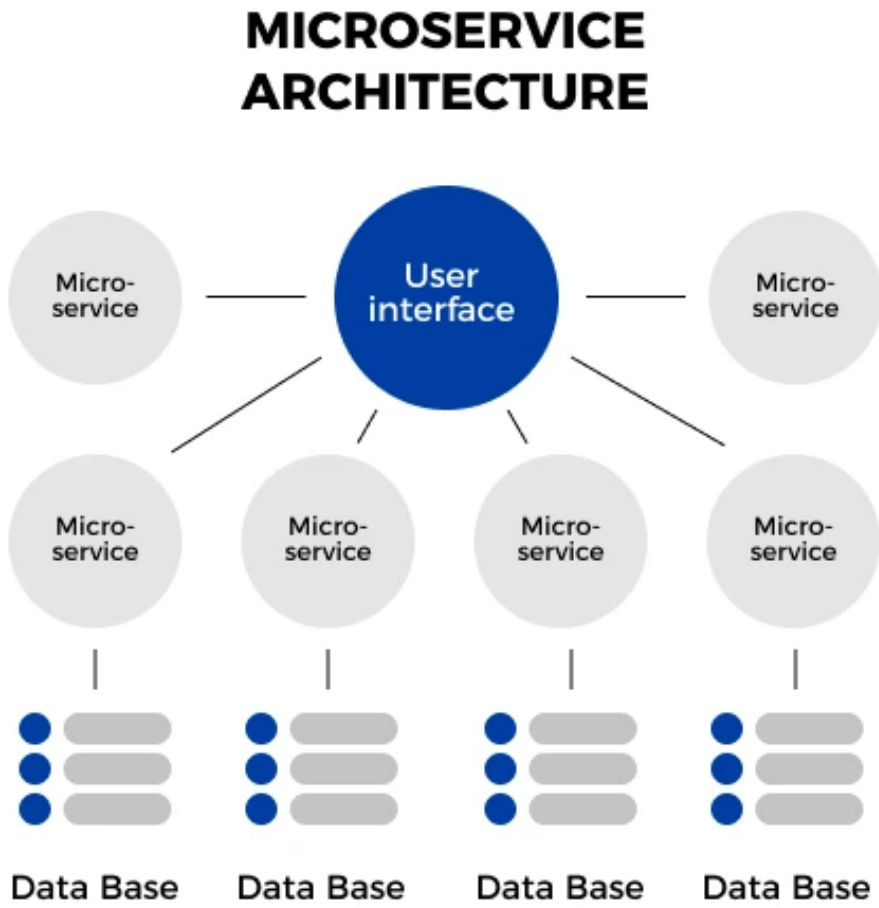
Microservices Architecture

- **Microservices Architecture** is a software architecture in which the components of the software are broken down into small, independent services.
- **Microservices Architecture** is a modern software architecture that is used to build large and complex software systems.
- **Microservices Architecture** is a flexible and scalable software architecture that is used to build software systems that require high scalability and flexibility.

Monolithic Architecture Schema





Outline

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Continuous Integration

- **Continuous Integration** is a software development practice in which developers integrate code into a shared repository frequently.
- **Continuous Integration** is a software development practice that helps developers to detect and fix integration errors early.

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Continuous Deployment

- Developers deploy code into production frequently.
- **Continuous Deployment** is a software development practice that helps developers deliver new features to customers quickly.
- **Continuous Deployment** is also a practice that helps developers improve the quality of the software.

