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Database Design

9-1

Introduction to Relational Database Concepts

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Objectives

- This lesson covers the following objectives:
  - Define a primary key
  - Define a foreign key
  - Define a column-integrity rule
  - Identify row, column, primary key, unique key, and foreign key elements given a diagram of a table containing these elements
  - Identify violations of data-integrity rules

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This lesson talks about relational databases, primary keys, foreign keys, and data integrity. This will help with the conceptual to physical mapping later in this section, and with the transition to SQL later.

The word “relation” is an abstract mathematical term used in set theory. A mathematical relation has the same logical properties as a table in a database. This is the origin of the term “relational database”, i.e. a database consisting of a set of relations (i.e., tables).

Purpose

- The conceptual data model will be transformed into a relational database design
- This means that our entities, attributes, relationships, and unique identifiers will be translated into objects in a relational database
- Compare this to a clothing designer who is taking his design from paper and implementing it with fabric
- The designer needs to understand how to sew the designs just like you will need to understand the structure of relational database objects

This lesson introduces a new set of terminology. An entity is not a table, and an attribute is not a column. We will be transforming (mutating) one set of objects (ER conceptual modeling constructs) into another (data design physical model constructs).

Relational Database Illustrated

- A relational database is a database that is seen by the user as a collection of two-dimensional tables, each containing rows and columns
- The table below contains employee data

EMPLOYEES (table name)

EMPLOYEE_ID	FIRST_NAME	LAST_NAME	DEPARTMENT_ID
100	Steven	King	90
101	Neena	Kochhar	90
102	Lex	De Haan	90
200	Jennifer	Whalen	10
205	Shelley	Higgins	110

Row

Column

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Relational database: Collections of objects or relations, set of operators to act on those relations, and data integrity for accuracy and consistency.

Each row of data describes an employee. Each column is an attribute of that employee. If we wanted to find out the last name and department number of employee number 210, we would need to access the third row in the table, and then find the values for first_name and department_no for that row. But how do we find the correct row in the first place? Would we have to go through the whole table and look at every row? Answer: No. (Move on to next page.)

Language to Access Data

- Structured query language (SQL) allows us to access data in relational databases in an efficient way
- Instead of manually searching through each row to find the record for employee number 200, we use the following SQL statement:

```
SELECT last_name, department_id
FROM employees
WHERE employee_id = 200;
```

- You can see the result of this statement on the next slide

SQL Query Illustrated

EMPLOYEES (table name)

EMPLOYEE_ID	FIRST_NAME	LAST_NAME	DEPARTMENT_ID
100	Steven	King	90
101	Neena	Kochhar	90
102	Lex	De Haan	90
200	**Jennifer**	**Whalen**	**10**
205	Shelley	Higgins	110

```
SELECT last_name, department_id
FROM employees
WHERE employee_id = 200;
```

LAST_NAME	DEPARTMENT_ID
Whalen	10

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Specific SQL Query

- To find all the employees in department number 90, we write a different SQL statement:

```
SELECT *
FROM employees
WHERE department_id = 90;
```

- Again, you can see the result on the next slide

The "*" after SELECT means we want all the columns in the table.

Specific SQL Query

EMPLOYEES (table name)

EMPLOYEE_ID	FIRST_NAME	LAST_NAME	....	DEPARTMENT_ID
100	Steven	King	....	90
101	Neena	Kochhar	....	90
102	Lex	De Haan	....	90
200	Jennifer	Whalen	....	10
205	Shelley	Higgins	....	110

```
SELECT  *
FROM employees
WHERE department_id = 90;
```

EMPLOYEE_ID	FIRST_NAME	LAST_NAME	....	DEPARTMENT_ID
100	Steven	King	....	90
101	Neena	Kochhar	....	90
102	Lex	De Haan	....	90

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SQL allows us to access the whole table or just parts of the table, depending on what comes after SELECT and what is specified in the WHERE clause.

Primary Key

- A primary key (PK) is a column or set of columns that uniquely identifies each row in a table

ACCOUNTS

BANK_NO	ACCT_NO	BALANCE	DATE_OPENED
104	75760	120,050.00	21-OKT-89
104	77956	100.10	
105	89570	55,775.00	15-JAN-85
103	55890	15,001.85	10-MAR-91
105	75760	5.00	22-SEP-03

Multiple Column Primary Key

EMPLOYEES

EMPLOYEE_ID	FIRST_NAME	LAST_NAME	....	DEPARTMENT_ID
100	Steven	King	....	90
101	Neena	Kochhar	....	90
102	Lex	De Haan	....	90
200	Jennifer	Whalen	....	10
205	Shelley	Higgins	....	110

Single Column Primary Key

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Primary key: A constraint which ensures that the column contains no null values and uniquely identifies each row of the table.
Notice that in ACCOUNTS, BANK_NO is not unique and ACCT_NO is not unique. However, the combination of BANK_NO and ACCT_NO is unique.

