Introduction to Databases

Database Foundations

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2025-III

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Outline

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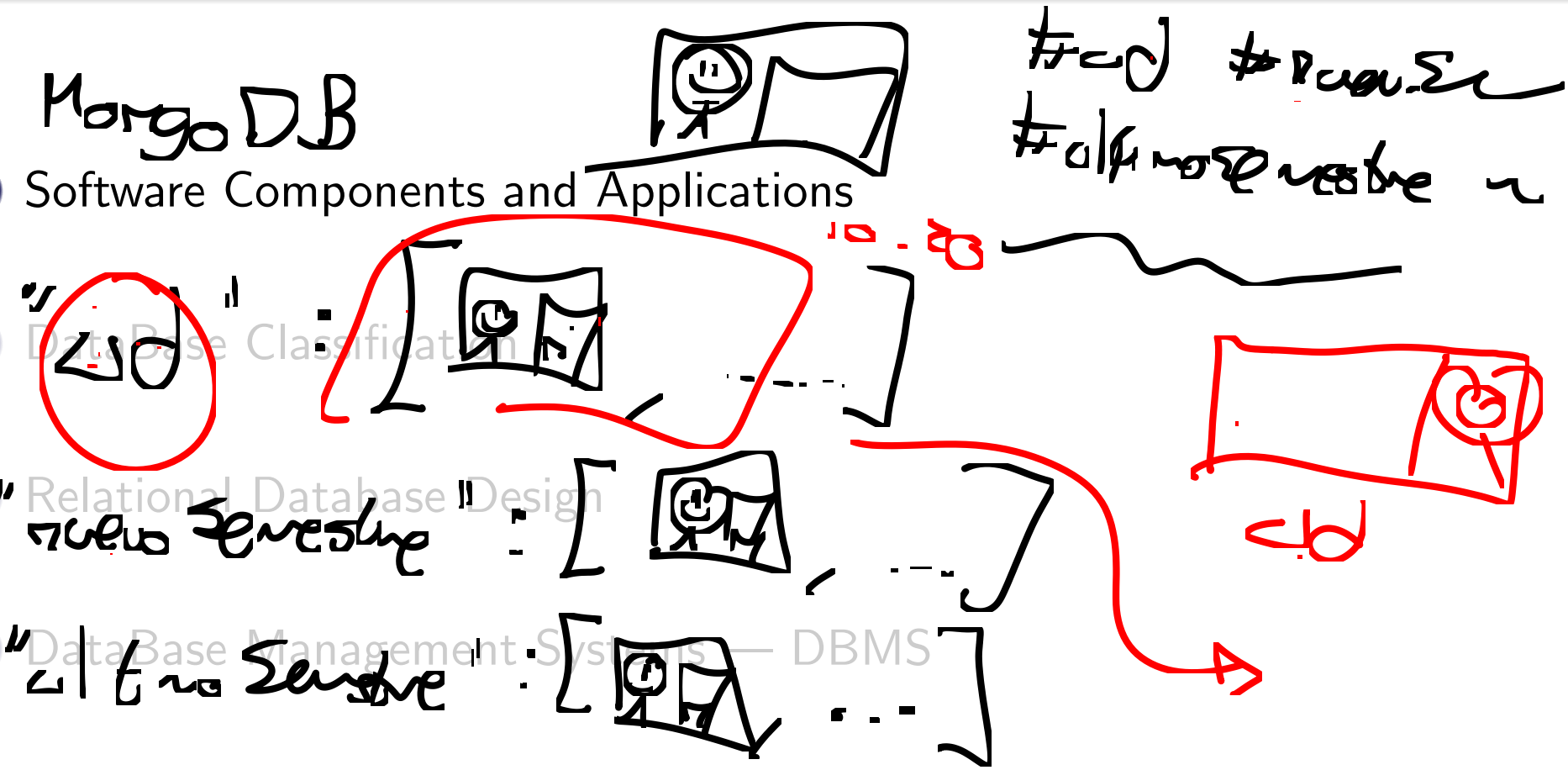
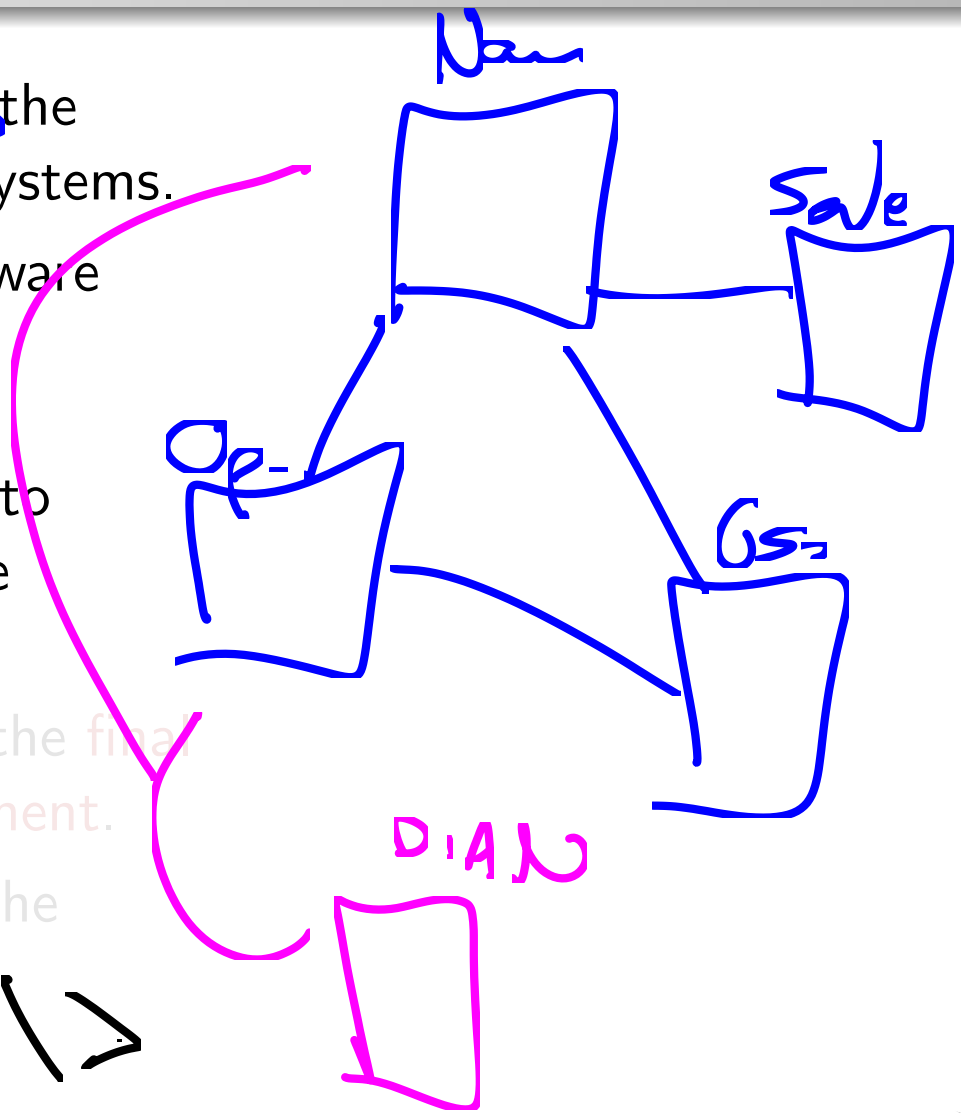


Modular Software Components

- **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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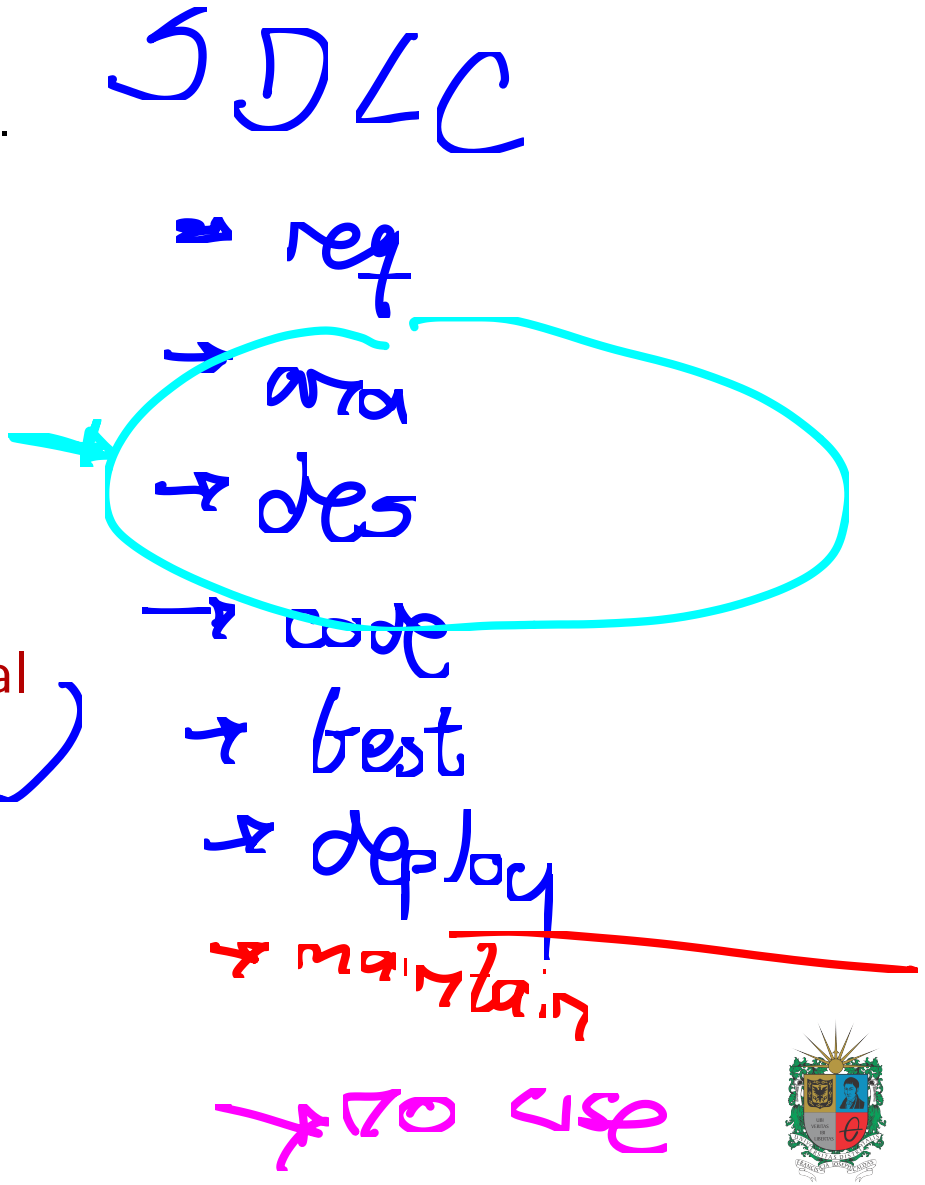
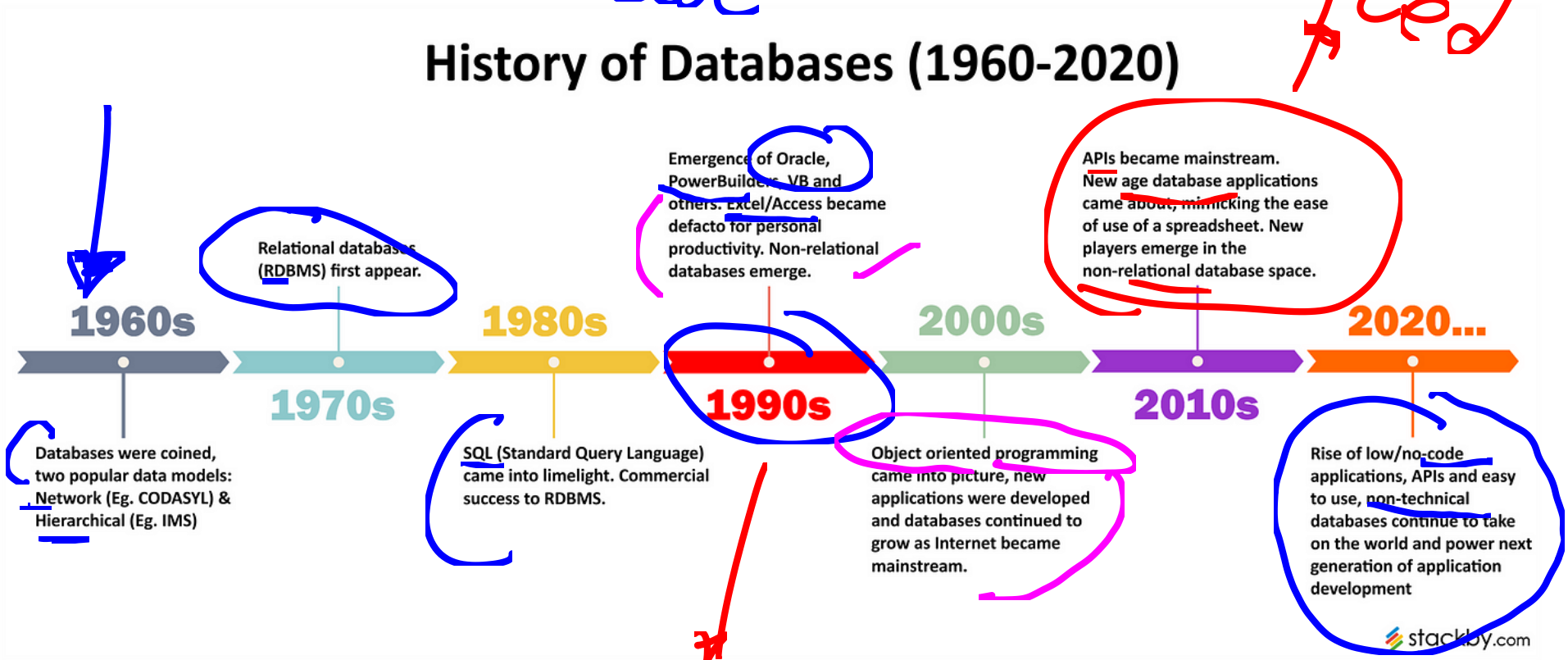
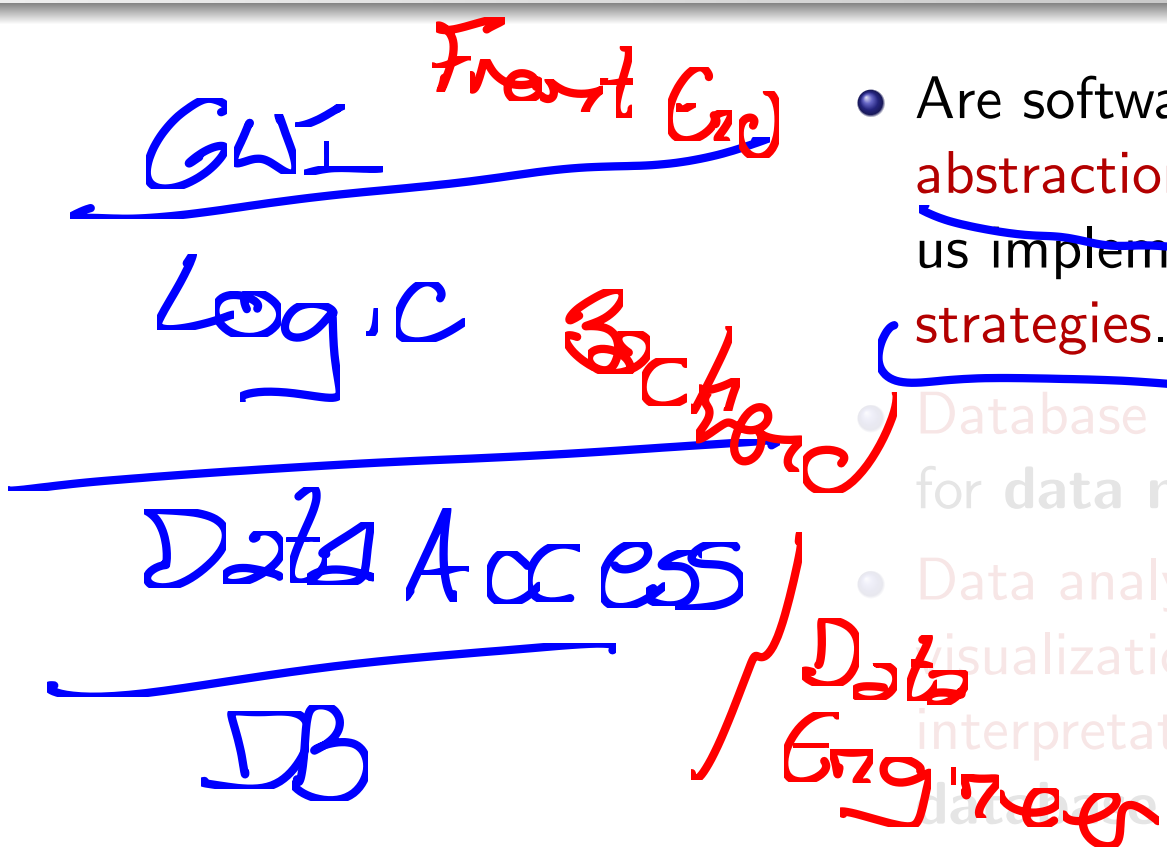


