Relation Schema

STUDENT

SID	*LName*	*Name*	*Class*	*Major*
123	Smith	John	3	CS
395	Aiken	Mary	4	CS

⇐ **Schema**

◆ ***What is the meaning***?

- A relation schema R specifies
  - The name of the relation
  - the attribute names A_i of R
  - the domain D_i (data type + format) for each attribute A_i
- data type is a set of **atomic data** values:
  - no attribute is a set-valued (1st Normal Form, 1-NF)
  - no attribute is composite
- format specifies the representation of a data value

Example Table Schema

Schema of STUDENT(SID, Name, Major, GPA)

```
CREATE TABLE STUDENT
(   SID    INTEGER,
    Name  CHAR(20),
    Major  CHAR(4),
    GPA   DEC(3,2)
);
```

Creating a Schema

- Corresponding database is at an **empty** state!
- Initial state when the database is **populated** (loaded)
- Domain (type) of each field is **specified** and **enforced** by the DBMS whenever tuples are added or modified

Example: Domain Constraints

SID	*Name*	*Login*	*Age*	*GPA*
546007	Jones	jones@cs	18	3.4
546100	Smith	smith@ee	18	3.2
546500	Smith	smith@math	19	3.8

- Example of **IC Violation**:

UPDATE *Students*

SET *Age* = \`Eighteen\` ✗ ✗ ✗

WHERE *Name* = Jones;

Useful Terms

- ❑ Cardinality of a relation r(R): # of tuples in r(R) (denoted by |r(R)|)
- ❑ Arity or degree of r(R): # of attributes in R (denoted by |R|)

|R| = 4

|r(R)| = 3

SID	*Degree*	*Major*	*Year*
123	BS	Math	1992
064	BA	History	1991
445	PhD	CS	1999

- ◆ |R| > 0 and |r(R)| ≥ 0
- ◆ Cardinality is property of a relation
- ◆ Arity is property of relation schema or a relation

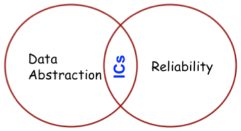
Relational Database Schema

- ❑ A *database schema* is a set of relation schemas and a set of ***integrity constraints***

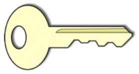
- ❑ Integrity Constraints
  - *Structural* Integrity Constraints
    - key constraints: uniqueness of keys
    - entity integrity constraint: no primary key value can be **NULL**
    - referential integrity constraint
  - *Semantic* Integrity Constraints
    - E.g., ??

Integrity Constraints (ICs)

- ❑ **IC**: condition that must be true for *any* instance of the database (e.g., domain constraints)
  - A **legal** instance of a relation is one that satisfies all specified ICs
  - ICs are specified when schema is **defined**
  - ICs are enforced when tables are **modified**



Primary Key Constraint



- ❑ A set of fields is a **key** for a relation if :
  - No two distinct tuples can have same values in all key fields

- ❑ If there is more than one key for a relation:
  - Each is called a candidate key
  - One candidate key is designated as the ***primary* key**
  - Other candidate key(s) are designated as **alternative** or ***unique* key(s)**

Example of Keys

SID	*Name*	*Login*	*Age*	*GPA*
546007	Jones	jones@cs	18	3.4
546100	Smith	smith@ee	18	3.2
546500	Smith	smith@math	19	3.8

- **Candidate Keys:** *SID*, and *Login*
- **Primary Key:** *SID*
- **Unique Key:** *Login*

Example Table Schema in SQL

Schema of STUDENT(SID, Login, Name, Major, GPA)

```
CREATE TABLE  STUDENT
(    SID      INTEGER   NOT NULL,
     Login    CHAR(15),
     Name   CHAR(20),
     Major   CHAR(4),
     GPA     DEC(3,2),
     CONSTRAINT STUDENT_PK
        PRIMARY KEY (SID),
     CONSTRAINT STUDENT_UN
        UNIQUE (Login)                -- UNIQUE  can take NULL values
 );
```

Example Table Schema in SQL (2)

Schema of STUDENT(SID, Login, Name, SSN, GPA)

```
CREATE TABLE  STUDENT
(    SID      INTEGER   NOT NULL,
     Login    CHAR(15),
     Name   CHAR(20),
     SSN   CHAR(9),
     GPA      DEC(3,2),
     CONSTRAINT STUDENT_PK   PRIMARY KEY (SID),
     CONSTRAINT STUDENT_UN_SSN
        UNIQUE (SSN),
     CONSTRAINT STUDENT_UN_Login
        UNIQUE (Login)
 );
```

