CMSC 132: Object-Oriented Programming II

Interface

Java_Interfaces

- A **Java Interface** is a formal way for a class to **promise** to implement certain methods. We say that a class **implements** an interface if it provides these methods

- **Interface**:
  - Is defined by the keyword **interface** (rather than **class**)
  - It defines **methods** (as many as you like), but does **not** give **method bodies** (the executable statements that make up the method)
  - All abstract, default, and static methods in an interface are implicitly public, so you can omit the public modifier.
  - Notice that an **interface is not a class**. You **cannot** create an instance of an interface.

Defining an Interface

- **Defining a Java Interface**:

```
public interface Set<E> {
      public void insert(E e);
      public void clear();
      public boolean contains(E o);
      public boolean isEmpty();
      public boolean remove(E o);
      public int size();
}
```

Implementing an Interface

- A class is said to "**implement**" an interface if it provides definitions for these methods

```
public class BagSet<E> implements Set<E>{
…
}
```

- Now, we may use a BagSet any place that an object of type Set is expected
- A class implementing an interface can implement additional methods
- A class can implement several interfaces

Motivation for Interfaces

- **Two Opposing Goals,** which Java programmers must deal with:

  Strong typing and General-Purpose Functions
- **Strong Typing**: In strongly typed languages, like Java, the type of every variable must be specified. This makes debugging much easier
- **General-Purpose Functions**: We would like to write methods that can be applied to many different types. For example, methods for **sorting** that can work with ints, doubles, Strings, etc. Advantages:
  - Less Coding
  - Less likely to have typos
  - Easier maintenance of code
- **The Problem**: Strong typing implies that, for example, to write a sorting function, we need to specify the types of the parameters (int, double, String, etc.). This makes it **impossible to write a generic sorting function**. It would seem that we need to implement many sorting functions (**sortInts( ), sortDoubles( ), sortStrings( ), sortDates( ), sortRationals( ), …**)
- **The Solution:** How can we solve the problem? By using Interfaces!

Java Interfaces

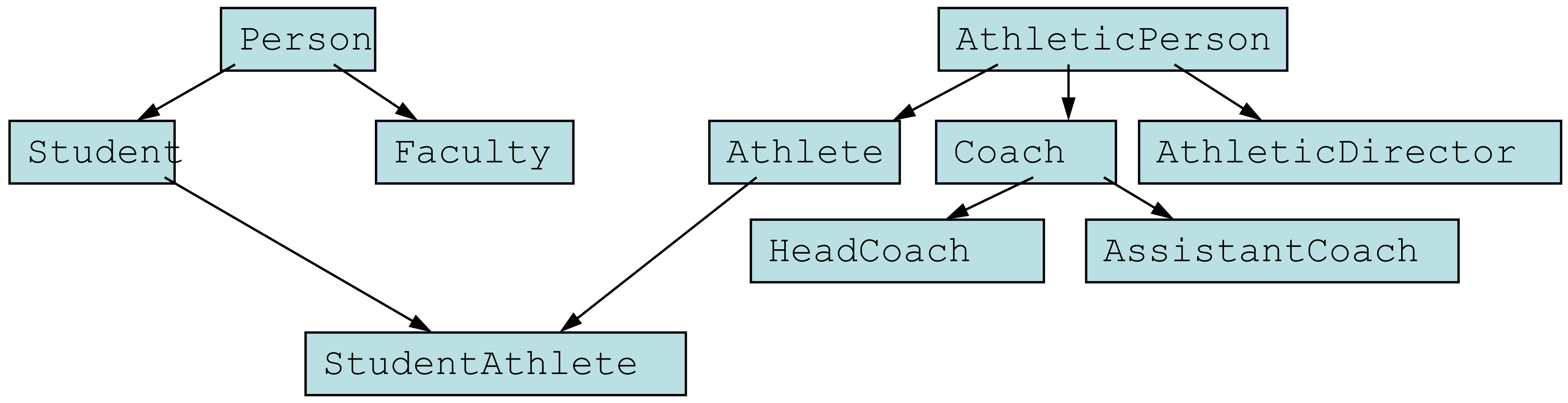
- **How it works**: Suppose you want to write a sorting method for objects of some class X. Sorting requires that you be able to compare the relative values of objects (<, >, <=, >=, ==)
  - You implement a **general-purpose sorting method** using a comparison method (e.g., compareTo( ))
  - The user of your sorting function **defines this comparison method** (compareTo( )) for objects of class X.
  - Now it is possible to **invoke** your general sorting method on objects of class X
- **To make this work**: Java needs to provide some mechanism for general-purpose functions (like sort) to specify **what behavior they require** from specific classes (like X). This is the purpose of a Java interface.