History of DataBases

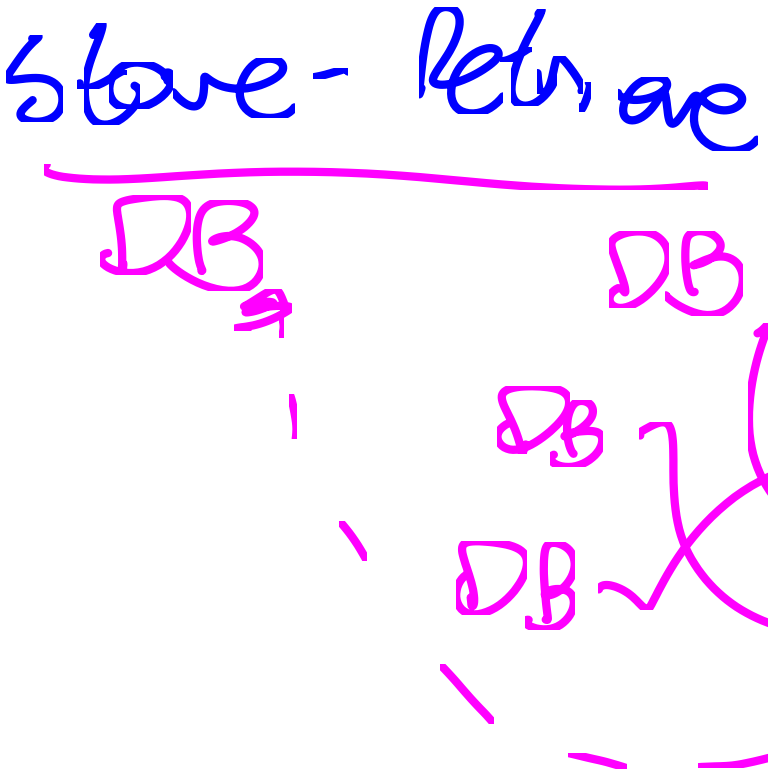


Applications



- Are software based on **layers** of abstraction and modularity that let us 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.

Applications



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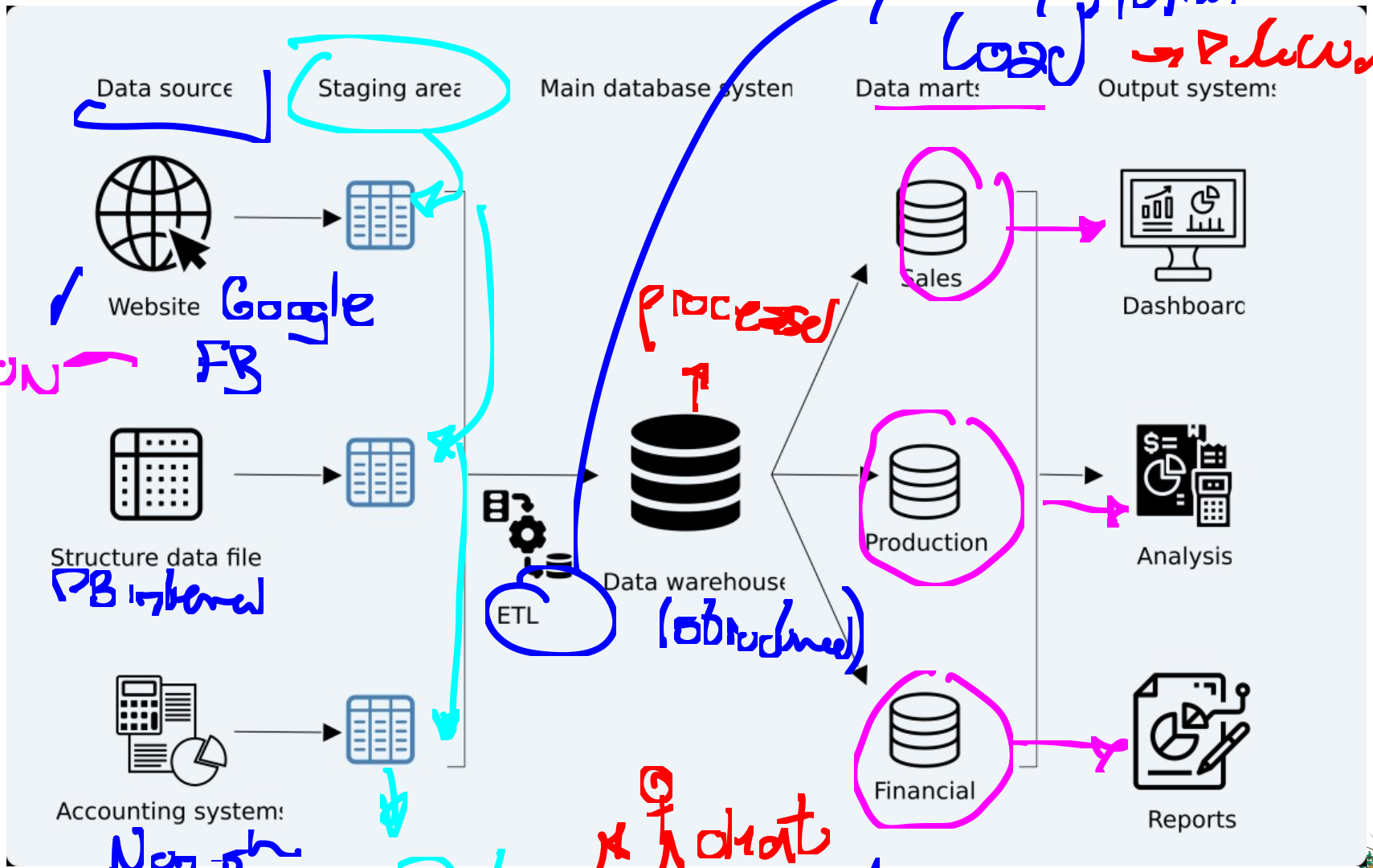
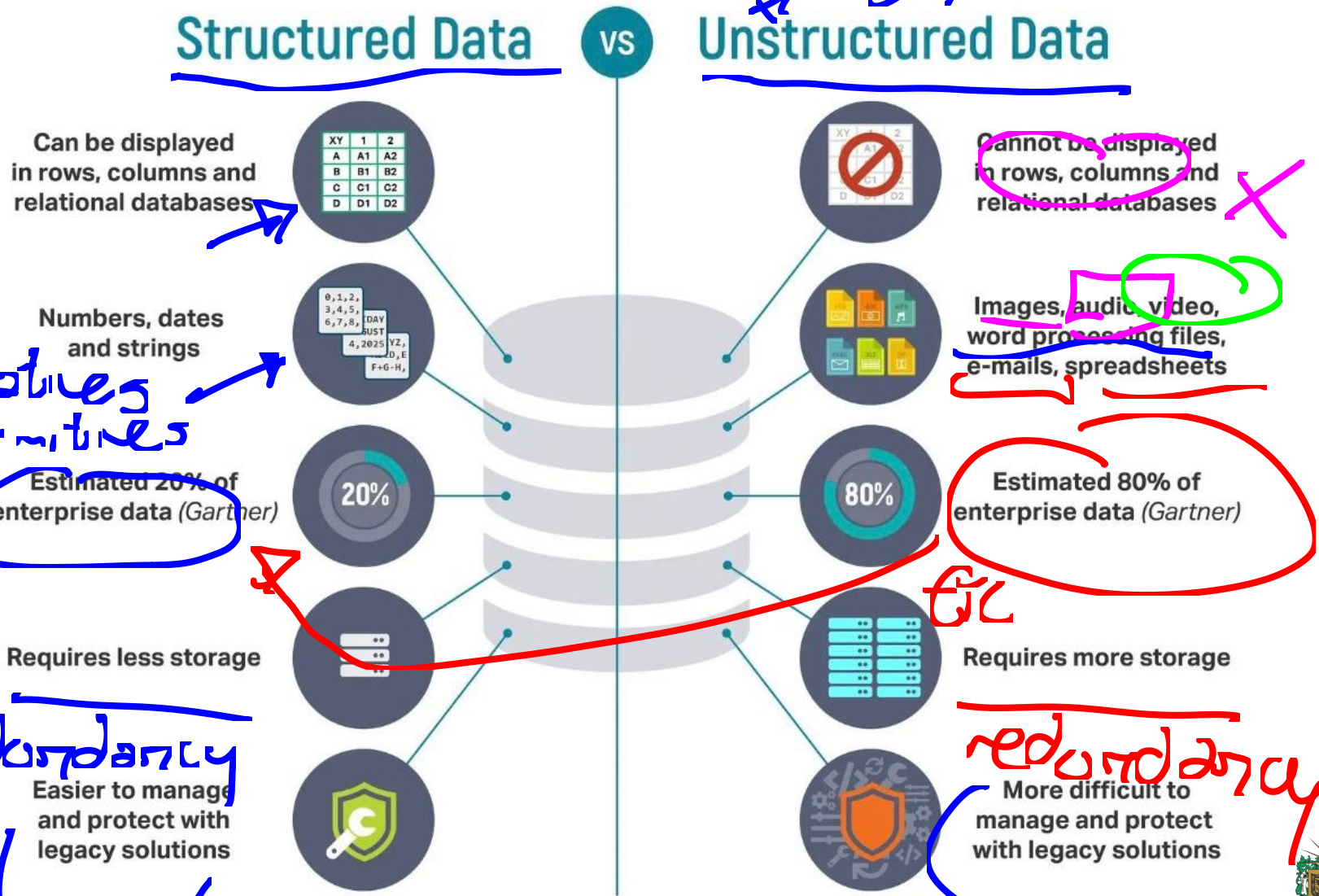
Case Study: Database System

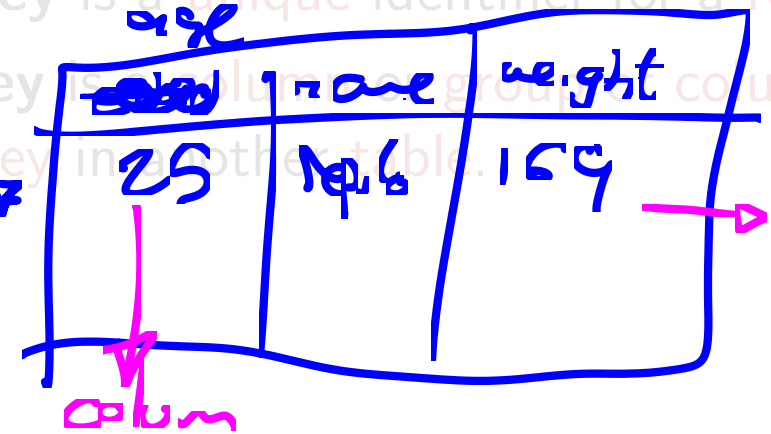


Structured and Unstructured Data



Tabular Structures

- **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 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.



