Introduction to the Relational Model

CE384: Database Design
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Course overview

- Lectures
  - Goal: To introduce concepts in designing database, and motivate their use and importance.
  - Note: We try to cover useful materials in class, but we recommend you reading more!
- Assignments
  - Purpose: To give you a chance to exercise your mind, and to solidify the concepts introduced to you in class.
  - Outline: Homeworks have practical part.
  - Importance: Not important unless you want to learn the material and get a good grade!

01

Structure of Relational Databases

Relational Database: Definitions

- Relational database: a set of relations

- Relation: made up of 2 parts:
  - Schema : specifies name of relation, plus name and type of each column.
    - e.g., Students(sid: string, name: string, login: string, age: integer, gpa: real).
  - Instance : a table, with rows and columns.
    #Rows = cardinality, #fields = degree / arity.

- Can think of a relation as a set of rows or tuples (all rows are distinct).

Relational Database: Definitions

- A row in a table represents a relationship among a set of values.
- In mathematical terminology, a tuple is simply a sequence (or list) of values. A relationship between n values is represented mathematically by an n-tuple of values, that is, a tuple with n values, which corresponds to a row in a table.
- In the relational model the term relation is used to refer to a table, while the term tuple is used to refer to a row. Similarly, the term attribute refers to a column of a table.
- Relation instance to refer to a specific instance of a relation, containing a specific set of rows.

Relational Database: Definitions

- Degree d(R): Total no of attributes/columns present in a relation/table is called degree of the relation and is denoted by d(R).
- Cardinality |R|: Total no if tuples present in a relation or Rows present in a table, is called cardinality of a relation and is denoted by |R|.
- Domain: Total range of accepted values for an attribute of the relation is called the domain of the attribute. We require that, for all relations r, the domains of all attributes of r be atomic.
- A domain is atomic if elements of the domain are considered to be indivisible units.

For example, suppose the table instructor had an attribute phone number, which can store a set of phone numbers corresponding to the instructor. Then the domain of phone number would not be atomic, since an element of the domain is a set of phone numbers, and it has subparts, namely, the individual phone numbers in the set.

Relational Database: Definitions

- The null value is a special value that signifies that the value is unknown or does not exist.

Example Instance of Students Relation

tuples →

sid	name	login	age	gpa
53666	Jones	jones@cs	18	3.4
53688	Smith	smith@eecs	18	3.2
53650	Smith	smith@math	19	3.8

- Cardinality = 3, degree = 5, all rows distinct
- schema for that relation is: Student(sid,name,login,age,gpa)

Integrity Constraints (ICs)

- IC: condition that must be true for any instance of the database; e.g., domain constraints.
  - ICs are specified when schema is defined.
  - ICs are checked when relations are modified.
- A legal instance of a relation is one that satisfies all specified ICs.
  - DBMS should not allow illegal instances.
- If the DBMS checks ICs, stored data is more faithful to real-world meaning.
  - Avoids data entry errors, too!

