# Inheritance and Polymorphism, Part 2

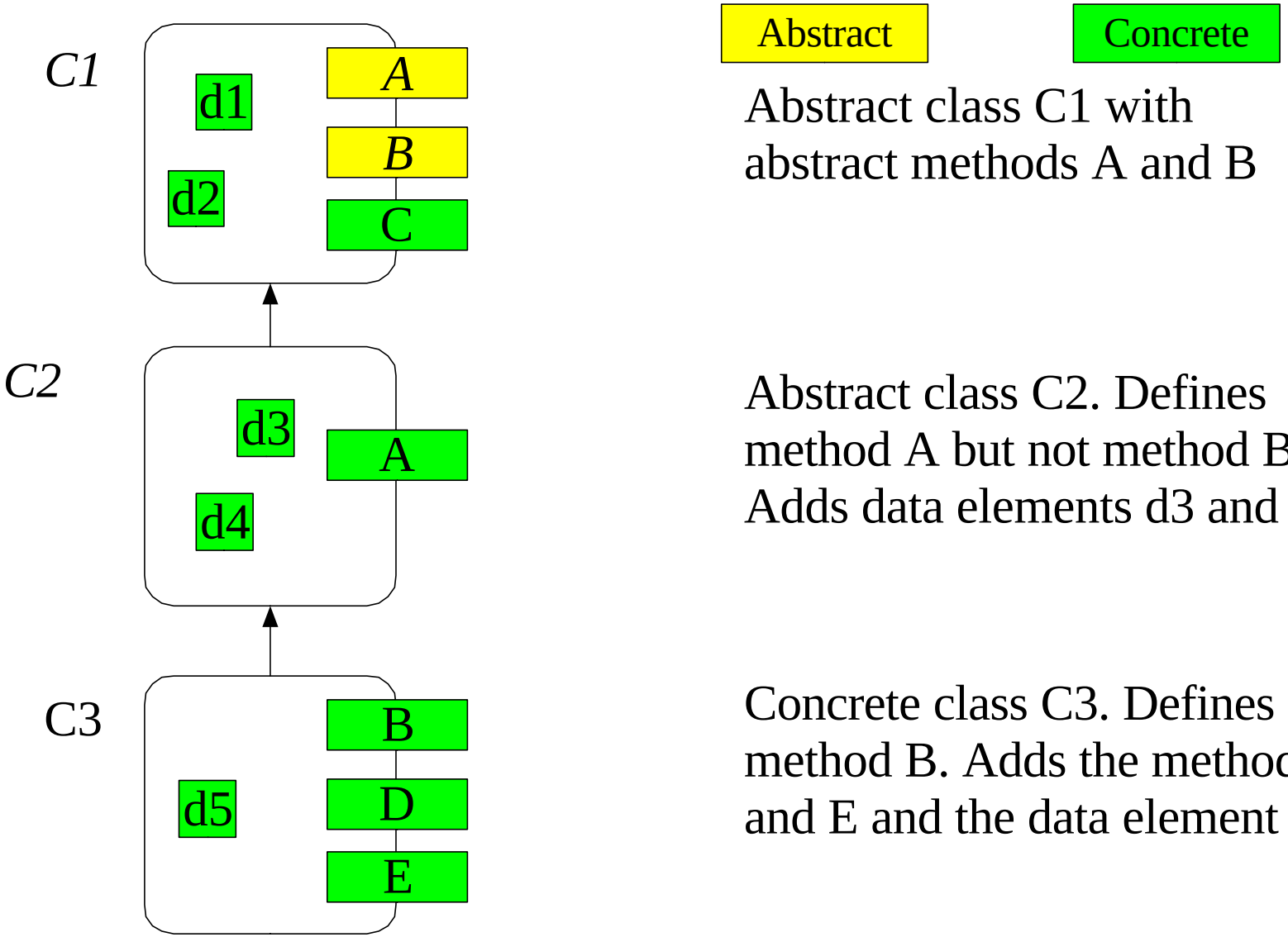
- Abstract Classes and Methods
- Multiple Inheritance
- Interfaces
- Inner Classes

# Abstract Class and Method

- An *abstract class* is a class with an abstract method.
- An *abstract method* is method with out a body, i.e., only declared but not defined.

