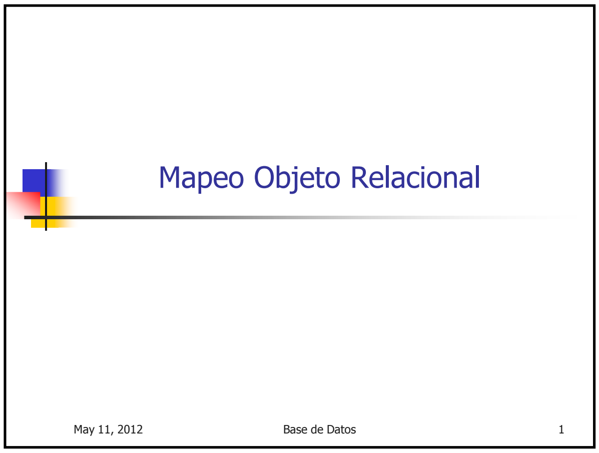
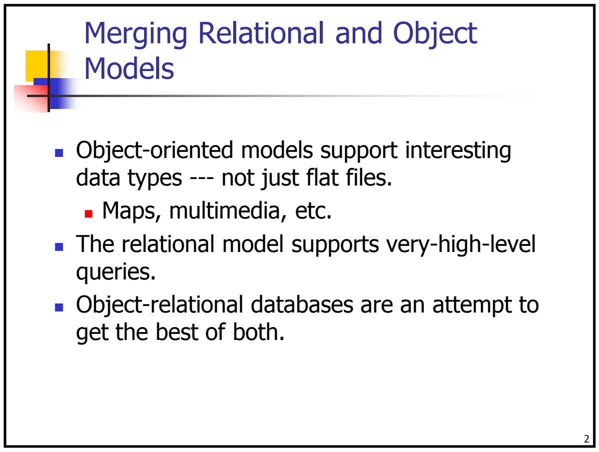
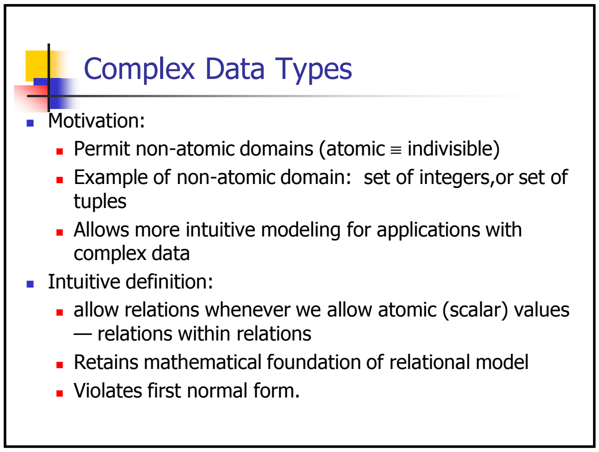


Mapeo Objeto Relacional



Merging Relational and Object Models

- Object-oriented models support interesting data types --- not just flat files.
  - Maps, multimedia, etc.
- The relational model supports very-high-level queries.
- Object-relational databases are an attempt to get the best of both.



Complex Data Types

- Motivation:
  - Permit non-atomic domains (atomic ≡ indivisible)
  - Example of non-atomic domain: set of integers,or set of tuples
  - Allows more intuitive modeling for applications with complex data
- Intuitive definition:
  - allow relations whenever we allow atomic (scalar) values — relations within relations
  - Retains mathematical foundation of relational model
  - Violates first normal form.

Example of a Nested Relation

- Example: library information system
- Each book has
  - title,
  - a list (array) of authors,
  - Publisher, with subfields *name* and *branch*, and
  - a set of keywords
- Non-1NF relation *books*

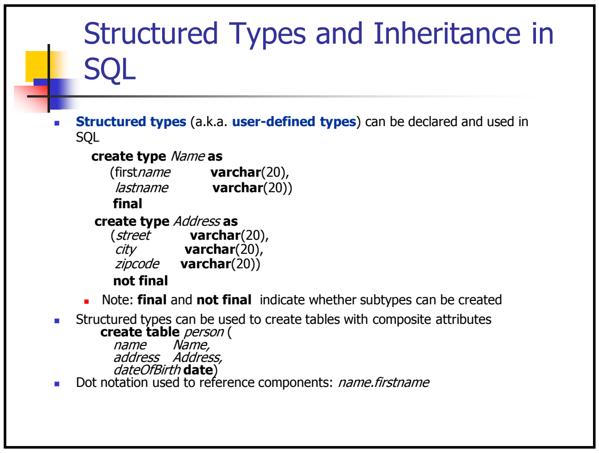
title	*author_array*	*publisher*	*keyword_set*
		(*name, branch*)	
Compilers	[Smith, Jones]	(McGraw-Hill, NewYork)	{parsing, analysis}
Networks	[Jones, Frick]	(Oxford, London)	{Internet, Web}

