Lecture 38: More about Interfaces

Last time:

1. Safe downcasting
2. `equals` reconsidered
3. Copying and cloning
4. Composition

Today:

1. Overloading and overriding revisited
2. Interfaces and class inheritance
3. Interface hierarchies

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Inheritance Recap

- All objects are derived (directly or indirectly) from **`Object`**
- Late binding and inheritance allows you to create polymorphic variables
- When a method in a base class is not provided, the method and class are said to be abstract. Abstract methods may be implemented in (concrete) derived classes
- Run-time information about class / type information of objects can be obtained using **`getClass()`** method and **`instanceof`** operator
- Upcasting of object to superclass type is always safe and done automatically
- Downcasting may not be safe, depending on actual class object belongs to at run-time. Safe downcasting can be done using `instanceof`
- In presence of inheritance, issues arise in definitions of `equals()`, copying, because parameter may belong to subclass of argument type (e.g. in `Person` copy constructor, parameter may be `Student` rather than `Person`)
- For `equals()`, make argument type `Object` and check for class membership using `getClass()`
- To copy objects, use cloning: embed information about copying in objects rather than classes by implementing `clone()` method to perform copying
- Composition is another way to implement one class based on another. It is different from inheritance: an object in a class created with composition “has-a” instance of an object in the earlier class, as opposed to having an “is-a” relationship.

Overloading and Overriding Redux

- Overloading
  - Different methods can have same name; in this case, method name is overloaded
  - Overloaded methods must have different argument lists (different # of args, or different types)
  - Overloading can occur due to inheritance!
    - Recall old (inferior) treatment of equality in `Person` / `Student`

```
public class Person {
    …
    public boolean equals (Person p) { … }
}
public class Student {
    …
    public boolean equals (Student p) { …. }
}
```

    - `Student` has two (actually, three!) overloaded versions of `equals()`
      - `Student` version
      - `Person` version
      - `Object` version
- Overriding
  - A subclass can redefine an existing method from a superclass
  - When overriding a method the subclass method prototype must match exactly the prototype of the superclass (same name, same return type, same arguments). Otherwise: overloading!
  - You may change access specifier (public, private, protected), but derived classes cannot decrease the visibility.

Example

```
public class Base {
    protected void m (int x) { … }
}

public class Derived extends Base {
    public void m (int x) { … }
    public int m (int x) { … }
    public void m (double d) { … }
}

// The following appears in the same package as above

    Base b = new Base( );
    Base d = new Derived( );
    Derived e = new Derived( );
    b.m (5);
    d.m (6);
    d.m (7.0);
    e.m (8.0);
```

Overriding: with increased visibility

Error! duplicate method declaration

Overloading

calls Base:m(int)

calls Derived:m(int)

Error! Since d is declared Base, the compiler looks for Base:m(double) Doesn't exist! So this does not make it past the compiler, even though Derived:m(double) is defined!

calls Derived:m(double)

Is `Object` Abstract?

- No!
- You can create instance of `Object` using `new`

  ```
  Object o = new Object();
  ```
- But there’s not a lot you can do with them

Recall Interfaces

- Interfaces contain lists of method prototypes
- Example from Lecture #23:

```
public interface UMStudent {
    public void goToClass();
    public void study();
    public void add(int a, int b);
    public String getName();
}
```

- Classes can be indicated as implementing interfaces

```
    public class CSMajor implements UMStudent {
      …
    }
```

  - To satisfy Java compiler, `CSMajor` must provide implementatons of `goToClass()`, `study()`, etc.
- Interfaces can be used as types, and thus to support polymorphism:

```
    public void psychoAnalyze(UMStudent student) { … }
```

