>>

SQL Data Definition Language

∧ >>

❖ Relational Data Definition

In order to give a relational data model, we need to:

- describe tables
- describe attributes that comprise tables
- describe any constraints on the data

A relation schema defines an individual table

- table name, attribute names, attribute domains, keys, etc.

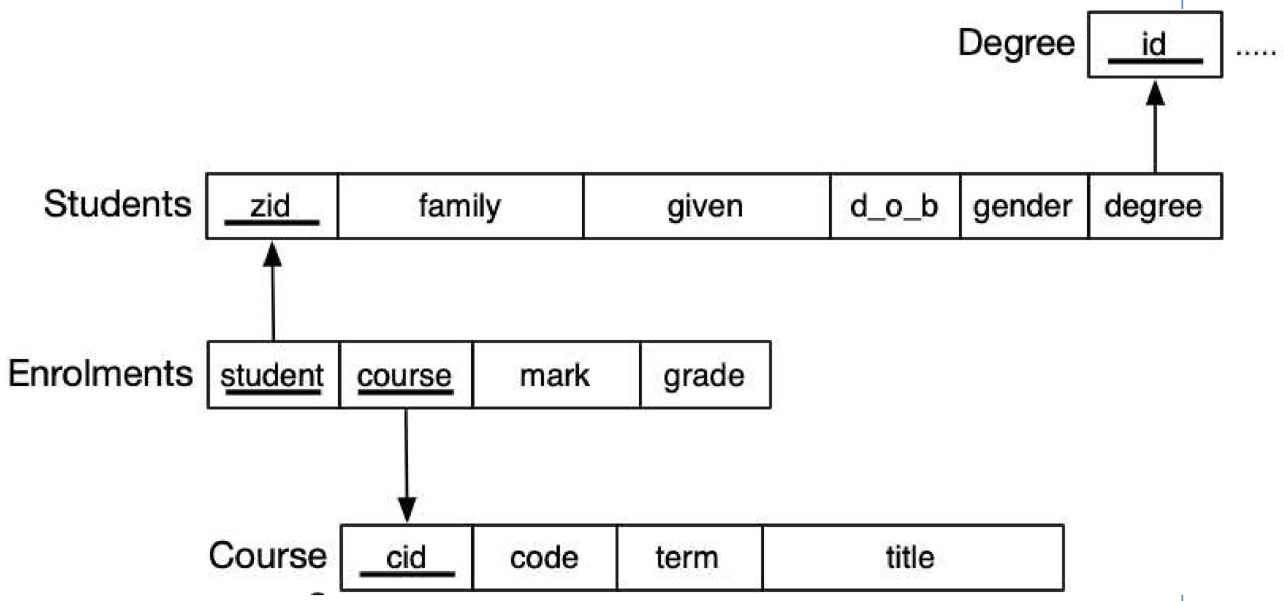
A database schema is a collection of relation schemas that

- defines the structure the whole database
- additional constraints on the whole database

schemas are like your blueprints

❖ Example Relational Schema

So far, we have given relational schemas informally, e.g.



❖ SQL Data Definition Language

In the example schema above, we provided only

- relation names, attribute names, primary keys, foreign keys

A usable database needs to provide much more detail

SQL has a rich data definition language (DDL) that can describe

- names of tables
- names and domains for attributes
- various types of constraints (e.g. primary/foreign keys)

It also provides mechanisms for performance tuning (see later).

<< ∧ >>

❖ Defining a Database Schema

Tables (relations) are described using:

```
CREATE TABLE TableName (
     attribute1  domain1  constraints1,
     attribute2  domain2  constraints2,
     ...
     table-level constraints, ...
)
```

This SQL statement ..

- defines the table schema (adds it to database meta-data)
- creates an empty instance of the table (zero tuples)

Tables are removed via **DROP TABLE *TableName*;**

<< ^ >>

❖ Defining a Database Schema (cont)

Example: defining the **`Students`** table ...

```
CREATE TABLE Students (
    zid       serial,
    family    varchar(40),
    given     varchar(40) NOT NULL,
    d_o_b     date NOT NULL,
    gender    char(1) CHECK (gender in ('M','F')),
    degree    integer,
    PRIMARY KEY (zid),  automatically UNIQUE NOT NULL
    FOREIGN KEY (degree) REFERENCES Degrees(did)
);
```

Note that there is much more info here than in the relational schema diagram.

