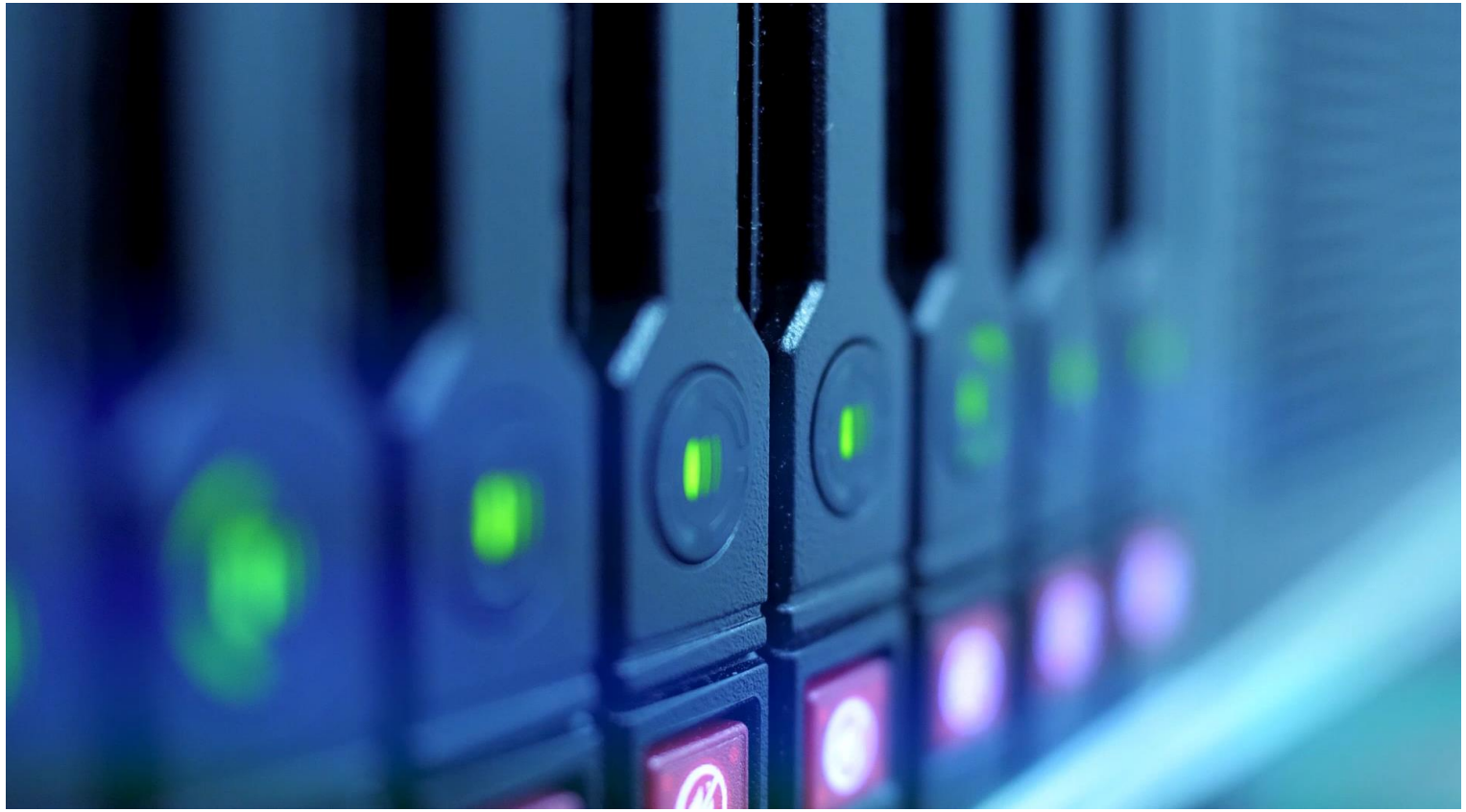
Introduction to Database



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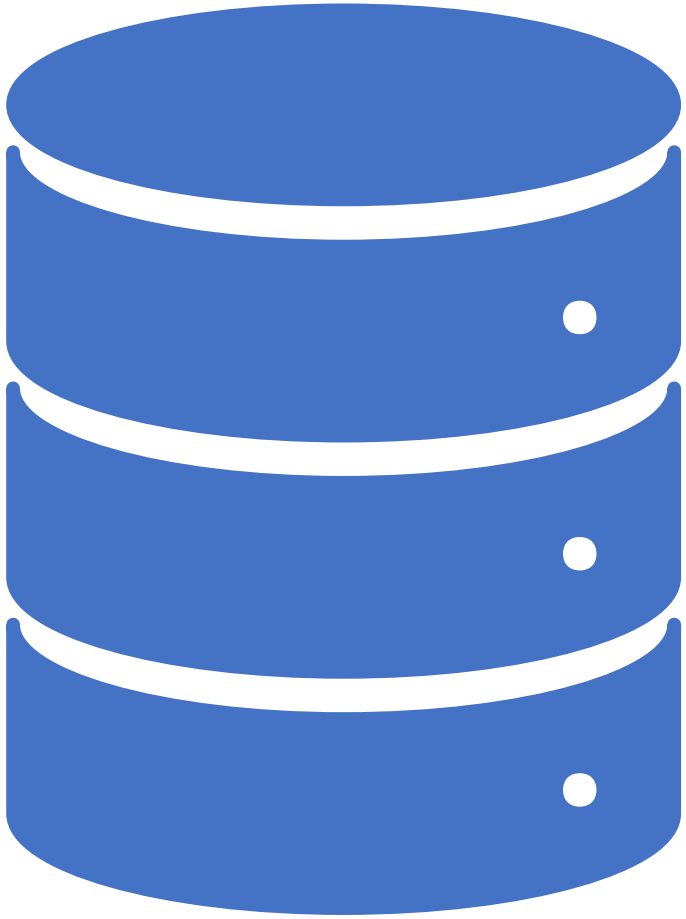
What is Database

- The database is a collection of inter-related data which is used to retrieve, insert and delete the data efficiently. It is also used to organize the data in the form of a table, schema, views, and reports, etc.
- **For example:** The college Database organizes the data about the admin, staff, students and faculty etc.
- Using the database, you can easily retrieve, insert, and delete the information.



