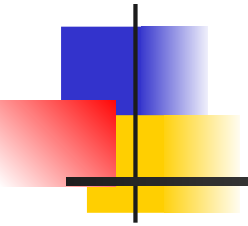


Modeling with Inheritance

James Brucker

Uses of Inheritance

1. *Factor out common elements* (code reuse)
   - parent class implements behavior needed by children
   - parent defines *attributes* for all classes
   - avoids duplicate or inconsistent code.
2. *Specialize*
   - child class can redefine behavior of the parent
3. *Enable polymorphism*

Benefits of Inheritance?

1. Reuse code

2. Define a family of related types (polymorphism)

When To Use Inheritance?

Liskov Substitution Principle

In a program, if all objects of the superclass are replaced by objects from a subclass, the program should still work correctly.

Example:

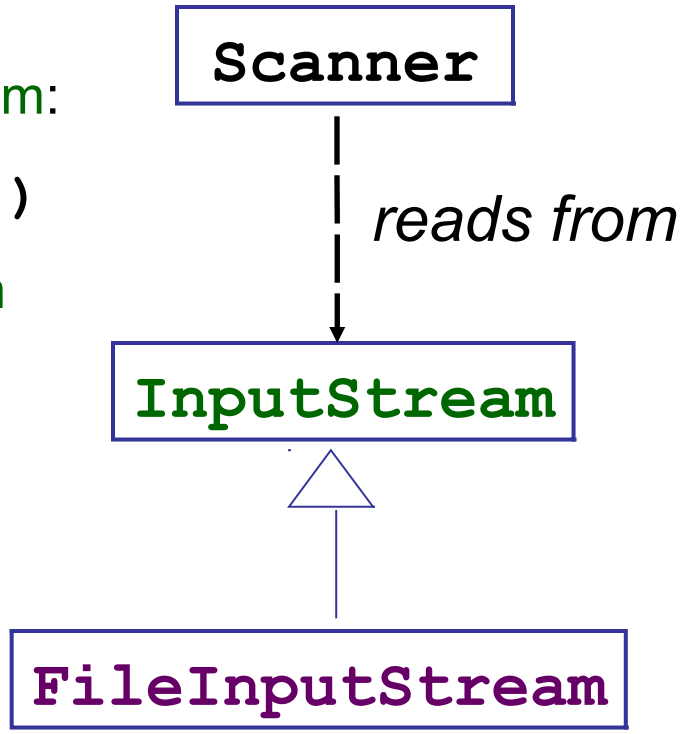
1. Scanner can read from an InputStream:

   s = **`new Scanner( InputStream )`**

2. FileInputStream extends InputStream

3. Scanner should also work correctly using a FileInputStream,

   s = new Scanner(fileInputStream)



Liskov Principle example

A method that is expecting an object of a ParentClass type should also work if invoked with an object from any subclass.

```
public void doSomething( ParentClass obj )
```

should work with:

1. doSomething (new ParentClass())
2. doSomething (new Subclass())
3. doSomething (new SubSubSubclass())

Substitution Principle (2)

A Scanner can read from an `InputStream`

```
InputStream input = System.in;

// construct Scanner using InputStream
Scanner scanner = new Scanner( input );

while( scanner.hasNext() ) {
   String w = scanner.next( );
   System.out.print(w);
```

Substitution Principle (3)

Substitute a FileInputStream for the InputStream.

Scanner should still work!

```
InputStream input = null;
try {
    input = new FileInputStream(
                        "/temp/sample.txt");
}
catch ( FileNotFoundException e ) {  }
Scanner scanner = new Scanner( input );
while (scanner.hasNext()) {
    String w = scanner.next( );
    System.out.print(w);
```

Specialization

- A subclass can *override* (redefine) a method inherited from the parent, in order to specialize the behavior.
- Subclass *specializes* the behavior for its own needs, but still conforms to *contract* of parent's behavior.

```
public class Person {
    private String name;
    public String getName() { return name; }
    public String toString() { return name; }
}
public class Student extends Person {
    protected String studentId;
    // redefine toString() to include Student ID.
    public String toString() {
        return getName()+" ID: "+studentId;
    }
}
```

Specialization *shadows* attributes

- If a child class defines an attribute with the same name as attribute of parent class, it creates a *new attribute* that "hides" the parent attribute.
- But the parent attribute is still there (in objects of child class)!
- This is called ***shadowing***. Also called *hiding*.
- Use "**`super`**" to access parent's members.

```
public class Person {
    protected long id;
    . . .
}

public class Student extends Person {
    private String id;  // OK to define a new id!
    public String toString() {
      return "student id: "+ id
             +" citizen id: "+super.id;
```

Shadow Attributes

- In general, **don't do it**.
- Redefining an attribute (deliberately) is poor design. Better to fix the design.
- duplicating an inaccessible, private variable (by coincidence) is OK.

