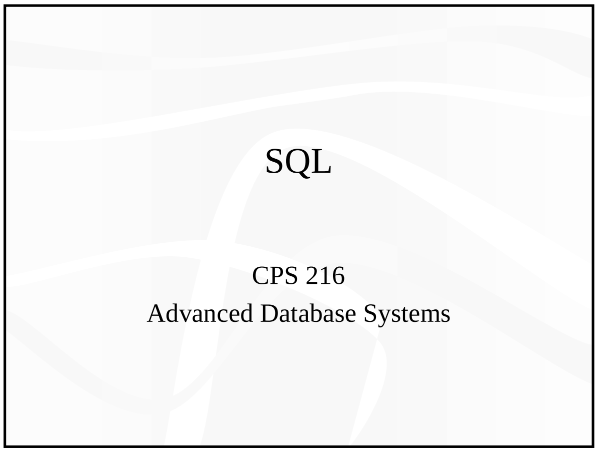
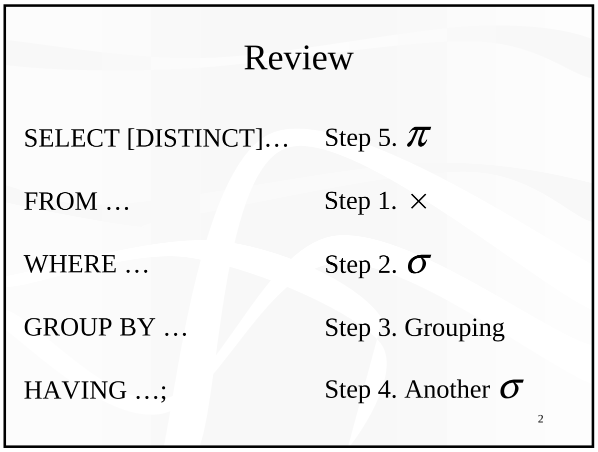


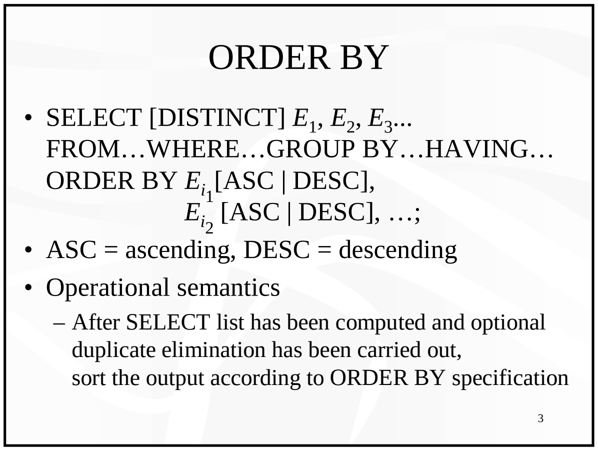
SQL

CPS 216
Advanced Database Systems



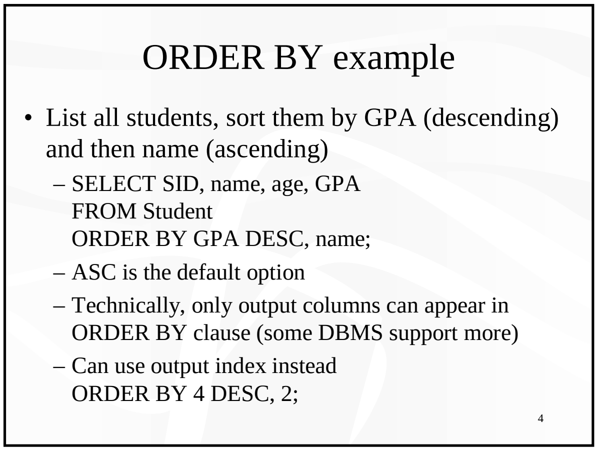
Review

SELECT [DISTINCT]…	Step 5. π
FROM …	Step 1. ×
WHERE …	Step 2. σ
GROUP BY …	Step 3. Grouping
HAVING …;	Step 4. Another σ