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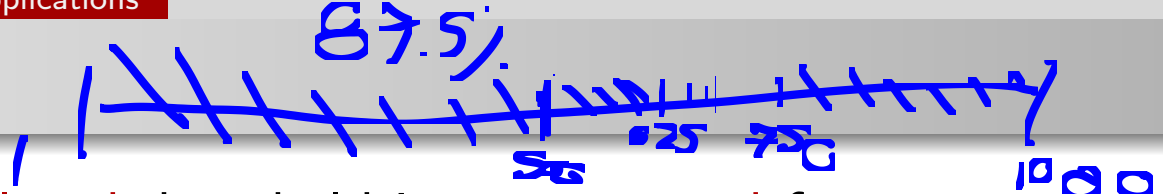

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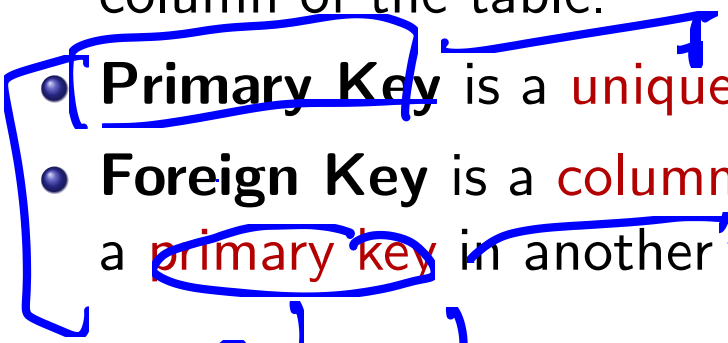
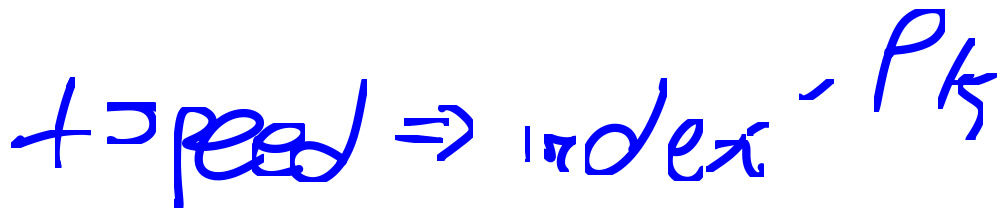
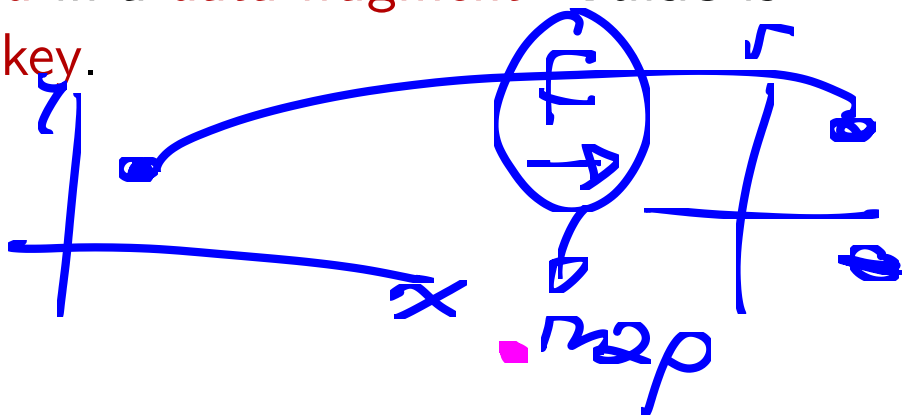




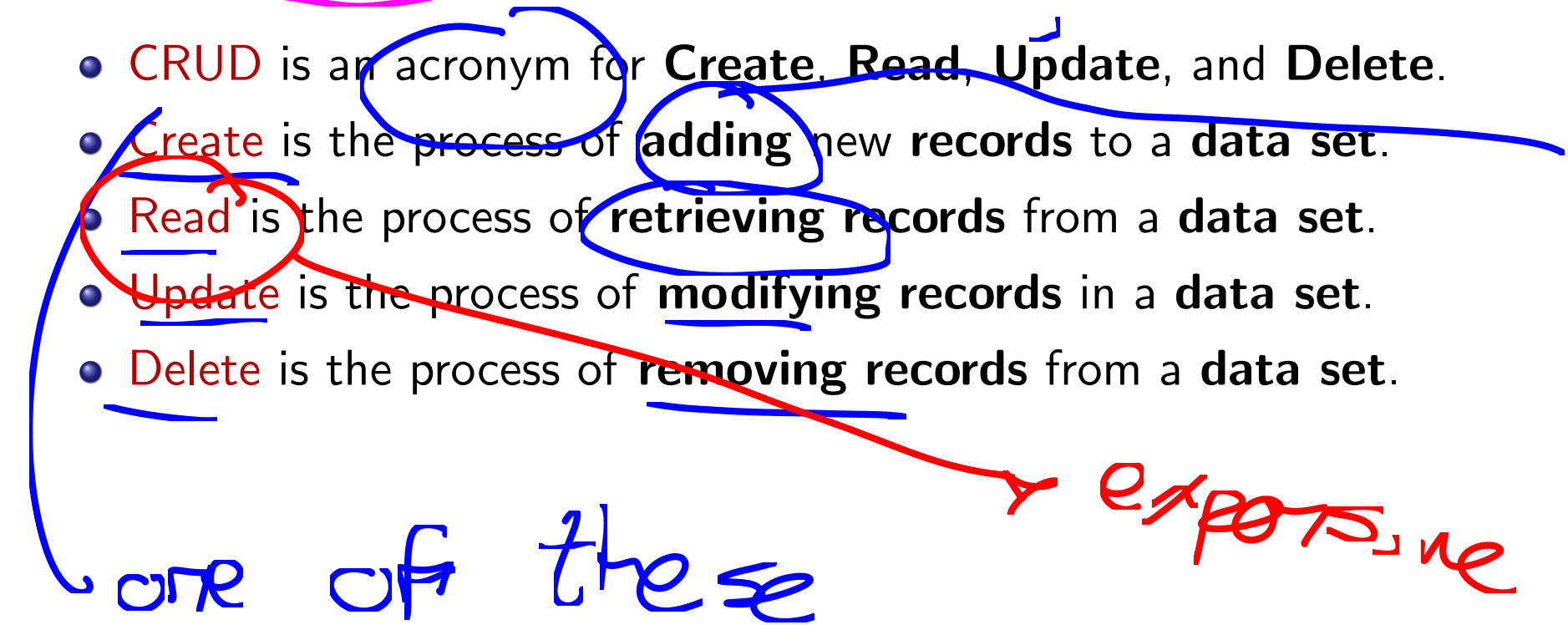
Key-Value Data Structures

- **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.



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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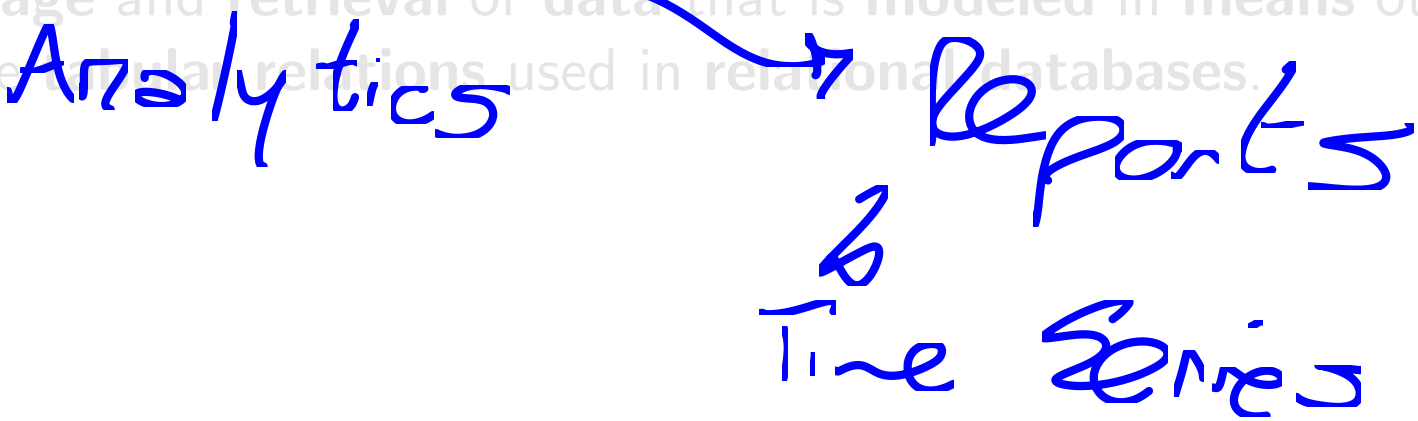

