

The Relational Model (Part III)

Annoucement

- **TA-student assignment**

- Aughdon Breslin: Students' last name in [Anerine, Crabtree]
- Sebastian Churion: Students' last name in [Cruz, Hurtado]
- Alexander Rubino: Students' last name in [Jang, Parekh]
- Dennis Salmanowitz: Students' last name in [Park, So]
- Grace Mattern: Students' last name in [Taveras, Zickert]

Integrity Constraints

- Integrity constraints (ICs): conditions specified on a database schema
- Legal instances: instances that satisfy ICs
- Types of ICs
 - Keys
 - Foreign keys
 - Domain constraints: (e.g., the age of driver license holders must be at least 18)

Referential Integrity Constraint

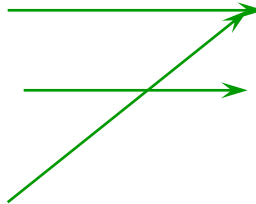
- Constraint: any enrolled student must be a student first.
- Referential integrity: for each student in Enrolled table, it must have a corresponding record (with the same sid) in the Students table.

Enrolled

<u>sid</u>	<u>cid</u>	grade
10311	CS115	A
10312	CS284	B
10311	CS284	A

Students

<u>Sid</u>	Name	Year	GPA
10311	Alice	Junior	3.4
10312	Bob	Junior	3
10550	Cathy	Freshman	3



Enforcing Referential Integrity

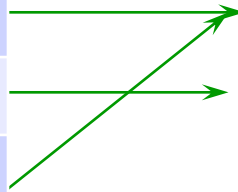
- What should be done if an Enrolled tuple with a non-existent student id is inserted?
 - Reject it!*

Enrolled

<u>sid</u>	<u>cid</u>	grade
10311	CS115	A
10312	CS284	B
10311	CS284	A
10720	CS442	A

Students

Sid	Name	Year	GPA
10311	Alice	Junior	3.4
10312	Bob	Junior	3
10550	Cathy	Freshman	3

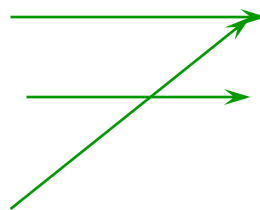


Enforcing Referential Integrity (cont.)

- What should be done if deleting Alice's record (Sid=10311) from *Students* table?
 - Option 1: Also delete all Enrolled tuples that refer to it.
 - Option 2: Disallow deletion of a Students tuple that is referred to.
 - Option 3: Set sid in Enrolled tuples that refer to it to a *default sid*.
 - Option 4: Set sid in Enrolled tuples that refer to it to a special value *null*, denoting '*unknown*' or '*inapplicable*'.
- Similar if the primary key of Students tuple is updated.

<u>sid</u>	<u>cid</u>	grade
10311	CS115	A
10312	CS284	B
10311	CS284	A

Enrolled



<u>Sid</u>	Name	Year	GPA
10311	Alice	Junior	3.4
10312	Bob	Junior	3
10550	Cathy	Freshman	3

Students

Foreign Keys

- A foreign key (FK) of relation R is a set of attributes that is a key of relation S (S is different from R)
- FK enforces the referential integrity that some attributes in R must refer to the key of S

Enrolled

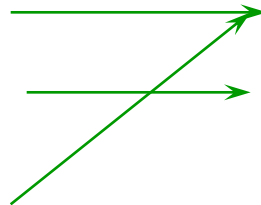
<u>sid</u>	<u>cid</u>	grade
10311	CS115	A
10312	CS284	B
10311	CS284	A

Key: (sid, cid)

Students

<u>Sid</u>	Name	Year	GPA
10311	Alice	Junior	3.4
10312	Bob	Junior	3
10550	Cathy	Freshman	3

Key: (sid)



Enrolled.sid is a foreign key referenced Students.sid

Define Foreign Keys in SQL

```
CREATE TABLE table_name (  
    <field1> <domain>,  
    <field2> <domain>,  
    ...  
    PRIMARY KEY (PK_field1, PK_field2,...),  
    UNIQUE (CK_field1,CK_field2,...),  
    FOREIGN KEY (FK1_field1, FK1_field2,...) REFERENCES Table1 (field1, field2,...),  
    FOREIGN KEY (FK2_field1, FK2_field2,...) REFERENCES Table2 (field1, field2,...),  
    ...  
)
```

Notes:

- Referenced attributes in **REFERENCES** statement must be declared as either PRIMARY KEY or UNIQUE in the referenced table.
- There can be multiple foreign keys, each refer to a different table.
- Reference attributes can be omitted if they have the same names as foreign keys.
- Unlike a primary key, a foreign key need not be unique (i.e., a foreign key is not necessarily a key).