A primary key attribute is implicitly defined to be **`UNIQUE`** and **`NOT NULL`**

<< ∧ >>

❖ Defining a Database Schema (cont)

Example: alternative definition of the **Students** table ...

```
CREATE DOMAIN GenderType AS
       char(1) CHECK (value in ('M','F'));

CREATE TABLE Students (
    zid     serial PRIMARY KEY,
            -- only works if primary key is one attr
    family  text,   -- no need to worry about max length
    given   text NOT NULL,
    d_o_b   date NOT NULL,
    gender  GenderType,
    degree  integer REFERENCES Degrees(did)
);
```

At this stage, prefer to use the long-form declaration of primary and foreign keys

<< ^ >>

❖ Defining a Database Schema (cont)

Example: defining the **Courses** table ...

```
CREATE TABLE Courses (
    cid    serial,
    code   char(8) NOT NULL
                   CHECK (code ~ '[A-Z]{4}[0-9]{4}'),
    term   char(4) NOT NULL
                   CHECK (term ~ '[0-9]{2}T[0-3]'),
    title  text UNIQUE NOT NULL,
    PRIMARY KEY (cid)
);
```

Uses non-standard regular expression checking on **code** and **term**

No two **Courses** can have the same title; but not used as primary key

<< ∧ >>

❖ Defining a Database Schema (cont)

Example: defining the **`Enrolments`** relationship ...

even though we are modelling a relationship, we still use a TABLE

```
CREATE TABLE Enrolments (
    student integer,
    course  integer,
    mark    integer CHECK (mark BETWEEN 0 AND 100),
    grade   GradeType,
    PRIMARY KEY (student,course),
    FOREIGN KEY (student)
                REFERENCES Students(zid)
    FOREIGN KEY (course)
                REFERENCES Courses(cid)
);
```

Could not enforce total partcipation constraint if e.g. all courses must have > 0 students

It's possible to make a course that has 0 students, in fact, when you make a course it has 0 by default because there will be no enrolments tuples with that course in it yet.

Possible alternative names for foreign keys **`student_id`** and **`course_id`**

Basically, when you use many-to-many, you cannot enforce total participation because the relationship table is separate from the entity itself, and so creating one doesn't force creating the other.

<< ^ >>

❖ Data Integrity

Defining tables as above affects behaviour of DBMS when changing data

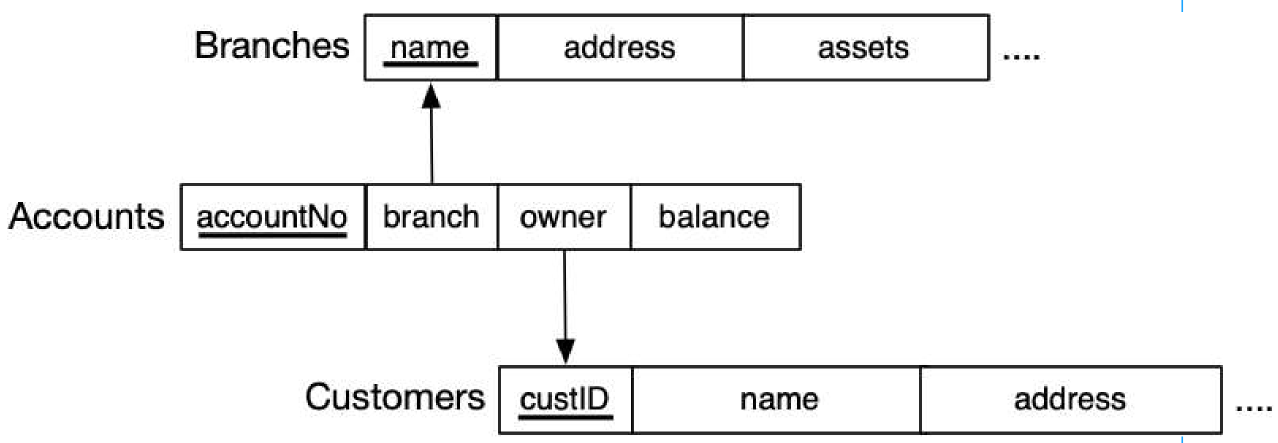
Constraints and types ensure that integrity of data is preserved

- no duplicate keys PRIMARY KEY handles this, ensures this PK value does not already exist in the table before insertion is allowed.
- no "dangling references" FOREIGN KEY handles this, ensures FK is a PK in referenced table before insertion is allowed. It checks for the actual instance e.g. if FK is 3, then it will look for a PK of 3 in the referenced table b4 insert
- all attributes have valid values NOT NULL, UNIQUE, integer, varchar etc.
- etc. etc. etc.