- It is not possible to make instances of abstract classes.
- Abstract method are defined in subclasses of the abstract class.

# Abstract Class and Method, Example




Abstract class C1 with abstract methods A and B

Abstract class C2. Defines method A but not method B. Adds data elements d3 and d4

Concrete class C3. Defines method B. Adds the methods D and E and the data element d5.

# Abstract Classes in Java

```
abstract class ClassName {
   // <class body>
}
```

- Classes with abstract methods must declared abstract.
- Classes without abstract methods can be declared abstract.
- A subclass to a concrete superclass can be abstract.
- Constructors can be defined on abstract classes.
- Instances of abstract classes cannot be made.

- Abstract fields not possible.

# Abstract Class in Java, Example

```
// [Source: Kurt Nørmark]
public abstract class Stack{

  abstract public void push(Object el);
  abstract public void pop();
  abstract public Object top();
  abstract public boolean full();
  abstract public boolean empty();
  abstract public int size();

  public void toggleTop(){
    if (size() >= 2){
      Object topEl1 = top();  pop();
      Object topEl2 = top();  pop();
      push(topEl1); push(topEl2);
    }
  }

  public String toString(){
    return "Stack";
  }
}
```

# Abstract Methods in Java

```
Abstract [access modifier] return type
      methodName([parameters]);
```

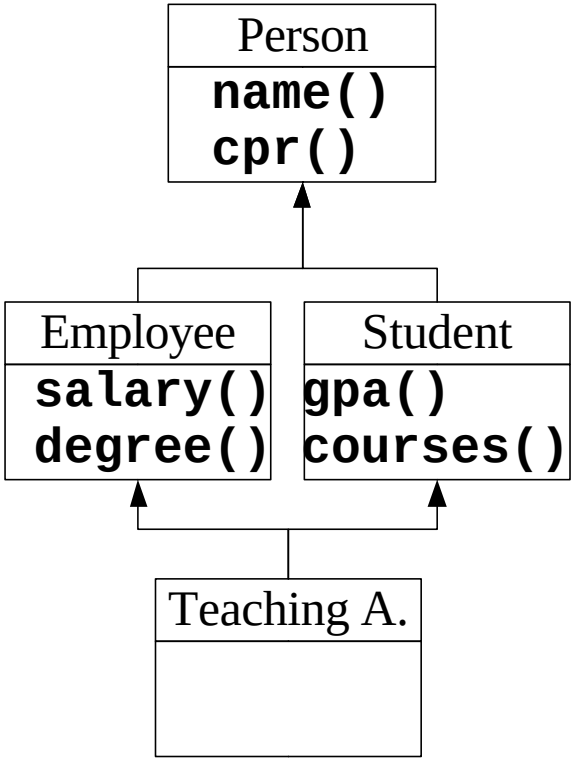
- A method body does not have be defined.
- Abstract method are overwritten in subclasses.
- Idea taken directly from C++

- You are saying: The object should have this properties I just do not know how to implement the property at this level of abstraction.

# Abstract Methods in Java, Example

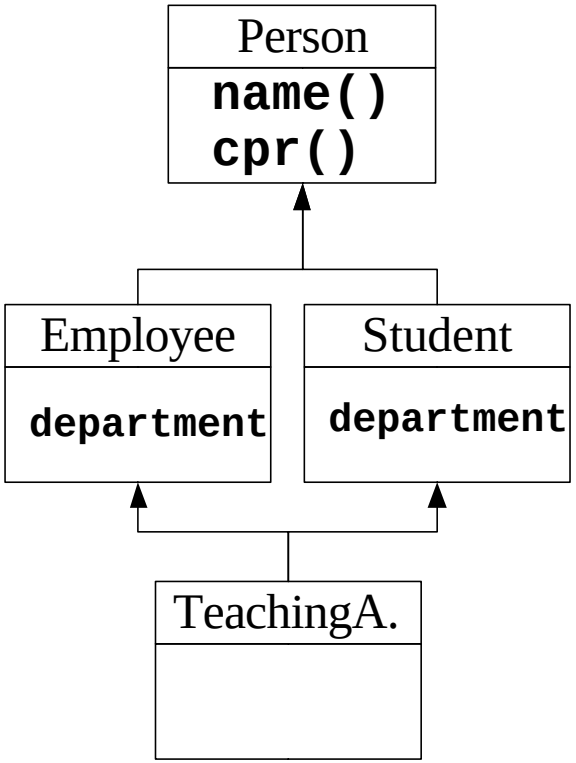
```
public abstract class Number {
   public abstract int intValue();
   public abstract long longValue();
   public abstract double doubleValue();
   public abstract float floatValue();
   public byte byteValue(){
      // method body
   }
   public short shortValue(){
      // method body
   }
}
```

