Stony Brook University

CSE 305 / CSE532

Lecture 03 (Chapter 03)
SQL

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Slide adapted from the author's slides and Dr. Ilchul Yoon's slides.

Adapted from book authors' slides

SUNY Korea

SQL

- Language for describing database **schema** & **operations** on tables

- **Data Definition Language (DDL)**: sublanguage of SQL for describing schema

Tables

- SQL entity that corresponds to a relation
- An element of the database schema

Table Declaration

```
CREATE TABLE Student (
   Id:  INTEGER,
   Name:  CHAR(20),
   Address:  CHAR(50),
   Status:  CHAR(10)
)
```

Id	*Name*	*Address*	*Status*
101222333 234567890	John Mary	10 Cedar St 22 Main St	Freshman Sophomore

Student

Primary/Candidate Keys

```
CREATE TABLE Course (
   CrsCode CHAR(6),
   CrsName CHAR(20),
   DeptId CHAR(4),
   Descr CHAR(100),
   PRIMARY KEY (CrsCode),
   UNIQUE (DeptId, CrsName)   -- candidate key
)
```

Comments start with 2 dashes

Null

- Problem: Not all information might be known when row is inserted (e.g., *Grade* might be missing from Transcript)
- A column might not be applicable for a particular row (e.g., MaidenName if row describes a male)

- Solution: Use place holder – null
  - Not a value of any domain (although called null value)
    - Indicates the absence of a value
  - Not allowed in certain situations
    - Primary keys and columns constrained by NOT NULL

Default Value

- Value to be assigned if attribute value in a row is not specified

```
CREATE TABLE Student (
    Id  INTEGER,
    Name  CHAR(20) NOT NULL,
    Address  CHAR(50),
    Status  CHAR(10) DEFAULT 'freshman',
    PRIMARY KEY (Id) )
```

Semantic Constraints in SQL

- Primary key and foreign key are examples of structural constraints
- Semantic constraints
  - Express the logic of the application at hand:
    - e.g., number of registered students $\leq$ maximum enrollment

Semantic Constraints (cont'd)

- Used for application dependent conditions
- Example: limit attribute values

```
CREATE TABLE Transcript (
    StudId   INTEGER,
    CrsCode   CHAR(6),
    Semester   CHAR(6),
    Grade   CHAR(1),
    CHECK (Grade IN ('A', 'B', 'C', 'D', 'F')),
    CHECK (StudId > 0 AND StudId < 1000000000) )
```

- Each row in table must satisfy condition

Semantic Constraints (cont'd)

- Example: relate values of attributes in different columns

```
CREATE TABLE Employee (
    Id    INTEGER,
    Name    CHAR(20),
    Salary    INTEGER,
    MngrSalary    INTEGER,
    CHECK ( MngrSalary > Salary) )
```

Constraints – Problems

- Problem 1: Empty table always satisfies all CHECK constraints (an idiosyncrasy of the SQL standard)

```
CREATE TABLE Employee (
    Id  INTEGER,
    Name  CHAR(20),
    Salary  INTEGER,
    MngrSalary  INTEGER,
    CHECK ( 0 < (SELECT COUNT (*) FROM Employee)) )
```

- If Employee is empty, there are no rows on which to evaluate the CHECK condition.

Constraints – Problems

- Problem 2: Inter-relational constraints should be symmetric

```
CREATE TABLE Employee (
    Id  INTEGER,
    Name  CHAR(20),
    Salary  INTEGER,
    MngrSalary  INTEGER,
    CHECK ((SELECT  COUNT (*) FROM Manager) <
                  (SELECT  COUNT (*) FROM Employee)) )
```

  - Why should constraint be in Employee and not Manager?
  - What if Employee is empty?

