Unit-2

Database Design and ER-Model

What are Keys in DBMS?

KEYS in DBMS is an attribute or set of attributes which helps you to identify a row(tuple) in a relation(table). They allow you to find the relation between two tables. Keys help you uniquely identify a row in a table by a combination of one or more columns in that table. Key is also helpful for finding unique record or row from the table. Database key is also helpful for finding unique record or row from the table.

Why we need a Key?

Here are some reasons for using sql key in the DBMS system.

- Keys help you to identify any row of data in a table. In a real-world application, a table could contain thousands of records. Moreover, the records could be duplicated. Keys in RDBMS ensure that you can uniquely identify a table record despite these challenges.
- Allows you to establish a relationship between and identify the relation between tables
- Help you to enforce identity and integrity in the relationship.

Types of Keys in DBMS (Database Management System)

There are mainly Eight different types of Keys in DBMS and each key has it’s different functionality:

1. Super Key
2. Primary Key
3. Candidate Key
4. Foreign Key
5. Composite Key
6. Surrogate Key

Let’s look at each of the keys in DBMS with example:

- **Super Key –** A super key is a group of single or multiple keys which identifies rows in a table.
- **Primary Key –** is a column or group of columns in a table that uniquely

StudID	Roll No	First Name	LastName	Email

identify every row in that table.
- **Candidate Key –** is a set of attributes that uniquely identify tuples in a table. Candidate Key is a super key with no repeated attributes.
- **Foreign Key –** is a column that creates a relationship between two tables. The purpose of Foreign keys is to maintain data integrity and allow navigation between two different instances of an entity.
- **Composite Key –** is a combination of two or more columns that uniquely identify rows in a table. The combination of columns guarantees uniqueness, though individual

- **Surrogate Key –** An artificial key which aims to uniquely identify each record is called a surrogate key. These kind of key are unique because they are created when you don’t have any natural primary key.

What is the Super key?

A superkey is a group of single or multiple keys which identifies rows in a table. A Super key may have additional attributes that are not needed for unique identification.

Example:

EmpSSN	EmpNum	Empname
9812345098	AB05	Shown
9876512345	AB06	Roslyn
199937890	AB07	James

In the above-given example, EmpSSN and EmpNum name are superkeys.

What is a Primary Key?

PRIMARY KEY in DBMS is a column or group of columns in a table that uniquely identify every row in that table. The Primary Key can’t be a duplicate meaning the same value can’t appear more than once in the table. A table cannot have more than one primary key.

Rules for defining Primary key:

- Two rows can’t have the same primary key value
- It must for every row to have a primary key value.
- The primary key field cannot be null.
- The value in a primary key column can never be modified or updated if any foreign key refers to that primary key.
- In the following example, <code>StudID</code> is a Primary Key.

Example:

In the following example, “**studid”** is a Primary Key.

StudID	Roll No	First Name	LastName	Email
1	11	Tom	Price	abc@gmail.com
2	12	Nick	Wright	xyz@gmail.com
3	13	Dana	Natan	mno@yahoo.com

What is a Candidate Key?

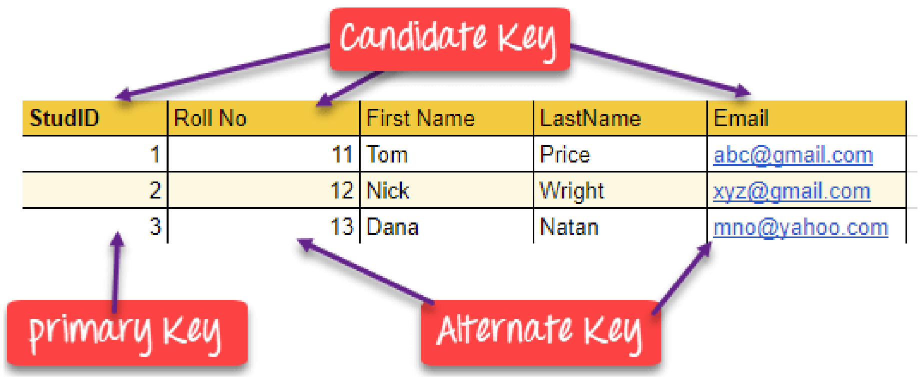
CANDIDATE KEY in SQL is a set of attributes that uniquely identify tuples in a table. Candidate Key is a super key with no repeated attributes. The Primary key should be selected from the candidate keys. Every table must have at least a single candidate key. A table can have multiple candidate keys but only a single primary key.

