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The Relational Model of Data (ii)

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Defining Relational Schema in SQL

- Two aspects:
  - Data definition language – declaring database schemas
  - Data manipulation language – querying & modifying the database
- Three kinds of relations
  - Stored relations
  - Views
  - Temporary tables
- CREATE TABLE statement

Creating Relations in SQL

```
CREATE TABLE Students (sid CHAR(20),
        name CHAR(20),  login CHAR(10),
        age INTEGER, gpa REAL)

CREATE TABLE Enrolled (sid CHAR(20),  cid CHAR(20),
         grade CHAR(2))
```

- The type (domain) of each field must be specified
- The domain constraints are enforced by the DBMS whenever tuples are added or modified.

SQL Data Types

- Character Strings
  - CHAR(n), VARCHAR(n)
- Bit Strings
  - BIT(n), BIT VARYING(n)
- Boolean - BOOLEAN
- Integer
  - INT, INTEGER, SHORTINT, BIGINT
- Floating point numbers
  - FLOAT, REAL, DOUBLE PRECISION, DECIMAL(n,d)
- Dates and Times
  - DATE (eg. '1948-05-14'), TIME (eg. '15:00:02.5')

Destroying and Altering Relations

DROP TABLE Students

- Destroys the relation Students. The schema information *and* the tuples are deleted.

ALTER TABLE Students ADD firstYear

- The schema of Students is altered by adding a new field; every tuple in the current instance is extended with a *null* value in the new field.

ALTER TABLE Students DROP age

- Deletes the age column

Default Values

- Specify default values for fields in table declaration

```
CREATE TABLE MovieStar (...
        gender CHAR(1) DEFAULT '?',
        birthdate DATE DEFAULT DATE '0000-00-00')
```

- Or in an alter table statement

```
ALTER TABLE MovieStar ADD phone CHAR(16)
DEFAULT 'unlisted';
```

Adding and Deleting Tuples

- Insert a single tuple:

```
INSERT INTO Students (sid, name, login, age, gpa)
VALUES (53688, 'Smith', 'smith@ee', 18, 3.2)
```

- For inserting a lot of tuples into a table, you should be using bulk loading commands like LOAD.

- Can delete all tuples satisfying some condition (e.g., name = Smith):

```
DELETE
FROM Students S
WHERE S.name = 'Smith'
```

Powerful variants of these commands are available; more later!

Simple SQL Queries

- Listing the contents of a table

```
SELECT *
FROM Students
```

Asterisk denotes a wildcard that matches all columns

- If you want only the sid, name

```
SELECT sid, name
FROM Students
```

- If you want only the students with GPA 3.2

```
SELECT sid, name
FROM Students
WHERE  gpa=3.2
```

Integrity Constraints (ICs)

- IC: condition that must be true for *any* instance of the database; e.g., *domain constraints.*
  - ICs are specified when schema is defined.
  - ICs are checked when relations are modified.
- A *legal* instance of a relation is one that satisfies all specified ICs.
  - DBMS should not allow illegal instances.
- Why are integrity constraints useful ?

Primary Key Constraints

- A set of fields is a *key* for a relation if :
  1. No two distinct tuples can have same values in all key fields, and
  2. This is not true for any subset of the key.
  - Part 2 false? A *superkey*.
  - If there's >1 key for a relation, one of the keys is chosen (by DBA) to be the *primary key*.
- E.g., *sid* is a key for Students. (What about *name*?) The set {*sid, gpa*} is a superkey.

Primary and Candidate Keys in SQL

- Possibly many *candidate keys* (specified using UNIQUE), one of which is chosen as the *primary key*.

```
CREATE TABLE Enrolled (sid CHAR(20), cid  CHAR(20),
        grade CHAR(2), PRIMARY KEY  (sid,cid) )

CREATE TABLE Enrolled (sid CHAR(20)
        cid  CHAR(20), grade CHAR(2), PRIMARY KEY  (sid),
        UNIQUE (cid, grade) )
```

Foreign Keys, Referential Integrity

- *Foreign key* : Set of fields in one relation that is used to `refer' to a tuple in another relation. (Must correspond to primary key of the second relation.) Like a `logical pointer'.

- E.g. *sid* is a foreign key referring to Students:
  - Enrolled(*sid*: string, *cid*: string, *grade*: string)
  - If all foreign key constraints are enforced, *referential integrity* is achieved, i.e., no dangling references.
  - Can you name a data model w/o referential integrity?

Foreign Keys in SQL

- Only students listed in the Students relation should be allowed to enroll for courses.

```
CREATE TABLE Enrolled (sid CHAR(20),  cid CHAR(20),
        grade CHAR(2), PRIMARY KEY  (sid,cid),
        FOREIGN KEY (sid) REFERENCES Students )
```

Enrolled

sid	cid	grade
53666	Carnatic101	C
53666	Reggae203	B
53650	Topology112	A
53666	History105	B

Students

sid	name	login	age	gpa
53666	Jones	jones@cs	18	3.4
53688	Smith	smith@eecs	18	3.2
53650	Smith	smith@math	19	3.8

Enforcing Referential Integrity

- Consider Students and Enrolled; *sid* in Enrolled is a foreign key that references Students.
- What should be done if an Enrolled tuple with a non-existent student id is inserted?
- What should be done if a Students tuple is deleted?
  - Also delete all Enrolled tuples that refer to it.
  - Disallow deletion of a Students tuple that is referred to.
  - Set *sid* in Enrolled tuples that refer to it to a *default sid*.
  - (In SQL, also: Set sid in Enrolled tuples that refer to it to a special value *null*, denoting *`unknown'* or *`inapplicable'*.)
- Similar if primary key of Students tuple is updated.

Referential Integrity in SQL

- SQL/92 and SQL:1999 support all 4 options on deletes and updates.
  - Default is NO ACTION (*delete/update is rejected*)
  - CASCADE (also delete all tuples that refer to deleted tuple)
  - SET NULL / SET DEFAULT (sets foreign key value of referencing tuple)

```
CREATE TABLE Enrolled
   (sid CHAR(20),
    cid CHAR(20),
    grade CHAR(2),
    PRIMARY KEY  (sid,cid),
    FOREIGN KEY (sid)
      REFERENCES Students
            ON DELETE CASCADE
            ON UPDATE SET DEFAULT )
```

Where do ICs Come From?

- ICs are based upon the semantics of the real-world enterprise that is being described in the database relations.

- We can check a database instance to see if an IC is violated, but we can NEVER infer that an IC is true by looking at an instance.
  - An IC is a statement about *all possible* instances!
  - From example, we know *name* is not a key, but the assertion that *sid* is a key is given to us.

- Key and foreign key ICs are the most common; more general ICs supported too.