Interfaces, Cloning, and Inner Classes

Chapter 6

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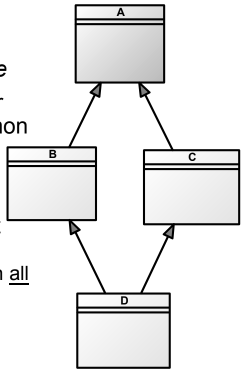
Multiple Inheritance

The “Deadly Diamond”

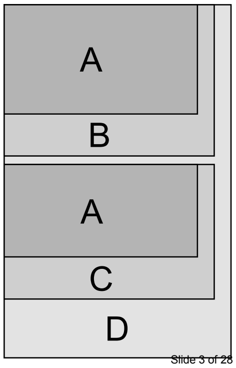


- Java™ only supports *single inheritance*
- *Multiple inheritance* is okay if the super classes (B and C) do not have a common ancestor (A)
  - This results in the “deadly diamond” inheritance hierarchy
- All Java™ classes extend class Object either directly or indirectly
  - If Java™ allowed multiple inheritance, then all Java™ programs would exhibit the deadly diamond architecture

Java™ and Multiple Inheritance

The problem with the “deadly diamond”

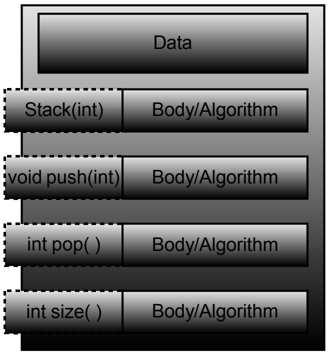
- Class D object
  - Contains a class B subobject
  - Contains a class C subobject
- Class B object
  - Contains a class A subobject
- Class C object
  - Contains a class A subobject
- Therefore, a class D object contains 2 class A subobjects
- Solving this problems (ala C++)
  - Results in inelegant code
  - Complex and inefficient compilers



Public Interfaces

Interface: another overloaded word

- A user (application programmer) uses, accesses, or *interfaces* an object through its *public interface*
- An object’s public interface includes its public
  - Methods
  - Data (often constants)
- The constructor, push, pop, and size are the Stack interface



`interface`

A partial replacement for multiple inheritance

- Permits a class to “reflect the behavior of [multiple] parents” even when the one “extends” has been used
- An **`interface`** defines a public interface or signature
  - Specifies method header or *signature* only
    - Method name
    - Return value type
    - Argument list
  - Method body is not defined
- Example

```
public interface ActionListener
{
    public  void  actionPerformed(ActionEvent event);
}
```

Implementing Interfaces

Using interfaces

- An **`interface`** is a contract
  - Compiler verifies that the implementing class overrides all **`interface`** methods (it is a compile time error if it doesn’t)
- An **`interface`** is a data type
  - Variables point to objects instantiated from implementing classes
- Example

```
public class Bar  implements  ActionListener
{   ActionListener foo = new Bar();

    public void actionPerformed(ActionEvent event)
    {
            . . .
    }
}
```

`interface` vs Abstract Class

Comparing similar constructs

- Similarities
  - Specify **`abstract`** methods, which must be overridden elsewhere
  - Specify constants (data that is **`public`**, **`static`** and **`final`**)
  - Can be used as a generic type specifier that can reference any object instantiated from a class that implements that interface, which is useful in upcasting
  - Can participate in polymorphism
  - Can be the right hand operand of **`instanceof`**
  - Cannot instantiate either an abstract class or an interface
- Differences
  - Interfaces do not specify concrete methods
  - Interfaces do not specify instance variables
  - Interfaces do not contain anything that would form a subobject

Interface Summary

Key concepts

- Interface
  - Methods are abstract
    - The **`abstract`** keyword may be used but is superfluous (i.e., not required)
    - They do not have bodies
  - Data are **`public`**, **`static`**, **`final`**
    - The keywords may be used but are superfluous (i.e., not required)
    - They are constant and must be initialized
- **`public`** interface name and file name must agree
  - Non-public interfaces should also follow this naming convention
  - **`public`** interfaces can be implemented outside of the package
  - *friendly* interfaces can only be implemented within the package
- A class can implement multiple interfaces
  - State **`implements`** once
  - Specify the interfaces as a comma separated list of interface names