Properties of Candidate key:

- It must contain unique values
- Candidate key in SQL may have multiple attributes
- Must not contain null values

- It should contain minimum fields to ensure uniqueness
- Uniquely identify each record in a table

Candidate key Example: In the given table Stud ID, Roll No, and email are candidate keys which help us to uniquely identify the student record in the table.


Candidate Key
primary Key
Alternate Key

StudID	Roll No	First Name	LastName	Email
1	11	Tom	Price	abc@gmail.com
2	12	Nick	Wright	xyz@gmail.com
3	13	Dana	Natan	mno@yahoo.com

What is the Foreign key?

FOREIGN KEY is a column that creates a relationship between two tables. The purpose of Foreign keys is to maintain data integrity and allow navigation

between two different instances of an entity. It acts as a cross-reference between two tables as it references the primary key of another table.
Example:

DeptCode	DeptName
001	Science
002	English
005	Computer

Teacher ID	Fname	Lname
B002	David	Warner
B017	Sara	Joseph
B009	Mike	Brunton

In this key in dbms example, we have two table, teach and department in a school. However, there is no way to see which search work in which department.

In this table, adding the foreign key in Deptcode to the Teacher name, we can create a relationship between the two tables.

Teacher ID	DeptCode	Fname	Lname
B002	002	David	Warner
B017	002	Sara	Joseph
B009	001	Mike	Brunton

This concept is also known as Referential Integrity.

What is the Composite key?

COMPOSITE KEY is a combination of two or more columns that uniquely identify rows in a table. The combination of columns guarantees uniqueness, though individually uniqueness is not guaranteed. Hence, they are combined to uniquely identify records in a table.

The difference between compound and the composite key is that any part of the compound key can be a foreign key, but the composite key may or maybe not a part of the foreign key.

Ex->**ROLLNO+SNAME->COURSE,ADDRESS**

What is a Surrogate key?

SURROGATE KEYS is An artificial key which aims to uniquely identify each record is called a surrogate key. This kind of partial key in dbms is unique because it is created when you don’t have any natural primary key. They do not lend any meaning to the data in the table. Surrogate key in DBMS is usually an integer. A surrogate key is a value generated right before the record is inserted into a table.

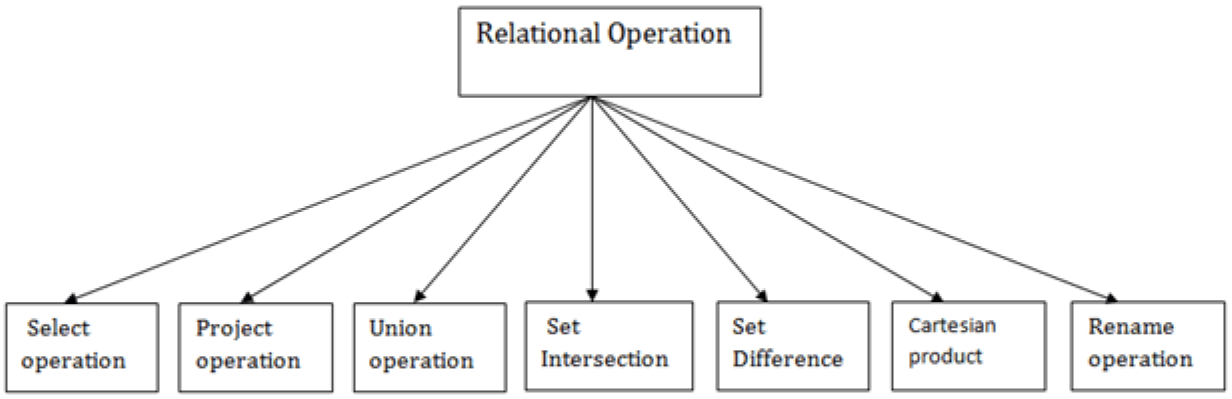
Fname	**Lastname**	**Start Time**	**End Time**
Anne	Smith	09:00	18:00
Jack	Francis	08:00	17:00
Anna	McLean	11:00	20:00
Shown	Willam	14:00	23:00

Above, given example, shown shift timings of the different employee. In this example, a surrogate key is needed to uniquely identify each employee.

