Relational Model

Physical Data Modeling

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Learning Objectives

By the end of this video, you will be able to:

- Define what the relational model is.
- Identify the elements of a relation.
- Describe how schemas are specified and shown in a DBMS.
- Define schema and instance and explain their differences.

An Example of a Relation

Attributes, Fields, Columns

Students

id	name	major	birthday
1	Bugs Bunny	CS	2004-11-06
2	Donald Duck	Bio	1997-02-01
3	Peter Pan	Econ	1998-10-01
4	Mickey Mouse	CS	1995-04-01

Tuples, Records, Rows

An example relation

Domains

- Each attribute has a **data type**, called its **domain**.
- Must be **atomic** type-- simple values, no further structure.
- Common types: integer, string, real, …
- The exact domains supported depend on the system used.
- Examples:
  - SQLite
    - text, integer, real, blob.
  - MySQL
    - char, varchar, int, float, date, time, year, …

SQLite

MySQL

Schemas of Relations and Databases

- **Schema of a RELATION**
  - Relation name, attribute names, and their domains.
    - Students(id: string, name: string, major: enum(’cs', ’ece', ’ss', ’music’), birthdate: date)
  - May omit domains in notation if they are clear.
    - Students(id, name, major, birthdate)

- **Schema of a DATABASE**
  - A set of relation schemas
    - Students(id, name, major, birthdate)
    - Professors(id, name, dept, course)
    - Courses(number, title, credit)
    - … …

Constraints: Part of a Schema

- Key constraint
  - Unique: Attributes must be unique among tuples in the table.
  - Primary key: Attributes are the primary key of the table.

- Null constraint
  - Not NULL: Attributes cannot be missing/unspecified.

- Default constraint
  - The default value will be added to records if no other value is specified.

Specifying and Showing Schemas

- Using the SQL language to create tables.
- E.g., MySQL
  - Specifying schema for a table:

```
mysql> CREATE TABLE Students (
    ->        id char(10),
    ->        name varchar(100),
    ->        major enum('CS', 'EE', 'Bio', 'Econ'),
    ->        birthday date
    ->        );
Query OK, 0 rows affected (0.02 sec)
```

Screenshot of a MySQL session for specifying a schema

  - Showing schema for a bale:

```
mysql> DESCRIBE Students;
+----------+-------------------------------+------+-----+---------+-------+
| Field    | Type                          | Null | Key | Default | Extra |
+----------+-------------------------------+------+-----+---------+-------+
| id       | char(10)                      | YES  |     | NULL    |       |
| name     | varchar(100)                  | YES  |     | NULL    |       |
| major    | enum('CS','EE','Bio','Econ') | YES  |     | NULL    |       |
| birthday | date                          | YES  |     | NULL    |       |
+----------+-------------------------------+------+-----+---------+-------+
4 rows in set (0.00 sec)
```

Screenshot of a MySQL session for showing a schema

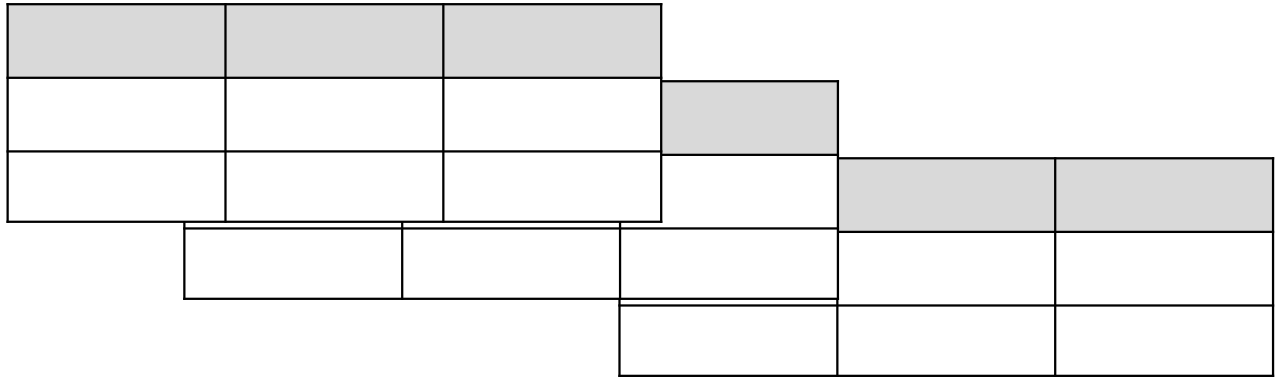
Instances of a Schema

- **Relational schema** $R(A_1, \ldots, A_k)$
- **Instance:** Set of tuples for the relation

id	name	major	birthday
1	Bugs Bunny	CS	2004-11-06
2	Donald Duck	Bio	1997-02-01
3	Peter Pan	Econ	1998-10-01
4	Mickey Mouse	CS	1995-04-01

An example relation

- **Database schema** $R_{1(\ldots)}, \ldots, R_n(\ldots)$
  Instance = instances of $R_1, \ldots, R_n$.