# Multiple Inheritance, Example




- For the teaching assistant when want the properties from both Employee and Student.

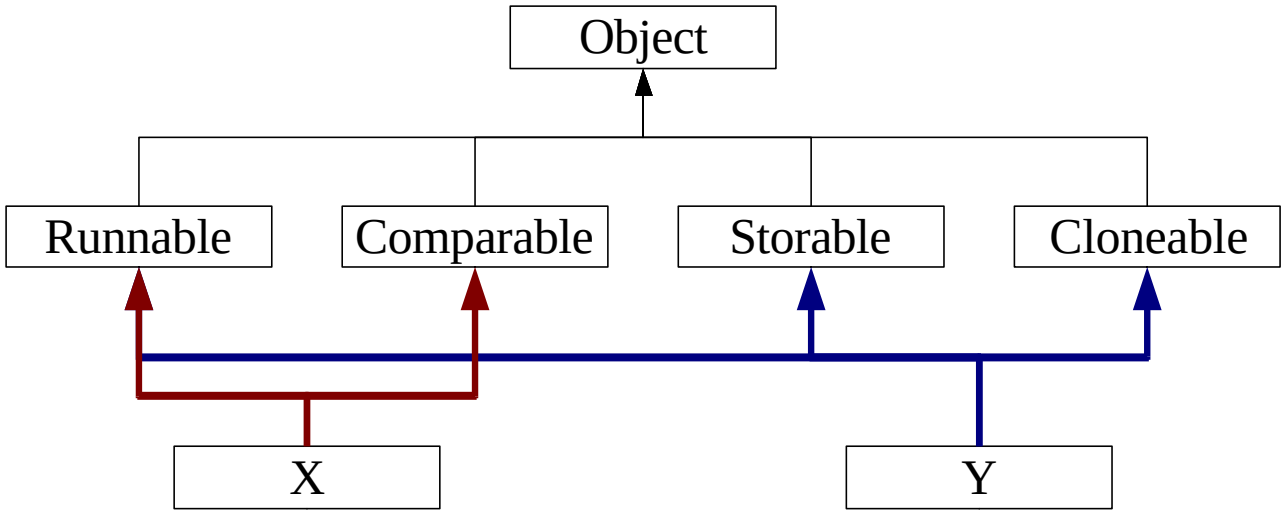
# Problems with Multiple Inheritance




```
ta = new TeachingAssistant();
ta.department;
```