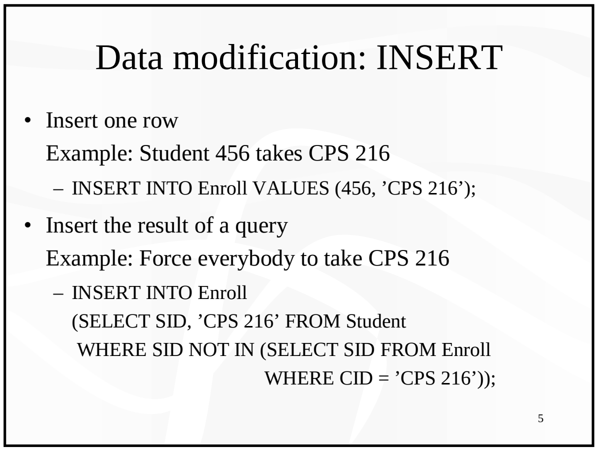
ORDER BY

- SELECT [DISTINCT] E_1, E_2, E_3...
  FROM…WHERE…GROUP BY…HAVING…
  ORDER BY E_{i_1}[ASC | DESC],
  E_{i_2} [ASC | DESC], …;
- ASC = ascending, DESC = descending
- Operational semantics
  - After SELECT list has been computed and optional duplicate elimination has been carried out, sort the output according to ORDER BY specification



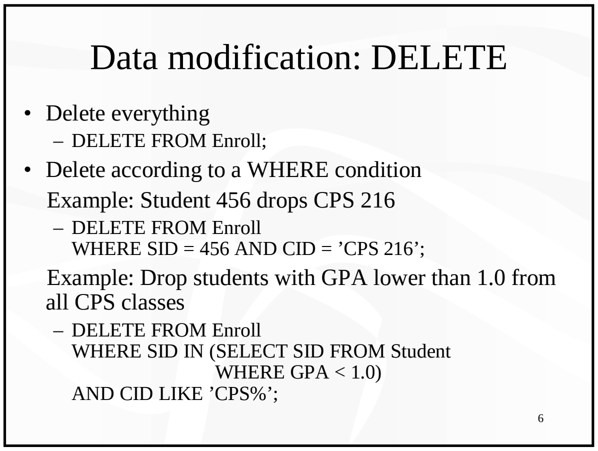
ORDER BY example

- List all students, sort them by GPA (descending) and then name (ascending)
  - SELECT SID, name, age, GPA
    FROM Student
    ORDER BY GPA DESC, name;
  - ASC is the default option
  - Technically, only output columns can appear in ORDER BY clause (some DBMS support more)
  - Can use output index instead
    ORDER BY 4 DESC, 2;



Data modification: INSERT

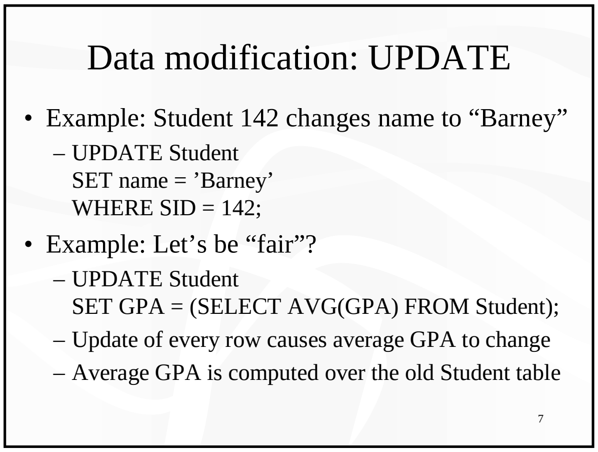
- Insert one row
  Example: Student 456 takes CPS 216
  - INSERT INTO Enroll VALUES (456, ’CPS 216’);
- Insert the result of a query
  Example: Force everybody to take CPS 216
  - INSERT INTO Enroll
    (SELECT SID, ’CPS 216’ FROM Student
     WHERE SID NOT IN (SELECT SID FROM Enroll
                       WHERE CID = ’CPS 216’));



Data modification: DELETE

- Delete everything
  - DELETE FROM Enroll;
- Delete according to a WHERE condition
  Example: Student 456 drops CPS 216
  - DELETE FROM Enroll
    WHERE SID = 456 AND CID = ’CPS 216’;