Assertion

- Element of schema (like table)
- **Symmetrically** specifies an inter-relational constraint
- Applies to entire database (not just the individual rows of a single table)
  - Does it work even if Employee is empty?

```
CREATE ASSERTION DontFireEveryone
  CHECK (0 < SELECT  COUNT (*)  FROM Employee)
```

Assertion

```
CREATE ASSERTION KeepEmployeeSalariesDown
    CHECK (NOT EXISTS(
                SELECT * FROM Employee E
                  WHERE E.Salary > E.MngrSalary))
```

Assertions and Inclusion Dependency

```
CREATE ASSERTION  NoEmptyCourses
   CHECK  (NOT  EXISTS (
                SELECT *  FROM Teaching T
                  WHERE   -- for each row T check
                             -- the following condition
                    NOT  EXISTS (
                    SELECT * FROM Transcript  R
                      WHERE T.CrsCode = R.CrsCode
                        AND T.Semester = R.Semester)
   ) )
```

Courses with no students

Students in a particular course

Referential integrity constraint that is not a foreign key constraint

(CrsCode, Semester) of Teaching *references*
(CrsCode, Semester) of Transcript

Target attributes is not a CK in Transcript

Domains

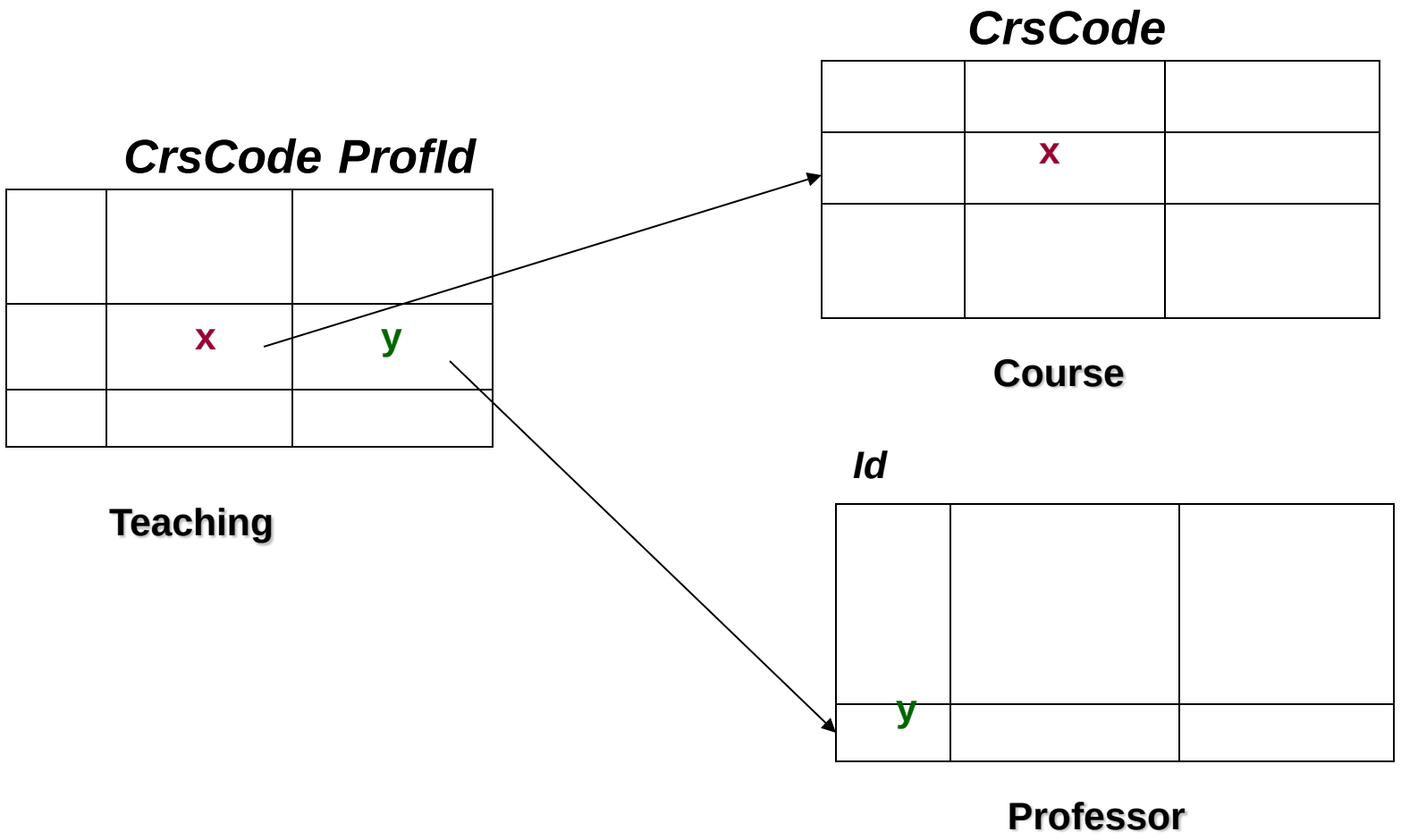
- Possible attribute values can be specified
  - Using a CHECK constraint or
  - Creating a new domain
- Domain can be used in several declarations
- Domain is a schema element

```
CREATE DOMAIN Grades CHAR (1)
   CHECK  (VALUE IN ('A', 'B', 'C', 'D', 'F'))
CREATE TABLE Transcript (
      ....,
      Grade: Grades,
      ...  )
```