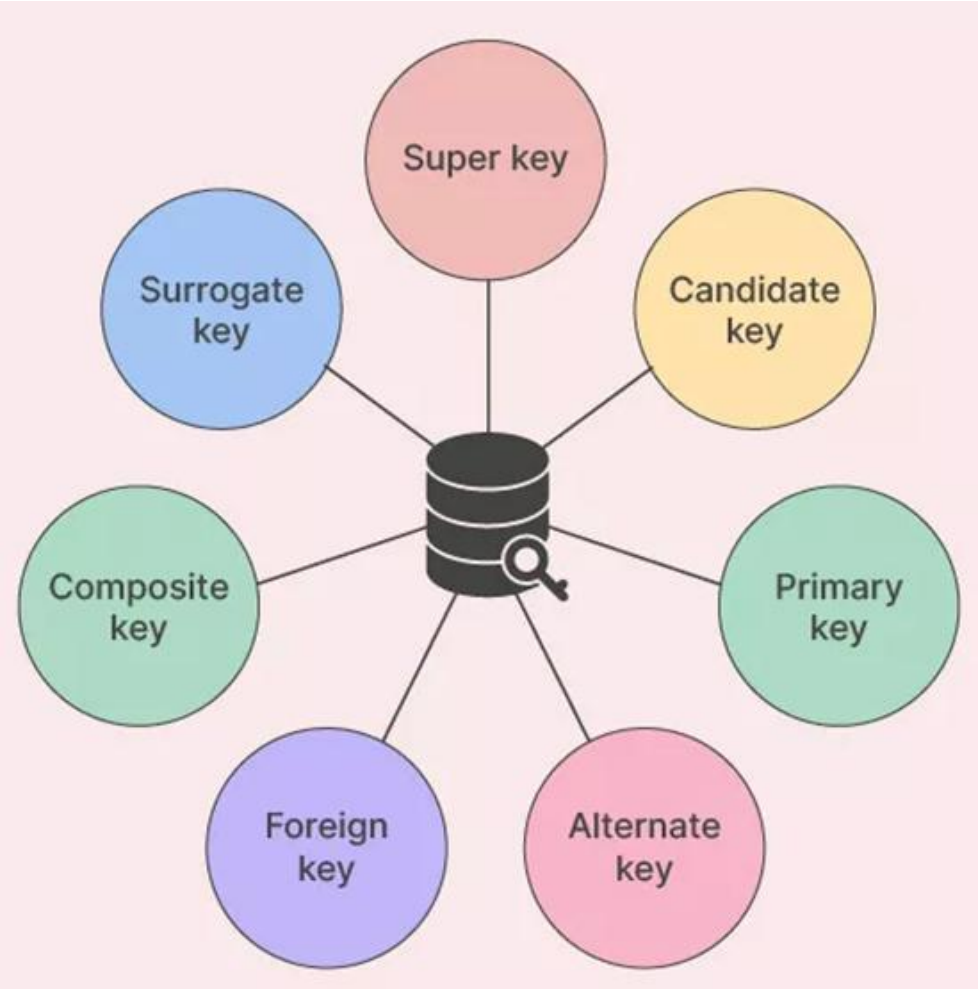
02

Different Types of Keys

Keys

- 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.

Type of Keys


Super key
Surrogate key
Candidate key
Composite key
Primary key
Foreign key
Alternate key

Super Key

- A super key 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.

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

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

Candidate Key

- Candidate Key: A super key such that no proper subset is a super key within the relation. A candidate key *K* for a relation *R* has two properties:
  - Uniqueness: In each tuple of R, the values of K uniquely identify that tuple.
  - Irreducibility: No proper subset of K has the uniqueness property.

```
Student{ID, Aadhar_ID, F_name, M_name, L_name, Age}
```

Here we can see the two candidate keys ID and Aadhar_ID. So here, there are present more than one candidate keys, which can uniquely identify a tuple in a relation.

Identifying a candidate key requires that we know the “real-world” meaning of the attribute(s) involved so that we can decide whether duplicates are possible.

Primary Key

- Primary Key is a set of attributes (or attribute) which uniquely identify the tuples in relation or table. The candidate key that is selected to identify tuples uniquely within the relation. The primary key is a minimal super key, so there is one and only one primary key in any relationship. For example,

Here `Student{ID, Aadhar_ID, F_name, M_name, L_name, Age}` can be same, but ID or Aadhar_ID can't be same.

  - 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.

Primary Key Constraints

- A set of fields is a (candidate) key for a relation if :
  1. No two distinct tuples can have same values in all key fields, and
  2. This is not true for any subset of the key.
- Part 2 false? A superkey.
- If there's >1 key for a relation, one of the keys is chosen (by DBA) to be the primary key.
- E.g., sid is a key for Students. (What about name?) The set {sid, gpa} is a superkey.