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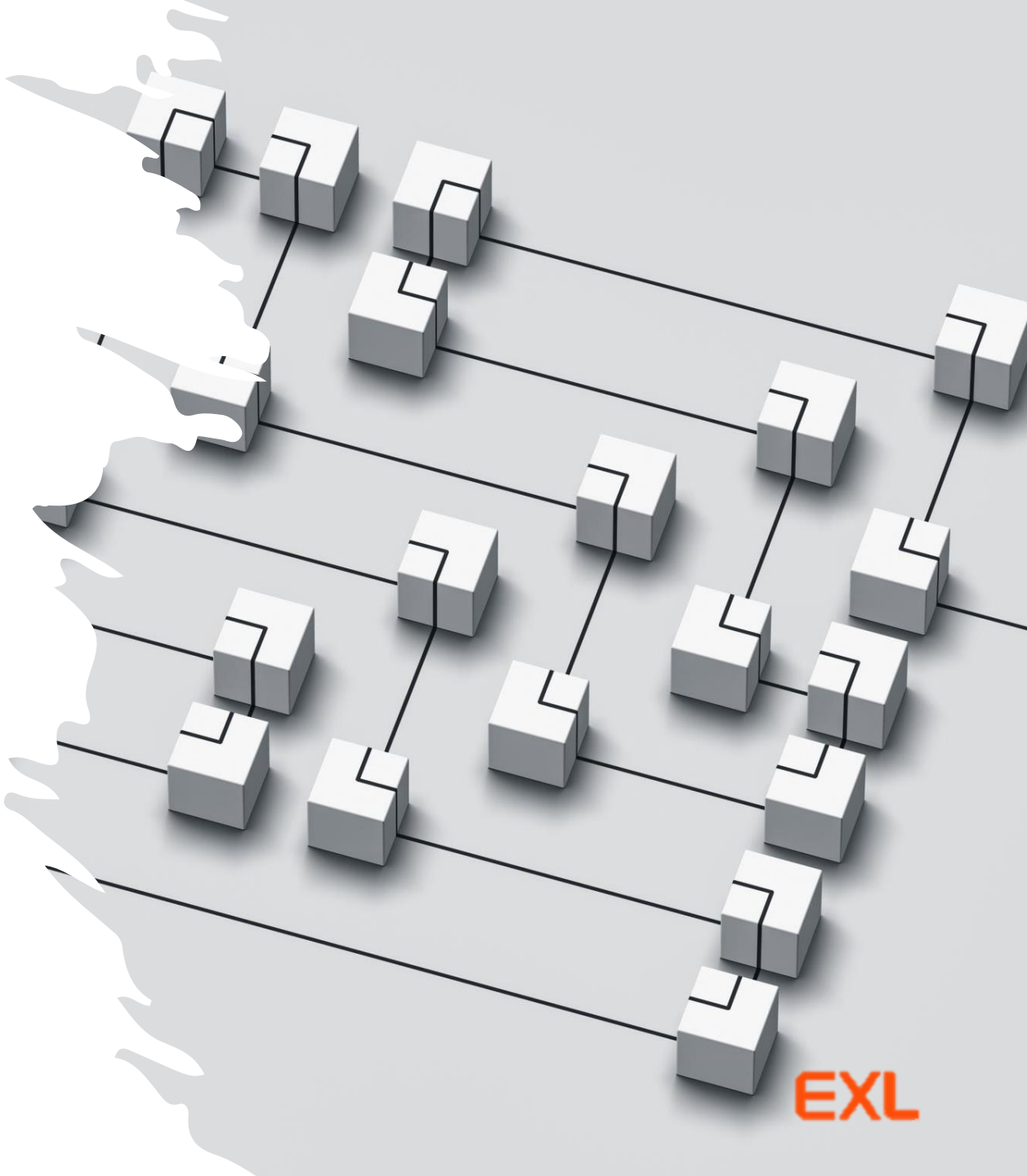
Database Management System

- Database management system is a software which is used to manage the database. For example: MySQL, Oracle, etc. are a very popular commercial database which is used in different applications.
- DBMS provides an interface to perform various operations like database creation, storing data in it, updating data, creating a table in the database and a lot more.
- It provides protection and security to the database. In the case of multiple users, it also maintains data consistency.



DBMS allows users the following tasks:

Data Definition: It is used for creation, modification, and removal of definition that defines the organization of data in the database.

Data Updation: It is used for the insertion, modification, and deletion of the actual data in the database.

Data Retrieval: It is used to retrieve the data from the database which can be used by applications for various purposes.

User Administration: It is used for registering and monitoring users, maintain data integrity, enforcing data security, dealing with concurrency control, monitoring performance and recovering information corrupted by unexpected failure.

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Characteristics of DBMS

- 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.

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Advantages of DBMS

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

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Disadvantages of DBMS

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.

