CS2102 Database Systems

Slides adapted from Prof. Chan Chee Yong

LECTURE 03

SQL #1

PREVIOUS LECTURE

Relational data model

Relation schema

- Each relation has a definition called a relation schema
  - Schema specifies attributes and data constraints
  - Data constrains include domain constraints
  - Each row in a relation is called a tuple/record

Relations

- A relation is defined as a set of *tuples*

Relational database schema

- A relational database schema consists of a set of *schemas*
- *Relational database schema*
  = relational schemas + data constraints

Relational database

- A relational database is a collection of *tables*

PREVIOUS LECTURE

Integrity constraints (ICs)

Definitions

- Integrity constraint
  - A condition that *restricts* the data that can be stored in database instance

Types

- Domain constraints
  - Restrict attribute values of relations
- Key constraints
- Foreign key constraints
- Other general constraints

PREVIOUS LECTURE

Key constraints

Superkey

- A superkey is a subset of attributes in a relation that *uniquely identifies* its tuples
  - No two distinct tuples of relation have the same values in all attributes of superkey

Key

- A key is a superkey that satisfies the additional property
  - Not `null` & no *proper subset* of a key is a superkey
  - ➢ *Minimal* subset of attributes that *uniquely identifies* its tuples
- A relation can have *multiple keys*
  - These are called candidate keys
  - One of the candidate keys is then selected as the primary keys

PREVIOUS LECTURE

Foreign key constraints

Foreign key

- A subset of attributes in a relation is a foreign key if it *refers to the primary key of a second relation*
- Foreign key constraints
  - Each foreign key value in referencing relation must either
    - *Appear as primary key* value in referenced relation, *or*
    - Be a `null` value
  - Referencing & referenced relations could be the same relation
  - Also called referential integrity constraints

PREVIOUS LECTURE

Relational algebra

Selection: $\boldsymbol{\sigma_c}$

- $\sigma_c(R)$ selects tuples from relation R that satisfies selection condition c

Projection: $\boldsymbol{\pi_\ell}$

- $\pi_\ell(R)$ projects attributes given by a list ℓ of attributes from relation R

Renaming: $\boldsymbol{\rho_{S(B_1,B_2,\ldots,B_n)}(R)}$

- $\rho_{S(B_1,B_2,\ldots,B_n)}(R)$ renames $R(A_1, A_2, \ldots, A_n)$ to $S(B_1, B_2, \ldots, B_n)$
  - When the attributes are not renamed $\boldsymbol{\rho_S(R)}$
  - When the table is not renamed $\boldsymbol{\rho_{(B_1,B_2,\ldots,B_n)}(R)}$

PREVIOUS LECTURE

Relational algebra

Union: $R \cup S$

- Returns a relation containing all tuples that occur in R, S, or both

Intersection: $R \cap S$

- Returns a relation containing all tuples that occur in both R and S

Set-difference: $R - S$

- Returns a relation containing all tuples that occur in R but not in S

- Union ($\cup$), intersection ($\cap$), and set-difference ($-$) operators require input relations to be union compatible

Cross-product: $\times$

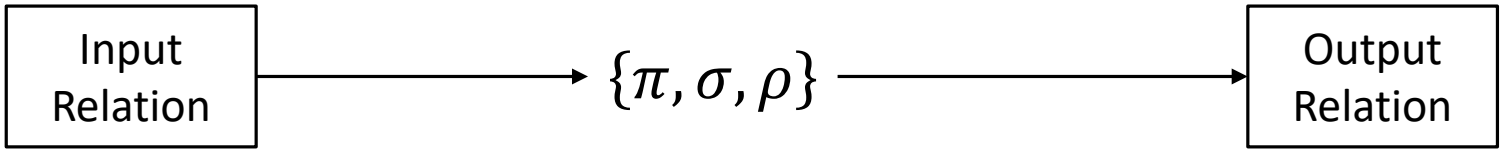
- Consider a relation $R_1(A, B, C)$ and $R_2(X, Y)$
- $R_1 \times R_2$ returns a relation with schema (A, B, C, X, Y) defined as follows:
  - $R_1 \times R_2 = \{(a, b, c, x, y) \mid (a, b, c) \in R_1, (x, y) \in R_2\}$
- Also known as cartesian product

