

Interfaces

Introduction to Programming and
Computational Problem Solving II

CSE 8B

Lecture 16

Announcements

- Assignment 6 is due today, 11:59 PM
 - Upgrade beginning Mar 8, 12:01 AM
- Assignment 7 will be released today
 - Due Mar 12, 11:59 PM

Abstract classes and interfaces

- Remember, a superclass defines common behavior for **related** subclasses
- An *interface* can be used to define common behavior for classes, including **unrelated** classes
- Interfaces and abstract classes (covered last lecture) are closely related to each other

Abstract classes

- Remember, inheritance enables you to define a general class (i.e., a *superclass*) and later extend it to more specialized classes (i.e., *subclasses*)
- Sometimes, a superclass is so general it cannot be used to create objects
 - Such a class is called an *abstract class*
- An **abstract** class can contain abstract methods that are implemented in **concrete** subclasses
- Just like nonabstract classes, models **is-a** relationships
 - For example
 - Circle **is-a** GeometricObject
 - Rectangle **is-a** GeometricObject

Abstract class as a data type

- Remember, an abstract class cannot be instantiated using the new operator
- However, an abstract class can be used as a data type

– Example

```
GeometricObject[] objects = new GeometricObject[2];  
objects[0] = new Circle();  
objects[1] = new Rectangle();
```

Abstract classes and interfaces

- An abstract class can contain abstract methods that are implemented in concrete subclasses
- An interface is a class-like construct that contains **only** constants and abstract methods
 - In many ways, an interface is similar to an abstract class, but the intent of an interface is to specify common behavior for **objects**
 - For example, you can specify that the **objects** are comparable and/or cloneable using appropriate interfaces

Defining an interface

- To distinguish an interface from a class, Java uses the keyword `interface`

- The syntax to define an interface is

```
public interface InterfaceName {  
    // Constant declarations  
    // Abstract method signatures  
}
```

- Example

```
public interface Edible {  
    // Describe how to eat  
    public abstract String howToEat();  
}
```

Interfaces

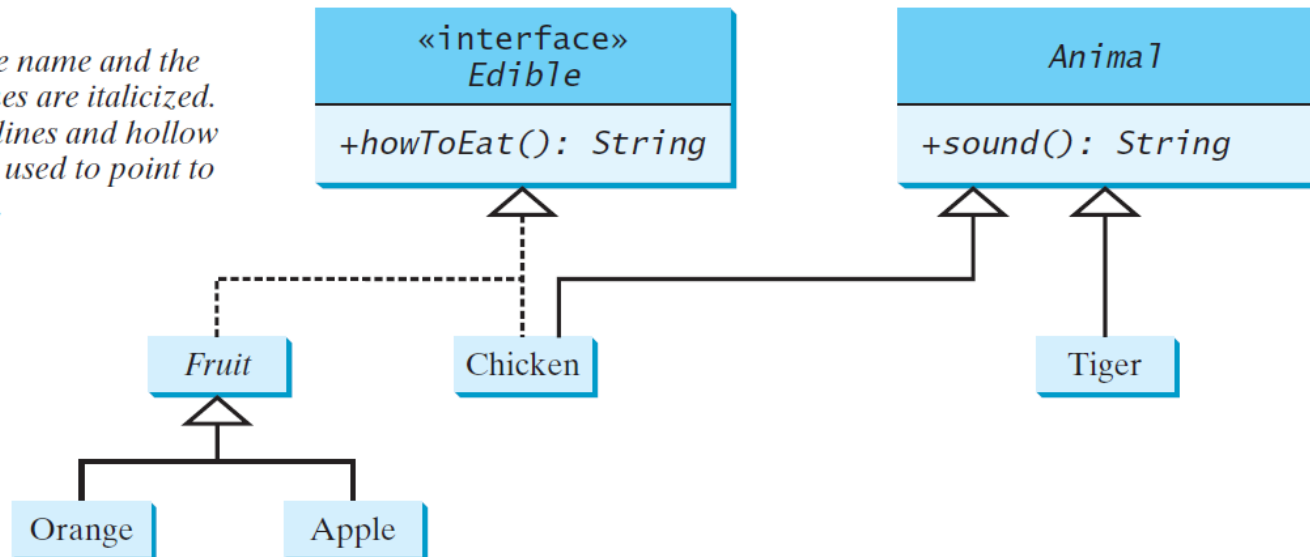
- An interface is treated like a special class in Java
- Each interface is compiled into a separate bytecode file, just like a regular class
- Like an abstract class, you cannot create an instance from an interface using the `new` operator
- Naming convention
 - Class names are nouns
 - Interface names may be adjectives or nouns
- Interfaces model **is-kind-of** relationships
 - For example
 - Fruit **is-kind-of** Edible