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:

- The select operation selects tuples that satisfy a given predicate.
- It is denoted by sigma (σ)

1. Notation: σ p(r)

Where **σ** is used for selection prediction
r is used for relation
p is used as a propositional logic formula which may use connectors like: AND OR and NOT. These relational can use as relational operators like =, ≠, ≥, <, >, ≤.

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

Input:

σ BRANCH_NAME="perryride" (LOAN)

Output:

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

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 ∏

1. Notation: ∏ A1, A2, An (r)

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

   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

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/SYN-> : 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.

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

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

Input

1. ∏ CUSTOMER_NAME (BORROW) ∪ ∏ CUSTOMER_NAME (DEPOSITOR)

Output:

CUSTOMER_NAME
Johnson
Smith
Hayes
Turner
Jones
Lindsay
Jackson

Curry
Williams

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 ∩.

1. Notation: R ∩ S

Example: Using the above DEPOSITOR table and BORROW table

Input:

∏ CUSTOMER_NAME (BORROW) ∩ ∏ CUSTOMER_NAME (DEPOSITOR)

Output:

CUSTOMER_NAME
Smith
Jones

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:

Ex->∏ CUSTOMER_NAME (BORROW) - ∏ CUSTOMER_NAME (DEPOSITOR)

Output:

CUSTOMER_NAME
Jackson
Hayes
Willians
Curry

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.

Notation: E X D

Example:

EMPLOYEE

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

DEPARTMENT

DEPT_NO	DEPT_NAME
A	Marketing
B	Sales
C	Legal

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)

SQL Set Operations

The SQL Set operation is used to combine the two or more SQL SELECT statements.

Types of Set Operation

1. Union
2. UnionAll
3. Intersect
4. Minus

1. Union

- The SQL Union operation is used to combine the result of two or more SQL SELECT queries.
- In the union operation, all the number of datatype and columns must be same in both the tables on which UNION operation is being applied.
- The union operation eliminates the duplicate rows from its resultset.

Syntax

```
SELECT column_name FROM table1
UNION
SELECT column_name FROM table2;
```

Example:

The First table

ID	NAME
1	Jack
2	Harry
3	Jackson

The Second table

ID	NAME
3	Jackson
4	Stephan
5	David

Union SQL query will be:

1. SELECT * FROM First
2. UNION
3. SELECT * FROM Second;

The resultset table will look like:

ID	NAME
1	Jack
2	Harry
3	Jackson
4	Stephan
5	David

2. Union All

Union All operation is equal to the Union operation. It returns the set without removing duplication and sorting the data.

Syntax:

```
SELECT column_name FROM table1
UNION ALL
SELECT column_name FROM table2;
```

Example: Using the above First and Second table.

Union All query will be like

```
SELECT * FROM First
UNION ALL
SELECT * FROM Second;
```

The resultset table will look like:

ID	NAME
1	Jack
2	Harry
3	Jackson
3	Jackson
4	Stephan
5	David

3. Intersect

- It is used to combine two SELECT statements. The Intersect operation returns the common rows from both the SELECT statements.
- In the Intersect operation, the number of datatype and columns must be the same.
- It has no duplicates and it arranges the data in ascending order by default.

Syntax:

1. SELECT column_name FROM table1
2. INTERSECT
3. SELECT column_name FROM table2;

Example:

Using the above First and Second table.

Intersect query will be

SELECT * FROM First
1. INTERSECT
2. SELECT * FROM Second;
3. The resultset table will look like:

ID	NAME
3	Jackson

4. Minus

- It combines the result of two SELECT statements. Minus operator is used to display the rows which are present in the first query but absent in the second query.

- It has no duplicates and data arranged in ascending order by default.