Preserving data integrity is a *critical* function of a DBMS.

❖ Another Example Schema

Variation on banking schema used elsewhere



<< ^ >>

❖ Default Values

Can specify a **DEFAULT** value for an attribute

- will be assigned to attribute if no value is supplied during insert

Example:

```
CREATE TABLE Accounts (
    acctNo  char(5) PRIMARY KEY,
    branch  varchar(30) REFERENCES Branches(name)
                        DEFAULT 'Central',
    owner   integer REFERENCES Customers(custID),
    balance float DEFAULT 0.0
);

INSERT INTO Accounts(acctNo,owner) VALUES ('A-456',645342)
-- produces the tuple
Accounts('A-456', 'Central', 645342, 0.0)
```

❖ Defining Keys

Primary keys:

- if PK is one attribute, can define as attribute constraint
- if PK is multiple attributes, must define in table constraints
- PK implies **NOT NULL UNIQUE** for all attributes in key

Foreign keys:

- if FK is one attribute, can define as attribute constraint
- can omit **FOREIGN KEY** keywords in attribute constraint
- if FK has multiple attributes, must define as a single table constraint
- should always specify corresponding PK attribute in FK constraint, e.g

```
customer integer
            FOREIGN KEY REFERENCES Customers(customerNo)
```

❖ Defining Keys (cont)

Defining primary keys assures entity integrity

- must give values for all attributes in the primary key

For example this insertion would fail ...

```
INSERT INTO Enrolments(student,course,mark,grade)
       VALUES (5123456, NULL, NULL, NULL);
```

because no **`course`** was specified; but **`mark`** and **`grade`** can be **`NULL`**

Defining primary keys assures uniqueness

- cannot insert a tuple which contains an existing PK value

❖ Defining Keys (cont)

Defining foreign keys assures referential integrity.

On insertion, cannot add a tuple where FK value does not exist as a PK

For example, this insert would fail ...

```
INSERT INTO Accounts(acctNo, owner, branch, balance)
       VALUES ('A-123', 765432, 'Nowhere', 5000);
```

if there is no customer with id **765432** or no branch **Nowhere**

<< ∧ >>

❖ Defining Keys (cont)

On deletion, interesting issues arise, e.g.

`Accounts.branch` refers to primary key **`Branches.name`**

If we want to delete a tuple from **`Branches`**, and there are tuples in **`Accounts`** that refer to it, we could ...

- **reject** the deletion (PostgreSQL/Oracle default behaviour)
- **set-NULL** the foreign key attributes in **`Account`** records
- **cascade** the deletion and remove **`Account`** records

SQL allows us to choose a strategy appropriate for the application

<< ∧ >>

❖ Attribute Value Constraints

`NOT NULL` and **`UNIQUE`** are special constraints on attributes.

SQL has a general mechanism for specifying attribute constraints

```
attrName  type  CHECK ( Condition )
```

Condition is a boolean expression and can involve other attributes, relations and **`SELECT`** queries.

```
CREATE TABLE Example
(
    gender char(1)  CHECK  (gender IN ('M','F')),
    Xvalue integer  NOT NULL,
    Yvalue integer  CHECK  (Yvalue > Xvalue),
    Zvalue float    CHECK  (Zvalue >
                            (SELECT MAX(price)
                             FROM   Sells)
                   )
);
```

(but many RDBMSs (e.g. Oracle and PostgreSQL) don't allow **`SELECT`** in **`CHECK`**)

<< ∧

❖ Named Constraints

A constraint in an SQL table definition can (optionally) be named via

```
CONSTRAINT  constraintName  constraint
```

Example:

```
CREATE TABLE Example
(
    gender char(1) CONSTRAINT GenderCheck
                   CHECK (gender IN ('M','F')),
    Xvalue integer NOT NULL,
    Yvalue integer CONSTRAINT XYOrder
                   CHECK (Yvalue > Xvalue),
);
```

Produced: 21 Sep 2020