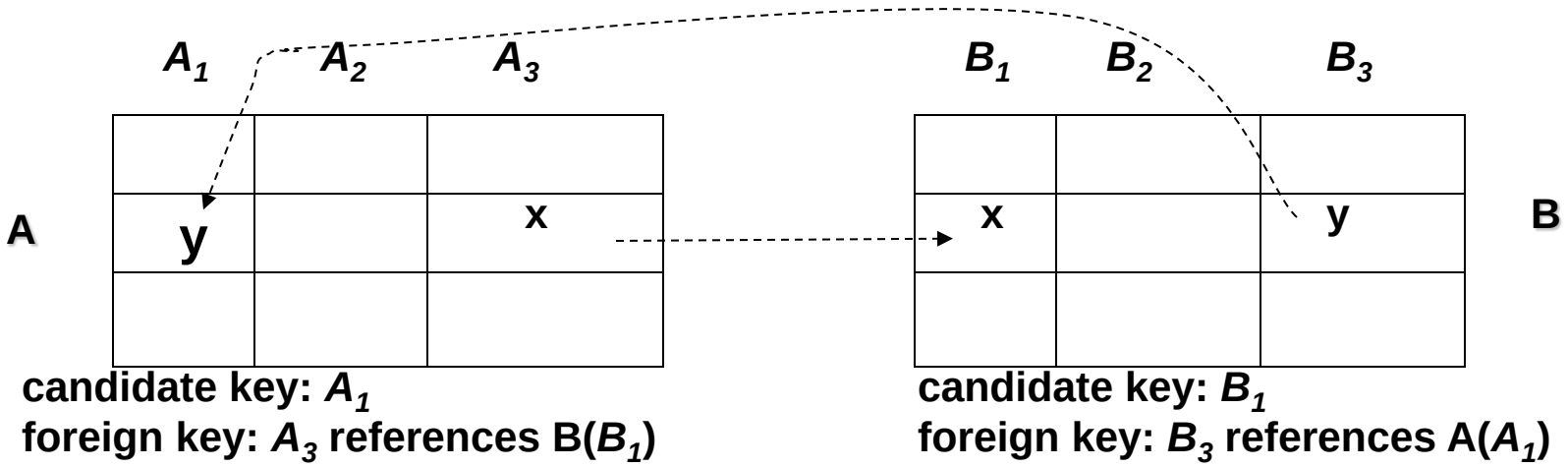
Foreign Key Constraint

```
CREATE TABLE Teaching (
    ProfId    INTEGER,
    CrsCode   CHAR (6),
    Semester  CHAR (6),
    PRIMARY KEY (CrsCode, Semester),
    FOREIGN KEY (CrsCode) REFERENCES Course,
    FOREIGN KEY (ProfId) REFERENCES Professor (Id) )
```

Foreign Key Constraint



Circularity in Foreign Key Constraint



Problem 1: Creation of A requires existence of B and vice versa

Solution:

```
CREATE TABLE A ( ……)    -- no foreign key
CREATE TABLE B ( ……)    -- include foreign key
ALTER TABLE A
  ADD CONSTRAINT cons
    FOREIGN KEY (A3) REFERENCES B (B1)
```

Circularity in Foreign Key Constraint (cont'd)