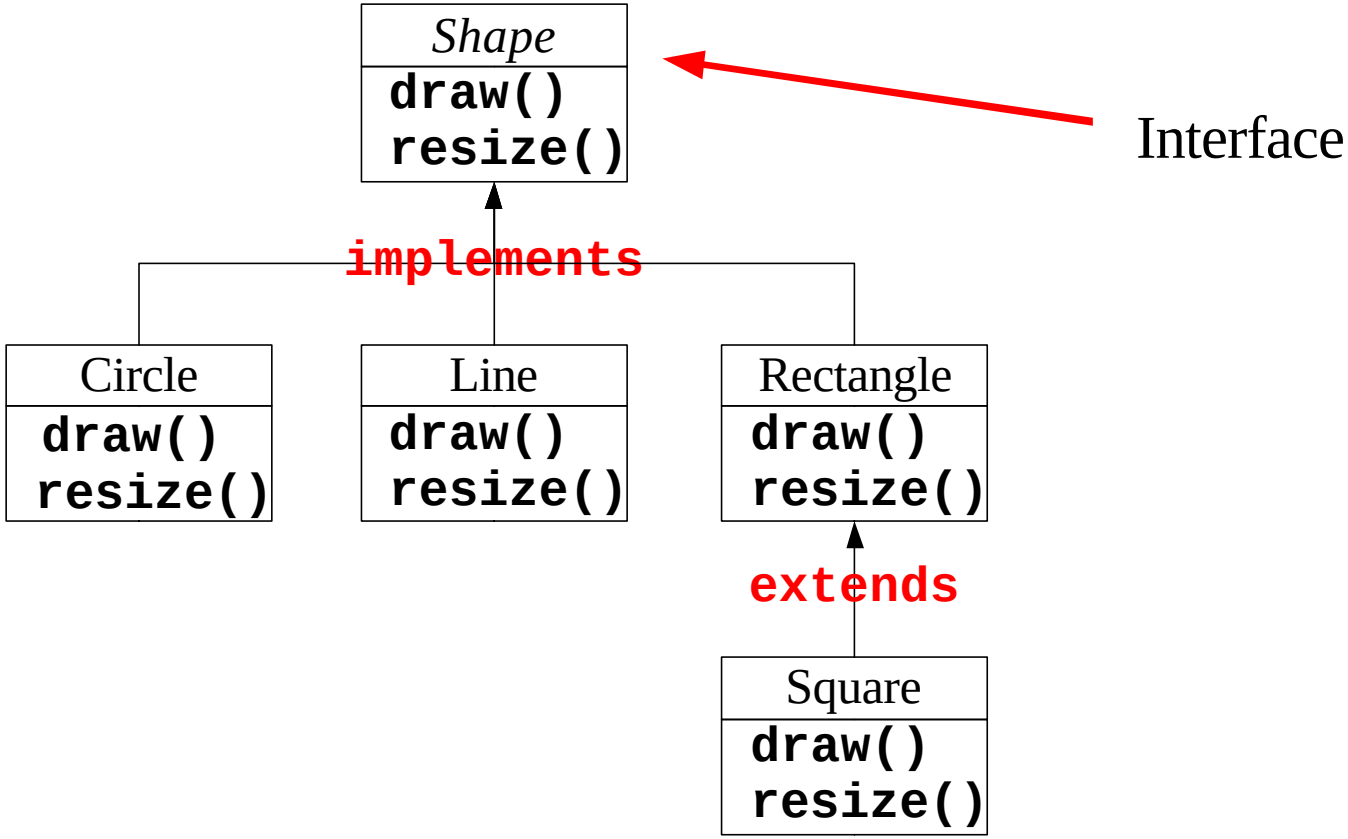
- Name clash problem: Which **`department`** does **`ta`** refers to?
- Combination problem: Can **`department`** from Employee and Student be combined in Teaching Assistant?
- Selection problem: Can you select between **`department`** from Employee and **`department`** from Student?
- Replication problem: Should there be two **`departments`** in TeachingAssistent?

# Multiple Classifications




- Multiple and overlapping classification for the classes X and Y, i.e.,
  - class X is Runnable and Comparable
  - class Y is Runnable, Storable, and Cloneable

# Java's **`interface`** Concept



# Java's **interface** Concept, cont.

```
public interface Shape {
    double PI = 3.14;   // static and final => upper case
    void draw();        // automatic public
    void resize();      // automatic public
}

public class Rectangle implements Shape {
    public void draw() {System.out.println ("Rectangle"); }
    public void resize () {}

}


public class Square extends Rectangle {
    public void draw() {System.out.println ("Square"); }
    public void resize () {}

}
```

# Java's `interface` Concept

- An *interface* is a collection of method declarations.
  - An interface is a class-like concept.
  - An interface has no variable declarations or method bodies.

- Describes a set of methods that a class can be forced to implement.
- An interface can be used to define a set of "constants".
- An interface can be used as a type concept.
  - Variable and parameter can be of interface types.
- Interfaces can be used to implement multiple inheritance like hierarchies.