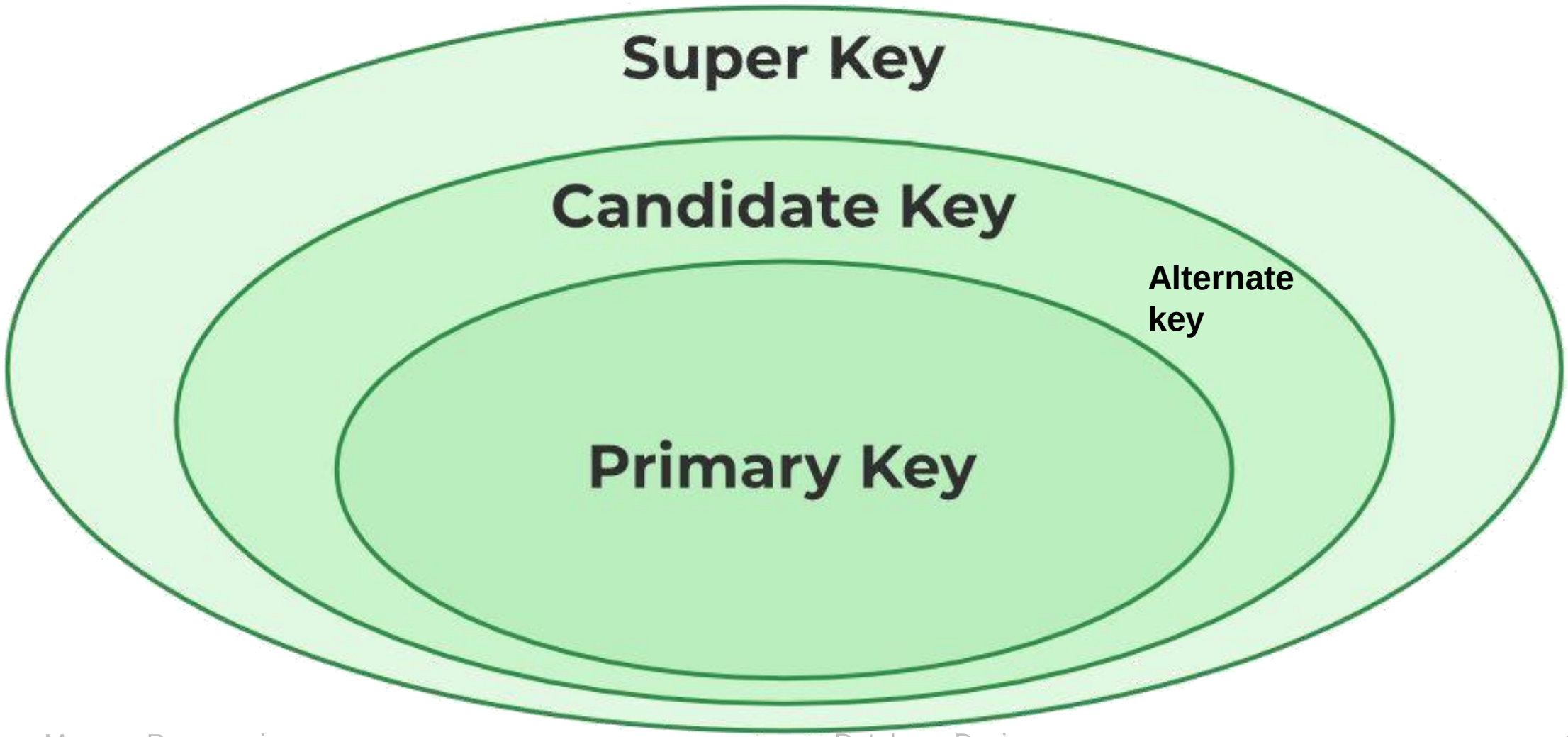
Alternate Key

- **Alternate Key:** The candidate keys that are not selected to be the primary key are called alternate keys. This is a column or group of columns in a table that uniquely identify every row in that table. A table can have multiple choices for a primary key but only one can be set as the primary key. All the keys which are not primary key are called an Alternate Key.
- **Alternate key = candidate key - primary key**

In this table, StudID, Roll No, Email are qualified to become a primary key. But since StudID is the primary key, Roll No, Email becomes the alternative 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