PREVIOUS LECTURE

Closure properties

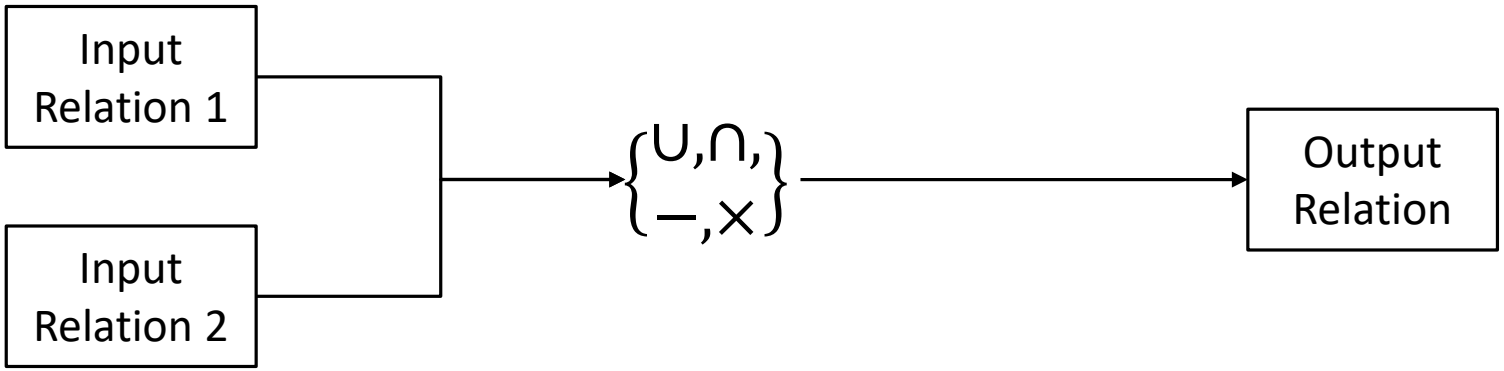
Closure of relation under unary operators *(as diagrams)*

- Unary operator takes in a *relation as input* and gives a *relation as output*



Closure of relation under binary operators *(as diagrams)*

- Binary operator takes in two *relations as inputs* and gives a *relation as output*



- Structured Query Language
  - Null values
  - Create/drop table
  - Table modification
  - Constraint checking
- Queries
  - Simple queries

Overview

- Structured Query Language
  - Null values
  - Create/drop table
  - Table modification
  - Constraint checking
- Queries
  - Simple queries

Structured Query Language

SELF-READ

Structured Query Language

Introduction

- Designed by D. Chamberlin & R. Boyce (IBM Research) in 1974
  - Original name: SEQUEL (*Structured English QUEry Language*)
- SQL is not a general-purpose language but a domain-specific language (DSL)
  - Designed for computations on relations
- Unlike relational algebra which is a *procedural language*, SQL is a declarative language
  - Focuses on *what* to compute instead of *how* to compute

SELF-READ

Structured Query Language

- **Using SQL**
  - **Directly write SQL statements**
    - *Command line interface*
      - PostgreSQL's psql
    - *Graphical user interface*
      - PostgreSQL's pgAdmin
  - **Included SQL in application programs**
    - *Statement-level interface (SLI)*
      - Embdded SQL
      - Dynamic SQL
    - *Call-level interface (CLI)*
      - JDBC (Java DataBase Connectivity)
      - ODBC (Open DataBase Connectivity)

SELF-READ

Structured Query Language

About SQL

- Current ANSI/ISO standard for SQL is called SQL:2016
  - Different DBMSs may have minor variations in SQL syntax
- SQL consists of two main parts:
  - **Data Definition Language (DDL)**
    - Used to create/delete/modify *schemas*
  - **Data Manipulation Language**
    - Used to ask queries/insert/delete/modify *data*

Null values

Three-valued logic system

- TRUE
- FALSE
- UNKNOWN

x	*y*	*x AND y*	*x OR y*	*NOT x*
FALSE FALSE FALSE	FALSE UNKNOWN TRUE			
UNKNOWN UNKNOWN UNKNOWN	FALSE UNKNOWN TRUE			
TRUE TRUE TRUE	FALSE UNKNOWN TRUE			