  Example: Drop students with GPA lower than 1.0 from all CPS classes
  - DELETE FROM Enroll
    WHERE SID IN (SELECT SID FROM Student
                  WHERE GPA < 1.0)
    AND CID LIKE ’CPS%’;

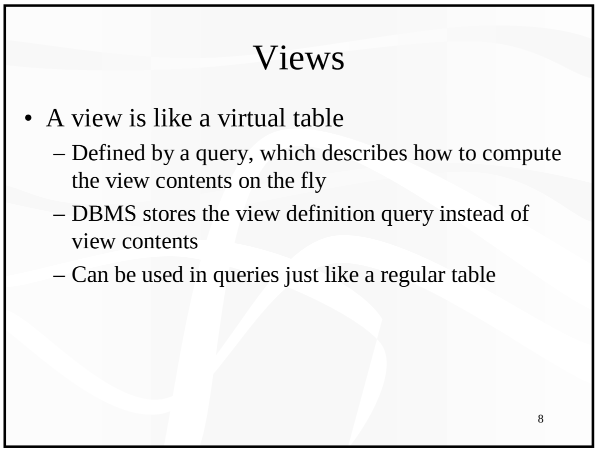


Data modification: UPDATE

- Example: Student 142 changes name to “Barney”

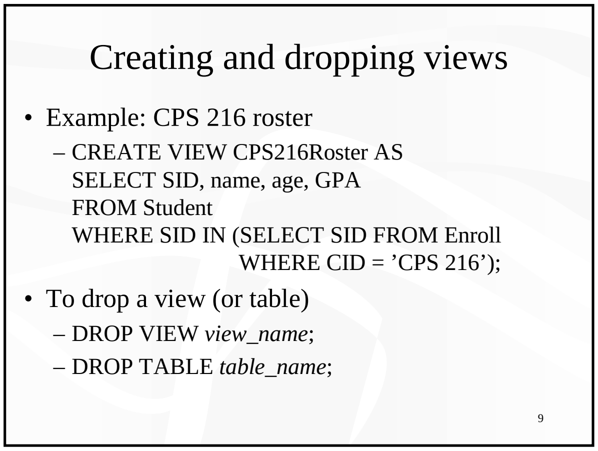
  -
    ```
    UPDATE Student
    SET name = ’Barney’
    WHERE SID = 142;
    ```
- Example: Let’s be “fair”?

  -
    ```
    UPDATE Student
    SET GPA = (SELECT AVG(GPA) FROM Student);
    ```
  - Update of every row causes average GPA to change
  - Average GPA is computed over the old Student table



Views

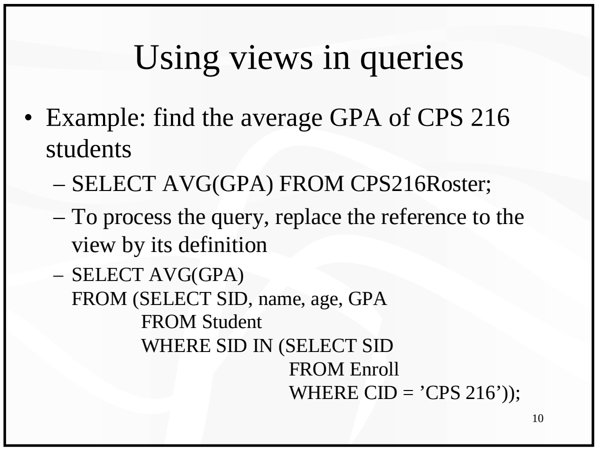
- A view is like a virtual table
  - Defined by a query, which describes how to compute the view contents on the fly
  - DBMS stores the view definition query instead of view contents
  - Can be used in queries just like a regular table