`interface` Example

Interface syntax

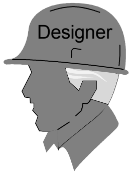
```
public interface MyInterface
{
      public void mymethod( );                          // no method body
}
```

```
public class IFexample implements MyInterface
{     public void mymethod( )                           // needed to compile
      {     System.out.println("IFexample method");
      }
}
```

```
public libraryService( )
{     MyInterface IFobject = new IFexample( );          // type specifier
      IFobject.mymethod( );                             // guaranteed
}
```

Interface Example

"Library" or "server" code (see Sortable.java and SelectSort.java)



```
public interface Sortable
{
   public int compare(Sortable  otherObject);
}
```

```
public  static  void  sort(Sortable[ ]  list)
{
   for (int bottom = list.length - 1; bottom >= 1; bottom--)
   {  Sortable     currentMax = list[bottom];
      int          currentMaxIndex = bottom;
      for (int i = bottom - 1; i >= 0; i--)
         if (currentMax.compare(list[i]) < 0)
         {  currentMax = list[i];
            currentMaxIndex = i;
         }
       if (currentMaxIndex != bottom)
       { list[currentMaxIndex] = list[bottom];
         list[bottom] = currentMax;
       }
   }
}
```

Interface Example Continued

"Application" or "client" code (see Main.java)

```
class Widget implements Sortable
{  int partNumber;

   public  Widget(int pn)
   {
      partNumber = pn;
   }

   public    int   compare(Sortable otherObject)
   {  if (partNumber < ((Widget)otherObject).partNumber)
         return  -1;
      else if (partNumber == ((Widget)otherObject).partNumber)
         return  0;
      else
         return  1;
   }
}
```

Interface Example Continued

"Application" code continued (see Main.java)

```
// Fills an array with Widgets.  Each Widget has a part number, which
// is generated with a pseudo random number generator.  The array of
// Widgets is sorted by part number with the selection sort algorithm.

public class Main
{
   public static void main(String[ ] args)
   {
      Widget[ ]    list = new Widget[20];

      for (int i = 0; i < 20; i++)
         list[i] = new Widget((int)(Math.random( )*100));

      SelectSort.sort(list);

      for (int i = 0; i < 20; i++)
         System.out.println(list[i].getPartNumber( ));
   } // main

} // class Main
```

An Aside: `class Arrays`

New with 1.2: `java.util.Arrays`

- static void sort(*type*[ ] a)
- static void sort(*type*[ ] a, int fromIndex, int toIndex)
  - fromIndex - the index of the first element (inclusive) to be sorted
  - toIndex - the index of the last element (exclusive) to be sorted
- *type* can be any built-in type
  - The sorting algorithm is a tuned quicksort
  - This algorithm offers n*log(n) performance
- *type* can be **`Object`**
  - The sorting algorithm is a modified mergesort
  - This sort is guaranteed to be *stable*: equal elements will not be reordered as a result of the sort
  - guaranteed n*log(n) performance
  - All elements in the array must implement the **`Comparable`** interface

An Aside: `class Arrays`

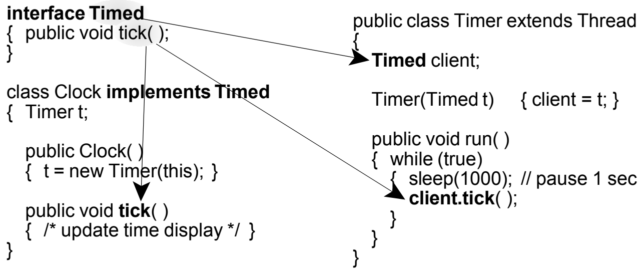
New with 1.2: **`java.util.Arrays`**

- static int binarySearch(*type*[ ] a, *type* key)
  - The array must be sorted into ascending order according to the natural ordering of its elements
  - If the array contains multiple elements with the specified value, there is no guarantee which one will be found
  - Returns the index if key is found, otherwise -(insertion point) - 1
    - Returns a value greater than or equal to 0 if key is found
    - Returns a value less than 0 if not found
  - *type* may be any built-in type
  - *type* may **`Object`**
    - Must implement **`Comparable`** interface
- interface Comparable { public int compareTo(Object o); }