Null values

Three-valued logic system

- TRUE
- FALSE
- UNKNOWN

x	*y*	*x AND y*	*x OR y*	*NOT x*
FALSE	FALSE	FALSE	FALSE	
FALSE	UNKNOWN			TRUE
FALSE	TRUE	FALSE	TRUE	
UNKNOWN	FALSE			
UNKNOWN	UNKNOWN			
UNKNOWN	TRUE			
TRUE	FALSE	FALSE	TRUE	
TRUE	UNKNOWN			FALSE
TRUE	TRUE	TRUE	TRUE	

Null values

Three-valued logic system

- TRUE
- FALSE
- UNKNOWN

x	*y*	*x AND y*	*x OR y*	*NOT x*
FALSE FALSE FALSE	FALSE UNKNOWN TRUE	FALSE FALSE FALSE	FALSE TRUE	TRUE
UNKNOWN UNKNOWN UNKNOWN	FALSE UNKNOWN TRUE	FALSE UNKNOWN UNKNOWN		
TRUE TRUE TRUE	FALSE UNKNOWN TRUE	FALSE UNKNOWN TRUE	TRUE TRUE	FALSE

Null values

Three-valued logic system

- TRUE
- FALSE
- UNKNOWN

x	*y*	*x AND y*	*x OR y*	*NOT x*
FALSE FALSE FALSE	FALSE UNKNOWN TRUE	FALSE FALSE FALSE	FALSE UNKNOWN TRUE	TRUE
UNKNOWN UNKNOWN UNKNOWN	FALSE UNKNOWN TRUE	FALSE UNKNOWN UNKNOWN	UNKNOWN UNKNOWN TRUE	
TRUE TRUE TRUE	FALSE UNKNOWN TRUE	FALSE UNKNOWN TRUE	TRUE TRUE TRUE	FALSE

Null values

Three-valued logic system

- TRUE
- FALSE
- UNKNOWN

x	*y*	*x AND y*	*x OR y*	*NOT x*
FALSE FALSE FALSE	FALSE UNKNOWN TRUE	FALSE FALSE FALSE	FALSE UNKNOWN TRUE	TRUE
UNKNOWN UNKNOWN UNKNOWN	FALSE UNKNOWN TRUE	FALSE UNKNOWN UNKNOWN	UNKNOWN UNKNOWN TRUE	UNKNOWN
TRUE TRUE TRUE	FALSE UNKNOWN TRUE	FALSE UNKNOWN TRUE	TRUE TRUE TRUE	FALSE

Null values

Three-valued logic system

- TRUE
- FALSE
- UNKNOWN

x	*y*	*x AND y*	*x OR y*	*NOT x*
FALSE FALSE FALSE	FALSE UNKNOWN TRUE	FALSE FALSE FALSE	FALSE UNKNOWN TRUE	TRUE
UNKNOWN UNKNOWN UNKNOWN	FALSE UNKNOWN TRUE	FALSE UNKNOWN UNKNOWN	UNKNOWN UNKNOWN TRUE	UNKNOWN
TRUE TRUE TRUE	FALSE UNKNOWN TRUE	FALSE UNKNOWN TRUE	TRUE TRUE TRUE	FALSE

Null values

Three-valued logic system

- TRUE
- FALSE
- UNKNOWN

Operation

- Result of comparison operation involving `null` value is *unknown*
- Result of arithmetic operation involving `null` value is *null*

Example: assume that the value of x is `null`

- `x < 100` →
- `x = null` →
- `x <> null` →
- `x + 20` →

Null values

Three-valued logic system

- TRUE
- FALSE
- UNKNOWN

Operation

- Result of comparison operation involving `null` value is *unknown*
- Result of arithmetic operation involving `null` value is *null*

Example: assume that the value of x is `null`

- `x < 100` → unknown
- `x = null` → unknown
- `x <> null` → unknown
- `x + 20` → null

Null values

Three-valued logic system

- TRUE
- FALSE
- UNKNOWN

Operation

- Result of comparison operation involving `null` value is *unknown*
- Result of arithmetic operation involving `null` value is *null*

Example: assume that the value of x is `null`

- `x < 100` → unknown
- `x = null` → unknown
- `x <> null` → unknown
- `x + 20` → null

Null values

Three-valued logic system

- TRUE
- FALSE
- UNKNOWN

Operation

- Result of comparison operation involving `null` value is *unknown*
- Result of arithmetic operation involving `null` value is *null*