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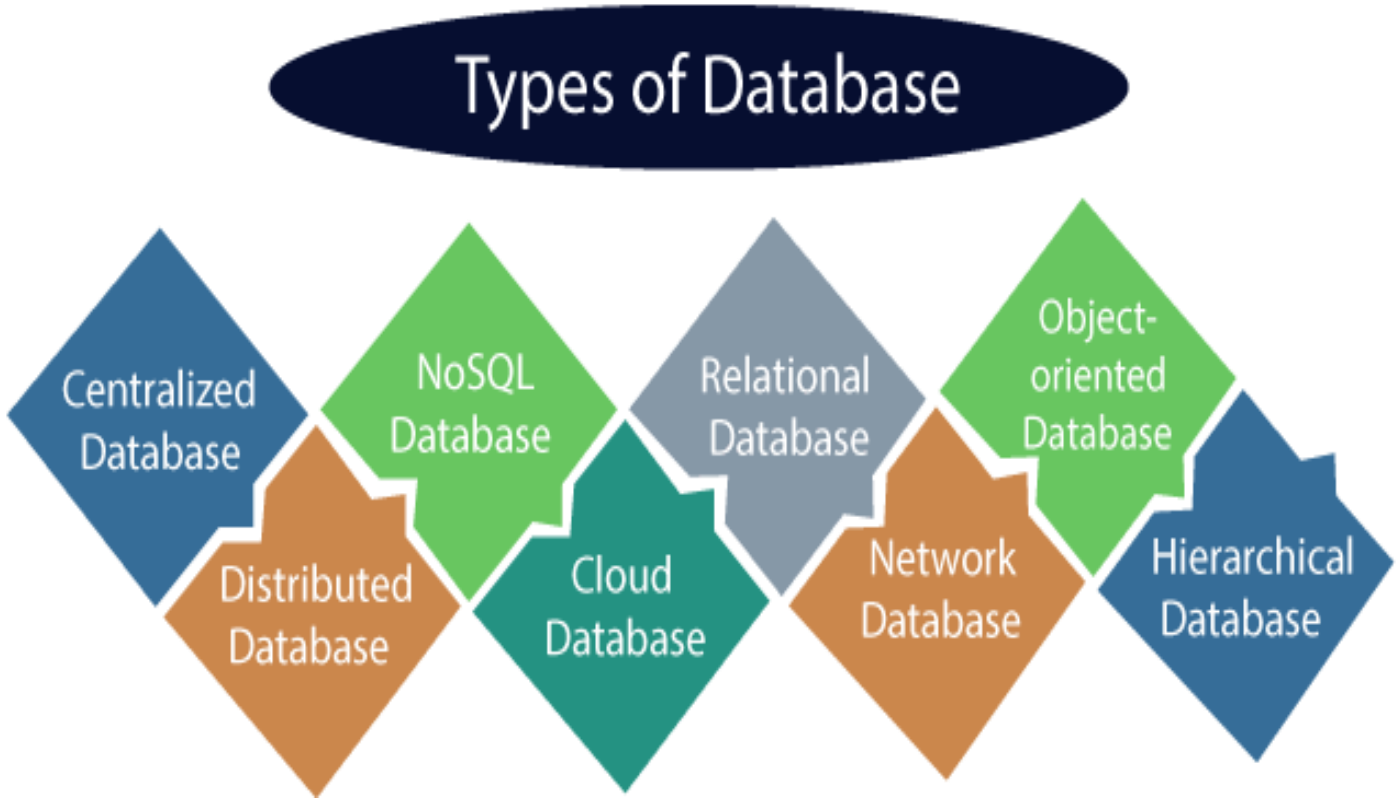
Types of Databases

- There are various types of databases used for storing different varieties of data:



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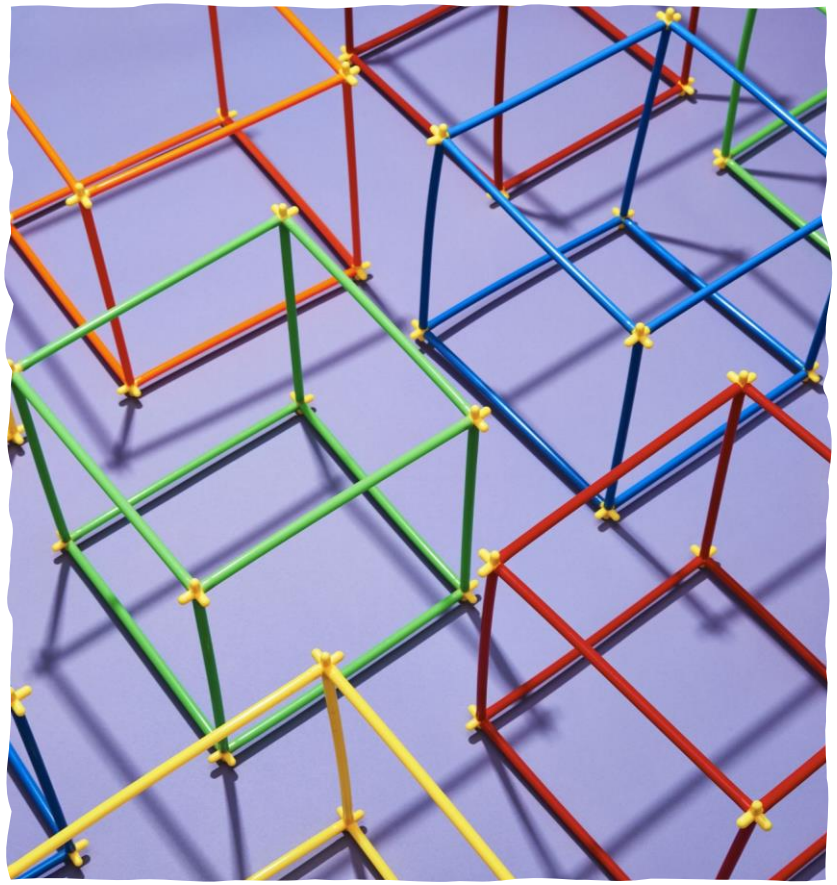
Centralized Database



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.

- Advantages of Centralized Database
- It has decreased the risk of data management, i.e., manipulation of data will not affect the core data.
- Data consistency is maintained as it manages data in a central repository.
- It provides better data quality, which enables organizations to establish data standards.
- It is less costly because fewer vendors are required to handle the data sets.

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Centralized Database

Disadvantages of Centralized Database

- The size of the centralized database is large, which increases the response time for fetching the data.
- It is not easy to update such an extensive database system.
- If any server failure occurs, entire data will be lost, which could be a huge loss.

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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.

We can further divide a distributed database system into:

- **Homogeneous DDB:** Those database systems which execute on the same operating system and use the same application process and carry the same hardware devices.
- **Heterogeneous DDB:** Those database systems which execute on different operating systems under different application procedures and carries different hardware devices.

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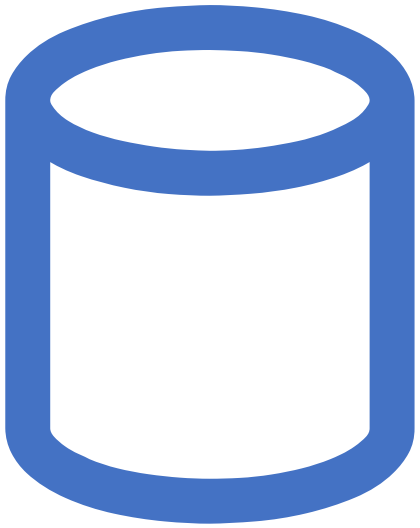

Advantages of Distributed Database

- Modular development is possible in a distributed database, i.e., the system can be expanded by including new computers and connecting them to the distributed system.
- One server failure will not affect the entire data set.

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.

Properties of Relational Database

- There are following four commonly known properties of a relational model known as ACID properties, where:
- **A means Atomicity:** This ensures the data operation will complete either with success or with failure. It follows the 'all or nothing' strategy. For example, a transaction will either be committed or will abort.
- **C means Consistency:** If we perform any operation over the data, its value before and after the operation should be preserved. For example, the account balance before and after the transaction should be correct, i.e., it should remain conserved.