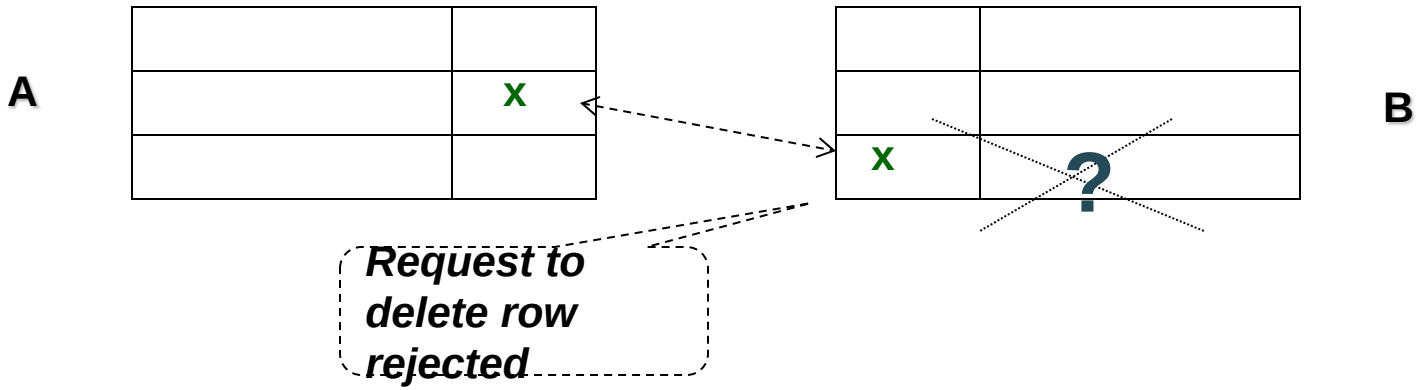
- Problem 2: Insertion of row in A requires prior existence of row in B and vice versa
- Solution: use appropriate constraint checking mode:
  - IMMEDIATE checking
  - DEFERRED checking

Reactive Constraints

- Constraints enable DBMS to recognize a bad state and reject the statement or transaction that creates it
- More generally, it would be nice to have a mechanism that allows a user to specify how to react to a violation of a constraint
- SQL-92 provides a limited form of such a reactive mechanism for foreign key violations

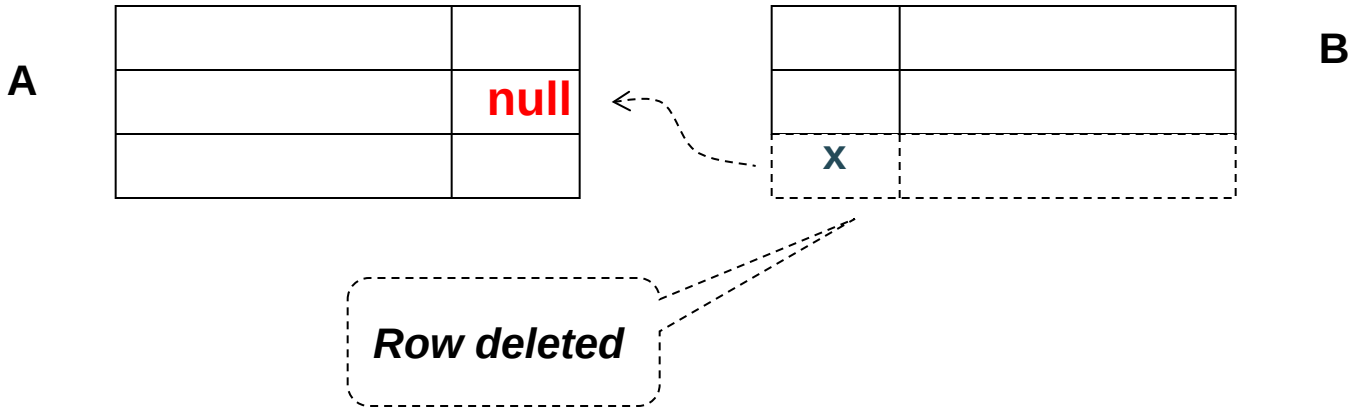
Handling Foreign Key Violations

- Insertion into A: Reject if no row exists in B containing foreign key of inserted row
- Deletion from B:
  - NO ACTION: Reject if row(s) in A references row to be deleted (default response)