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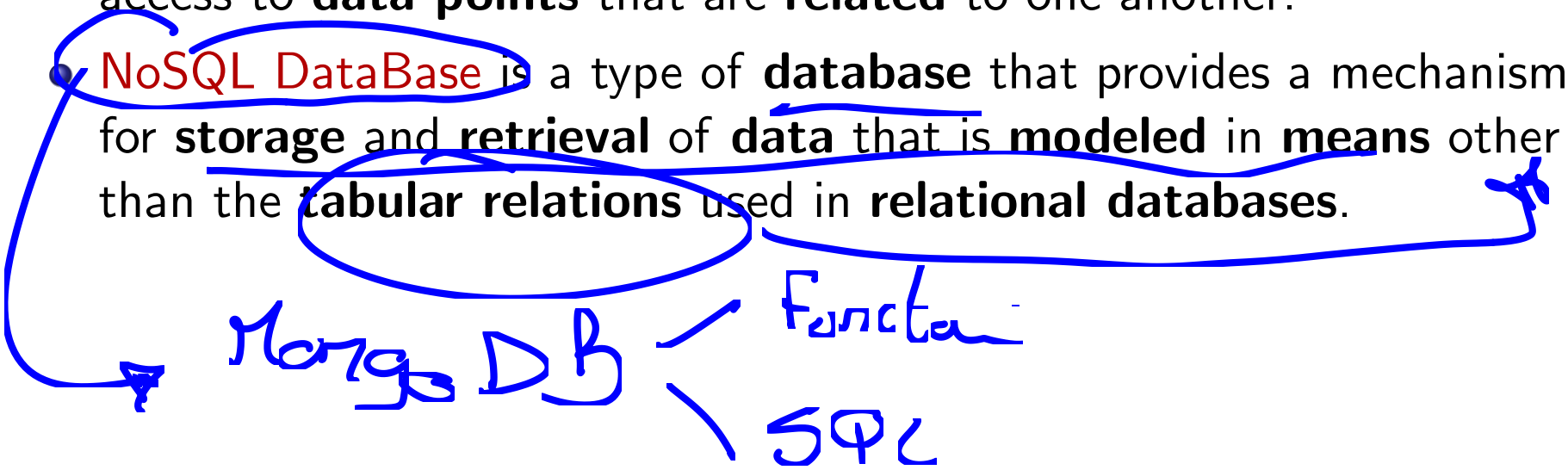
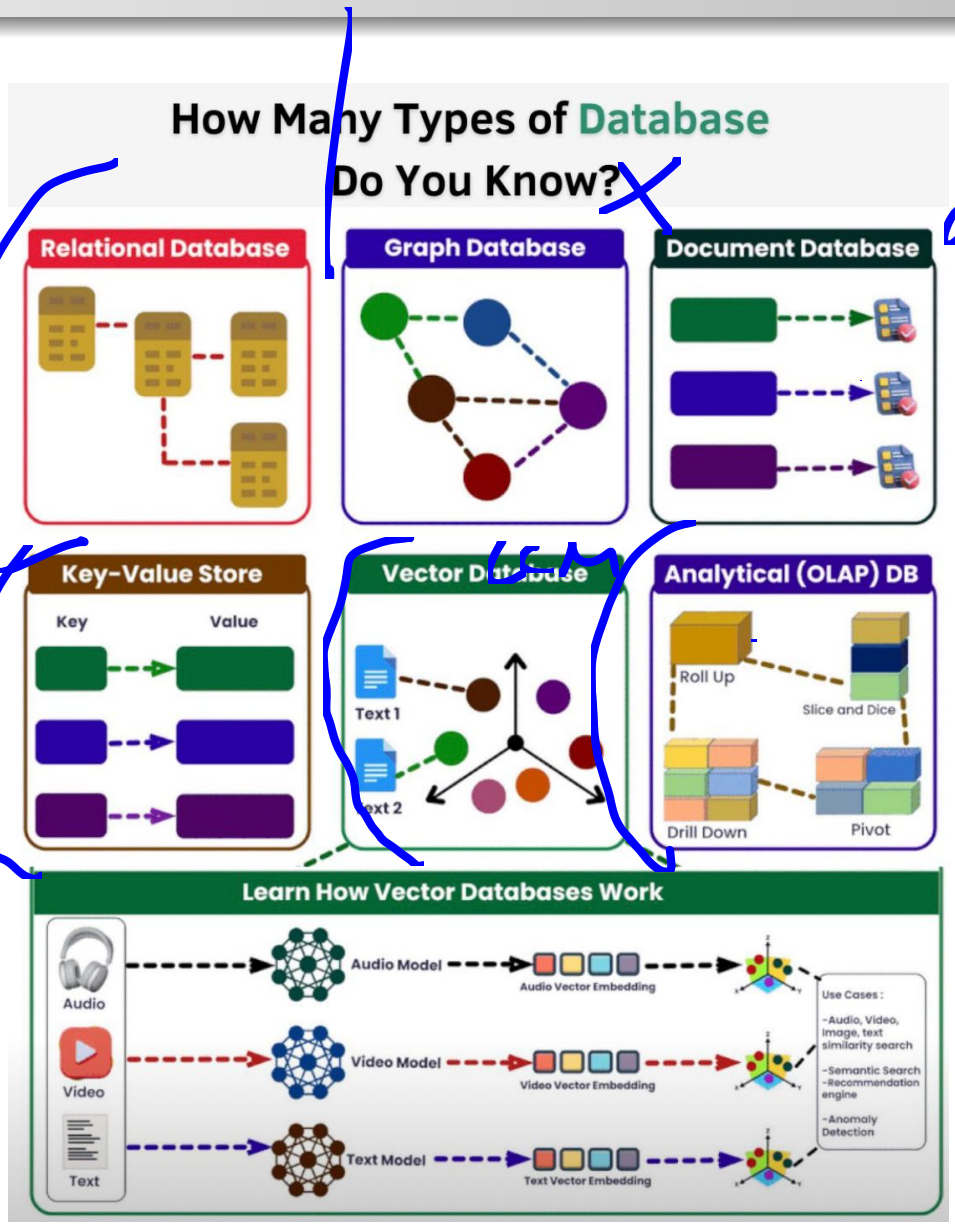
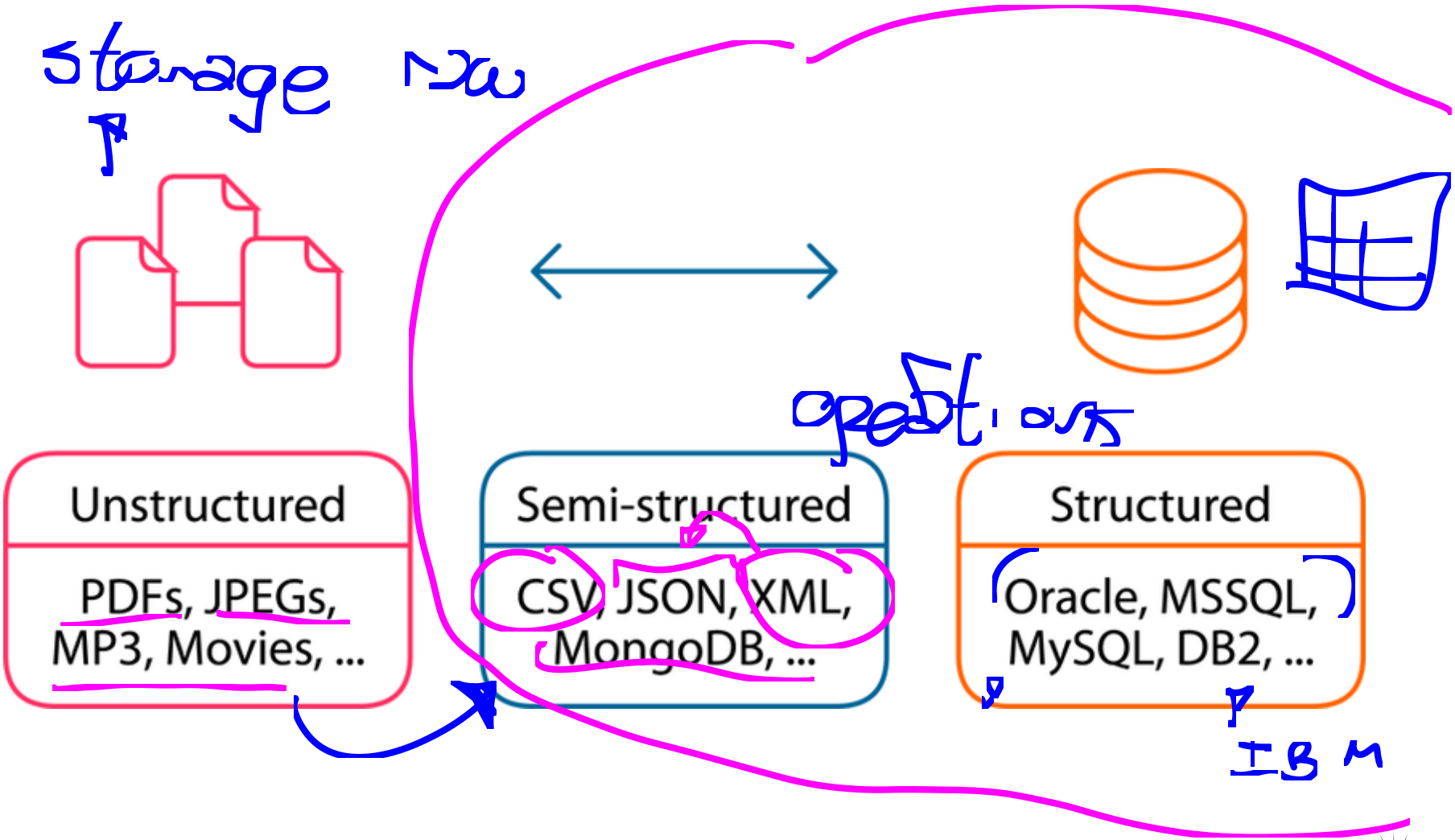


Types of Database



Semi-Structured Data



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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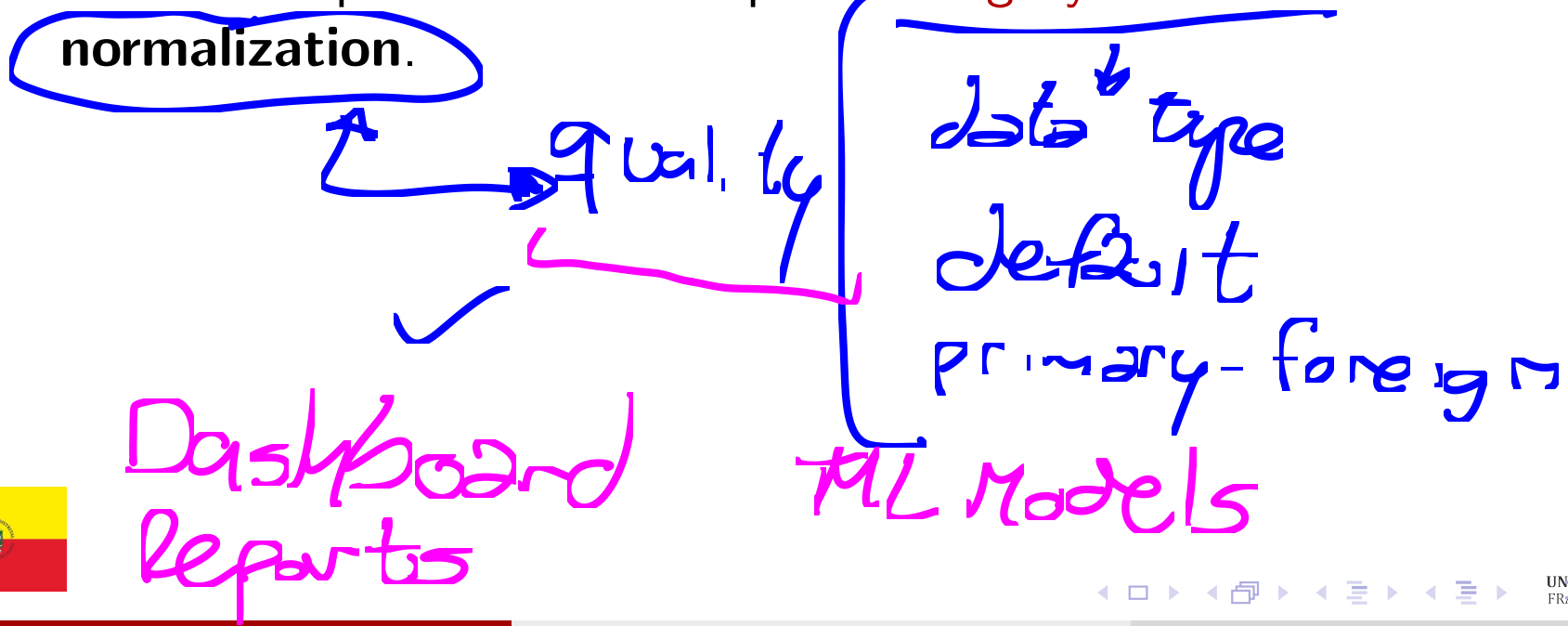
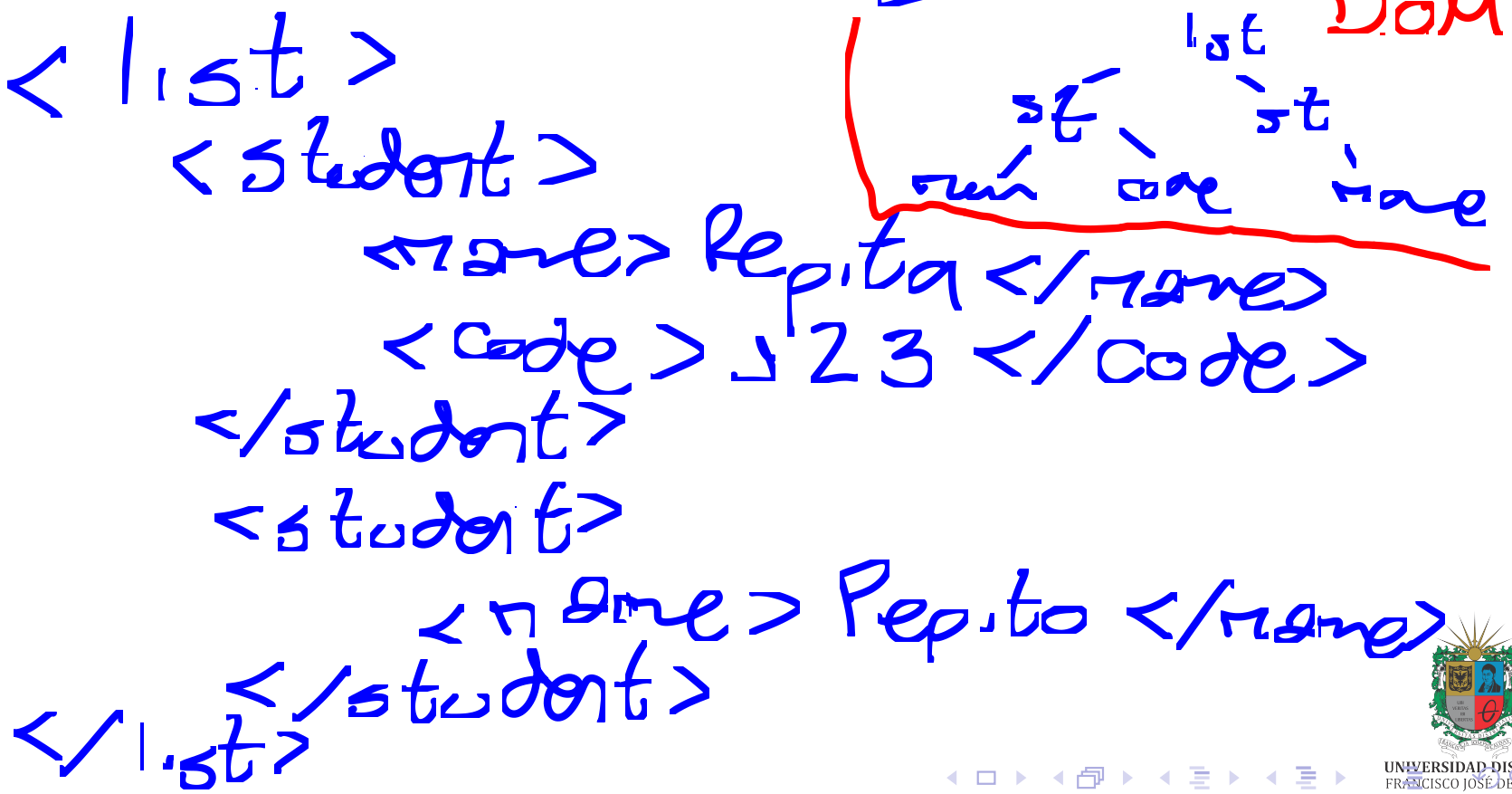


Hierarchical Model

- 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`.