Interface example

- Use the `Edible` interface to specify whether an object is edible

Notation:

The interface name and the method names are italicized. The dashed lines and hollow triangles are used to point to the interface.



Interfaces

- The class for the object implementing an interface uses the keyword `implements`

- Examples

```
abstract class Fruit implements Edible {  
    // Data fields, constructors, and methods  
}
```

```
class Chicken extends Animal implements Edible {  
    // Data fields, constructors, and methods  
}
```

- The relationship between the class and the interface is known as *interface inheritance*

Omitting modifiers in interfaces

- **All data fields** are `public static final` and **all methods** are `public abstract` in an interface
 - As such, these modifiers can be omitted

```
public interface T1 {  
    public static final int K = 1;  
  
    public abstract void p();  
}
```

Equivalent

```
public interface T1 {  
    int K = 1;  
  
    void p();  
}
```

Interface static members

- Interfaces can have static members
- Like class static members, the best practice is to make invocations of static methods and access of static data fields obvious
- Use
`InterfaceName.methodName(arguments)`
`InterfaceName.variable`

Interface default methods

- A default method provides a default implementation for the method in the interface

- Use the keyword `default`

- Example

```
public interface A {  
    public default void doSomething() {  
        System.out.println("Do something");  
    }  
    ...  
}
```

- A class that implements the interface may simply use the default implementation for the method or override the method with a new implementation

Interface example

- The `java.lang.Comparable` interface defines the `compareTo` method for comparing objects
package `java.lang`;

```
public interface Comparable<E> {  
    public int compareTo(E o);  
}
```

- The `compareTo` method returns
 - A negative integer if this object is less than `o`
 - Zero if this object is equal to `o`
 - A positive integer if this object is greater than `o`

The Comparable interface

- Many classes (e.g., the numeric wrapper classes) in the Java library implement `Comparable` to define a natural order for objects
 - The `compareTo` method is implemented in these classes

The Comparable interface

```
public class Integer extends Number
    implements Comparable<Integer> {
    // class body omitted

    @Override
    public int compareTo(Integer o) {
        // Implementation omitted
    }
}
```

```
public class BigInteger extends Number
    implements Comparable<BigInteger> {
    // class body omitted

    @Override
    public int compareTo(BigInteger o) {
        // Implementation omitted
    }
}
```

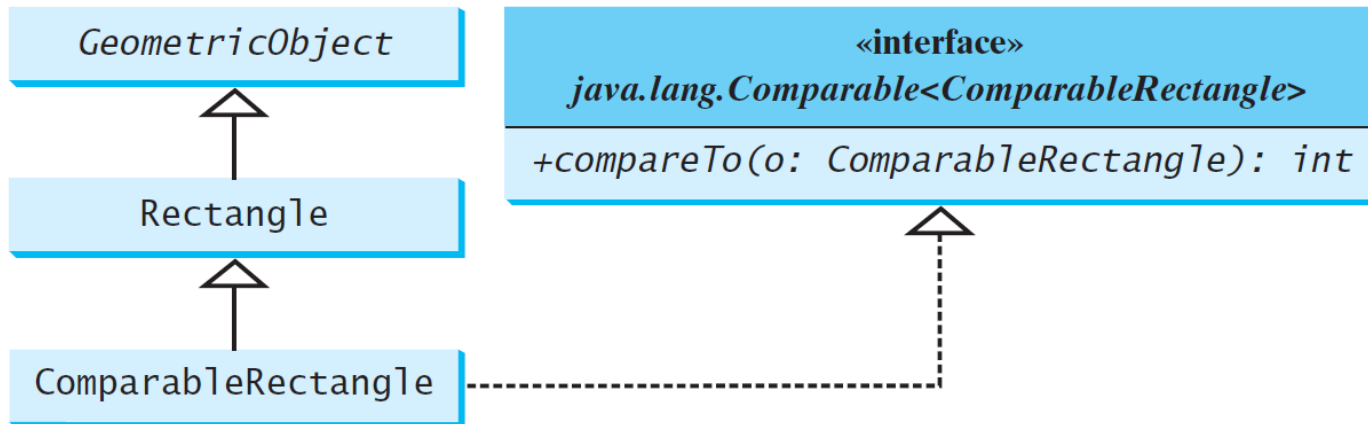
```
public class String extends Object
    implements Comparable<String> {
    // class body omitted

    @Override
    public int compareTo(String o) {
        // Implementation omitted
    }
}
```

```
public class Date extends Object
    implements Comparable<Date> {
    // class body omitted

    @Override
    public int compareTo(Date o) {
        // Implementation omitted
    }
}
```