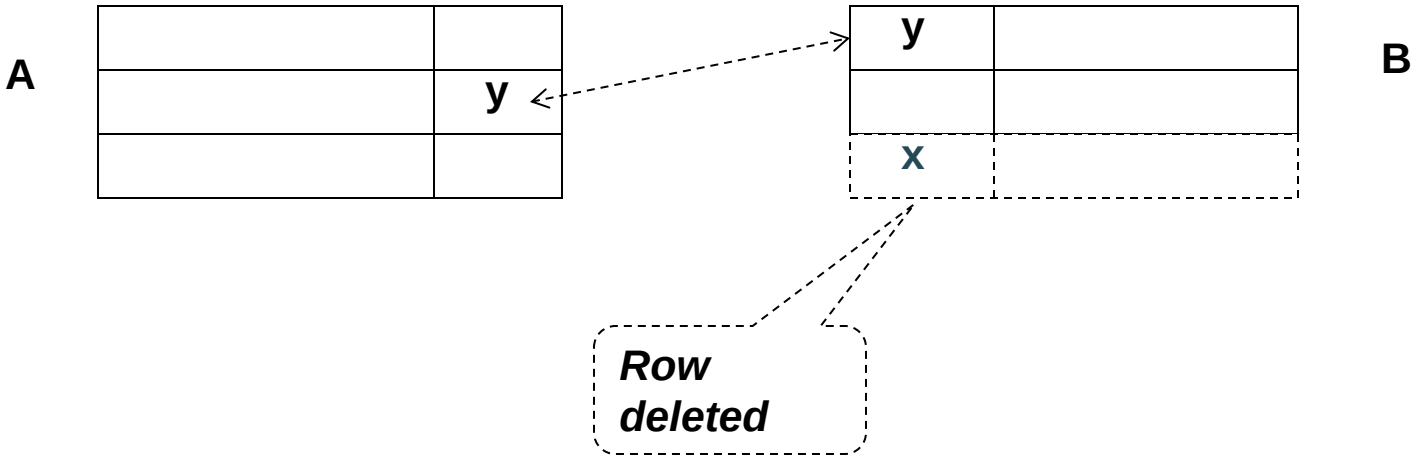
Handling Foreign Key Violations (cont'd)

- Deletion from B (cont'd):
  - SET NULL: Set value of foreign key in referencing row(s) in A to null



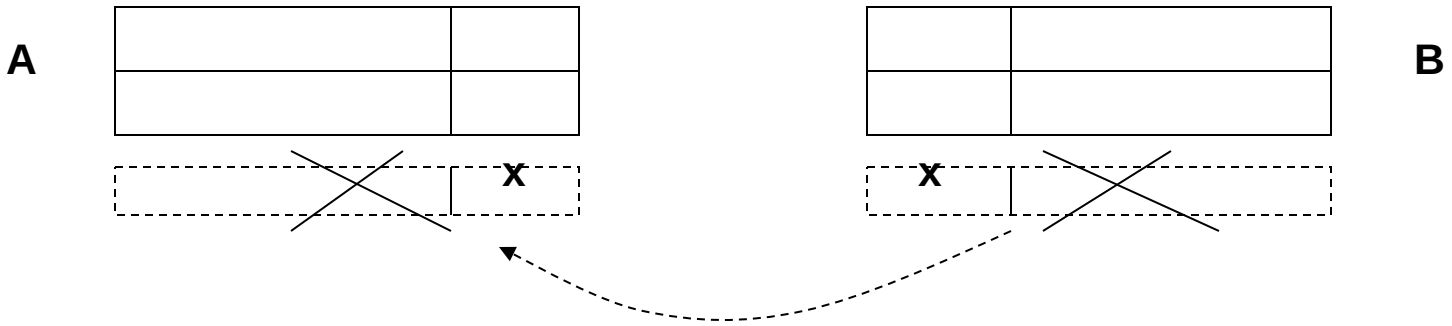
Handling Foreign Key Violations (cont'd)

- Deletion from B (cont'd):
  - SET DEFAULT: Set value of foreign key in referencing row(s) in A to default value (y) which must exist in B



