COMP353 Databases

Database Design:

Object Definition Language (ODL)

ODL

- **ODL** (Object Definition Language) is a standard text-based language for describing the structure of databases
- **ODL** is an extension of **IDL** (Interface Description Language), a component of **CORBA** (**C**ommon **O**bject **R**equest **B**roker **A**rchitecture)

Object Oriented World

- In an object oriented design, the “**world**” we want to model is thought of as being **composed of objects**
- Everything is an **object**
  - *people*
  - *bank accounts*
  - *airline flights*
- Every object has a unique object id (OID)
- Every **object** is an **instance** of a **class**
- A **class** simply represents a grouping of **similar objects**
- All objects that are instances of the same class have the same **properties** and **behaviors**

Class Declarations

- A declaration of a **class** in ODL consists of:
  - The keyword **class**
  - The **name** of the class
  - A bracketed { …} list of **properties** of the class

```
class <name> {
    <list of properties>
  };
class Movie {
    …
  };
```

Properties of ODL classes

- ODL classes can have three kinds of properties:
  - **Attributes**
    - properties whose types are built from **primitive/basic types** such as integers, strings,…
  - **Relationships**
    - properties whose type is either a **reference** to an object or a **collection** of such references
  - **Methods**
    - **functions** that may be applied to objects of the class

Attributes in ODL

- Attributes are the **simplest kinds** of properties
- An attribute **describes some aspect of an object** by associating, with the object, a value of some simple **type**
- For example, attributes of a **Student** object
  - Student ID
  - Name
  - Address
  - E-mail

Keys in ODL

- In **ODL**, we declare keys using the keyword **key**
  - If a key has more than one attribute, we surround them by (…)
    - Example: (two attributes forming a key)

```
class Movie
        (extent  Movies key (title, year) ) {
        attribute string title;
         …
    };
```

  - If a class has > one key, we may list them all, separated by commas
    - Example: (A class with two keys)

```
class Employee
         (extent  Employees key empID, SIN) {…};
```

Single-Value Constraints in ODL

- Often, we should *enforce* properties in the database saying that there is **at most one** value playing a particular role
  - For example**:**
    - that a movie object has a **unique** title, year, length, etc
    - that a movie is owned by a **unique** studio

Single-Value Constraints

- In **ODL:**
  - An attribute is **not** of a collection type

    (Set, Bag, Array, List, Dictionary are **collection types**.)
  - A relationship is either a class type or (a single use of) a collection type constructor applied to a class type.
- Recall that in the **E/R** notation**:**
  - attributes are **atomic**
  - an arrow (⟶) can be used to express the multiplicity of relationships (1:1), (1:M), and (N:M)

Type system

A **type system** consists of

- **Basic types**
- **Type constructors**
  - recursive rules whereby **complex types** are built from simpler ones

Basis of types in ODL

- **Primitive types (atomic)**
  - Integer
  - Float
  - Char
  - Character String
  - Boolean
  - Date
  - Enumeration (a **list of names** declared to be **synonyms for integers**
- **Class types**
  - Movie

Type constructors in ODL

- **Set**
  - Set <integer>
  - Set <Movie>
- **Bag**
  - Bag <integer>
  - Bag <Movie>
- **Array**
  - Array <integer, 10>
  - Array <Movie, 3>
- **Structure**
  - Struct *Address* {string *street*, string *city*}
- **List**
  - List <integer>
  - List <Student>
- **Dictionary** <keyType, valueType>
  - Dictionary<Student, string>

- **Note:**
  - Set, Bag, Array, List and Dictionary are called **collection types**
  - Collection type cannot be applied repeatedly (nested)
    - E.g., it is **illegal** to write Set<Array<integer,10>>

Example

```
class Movie {
    attribute string title;
    attribute integer year;
    attribute integer length;
    attribute enum Film {color, blackAndWhite} filmType;
    };
```

(“Gone with the Wind”, 1939, 231, color) is a Movie object.

Example (non-atomic type)

```
class Star {
    attribute string name;
    attribute Struct Address {
        string street,
        Array<char, 10> city
        } homeAddress;
     attribute Address officeAddress;
    };
```

Example

```
class Student {
    attribute string ID;
    attribute string lastName;
    attribute string firstName;
    attribute date dob;     /* date is a basic type in ODL */
   attribute string program;
   attribute Struct Address {
         string street,
         string city
           } homeAddress;
    };
```

Example

```
class Course {
    attribute string courseNumber;
    attribute string courseName;
    attribute integer noOfCredits;
    attribute string department;
    };
```

Relationships in ODL

- If we are designing a database about **Movies** and **Stars**, what are we missing? The relationships….
- How are **Movies** and **Stars** related?
- Every movie has a star (or stars)