Defining classes to implement Comparable



```
public class ComparableRectangle extends Rectangle
    implements Comparable<ComparableRectangle> {
    // Construct a ComparableRectangle with specified properties
    public ComparableRectangle(double width, double height) {
        super(width, height);
    }

    @Override // Implement the compareTo method defined in Comparable
    public int compareTo(ComparableRectangle o) {
        if (getArea() > o.getArea())
            return 1;
        else if (getArea() < o.getArea())
            return -1;
        else
            return 0;
    }
    ...
}
```

Interface example

- The `java.lang.Cloneable` interface specifies that an object can be cloned
package `java.lang`;

```
public interface Cloneable {  
}
```

- The interface is empty
 - An interface with an empty body is called a *marker interface*
- A class that implements the `Cloneable` interface is **marked** cloneable
 - Its objects can be cloned using the `clone` method **defined in the `Object` class**
 - For any object `x`, typically
 - `x.clone() != x`
 - `x.clone().getClass() == x.getClass()`
 - `x.clone().equals(x)`
 - `x.clone()` **should be independent of `x`**

The Cloneable interface

- Like Comparable, many classes in the Java library implement Cloneable

- The instances of these classes can be cloned

- Examples

```
Calendar calendar = new GregorianCalendar(2003, 2, 1);
Calendar calendarCopy = (Calendar)calendar.clone();
System.out.println("calendar == calendarCopy is " +
    (calendar == calendarCopy));
System.out.println("calendar.equals(calendarCopy) is " +
    calendar.equals(calendarCopy));
```

Explicit
casting

displays

```
calendar == calendarCopy is false
calendar.equals(calendarCopy) is true
```

The Cloneable interface

- Arrays are cloneable
 - You can clone an array using the clone method

```
int[] list1 = {1, 2};  
int[] list2 = list1.clone();
```
 - ArrayList implements Cloneable

Defining classes to implement Cloneable

- A class that implements the Cloneable interface must override the clone method defined in the Object class
 - `protected native Object clone() throws CloneNotSupportedException;`
- The keyword `native` indicates this method is not written in Java
 - It is implemented in the JVM for the native platform
- The class must override the clone method and change the visibility modifier to `public`, so it can be used in any package
- The class must implement Cloneable
 - Otherwise, CloneNotSupportedException is thrown

Defining classes to implement Cloneable

- The clone method in a class that implements the Cloneable interface should return the object obtained by invoking the super.clone method but, to achieve independence, must also **deep copy** the contents of data fields that are **mutable objects**

```
public abstract class GeometricObject
    implements Cloneable
{
    private String color;
    private boolean filled;
    private java.util.Date dateCreated;
    ...
    @Override
    public Object clone() throws CloneNotSupportedException {
        GeometricObject go = (GeometricObject)super.clone();
        // String is immutable, so deep copy is not required
        // boolean is primitive, so deep copy is not required
        go.dateCreated = (java.util.Date)dateCreated.clone();
        return go;
    }
}
```

