CMPT 354: Database System I

Lecture 2. Relational Model

Outline

- An overview of data models
- Basics of the Relational Model
- Define a relational schema in SQL

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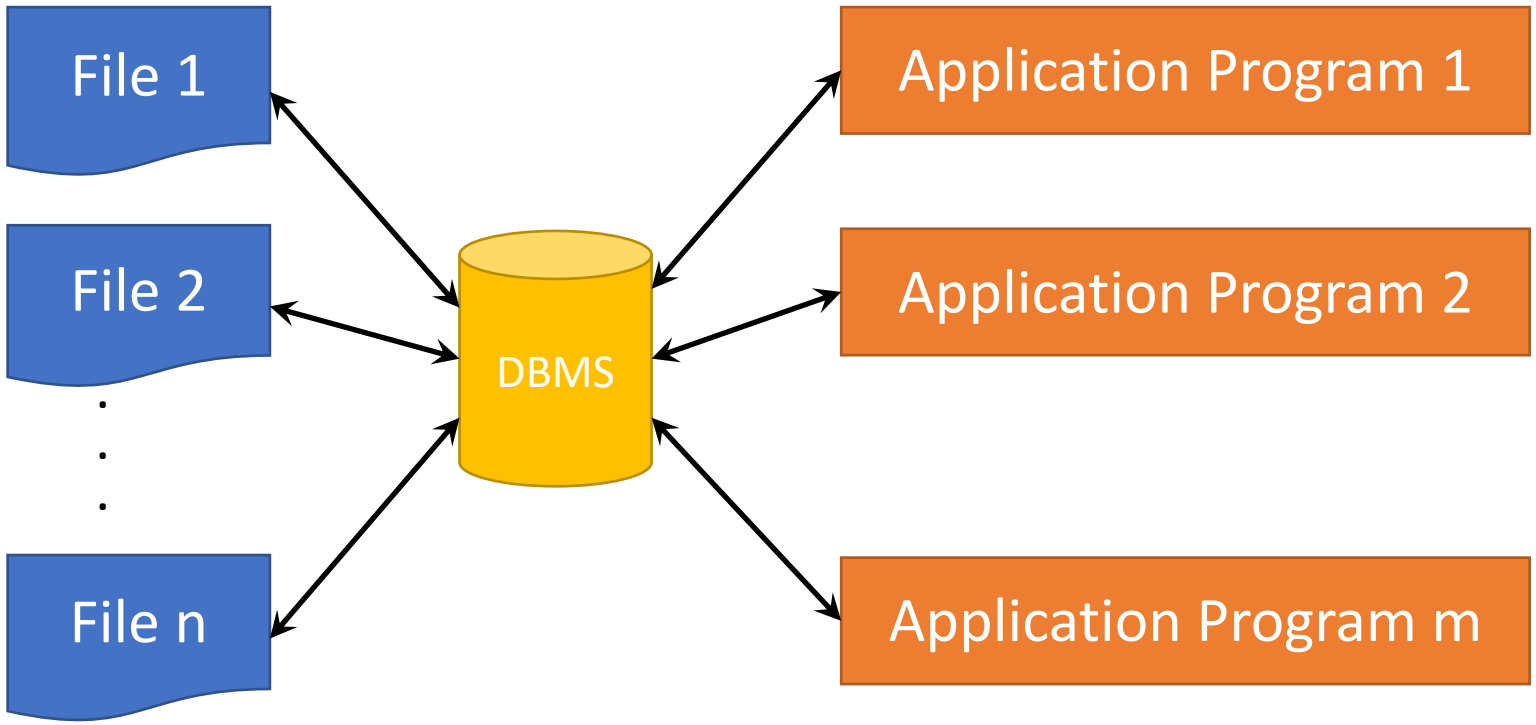
- **An overview of data models**
- Basics of the Relational Model
- Define a relational schema in SQL

Review

- What is a database?
  - A collection of files that store related data
- What is a DBMS?
  - A piece of software designed to store and manage databases

