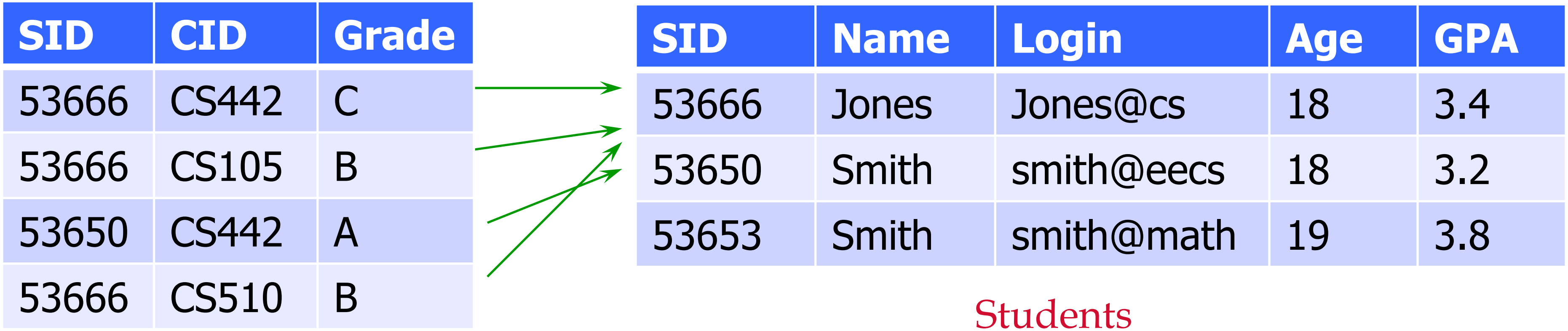
The Relational Model (Part III)

Integrity Constraints

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

Foreign Keys

- **A foreign key is an attribute in one relation, each of whose values can be linked to a value in the primary key attribute of another relation.**



SID	CID	Grade
53666	CS442	C
53666	CS105	B
53650	CS442	A
53666	CS510	B

Enrolled

SID	Name	Login	Age	GPA
53666	Jones	Jones@cs	18	3.4
53650	Smith	smith@eecs	18	3.2
53653	Smith	smith@math	19	3.8

Students

Referential Integrity

- **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.)

Exercise

Complete Player table

PlayerID	Name
2	Jimmy
7	Sue
11	Bobby

- **Is there a violation of referential integrity with this data? On which record(s)? How to fix the violation?**

Complete Penalty table

PenaltyNum	Type	Date	Time	PlayerID
1	Yellow	9/14/2006	5:15pm	2
2	Yellow	9/20/2006	5:05pm	3
3	Red	10/5/2006	5:45pm	7

How to Fix Violation of Referential Integrity?

In standard SQL:

```
ALTER TABLE <Table_Name> ADD FOREIGN KEY
(keyfield1, keyfield2,…) REFERENCES table1
[ON DELETE reference_option]
[ON UPDATE reference_option];
```

Reference Options for DELETE/UPDATE

ALTER TABLE <Table_Name> ADD FOREIGN KEY (keyfield1, keyfield2,…) REFERENCES ***table1***

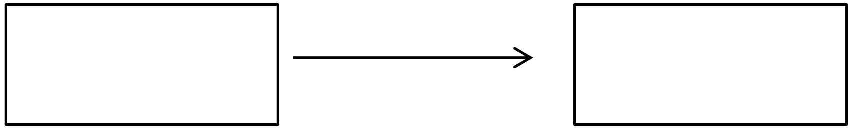
[ON DELETE ***reference_option***]

[ON UPDATE ***reference_option***];

- **Four reference-options**
  - CASCADE
  - NO ACTION
  - SET NULL
  - SET DEFAULT

Reference Option 1: CASCADE

- CASCADE: Whenever rows in the master (referenced) table are deleted, the respective rows of the child (referencing) table with a matching foreign key column will be deleted as well.



Foreign key

Key

Child
(referencing) table

Master
(referenced) table

- 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.

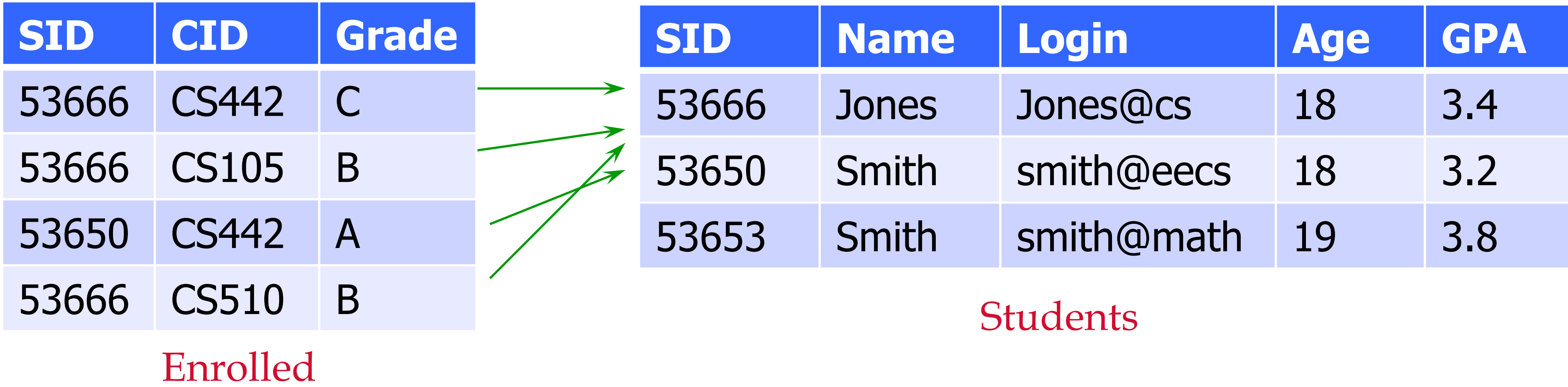
- In an update cascade, when the updated record results in a violation of referential integrity, the system will update the records in the referenced tables.