Complex Types and SQL

- Extensions introduced in SQL:1999 to support complex types:
  - Collection and large object types
    - Nested relations are an example of collection types
  - Structured types
    - Nested record structures like composite attributes
  - Inheritance
  - Object orientation
    - Including object identifiers and references
- Not fully implemented in any database system currently
  - But some features are present in each of the major commercial database systems
    - Read the manual of your database system to see what it supports

User Defined Types

- A *user-defined type*, or UDT, is essentially a class definition, with a structure and methods.
- Two uses:
  1. As a *rowtype*, that is, the type of a relation.
  2. As the type of an attribute of a relation.



Structured Types and Inheritance in SQL

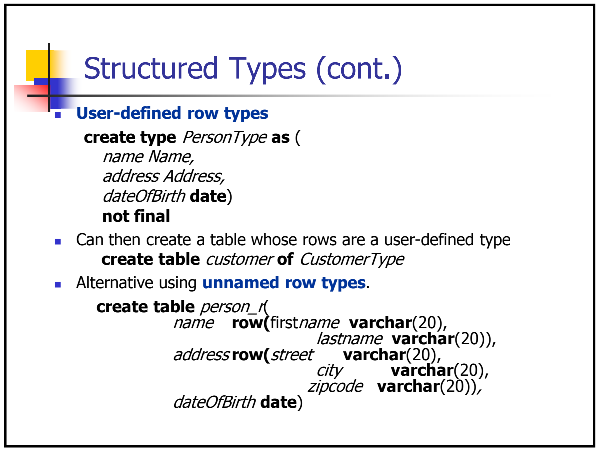
- **Structured types** (a.k.a. **user-defined types**) can be declared and used in SQL

```
create type Name as
   (firstname       varchar(20),
    lastname        varchar(20))
    final
create type Address as
   (street        varchar(20),
    city          varchar(20),
    zipcode     varchar(20))
    not final
```

  - Note: **final** and **not final** indicate whether subtypes can be created
- Structured types can be used to create tables with composite attributes

```
create table person (
   name       Name,
   address    Address,
   dateOfBirth date)
```

- Dot notation used to reference components: *name.firstname*



Structured Types (cont.)

- **User-defined row types**

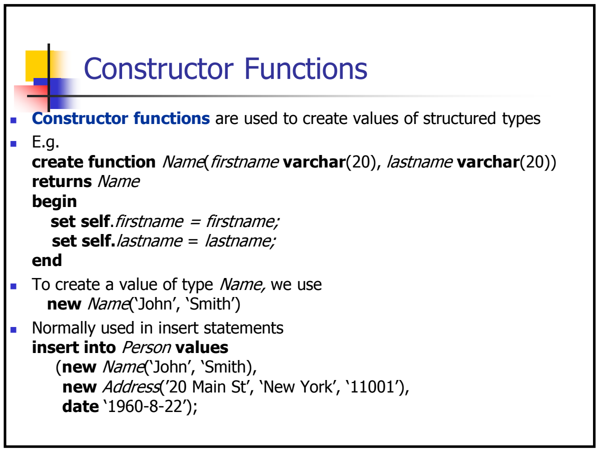
```
create type PersonType as (
   name Name,
   address Address,
   dateOfBirth date)
   not final
```

- Can then create a table whose rows are a user-defined type

```
create table customer of CustomerType
```

- Alternative using **unnamed row types**.

```
create table person_r(
        name     row(firstname  varchar(20),
                     lastname  varchar(20)),
        address row(street     varchar(20),
                     city          varchar(20),
                    zipcode   varchar(20)),
        dateOfBirth date)
```



Constructor Functions

- **Constructor functions** are used to create values of structured types
- E.g.