Example Table Schema in SQL (3)

Schema of STUDENT(SID, SSN, Name, Login, GPA)

```
CREATE TABLE  STUDENT
(    SID     INTEGER
         CONSTRAINT STUDENT_PK_NOT_NULL NOT NULL
         CONSTRAINT STUDENT_PK   PRIMARY KEY,
     SSN    CHAR(9)
         CONSTRAINT STUDENT_UN_SSN UNIQUE,
     Name   CHAR(20),
     Login   CHAR(15),
     GPA     DEC(3,2),
     CONSTRAINT STUDENT_UN_Login
         UNIQUE (Login)
 );
```

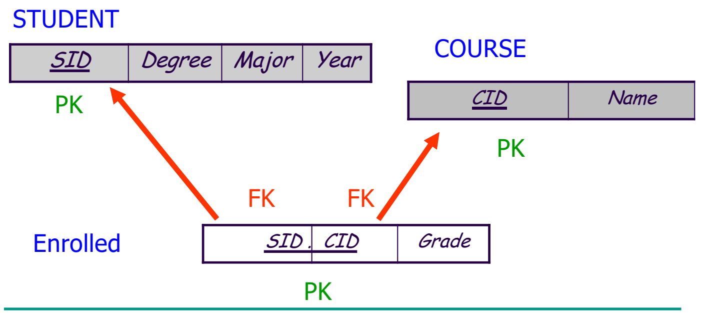
Identifying the Key

- What is the key in relation GRADUATE=(SID, Degree, Major, Year) ?

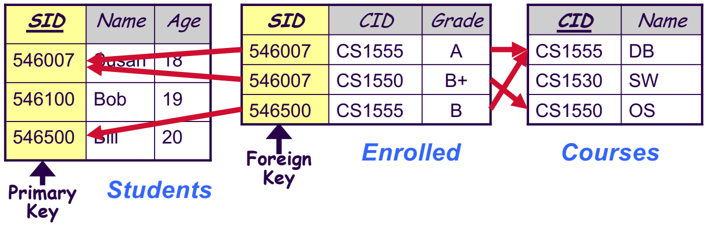
SID	*Degree*	*Major*	*Year*
123	BS	CS	1992
123	MS	CS	1993
064	BA	History	1991
445	PhD	CS	1999
123	BS	Math	1992
123	MS	Math	1992

Foreign Keys

- *Foreign key* (FK) in relation R_2 is a set of attributes of R_2 that forms a primary key (PK) of another relation R_1.
  - Attributes in FK and PK have the **same domain**



Foreign Key & Primary Key



SID	*Name*	*Age*
546007	Susan	18
546100	Bob	19
546500	Bill	20

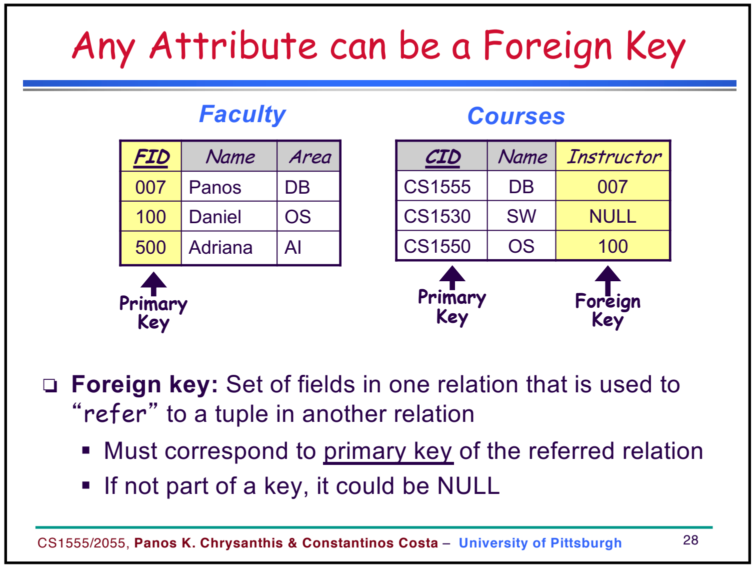
SID	*CID*	*Grade*
546007	CS1555	A
546007	CS1550	B+
546500	CS1555	B

CID	*Name*
CS1555	DB
CS1530	SW
CS1550	OS

- **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 referred relation
  - E.g. *SID* is a foreign key referring to *Students*