Example: assume that the value of x is `null`

- `x < 100` → unknown
- `x = null` → unknown
- `x <> null` → unknown
- `x + 20` → null

We cannot say if two null values are the same or different from one another because they are unknown

Null values

Three-valued logic system

- TRUE
- FALSE
- UNKNOWN

Check

- How to check if a value is *equal* to `null`?
- Use the `IS NULL` comparison predicate

x	*x IS NULL*	*x IS NOT NULL*
null		
non-null		

Null values

Three-valued logic system

- TRUE
- FALSE
- UNKNOWN

Check

- How to check if a value is *equal* to `null`?
- Use the `IS NULL` comparison predicate

x	*x IS NULL*	*x IS NOT NULL*
null	TRUE	FALSE
non-null	FALSE	TRUE

Null values

Three-valued logic system

- TRUE
- FALSE
- UNKNOWN

Check

- How to treat `null` values as ordinary values for comparison?
- Use the `IS DISTINCT FROM` comparison predicate

x	*y*	*x IS DISTINCT FROM y*
null		
null		
non-null		
non-null		

Null values

Three-valued logic system

- TRUE
- FALSE
- UNKNOWN

Check

- How to treat `null` values as ordinary values for comparison?
- Use the `IS DISTINCT FROM` comparison predicate

x	*y*	*x IS DISTINCT FROM y*
null	null	FALSE
null	non-null	TRUE
non-null	null	TRUE
non-null	non-null	x <> y

SQL syntax

Comments

- Comments in SQL are preceded by two hyphens
- `-- this is a single-line comment`

C-style comments

- SQL also supports C-style comments
- ```
  /* this is also a comment
     and can be multi-line */
  ```

Grammar

- Keywords are in `UPPERCASE`, variables are in **`lowercase`**
- Optional components are in `[ square brackets ]`
- Choices are separated by `|`
- Non-optional choices are in `{ curly brackets }`
- Possibly infinite repetitions are denoted by `...`
  ```

Create/drop table

Create table syntax

```
CREATE TABLE [ IF NOT EXISTS ] table_name ( [
  { column_name data_type
      [ column_constraints [ ... ] ]
    | table_constraints }
  [, ...]
] );
```

- Reference: https://www.postgresql.org/docs/11/sql-createtable.html

Drop table syntax

```
DROP TABLE [ IF EXISTS ] table_name
```

- Reference: https://www.postgresql.org/docs/11/sql-droptable.html

Create/drop table

Examples

```
CREATE TABLE Students (
    -- column1  data_type1
    -- column2  data_type2
    -- column3  data_type3
    -- etc
  );


DROP TABLE Students;
```

Create/drop table

Examples

```
CREATE TABLE Students (
    -- column1  data_type1
    -- column2  data_type2
    -- column3  data_type3
    -- etc
  );


DROP TABLE Students;
```

SQL is case-insensitive

Create/drop table

Specifying constraints

- Domain constraints

```
CREATE TABLE [ IF NOT EXISTS ] table_name ( [
  { column_name data_type
      [ column_constraints [ ... ] ]
    | table_constraints }
  [, ...]
] )
```

Create/drop table

Specifying constraints

- Domain constraints
  - Built-in data types
  - Domain of each includes a special value `null`
  - Reference: https://www.postgresql.org/docs/11/datatype.html

Data Type	*Values*
boolean	false/true
integer	signed four-byte integer
float8	double-precision floating-point number (8 bytes)
numeric	arbitrary-precision floating-point number
numeric(p,s)	maximum total of p digits with maximum of s in fractional part
char(n)	fixed-length string consisting of n characters
varchar(n)	variable-length string up to n characters
text	variable-length character string
date	calendar date (year, month, day)
timestamp	date and time

Create/drop table

Examples

```
CREATE TABLE students (
   studentID     integer,
   name          varchar(100),
   birthDate     date

);
```

students

studentID	*name*	*birthDate*
3118	Alice	1999-12-25
3118	Trudy	1999-12-25
1423	Bob	2000-05-27
5609	Carol	1999-06-11

Create/drop table

Specifying constraints

- Key constraints