Extension

- A subclass can define *new behavior* that the superclass does not have.
- A subclass can also define *new attributes*.

```
public class Person {
   private String name;
   public String toString() { return name; }
}

public class Student extends Person {
   protected List<Course> courses; // new attribute

    // new behavior
   public void addCourse(Course c) { . . . }
   public void getCredits( ) {
        // compute credits for all courses that
        // student got a passing grade.
    }
```

Bad Example: violates "is a" rule

A stack of objects is a simple data collection, like this...

Stack
+ push(Object) + pop( ) + peek( ) + isEmpty( )

To store the data in the stack we could use a linked list...

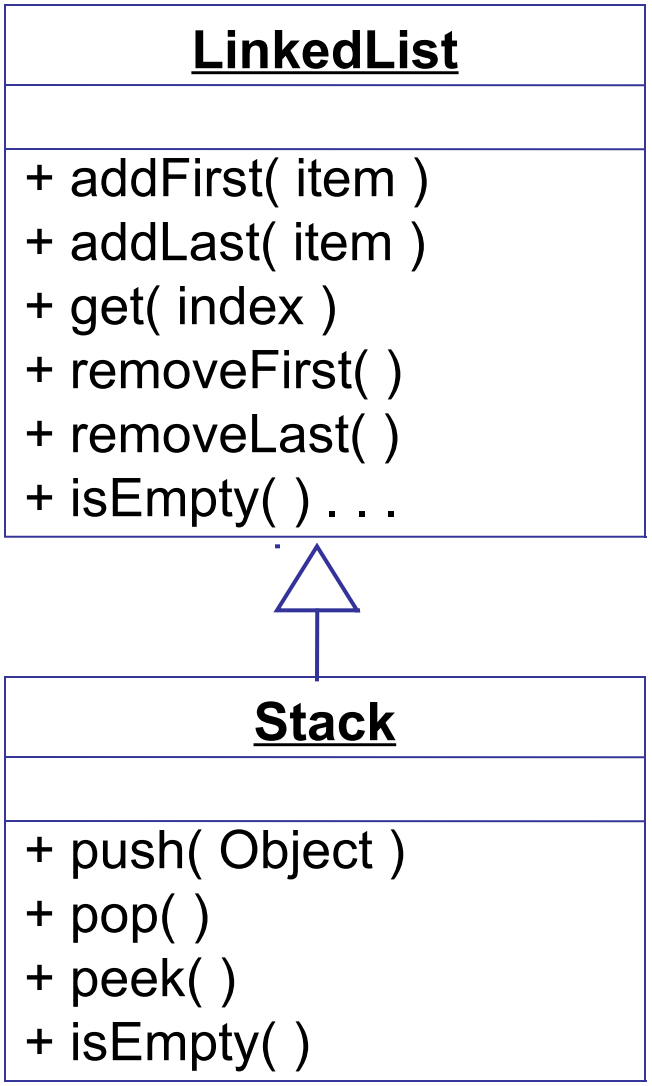
LinkedList
+ addFirst(item) + addLast(item) + getFirst( ) + getLast( ) + get(index) + remove(index)

Example: A Stack (2)

Can we define Stack as a subclass of LinkedList?

All we need to do is add the 4 stack methods and we're done!

```
Class Stack
        extends LinkedList {
  public Stack() { super(); }
  public void push(Object o){
     addFirst( o );
  }
  public Object pop() {
     return removeFirst( );
   }
  public Object peek() {
     return get(0);
   }
```



Example: A Stack (3)

The problem with this is that Stack will exhibit **all** the behavior of a LinkedList, including methods that should not exist for a stack.

```
/* Stack example */
public void stackTest( ) {
   Stack stack = new Stack( );
   stack.push( "First item" );
   stack.push( "Second item" );
   stack.push( "Third item" );
   stack.push( "Fourth item" );
   // cheat! get the 3nd item
   String s = stack.get( 2 );
   // cheat! add item at front of stack
   stack.addFirst( "Ha ha ha!");
```