# Java's **interface** Concept, cont.

```
interface InterfaceName {
   // "constant" declarations
   // method declarations
}

class ClassName implements InterfaceName {
   ...
}

class ClassName extends SuperClass implements InterfaceName
{
   ...
}

class ClassName extends SuperClass
         implements InterfaceName1, InterfaceName2 {
   ...
}

interface InterfaceName extends InterfaceName {
   ...
}
```

# Semantic Rules for Interfaces

- Type
  - An interface can be used as a type, like classes
  - A variable or parameter declared of an interface type is polymorph
    - Any object of a class that implements the interface can be referred by the variable

- Instantiaztion
  - Does not make sense on an interface.

- Access modifiers
  - An interface can be public or "friendly" (the default).
  - All methods in an interface are default abstract and public.
    - Static, final, private, and protected cannot be used.
  - All variables ("constants") are public static final by default
    - Private, protected cannot be used.

# The **`Iterator`** Interface

- The **`Iterator`** interface in the package **`java.util`** is a basic iterator that works on collections.

```
package java.util;
public interface Iterator {
    // public abstract boolean hasNext()
    boolean hasNext();
    Object next();
    void remove(); // optional
}
```

# The **`Iterator`** Interface, cont

```
// declare a variable of Interface type
Iterator iter = myShapes.iterator();
while (iter.hasNext()) {
  Shape s = (Shape)iter.next();
  s.draw();
}
```

- Note the *cast* **`(Shape)`** since **`Collection`** and **`Iterator`** manage **`Object`**s.
- When a collection has a natural ordering, **`Iterator`** will respect it.

# The **`Iterator`** Interface, cont

```
// ArrayList covered in Collections lecture
ArrayList al = new ArrayList();
for (int i = 0; i < 8; i++){
    al.add (new Integer(i));
}
Iterator iter = al.iterator();
while (iter.hasNext()){
  Integer i = (Integer)iter.next();
  System.out.println (i);
}
```

- Put this in **`main`** method and execute it.
- Note the again the cast **`(Integer)s`**.

# The `Cloneable` Interface

- A class X that implements the **`Cloneable`** interface tells clients that X objects can be cloned.
- The interface is empty, i.e. has no methods.
- Returns an identical copy of an object.
  - A *shallow copy*, by default.
  - A *deep copy* is often preferable.

- Prevention of cloning
  - Necessary if unique attribute, e.g., database lock or open file reference.
  - Not sufficient to omit to implement **`Cloneable`**.
    - Sub classes might implement it.
  - **`clone`** method should throw an exception:
    - **`CloneNotSupportedException`**

# The **Cloneable** Interface, Example 1

```
// Car example revisited
public class Car implements Cloneable {
    private String make;
    private String model;
    private double price;
   // default constructor
   public Car() {
        this ("", "", 0.0);
    }
   // give reasonable values to instance variables
   public Car(String make, String model, double price){
        this.make  = make;
        this.model = model;
        this.price = price;
    }
    // the Cloneable interface
    public Object clone() {
        return new Car (this.make, this.model, this.price);
    }
}
```

# The **Cloneable** Interface, Example 2

```
package geometric; // [Source: java.sun.com]

/** A clonable Point */
public class Point extends java.awt.Point implements Cloneable
{
    // the Cloneable interface
    public Object clone(){
        try {
            return (super.clone()); // protected in Object
        }
        // must catch exception will be covered later
        catch (CloneNotSupportedException e){
            return null;
        }
  }
  public Point(int x, int y){
    super(x,y);
  }
}
```

# The **`Serializable`** Interface

- A class X that implements the **`Serializable`** interface tells clients that X objects can be stored on file or other persistent media.
- The interface is empty, i.e., has no methods.