```
CREATE TABLE [ IF NOT EXISTS ] table_name ( [
  { column_name data_type
      [ column_constraints [ ... ] ]
    | table_constraints }
  [, ...]
] )
```

Create/drop table

Specifying constraints

- Key constraints
  - *Recap:*
    - Superkey — *uniquely identifies its tuples*
      - *No two distinct tuples of relations have the same values in all attributes of superkey*
    - Key — *minimal superkey*
    - Candidate key — *if there are multiple keys*
    - Primary key — *one is selected as primary key*
      - Keyword: `PRIMARY KEY`

Create/drop table

Examples

```
CREATE TABLE Students ( -- column constraints
  studentID     integer PRIMARY KEY, -- one PK
  name          varchar(100),
  birthDate     date


);
```

Create/drop table

Examples

```
CREATE TABLE Students ( -- column constraints
  studentID     integer PRIMARY KEY, -- one PK
  name          varchar(100),
  birthDate     date


);
```

Students

studentID	***name***	***birthDate***
3118	Alice	1999-12-25
3118	Trudy	1999-12-25
1423	Bob	2000-05-27
5609	Carol	1999-06-11

Create/drop table

Examples

```
CREATE TABLE Students ( -- column constraints
  studentID     integer PRIMARY KEY, -- one PK
  name          varchar(100),
  birthDate     date


);
```

Students

studentID	***name***	***birthDate***
~~3118~~	~~Alice~~	~~1999-12-25~~
~~3118~~	~~Trudy~~	~~1999-12-25~~
1423	Bob	2000-05-27
5609	Carol	1999-06-11

Create/drop table

Examples

```
CREATE TABLE Students ( -- column constraints
  studentID     integer PRIMARY KEY, -- one PK
  name          varchar(100),
  birthDate     date


);
```

Students

studentID	***name***	***birthDate***
~~3118~~	~~Alice~~	~~1999-12-25~~
~~3118~~	~~Trudy~~	~~1999-12-25~~
1423	Bob	2000-05-27
5609	Carol	1999-06-11

Students

studentID	***name***	***birthDate***
3118	Alice	1999-12-25
1423	Bob	2000-05-27
5609	Carol	1999-06-11

Create/drop table

Examples

```
CREATE TABLE Enrolls ( -- table constraints
  sid    integer,
  cid    integer,
  grade  char(2),
  PRIMARY KEY(sid, cid) -- one or more PK
);
```

Create/drop table

Examples

```
CREATE TABLE enrolls ( -- table constraints
  sid    integer,
  cid    integer,
  grade  char(2),
  PRIMARY KEY(sid, cid) -- one or more PK
);
```

Enrolls

sid	***cid***	***grade***
3118	112	3.8
1423	101	4.0
1423	311	3.8
3118	112	4.0

Create/drop table

Examples

```
CREATE TABLE enrolls ( -- table constraints
  sid    integer,
  cid    integer,
  grade  char(2),
  PRIMARY KEY(sid, cid) -- one or more PK
);
```

Enrolls

sid	***cid***	***grade***
~~3118~~	~~112~~	~~3.8~~
1423	101	4.0
1423	311	3.8
~~3118~~	~~112~~	~~4.0~~

Create/drop table

Examples

```
CREATE TABLE enrolls ( -- table constraints
  sid    integer,
  cid    integer,
  grade  char(2),
  PRIMARY KEY(sid, cid) -- one or more PK
);
```

Enrolls

sid	***cid***	***grade***
~~3118~~	~~112~~	~~3.8~~
1423	101	4.0
1423	311	3.8
~~3118~~	~~112~~	~~4.0~~

Enrolls

sid	***cid***	***grade***
1423	101	4.0
1423	311	3.8
3118	112	4.0

Create/drop table

Specifying constraints

- Foreign key constraints

```
CREATE TABLE [ IF NOT EXISTS ] table_name ( [
  { column_name data_type
      [ column_constraints [ ... ] ]
    | table_constraints }
  [, ...]
] )
```

Create/drop table

Specifying constraints

- Foreign key constraints
  - Recap:
    - Foreign key *refers to primary key of second relation*
      - Each foreign key value in referencing relation must either
        - *Appear as primary key* value in referenced relation, *or*
        - Be a `null` value
      - Referencing & referenced relations could be the same relation
      - Also called referential integrity constraints
      - Keyword: `FOREIGN KEY` and `REFERENCES`

Create/drop table

Examples