Document-Based Model

Database(s)

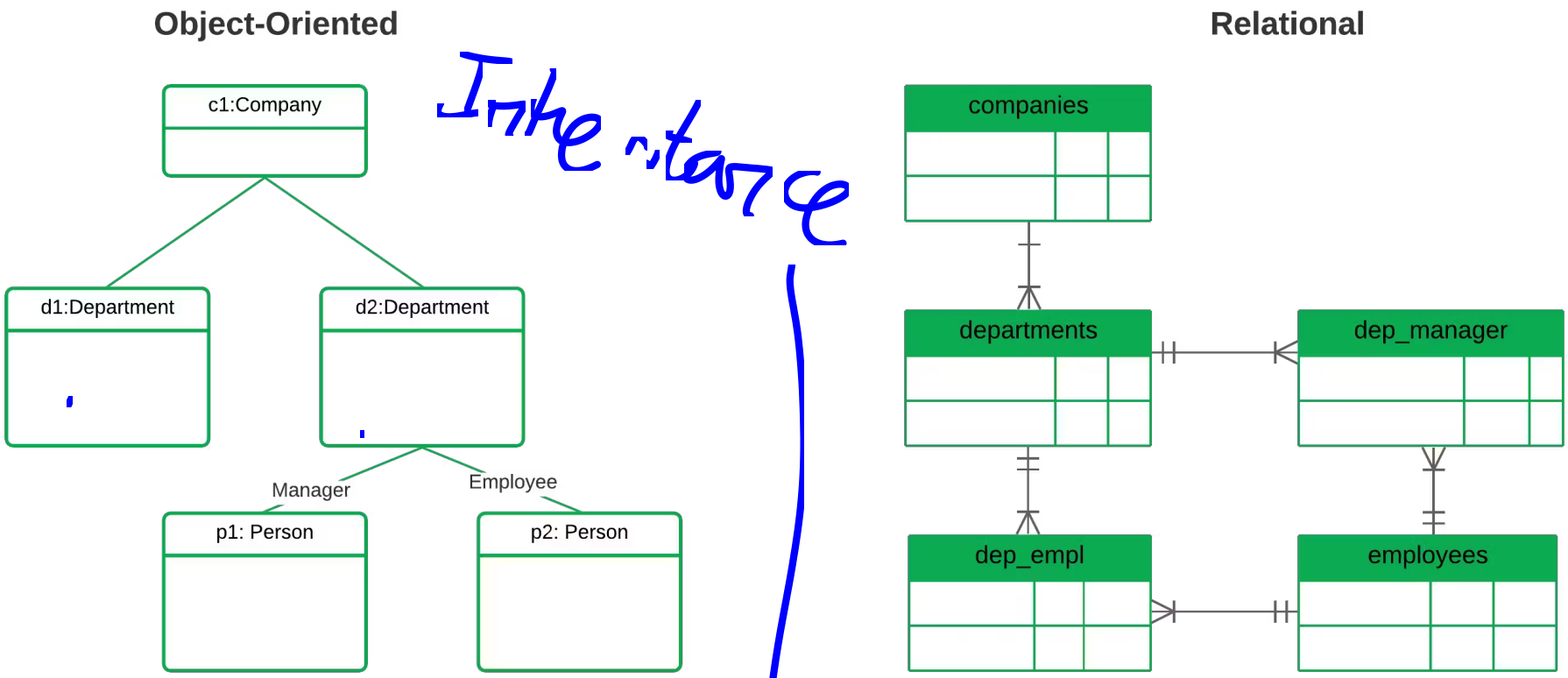
Collection(s)

Document(s)

```
{
  _id:1,
  key:"Lime",
  qty: 50
}
```

Field(s)