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Relational Database

- **I means Isolation:** There can be concurrent users for accessing data at the same time from the database. Thus, isolation between the data should remain isolated. For example, when multiple transactions occur at the same time, one transaction effects should not be visible to the other transactions in the database.
- **D means Durability:** It ensures that once it completes the operation and commits the data, data changes should remain permanent.

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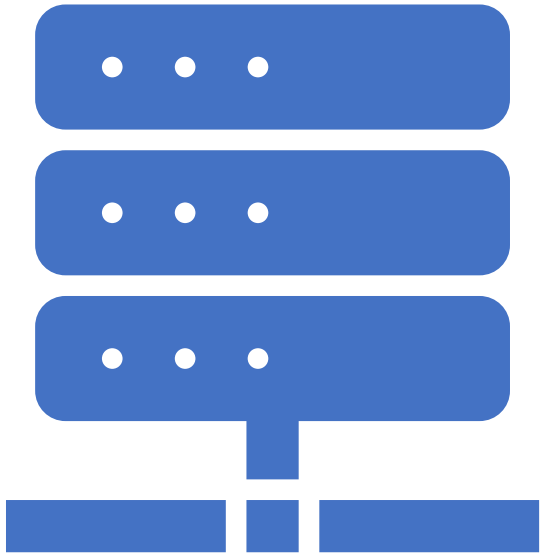

Cloud Database

- 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.

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Personal Database

Collecting and storing data on the user's system defines a Personal Database. This database is basically designed for a single user.

Advantage of Personal Database

It is simple and easy to handle.

It occupies less storage space as it is small in size.

Operational and Enterprise Database

- **Operational database** which creates and updates the database in real-time. It is basically designed for executing and handling the daily data operations in several businesses. For example, An organization uses operational databases for managing per day transactions.
- **Enterprise Database** Large organizations or enterprises use this database for managing a massive amount of data. It helps organizations to increase and improve their efficiency. Such a database allows simultaneous access to users.

Advantages of Enterprise Database:

- Multi processes are supportable over the Enterprise database.
- It allows executing parallel queries on the system.

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Relational Model in DBMS

Relational model can represent as a table with columns and rows. Each row is known as a tuple. Each table of the column has a name or attribute.

- **Domain:** It contains a set of atomic values that an attribute can take.
- **Attribute:** It contains the name of a column in a particular table. Each attribute Ai must have a domain, dom(Ai)
- **Relational instance:** In the relational database system, the relational instance is represented by a finite set of tuples. Relation instances do not have duplicate tuples.
- **Relational schema:** A relational schema contains the name of the relation and name of all columns or attributes.
- **Relational key:** In the relational key, each row has one or more attributes. It can identify the row in the relation uniquely.

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Example: STUDENT Relation

- In the given table, NAME, ROLL_NO, PHONE_NO, ADDRESS, and AGE are the attributes.
- The instance of schema STUDENT has 5 tuples.
- t3 = <Laxman, 33289, 8583287182, Gurugram, 20>

NAME	ROLL_NO	PHONE_NO	ADDRESS	AGE
Ram	14795	7305758992	Noida	24
Shyam	12839	9026288936	Delhi	35
Laxman	33289	8583287182	Gurugram	20
Mahesh	27857	7086819134	Ghaziabad	27
Ganesh	17282	9028 9i3988	Delhi	40

EXL

Properties of Relations

- Name of the relation is distinct from all other relations.
- Each relation cell contains exactly one atomic (single) value
- Each attribute contains a distinct name
- Attribute domain has no significance
- tuple has no duplicate value
- Order of tuple can have a different sequence