Syntax:

```
SELECT column_name FROM table1
1. MINUS
2. SELECT column_name FROM table2;
```

Example

Using the above First and Second table.

Minus query will be

```
Ex-SELECT * FROM First
   MINUS
   SELECT * FROM Second;
```

The resultset table will look like:

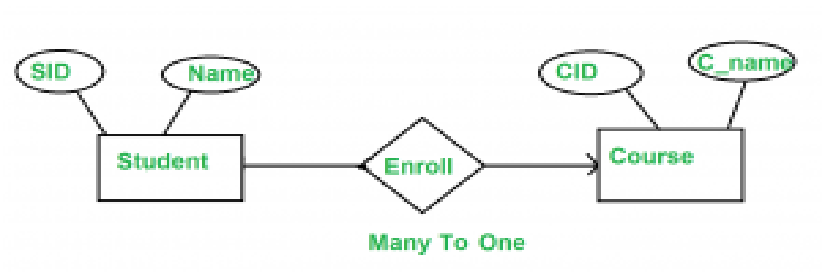
ID	NAME
1	Jack
2	Harry

Reduction of schemas to relational schemas

Entity-Relationship (ER) Diagram is a diagrammatic representation of data in databases, it shows how data is related.

Note: This article is for those who already know what is ER diagram and how to draw ER diagram.

1) When there are Many to One cardinalities **in** the **ER diagram.**
For example, a student can be enrolled only in one course, but a course can be enrolled by many students.



For Student(SID, Name), SID is the primary key. For Course(CID, C_name), CID is the primary key

Student

(SID	Name)
1	A
2	B
3	C
4	D

Course

(CID	C_name)
c1	Z
c2	Y
c3	X

Enroll

(SID	CID)
1	C1
2	C1
3	c3
4	C2

Now the question is, what should be the primary key for Enroll? Should it be SID or CID or both combined into one. We can't have CID as the primary key because a CID can have multiple SIDs. (SID, CID) can distinguish table uniquely, but it is not minimum. So SID is the primary key for the relation enrollment.

For the above ER diagram, we considered three tables in the database

Student

Enroll

Course

But we can combine Student and Enroll table renamed as Student_enroll.

Student_Enroll

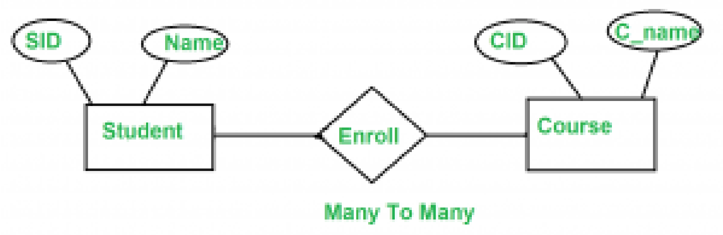
SID	Name	CID
1	A	c1
2	B	c1
3	C	c3
4	D	c2

Student and enroll tables are merged now.

So require a minimum of two DBMS tables for Student_enroll and Course.

Note: In One to Many relationships we can have a minimum of two tables.

2. When there are Many to Many cardinalities in ER Diagram.
Let us consider the above example with the change that now a student can enroll in more than 1 course.



Student	
(SID	Name)
1	A
2	B
3	C
4	D

Course	
(CID	C_name)
c1	Z
c2	Y
c3	X

Enroll	
(SID	CID)
1	C1
1	C2
2	C1
2	C2
3	c3

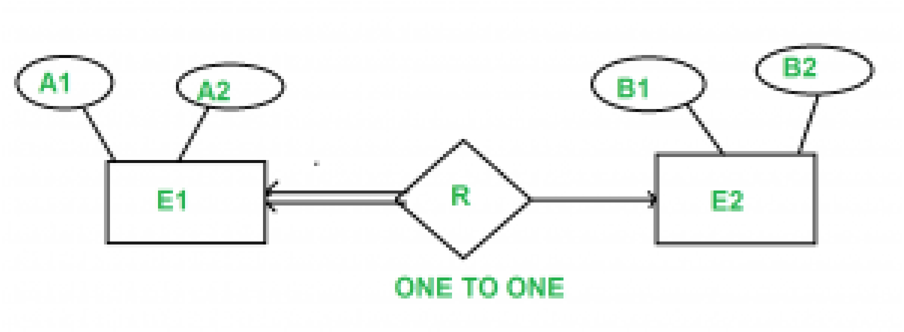
4 C2

Now, the same question arises. What is the primary key of Enroll relation? If we carefully analyze, the primary key for Enroll table is (SID, CID).