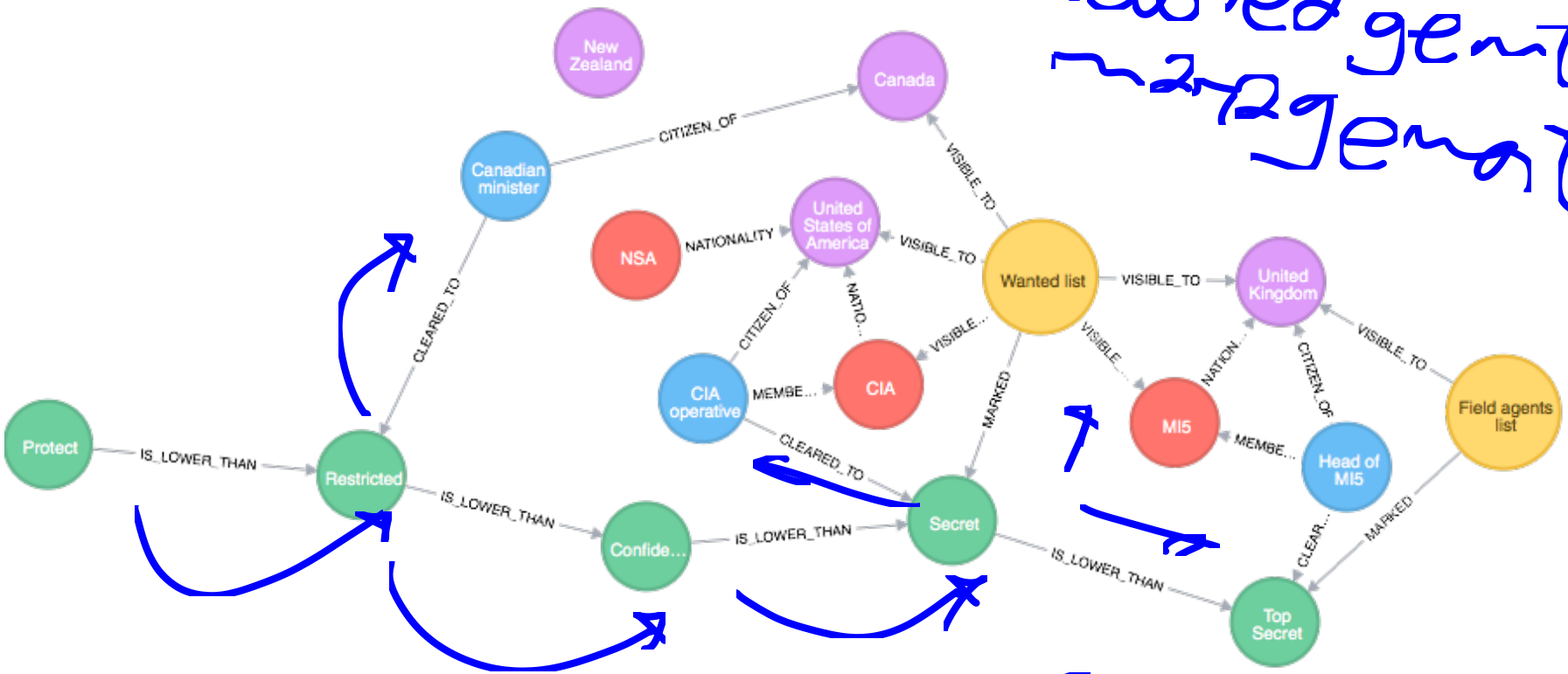
Object-Oriented Model



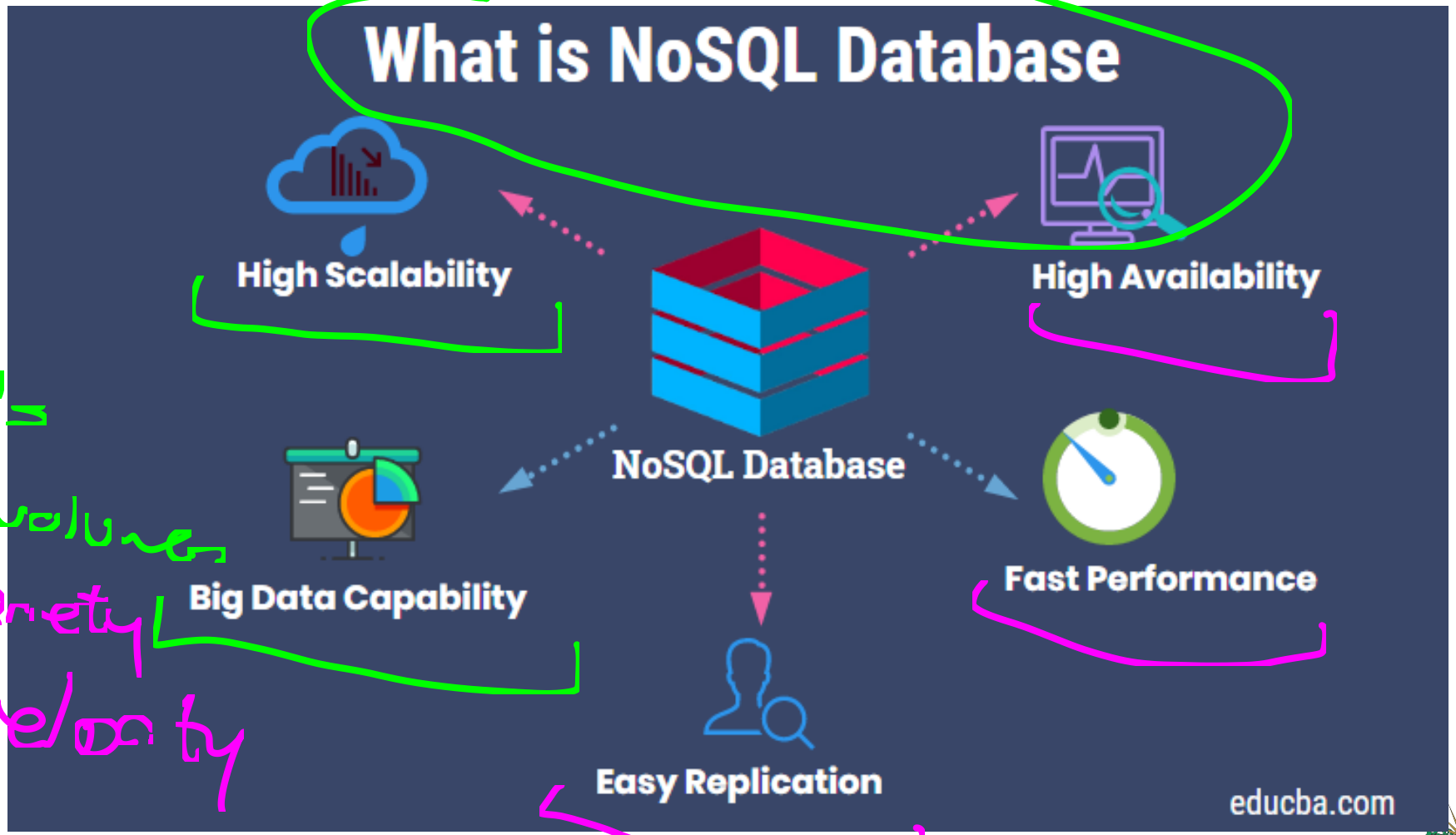
In the instance

methods → procedures stored

Graph-Based Model



NoSQL Model



V's
- volumen
- Variety
- velocity

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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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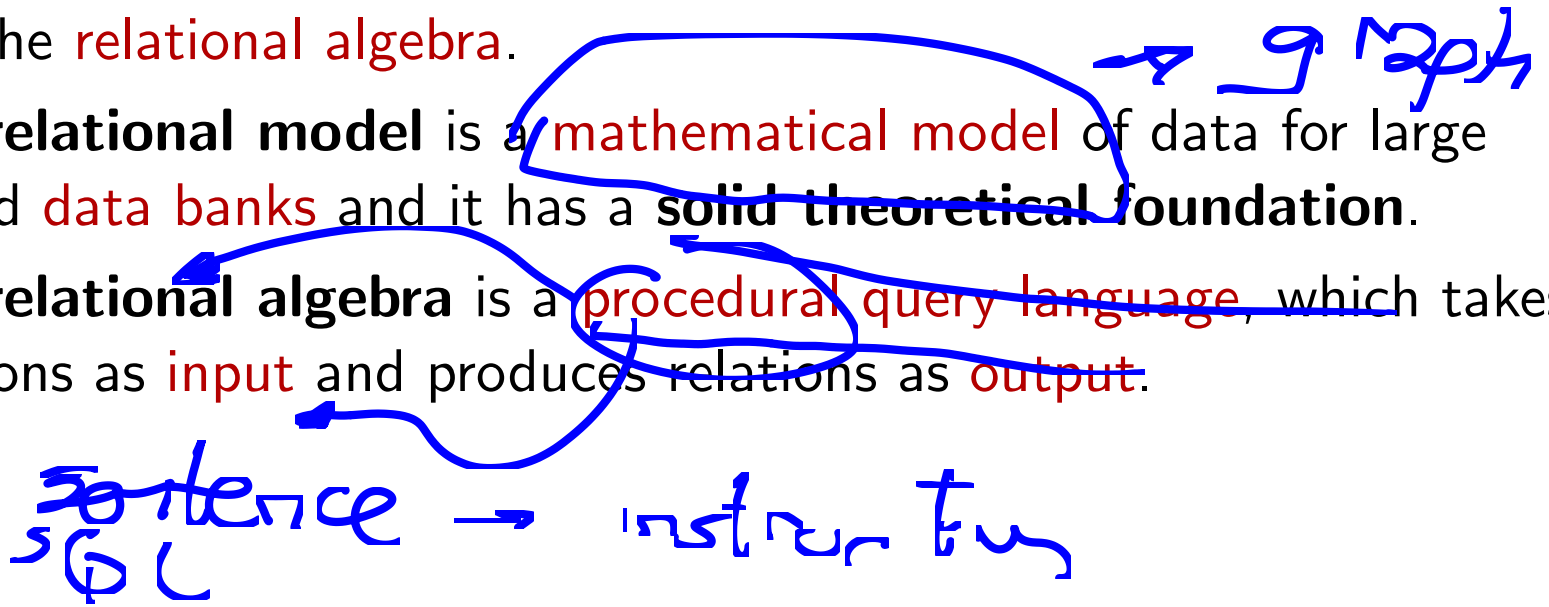
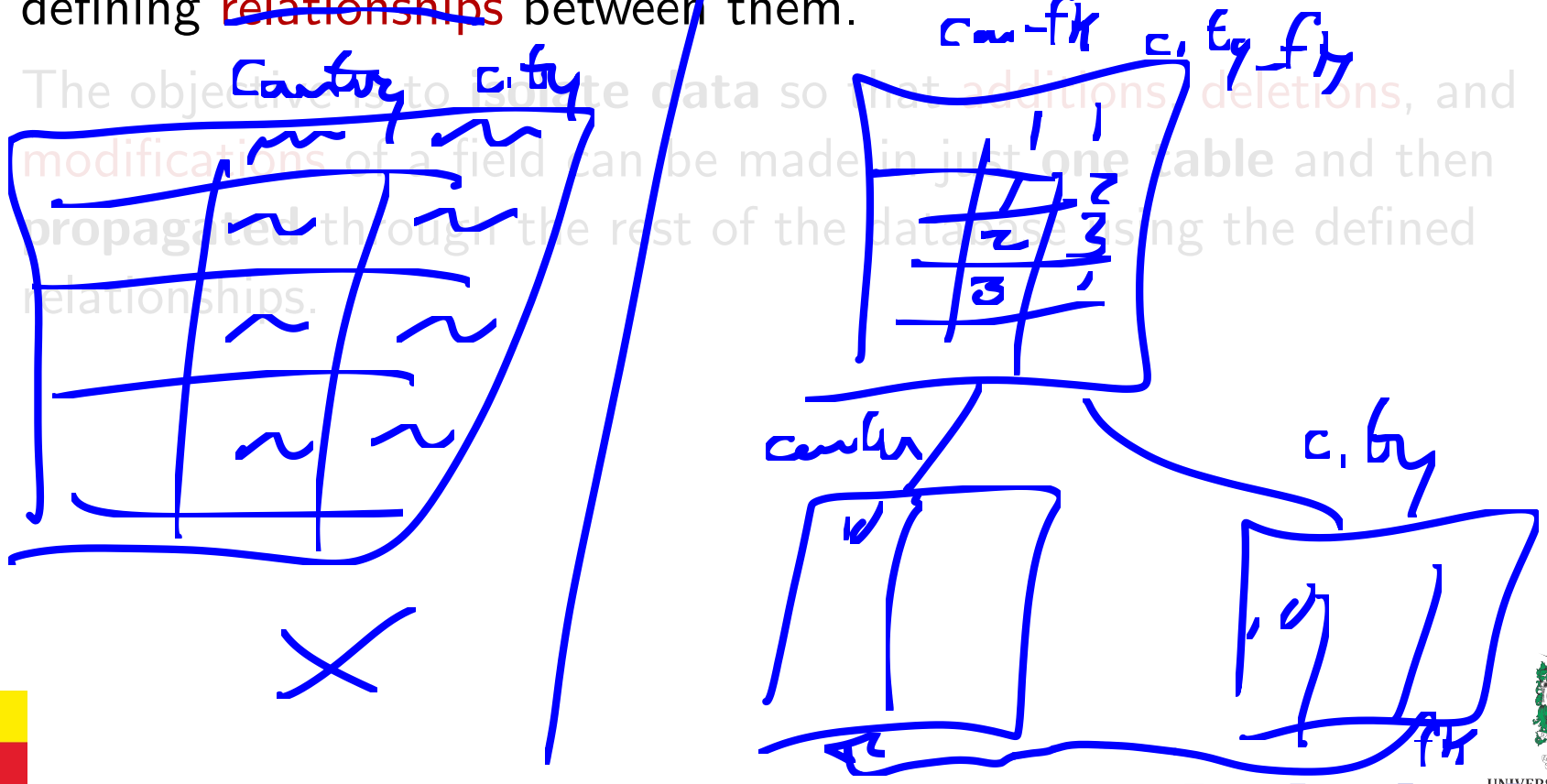


Normalization in Databases

- **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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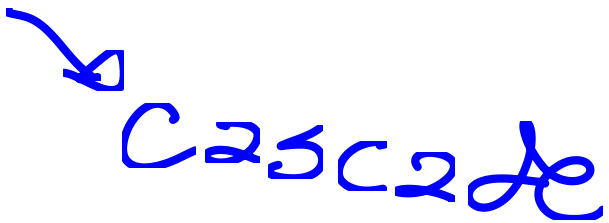

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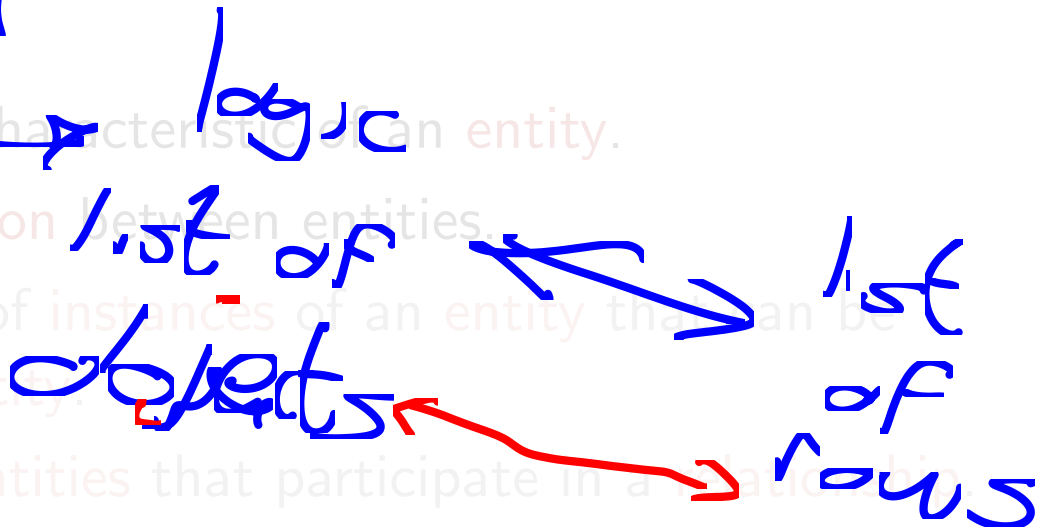
Definitions

- **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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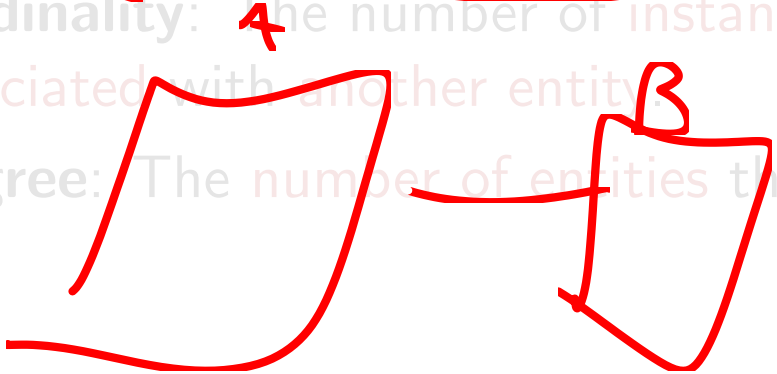

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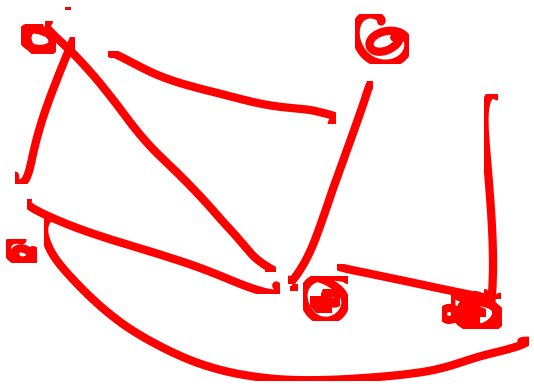
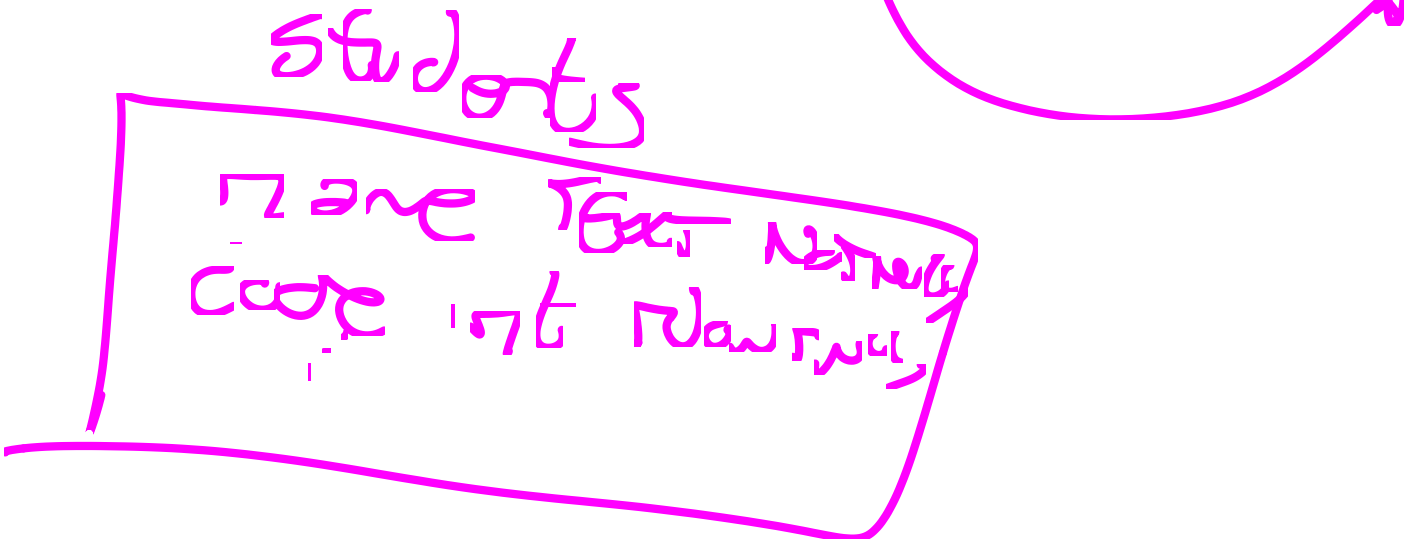


Entity-Relation Model

- 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.



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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**: **Cost**: DBMS can be expensive for large 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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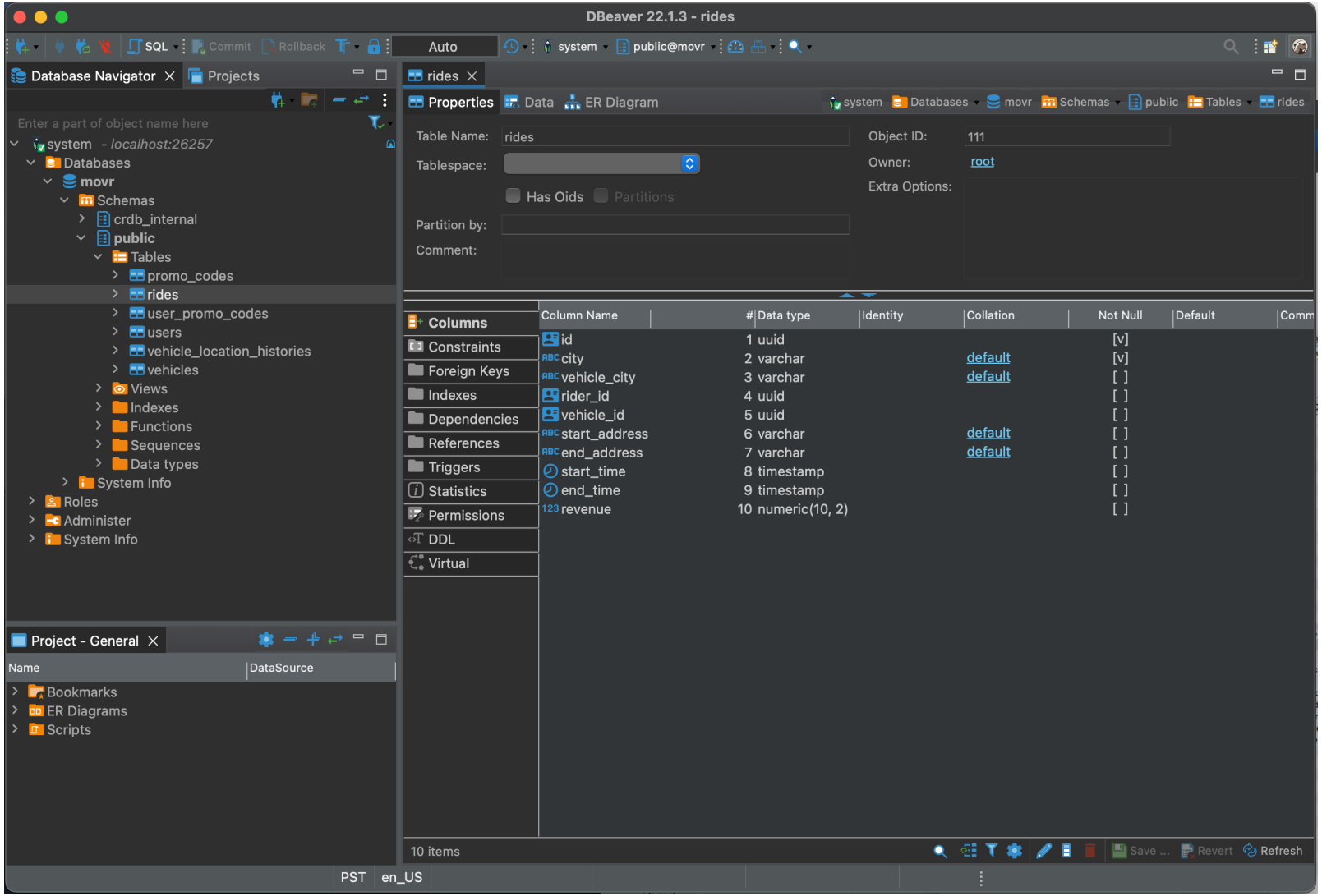
Case Study: DBeaver



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.