Example

- Can we write “ **attribute Star starOf;** ” ?

```
class Movie {
    attribute string title;
    attribute integer year;
    attribute integer length;
    attribute enum Film {color, blackAndWhite} filmType;
    attribute Star starOf;
    };
```

- **No**, the attribute types **must not** be classes

Example

- **starOf** is a relationship between **Movie** and **Star**

```
class Movie {
    attribute string title;
    attribute integer year;
    attribute integer length;
    attribute enum Film {color, blackAndWhite} filmType;
    relationship Star starOf;
    };
```

Inverse Relationships

- How are **Movies** and **Stars** related?
- Not only every movie has a star but also every star has a role in some movie(s)
- To fix this in the **Star** class, we add the line:

  relationship Movie starredIn;

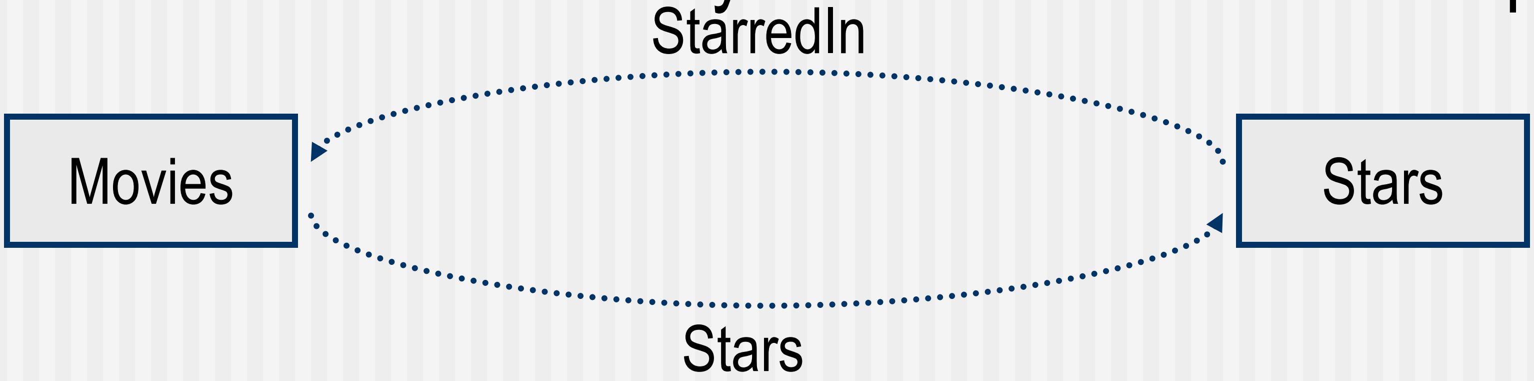
Example

```
class Star {
    attribute string name;
    attribute Struct Address {
        string street,
        string city
        } address;
    relationship Movie starredIn;
    };
```

- What is the problem here?

Inverse Relationships

- We are omitting a very important aspect of the relationship between movies and stars
- We need a way to ensure that if a star **S** is connected to a movie **M** via ***stars***, then conversely, **M** is connected to **S** via ***starredIn***
- In ODL that is done by **inverse** of a relationship



Example

```
class Movie {
    attribute string title;
    attribute integer year;
    attribute integer length;
    attribute enum Film {color, blackAndWhite} filmType;
    relationship Star stars
                  inverse Star::starredIn;
};
```

Example

```
class Star {
    attribute string name;
    attribute Struct Address {
           string street,
           string city
    } address;
    relationship Movie starredIn
                      inverse Movie::stars;
};
```

Relationships in ODL

- Our design is missing another important point!
- A movie typically has several stars
- A star usually plays in more than one movie
- To fix this, we write:

relationship Set<Star**>** stars;

Example

```
class Movie {
    attribute string title;
    attribute integer year;
    attribute integer length;
    attribute enum Film {color, blackAndWhite} filmType;
    relationship Set<Star> stars
                    inverse Star::starredIn;
};
```

Example

```
class Star {
    attribute string name;
    attribute Struct Address {
            string street,
            string city
    } address;
    relationship Set<Movie> starredIn
                    inverse Movie::stars;
};
```

Example

- Suppose we introduce another class, **Studio**, representing the studios, i.e., companies that produce movies

```
class Studio {
    attribute string name;
    attribute string address;
    };
```

Example

- How are **Movies** and **Studios** related?
- Every **Studio** owns several **Movies**

```
class Studio {
    attribute string name;
    attribute string address;
    relationship Set<Movie> owns
                    inverse Movie::ownedBy;
    };
```

Example

- What about inverse?
- Every **Movie** is owned by some **Studio**

```
class Movie {
    attribute string title;
    attribute integer year;
    attribute integer length;
    attribute enum Film {color, blackAndWhite} filmType;
    relationship Set<Star> stars inverse Star::starredIn;
    relationship Studio ownedBy inverse Studio::owns;
    };
```

Multiplicity of relationships

- **In general**, when we have a pair of inverse relationships, there are **four** cases:
  - The relationship is unique in both directions (1)
  - The relationship is unique in just one direction (2)
  - The relationship is not unique in any direction (1)
  - The *multiplicity* is thus referred to the kinds of these 4 relationships, also denoted as 1-1 (read as one-one), 1-M (one-many), M-1 (many-one), and M-N (many-many).