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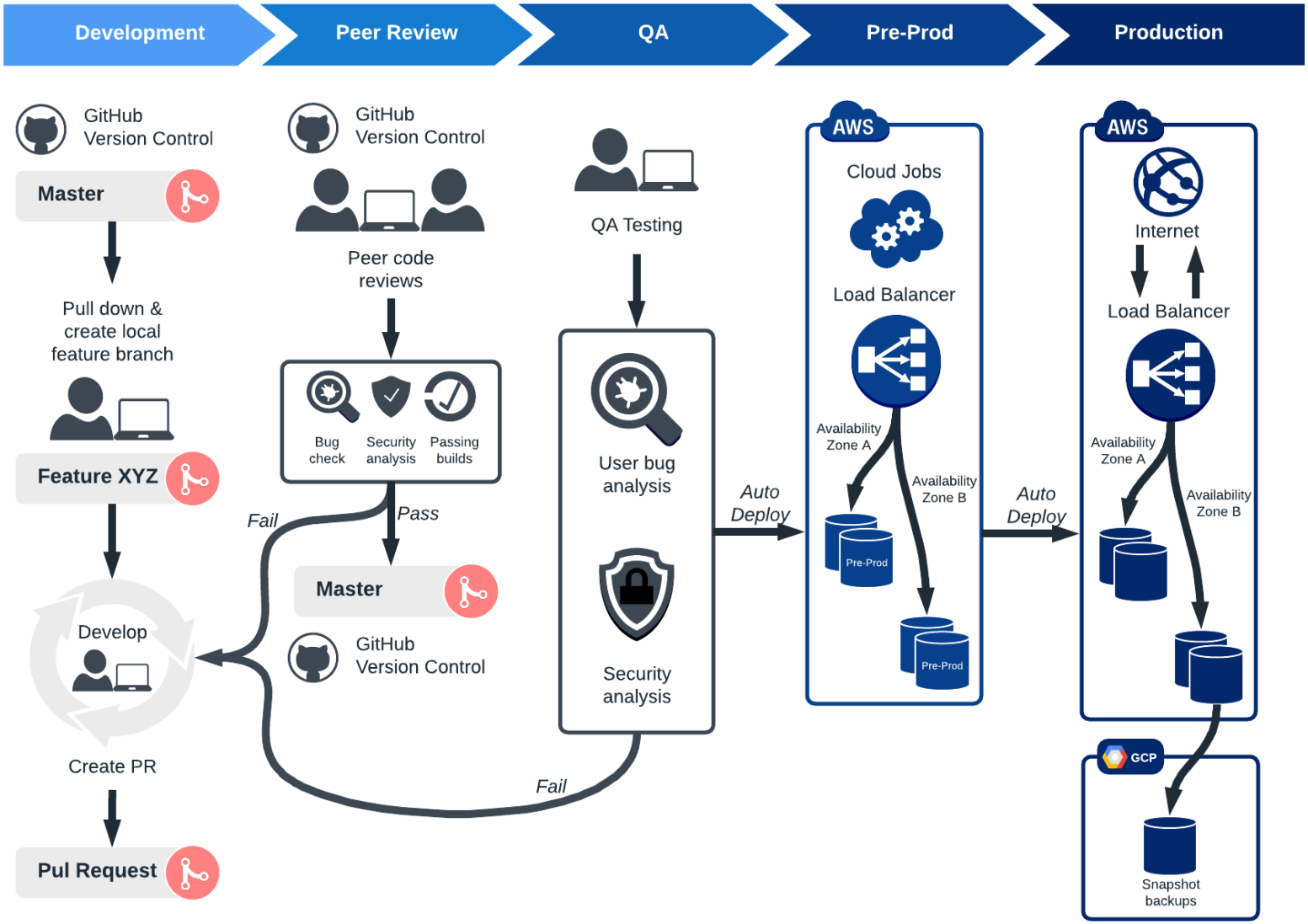
Development Workflow using CI/CD



Containers and Docker

- **Containers** are a lightweight and portable way to package software.
- **Containers** are a method to isolate applications from the underlying system.
- **Docker** is a platform that allows developers to build, ship, and run containers.