Callback Methods

Another use for interfaces

- Replacement for function pointers
- Think of *Timed* & *Timer* as library code; *Clock* is written later



```
interface Timed
{  public void tick( );
}

class Clock implements Timed
{  Timer t;

   public Clock( )
   {  t = new Timer(this); }

   public void tick( )
   {  /* update time display */  }
}
```

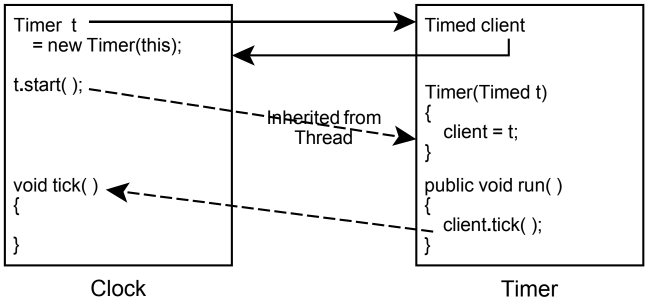
```
public class Timer extends Thread
{
   Timed client;

   Timer(Timed t)     { client = t; }

   public void run( )
   {  while (true)
      {  sleep(1000);  // pause 1 sec
         client.tick( );
      }
   }
}
```

Callback Illustrated

An association relationship



```
Timer  t
   = new Timer(this);

t.start( );


void tick( )
{

}
```

Clock

```
Timed client


Timer(Timed t)
{
   client = t;
}
public void run( )
{
   client.tick( );
}
```

Timer

Extending Interfaces

Interface inheritance

- Interfaces cannot extend classes
- One interface can extend another interface
- Any class that implements an interface which extends another interface, must define the methods in both interfaces

```
interface Swappable extends Sortable
{
   void swap(Sortable x, Sortable y);
}
```

Copying Objects

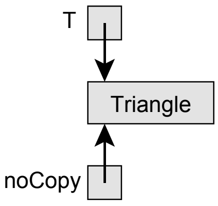
The assignment operator (see Driver.java, line 11)

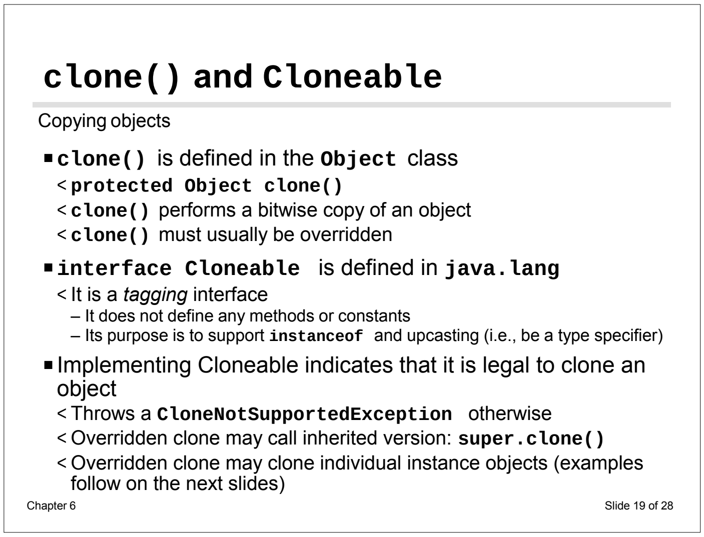
- Copies the value (address) stored in T to noCopy
- T and noCopy point to the same object

```
Triangle  T = new Triangle(0,0, 0,100, 200,200);

Triangle  noCopy = T;

if (noCopy == T)
         System.out.println("noCopy == T");
else
         System.out.println("noCopy != T");
```