Shallow copy: for data fields that are **mutable objects**, the **references** are copied

Interfaces vs. abstract classes

- In an interface, the data must be constants; an abstract class can have all types of data
- Each method in an interface has only a signature without implementation (except default and static methods); an abstract class can have concrete methods

	<i>Variables</i>	<i>Constructors</i>	<i>Methods</i>
Abstract class	No restrictions.	Constructors are invoked by subclasses through constructor chaining. An abstract class cannot be instantiated using the new operator.	No restrictions.
Interface	All variables must be public static final .	No constructors. An interface cannot be instantiated using the new operator.	May contain public abstract instance methods, public default, and public static methods.

Interfaces vs. abstract classes

- An interface can inherit other interfaces using the `extends` keyword. Such an interface is called a *subinterface*.

```
public interface NewInterface
    extends Interface1, ..., InterfaceN {
    // constants and abstract methods
}
```

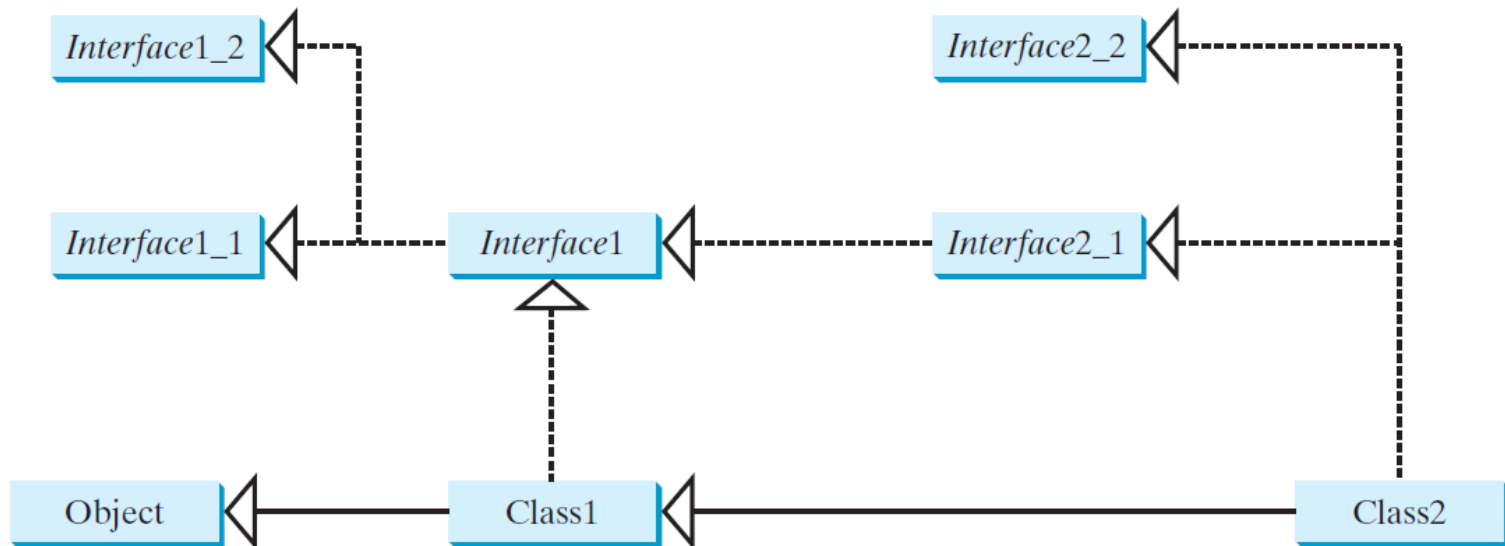
- A class implementing `NewInterface` must implement the abstract methods defined in `NewInterface`, `Interface1`, ..., and `InterfaceN`.
- An interface can extend other interfaces, but not classes

Interfaces vs. abstract classes

- All classes share a single root, the `Object` class, but **there is no single root for interfaces**
- Like a class, an interface also defines a type
 - A variable of an interface type can reference any instance of the class that implements the interface
- If interface 2 extends interface 1, then interface 1 is like a superclass for interface 2
- You can use an interface as a data type and cast a variable of an interface type to its subclass, and vice versa