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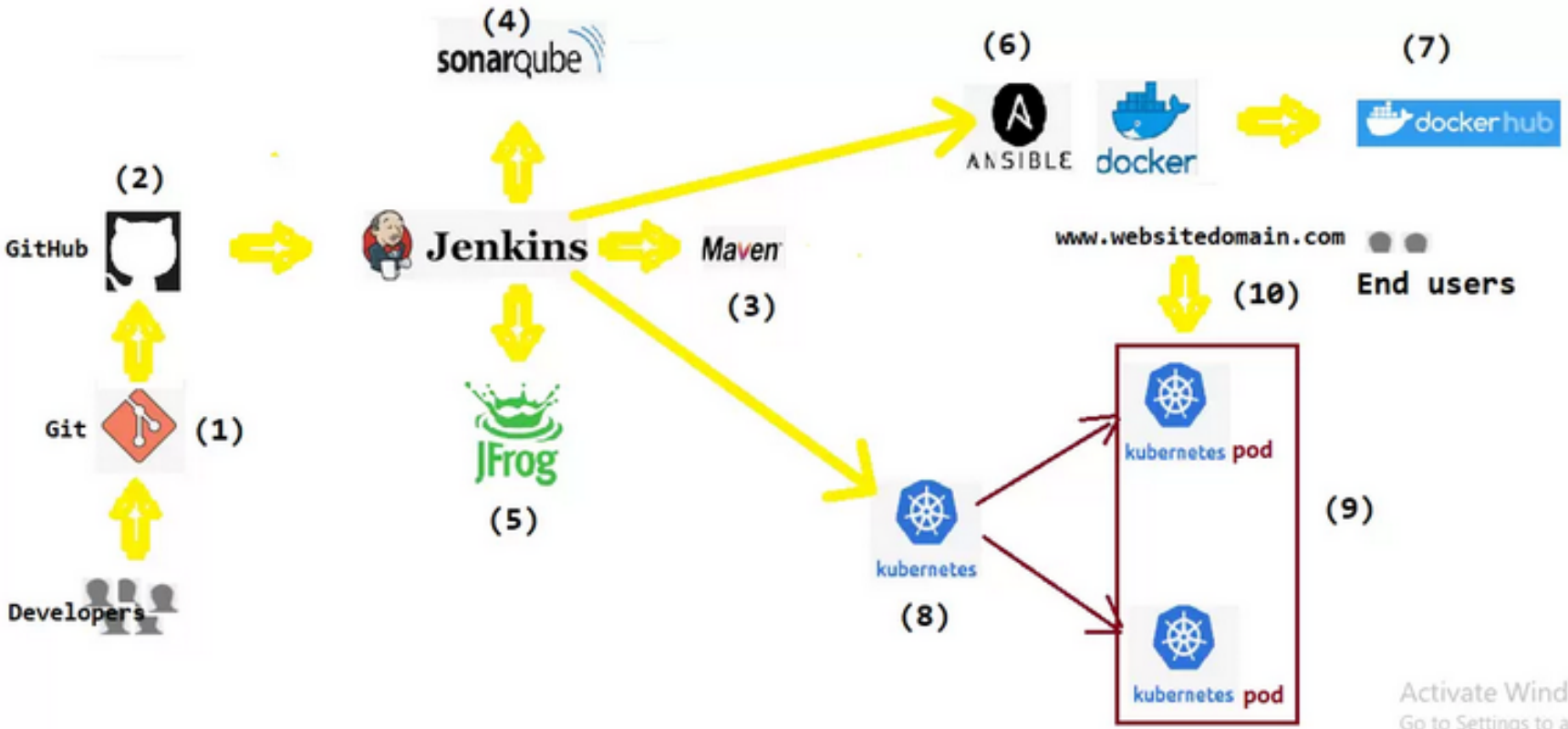
From Code to Docker



Outline

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What is Data Engineering?

- **Data Engineering** is the aspect of data science that focuses on practical applications of data collection and analysis.
- **Data Engineers** are responsible for building and maintaining the architecture that allows data scientists to perform their work.
- **Data Engineering** is a set of operations aimed at creating interfaces and mechanisms for the flow and access of data.