Behavior inherited from ListedList

"is a" (kind of) relationship

A simple test for whether inheritance is reasonable:

Subclass is a S*uperclass*

- CheckingAccount **is a** (kind of) BankAccount
- Number **is an** (kind of) Object
- Double **is a** (kind of) Number
- Rectangle is a 2-D Shape
  - `Rectangle extends Shape2D`

"is a" test doesn't always work

X A Square is a Rectangle

but a rectangle can have length ≠ width

X ArrayList is a List

List is a *type* (interface) not a class

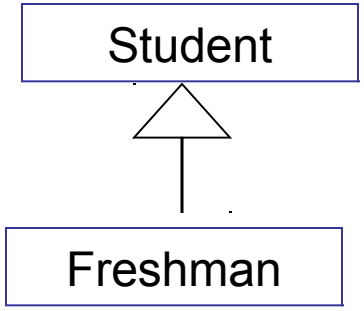
X A Freshman is a Student

but next year she will be a sophomore.

✓ Use an attribute for features that change.

X George Bush is a President

an *instance* of a class, not a subclass

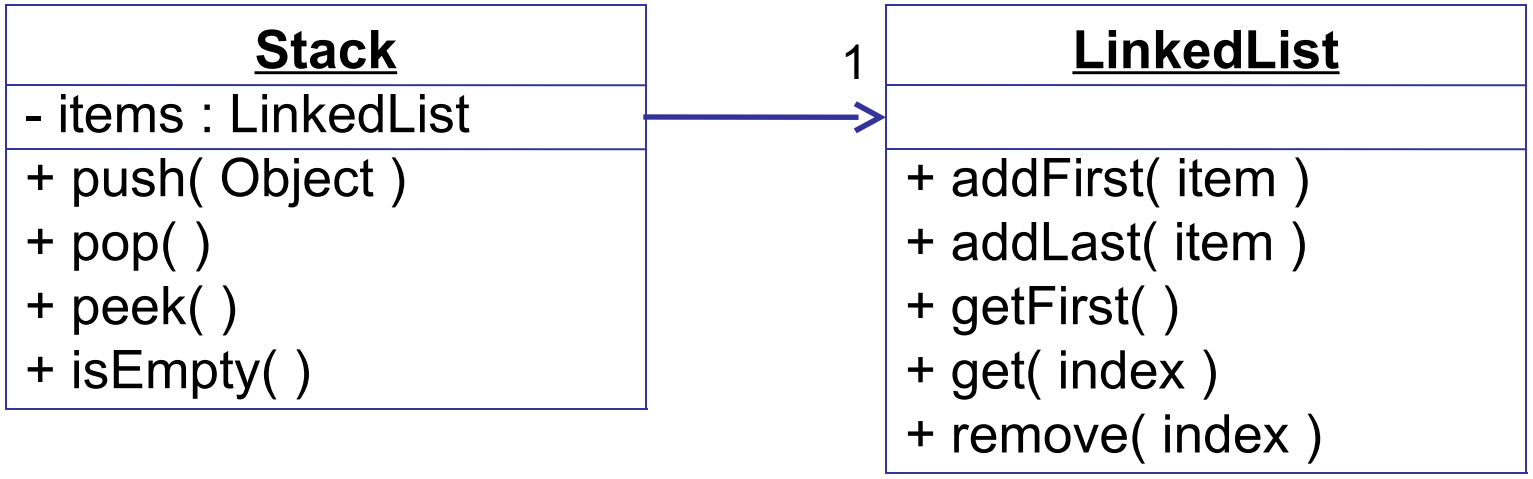


Attribute: "has a"

- In the case of a Stack, we would say:

  "*a Stack **has a** LinkedList*"

- "**has a**" means that something should be an attribute
- "has a" indicates an association.
- UML uses an open arrowhead for association