Data Storage with DBMS



Data Model

- Data Model
  - mathematical formalism (or conceptual way) for describing the data
- The description generally consists of three parts:
  - Structure of the data
  - Operations on the data
  - Constraints on the data

Structure of the data

- Schema (e.g., table names, attribute names)
  - Describe the **conceptual** structure of the data
- Different from data structure (e.g., list, array)
  - Data structure can be seen as a **physical** data model

Operations on the data

- Query language (e.g., SQL)
  - Describe what operations that can be performed on data
- Two kinds of operations
  - operations that retrieve information
  - operations that change the database
- Different from programming languages (e.g., C, Java)
  - Support a set of limited operations
  - Allow for query optimizations

Constraints on the data

- Constraints (e.g., age > 0, student# is unique)
  - describe limitations on what the data can be.

- Different kinds of constraints
  - Domain constraints
  - Integrity constraints

- Why does it matter?
  - Ensure the correctness of data

Commonly Used Data Models

- Relational Data Model
- Key-Value Data Model
- Semi-structured Data Model (e.g., Json, XML)

The Relational Model in Brief

Students

Id	Name	Age	GPA
1000	Mike	21	3.8
1001	Bill	19	3.4
1002	Alice	20	3.6

- Structure of the data
  - Table structure
- Operations on the data
  - SQL
- Constraints on the data
  - E.g., id is unique, age > 10, name is not NULL

The Key-Value Model in Brief

Key → Value
1000 → (Mike, 21, 3.8)
1001 → (Bill, 19, 3.4)
1002 → (Alice, 20, 3.6)

- Structure of the data
  - (Key, Value) pairs
  - Key is an integer/string, value can be any object
- Operations on the data
  - get(key), put(key, value)
- Constraints on the data
  - E.g., key is unique, value is not NULL

The Semistructured Model in Brief

- Structure of the Data
  - Tree structure
- Operations on the data
  - XPath
- Constraints
  - E.g., <Age> has to be integer, each <Student> has a <Name> element nested within in

```
<Students>
  <Student id=1000>
    <Name>Mike</Name>
    <Age>20</Age>
    <GPA>3.8</GPA>
  </Student>
  <Student id=1001>
    <Name>Bill</Name>
    <Age>19</Age>
    <GPA>3.4</GPA>
  </Student>
  <Student id=1002>
    <Name>Alice</Name>
    <Age>21</Age>
    <GPA>3.6</GPA>
  </Student>
</Students>
```