Foreign Key Constraints

- If foreign key constraints are enforced, **referential integrity** is achieved
  - E.g.: Only students can enroll in a class
    - – Only students listed in the "Students" relation should be allowed to enroll for courses
- Like a "*logical pointer*"
  - There shouldn't be dangling references
    - – Either valid PK or NULL



Any Attribute can be a Foreign Key

Faculty

FID	Name	Area
007	Panos	DB
100	Daniel	OS
500	Adriana	AI

Primary Key

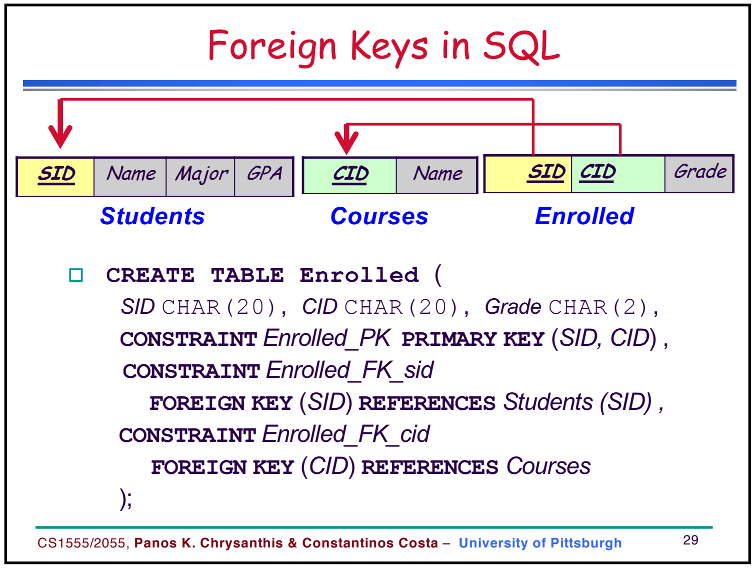
Courses

CID	Name	Instructor
CS1555	DB	007
CS1530	SW	NULL
CS1550	OS	100

Primary Key

Foreign Key

- **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 referred relation
  - If not part of a key, it could be NULL



Foreign Keys in SQL

SID	Name	Major	GPA

Students

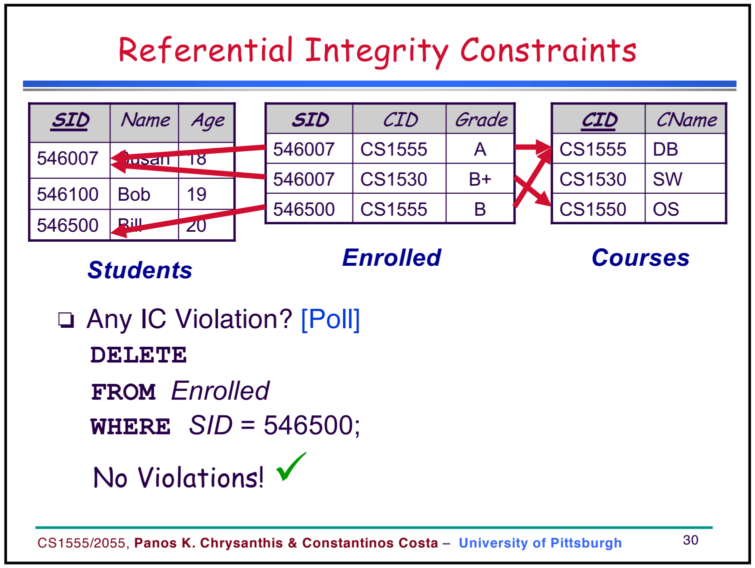
CID	Name

Courses

SID	CID	Grade

Enrolled

```
CREATE TABLE Enrolled (
  SID CHAR(20), CID CHAR(20), Grade CHAR(2),
  CONSTRAINT Enrolled_PK PRIMARY KEY (SID, CID) ,
  CONSTRAINT Enrolled_FK_sid
    FOREIGN KEY (SID) REFERENCES Students (SID) ,
  CONSTRAINT Enrolled_FK_cid
    FOREIGN KEY (CID) REFERENCES Courses
);
```