Comparable Interfaces

- The **Comparable** interface specifies a method called **compareTo** that takes an object as a parameter and returns a negative integer, zero, or a positive integer as the current object is less than, equal to, or greater than the specified object
- Have we seen classes implementing this interface? Yes!
  - **String**
  - **Integer**
  - **Double**
  - All primitive wrapper classes implement **Comparable**
- By using interfaces a function like Collections.sort() can sort an ArrayList of objects that implement the Comparable interface. For example, an ArrayList of Integers, of Strings, etc.
- Can Collections.sort() sort an ArrayList of your own objects (e.g., ArrayList of Cars?) Yes! Just make the Car class implement the **Comparable** interface

Multiple Inheritance

- There are many situations where a simple class hierarchy is not adequate to describe a class' structure
- Example: Suppose that we have our class hierarchy of university people and we also develop a class hierarchy of athletic people:



- **StudentAthlete**: Suppose we want to create an object that inherits all the elements of a **Student** (admission year, GPA) as well as all the elements of an **Athlete** (sport, amateur-status)

Multiple Inheritance

- Can we define a **StudentAthlete** by inheriting all the elements from both **Student** and **Athlete**?

  public class StudentAthlete extends Student, extends Athlete { … }

- Alas, no. At least not in Java

  `Nice try! But not allowed in Java`

- **Multiple Inheritance**:
  - Building a class by extending multiple base classes is called **multiple inheritance**
  - It is a very powerful programming construct, but it has many **subtleties** and **pitfalls**. (E.g., If Athlete and Student both have a **name** instance variable and a **toString( )** method, which one do we inherit?)
  - Java **does not** support multiple inheritance. (Although C++ does.)
    - In Java a class can be **extended** from **only one** base class
    - However, a class can **implement any number** of **interfaces**.

Multiple Inheritance with Interfaces

- Java lacks multiple inheritance, but there is an alternative
  What **public methods** do we require of an Athlete object?
  - String **getSport**( ): Return the athlete's sport
  - boolean **isAmateur**( ): Does this athlete have amateur status?
- We can define an interface **Athlete** that contains these methods:

```
public interface Athlete {
    public String getSport( );
    public boolean isAmateur( );
}
```

- Now, we can define a StudentAthlete that **extends** Student and **implements** Athlete

Multiple Inheritance with Interfaces

- StudentAthlete **extends** Student and **implements** Athlete:

```
public class StudentAthlete extends Student implements Athlete
  {
    private String mySport;
    private boolean amateur;
    // … other things omitted
    public String getSport( ) { return mySport; }
    public boolean isAmateur( ) { return amateur; }
}
```

- **StudentAthlete** can be used:
  - Anywhere that a **Student object is expected** (because it is **derived** from Student)
  - Anywhere that an **Athlete object is expected** (because it **implements** the public interface of Athlete)
- So, we have effectively achieved some of the goals of **multiple inheritance**, by using Java' single inheritance mechanism

Common Uses of Interfaces

- Interfaces are flexible things and can be used for many purposes in Java:
  - A work-around for Java's lack of **multiple inheritance.**
    (We have just seen this.)
  - Specifying **minimal functional requirements** for classes (This is its **principal** purpose.)
  - For defining groups of related **symbolic constants**.
    (This is a somewhat **unexpected** use, but is not uncommon.)

Using Interfaces for Symbolic Constants

- In addition to containing method declarations, interfaces can contain **constants**, that is, variables that are **public final static**.

```
interface OlympicMedal {
  static final String GOLD = "Gold";
  static final String SILVER = "Silver";
  static final String BRONZE = "Bronze";
}
```

- **Considered bad practice.**

Default Methods

- Java 8 introduces "*Default Method*", a new feature
- Add new methods to the interfaces without breaking the existing implementation of these interface.

```
public interface A {
  public void m1();
  default public void m2 {
      println("default m2″;
  }
}
public class B implements A {
  public void m1() {…}
}
B b = new B();
b.m2(); // print "default m2"
```

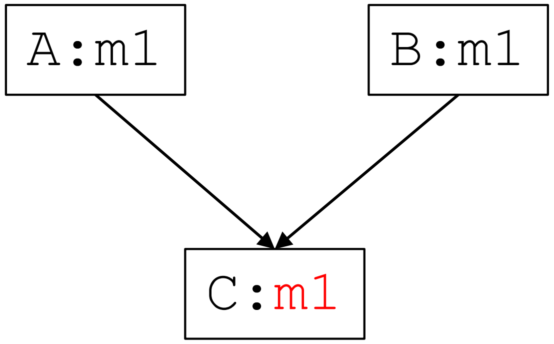
Abstract classes versus interfaces

- After introducing *Default Method*, it seems that interfaces and abstract classes are same.
- However, they are still different concept in Java 8.
- Abstract class can define constructor. They can have a state associated with them.
- *default method* can be implemented only in the terms of invoking other interface methods, with no reference to a particular implementation's state.
- Both use for different purposes and choosing between two really depends on the scenario context.

Multiple Inheritance Ambiguity Problems

Since java class can implement multiple interfaces and each interface can define *default method* with same method signature, therefore, the inherited methods can conflict with each other.