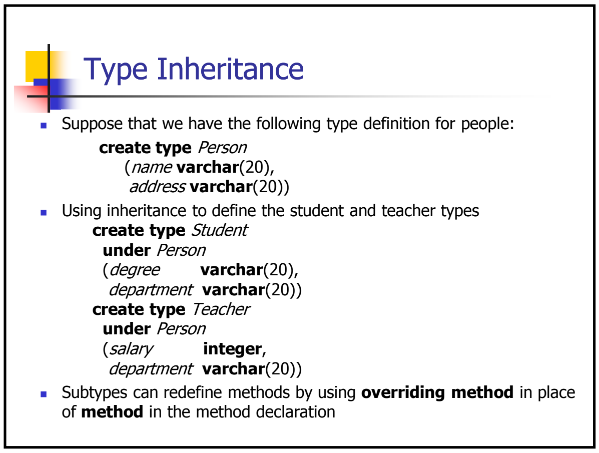
```
create function Name(firstname varchar(20), lastname varchar(20))
returns Name
begin
   set self.firstname = firstname;
   set self.lastname = lastname;
end
```

- To create a value of type *Name,* we use

```
new Name('John', 'Smith')
```

- Normally used in insert statements

```
insert into Person values
   (new Name('John', 'Smith),
    new Address('20 Main St', 'New York', '11001'),
    date '1960-8-22');
```



Type Inheritance

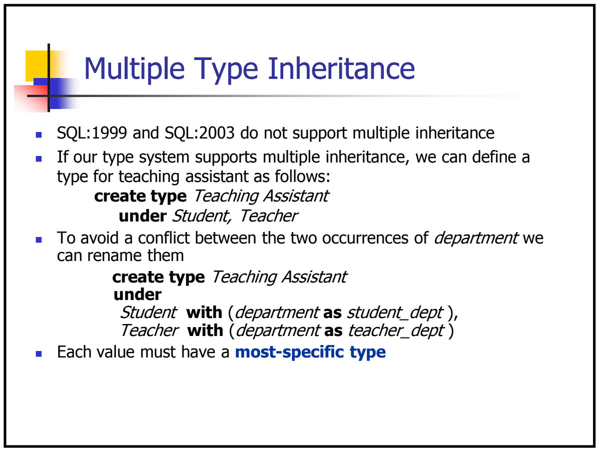
- Suppose that we have the following type definition for people:

```
create type Person
    (name varchar(20),
     address varchar(20))
```

- Using inheritance to define the student and teacher types

```
create type Student
  under Person
  (degree        varchar(20),
   department  varchar(20))
create type Teacher
  under Person
  (salary          integer,
   department  varchar(20))
```

- Subtypes can redefine methods by using **overriding method** in place of **method** in the method declaration



Multiple Type Inheritance

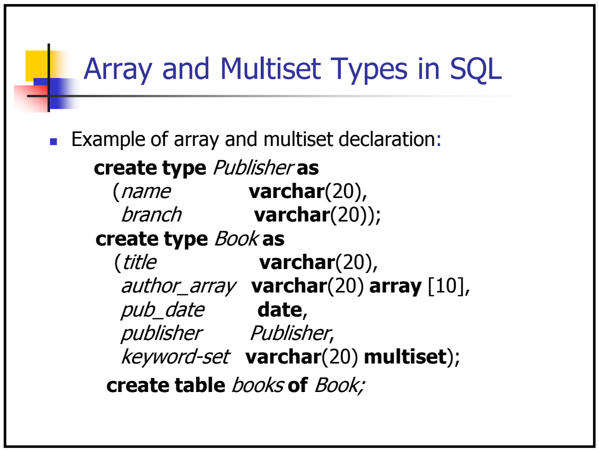
- SQL:1999 and SQL:2003 do not support multiple inheritance
- If our type system supports multiple inheritance, we can define a type for teaching assistant as follows:

```
create type Teaching Assistant
    under Student, Teacher
```

- To avoid a conflict between the two occurrences of *department* we can rename them

```
create type Teaching Assistant
under
  Student  with (department as student_dept ),
  Teacher  with (department as teacher_dept )
```

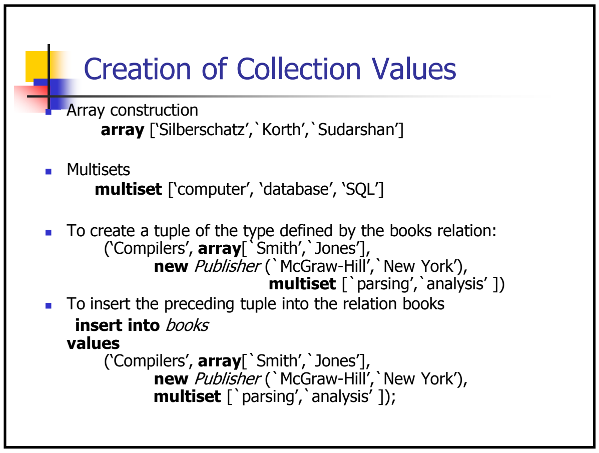
- Each value must have a **most-specific type**