Case 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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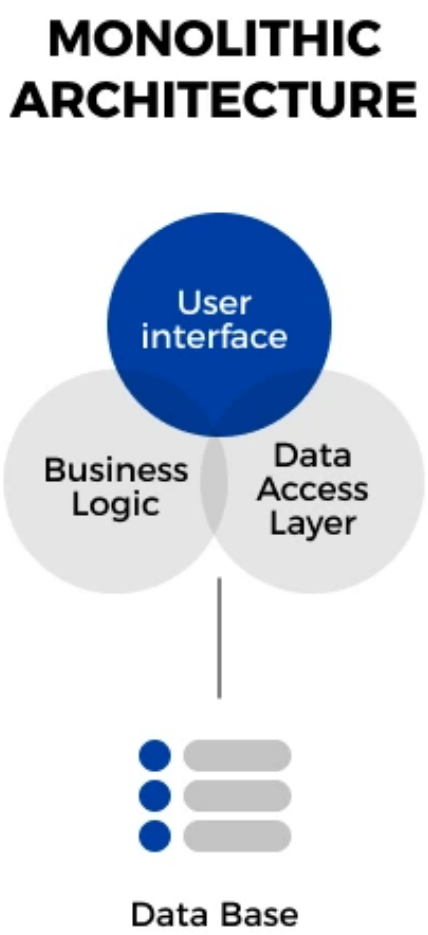
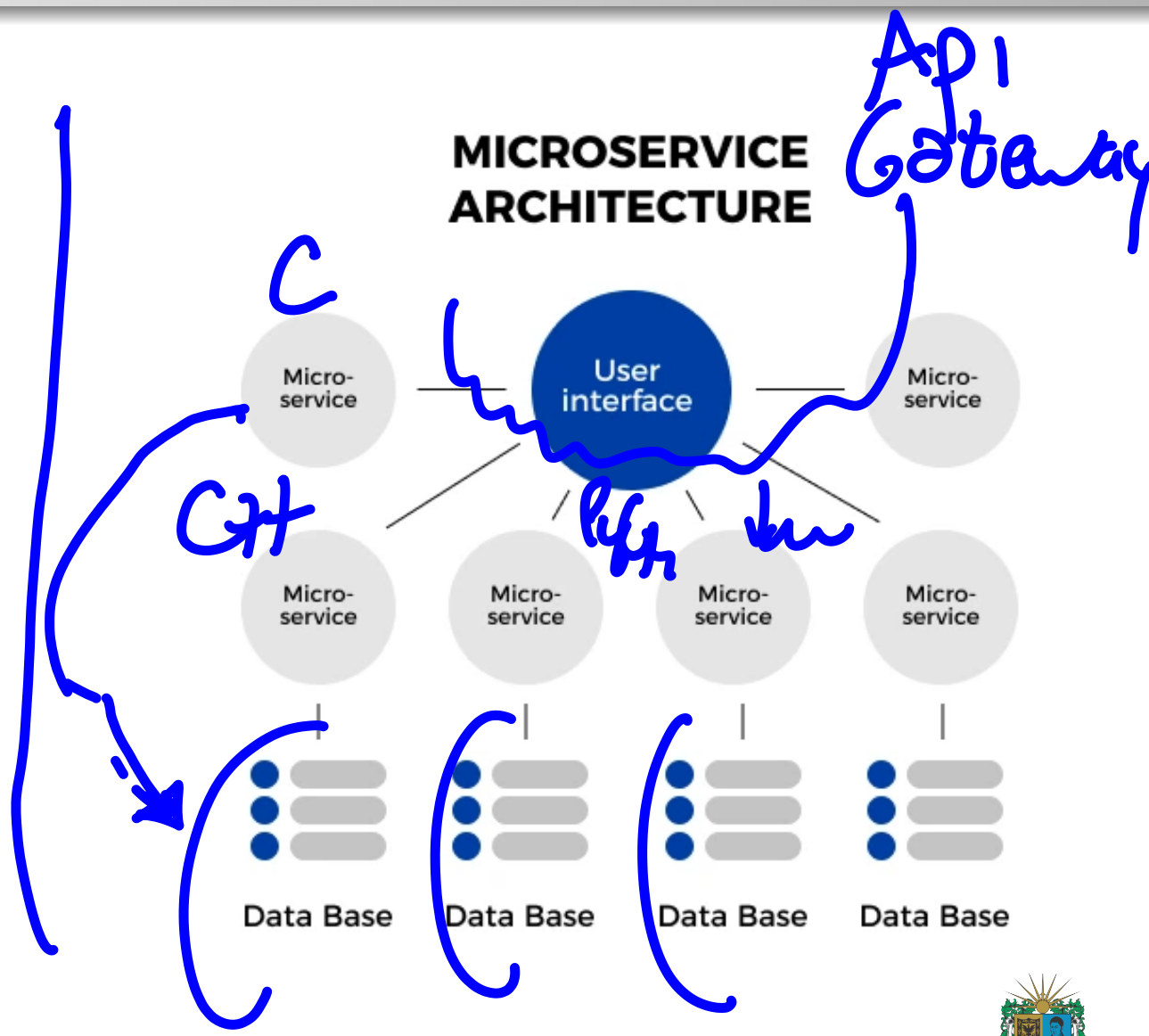
Microservices Architecture

- **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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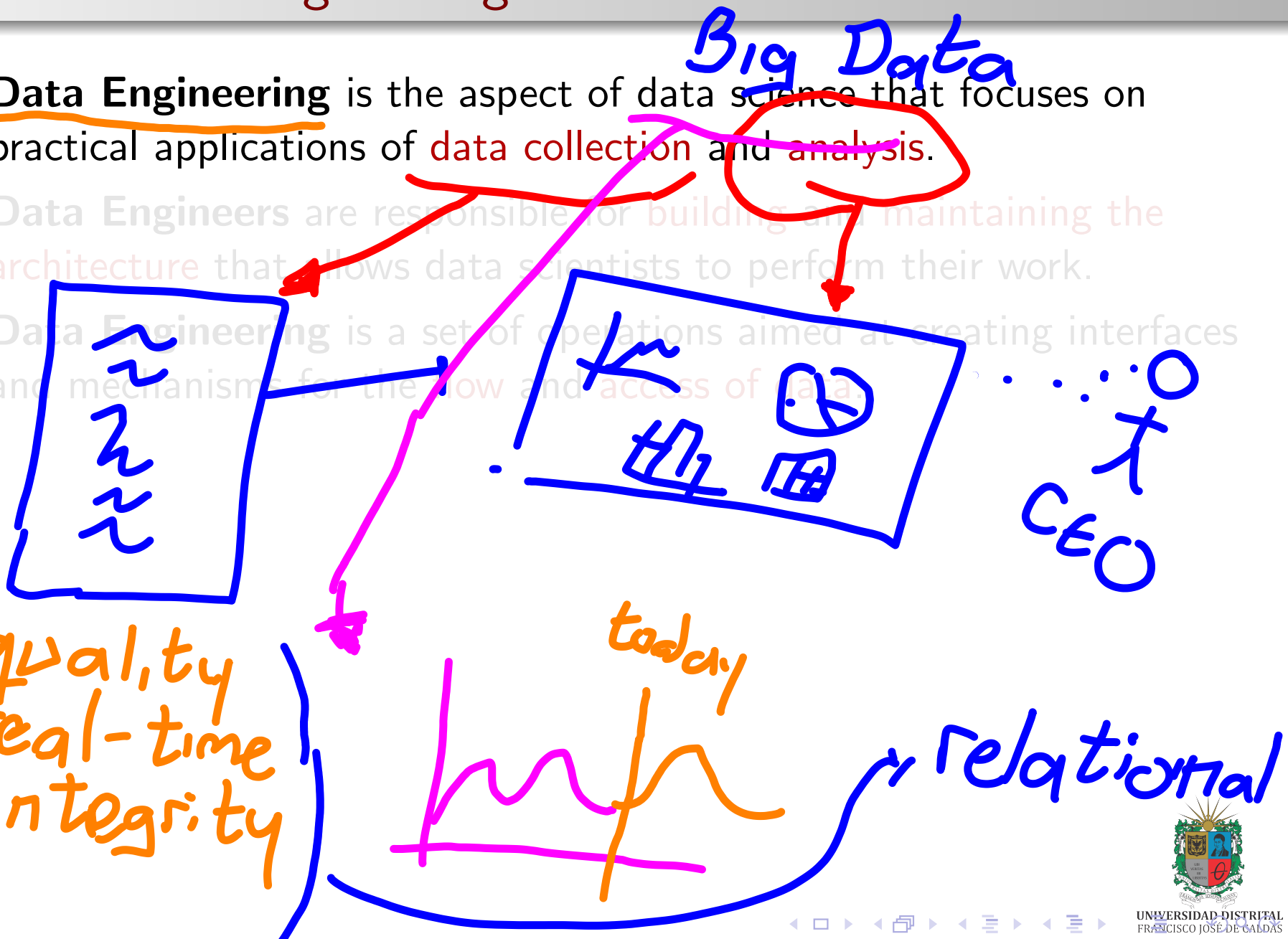
What is Data Engineering?

- **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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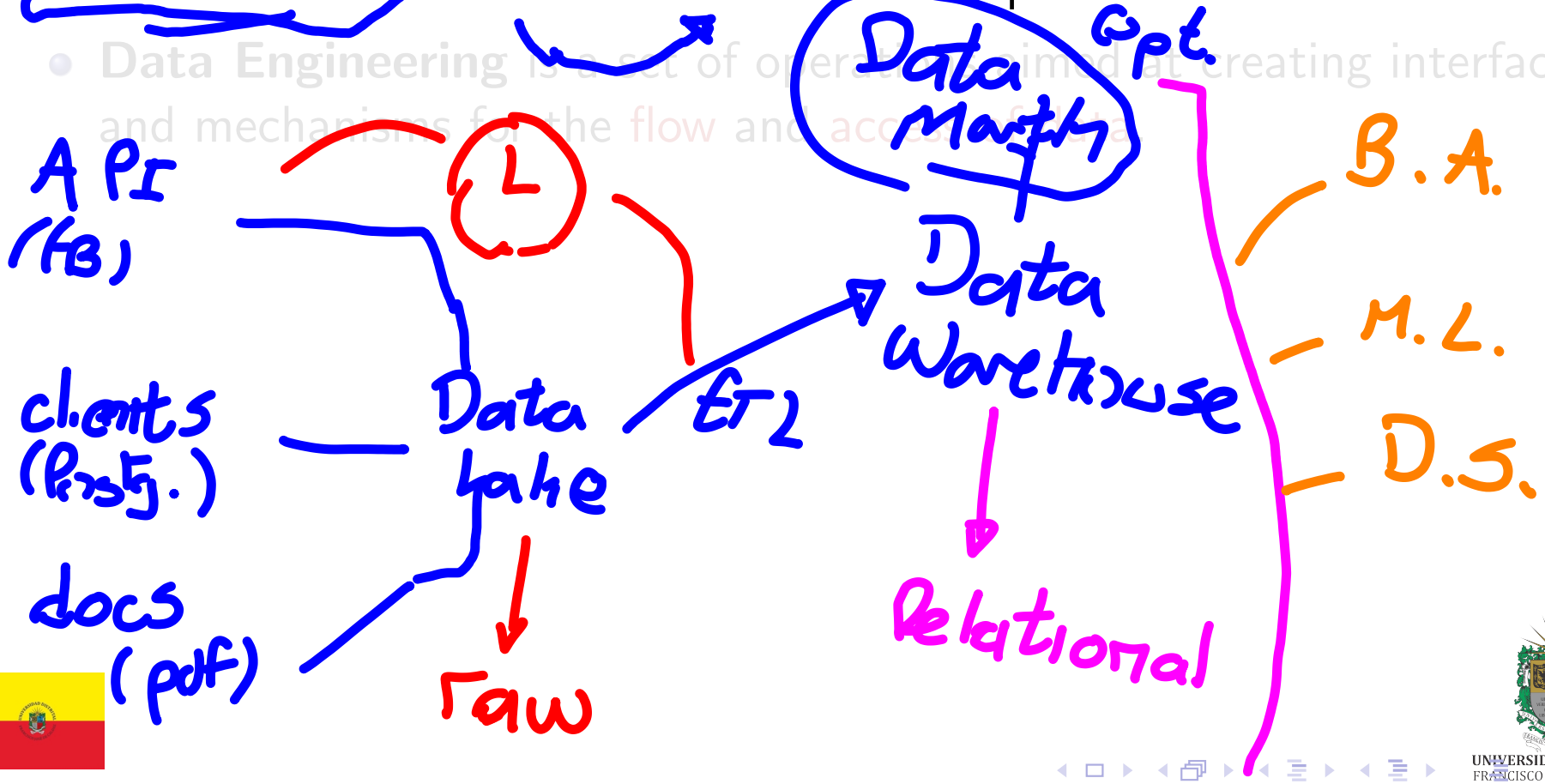

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- observability → DevOps

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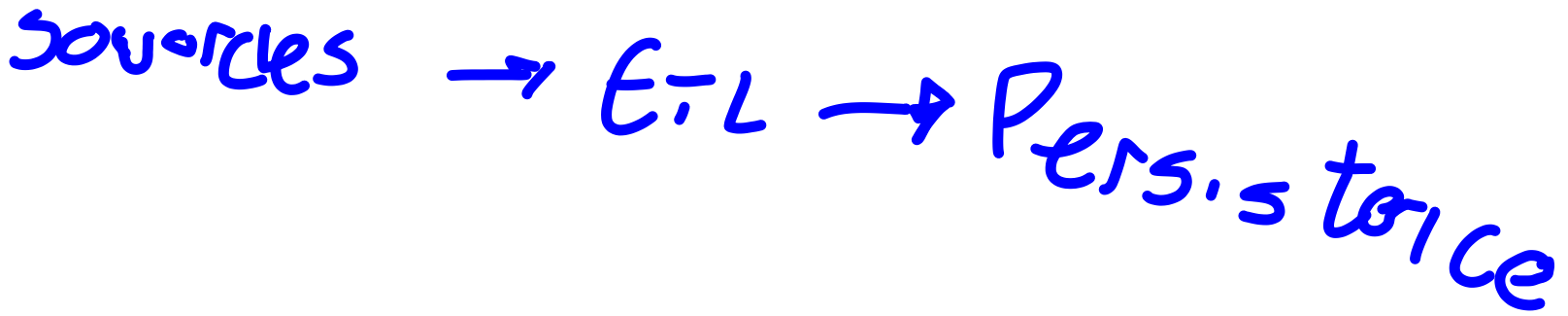
Why is Data Engineering Important?