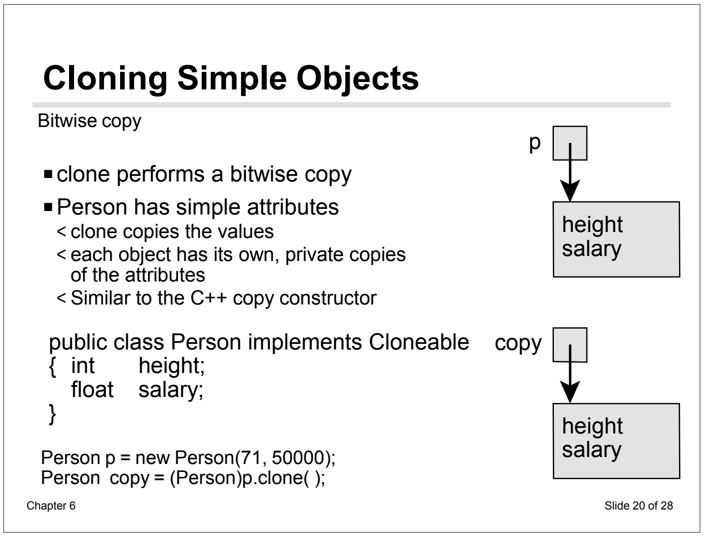




`clone()` and `Cloneable`

Copying objects

- **`clone()`** is defined in the **`Object`** class
  - < **`protected Object clone()`**
  - < **`clone()`** performs a bitwise copy of an object
  - < **`clone()`** must usually be overridden
- **`interface Cloneable`** is defined in **`java.lang`**
  - < It is a *tagging* interface
    - – It does not define any methods or constants
    - – Its purpose is to support **`instanceof`** and upcasting (i.e., be a type specifier)
- Implementing Cloneable indicates that it is legal to clone an object
  - < Throws a **`CloneNotSupportedException`** otherwise
  - < Overridden clone may call inherited version: **`super.clone()`**
  - < Overridden clone may clone individual instance objects (examples follow on the next slides)



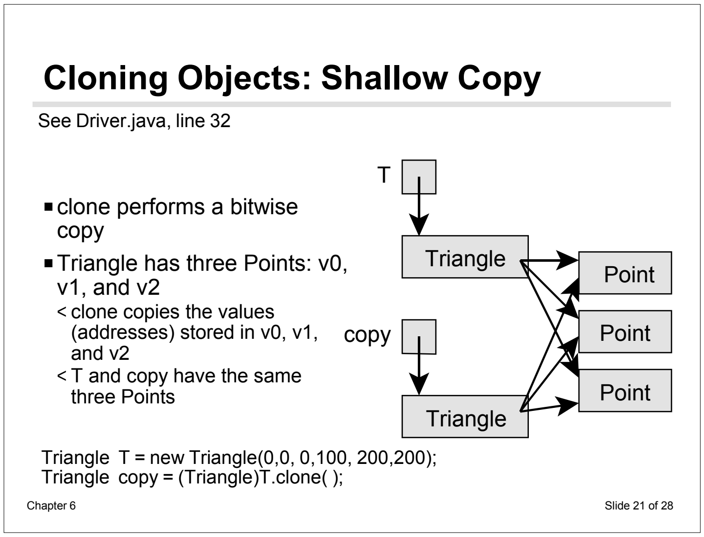
Cloning Simple Objects

Bitwise copy

- clone performs a bitwise copy
- Person has simple attributes
  - < clone copies the values
  - < each object has its own, private copies of the attributes
  - < Similar to the C++ copy constructor

```
public class Person implements Cloneable
{  int     height;
   float   salary;
}

Person p = new Person(71, 50000);
Person  copy = (Person)p.clone( );
```