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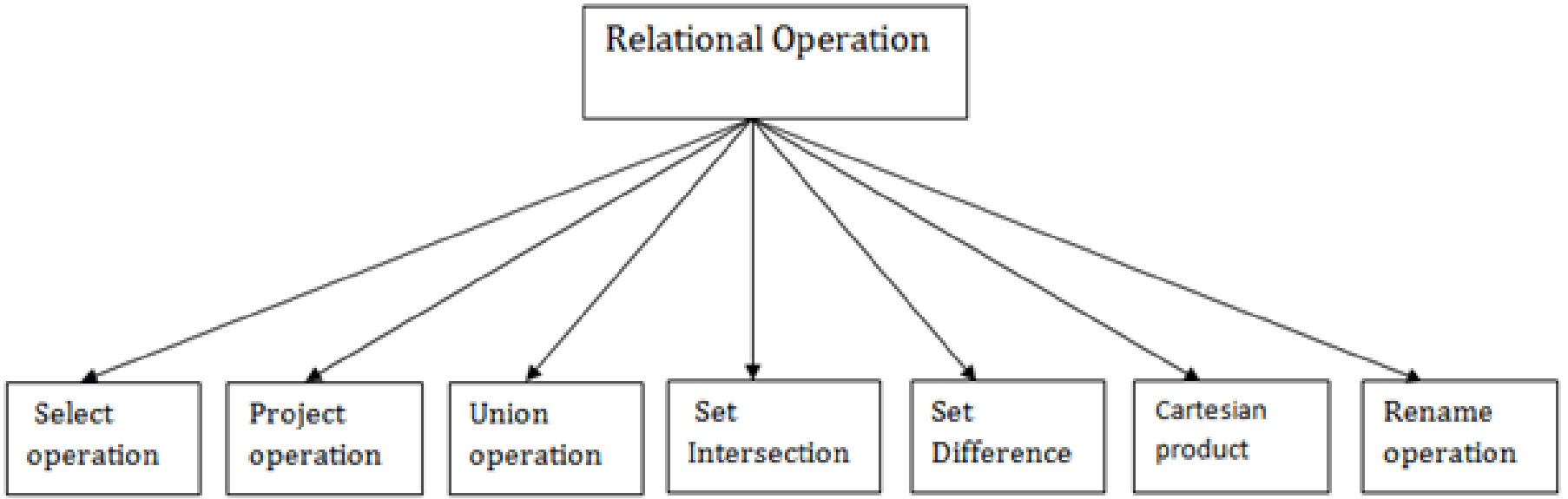
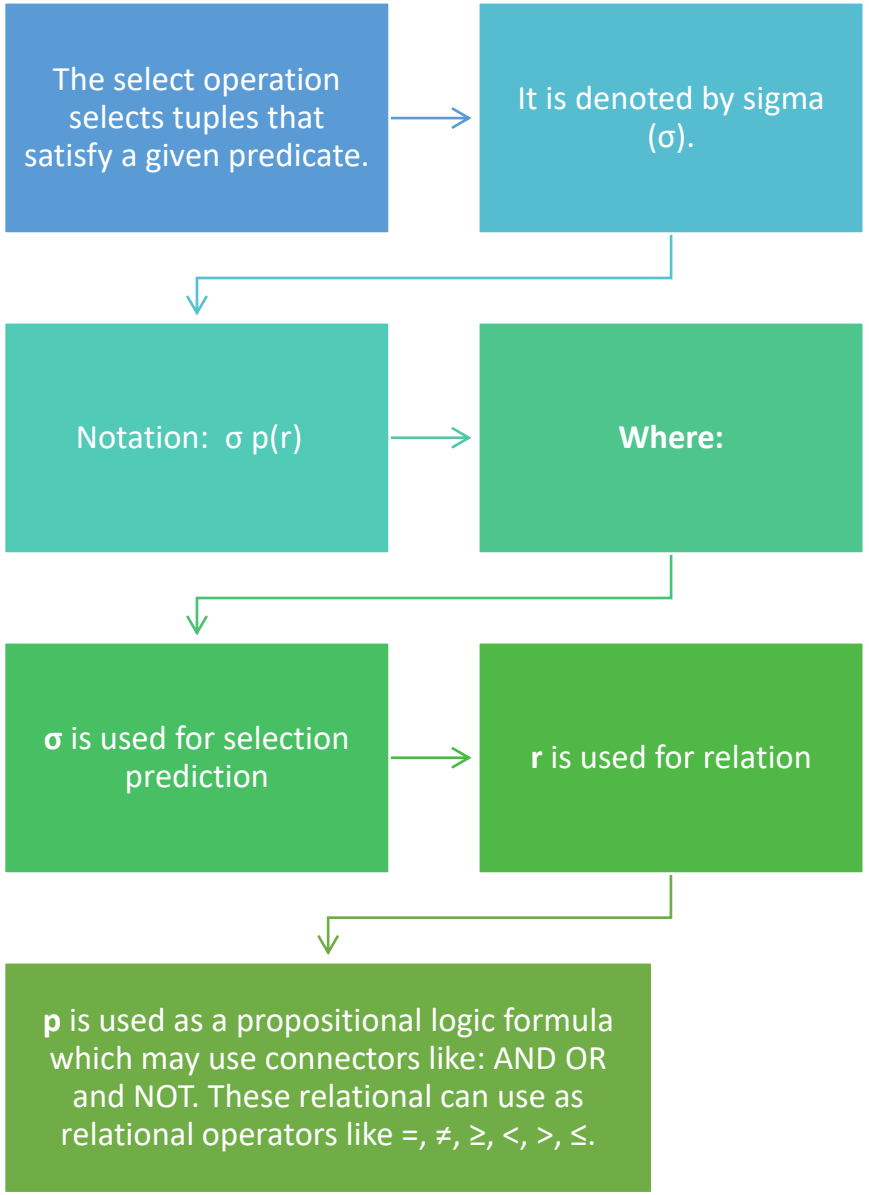
Relational Algebra

Relational algebra is a procedural query language. It gives a step-by-step process to obtain the result of the query. It uses operators to perform queries.

Types of Relational operation



1. Select Operation:



EXL

For example: LOAN Relation

BRANCH_NAME	LOAN_NO	AMOUNT
Downtown	L-17	1000
Redwood	L-23	2000
Perryride	L-15	1500
Downtown	L-14	1500
Mianus	L-13	500
Roundhill	L-11	900
Perryride	L-16	1300

EXL

Input:

- σ BRANCH_NAME="perryride" (LOAN)
- **Output:**

BRANCH_NAME	LOAN_NO	AMOUNT
Perryride	L-15	1500
Perryride	L-16	1300

EXL

2. Project Operation:

This operation shows the list of those attributes that we wish to appear in the result. Rest of the attributes are eliminated from the table.

It is denoted by ∏.

Notation: ∏ A1, A2, An (r)

Where: A1, **A2**, **A3** is used as an attribute name of relation **r**.

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Example: CUSTOMER RELATION

NAME	STREET	CITY
Jones	Main	Harrison
Smith	North	Rye
Hays	Main	Harrison
Curry	North	Rye
Johnson	Alma	Brooklyn
Brooks	Senator	Brooklyn

Input:

- ∏ NAME, CITY (CUSTOMER)
- **Output:**

NAME	CITY
Jones	Harrison
Smith	Rye
Hays	Harrison
Curry	Rye
Johnson	Brooklyn
Brooks	Brooklyn

EXL

3. Union Operation:

Suppose there are two tuples R and S. The union operation contains all the tuples that are either in R or S or both in R & S.

It eliminates the duplicate tuples. It is denoted by ∪.

Notation: R ∪ S

A union operation must hold the following condition:

R and S must have the attribute of the same number.

Duplicate tuples are eliminated automatically.

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Example: **DEPOSITOR RELATION**

CUSTOMER_NAME	ACCOUNT_NO
Johnson	A-101
Smith	A-121
Mayes	A-321
Turner	A-176
Johnson	A-273
Jones	A-472
Lindsay	A-284

EXL

BORROW RELATION

CUSTOMER_NAME	LOAN_NO
Jones	L-17
Smith	L-23
Hayes	L-15
Jackson	L-14
Curry	L-93
Smith	L-11
Williams	L-17

EXL

Input:

- ∏ CUSTOMER_NAME (BORROW) ∪ ∏ CUSTOMER_NAME (DEPOSITOR)
- **Output:**

CUSTOMER_NAME
Johnson
Smith
Hayes
Turner
Jones
Lindsay
Jackson
Curry
Williams
Mayes

EXL

4. Set Intersection:

Suppose there are two tuples R and S. The set intersection operation contains all tuples that are in both R & S.

It is denoted by intersection ∩.

Notation: R ∩ S

Example: Using the above DEPOSITOR table and BORROW table

Input:

∏ CUSTOMER_NAME (BORROW) ∩ ∏ CUSTOMER_NAME (DEPOSITOR)

EXL

Output:

CUSTOMER_NAME
Smith
Jones

EXL

5. Set Difference:

Suppose there are two tuples R and S. The set intersection operation contains all tuples that are in R but not in S.