Array and Multiset Types in SQL

- Example of array and multiset declaration:

```
create type Publisher as
   (name            varchar(20),
    branch          varchar(20));
create type Book as
   (title              varchar(20),
    author_array   varchar(20) array [10],
    pub_date        date,
    publisher        Publisher,
    keyword-set   varchar(20) multiset);
  create table books of Book;
```



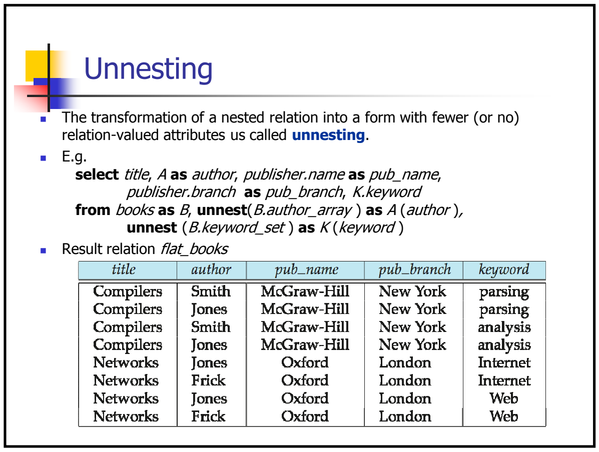
Creation of Collection Values

- Array construction
  array [‘Silberschatz’,`Korth’,`Sudarshan’]
- Multisets
  multiset [‘computer’, ‘database’, ‘SQL’]
- To create a tuple of the type defined by the books relation:

```
     (‘Compilers’, array[`Smith’,`Jones’],
           new Publisher (`McGraw-Hill’,`New York’),
                           multiset [`parsing’,`analysis’ ])
```

- To insert the preceding tuple into the relation books

```
 insert into books
values
     (‘Compilers’, array[`Smith’,`Jones’],
           new Publisher (`McGraw-Hill’,`New York’),
           multiset [`parsing’,`analysis’ ]);
```



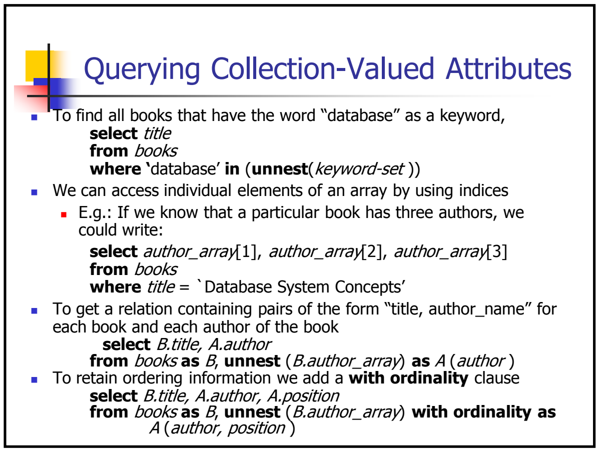
Unnesting

- The transformation of a nested relation into a form with fewer (or no) relation-valued attributes us called **unnesting**.
- E.g.

```
  select title, A as author, publisher.name as pub_name,
         publisher.branch  as pub_branch, K.keyword
  from books as B, unnest(B.author_array ) as A (author ),
         unnest (B.keyword_set ) as K (keyword )
```

- Result relation *flat_books*

title	*author*	*pub_name*	*pub_branch*	*keyword*
Compilers	Smith	McGraw-Hill	New York	parsing
Compilers	Jones	McGraw-Hill	New York	parsing
Compilers	Smith	McGraw-Hill	New York	analysis
Compilers	Jones	McGraw-Hill	New York	analysis
Networks	Jones	Oxford	London	Internet
Networks	Frick	Oxford	London	Internet
Networks	Jones	Oxford	London	Web
Networks	Frick	Oxford	London	Web



Querying Collection-Valued Attributes

- To find all books that have the word “database” as a keyword,

```
     select title
     from books
     where ‘database’ in (unnest(keyword-set ))
```

- We can access individual elements of an array by using indices
  - E.g.: If we know that a particular book has three authors, we could write:

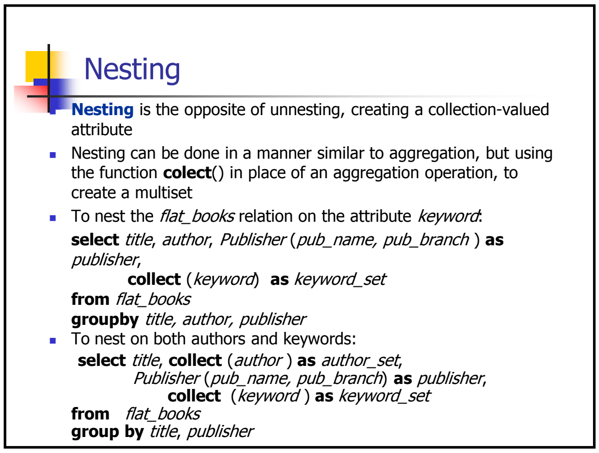
```
     select author_array[1], author_array[2], author_array[3]
     from books
     where title = `Database System Concepts’
```

- To get a relation containing pairs of the form “title, author_name” for each book and each author of the book

```
        select B.title, A.author
     from books as B, unnest (B.author_array) as A (author )
```

- To retain ordering information we add a **with ordinality** clause

```
     select B.title, A.author, A.position
     from books as B, unnest (B.author_array) with ordinality as
               A (author, position )
```



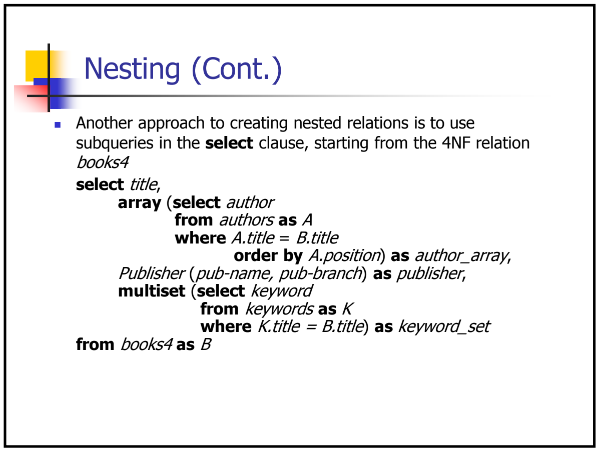
Nesting

- **Nesting** is the opposite of unnesting, creating a collection-valued attribute
- Nesting can be done in a manner similar to aggregation, but using the function **colect**() in place of an aggregation operation, to create a multiset
- To nest the *flat_books* relation on the attribute *keyword*:

```
select title, author, Publisher (pub_name, pub_branch ) as
publisher,
        collect (keyword)  as keyword_set
from flat_books
groupby title, author, publisher
```

- To nest on both authors and keywords:

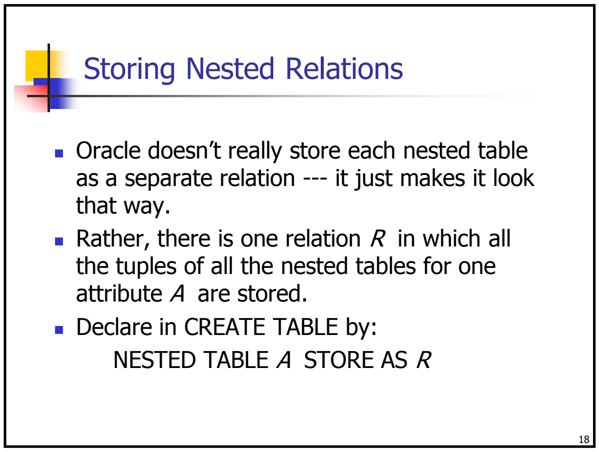
```
 select title, collect (author ) as author_set,
        Publisher (pub_name, pub_branch) as publisher,
             collect  (keyword ) as keyword_set
from   flat_books
group by title, publisher
```



Nesting (Cont.)