Interfaces vs. abstract classes

- **A class can implement multiple interfaces, but it can only extend one superclass**
- Suppose that `c` is an instance of `Class2`
 - `c` is also an instance of `Object`, `Class1`, `Interface1`, `Interface1_1`, `Interface1_2`, `Interface2_1`, and `Interface2_2`



Conflicting interfaces

- On rare occasion, a class may implement two interfaces with conflicting information (e.g., two same constants with different values or two methods with same signature but different return type)
- This type of errors will be detected by the compiler

Class design guidelines

Coherence

- A class should describe a single entity, and all the class operations should logically fit together to support a coherent purpose
- A single entity with many responsibilities can be broken into several classes to separate responsibilities

Consistency

- Follow standard Java programming style and naming conventions
- Choose informative names for classes, data fields, and methods
 - Make names consistent
- Place the data declaration before the constructor, and place constructors before methods
- Provide a no-arg constructor (or document why the class does not support one)

Encapsulation

- A class should use the `private` modifier to hide its data from direct access by clients
- Provide getter methods and setter methods to provide users with access to the private data, but only to private data you want the user to see or to modify
- A class should also hide methods not intended for client use
- Make methods `protected` if they are intended for extenders of the class

Clarity and completeness

- A class should have a clear contract that is easy to explain and easy to understand
- Design a class that imposes no restrictions on how or when the user can use it
 - Design the properties in a way that lets the user set them in any order and with any combination of values
 - Design methods that function independently of their order of occurrence
- Methods should be defined intuitively without causing confusion
- You should not declare a data field that can be derived from other data fields
- A class should provide a variety of ways for customization through properties and methods that, together, are **minimal and complete**

Instance vs. static

- A variable or method dependent on a specific instance of the class must be an instance variable or method
- A variable shared by all the instances of a class should be declared static
- A method not dependent on a specific instance should be defined as a static method
- Always reference static variables and methods from a class name to improve readability and avoid errors
- Do not initialize a static data field from a constructor parameter
 - Use a setter method to change the static data field

Inheritance vs. aggregation

- Use inheritance to model **is-a** relationships
- Use aggregation (and composition) to model **has-a** relationships

Interfaces vs. abstract classes

- Abstract classes and interfaces can both be used to model common behavior for objects
 - Interfaces cannot contain data fields, only constants
- In general, a strong **is-a** relationship clearly describes a parent-child relationship should be modeled using **classes**
- An **is-kind-of** relationship indicates an object possesses a certain property and can be modeled using **interfaces**
 - An interface can define a common supertype for **unrelated classes**
- **A subclass can extend only one superclass, but can implement any number of interfaces**
- You can also use interfaces to circumvent single inheritance restriction if multiple inheritance is desired
 - You must design one as a superclass, and others as interface

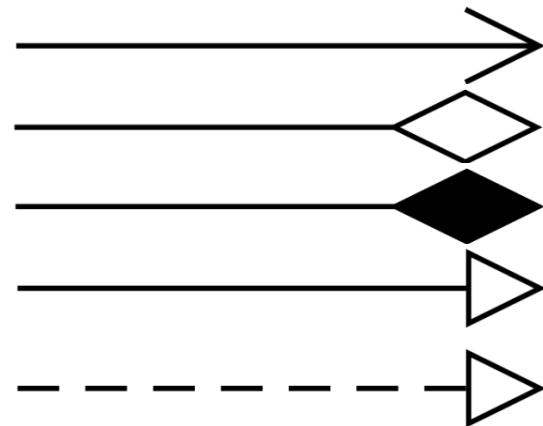
Unified Modeling Language (UML)

+ public

protected

- private

- Static variables and methods are underlined
- Abstract class names and methods are *italicized*
- Interface names and methods are *italicized*
- Open or no arrow is association
- Hollow diamond is aggregation
- Filled diamond is composition
- Hollow triangle is inheritance
- Dashed line with hollow triangle is implementation of interface



Next Lecture

- Assertions and career day
 - Participation is optional
 - No prelecture quiz
 - Not on final assessment