Creating and dropping views

- Example: CPS 216 roster

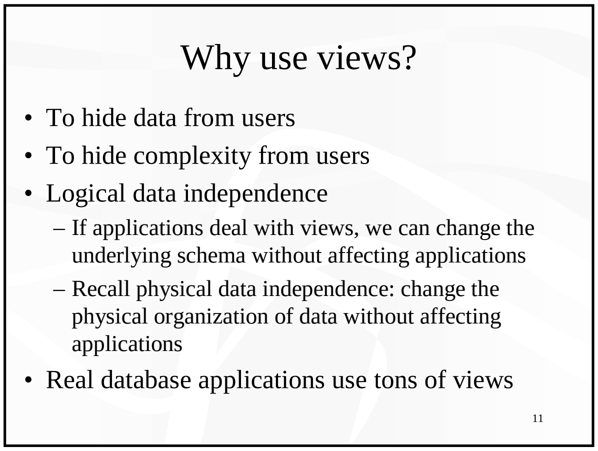
  -
    ```
    CREATE VIEW CPS216Roster AS
    SELECT SID, name, age, GPA
    FROM Student
    WHERE SID IN (SELECT SID FROM Enroll
                  WHERE CID = ’CPS 216’);
    ```
- To drop a view (or table)
  - DROP VIEW *view_name*;
  - DROP TABLE *table_name*;



Using views in queries

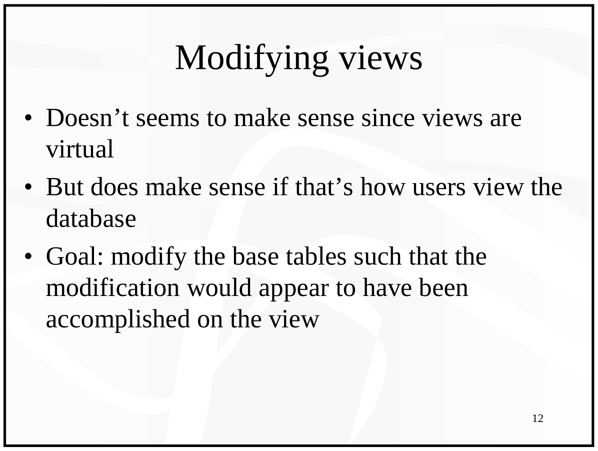
- Example: find the average GPA of CPS 216 students
  - SELECT AVG(GPA) FROM CPS216Roster;
  - To process the query, replace the reference to the view by its definition

  -
    ```
    SELECT AVG(GPA)
    FROM (SELECT SID, name, age, GPA
          FROM Student
          WHERE SID IN (SELECT SID
                        FROM Enroll
                        WHERE CID = ’CPS 216’));
    ```



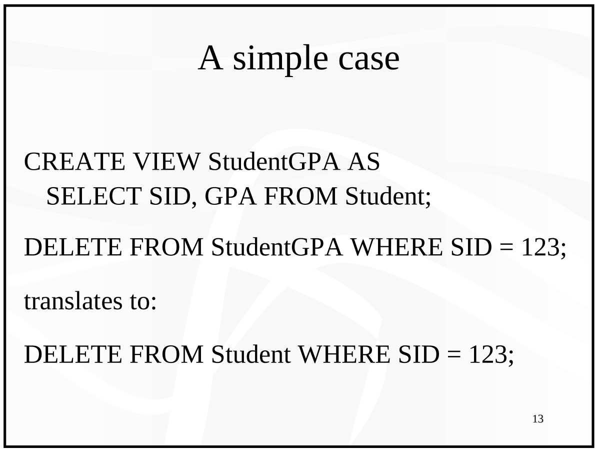
Why use views?

- To hide data from users
- To hide complexity from users
- Logical data independence
  - If applications deal with views, we can change the underlying schema without affecting applications
  - Recall physical data independence: change the physical organization of data without affecting applications
- Real database applications use tons of views



Modifying views

- Doesn’t seems to make sense since views are virtual
- But does make sense if that’s how users view the database
- Goal: modify the base tables such that the modification would appear to have been accomplished on the view