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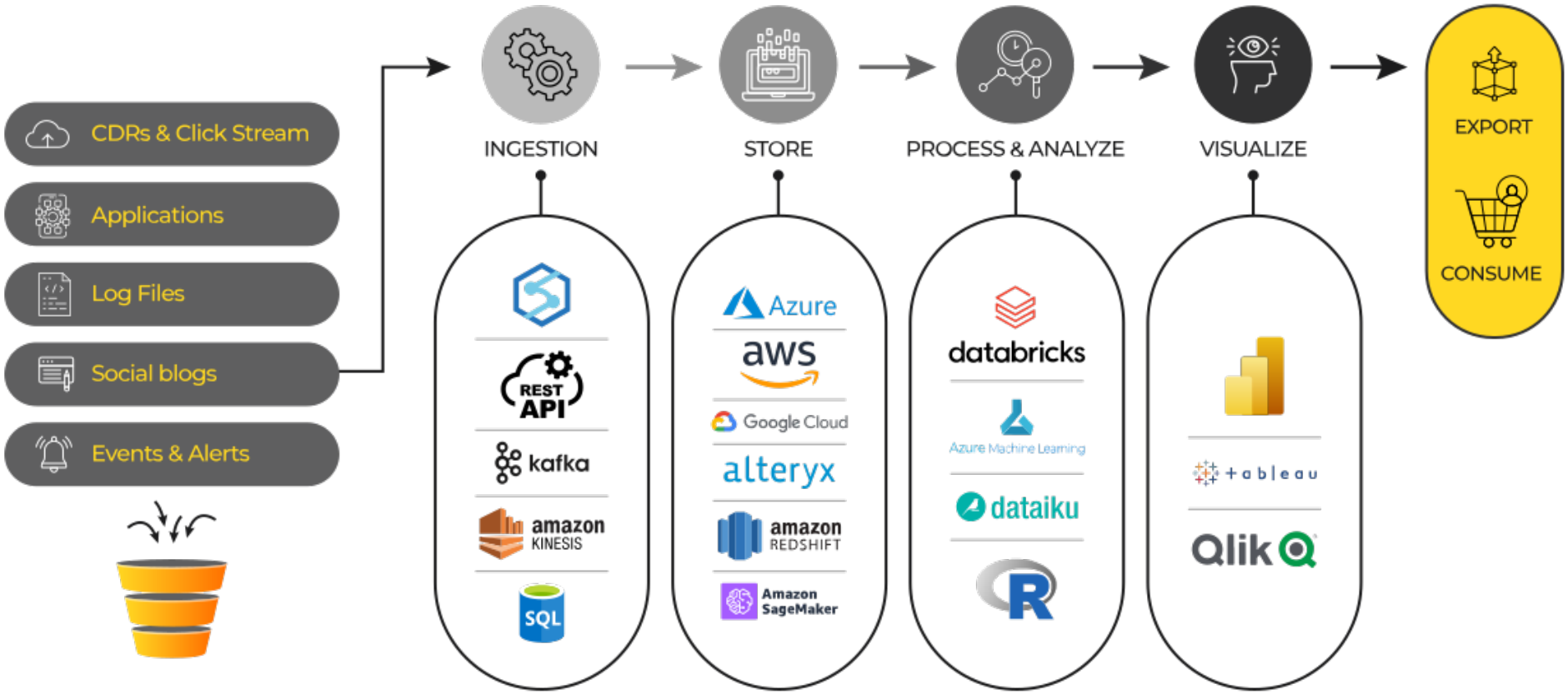