# Interface vs. Abstract Class

| Interface | Abstract Class |
| --- | --- |
| • Methods can be declared. | • Methods can be declared |
| • No method bodies | • Method bodies can be defined |
| • “Constants” can be declared | • All types of variables can be declared |
| • Has no constructor | • Can have constructors |
| • Multiple inheritance possible. | • Multiple inheritance not possible. |
| • Has no top interface. | • Always inherits from **`Object`**. |
| • Multiple "parent" interfaces. | • Only one "parent" class |

# Interfaces and Classes Combined

- By using interfaces objects do not reveal which classes the belong to.
  - With an interface it is possible to send a message to an object without knowing which class(es) it belongs. The client only know that certain methods are accessible
  - By implementing multiple interfaces it is possible for an object to change role during its life span.

- Design guidelines
  - Use classes for specialization and generalization
  - Use interfaces to add properties to classes.

# Multiple Inheritance vs. Interface

| Multiple Inheritance | Interface |
| --- | --- |
| • Declaration and definition is inherited. | • Only declaration is inherited. |
| • Little coding to implement subclass. | • Must coding to implement an interface. |
| • Hard conflict can exist. | • No hard conflicts. |
| • Very hard to understand (C++ close to impossible). | • Fairly easy to understand. |
| • Flexible | • Very flexible. Interface totally separated from implementation. |

# Inner Classes

- Fundamental language feature, added in Java 1.1.
- Used a lot in JFC/Swing (GUI programming).
- Nest a class within a class.
- Class name is hidden.
- More than hiding and organization
  - Call-back mechanism.
  - Can access members of enclosing object.

# Inner Classes, Example

```
public class Parcel1 {  // [Source: bruceeckel.com]
  class Contents {
    private int i = 11;
    public int value() { return i; }
  }
  class Destination {
    private String label;
    Destination(String whereTo) {
      label = whereTo;
    }
    String readLabel() { return label; }
  }
  public void ship(String dest) {
    Contents c = new Contents();
    Destination d = new Destination(dest);
    System.out.println(d.readLabel());
  }
  public static void main(String[] args) {
    Parcel1 p = new Parcel1();
    p.ship("Tanzania");
  }
}
```

# Interfaces and Inner Classes

- An outer class will often have a method that returns a reference to an inner class.

```
// [Source: bruceeckel.com]

public interface Contents {
   int value();
}

public interface Destination {
   String readLabel();
}
```

# Interfaces and Inner Classes, cont

```
public class Parcel3 { // [Source: bruceeckel.com]
  private class PContents implements Contents {
    private int i = 11;
    public int value() { return i; }
  }
  protected class PDestination implements Destination {
    private String label;
    private PDestination(String whereTo) {
      label = whereTo;
    }
    public String readLabel() { return label; }
  }
  public Destination dest(String s) {
    return new PDestination(s);
  }
  public Contents cont() {
    return new PContents();
  }
}
```

# Interfaces and Inner Classes, cont

```
class Test { // [Source: bruceeckel.com]
  public static void main(String[] args) {
    Parcel3 p = new Parcel3();
    Contents c = p.cont();
    Destination d = p.dest("Tanzania");
    // Illegal -- can't access private class:
    //! Parcel3.PContents pc = p.new PContents();
  }
}
```

# Anonymous Inner Classes, Example

- When a class in only needed in one place.
- Convenient shorthand.
- Works for both interfaces and classes.

```
// [Source: bruceeckel.com]

public class Parcel6 {
  public Contents cont() {
    return new Contents() {
      private int i = 11;
      public int value() { return i; }
    };
  }
  public static void main(String[] args) {
    Parcel6 p = new Parcel6();
    Contents c = p.cont();
  }
}
```

Note the semicolon

# Why Inner Classes?

- Each inner class can independently inherit from other classes, i.e., the inner class is not limited by whether the outer class is already inheriting from a class.

- With concrete or abstract classes, inner classes are the only way to produce the effect of "multiple implementation inheritance"

# Summary

- Purpose: Interfaces and abstract classes can be used for program design, not just program implementation [Meyer pp 239 ff].
- Abstract classes
  - Complete abstract class no methods are abstract but instatiation does not make sense.
  - Incomplete abstract class, some method are abstract.
- Java only supports single inheritance.
- Java "fakes" multiple inheritance via interfaces.
  - Very flexible because the object interface is totally separated from the objects implementation.
- Classes can be nested in Java
  - Name inner classes
  - Anonymous inner classes