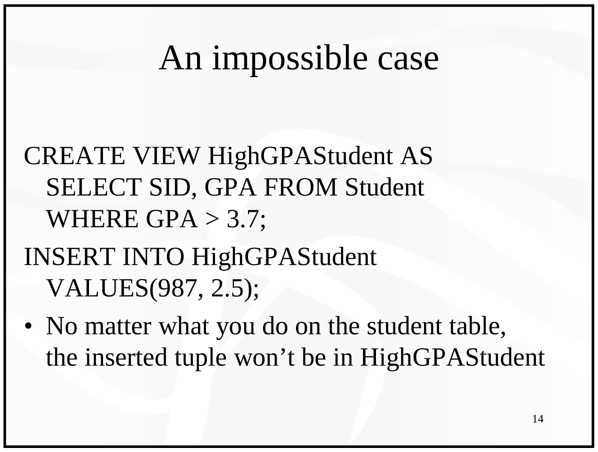
A simple case

```
CREATE VIEW StudentGPA AS
   SELECT SID, GPA FROM Student;
```

```
DELETE FROM StudentGPA WHERE SID = 123;
```

translates to:

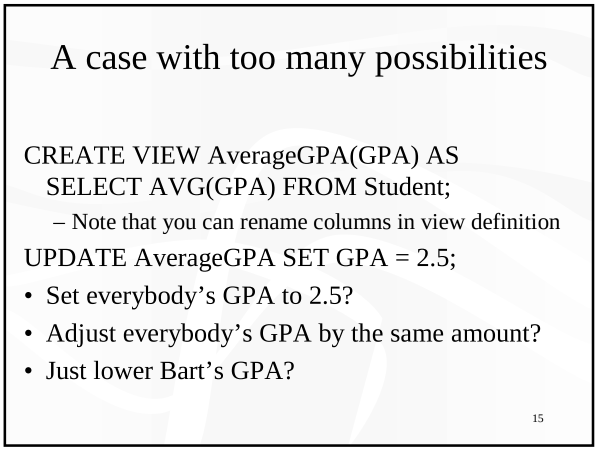
```
DELETE FROM Student WHERE SID = 123;
```



An impossible case

```
CREATE VIEW HighGPAStudent AS
   SELECT SID, GPA FROM Student
   WHERE GPA > 3.7;
INSERT INTO HighGPAStudent
   VALUES(987, 2.5);
```

- No matter what you do on the student table, the inserted tuple won’t be in HighGPAStudent



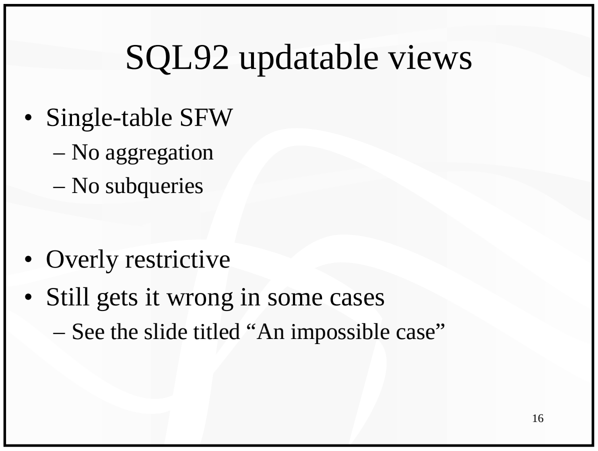
A case with too many possibilities

```
CREATE VIEW AverageGPA(GPA) AS
   SELECT AVG(GPA) FROM Student;
```

  – Note that you can rename columns in view definition

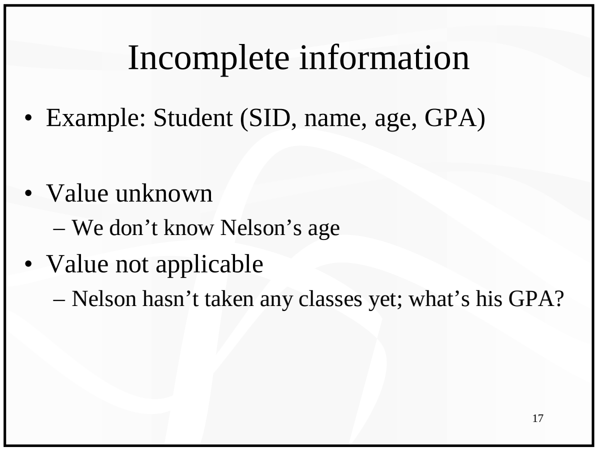
```
UPDATE AverageGPA SET GPA = 2.5;
```

- Set everybody’s GPA to 2.5?
- Adjust everybody’s GPA by the same amount?
- Just lower Bart’s GPA?