But in this case, we can't merge Enroll table with any one of the Student and Course. If we try to merge Enroll with any one of the Student and Course it will create redundant data.

Note: Minimum of three tables are required in the Many to Many relationships.

3. One to One Relationship
There are two possibilities
A) If we have One to One relationship and we have total participation at at-least one end.
For example, consider the below ER diagram.



A1 and B1 are primary keys of E1 and E2 respectively.

In the above diagram, we have total participation at the E1 end.

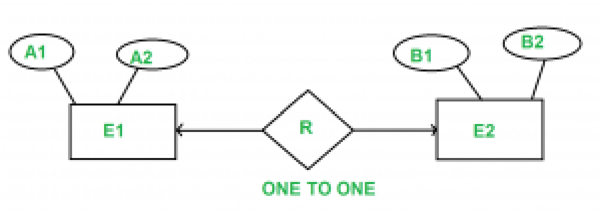
Only a single table is required in this case having the primary key of E1 as its primary key.

Since E1 is in total participation, each entry in E1 is related to only one entry in E2, but not all entries in E2 are related to an entry in E1.

The primary key of E1 should be allowed as the primary key of the reduced table since if the primary key of E2 is used, it might have null values for many of its entries in the reduced table.

Note: Only 1 table required.

B) One to One relationship with no total participation.



A1 and B1 are primary keys of E1 and E2 respectively.

The primary key of R can be A1 or B1, but we can't still combine all three tables into one. if we do so, some entries in the combined table may have NULL entries. So the idea of merging all three tables into one is not good.

But we can merge R into E1 or E2. So a minimum of 2 tables is required.

ER Design Issues

The basic design issues of an ER database schema in the following points:

1) Use of Entity Set vs Attributes

The use of an entity set or attribute depends on the structure of the real-world enterprise that is being modelled and the semantics associated with its attributes. It leads to a mistake when the user use the primary key of an entity set as an attribute of another entity set.

2) Use of Entity Set vs. Relationship Sets

It is difficult to examine if an object can be best expressed by an entity set or relationship set. To understand and determine the right use, the user need to designate a relationship set for describing an action that occurs in-between the entities

3) Use of Binary vs n-ary Relationship Sets

Generally, the relationships described in the databases are binary relationships. However, non-binary relationships can be represented by several binary relationships. For example, we can create and represent a ternary relationship 'parent' that may relate to a child, his father, as well as his mother. Such relationship can also be represented by two binary relationships i.e, mother and father, that may relate to their child. Thus, it is possible to represent a non-binary relationship by a set of distinct binary relationships.

4) Placing Relationship Attributes

The cardinality ratios can become an affective measure in the placement of the relationship attributes. So, it is better to associate the attributes of one-to-one or one-to-many relationship sets with any participating entity sets, instead of any relationship set.

Thus, it requires the overall knowledge of each part that is involved in desgining and modelling an ER diagram. The basic requirement is to analyse the real-world enterprise and the connectivity of one entity or attribute with other.

Functional Dependency

The functional dependency is a relationshipthat exists between two attributes. It typically exists between the primary key and non-key attribute within a table.

$$X \rightarrow Y$$

The left side of FD is known as a determinant, the right side of the production is known as a dependent.