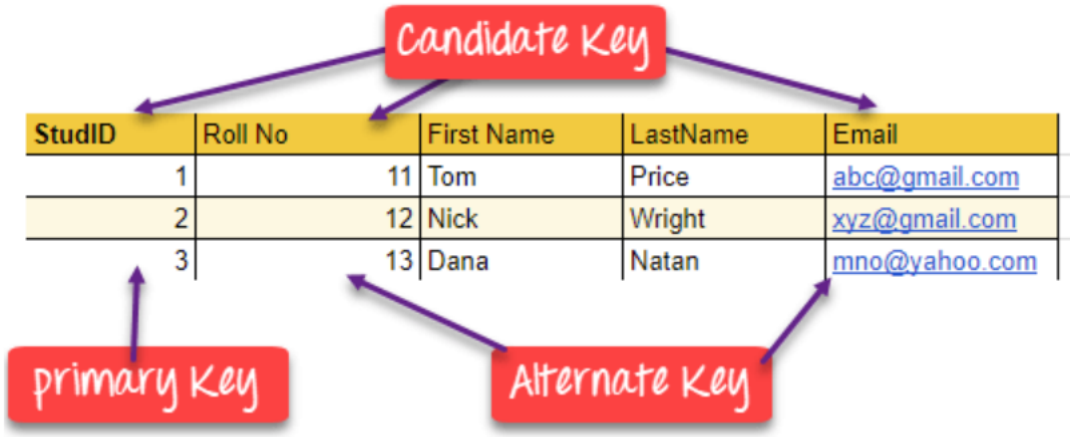
Conclusion



Example

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.

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



Candidate Key in DBMS

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. An attribute, or set of attributes, within one relation that matches the candidate key of some (possibly the same) relation.

Foreign Key

DeptCode	DeptName
001	Science
002	English
005	Computer

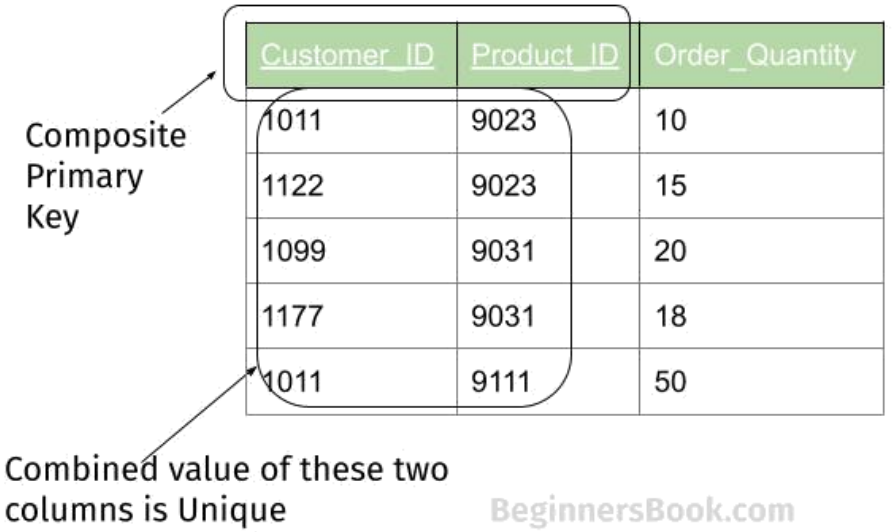
Teacher ID	Fname	Lname
B002	David	Warner
B017	Sara	Joseph
B009	Mike	Brunton

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

Composite Key

- Composite Key: a candidate key that consists of two or more attributes, (table columns) that together uniquely identify an entity occurrence (table row).
- Composite key cannot be null and should be unique.
  - The main difference between the primary key and the composite key is the primary key is derived from a unique column. Composite is derived by a combination of two or columns. Individually they are not unique but when combined they provide uniqueness.
  - After getting the composite key, we mention it as the primary key Which will be used for the identification of the rows from the table.
  - If a table already consists of a primary key having a single attribute as an entity for uniquely identifying the records in a table, then the composite key is of no use as we always select the primary key having minimum attributes (or columns).



Compound Key

- Compound Key: is a composite key for which each attribute that makes up the key is a foreign key in its own right.
  - A compound key is where two or more attributes are used to uniquely identify each record in a table.
  - Each attribute from the compound key is a primary key from a different table.
  - A compound key is used when no single attribute in a table can be used as a primary key.

Compound Key Example

Two-Wheel-Rental Inc hires bikes to customers for one day. They have a relational database with three tables as shown below:

Members	Bikes	Hire
MemberID	BikeID	MemberID*
Name	Make	BikeID*
Address	Colour	HireDate
Telephone	MT338X440	

The Hire table needs a compound key of MemberID, BikeID and HireDate.