Multiplicity of relationships

- A **many-many** relationship from a class **C** to a class **D** is one in which, for each C there is a set of **D**s associated with **C,** and in the inverse relationship, associated with each D is a set of **C**s
  - For example, each student can take many courses and each course can be taken by more than one student

```
class Student {
        . . .
        relationship Set<Course> takes inverse Course::takenBy;
        };
class Course {
        . . .
        relationship Set<Student> takenBy inverse Student:: takes;
        };
```

Multiplicity of relationships

- A **many-one** relationship from class **C** to a class **D**, is one where for each **C** there is a at most one **D**, but no such a constraint in the reverse direction (similarly for one-many)
  - For example, many employees may work in the same department, but each employee works only in one department

```
class Employee {
        . . .
        relationship Department worksIn inverse Department::workers;
        };
class Department {
        . . .
        relationship Set< Employee > workers inverse
            Employee::worksIn;
        };
```

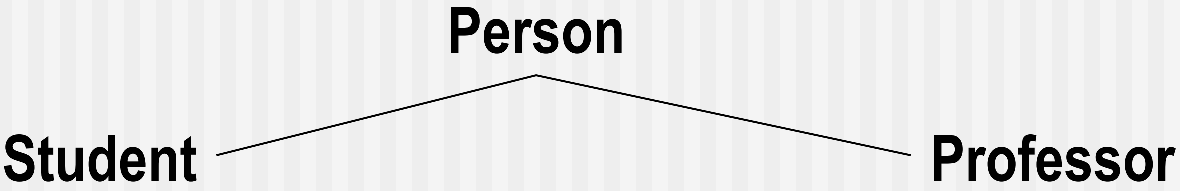
Multiplicity of relationships

- A **one-one** relationship from class **C** to class **D** is one that for each **C** there is a at most one **D**, and conversely, for each **D** there is at most one **C**
  - For example, each department has at most one professor as its chairperson and each professor can be the chair of at most one department

```
class Professor {
        . . .
        relationship Department chairOf  inverse  Department::chair;
        };
class Department {
        . . .
        relationship Professor chair inverse Professor:: chairOf;
        };
```

Inheritance in Object Oriented World

- Objects can be organized into a hierarchical inheritance/is structure
- A child class (or subclass) will inherit properties form a parent class (or all the superclasses) higher in the hierarchy.



Person

Student

Professor

Subclasses in ODL

- Often, a class contains some objects that have **special properties** not associated with all members of the class
- If so, we find it useful to organize the class into ***subclasses***, each subclass having its **own special** attributes and/or relationships

Subclasses in ODL

- We define a class ***C*** to be a subclass of another class ***D*** by following the name ***C*** in its declaration with a keyword **extends** and the name ***D***

```
class Cartoon extends Movie {
    relationship Set<Star> voices;
    };
```

A subclass *inherits* all the properties of its superclasses

So, each cartoon object has *title, year, length, filmType*, and inherits relationships *stars* and *ownedBy* from Movie, in addition to its own relationship *voices*.