For example:

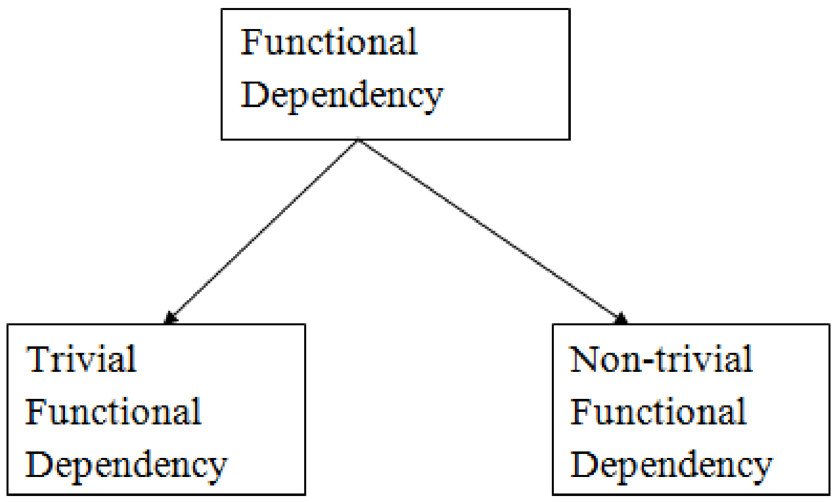
Assume we have an employee table with attributes: Emp_Id, Emp_Name, Emp_Address.Here Emp_Id attribute can uniquely identify the Emp_Name attribute of employee table because if we know the Emp_Id, we can tell that employee name associated with it.

Functional dependency can be written as

$$\text{Emp\_Id} \rightarrow \text{Emp\_Name}$$

We can say that Emp_Name is functionally dependent on Emp_Id.

Types of Functional dependency


Functional Dependency
Trivial Functional Dependency
Non-trivial Functional Dependency

1. Trivial functional dependency

- A → B has trivial functional dependency if B is a subset of A.
- The following dependencies are also trivial like: A → A,   B → B

Example:

1. Consider a table with two columns Employee_Id and Employee_Name.
2. {Employee_id, Employee_Name} → Employee_Id is a trivial function al dependency as
3. Employee_Id is a subset of {Employee_Id, Employee_Name}.
4. Also, Employee_Id → Employee_Id and Employee_Name → Employe e_Name are trivial dependencies too.

2. Non-trivial functional dependency

- A → B has a non-trivial functional dependency if B is not a subset of A.
- When A intersection B is NULL, then A → B is called as complete non-trivial.

Example

ID → Name,

Name → DOB

Normalization

What is Normalization?

- Normalization is the process of organizing the data in the database.
- Normalization divides the larger table into smaller and links them using relationships.
- The normal form is used to reduce redundancy from the database table.

Why do we need Normalization?

The main reason for normalizing the relations is removing these anomalies. Failure to eliminate anomalies leads to data redundancy and can cause data integrity and other problems as the database grows. Normalization consists of a series of guidelines that helps to guide you in creating a good database structure.

Data modification anomalies can be categorized into three types:

- **Insertion Anomaly:** Insertion Anomaly refers to when one cannot insert a new tuple into a relationship due to lack of data.
- **Deletion Anomaly:** The delete anomaly refers to the situation where the deletion of data results in the unintended loss of some other important data.

- **Updatation Anomaly:** The update anomaly is when an update of a single data value requires multiple rows of data to be updated.

Types of Normal Forms:

Normalization works through a series of stages called Normal forms. The normal forms apply to individual relations. The relation is said to be in particular normal form if it satisfies constraints.

Following are the various types of Normal forms:

Normal Form	**Description**
1NF	A relation is in 1NF if it contains an atomic value.
2NF	A relation will be in 2NF if it is in 1NF and all non-key attributes are fully functional dependent on the primary key.
3NF	A relation will be in 3NF if it is in 2NF and no transition dependency exists.
BCNF	A stronger definition of 3NF is known as Boyce Codd's normal form.

4NF	A relation will be in 4NF if it is in Boyce Codd's normal form and has no multi-valued dependency.

Advantages of Normalization

- Normalization helps to minimize data redundancy.
- Greater overall database organization.
- Data consistency within the database.
- Much more flexible database design.
- Enforces the concept of relational integrity.

Disadvantages of Normalization

- You cannot start building the database before knowing what the user needs.
- It is very time-consuming and difficult to normalize relations of a higher degree.
- Careless decomposition may lead to a bad database design, leading to serious problems.

First Normal Form (1NF)

- A relation will be 1NF if it contains an atomic value.