An example database instance

Updates: Changing Instances

- The database maintains a current database state.
- Updates to instance: Frequent.
  - Add a tuple.
  - Delete a tuple.
  - Modify a tuple.

```
mysql> INSERT INTO Students VALUES ('1', 'Bugs Bunny', 'CS', '2004-11-06');
Query OK, 1 row affected (0.00 sec)

mysql> INSERT INTO Students VALUES ('2', 'Donald Duck', 'Bio', '1997-02-01');
Query OK, 1 row affected (0.00 sec)

mysql> INSERT INTO Students VALUES ('3', 'Peter Pan', 'Econ', '1998-10-01');
Query OK, 1 row affected (0.00 sec)

mysql> INSERT INTO Students VALUES ('4', 'Mickey Mouse', 'CS', '1995-04-01');
Query OK, 1 row affected (0.01 sec)

mysql> SELECT * FROM Students;
+------+--------------+-------+------------+
| id   | name         | major | birthday   |
+------+--------------+-------+------------+
| 1    | Bugs Bunny   | CS    | 2004-11-06 |
| 2    | Donald Duck  | Bio   | 1997-02-01 |
| 3    | Peter Pan    | Econ  | 1998-10-01 |
| 4    | Mickey Mouse | CS    | 1995-04-01 |
+------+--------------+-------+------------+
4 rows in set (0.00 sec)
```

Screenshot of a MySQL session for updating database instances

Updates: Changing Schemas

- Updates to schema: Infrequent.
  - Add/delete an attribute.
  - Change domains of an attribute.
  - Add/delete a table.
- Think of it as columns vs. rows of a table
  - Rows change much more frequently than columns.

```
mysql> ALTER TABLE Students MODIFY id int;
Query OK, 4 rows affected (0.04 sec)
Records: 4  Duplicates: 0  Warnings: 0

mysql> ALTER TABLE Students ADD hobby char(30);
Query OK, 0 rows affected (0.04 sec)
Records: 0  Duplicates: 0  Warnings: 0

mysql> DESCRIBE Students;
+----------+-------------------------------+------+-----+---------+-------+
| Field    | Type                          | Null | Key | Default | Extra |
+----------+-------------------------------+------+-----+---------+-------+
| id       | int(11)                       | YES  |     | NULL    |       |
| name     | varchar(100)                  | YES  |     | NULL    |       |
| major    | enum('CS','EE','Bio','Econ') | YES  |     | NULL    |       |
| birthday | date                          | YES  |     | NULL    |       |
| hobby    | char(30)                      | YES  |     | NULL    |       |
+----------+-------------------------------+------+-----+---------+-------+
5 rows in set (0.00 sec)

mysql> SELECT * FROM Students;
+------+--------------+-------+------------+-------+
| id   | name         | major | birthday   | hobby |
+------+--------------+-------+------------+-------+
|    1 | Bugs Bunny   | CS    | 2004-11-06 | NULL  |
|    2 | Donald Duck  | Bio   | 1997-02-01 | NULL  |
|    3 | Peter Pan    | Econ  | 1998-10-01 | NULL  |
|    4 | Mickey Mouse | CS    | 1995-04-01 | NULL  |
+------+--------------+-------+------------+-------+
4 rows in set (0.00 sec)
```

Screenshot of a MySQL session for updating database schemas

Food for Thought

Changing the schema of a database could be a painful process. Can you imagine why?

```
mysql> CREATE TABLE Students (
    ->        id char(10),
    ->        name varchar(100),
    ->        major enum('CS', 'EE', 'Bio', 'Econ'),
    ->        birthday date
    ->        );
Query OK, 0 rows affected (0.02 sec)

mysql>
mysql> INSERT INTO Students VALUES ('1', 'Bugs Bunny', 'CS', '2004-11-06');
Query OK, 1 row affected (0.00 sec)

mysql> INSERT INTO Students VALUES ('2', 'Donald Duck', 'Bio', '1997-02-01');
Query OK, 1 row affected (0.00 sec)

mysql> INSERT INTO Students VALUES ('3', 'Peter Pan', 'Econ', '1998-10-01');
Query OK, 1 row affected (0.00 sec)

mysql> INSERT INTO Students VALUES ('4', 'Mickey Mouse', 'CS', '1995-04-01');
Query OK, 1 row affected (0.01 sec)

mysql>
mysql> SELECT * FROM Students;
+------+-------------+-------+------------+
| id   | name        | major | birthday   |
+------+-------------+-------+------------+
| 1    | Bugs Bunny  | CS    | 2004-11-06 |
| 2    | Donald Duck | Bio   | 1997-02-01 |
| 3    | Peter Pan   | Econ  | 1998-10-01 |
| 4    | Mickey Mouse| CS    | 1995-04-01 |
+------+-------------+-------+------------+
4 rows in set (0.00 sec)
```

```
mysql> ALTER TABLE Students MODIFY id int;
Query OK, 4 rows affected (0.04 sec)
Records: 4  Duplicates: 0  Warnings: 0

mysql> ALTER TABLE Students ADD hobby char(30);
Query OK, 0 rows affected (0.04 sec)
Records: 0  Duplicates: 0  Warnings: 0

mysql> DESCRIBE Students;
+----------+-------------------------------+------+-----+---------+-------+
| Field    | Type                          | Null | Key | Default | Extra |
+----------+-------------------------------+------+-----+---------+-------+
| id       | int(11)                       | YES  |     | NULL    |       |
| name     | varchar(100)                  | YES  |     | NULL    |       |
| major    | enum('CS','EE','Bio','Econ')  | YES  |     | NULL    |       |
| birthday | date                          | YES  |     | NULL    |       |
| hobby    | char(30)                      | YES  |     | NULL    |       |
+----------+-------------------------------+------+-----+---------+-------+
5 rows in set (0.00 sec)

mysql> SELECT * FROM Students;
+------+-------------+-------+------------+-------+
| id   | name        | major | birthday   | hobby |
+------+-------------+-------+------------+-------+
|    1 | Bugs Bunny  | CS    | 2004-11-06 | NULL  |
|    2 | Donald Duck | Bio   | 1997-02-01 | NULL  |
|    3 | Peter Pan   | Econ  | 1998-10-01 | NULL  |
|    4 | Mickey Mouse| CS    | 1995-04-01 | NULL  |
+------+-------------+-------+------------+-------+
4 rows in set (0.00 sec)
```

Screenshot of a MySQL session for updating database schemas