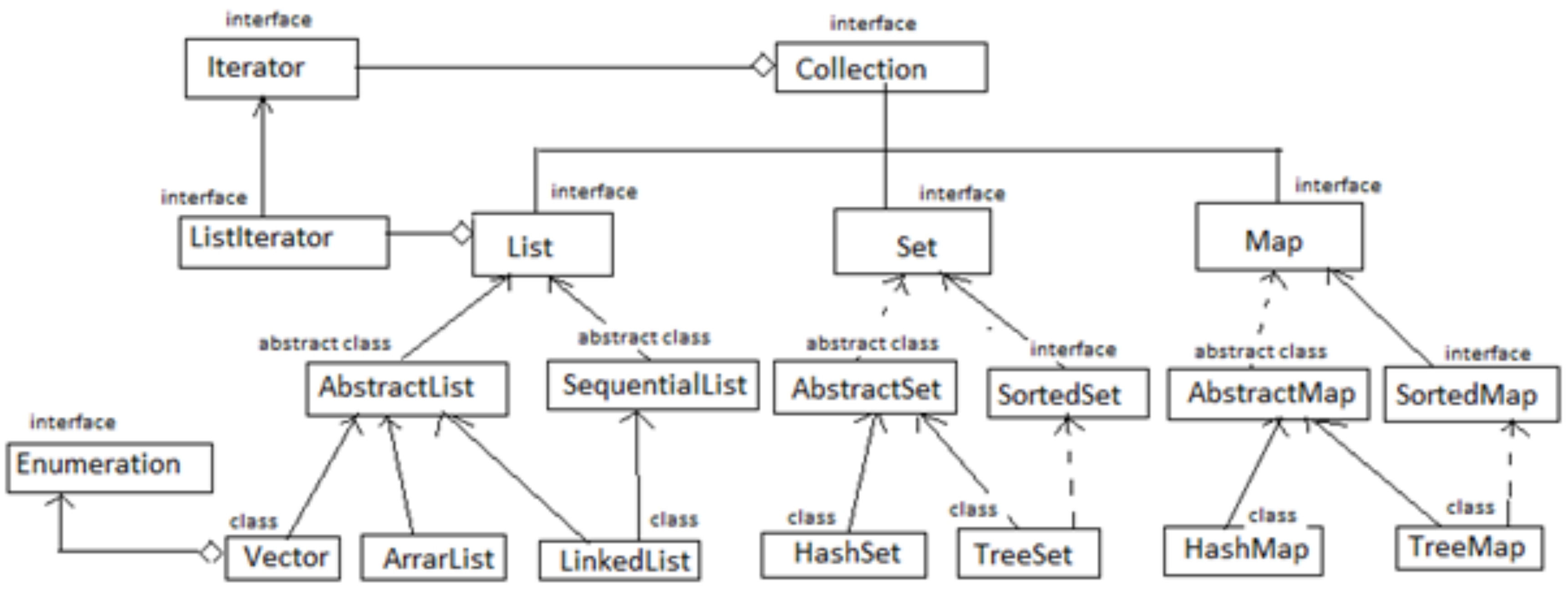
```
public interface A {
  default int m1(){
    return 1;
  }
}
public interface B {
  default int m1(){
    Return 2;
  }
}
public class C implements A, B
{
}
```



This code will fail to compile

Interface Hierarchies

- Inheritance applies to interfaces, just as it does to classes. When an interface is **extended**, it inherits all the previous methods



Quiz 1: True /False

- An interface can contain following type of members:
  - public, static, final fields (i.e., constants)
  - default and static methods with bodies

A. True
B. False

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Quiz 2: True /False

A class can implement multiple interfaces and many classes can implement the same interface.

A. **True**
B. **False**

Quiz 2: True /False

A class can implement multiple interfaces and many classes can implement the same interface.

A. **True**
B. **False**

Quiz 3: What is the output?

```
abstract class Demo{
  public int a;
  public Demo(){ a = 10; }
  abstract public void set();
  abstract final public void get();
}
class Test extends Demo{
  public void set(int a){this.a = a;}
  final public void get(){
       System.out.println("a = " + a);
}
public static void main(String[] args){
  Test obj = new Test();
  obj.set(20);
  obj.get();     }
}
```

A. a = 10
B. a = 20
C. Compile error

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public static void main(String[] args){
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  obj.set(20);
  obj.get();    }
}
```

Final method can't be overridden. Thus, an abstract function can't be final.

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B. a = 20
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Quiz 4:

Can an interface extend another interface?

A. No. Only classes can be extended.
B. No. Interfaces can not be part of a hierarchy.
C. Yes. Since all interfaces automatically extend Object.
D. Yes.

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Quiz 5:

Can an interface be given the private access modifier?

A. No. Then the interface could never be used.
B. No. Since only private classes could use the interface.
C. Yes. This would make all of its methods and constants private.
D. Yes. This would mean that only classes in the same file could use the interface.

Quiz 5:

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