- It states that an attribute of a table cannot hold multiple values. It must hold only single-valued attributes.
- First normal form disallows the multi-valued attribute, composite attribute, and their combinations.

EMP_ID	EMP_NAME	EMP_PHONE	EMP_STATE
14	John	7272826385, 9064738238	UP
20	Harry	8574783832	Bihar
12	Sam	7390372389, 8589830302	Punjab

Example: Relation EMPLOYEE is not in 1NF because of multi-valued attribute EMP_PHONE.

EMPLOYEE table:

The decomposition of the EMPLOYEE table into 1NF has been shown below.

EMP_ID	EMP_NAME	EMP_PHONE	EMP_STATE
14	John	7272826385	UP
14	John	9064738238	UP
20	Harry	8574783832	Bihar
12	Sam	7390372389	Punjab
12	Sam	8589830302	Punjab

Second Normal Form (2NF)

- In the 2NF, relational must be in 1NF.
- In the second normal form, all non-key attributes are fully functional dependent on the primary key

Example: Let's assume, a school can store the data of teachers and the subjects they teach. In a school, a teacher can teach more than one subject.

TEACHER table

TEACHER_ID	SUBJECT	TEACHER_AGE
25	Chemistry	30
25	Biology	30
47	English	35
83	Math	38
83	Computer	38

In the given table, non-prime attribute TEACHER_AGE is dependent on TEACHER_ID which is a proper subset of a candidate key. That's why it violates the rule for 2NF.

To convert the given table into 2NF, we decompose it into two tables:

TEACHER_DETAIL table:

TEACHER_ID	TEACHER_AGE
25	30
47	35
83	38

TEACHER_SUBJECT table:

TEACHER_ID	SUBJECT
25	Chemistry
25	Biology
47	English
83	Math
83	Computer

For a table to be in third normal form, it needs to satisfy the following conditions:

- It should be in second normal form
- It should not have any transitive dependencies for non-prime attributes

Transitive dependencies are indirect relationships between values in the same table that cause functional dependencies.

For a table to not have any transitive dependencies, we need to ensure that no non-prime attribute determines another non-prime attribute as only prime attributes or candidate keys can determine non-prime attributes for a table in 3NF.

The following figure shows an example of a transitive dependency:

Third Normal Form (3NF)

- A relation will be in 3NF if it is in 2NF and not contain any transitive partial dependency.
- 3NF is used to reduce the data duplication. It is also used to achieve the data integrity.
- If there is no transitive dependency for non-prime attributes, then the relation must be in third normal form.

A relation is in third normal form if it holds atleast one of the following conditions for every non-trivial function dependency X → Y.

1. X is a super key.
2. Y is a prime attribute, i.e., each element of Y is part of some candidate key.

Example:

EMPLOYEE_DETAIL table:

EMP_ID	EMP_NAME	EMP_ZIP	EMP_STATE	EMP_CITY
222	Harry	201010	UP	Noida
333	Stephan	02228	US	Boston
444	Lan	60007	US	Chicago
555	Katharine	06389	UK	Norwich
666	John	462007	MP	Bhopal

Super key in the table above table

{EMP_ID}, {EMP_ID, EMP_NAME}, {EMP_ID, EMP_NAME, EMP_ZIP}....so on

Candidate key: {EMP_ID}

Non-prime attributes: In the given table, all attributes except EMP_ID are non-prime.

Here, EMP_STATE & EMP_CITY dependent on EMP_ZIP and EMP_ZIP dependent on EMP_ID. The non-prime attributes (EMP_STATE, EMP_CITY) transitively dependent on super key(EMP_ID). It violates the rule of third normal form.

That's why we need to move the EMP_CITY and EMP_STATE to the new <EMPLOYEE_ZIP> table, with EMP_ZIP as a Primary key.The resultant table is as follows

EMPLOYEE table:

EMP_ID	EMP_NAME	EMP_ZIP
222	Harry	201010
333	Stephan	02228
444	Lan	60007
555	Katharine	06389
666	John	462007

EMPLOYEE_ZIP table:

EMP_ZIP	EMP_STATE	EMP_CITY
201010	UP	Noida
02228	US	Boston
60007	US	Chicago
06389	UK	Norwich
462007	MP	Bhopal

Boyce Codd normal form (BCNF)

- BCNF is the advance version of 3NF. It is stricter than 3NF.
- A table is in BCNF if every functional dependency X → Y, X is the super key of the table.
- For BCNF, the table should be in 3NF, and for every FD, LHS is super key.