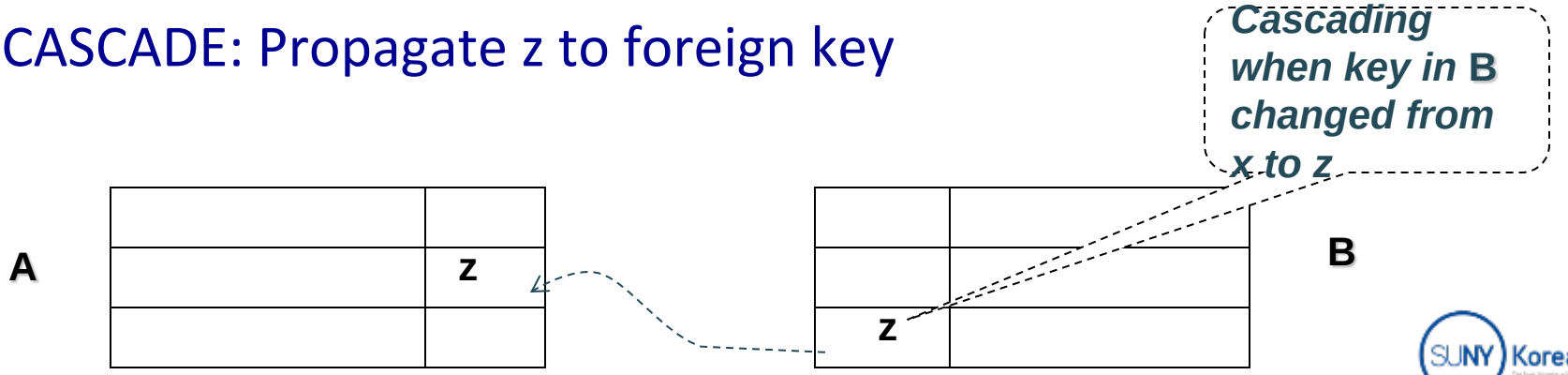
Handling Foreign Key Violations (cont'd)

- Deletion from B (cont'd):
  - CASCADE: Delete referencing row(s) in A as well



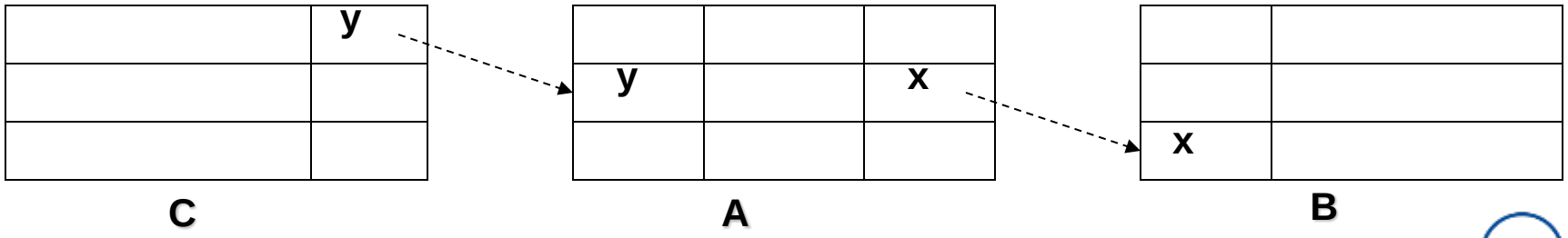
Handling Foreign Key Violations (cont'd)

- Update (change) foreign key in A: Reject if no row exists in B containing new foreign key
- Update candidate key in B (to z) – same actions as with deletion:
  - NO ACTION: Reject if row(s) in A references row to be updated (default response)
  - SET NULL: Set value of foreign key to null
  - SET DEFAULT: Set value of foreign key to default
  - CASCADE: Propagate z to foreign key



Handling Foreign Key Violations (cont'd)

- The action taken to repair the violation of a foreign key constraint in A may cause a violation of a foreign key constraint in C
  - The action specified in C controls how that violation is handled;
  - If the entire chain of violations cannot be resolved, the initial deletion from B is rejected.