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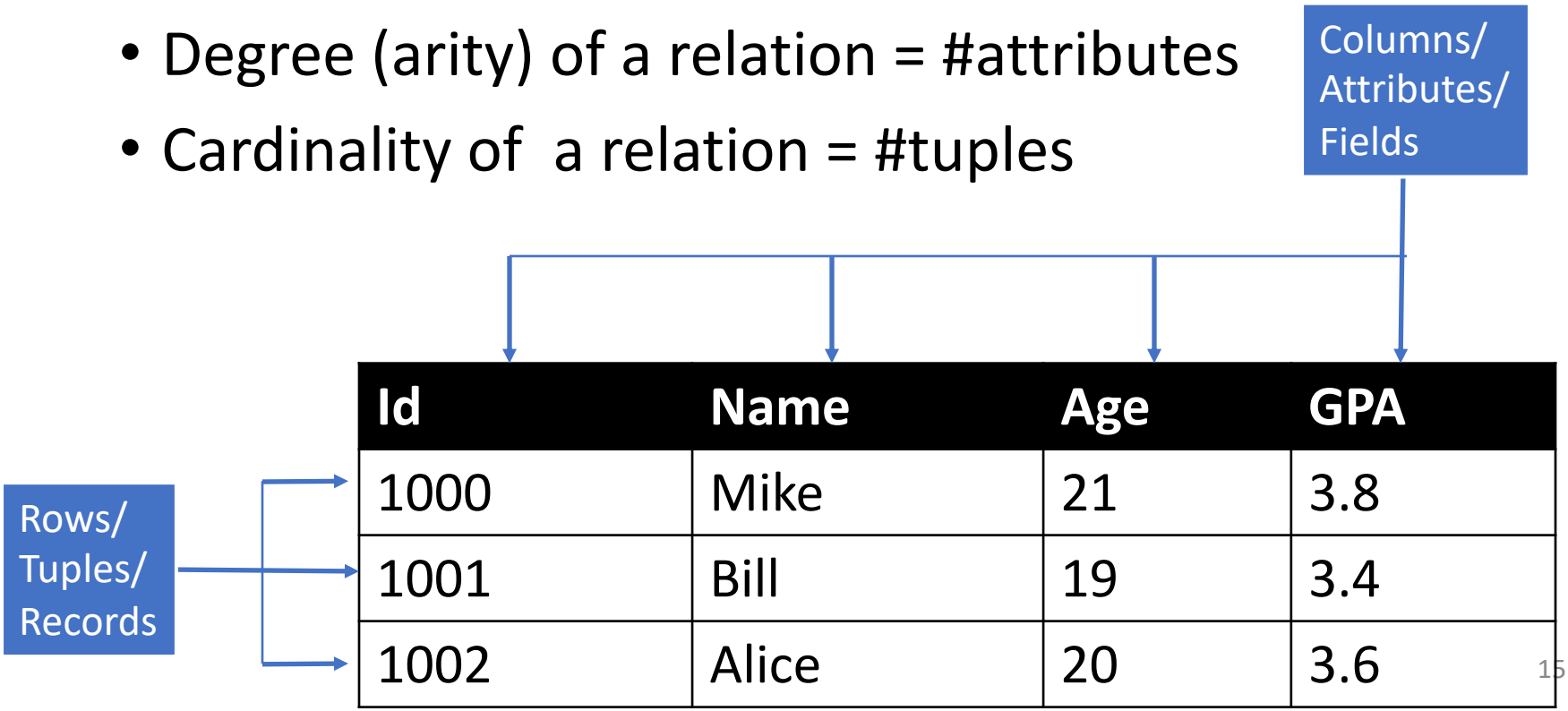
- An overview of data models
- **Basics of the Relational Model**
- Define a relational schema in SQL

Terminology

- Relations/Tables
- Columns/Attributes/Fields
- Rows/Tuples/Records
- Degree (arity) of a relation = #attributes
- Cardinality of a relation = #tuples



Id	Name	Age	GPA
1000	Mike	21	3.8
1001	Bill	19	3.4
1002	Alice	20	3.6

Schema

- Relation schema
  - The name of a relation + The set of attributes for a relation

Student(id, sname, age, gpa)

- Database schema
  - The set of schemas for the relations of a database

Suppose your database has 3 relations.

Student (sid, sname, age, gpa)

Take (sid, cid)

Course (cid, cname, credit)

Domains

- Each attribute has a domain (date type)
- Examples
  - Text: CHAR(20), VARCHAR(50), TEXT
  - Integer: INT, SMALLINT
  - Real: DOUBLE, FLOAT
  - Few more that are vendor specific

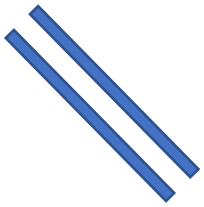
Student(id INT, sname VARCHAR(50), age INT, gpa FLOAT)

Equivalent Representations of a Relation

- Order does NOT matter!

Id	Name	Age	GPA
1000	Mike	21	3.8
1001	Bill	19	3.4
1002	Alice	20	3.6

Id	Name	GPA	Age
1000	Mike	3.8	21
1001	Bill	3.4	19
1002	Alice	3.6	20



Id	Name	Age	GPA
1000	Mike	21	3.8
1002	Alice	20	3.6
1001	Bill	19	3.4

Exercise-1: Terminology

Accounts

AcctNo	Type	Balance
12345	savings	12000
23456	checking	1000
34567	savings	25

Customers

fname	lname	idNo	account
Robbie	Banks	901-222	12345
Lena	Hand	805-333	12345
Lena	Hand	805-333	23456