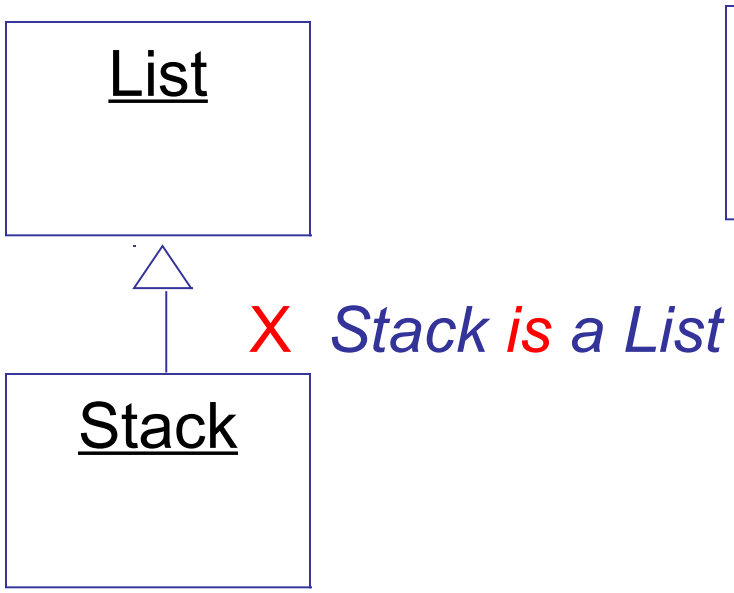


Composition vs Inheritance

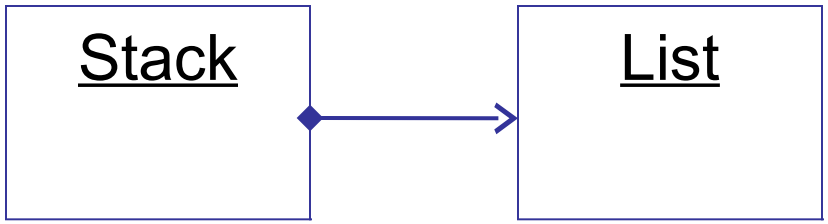
"*Favor composition over inheritance*"

(*design principle*)

Consider using aggregation (has a ...) instead of inheritance (is a ...).



X *Stack is a List*



✓ *Stack has a List*

Java LinkedList is a Stack !

- java.util.LinkedList provides the stack methods.
- You can use LinkedList as a Stack or Deque.
- Is this a good design?

Stack methods are defined in LinkedList

LinkedList<T>
+ addFirst(item) + addLast(item) + getFirst( ): T + get(index): T + remove(index) + isEmpty( ) + push(item) + pop( ): T + peek( ): T

Problems with Inheritance

- Can only have one parent class

- Binds objects to one hierarchy (not flexible)

- Sometimes the parent class *doesn't know how* a behavior should be implemented

  Example: `Shape` is parent for `Rectangle`, `Circle`, ...

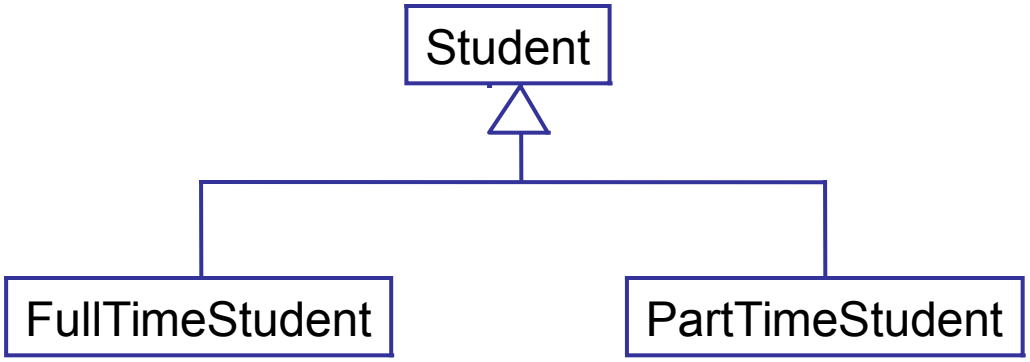
  what should `Shape.draw( )` do?

Don't Overuse Inheritance...

- Don't use a subclass in situations where an object may need to change class during its life time.