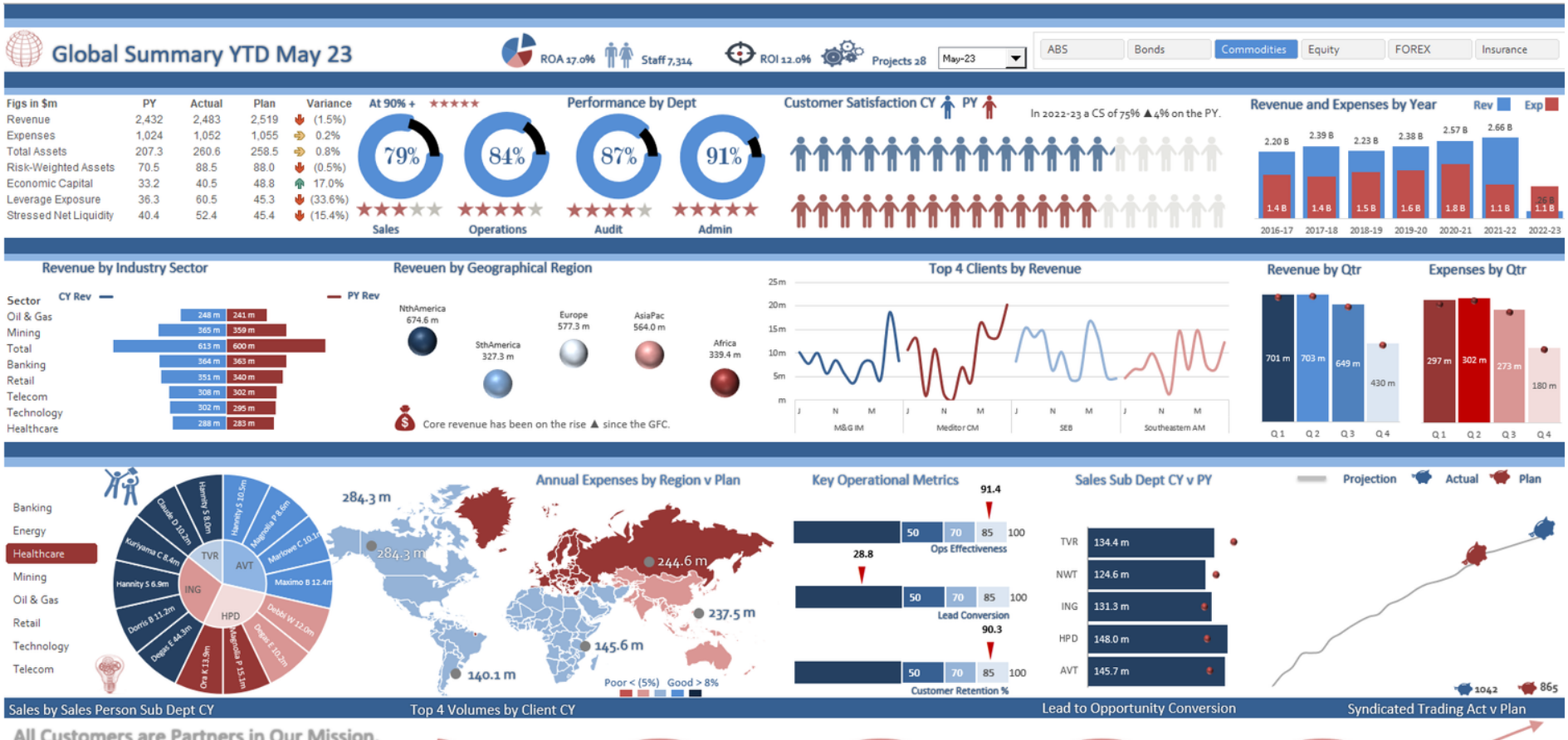
Why is important Data Engineering?