Referential Integrity Constraints

SID	Name	Age
546007	Susan	18
546100	Bob	19
546500	Bill	20

Students

SID	CID	Grade
546007	CS1555	A
546007	CS1530	B+
546500	CS1555	B

Enrolled

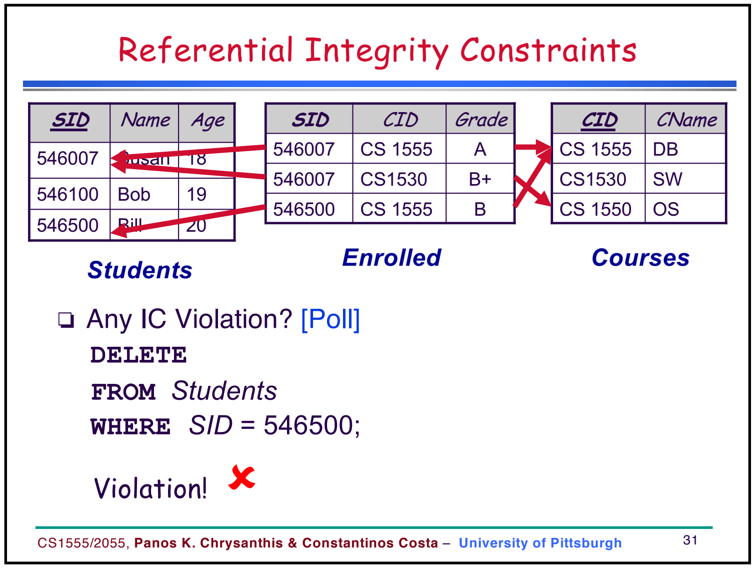
CID	CName
CS1555	DB
CS1530	SW
CS1550	OS

Courses

- Any IC Violation? [Poll]

```
DELETE
FROM Enrolled
WHERE SID = 546500;
```

No Violations! ✓



Referential Integrity Constraints

SID	Name	Age
546007	Susan	18
546100	Bob	19
546500	Bill	20

Students

SID	CID	Grade
546007	CS 1555	A
546007	CS1530	B+
546500	CS 1555	B

Enrolled

CID	CName
CS 1555	DB
CS1530	SW
CS 1550	OS

Courses

- Any IC Violation? [Poll]

```
DELETE
FROM Students
WHERE SID = 546500;
```

Violation! ✘

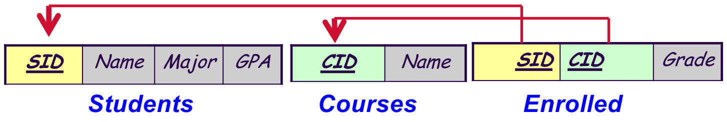
Referential Integrity Enforcement

- What are the alternatives when a "Students" tuple is **deleted**?
  1. **Delete all** Enrolled tuples that refer to it
  2. **Disallow** deletion of a Students tuple that is referred to
  3. **Set** *SID* in Enrolled tuples that refer to it to some "default" *SID* (e.g., 000000)
  4. **If** *SID was not part of the primary key*, **Set** *SID* to a special value "NULL", denoting *"unknown"* or *"inapplicable"*

Referential Integrity in SQL

- SQL/92 and SQL/99 support all 4 options on delete and update:
  - **`NO ACTION`** (default)
    - 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

RI Trigger Actions in SQL



- **CREATE TABLE Enrolled** (

```
  SID CHAR(20),  CID CHAR(20),  Grade CHAR(2),
  CONSTRAINT Enrolled_PK PRIMARY KEY (SID, CID) ,
  CONSTRAINT Enrolled_FK_sid
      FOREIGN KEY (SID) REFERENCES Students (SID) ,
  CONSTRAINT Enrolled_FK_cid
      FOREIGN KEY (CID) REFERENCES Courses
      ON UPDATE CASCADE ON DELETE NO ACTION
  );
```

Enforcing Integrity Constraints [Poll]

- What would be the outcome?
  - Insert (585811, 'Jie', 19, 3.95) into Students ✓
  - Insert (585811, NULL, NULL) into Enrollment ✗
  - Insert (546100, 'CS 1555', NULL) into Enrollment ✓
  - Insert (546100, 'Mary', 18, 3.65) into Students ✗
  - Delete ('CS 1530') from Courses ✗

Students

SID	*Name*	*Age*	*GPA*
546007	Susan	18	3.8
546100	Bob	19	3.65
546500	Bill	20	3.7

Courses

CID	*Name*
CS1555	DB
CS1530	SW
CS1550	OS

Enrollment

SID	*CID*	*Grade*
546007	CS1550	A
546007	CS1530	B+
546100	CS1550	B