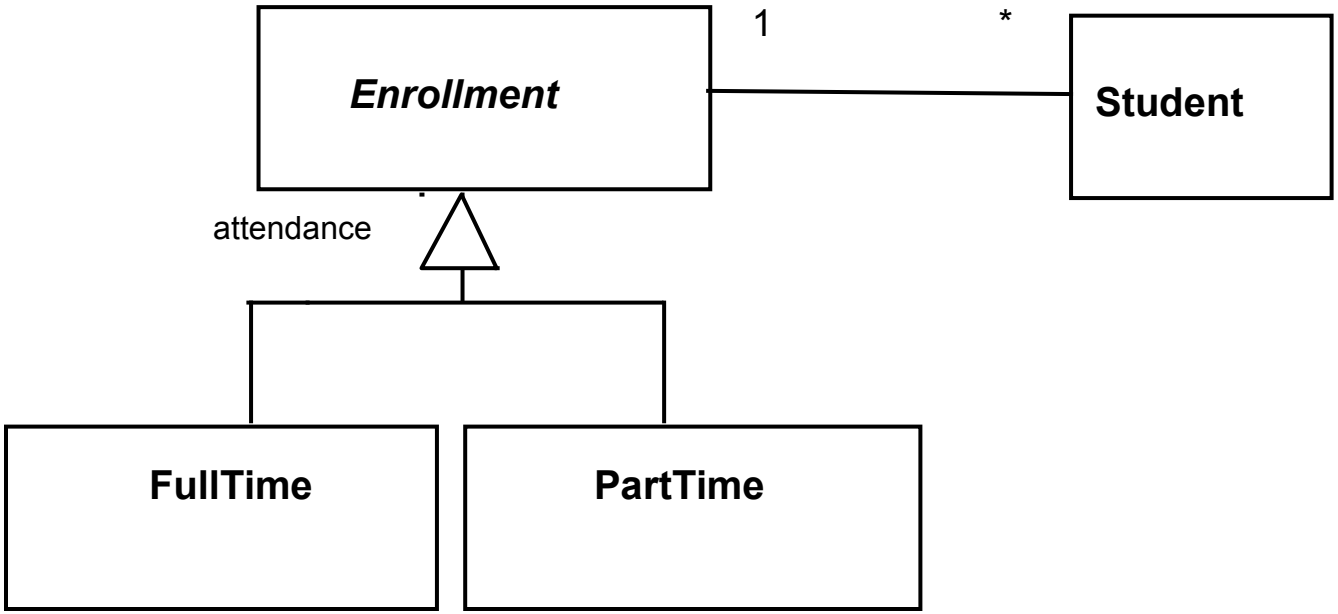
Example: Full-time and Part-time students have different requirements and behavior.

Should we model this using inheritance?



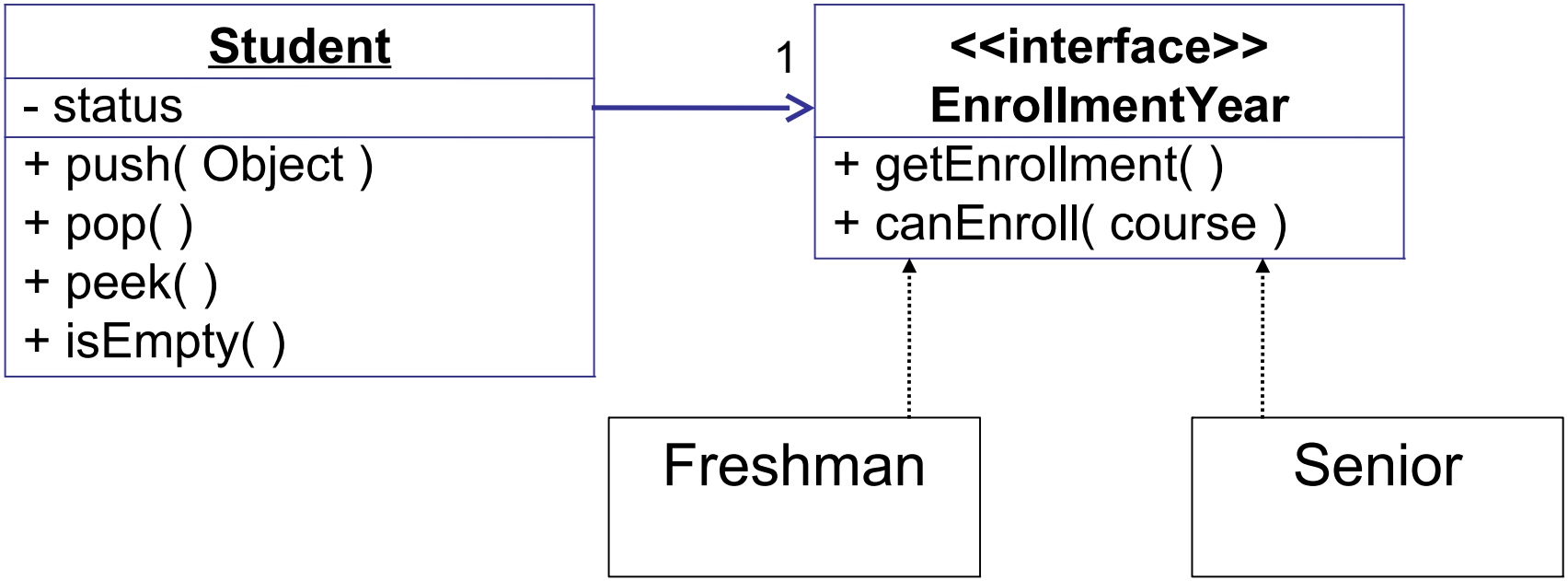
Modeling a "role" or "status"