It is denoted by intersection minus (-).

Notation: R - S

Example: Using the above DEPOSITOR table and BORROW table

Input:

∏ CUSTOMER_NAME (BORROW) -
∏ CUSTOMER_NAME (DEPOSITOR)

EXL

Output:

CUSTOMER_NAME
Jackson
Hayes
Willians
Curry

EXL

6. Cartesian product

- The Cartesian product is used to combine each row in one table with each row in the other table. It is also known as a cross product.
- It is denoted by X.

1. Notation: E X D

- Example: **EMPLOYEE Table**

EMP_ID	EMP_NAME	EMP_DEPT
1	Smith	A
2	Harry	C
3	John	B

EXL

DEPARTMENT

- Example: Department Table

DEPT_NO	DEPT_NAME
A	Marketing
B	Sales
C	Legal

EXL

Input:
EMPLOYEE X DEPARTMENT

- **Output:**

EMP_ID	EMP_NAME	EMP_DEPT	DEPT_NO	DEPT_NAME
1	Smith	A	A	Marketing
1	Smith	A	B	Sales
1	Smith	A	C	Legal
2	Harry	C	A	Marketing
2	Harry	C	B	Sales
2	Harry	C	C	Legal
3	John	B	A	Marketing
3	John	B	B	Sales
3	John	B	C	Legal

7. Rename Operation:

- The rename operation is used to rename the output relation. It is denoted by **rho** (ρ).
- **Example:** We can use the rename operator to rename STUDENT relation to STUDENT1.

1. ρ(STUDENT1, STUDENT)

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Join Operations:

- A Join operation combines related tuples from different relations, if and only if a given join condition is satisfied. It is denoted by ⋈.
- **Example: EMPLOYEE**

EMP_CODE	EMP_NAME
101	Stephan
102	Jack
103	Harry

- **Example: SALARY**

EMP_CODE	SALARY
101	50000
102	30000
103	25000

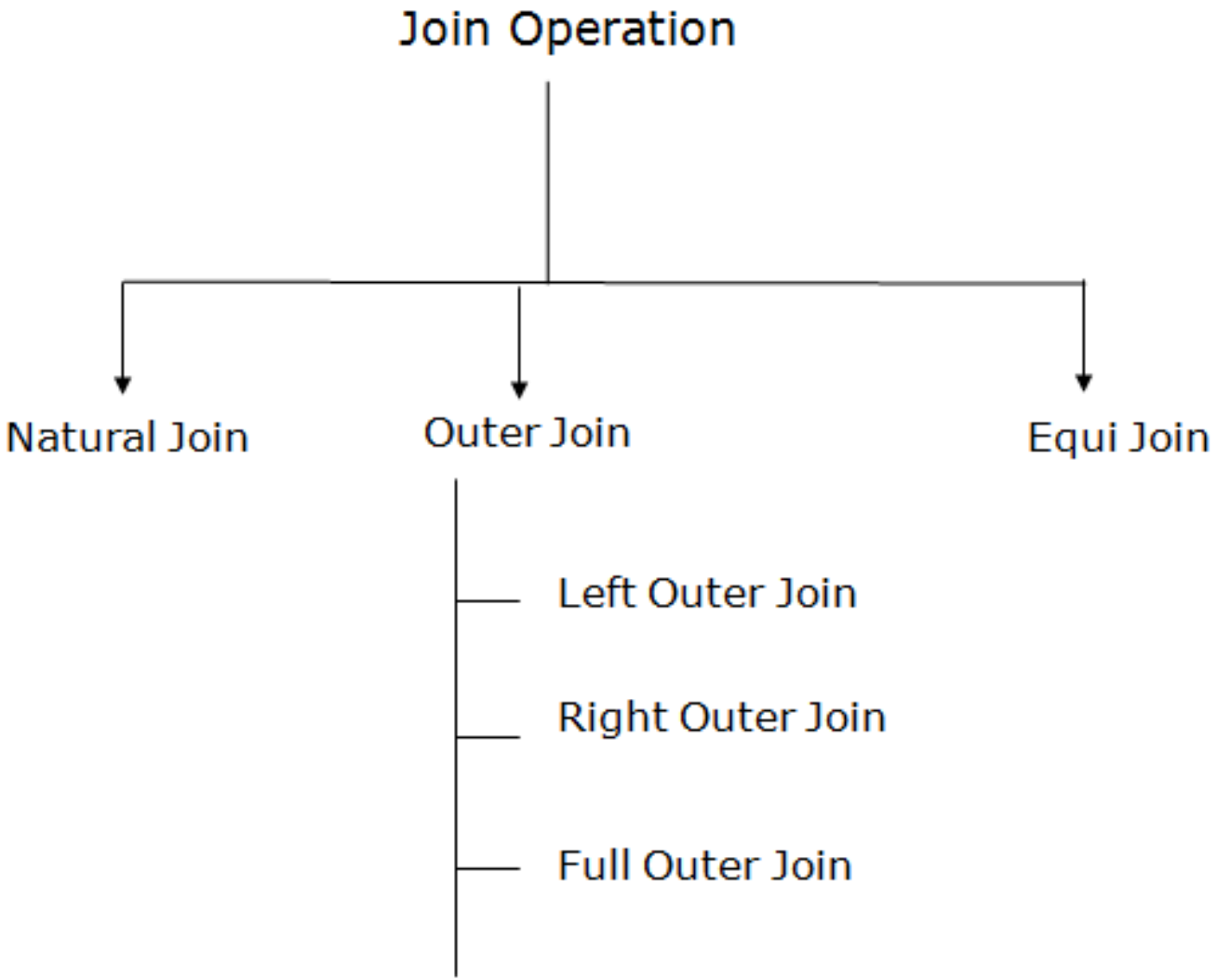
EXL

Operation:

- (EMPLOYEE ⋈ SALARY)
- **Result:**

EMP_CODE	EMP_NAME	SALARY
101	Stephan	50000
102	Jack	30000
103	Harry	25000

Types of Join operations:



EXL

1. Natural Join:

- A natural join is the set of tuples of all combinations in R and S that are equal on their common attribute names.
- It is denoted by ⋈.
- **Example:** Let's use the above EMPLOYEE table and SALARY table:
- **Input:**

1. ∏EMP_NAME, SALARY (EMPLOYEE ⋈ SALARY)