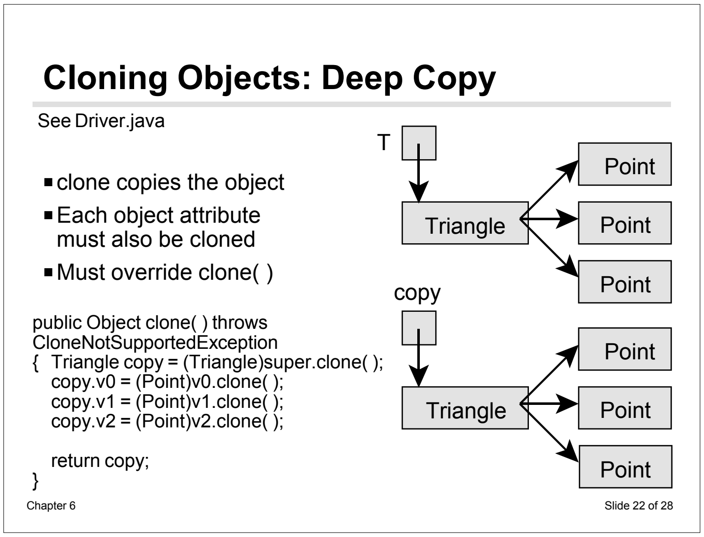


Cloning Objects: Shallow Copy

See Driver.java, line 32

- clone performs a bitwise copy
- Triangle has three Points: v0, v1, and v2
  - < clone copies the values (addresses) stored in v0, v1, and v2
  - < T and copy have the same three Points

```
Triangle  T = new Triangle(0,0, 0,100, 200,200);
Triangle  copy = (Triangle)T.clone( );
```



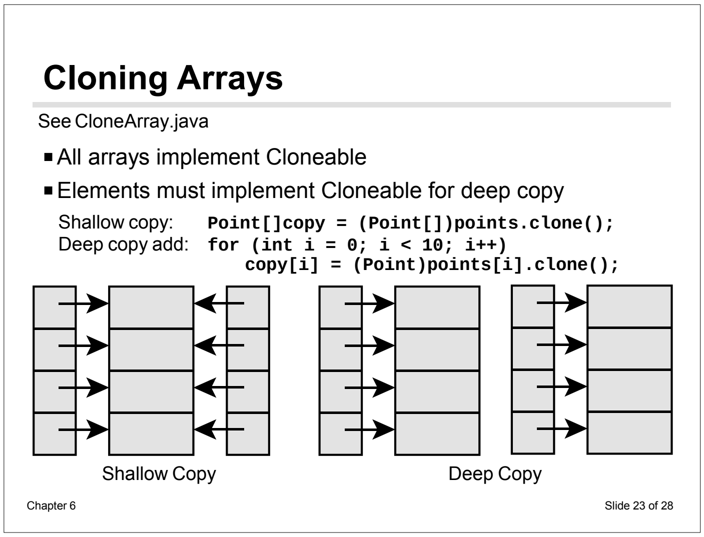
Cloning Objects: Deep Copy

See Driver.java

- clone copies the object
- Each object attribute must also be cloned
- Must override clone( )

```
public Object clone( ) throws
CloneNotSupportedException
{  Triangle copy = (Triangle)super.clone( );
   copy.v0 = (Point)v0.clone( );
   copy.v1 = (Point)v1.clone( );
   copy.v2 = (Point)v2.clone( );

   return copy;
}
```