- A student can change from Full-time to Part-time.
- Full-time or part-time is a *role* or *status*.
- Model this using an attribute that refers to an object of the appropriate status.



Prefer attribute over inheritance

- For Freshman - Student example, model Freshman as an attribute... and assign behavior to it.

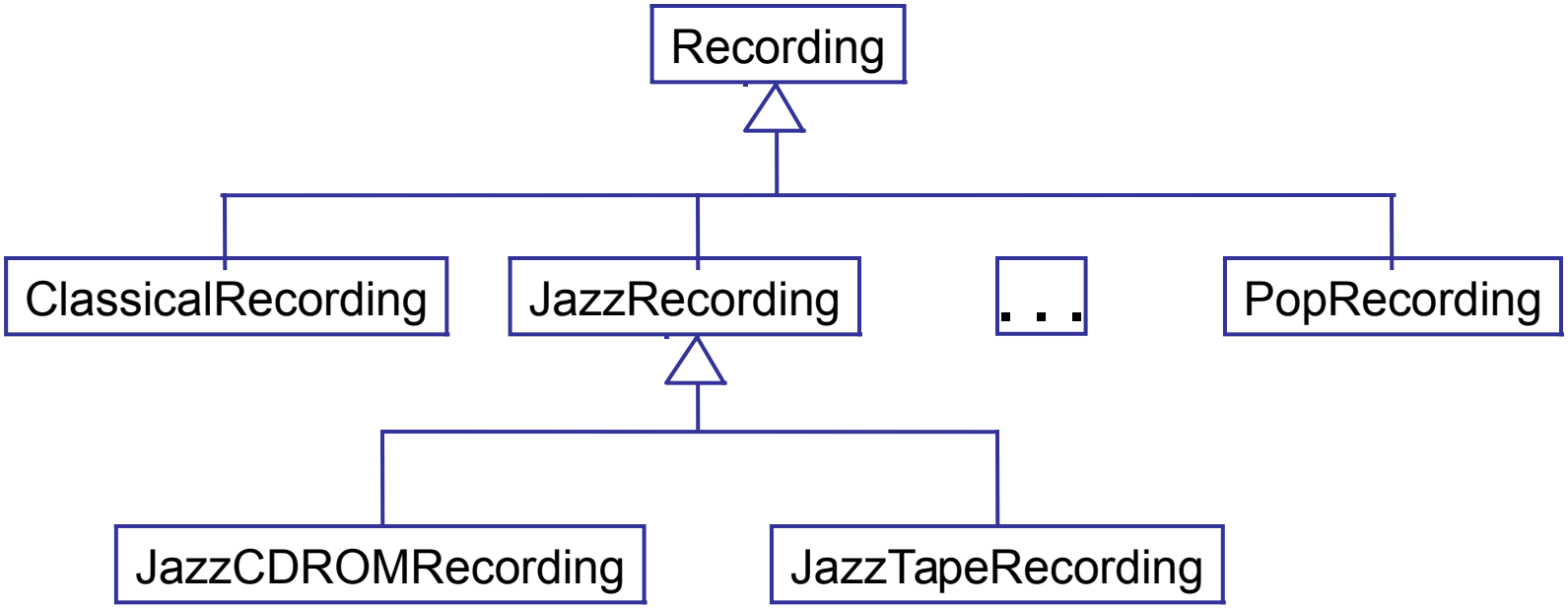


Don't Overuse Inheritance...

- Subclass doesn't add significant extension or specialization

  Example: a library has several types of recordings: Jazz Recording, Classical Recording, Pop Recording, ...

  Recordings may be Tape or CDROM



Use Interface to describe behavior

- "Set" is an interface because it doesn't *implement* any methods or provide any *attributes*.
- HashSet *implements* Set