Example 1

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

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

Delete Cascade Example



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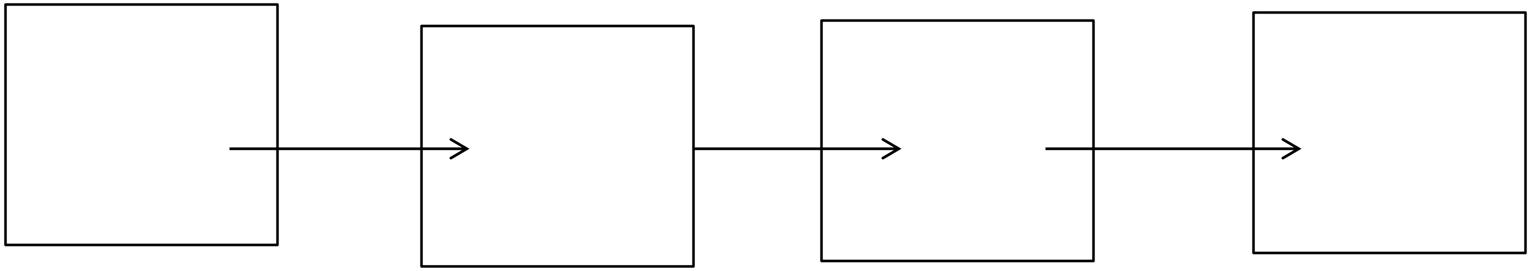
Students

- When delete a *student* tuple, the delete "cascades" to the *Enrolled* relation = delete all enrollment record of that student.

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

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-Products

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

Employee

EmployeeID	Employee Name
100	John Smith
101	Mia Lee

Customer

CustID	Cust Name
C1	Gianni Albin
C2	Martin Jones

Product

ProductID	ProductName
A1	Football
A2	Tennis Ball
A3	Golf Clubs

Order

OrderID	EmployeeID	CustID	OrderDate	Deliver_by	Comments
1	100	C1	29/03/2009	29/04/2009	Ring the bell
2	101	C2	16/04/2009	17/04/2009	N/A

- Order table has the foreign keys as OrderID (reference to Order-Products table), EmployeeID (reference to Employeed table), CustID (reference to Customer table)
- Order-Products table has the foreign key as ProductID with the reference to Product table
- Assume we configure ON DELETE CASCADE on Order and Order-Products tables.

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

A Chain of Cascade Actions: Example

Order-Products

OrderID	ProductID	Qty
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- Order-Products table has the foreign key as ProductID with the reference to Product table
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Question 2: If ON DELETE CASCADE is only configured on Order table, which table(s) will be updated if the product A1 is removed from Product Table?

A Chain of Cascade Actions: Example

Order-Products

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1	A2	15
1	A3	23
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- Order table has the foreign keys as OrderID (reference to Order-Products table), EmployeeID (reference to Employeed table), CustID (reference to Customer table)
- Order-Products table has the foreign key as ProductID with the reference to Product table
- Assume we configure ON DELETE CASCADE on Order and Order-Products tables.

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

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

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

Today’s lecture

- **Continue with integrity constraints**
  - Domain constraints
  - Foreign keys

Domain Constraints

- Domain constraints: test whether the values inserted in the database satisfy the specified constraints.

- Use *check* clause to ensure that an hourly-wage domain allows only values greater than a specified value.

  E.g.**CREATE DOMAIN** *hourly-wage* **FLOAT(5,2)**
  CONSTRINT *value-test* **CHECK** *(value* > = 4.00);

  The created domain *hourly-wage* can be used in CREATE TABLE statement

  CREATE TABLE employee (wage hourly-wage, …);

Domain Constraints (Cont.)

- Can have complex conditions in domain check
  - Example 1:

```
CREATE DOMAIN AccountType char(10)
    CONSTRAINT account-type-test
      CHECK (VALUE IN ( ‘Checking’, ‘Saving’ ))
```

  - Example 2:

```
CHECK (branch-name IN (SELECT branch-name
FROM branch))
```

(Note: CHECK clause can be used without CREATE DOMAIN clause)

More Examples of Domain Constraints

```
CREATE TABLE branch
  (bname char(15) not null,
   bcity char(30),
   assets integer,
   PRIMARY KEY (bname),
   CHECK (assets >= 0))
```

```
CREATE TABLE account
 (account# char(10) not null,
  bname char(15),
  balance integer,
  PRIMARY KEY(account#)
  FOREIGN KEY (bname),
       REFERENCES branch,
   CHECK (balance >= 0))
```

Relational Model: Summary

- **A tabular representation of data (rows, columns, cells)**
- **Simple and intuitive, currently the most widely used**
- **Integrity constraints can be specified by the DBA, based on application semantics. DBMS checks for violations.**
  - Three important ICs:
    - domain constraints,
    - keys
    - foreign keys