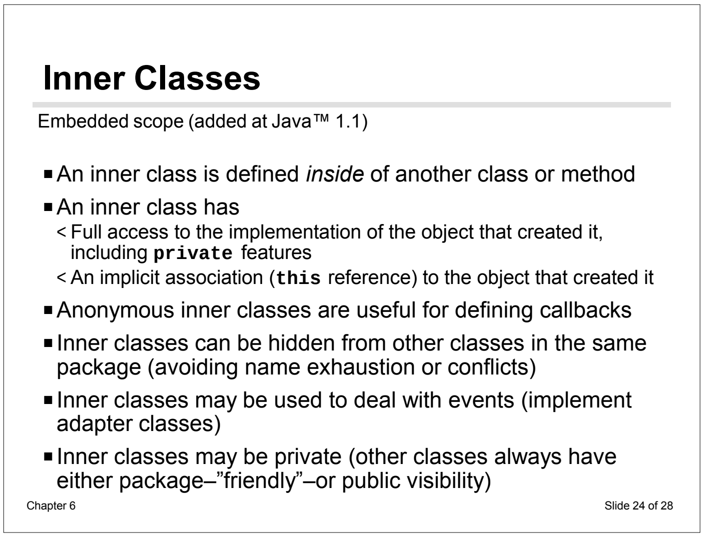


Cloning Arrays

See CloneArray.java

- All arrays implement Cloneable
- Elements must implement Cloneable for deep copy

```
Shallow copy:   Point[]copy = (Point[])points.clone();
Deep copy add:  for (int i = 0; i < 10; i++)
                   copy[i] = (Point)points[i].clone();
```



Inner Classes

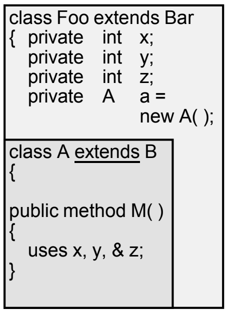
Embedded scope (added at Java™ 1.1)

- An inner class is defined *inside* of another class or method
- An inner class has
  - < Full access to the implementation of the object that created it, including **`private`** features
  - < An implicit association (**`this`** reference) to the object that created it
- Anonymous inner classes are useful for defining callbacks
- Inner classes can be hidden from other classes in the same package (avoiding name exhaustion or conflicts)
- Inner classes may be used to deal with events (implement adapter classes)
- Inner classes may be private (other classes always have either package–"friendly"–or public visibility)

Why Use Inner Classes?

Prevents duplicate data and huge constructor parameter lists

- Inner classes are not essential
  - < Make instance variables public
  - < Copy data to second object
- Outer class has <u>many</u>, <u>dynamic</u> variables
  - < Inner class needed for inheritance
  - < Inner class needs outer class variables
  - < Outer class variables change frequently



```
class Foo extends Bar
{  private   int   x;
   private   int   y;
   private   int   z;
   private   A     a =
                   new A( );
```

```
class A extends B
{

public method M( )
{
   uses x, y, & z;
}
```

Inner Class Example

Used in event handling

```
public class OuterClass
{  private String id = "OuterClass";        // private OuterClass instance variable

   private class InnerClass
   {  String name = "InnerClass";           // InnerClass instance variable

      public void demo( )
      {  System.out.println(id);            // access OuterClass instance variable
         System.out.println(name);          // access InnerClass instance variable
      }
   } // InnerClass

   static public void main(String args[ ])
   {  OuterClass OC = new OuterClass( ); }

   public OuterClass( )
   {  InnerClass IC = new InnerClass( );
      IC.demo( );
   }
} // OuterClass
```

Inner Classes Defined In Methods

see chap.07/awt/event3.java

- Inner classes defined inside of methods have access to all of the data and methods of the enclosing class through the **`this`** reference
- Inner classes defined inside of methods have access to all of the <u>final</u> *variables* and *parameters* of the method
  - < The **`final`** keyword is allowed with local variables and parameters (added at 1.1 with inner classes)
  - < It is possible that an object instantiated from the inner class could survive the method call
    - – The inner class object is given *copies* of the local variables and parameters
    - – To insure that the copies are up to date (i.e., that the method has not changed the values), the inner class object can only reference **`final`** variables

Anonymous Inner Classes

Used for event handling

- Is not given a name (which is why it is anonymous)
- Class can only be instantiated once
- Defined within a method of the enclosing class
- May access
  - < Class variables and methods from the enclosing class
  - < **`final`** data and parameters of the enclosing method
- Usage should not be more complicated than the example below (from chap.07/awt/event3.java)

```
addWindowListener ( new WindowAdapter( )
{      public void windowClosing(WindowEvent e)
            { System.exit(0); }
} );
```