- Another approach to creating nested relations is to use subqueries in the **select** clause, starting from the 4NF relation *books4*

```
select title,
      array (select author
              from authors as A
              where A.title = B.title
                      order by A.position) as author_array,
      Publisher (pub-name, pub-branch) as publisher,
      multiset (select keyword
                  from keywords as K
                  where K.title = B.title) as keyword_set
from books4 as B
```



Storing Nested Relations

- Oracle doesn't really store each nested table as a separate relation --- it just makes it look that way.
- Rather, there is one relation *R* in which all the tuples of all the nested tables for one attribute *A* are stored.
- Declare in CREATE TABLE by:

  NESTED TABLE *A* STORE AS *R*

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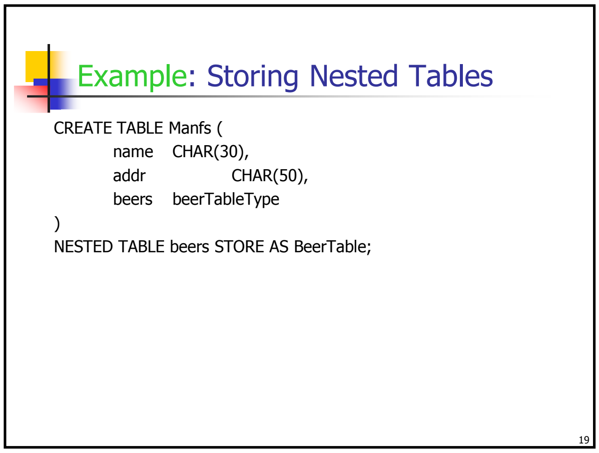
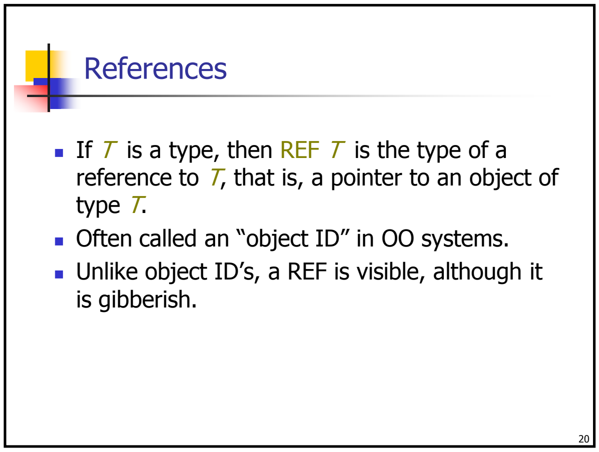


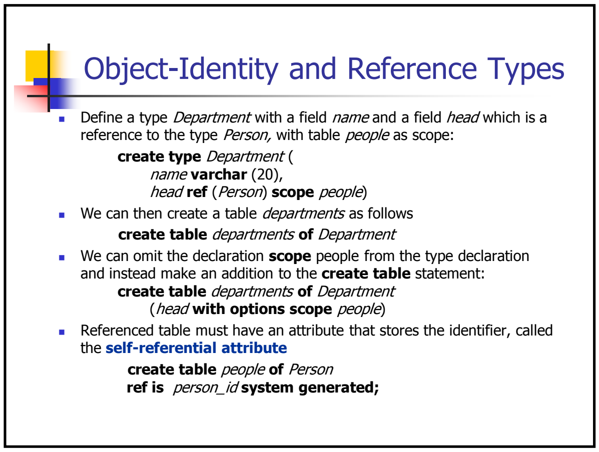
Example: Storing Nested Tables

```
CREATE TABLE Manfs (
        name    CHAR(30),
        addr            CHAR(50),
        beers   beerTableType
)
NESTED TABLE beers STORE AS BeerTable;
```



References

- If *T* is a type, then REF *T* is the type of a reference to *T*, that is, a pointer to an object of type *T*.
- Often called an "object ID" in OO systems.
- Unlike object ID's, a REF is visible, although it is gibberish.



Object-Identity and Reference Types

- Define a type *Department* with a field *name* and a field *head* which is a reference to the type *Person,* with table *people* as scope:

```
    create type Department (
        name varchar (20),
        head ref (Person) scope people)
```

- We can then create a table *departments* as follows

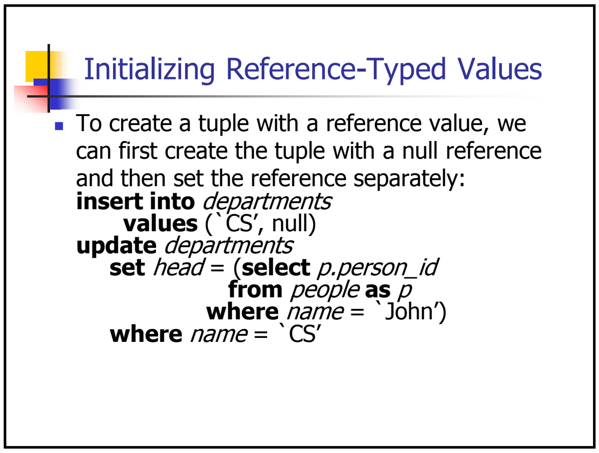
```
    create table departments of Department
```