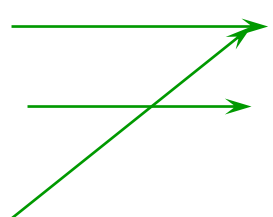
Example: Define Foreign Keys in SQL

Enrolled

<u>sid</u>	<u>cid</u>	grade
10311	CS115	A
10312	CS284	B
10311	CS284	A

Students

<u>Sid</u>	Name	Year	GPA
10311	Alice	Junior	3.4
10312	Bob	Junior	3
10550	Cathy	Freshman	3



- Define Enrolled.sid as a foreign key

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

Note:

Both FOREIGN KEY (sid) REFERENCES Students (sid) and FOREIGN KEY (sid) REFERENCES Students are correct.

Enforce Reference Integrity with Database Updates

- **Let the system do it automatically for you, by setting up the reference options for DELETE/UPDATE!**

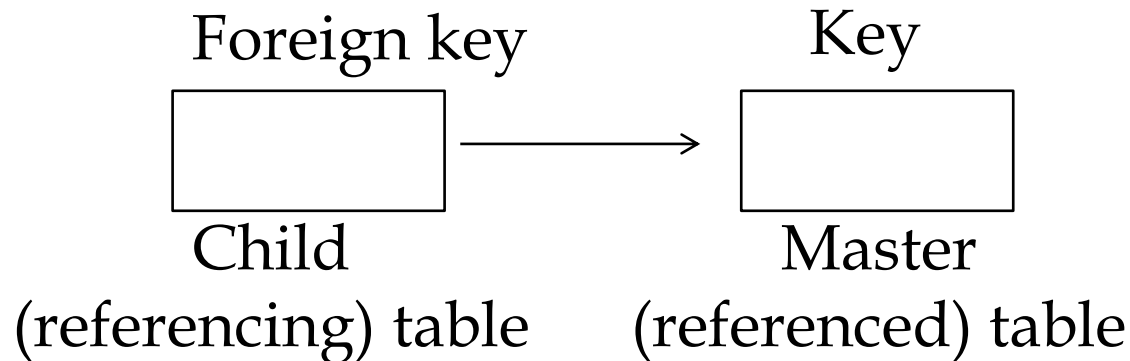
```
CREATE TABLE <name> (
```

```
.....
```

```
FOREIGN KEY (FK_field1, FK_field2,...) REFERENCES Table1 (field1,  
field2,...) [ON DELETE ref_option] [ON UPDATE ref_option]  
);
```

- **Four reference-options (ref_option)**
 - CASCADE
 - NO ACTION
 - SET NULL
 - SET DEFAULT

Reference Option 1: CASCADE



- **CASCADE:** Whenever rows in the master (referenced) table are deleted/updated, the respective rows of the child (referencing) table with a matching foreign key column will be deleted/updated automatically.
- **In SQL:**
ON DELETE CASCADE
ON UPDATE CASCADE

Delete/update Cascade

- In a delete cascade, any record that has references to the deleted item is also deleted automatically.
- In an update cascade, when the updated record results in a violation of referential integrity, the system will update the records in the referenced tables automatically.

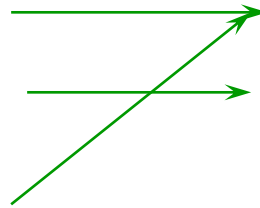
Example 1

Enrolled

<u>sid</u>	<u>cid</u>	grade
10311	CS115	A
10312	CS284	B
10311	CS284	A

Students

<u>Sid</u>	Name	Year	GPA
10311	Alice	Junior	3.4
10312	Bob	Junior	3
10550	Cathy	Freshman	3



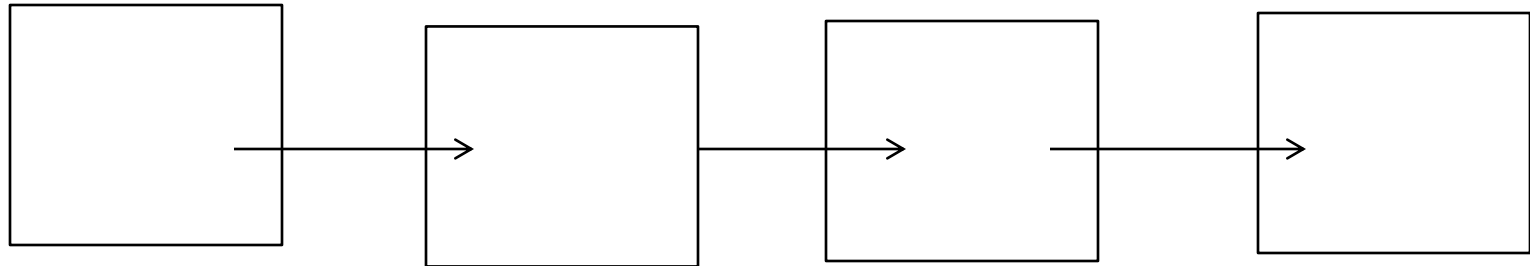
- Deleting a Students record will lead to automatic deleting all Enrolled tuples that refer to it.

```
CREATE TABLE Enrolled
(sid CHAR(20),
 cid CHAR(20),
 grade FLOAT,
 PRIMARY KEY (sid,cid),
 FOREIGN KEY (sid) REFERENCES Students ON DELETE CASCADE);
```