Primary Key

- Each table should have a primary key, and a primary key must be unique

ACCOUNTS

BANK_NO	ACCT_NO	BALANCE	DATE_OPENED
104	75760	120,050.00	21-OKT-89
104	77956	100.10	
105	89570	55,775.00	15-JAN-85
103	55890	15,001.85	10-MAR-91
105	75760	5.00	22-SEP-03

Multiple Column Primary Key

EMPLOYEES

EMPLOYEE_ID	FIRST_NAME	LAST_NAME	....	DEPARTMENT_ID
100	Steven	King	....	90
101	Neena	Kochhar	....	90
102	Lex	De Haan	....	90
200	Jennifer	Whalen	....	10
205	Shelley	Higgins	....	110

Single Column Primary Key

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Although it is possible to create a table without a Primary Key, it is not recommended.

Primary key: A constraint which ensures that the column contains no null values and uniquely identifies each row of the table.
Notice that in ACCOUNTS, BANK_NO is not unique and ACCT_NO is not unique. However, the combination of BANK_NO and ACCT_NO is unique.

Primary Key

- No part of the primary key can be null

ACCOUNTS

BANK_NO	ACCT_NO	BALANCE	DATE_OPENED
104	75760	120,050.00	21-OKT-89
104	77956	100.10	
105	89570	55,775.00	15-JAN-85
103	55890	15,001.85	10-MAR-91
105	75760	5.00	22-SEP-03

Multiple Column Primary Key

EMPLOYEES

EMPLOYEE_ID	FIRST_NAME	LAST_NAME	....	DEPARTMENT_ID
100	Steven	King	....	90
101	Neena	Kochhar	....	90
102	Lex	De Haan	....	90
200	Jennifer	Whalen	....	10
205	Shelley	Higgins	....	110

Single Column Primary Key

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Primary key: A constraint which ensures that the column contains no null values and uniquely identifies each row of the table.
Notice that in ACCOUNTS, BANK_NO is not unique and ACCT_NO is not unique. However, the combination of BANK_NO and ACCT_NO is unique.

Primary Key Candidates

- A table can have more than one column, or combinations of columns, that could serve as the table's primary key
- Each column, or combination of columns, is called a "candidate" key because it could be selected for use as the primary key

MEMBERS

MEMBER_ID	LAST_NAME	FIRST_NAME	PAYROLL_ID
100	SMITH	DANA	21215
310	ADAMS	TYLER	59877
210	CHEN	LAWRENCE	1101
405	GOMEZ	CARLOS	52
378	LOUNGANI	NEIL	90386

Candidate Key Candidate Key

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Candidate key: A column or combination of columns that could serve as the table's primary key.

What makes EMPLOYEE_ID and PAYROLL_ID good candidates for the primary key? Answer: They are both unique and not null.

Choose a Candidate Key

- Select one candidate key to be the primary key for the table
- The other candidates become alternate keys (or unique keys)

MEMBERS

MEMBER_ID	LAST_NAME	FIRST_NAME	PAYROLL_ID
100	SMITH	DANA	21215
310	ADAMS	TYLER	59877
210	CHEN	LAWRENCE	1101
405	GOMEZ	CARLOS	52
378	LOUNGANI	NEIL	90386

Primary Key

Alternate or Unique Key (UK)

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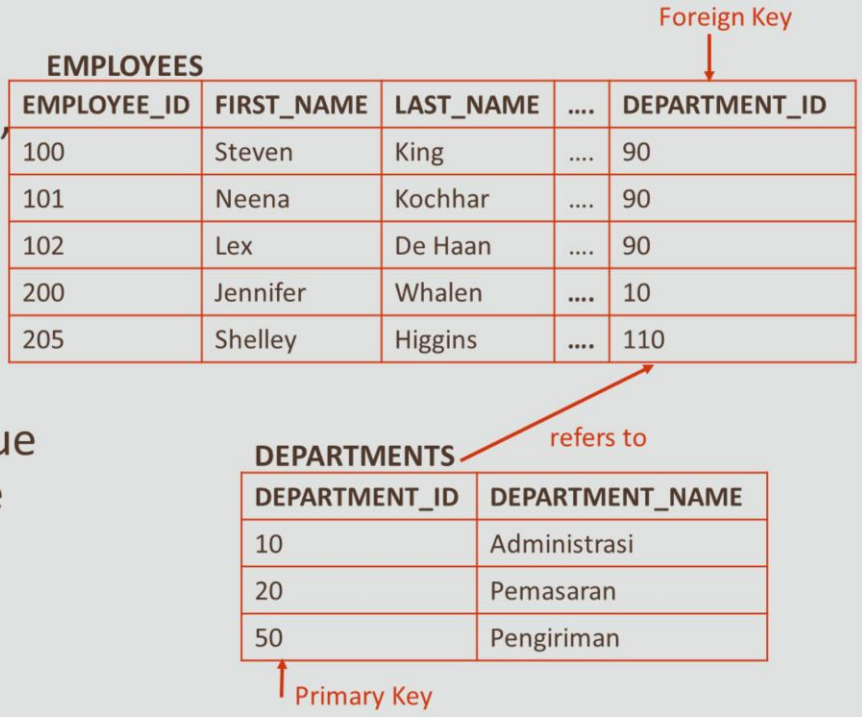
Unique key: An integrity constraint that requires every value in a column or set of columns be unique.