```
CREATE TABLE Enrolls (
 sid     integer REFERENCES Students(studentID),
  cid    integer, -- assume Students and Courses
  grade  char(2), -- table are defined
  FOREIGN KEY(cid) REFERENCES Courses(courseID)
);
```

Create/drop table

Examples

```
CREATE TABLE Enrolls (
  sid    integer REFERENCES Students(studentID),
  cid    integer, -- assume Students and Courses
  grade  char(2), -- table are defined
  FOREIGN KEY(cid) REFERENCES Courses(courseID)
);
```

Enrolls

sid	***cid***	***grade***
1423	101	4.0
1423	311	3.8
3118	112	4.0
null	313	4.5
5609	null	5.0
null	null	0.0
1111	312	1.2

students

studentID	..	..
3118	..	..
1423	..	..
5609	..	..

Courses

courseID	..	..
101	..	..
312	..	..
112	..	..

Create/drop table

Examples

```
CREATE TABLE enrolls (
 sid     integer REFERENCES Students(studentID),
  cid    integer, -- assume Students and Courses
  grade  char(2), -- table are defined
  FOREIGN KEY(cid) REFERENCES Courses(courseID)
);
```

enrolls

sid	***cid***	***grade***
1423	101	4.0
~~1423~~	~~311~~	~~3.8~~
3118	112	4.0
~~null~~	~~313~~	~~4.5~~
5609	null	5.0
null	null	0.0
~~1111~~	~~312~~	~~1.2~~

students

studentID	..	..
3118	..	..
1423	..	..
5609	..	..

courses

courseID	..	..
101	..	..
312	..	..
112	..	..

Create/drop table

Examples

```
CREATE TABLE Enrolls (
  sid    integer, -- assume Student_Course table
  cid    integer, -- is defined
  FOREIGN KEY(sid,cid) REFERENCES
    Student_Course(studentID, courseID)
);
```

Create/drop table

Examples

```
CREATE TABLE Enrolls (
  sid    integer, -- assume Student_Course table
  cid    integer, -- is defined
  FOREIGN KEY(sid,cid) REFERENCES
    Student_Course(studentID, courseID)
);
```

Enrolls

sid	***cid***	***grade***
1423	101	4.0
1423	311	3.8
3118	112	4.0
null	313	4.5
5609	null	5.0
null	null	0.0
1111	312	1.2

Student_Course

studentID	***courseID***
3118	112
1423	101
1423	312
5609	112

Create/drop table

Examples

```
CREATE TABLE Enrolls (
  sid    integer, -- assume Student_Course table
  cid    integer, -- is defined
  FOREIGN KEY(sid,cid) REFERENCES
    Student_Course(studentID, courseID)
);
```

Enrolls

sid	***cid***	***grade***
1423	101	4.0
~~1423~~	~~311~~	~~3.8~~
3118	112	4.0
null	313	4.5
5609	null	5.0
null	null	0.0
~~1111~~	~~312~~	~~1.2~~

Student_Course

studentID	***courseID***
3118	112
1423	101
1423	312
5609	112

Constraint checking

Foreign key constraint violation

- Deletion/update of a referenced tuple could violate a foreign key constraint
- Specify action to deal with violation as part of a foreign key constraint declaration

```
FOREIGN KEY(...) REFERENCES ...
    [ ON DELETE action ] [ ON UPDATE action ]
```

Students

studentID	..	..
3118	..	..
1423	..	..
5609	..	..

Enrolls

sid	*cid*	*grade*
1423	101	4.0
3118	112	4.0
5609	312	1.2

Constraint checking

Foreign key constraint violation

```
FOREIGN KEY(...) REFERENCES ...
    [ ON DELETE action ] [ ON UPDATE action ]
```

Actions

- `NO ACTION` — *rejects* delete/update if it violates constraint (*default option*)
- `RESTRICT` — similar to `NO ACTION` except that constraint checking *can't be deferred*
- `CASCADE` — *propagate* delete/update to referencing tuple
- `SET DEFAULT` — *updates* foreign keys of referencing tuples to some *default value*
- `SET NULL` — *updates* to `null` value

Constraint checking

Foreign key constraint violation

