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SQL Data Definition Language

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❖ 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

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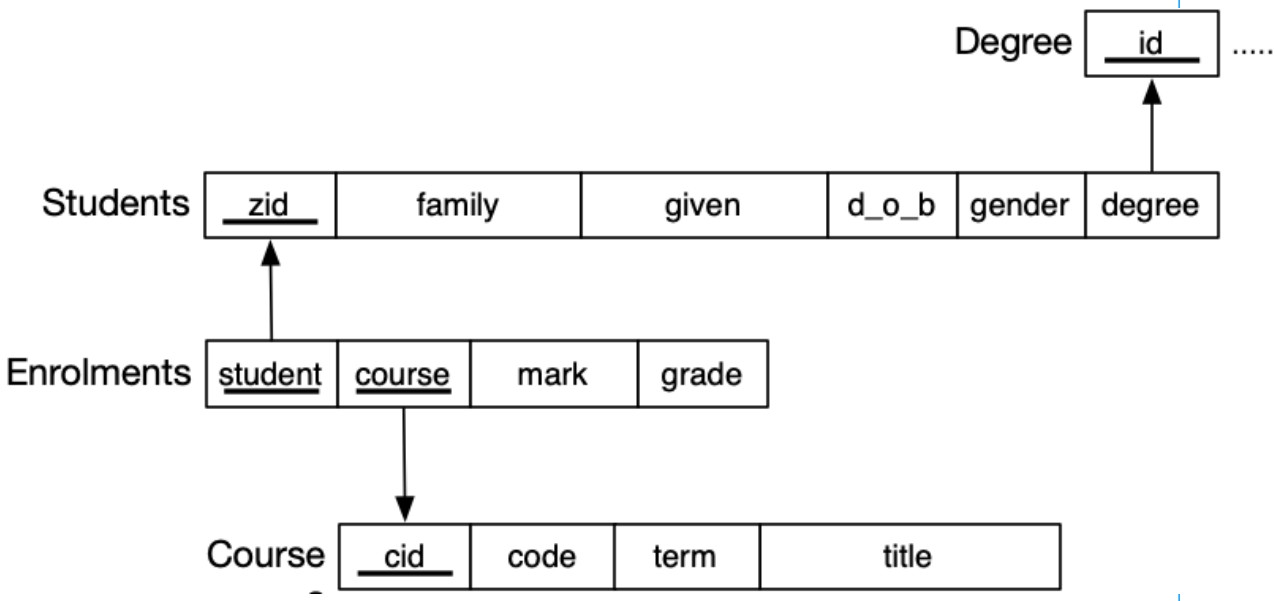
❖ Example Relational Schema

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



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❖ 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).

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❖ 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;`

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❖ 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),
    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`

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❖ 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

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❖ 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

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❖ Defining a Database Schema (cont)

Example: defining the `Enrolments` relationship ...

```
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

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

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❖ 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
- no "dangling references"
- all attributes have valid values
- etc. etc. etc.

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

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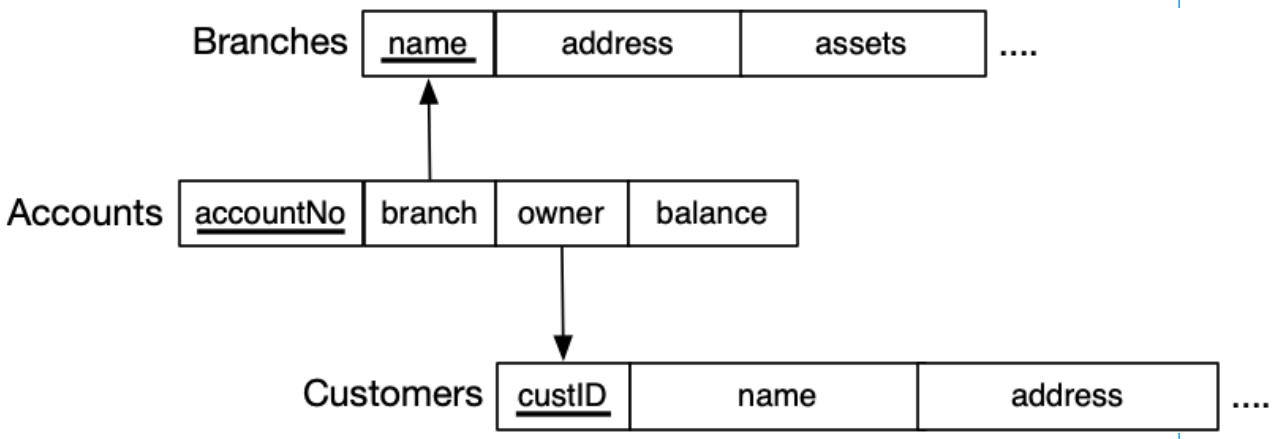
❖ Another Example Schema

Variation on banking schema used elsewhere



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❖ 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)
```

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❖ 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)
```

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❖ 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

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❖ 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`

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❖ 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

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❖ 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)

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❖ 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)
);
```

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