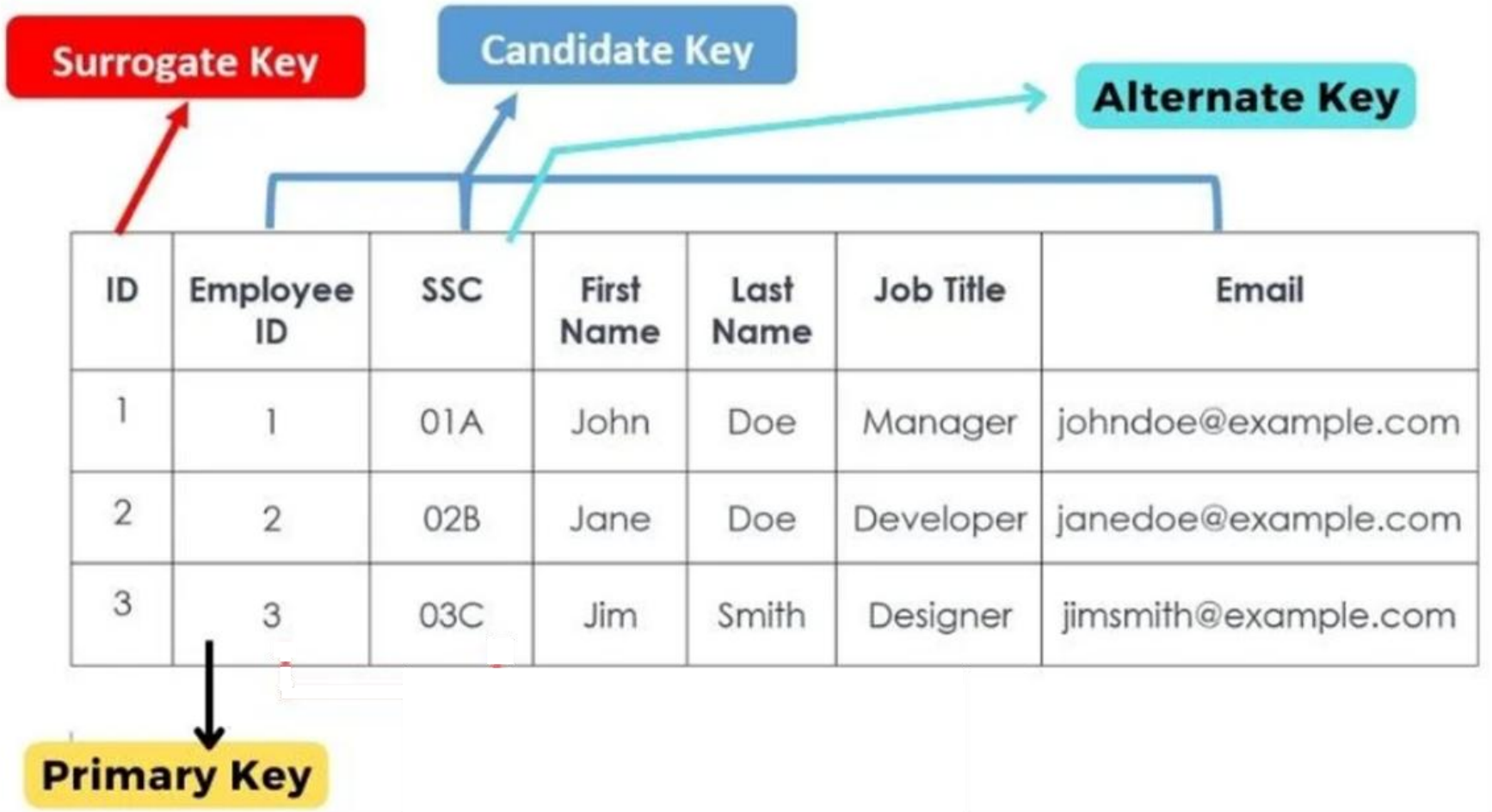
- MemberID alone can't be used – a member can make more than one hire
- BikeID alone can't be used – a bike can be hired by more than one member
- MemberID and BikeID can't be used – a member could hire the same bike on a different day

Members	Bikes	Hire
MemberID	BikeID	MemberID*
Name	Make	BikeID*
Address	Colour	HireDate
Telephone	MT338X440	

Surrogate Key

- 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.
  - A common example of surrogate key is auto-incrementing integer as primary key in a table.

Type of Keys



ID	Employee ID	SSC	First Name	Last Name	Job Title	Email
1	1	01A	John	Doe	Manager	johndoe@example.com
2	2	02B	Jane	Doe	Developer	janedoe@example.com
3	3	03C	Jim	Smith	Designer	jimsmith@example.com

Any Question?