```
FOREIGN KEY(...) REFERENCES ...
        ON DELETE SET NULL      ON UPDATE CASCADE
```

Students

studentID	..	..
3118	..	..
1423	..	..
5609	..	..

Enrolls

sid	*cid*	*grade*
1423	101	4.0
3118	112	4.0
5609	312	1.2

Constraint checking

Foreign key constraint violation

```
FOREIGN KEY(...) REFERENCES ...
      ON DELETE SET NULL     ON UPDATE CASCADE

-- delete 3118
```

Students

studentID	..	..
3118	..	..
1423	..	..
5609	..	..

Enrolls

sid	*cid*	*grade*
1423	101	4.0
3118	112	4.0
5609	312	1.2

Constraint checking

Foreign key constraint violation

```
FOREIGN KEY(...) REFERENCES ...
      ON DELETE SET NULL     ON UPDATE CASCADE

-- delete 3118
```

Students

studentID	..	..
~~3118~~	~~..~~	~~..~~
1423	..	..
5609	..	..

Enrolls

sid	*cid*	*grade*
1423	101	4.0
3118	112	4.0
5609	312	1.2

Constraint checking

Foreign key constraint violation

```
FOREIGN KEY(...) REFERENCES ...
      ON DELETE SET NULL     ON UPDATE CASCADE

-- delete 3118
```

Students

studentID	..	..
~~3118~~	~~..~~	~~..~~
1423	..	..
5609	..	..

Enrolls

sid	*cid*	*grade*
1423	101	4.0
null	112	4.0
5609	312	1.2

Constraint checking

Foreign key constraint violation

```
FOREIGN KEY(...) REFERENCES ...
        ON DELETE SET NULL      ON UPDATE CASCADE


-- delete 3118
-- change 1423 to 1444
```

Students

studentID	..	..
1423	..	..
5609	..	..

Enrolls

sid	*cid*	*grade*
1423	101	4.0
null	112	4.0
5609	312	1.2

Constraint checking

Foreign key constraint violation

```
FOREIGN KEY(...) REFERENCES ...
      ON DELETE SET NULL     ON UPDATE CASCADE

-- delete 3118
-- change 1423 to 1444
```

Students

studentID	..	..
1444	..	..
5609	..	..

Enrolls

sid	*cid*	*grade*
1423	101	4.0
null	112	4.0
5609	312	1.2

Constraint checking

Foreign key constraint violation

```
FOREIGN KEY(...) REFERENCES ...
        ON DELETE SET NULL      ON UPDATE CASCADE


-- delete 3118
-- change 1423 to 1444
```

Students

studentID	..	..
1444	..	..
5609	..	..

Enrolls

sid	*cid*	*grade*
1444	101	4.0
null	112	4.0
5609	312	1.2

Create/drop table

Specifying constraints

- Other general constraints

```
CREATE TABLE [ IF NOT EXISTS ] table_name ( [
  { column_name data_type
      [ column_constraints [ ... ] ]
    | table_constraints }
  [, ...]
] )
```

Create/drop table

Specifying constraints

- Other general constraints
  - Not-null constraints *keyword*: `NOT NULL`
  - Unique constraints *keyword*: `UNIQUE`
    - Check any two records $x, y \in \text{table}$ such that $x.\text{column} <> y.\text{column}$
  - General constraints *keyword*: `CHECK`
  - ❖ Constraint is violated if it evaluates to `FALSE`

- Default values
  - Specify default values *keyword*: `DEFAULT`

Create/drop table

Examples: not-null

```
CREATE TABLE Students (
  studentID     integer,
  name          varchar(100) NOT NULL,
  birthDate     date
);

CREATE TABLE Students (
  studentID     integer,
  name          varchar(100),
  birthDate     date,
  CHECK (name IS NOT NULL)
);
```

Create/drop table

Examples: unique

```
CREATE TABLE Students (
  studentID     integer,
  name          varchar(100) UNIQUE,
  birthDate     date
);
```

Students

studentID	***name***	***birthDate***
3118	Alice	1999-12-25
3119	Alice	1999-12-25
1423	Bob	2000-05-27
5609	Carol	1999-06-11

Create/drop table

Examples: unique