Output:

EMP_NAME	SALARY
Stephan	50000
Jack	30000
Harry	25000

EXL

2. Outer Join:

- The outer join operation is an extension of the join operation. It is used to deal with missing information.
- **Example: EMPLOYEE**

EMP_NAME	STREET	CITY
Ram	Civil line	Mumbai
Shyam	Park street	Kolkata
Ravi	M.G. Street	Delhi
Hari	Nehru nagar	Hyderabad

- **FACT_WORKERS**

EMP_NAME	BRANCH	SALARY
Ram	Infosys	10000
Shyam	Wipro	20000
Kuber	HCL	30000
Hari	TCS	50000

EXL

Input:

1.(EMPLOYEE ⋈ FACT_WORKERS)

Output:

EMP_NAME	STREET	CITY	BRANCH	SALARY
Ram	Civil line	Mumbai	Infosys	10000
Shyam	Park street	Kolkata	Wipro	20000
Hari	Nehru nagar	Hyderabad	TCS	50000

EXL

An outer join is basically of three types:

a.Left outer join, b. Right outer join, c. Full outer join

Left outer join:

- Left outer join contains the set of tuples of all combinations in R and S that are equal on their common attribute names.
- In the left outer join, tuples in R have no matching tuples in S.
- It is denoted by ⟕.

Example: Using the above EMPLOYEE table and FACT_WORKERS table

- **Input:**
  EMPLOYEE ⋈ FACT_WORKERS

EMP_NAME	STREET	CITY	BRANCH	SALARY
Ram	Civil line	Mumbai	Infosys	10000
Shyam	Park street	Kolkata	Wipro	20000
Hari	Nehru street	Hyderabad	TCS	50000
Ravi	M.G. Street	Delhi	NULL	NULL

EXL

Right outer join:

- Right outer join contains the set of tuples of all combinations in R and S that are equal on their common attribute names.
- In right outer join, tuples in S have no matching tuples in R.
- It is denoted by ⟖.
- **Example:** Using the above EMPLOYEE table and FACT_WORKERS Relation
- **Input:** EMPLOYEE ⟖ FACT_WORKERS

Output:

EMP_NAME	BRANCH	SALARY	STREET	CITY
Ram	Infosys	10000	Civil line	Mumbai
Shyam	Wipro	20000	Park street	Kolkata
Hari	TCS	50000	Nehru street	Hyderabad
Kuber	HCL	30000	NULL	NULL

EXL

Full outer join:

- Full outer join is like a left or right join except that it contains all rows from both tables.
- In full outer join, tuples in R that have no matching tuples in S and tuples in S that have no matching tuples in R in their common attribute name.
- It is denoted by ⟗.
- **Example:** Using the above EMPLOYEE table and FACT_WORKERS table
- **Input:** EMPLOYEE ⟗ FACT_WORKERS

Output:

EMP_NAME	STREET	CITY	BRANCH	SALARY
Ram	Civil line	Mumbai	Infosys	10000
Shyam	Park street	Kolkata	Wipro	20000
Hari	Nehru street	Hyderabad	TCS	50000
Ravi	M.G. Street	Delhi	NULL	NULL
Kuber	NULL	NULL	HCL	30000

EXL

Equi join:

- It is also known as an inner join. It is the most common join. It is based on matched data as per the equality condition. The equi join uses the comparison operator(=).
- **Example:**
- **CUSTOMER RELATION**

CLASS_ID	NAME
1	John
2	Harry
3	Jackson

- **PRODUCT**

PRODUCT_ID	CITY
1	Delhi
2	Mumbai
3	Noida

EXL

Input:

CUSTOMER ⋈ PRODUCT

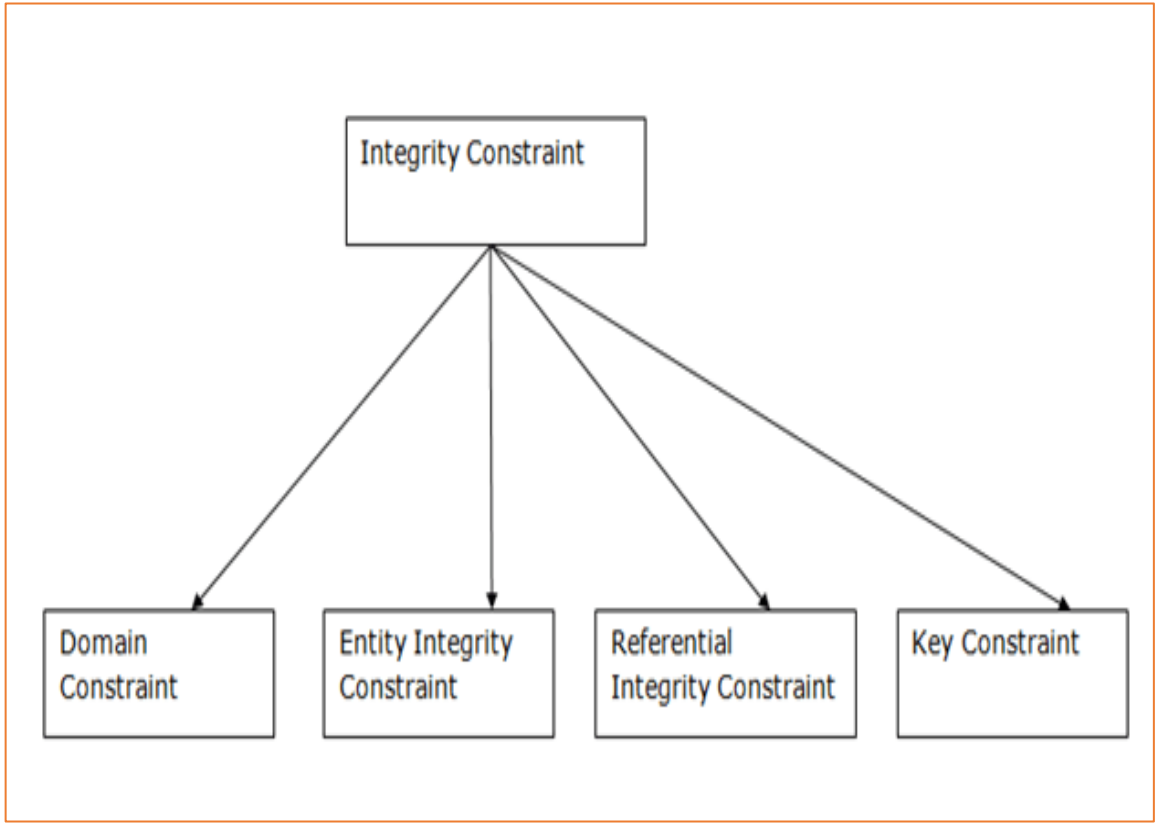
Output:

CLASS_ID	NAME	PRODUCT_ID	CITY
1	John	1	Delhi
2	Harry	2	Mumbai
3	Harry	3	Noida

EXL

Integrity Constraints

- Integrity constraints are a set of rules. It is used to maintain the quality of information.
- Integrity constraints ensure that the data insertion, updating, and other processes have to be performed in such a way that data integrity is not affected.
- Thus, integrity constraint is used to guard against accidental damage to the database.
- Types of Integrity Constraint



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Domain constraints

- Domain constraints can be defined as the definition of a valid set of values for an attribute.
- The data type of domain includes string, character, integer, time, date, currency, etc. The value of the attribute must be available in the corresponding domain.
- **Example:**

ID	NAME	SEMENSTER	AGE
1000	Tom	1st	17
1001	Johnson	2nd	24
1002	Leonardo	5th	21
1003	Kate	3rd	19
1004	Morgan	8th	A

Not allowed. Because AGE is an integer attribute

EXL

Entity integrity constraints

- The entity integrity constraint states that primary key value can't be null.
- This is because the primary key value is used to identify individual rows in relation and if the primary key has a null value, then we can't identify those rows.
- A table can contain a null value other than the primary key field.
- **Example:**

EMPLOYEE

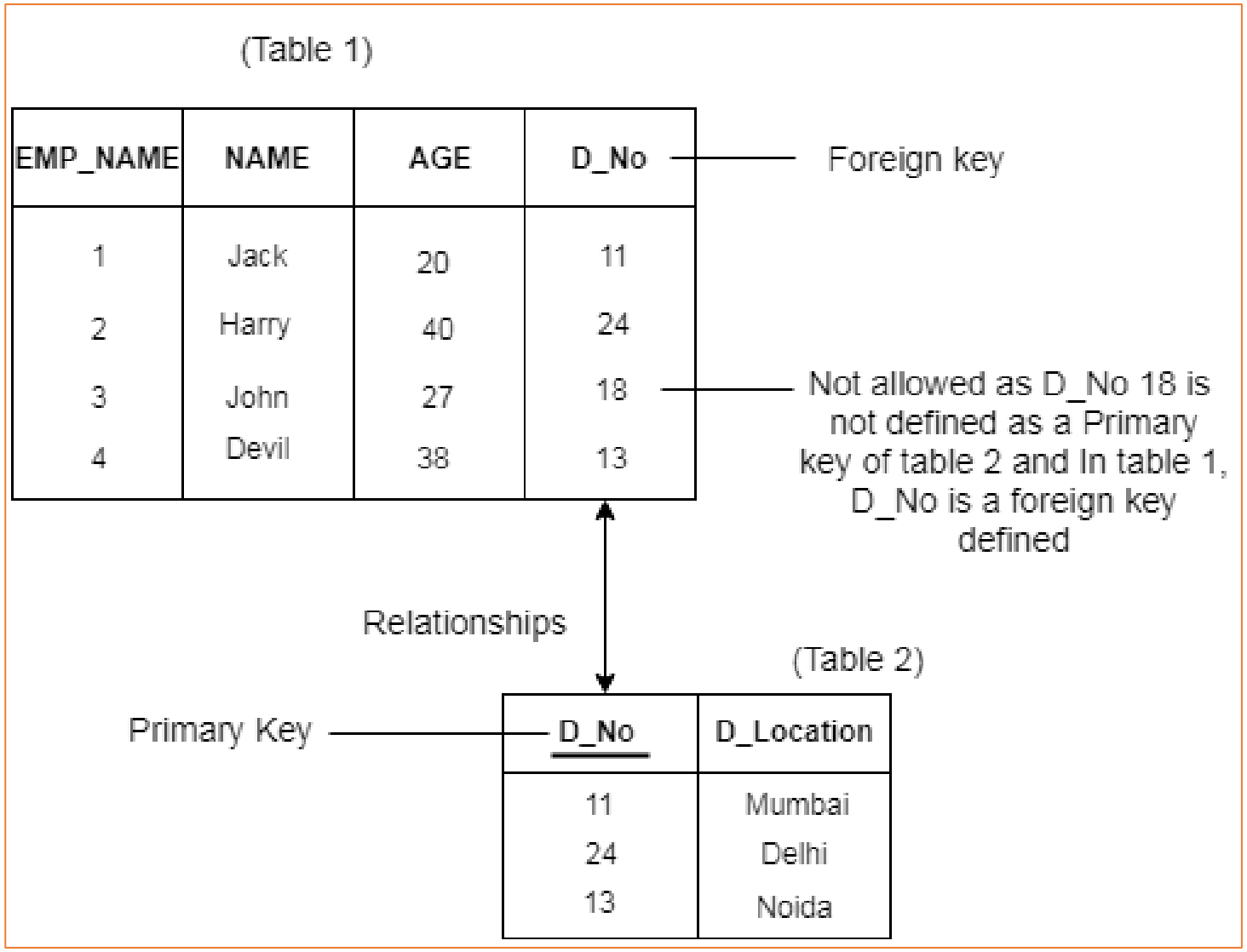
EMP_ID	EMP_NAME	SALARY
123	Jack	30000
142	Harry	60000
164	John	20000
	Jackson	27000

Not allowed as primary key can't contain a NULL value

EXL

Referential Integrity Constraints

- A referential integrity constraint is specified between two tables.
- In the Referential integrity constraints, if a foreign key in Table 1 refers to the Primary Key of Table 2, then every value of the Foreign Key in Table 1 must be null or be available in Table 2.
- **Example:**



Key constraints

- Keys are the entity set that is used to identify an entity within its entity set uniquely.
- An entity set can have multiple keys, but out of which one key will be the primary key. A primary key can contain a unique and not null value in the relational table.
- **Example:**

ID	NAME	SEMENSTER	AGE
1000	Tom	1st	17
1001	Johnson	2nd	24
1002	Leonardo	5th	21
1003	Kate	3rd	19
1002	Morgan	8th	22

Not allowed. Because all row must be unique