1. List two other terms of "rows"
2. List two other terms of "columns"
3. List another term of "table"

Exercise-2: Terminology

Accounts

AcctNo	Type	Balance
12345	savings	12000
23456	checking	1000
34567	savings	25

Customers

fname	lname	idNo	account
Robbie	Banks	901-222	12345
Lena	Hand	805-333	12345
Lena	Hand	805-333	23456

4. Indicate the attributes of each relation
5. Indicate the tuples of each relation
6. Indicate the degree of each relation
7. Indicate the cardinality of each relation

Exercise-3: Terminology

Accounts

AcctNo	Type	Balance
12345	savings	12000
23456	checking	1000
34567	savings	25

Customers

fname	lname	idNo	account
Robbie	Banks	901-222	12345
Lena	Hand	805-333	12345
Lena	Hand	805-333	23456

8. Indicate the schema for each relation
9. Indicate the database schema
10. Specify a suitable domain for each attribute

Exercise-4: Terminology

Customers

fname	lname	idNo	account
Robbie	Banks	901-222	12345
Lena	Hand	805-333	12345
Lena	Hand	805-333	23456

11. Indicate another equivalent way to represent this relation
12. How many different ways to represent this relation?

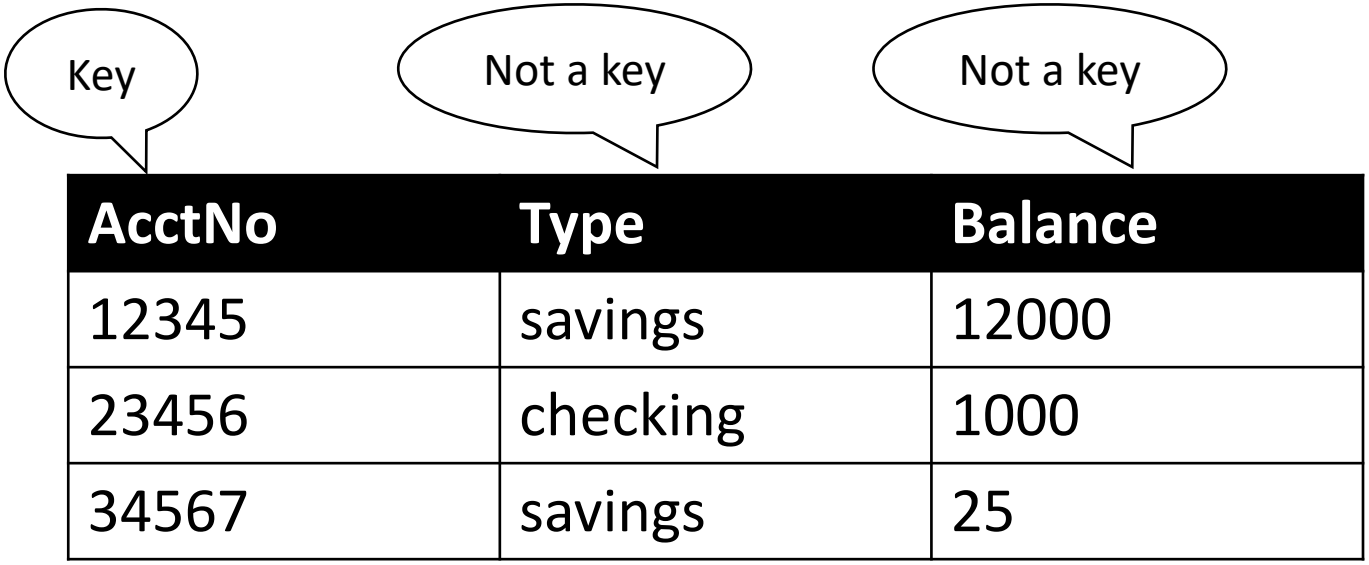
Keys