Example: Let's assume there is a company where employees work in more than one department.

EMPLOYEE table:

EMP_ID	EMP_COUNTRY	EMP_DEPT	DEPT_TYPE	EMP_DEPT_NO
264	India	Designing	D394	283
264	India	Testing	D394	300
364	UK	Stores	D283	232
364	UK	Developing	D283	549

In the above table Functional dependencies are as follows:

EMP_ID → EMP_COUNTRY

1. EMP_DEPT → {DEPT_TYPE, EMP_DEPT_NO}

Candidate key: {EMP-ID, EMP-DEPT}

The table is not in BCNF because neither EMP_DEPT nor EMP_ID alone are keys.

To convert the given table into BCNF, we decompose it into three tables:

EMP_COUNTRY table:

EMP_ID	EMP_COUNTRY
264	India
264	India

EMP_DEPT table:

EMP_DEPT	DEPT_TYPE	EMP_DEPT_NO
Designing	D394	283
Testing	D394	300
Stores	D283	232
Developing	D283	549

EMP_DEPT_MAPPING table:

EMP_ID	EMP_DEPT
D394	283
D394	300
D283	232
D283	549

Functional dependencies

1. EMP_ID → EMP_COUNTRY
2. EMP_DEPT → {DEPT_TYPE, EMP_DEPT_NO}

Candidate keys:

Forthefirsttable:EMP_ID
Forthesecondtable:EMP_DEPT
For the third table: {EMP_ID, EMP_DEPT}

Now, this is in BCNF because left side part of both the functional dependencies is a key.

Fourth normal form (4NF)

- A relation will be in 4NF if it is in Boyce Codd normal form and has no multi-valued dependency.

- For a dependency A → B, if for a single value of A, multiple values of B exists, then the relation will be a multi-valued dependency.

ExampLE

STUDENT

STU_ID	COURSE	HOBBY
21	Computer	Dancing
21	Math	Singing
34	Chemistry	Dancing
74	Biology	Cricket
59	Physics	Hockey

The given STUDENT table is in 3NF, but the COURSE and HOBBY are two independent entity. Hence, there is no relationship between COURSE and HOBBY.

In the STUDENT relation, a student with STU_ID, **21** contains twocourses, **Computer** and **Math** andwo hobbies, **Dancing** and **Singing**. So there is a Multi-valued dependency on STU_ID, which leads to unnecessary repetition of data.

So to make the above table into 4NF, we can decompose it into two tables:

STUDENT_COURSE

STU_ID	COURSE
21	Computer
21	Math
34	Chemistry
74	Biology
59	Physics

STUDENT_HOBBY

STU_ID	HOBBY
21	Dancing
21	Singing
34	Dancing

74	Cricket
59	Hockey

DATA ANOMOLIES AND ITS TYPES

The normalization process was created largely in order to reduce the negative effects of creating tables that will introduce anomalies into the database.

There are three types of **Data Anomalies**: Update Anomalies, Insertion Anomalies, and Deletion Anomalies.

Update Anomalies happen when the person charged with the task of keeping all the records current and accurate, is asked, for example, to change an employee’s title due to a promotion. If the data is stored redundantly in the same table, and the person misses any of them, then there will be multiple titles associated with the employee. The end user has no way of knowing which is the correct title.

Insertion Anomalies happen when inserting vital data into the database is not possible because other data is not already there. For example, if a system is designed to require that a customer be on file before a sale can be made to that customer, but you cannot add a customer until they have bought something, then you have an insert anomaly. It is the classic "catch-22" situation.

Deletion Anomalies happen when the deletion of unwanted information causes desired information to be deleted as well. For example, if a single database record contains information about a particular product along with information about a salesperson for the company and the salesperson quits, then information about the product is deleted along with salesperson information

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