- **Data Engineering** is the foundation of the high-quality data that is necessary for effective data science.
- **Data Engineering** is the process of collecting, transforming, and storing data in a way that's accessible and easy to analyze.

Data Engineering Architecture



Case of Study: Dashboards



Data Science

- **Data Science** is the process of extracting knowledge from data.
- **Data Science** is the process of analyzing and interpreting complex digital data.
- **Data Science** is the process of creating models that can predict future outcomes.
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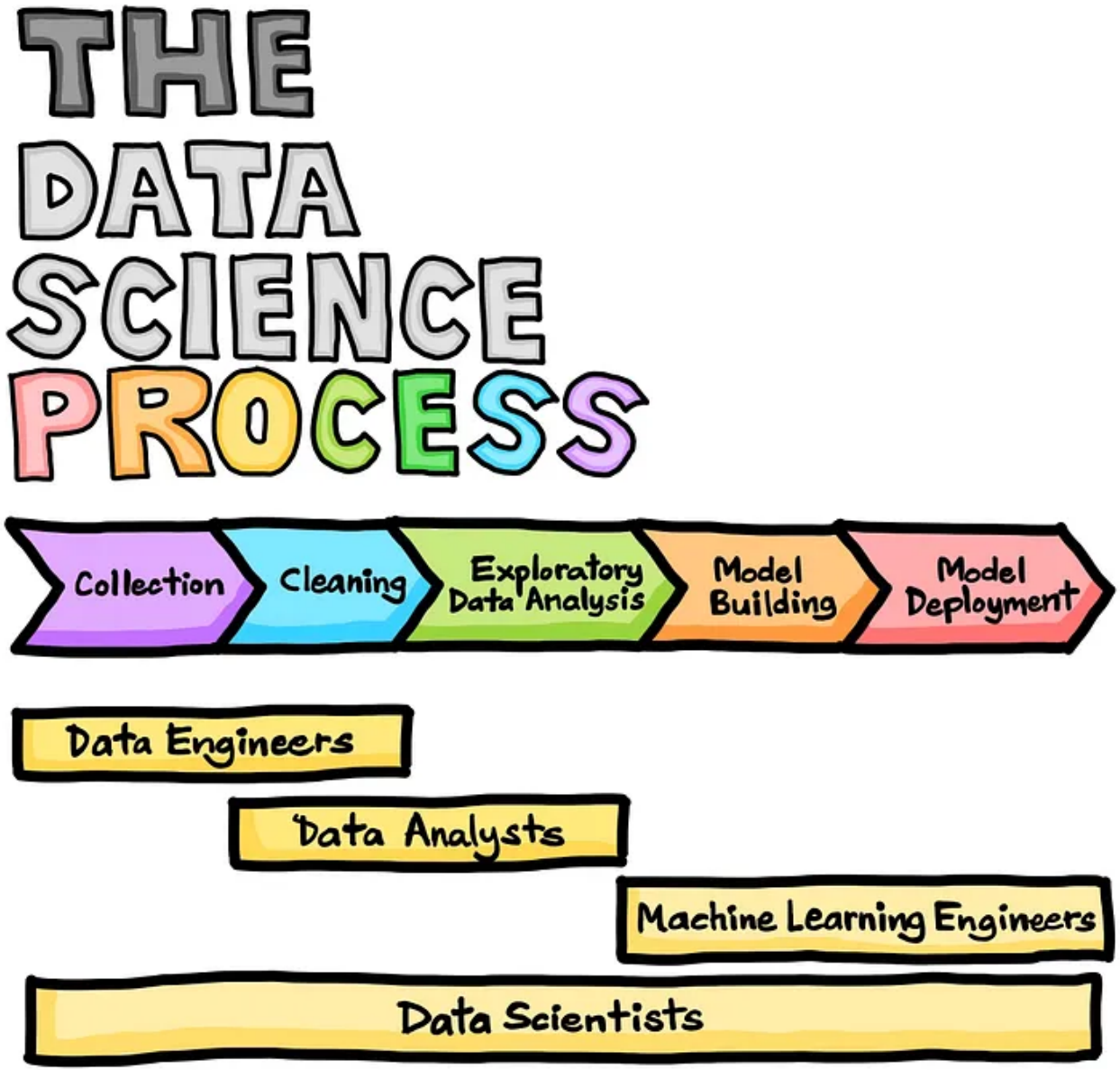
Data Science Workflow



DBOps vs Data Engineer

- **DBOps** is responsible for the operation of the database.
- **DBOps** is responsible for the performance of the database.
- **DBOps** is responsible for the security of the database.
- **Data Engineer** is responsible for the data architecture.
- **Data Engineer** is responsible for the data quality.
- **Data Engineer** is responsible for the data flow.

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How to improve data quality?

- **Data Quality** is the process of ensuring that data is accurate, complete, and reliable.
- **Data Quality** is the process of ensuring that data is consistent and up-to-date.
- **Data Quality** is the process of ensuring that data is free from errors and inconsistencies.
- **Data Quality** is the process of ensuring that data is of high quality and can be trusted.
- **Data Quality** is the process of ensuring that data is fit for purpose and can be used effectively.

Outline

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Thanks!

Questions?

Repo: `https://github.com/EngAndres/ud-public/tree/main/courses/databases-ii`

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