Why having alternate or unique keys can be useful? Answer: It's another way to locate a record. If you forget your employee ID, but know your payroll ID (or have a payroll stub with the ID on it), then you can still access your employee record.

Foreign Key

- A foreign key (FK) is a column, or combination of columns, in one table that contains values that match the primary key value in another table



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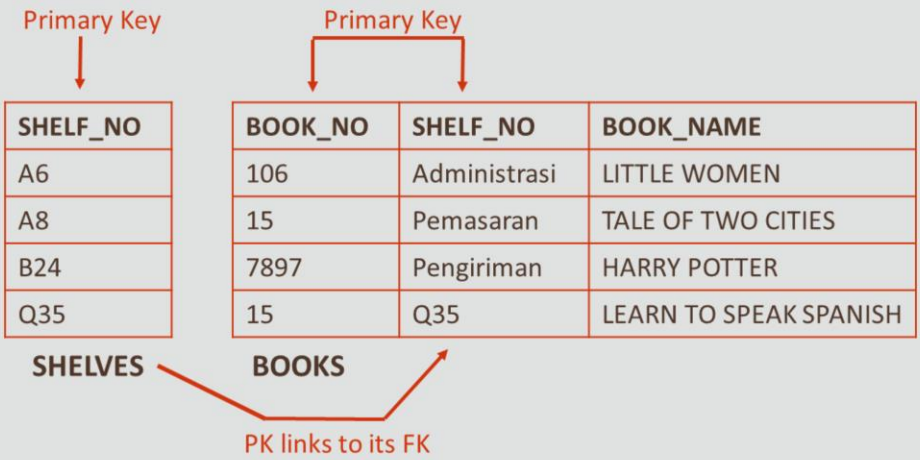
Foreign key: A column or set of columns that refers to a primary key in the same table or another table. If the foreign key (DEPARTMENT_ID) in EMPLOYEES has a value of 10, then there needs to be a row in DEPARTMENTS with a DEPARTMENT_ID of 10. Otherwise, it is a violation of referential integrity.

Foreign Key Rules

- If a primary key is composed of one or more foreign keys, the FK value cannot be NULL



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Notice that in the example, SHELF_NO is part of the primary key of BOOKS. It is also a foreign key to SHELVES. Since it is part of the PK of BOOKS, it cannot be null.

Column Integrity

- A column must contain only values that are consistent with the defined data format of the column

ACCOUNTS

BANK_NO	ACCT_NO	BALANCE	DATE_OPENED
104	75760	120050.00	21-OKT-89
104	77956	100.10	
105	89570	55775.00	15-JAN-85
103	55890	15001.85	10-MAR-91
105	75760	5.00	22-SEP-03

ACCOUNTS Table Definition

Column Name	Data Type	Optionality
BANK_NO	Number (5)	Not Null
ACCT_NO	Number (8)	Not Null
BALANCE	Number (12,2)	Not Null
DATE_OPENED	Date	

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Row: An entry in a table, consisting of values for each appropriate column.
Column: An implementation of an attribute or relationship in a table.

Summary of Data-Integrity Rules

- Data-integrity rules (also known as constraints) define the relationally correct state for a database
- Data-integrity rules ensure that users can perform only those operations that leave the database in a correct, consistent state

Summary of Data-Integrity Rules

Constraint Type	Explanation	Example
Entity Integrity	A primary key must be unique, and no part of the primary key can be null	The column emp_no in the EMPLOYEES table cannot be null
Referential Integrity	A foreign key must match an existing primary key value (or else be null if nulls are allowed)	The value in the dept_no column of the EMPLOYEES table must match a value in the dept_no column in the DEPARTMENTS table
Column Integrity	A column must contain only values consistent with the defined data format of the column	The value in the balance column of the ACCOUNTS table must be numeric
User-Defined Integrity	The data stored in a database must comply with the rules of the business	If the value in the balance column of the ACCOUNTS table is below 1.00, we must send a letter to the account owner (this will need additional programming to enforce)

The first three shown here are a summary of the data-integrity rules we've covered. The last one (an example of user-defined integrity) has not been covered yet, but students should understand its importance by now.

Terminology

- Key terms used in this lesson included:
  - Candidate key
  - Column
  - Foreign key
  - Primary key
  - Relational database
  - Row
  - Unique key

Summary

- In this lesson, you should have learned how to:
  - Define a primary key
  - Define a foreign key
  - Define a column-integrity rule
  - Identify row, column, primary key, unique key, and foreign key elements given a diagram of a table containing these elements
  - Identify violations of data-integrity rules


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