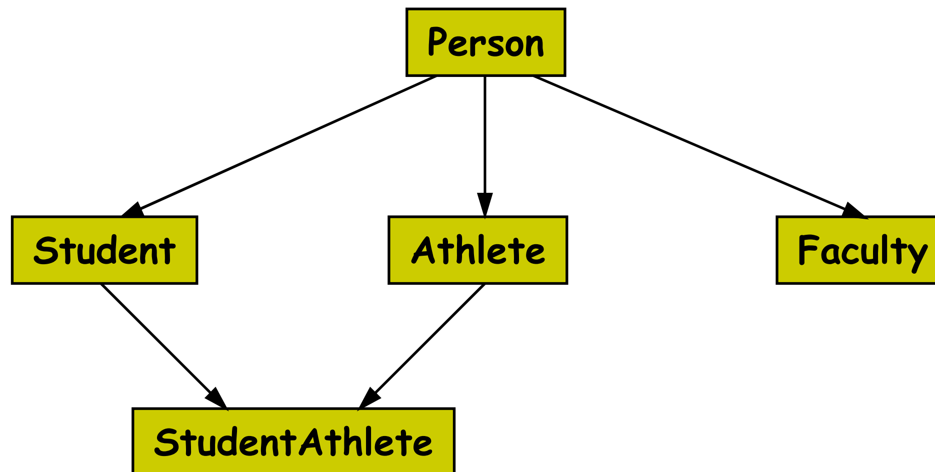
- From last time: interfaces are similar to, but different from, abstract classes
  - Abstract classes can contain abstract, concrete methods
  - Classes can implement multiple interfaces, but inherit (directly) from only one class

Main Uses of Interfaces

- API for classes
- Polymorphism
- “Faking multiple inheritance”
- Specifying sets of symbolic constants

“Multiple Inheritance”?

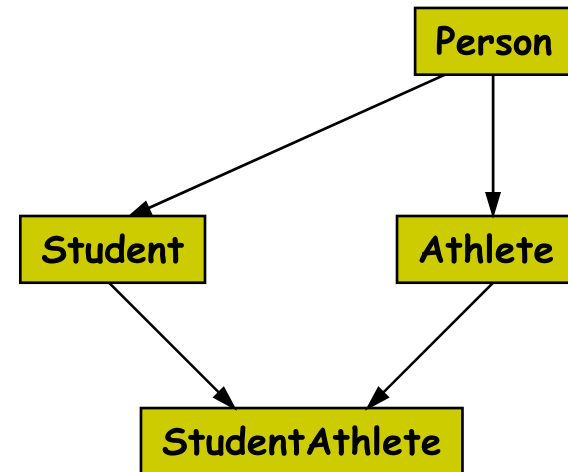
- Intuitively useful to be able to inherit from multiple classes (multiple inheritance)



- But Java does not allow this

Why Does Java Disallow Multiple Inheritance?

- Semantic difficulties!
- Consider `StudentAthlete`
  - Objects would get name field from `Student`
  - Objects would also get name field from `Athlete`
  - Duplicate fields: what to do?
- Some languages (e.g. C++) do allow multiple inheritance



Can We Achieve Some of Benefits of Multiple Inheritance in Java?

- Yes, using interfaces + inheritance
  - Idea: use inheritance for one of inherited classes, interfaces for others
  - Interfaces ensure that relevant methods are implemented
- Example

```
public class Person { … }

public class Student extends  Person { … }

public interface Athlete {
   public String getSport ();
   public void setSport (String sport);
}

public class StudentAthlete extends Student implements Athlete {
   …
}
```

- Objects of type `StudentAthlete` "are" `Students`
- They also can be wherever objects matching `Athlete` are required

Interfaces and Constants

- Interfaces can also contain `public final static` variables
- Sometimes interfaces are used to provide consistent definitions for constants throughout an application
- Example

```
public interface Months {
    public final static int       JANUARY = 1;
    public final static int       FEBRUARY = 2;
    public final static int       MARCH = 3;
    …
    public final static int       DECEMBER = 12;
}

public class MonthDemo implements Months {

    public static void main( String[ ] args ) {
      System.out.println( "March is month number " + MARCH );
    }
}
```

Because `MonthDemo` implements `Months`, it has access to the constants

Interface Hierarchies

- Inheritance may also be used to build new interfaces from previous ones
- A subinterface inherits all method / constant declarations from its base interface
- A subinterface may also introduce new methods / constants
- E.g. recall `Iterator<T>` interface

```
public interface Iterator {
   boolean hasNext( );                // any more items?
   T next( );                         // return the next item
   void remove( );                    // remove the current item
}
```

We can define a new, bidirectional iterator interface using inheritance

```
public interface BidirectionalIterator<T> extends Iterator<T> {
   boolean hasPrevious();    // any prior items?
   T previous();             // return the previous item
}
```