- Key = one (or multiple) attributes that uniquely identify a record

AcctNo	Type	Balance
12345	savings	12000
23456	checking	1000
34567	savings	25

Keys

- Key = one (or multiple) attributes that uniquely identify a record



AcctNo	Type	Balance
12345	savings	12000
23456	checking	1000
34567	savings	25

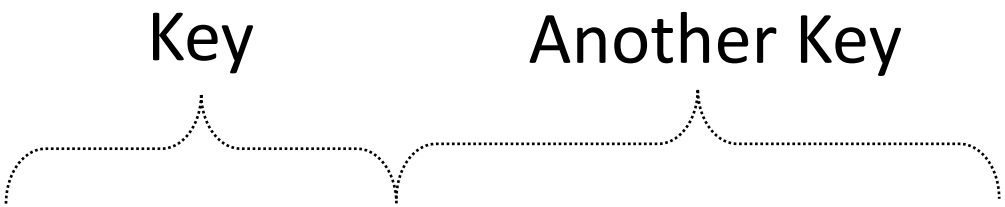
Multiple-attribute Key

- Multiple-attribute Key = multiple attributes that uniquely identify a record

Key = fname, lname

fname	lname	age	salary
Robbie	Banks	20	10k
Alice	Banks	30	8k
Alice	Smith	25	12k

Multiple Keys



SIN	fname	lname	age	salary
123-456-789	Robbie	Banks	20	10k
222-111-709	Alice	Banks	30	8k
345-498-712	Alice	Smith	25	12k

- We can choose one key as primary key (e.g., SSN)

Foreign Key

- Attribute(s) whose value is a key of a record in some other relation

Accounts

acctNo	type	balance
12345	savings	12000
23456	checking	1000
34567	savings	25

Customers

fname	lname	idNo	account
Robbie	Banks	901-222	12345
Lena	Hand	805-333	12345
Lena	Hand	805-333	23456

Foreign key to Accounts.acctNo

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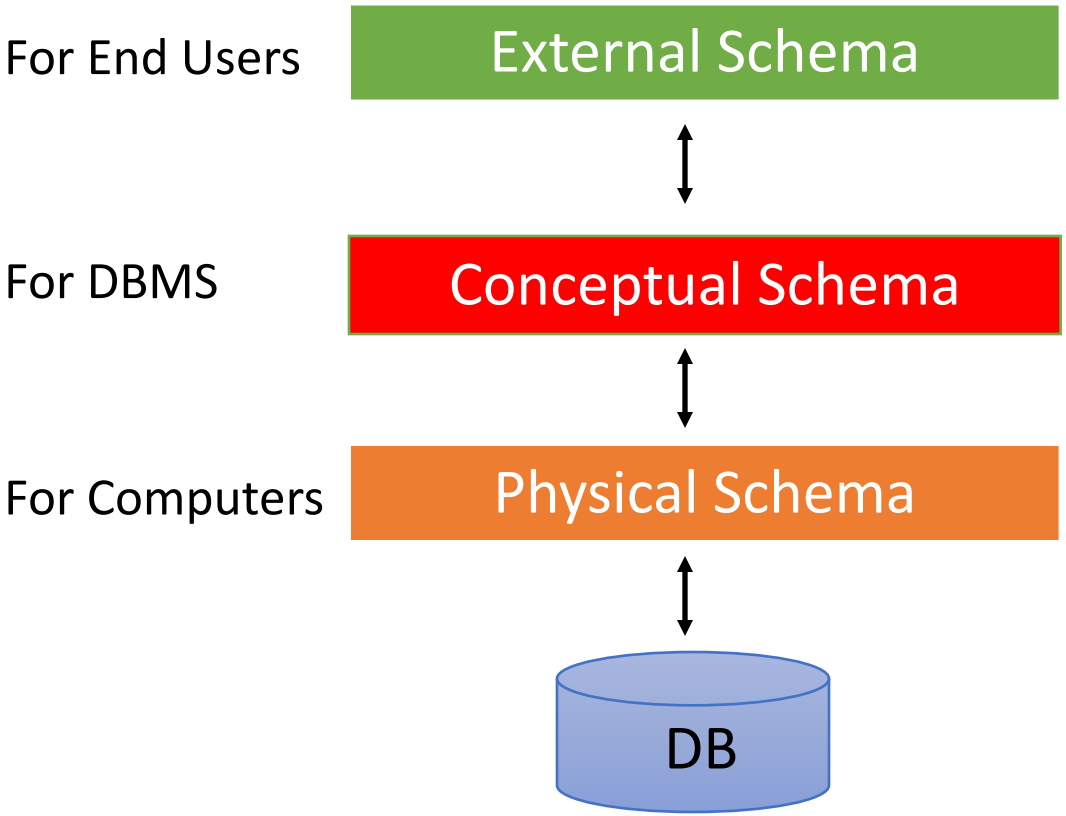
- **Define a relational schema in SQL**