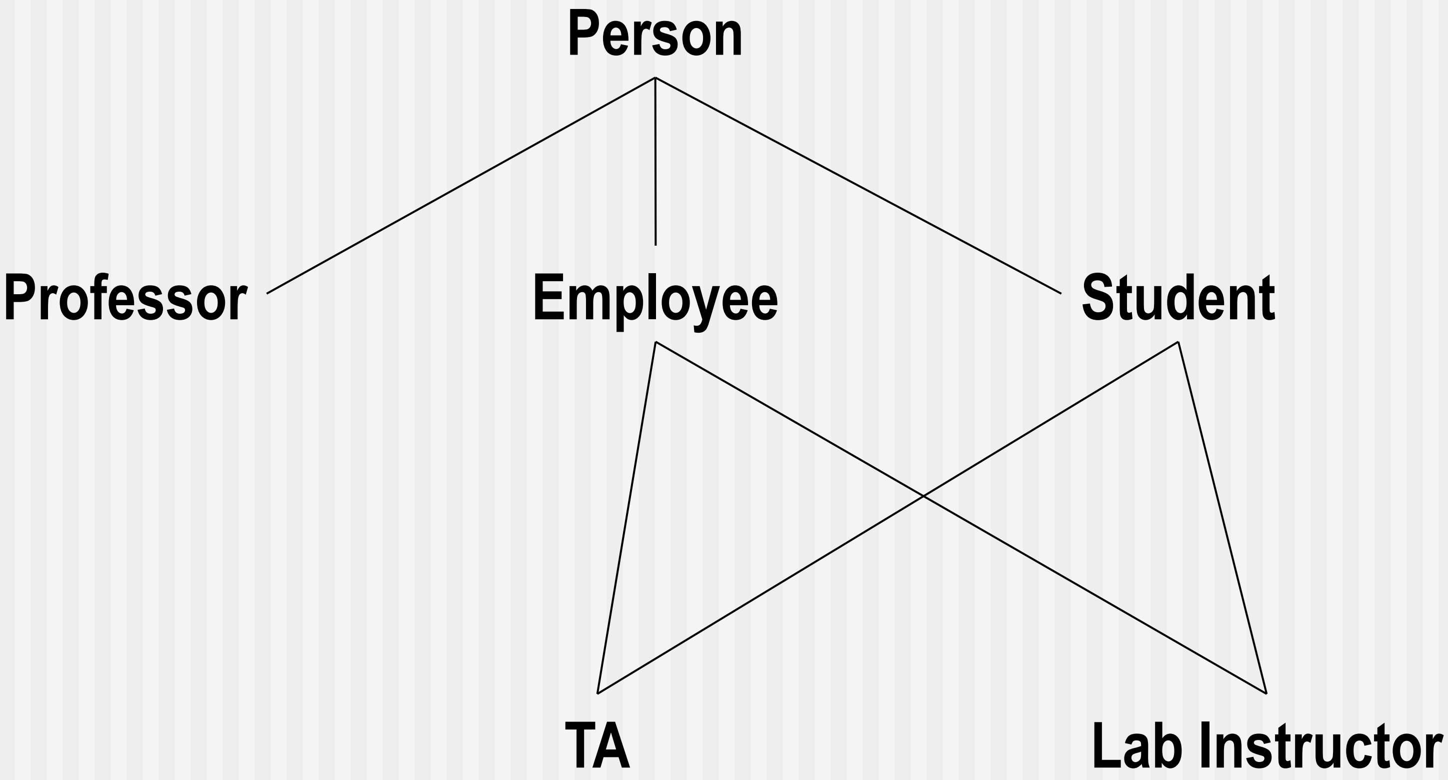
Example

```
class Person {
    attribute string lastName;
    attribute string firstName;
    attribute integer age;
    attribute Struct Address {
            string street,
            string city
              } homeAddress;
    };
class Student extends Person {
    attribute string ID;
    attribute string program;
    };
```

Inheritance in ODL

- A class may have **more than one** subclass.
- A class may have more than one class from which it inherits properties; those classes are its superclasses
- Subclasses may themselves have subclasses, yielding a **hierarchy** of classes where each class inherits the properties of its ancestors.

Multiple Inheritance in ODL



Person

Professor

Employee

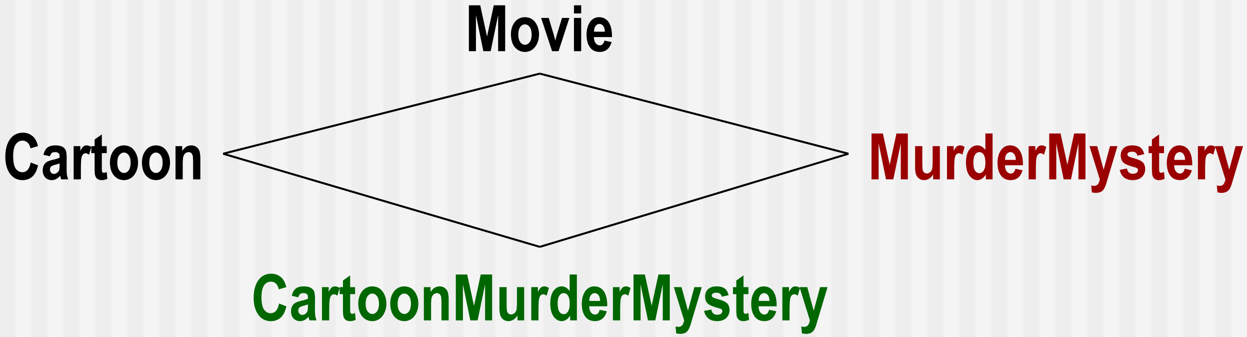
Student

TA

Lab Instructor

Example

```
class MurderMystery extends Movie {
      attribute string weapon;
      };
class CartoonMurderMystery extends Cartoon : MurderMystery;
```



- Thus, a **CartoonMurderMystery** object is defined to have all the properties of both of its superclasses: **Cartoon** and **MurderMystery**.