```
CREATE TABLE Students (
   studentID     integer,
   name          varchar(100) UNIQUE,
   birthDate     date
);
```

Students

studentID	***name***	***birthDate***
~~3118~~	~~Alice~~	~~1999-12-25~~
~~3119~~	~~Alice~~	~~1999-12-25~~
1423	Bob	2000-05-27
5609	Carol	1999-06-11

Create/drop table

Examples: unique

```
CREATE TABLE Students (
   studentID     integer,
   name          varchar(100) UNIQUE,
   birthDate     date
);
```

Students

studentID	***name***	***birthDate***
~~3118~~	~~Alice~~	~~1999-12-25~~
~~3119~~	~~Alice~~	~~1999-12-25~~
1423	Bob	2000-05-27
5609	Carol	1999-06-11

Check

$x, y \in$ students

such that

$x.\text{name} <> y.\text{name}$

evaluates to FALSE

Create/drop table

Examples: unique

```
CREATE TABLE Students (
   studentID     integer,
   name          varchar(100),
   birthDate     date,
   UNIQUE (studentID, name)
);
```

Students

studentID	***name***	***birthDate***
3118	Alice	1999-12-25
3119	Alice	1999-12-25
1423	Bob	2000-05-27
1423	Bob	1999-06-11

Create/drop table

Examples: unique

```
CREATE TABLE Students (
   studentID     integer,
   name          varchar(100),
   birthDate     date,
   UNIQUE (studentID, name)
);
```

Students

studentID	***name***	***birthDate***
3118	Alice	1999-12-25
3119	Alice	1999-12-25
~~1423~~	~~Bob~~	~~2000-05-27~~
~~1423~~	~~Bob~~	~~1999-06-11~~

Create/drop table

Examples: unique

```
CREATE TABLE Students (
   studentID     integer,
   name          varchar(100),
   birthDate     date,
   UNIQUE (studentID, name)
);
```

Students

studentID	***name***	***birthDate***
3118	Alice	1999-12-25
3119	Alice	1999-12-25
~~1423~~	~~Bob~~	~~2000-05-27~~
~~1423~~	~~Bob~~	~~1999-06-11~~

Check

$x, y \in$ students

such that

$(x.\text{studentID} <> y.\text{studentID})$

$\vee\ (x.\text{name} <> y.\text{name}\ )$

evaluates to FALSE

Create/drop table

Examples: general

```
CREATE TABLE Students (
   studentID     integer,
   name          varchar(100),
   birthDate     date,
   CHECK (studentID > 2000)
);
```

Students

studentID	***name***	***birthDate***
3118	Alice	1999-12-25
3119	Alice	1999-12-25
1423	Bob	2000-05-27
5609	Carol	1999-06-11

Create/drop table

Examples: general

```
CREATE TABLE Students (
   studentID     integer,
   name          varchar(100),
   birthDate     date,
   CHECK (studentID > 2000)
);
```

Students

studentID	***name***	***birthDate***
3118	Alice	1999-12-25
3119	Alice	1999-12-25
~~1423~~	~~Bob~~	~~2000-05-27~~
5609	Carol	1999-06-11

Create/drop table

Examples: general

```
CREATE TABLE Students (
   studentID     integer,
   name          varchar(100),
   birthDate     date,
   CHECK (studentID > 2000)
);
```

Students

studentID	***name***	***birthDate***
3118	Alice	1999-12-25
3119	Alice	1999-12-25
~~1423~~	~~Bob~~	~~2000-05-27~~
5609	Carol	1999-06-11

Check

$x \in$ students

such that

$x.\text{studentID} > 2000$

evaluates to FALSE

Create/drop table

Examples: default values

```
CREATE TABLE Students (
  studentID     integer,
  name          varchar(100) DEFAULT ‘John Doe’,
  birthDate     date
);
```

Create/drop table

Examples: default values

```
CREATE TABLE Students (
  studentID     integer,
  name          varchar(100) DEFAULT ‘John Doe’,
  birthDate     date
);
```

When we insert into `students` table, if the value is set as `DEFAULT`, the default value will be used

Create/drop table

Assertions

- Complex constraints
  - Multi-table constraints
  - Example:
    - Every student in `students` table *must be enrolled in at least two and at most five courses* in `enrolls` table
  - Limitation
    - *Create assertion statement is not implemented in many DBMSs*
    - We can use `triggers` to enforce complex constraints
      - Lecture 06