SQL DDL

- *SQL* stands for *Structured Query Language*
- SQL is divided into two parts
  - *Data Definition Language* (*DDL*) which is used to define external and conceptual schemas
  - *Data Manipulation Language* (*DML*) which allows users to create, modify and query data (next week)
- The *DDL* supports the creation, deletion and modification of tables
  - Including the specification of domain constraints and other constraints

Three-Schema Architecture



Types of Data Independence

- Physical data independence
  - Allows the physical schema to be modified without rewriting application programs
  - Usually to improve performance
    - e.g. adding or removing an index or moving a file to a different disk
- Logical data independence
  - Shields users from changes in the logical schema – i.e. their views remain unchanged
  - Allows the logical schema to be modified without rewriting application programs
    - e.g. adding an attribute to a relation

Creating Tables

- To create a table use the **CREATE TABLE** statement
  - Specify the table name, field names and domains

```
CREATE TABLE Student (
    sid          CHAR(11),
    firstName    CHAR(20),
    lastName     CHAR(20),
    age          INTEGER,
    gpa          FLOAT)
```

Question – is SQL case sensitive?

Answer – SQL keywords (create and table for example) are not case sensitive.

Named objects (tables, columns etc.) *may* be.

Inserting Records

- To insert a record into an existing table use the **INSERT** statement
  - The list of column names is optional
    - If omitted the values must be in the same order as the columns

```
INSERT INTO Student(sid, firstName, lastName, age, gpa)
VALUES ('111', 'Sam', 'Spade', 23, 3.8)
```

Deleting Records

- To delete a record use the **DELETE** statement
  - The **WHERE** clause specifies the record(s) to be deleted

```
DELETE
FROM Student
WHERE sid = '111'
```

- Be careful, the following SQL query deletes *all* the records in a table

```
DELETE
FROM Student
```

Modifying Records

- Use the **UPDATE** statement to modify a record, or records, in a table
  - Note that the **WHERE** statement is evaluated *before* the **SET** statement
- Like **DELETE** the **WHERE** clause specifies which records are to be updated

```
UPDATE Student
SET age = 37
WHERE sin = '111'
```

Deleting Tables

- To delete a *table* use the **DROP TABLE** statement
  - This not only deletes all of the records but also deletes the table schema

```
DROP TABLE Student
```

Modifying Tables

- Columns can be added or removed to tables using the **ALTER TABLE** statement
  - **ADD** to add a column and
  - **DROP** to remove a column

```
ALTER TABLE Student
ADD height INTEGER
```

```
ALTER TABLE Student
DROP height
```

Discussions

- Tables are NOT ordered
  - They are sets or multisets (bags)
- Tables DO NOT prescribe how they are implemented/stored on disk
  - This is called physical data independence

Acknowledge

- Some lecture slides were copied from or inspired by the following course materials
  - “W4111: Introduction to databases” by Eugene Wu at Columbia University
  - “CSE344: Introduction to Data Management” by Dan Suciu at University of Washington
  - “CMPT354: Database System I” by John Edgar at Simon Fraser University
  - “CS186: Introduction to Database Systems” by Joe Hellerstein at UC Berkeley
  - “CS145: Introduction to Databases” by Peter Bailis at Stanford
  - “CS 348: Introduction to Database Management” by Grant Weddell at University of Waterloo