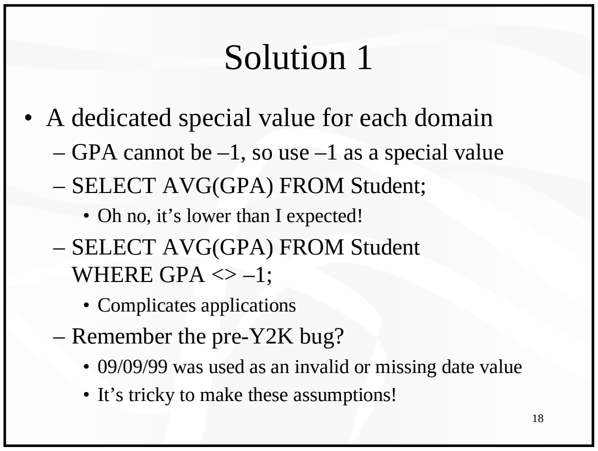
SQL92 updatable views

- Single-table SFW
  - No aggregation
  - No subqueries
- Overly restrictive
- Still gets it wrong in some cases
  - See the slide titled “An impossible case”



Incomplete information

- Example: Student (SID, name, age, GPA)
- Value unknown
  - We don’t know Nelson’s age
- Value not applicable
  - Nelson hasn’t taken any classes yet; what’s his GPA?



Solution 1

- A dedicated special value for each domain
  - GPA cannot be –1, so use –1 as a special value
  - SELECT AVG(GPA) FROM Student;
    - Oh no, it’s lower than I expected!
  - SELECT AVG(GPA) FROM Student WHERE GPA <> –1;
    - Complicates applications
  - Remember the pre-Y2K bug?
    - 09/09/99 was used as an invalid or missing date value
    - It’s tricky to make these assumptions!

Solution 2

- A valid-bit column for every real column
  - Student (SID, name, name_is_valid,
age, age_is_valid,
GPA, GPA_is_valid)
  - Too much overhead
  - SELECT AVG(GPA) FROM Student WHERE GPA_valid;
    - Still complicates applications

SQL's solution

- A special value NULL
  - Same for every domain
  - Special rules for dealing with NULLs
- Example: Student (SID, name, age, GPA)
  - <789, 'Nelson', NULL, NULL>

Computing with NULLs

- When we operate on a NULL and another value (including another NULL) using +, –, etc., the result is NULL
- Aggregate functions ignore NULL, except COUNT(*)

Three-valued logic

- TRUE = 1, FALSE = 0, UNKNOWN = 0.5
- *x* AND *y* = min(*x*, *y*)
x OR *y* = max(*x*, *y*)
NOT(*x*) = 1 – *x*
- When we compare a NULL with another value (including another NULL) using =, >, etc., the result is UNKNOWN
- WHERE and HAVING clauses only select tuples if the condition evaluates to TRUE
  - UNKNOWN is insufficient

Unfortunate consequences

- select avg(GPA) from Student;
select sum(GPA) / count(*) from Student;
  - Not equivalent
  - avg(GPA) = sum(GPA) / count(GPA) still holds
- select * from Student;
select * from Student
where GPA > 3.0 or GPA <= 3.0;
  - Not equivalent
- Be careful: NULL breaks many equivalences

Another problem

- Example: Who has NULL GPA values?
  - select * from Student where GPA = NULL;
    - Won't work; never returns anything!
  - (select * from Student) except all
(select * from Student where GPA = 0 OR GPA<>0);
    - Ugly!
  - New built-in predicates IS NULL and IS NOT NULL
select * from Student where GPA is null;

Recap

- Covered
  - ORDER BY
  - Data modification statements
  - Views
  - NULLs
- Skipped
  - Outerjoin
  - Alternative join syntax
  - Schema modification statements
- Next
  - Constraints

Constraints

- Restrictions on allowable data in a database
  - In addition to the simple structure and type restrictions imposed by the table definitions
  - Declared as part of the schema
  - Enforced by the DBMS
- Why use constraints?
  - Protect data integrity (catch errors)
  - Tell the DBMS about the data (so it can optimize better)