If DBA doesn't specify ON DELETE CASCADE, he/she has to delete records in Enrolled table manually

A Chain of Cascading Actions

- If there is a chain of foreign-key dependencies across multiple relations, with on delete cascade specified for each dependency, a deletion or update at one end of the chain can propagate across the entire chain.



A Chain of Cascade Actions: Example



Order

<u>OrderID</u>	<u>EmployeeID</u>	<u>CustID</u>	OrderDate
1	100	C1	29/03/2009
2	101	C2	16/04/2009

Order-Products

<u>OrderID</u>	ProductID	Qty
1	A1	1
2	A2	15
3	A3	23
4	A1	12

Product

<u>ProductID</u>	ProductName
A1	Football
A2	Tennis Ball
A3	Golf Clubs

- Order table has a foreign key as OrderID (reference to Order-Products table)
- Order-Products table has a foreign key as ProductID with the reference to Product table
- Assume we configure ON DELETE CASCADE on all foreign keys of Order and Order-Products tables.

Question 1: which table(s) will be updated automatically if the product A1 is removed from Product Table?

- Note: the Order-Products table contains one single record for OrderID=1

A Chain of Cascade Actions: Example



Order

<u>OrderID</u>	<u>EmployeeID</u>	<u>CustID</u>	OrderDate
1	100	C1	29/03/2009
2	101	C2	16/04/2009

Order-Products

<u>OrderID</u>	ProductID	Qty
1	A1	1
2	A2	15
3	A3	23
4	A1	12

Product

<u>ProductID</u>	ProductName
A1	Football
A2	Tennis Ball
A3	Golf Clubs



Question 2: If ON DELETE CASCADE is configured on the foreign key of Order table but not on Order-Products table, which table(s) will be updated automatically if the product A1 is removed from Product Table?

A Chain of Cascade Actions: Example



Order

<u>OrderID</u>	<u>EmployeeID</u>	<u>CustID</u>	OrderDate
1	100	C1	29/03/2009
2	101	C2	16/04/2009

Order-Products

<u>OrderID</u>	ProductID	Qty
1	A1	1
2	A2	15
3	A3	23
4	A1	12

Product

<u>ProductID</u>	ProductName
A1	Football
A2	Tennis Ball
A3	Golf Clubs



Question 3: If ON DELETE CASCADE is only configured on the foreign key of Order-Products table, which table(s) will be updated automatically if the product A1 is removed from Product Table?

A Chain of Cascade Actions: Example



Order

<u>OrderID</u>	<u>EmployeeID</u>	<u>CustID</u>	OrderDate
1	100	C1	29/03/2009
2	101	C2	16/04/2009

Order-Products

OrderID	ProductID	Qty
1	A1	1
2	A2	15
3	A3	23
1	A2	12

Product

<u>ProductID</u>	ProductName
A1	Football
A2	Tennis Ball
A3	Golf Clubs

Question 4: Now if the Order-Products table can contain multiple records for the same order (e.g., for OrderID=1), which table(s) will be updated if the product A1 is removed from Product Table?

Tips:

- What is the key of Order-Products table now?
- What is the foreign key of Order table now?

Reference Option 2: NO ACTION

- **NO ACTION (or RESTRICT):**
 - An error is raised;
 - The SQL statement is rolled back
- **In SQL:** ON DELETE NO ACTION
ON UPDATE NO ACTION

Reference Option 3: SET NULL

- **SET NULL**
 - The foreign key values in the referencing row are set to NULL when the referenced row is updated or deleted.
 - Can be specified only if some column of the foreign key allows null values.
- **In SQL:** ON DELETE SET NULL
 ON UPDATE SET NULL

Reference Option 4: SET DEFAULT

- **SET DEFAULT**
 - The foreign key values in the referencing row are set to default value when the referenced row is updated or deleted.
- **In SQL:** ON DELETE SET DEFAULT
 ON UPDATE SET DEFAULT

Choosing a Policy

- Different policies can be chosen independently for deletions and updates.
 - Example:
ON DELETE CASCADE
ON UPDATE NO ACTION
- If there is no policy specified, the default (reject) is used.

DBMS Products and Their Supports for Referential Integrity

Product	CASCADE	NO ACTION	SET NULL	SET DEFAULT
SQL server	Y	Y	N	N
Oracle	Y	Y	Y	N
MySQL	Y	Y	Y	Y
MS Access	Y	Y	N	N