Specifying Actions

```
CREATE TABLE Teaching (
    ProfId      INTEGER,
    CrsCode CHAR (6),
    Semester CHAR (6),
    PRIMARY KEY (CrsCode, Semester),

    FOREIGN KEY (ProfId) REFERENCES Professor (Id)
        ON DELETE NO ACTION
        ON UPDATE CASCADE,

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

Triggers

- A more general mechanism for handling events
  - Not in SQL-92, but is in SQL:1999
- Trigger is a schema element (like table, assertion, …)

```
CREATE TRIGGER CrsChange
    AFTER UPDATE OF CrsCode, Semester ON Transcript
    WHEN  (Grade IS NOT NULL)
        ROLLBACK
```

Guard

Views

- Schema element
- Part of external schema
- A virtual table constructed from actual tables on the fly
  - Can be accessed in queries like any other table
  - Not materialized, constructed when accessed

Views - Examples

- Part of external schema suitable for use in Bursar's office:

```
CREATE VIEW CoursesTaken (StudId, CrsCode, Semester) AS
    SELECT  T.StudId, T.CrsCode, T.Semester
    FROM Transcript T
```

- Part of external schema suitable for student with Id 123456789:

```
CREATE VIEW CoursesITook (CrsCode, Semester, Grade) AS
    SELECT  T.CrsCode, T.Semester, T.Grade
     FROM  Transcript T
     WHERE  T.StudId = '123456789'
```

Modifying the Schema

```
ALTER TABLE Student
    ADD COLUMN  Gpa  INTEGER DEFAULT 0

ALTER TABLE Student
    ADD CONSTRAINT GpaRange
        CHECK (Gpa >= 0 AND Gpa <= 4)

ALTER TABLE  Transcript
    DROP CONSTRAINT Cons
     -- constraint names are useful

DROP TABLE  Employee

DROP ASSERTION  DontFireEveryone
```

Constraint Name Example

```
CREATE TABLE TRANSCRIPT  (
        StudID  INTEGER,
        CrsCode         CHAR(6),
        Semester        CHAR(6),
        Grade           GRADES,
        CONSTRAINT TRKEY PK (Sid, C, Sem)
        CONSTRAINT STUDFK FK (Sid) REFERENCES STUDENT,
        CONSTRAINT CRSFK FK (C) REFERENCES COURSE,
        CONSTRAINT IDRANGE CHECK ( Sid > 0 AND Sid < 100000) )

ALTER TABLE TRANSCRIPT DROP CONSTRAINT STUDFK
```

Access Control

- Databases might contain sensitive information
- Access has to be limited:
  - Users have to be identified – **authentication**
    - Generally done with passwords
  - Each user must be limited to **modes of access** appropriate to that user - authorization
- SQL:92 provides tools for specifying an authorization policy but does not support authentication (vendor specific)

Controlling Authorization in SQL

GRANT ***access_list***
ON ***table***
TO ***user_list*** ***[WITH GRANT OPTION]***

Access modes: SELECT, INSERT, DELETE, UPDATE, REFERENCES

GRANT UPDATE (*Grade*) ON Transcript TO prof_smith
- **Only the *Grade* column can be updated by prof_smith**

GRANT SELECT ON Transcript TO joe
- **Individual columns cannot be specified for SELECT access (in the SQL standard) – all columns of Transcript can be read**
- ***But* SELECT access control to individual columns can be *simulated* through views (next)**

Controlling Authorization in SQL Using Views

- GRANT SELECT ON CoursesTaken TO joe

GRANT *access*
ON *view*
TO *user_list*

- Thus views can be used to simulate access control to individual columns of a table

Authorization Mode REFERENCES

- Foreign key constraint enforces relationship between tables that can be exploited to
  - Control access: can enable perpetrator prevent deletion of rows

```
GRANT REFERENCES
      ON Student
      TO Joe
```

```
CREATE TABLE DontDismissMe (
   Id INTEGER,
   FOREIGN KEY (Id) REFERENCES Student
        ON DELETE NO ACTION )
```

  - Reveal information: successful insertion into DontDissmissMe means a row with foreign key value exists in Student

```
INSERT INTO DontDismissMe ('111111111')
```