- We can omit the declaration **scope** people from the type declaration and instead make an addition to the **create table** statement:

```
    create table departments of Department
        (head with options scope people)
```

- Referenced table must have an attribute that stores the identifier, called the **self-referential attribute**

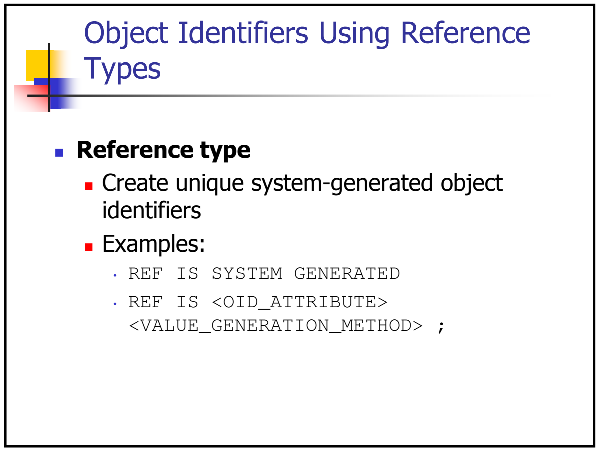
```
     create table people of Person
     ref is  person_id system generated;
```



Initializing Reference-Typed Values

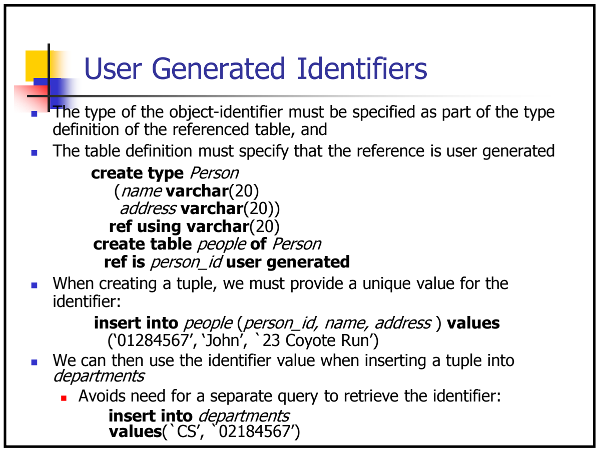
- To create a tuple with a reference value, we can first create the tuple with a null reference and then set the reference separately:

```
insert into departments
      values (`CS', null)
update departments
    set head = (select p.person_id
                from people as p
             where name = `John')
    where name = `CS'
```



Object Identifiers Using Reference Types

- **Reference type**
  - Create unique system-generated object identifiers
  - Examples:
    - `REF IS SYSTEM GENERATED`
    - `REF IS <OID_ATTRIBUTE>`
      `<VALUE_GENERATION_METHOD> ;`



User Generated Identifiers

- The type of the object-identifier must be specified as part of the type definition of the referenced table, and
- The table definition must specify that the reference is user generated

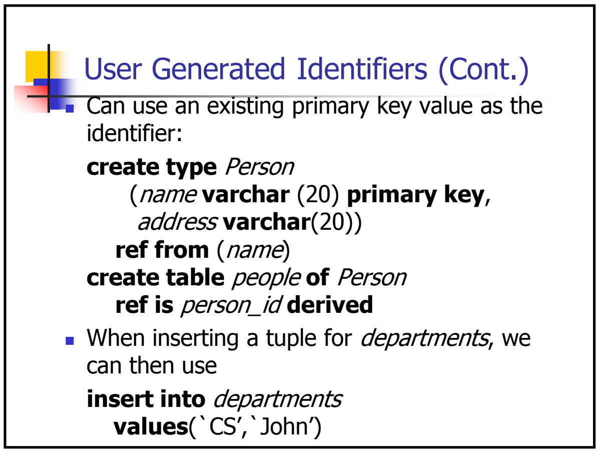
```
        create type Person
            (name varchar(20)
             address varchar(20))
           ref using varchar(20)
        create table people of Person
          ref is person_id user generated
```

- When creating a tuple, we must provide a unique value for the identifier:

```
        insert into people (person_id, name, address ) values
          ('01284567', 'John', `23 Coyote Run')
```