- **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.



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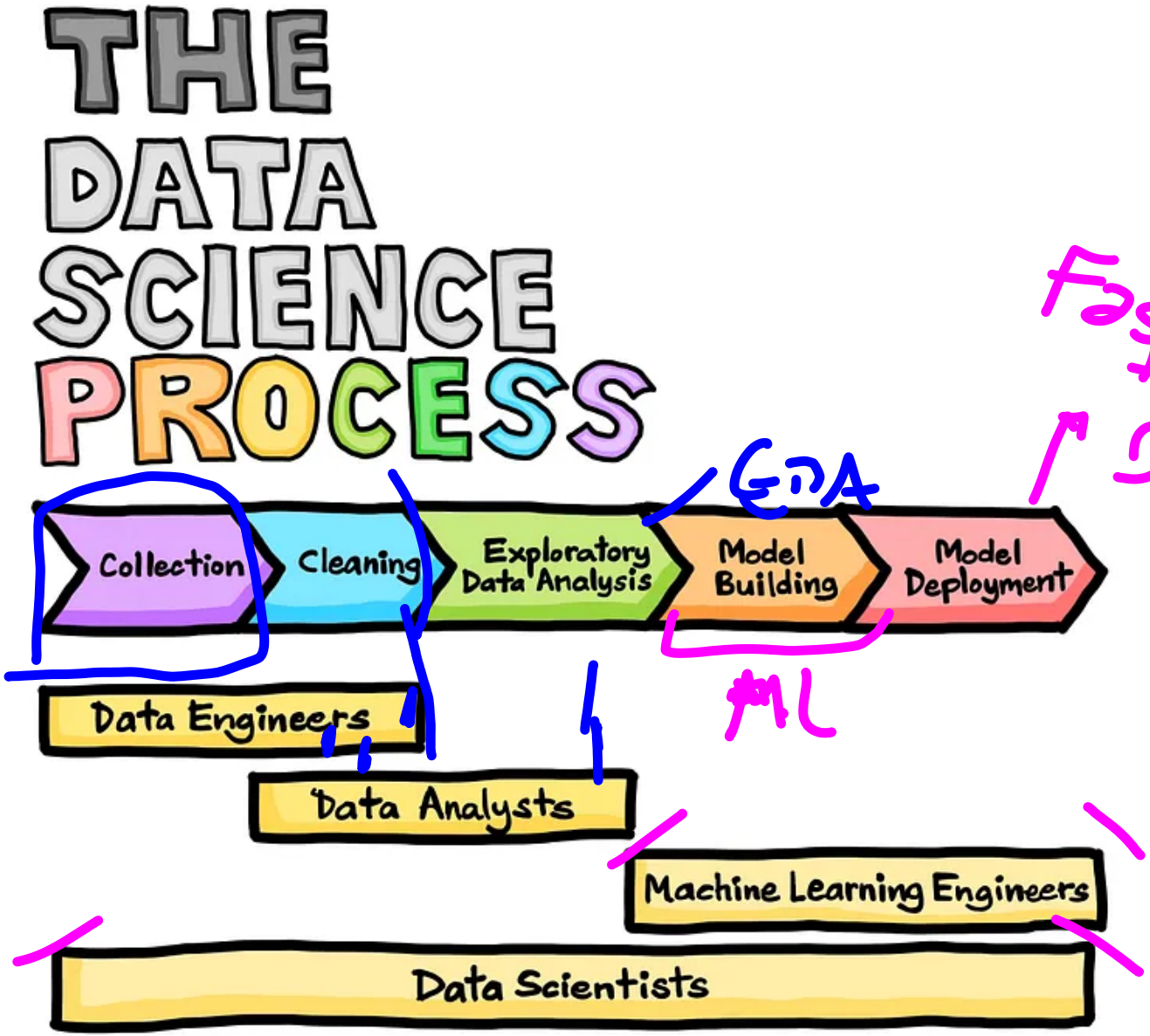
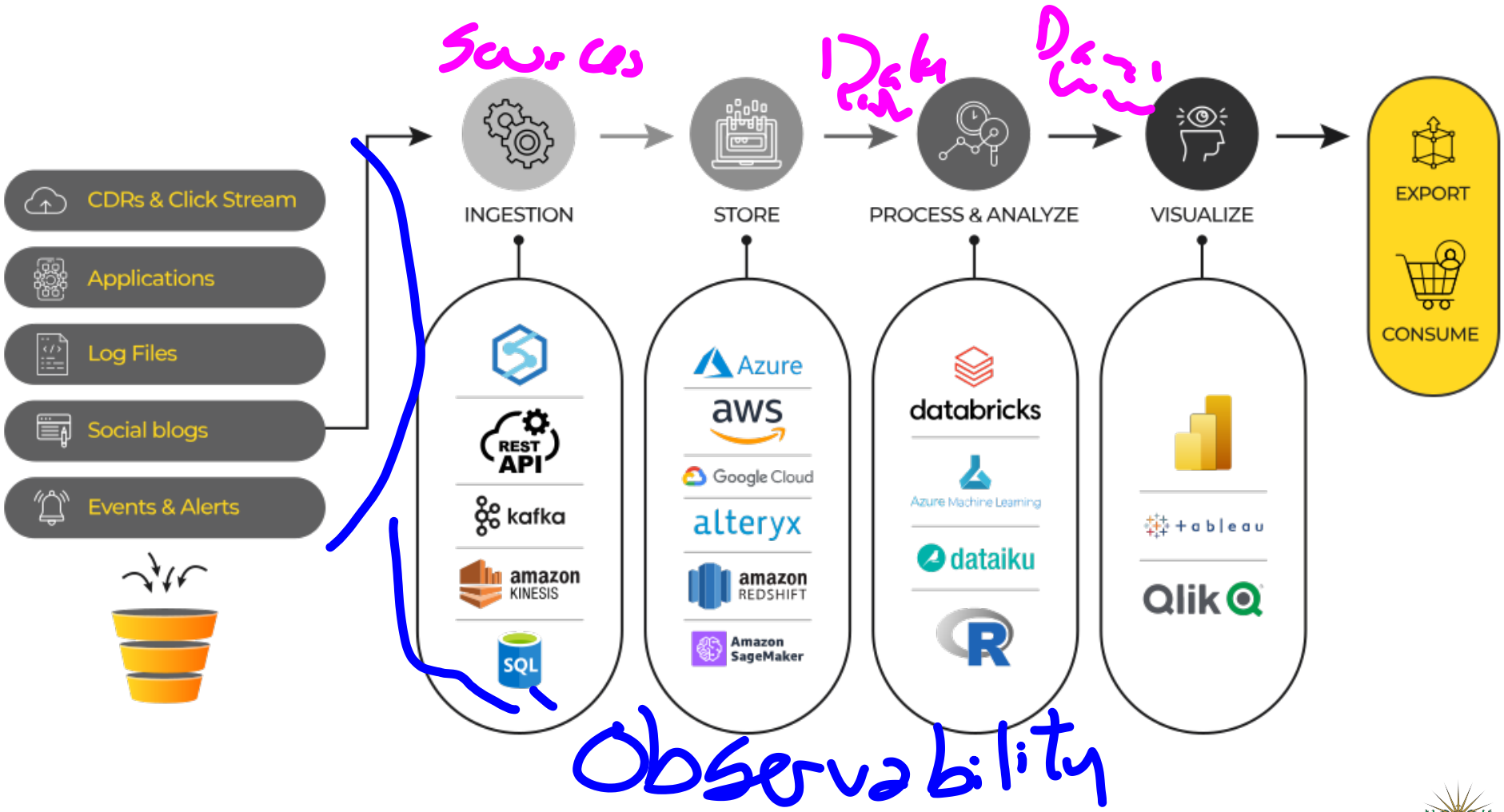
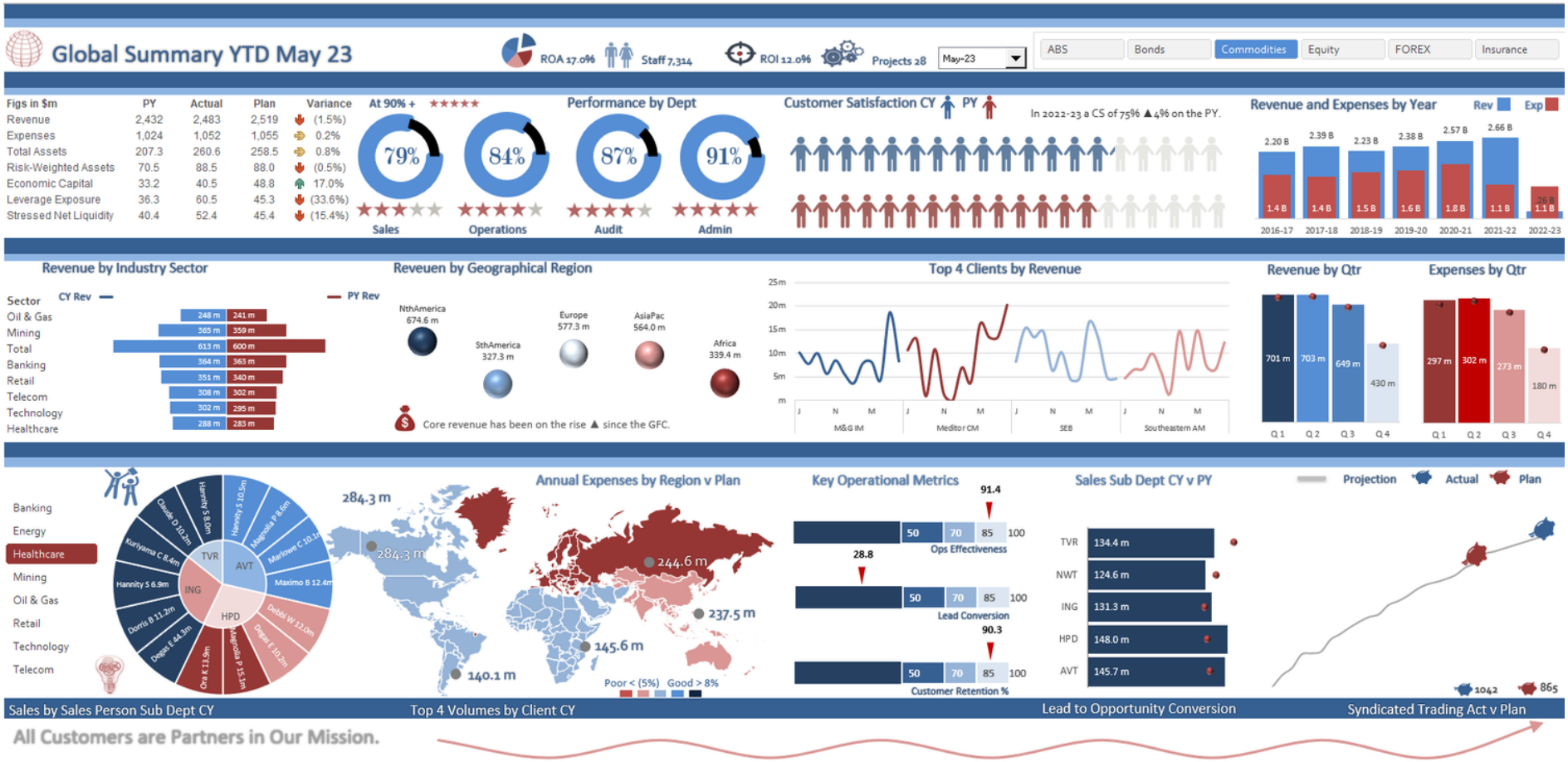
Data Science Workflow



Data Engineering Architecture



Case Study: Dashboards



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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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