Types of constraints

- NOT NULL
- Key
- Referential integrity
- General assertion
- Tuple- and attribute-based CHECKs

NOT NULL constraint example

- create table Student
```
    (SID integer not null,
     name varchar(30) not null,
     email varchar(30),
     age integer, GPA float);
```
- create table Course
```
    (CID char(10) not null,
     title varchar(100) not null);
```
- create table Enroll
```
    (SID integer not null, CID char(10) not null);
```

Key declaration

- At most one PRIMARY KEY per table
  - Typically implies a primary index
  - Rows are stored inside the index, typically sorted by primary key value
- Any number of UNIQUE keys per table
  - Typically implies a secondary index
  - Pointers to rows are stored inside the index

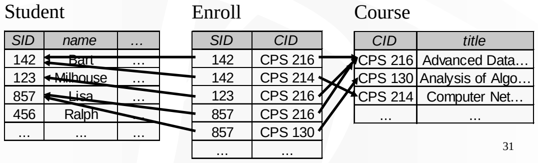
Key declaration examples

- create table Student
```
    (SID integer not null primary key,
     name varchar(30) not null,
     email varchar(30) unique,
     age integer, GPA float);
```
- create table Course
```
    (CID char(10) not null primary key,
     title varchar(100) not null);
```
- create table Enroll
```
    (SID integer not null, CID char(10) not null,
     primary key(SID, CID));
```

Works on Oracle
but not DB2:
DB2 requires UNIQUE
key columns
to be NOT NULL

Referential integrity example

- Enroll.SID references Student.SID
- Enroll.CID references Course.CID
- If an SID appears in Enroll, it must appear in Student
- If a CID appears in Enroll, it must appear in Course
- That is, no “dangling pointers”



Student

SID	*name*	*…*
142	Bart	…
123	Milhouse	…
857	Lisa	…
456	Ralph	…
...	...	...

Enroll

SID	*CID*
142	CPS 216
142	CPS 214
123	CPS 216
857	CPS 216
857	CPS 130
...	...

Course

CID	*title*
CPS 216	Advanced Data…
CPS 130	Analysis of Algo…
CPS 214	Computer Net…
...	...

Referential integrity in SQL

- Referenced column must be PRIMARY KEY
- Referencing column is called FOREIGN KEY
- Example declaration
  - create table Enroll

```
(SID integer not null references Student(SID),
 CID char(10) not null,
 primary key(SID, CID),
 foreign key CID references Course(CID));
```

Enforcing referential integrity

Example: Enroll.SID references Student.SID

- Insert or update a Enroll tuple so it refers to a non-existent SID
  - Reject
- Delete or update a Student tuple whose SID is referenced by some Enroll tuple
  - Reject
  - Cascade: ripple changes to all referring tuples
  - Set NULL: set all references to NULL
  - All three options can be specified in SQL

Deferred constraint checking

- No-chicken-no-egg problem
  - create table Dept

```
    (name char(20) not null primary key,
     chair char(30) not null references Prof(name));
create table Prof
    (name char(30) not null primary key,
     dept char(20) not null references Dept(name));
```

  - The first INSERT will always violate a constraint
- Deferred constraint checking is necessary
  - Check only at the end of a transaction
  - Allowed in SQL as an option

General assertion

- CREATE ASSERTION *assertion_name* CHECK *assertion_condition*;
- *assertion_condition* is checked for each modification that could potentially violate it
- Example: Enroll.SID references Student.SID

```
– CREATE ASSERTION EnrollStudentRefIntegrity
  CHECK (NOT EXISTS
             (SELECT * FROM Enroll
              WHERE SID NOT IN
                        (SELECT SID FROM Student)));
```

- SQL3, but not all (perhaps no) DBMS supports it

Tuple- and attribute-based CHECKs

- Associated with a single table
- Only checked when a tuple or an attribute is inserted or updated
- Example:

```
– CREATE TABLE Enroll
     (SID integer not null
          CHECK (SID IN (SELECT SID FROM Student)),
      CID …);
```

  - Is it a referential integrity constraint?
  - Not quite; not checked when Student is modified

Next time

Transactions!

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