- We can then use the identifier value when inserting a tuple into *departments*
  - Avoids need for a separate query to retrieve the identifier:

```
        insert into departments
        values(`CS', `02184567')
```



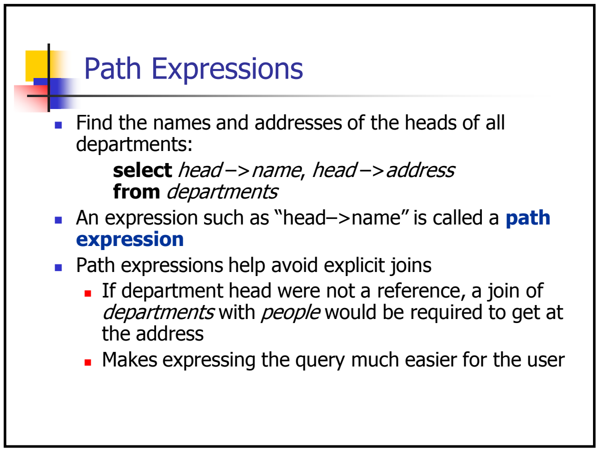
User Generated Identifiers (Cont.)

- Can use an existing primary key value as the identifier:

```
create type Person
      (name varchar (20) primary key,
       address varchar(20))
    ref from (name)
create table people of Person
    ref is person_id derived
```

- When inserting a tuple for *departments*, we can then use

```
insert into departments
    values(`CS',`John')
```

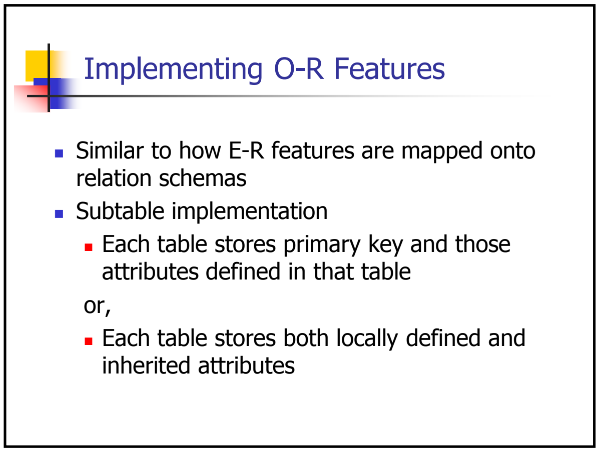


Path Expressions

- Find the names and addresses of the heads of all departments:

```
     select head–>name, head–>address
     from departments
```

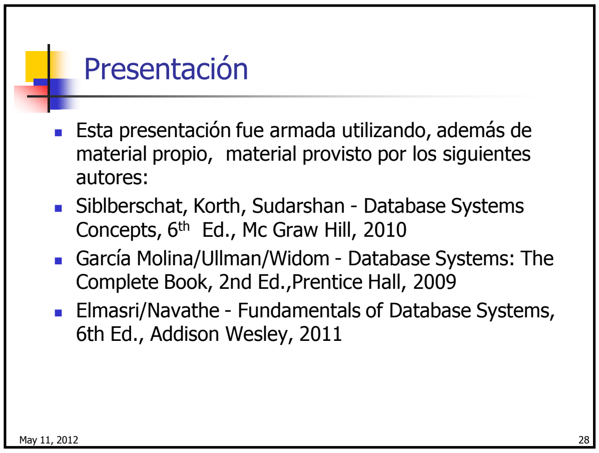
- An expression such as "head–>name" is called a **path expression**
- Path expressions help avoid explicit joins
  - If department head were not a reference, a join of *departments* with *people* would be required to get at the address
  - Makes expressing the query much easier for the user



Implementing O-R Features

- Similar to how E-R features are mapped onto relation schemas
- Subtable implementation
  - Each table stores primary key and those attributes defined in that table

  or,
  - Each table stores both locally defined and inherited attributes



Presentación

- Esta presentación fue armada utilizando, además de material propio, material provisto por los siguientes autores:
- Siblberschat, Korth, Sudarshan - Database Systems Concepts, 6th Ed., Mc Graw Hill, 2010
- García Molina/Ullman/Widom - Database Systems: The Complete Book, 2nd Ed.,Prentice Hall, 2009
- Elmasri/Navathe - Fundamentals of Database Systems, 6th Ed., Addison Wesley, 2011

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