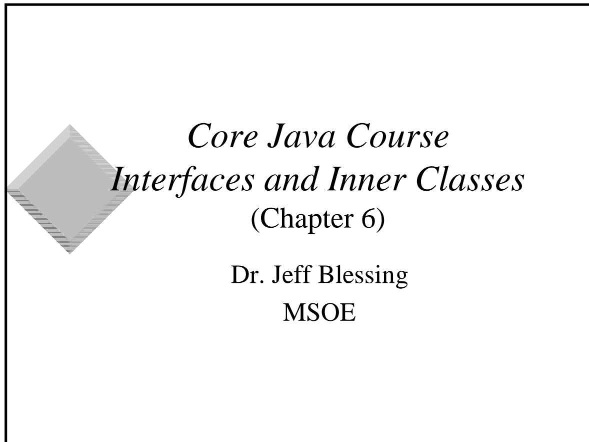

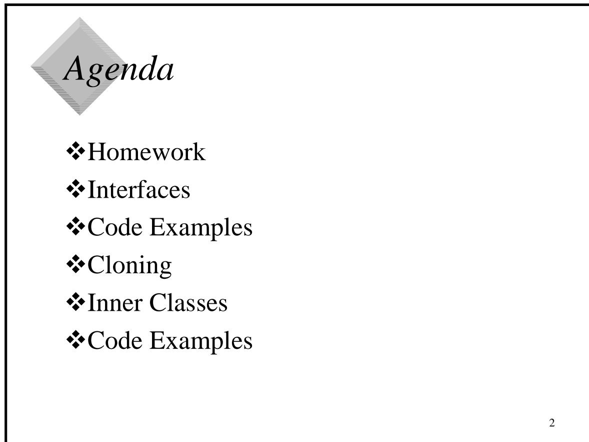

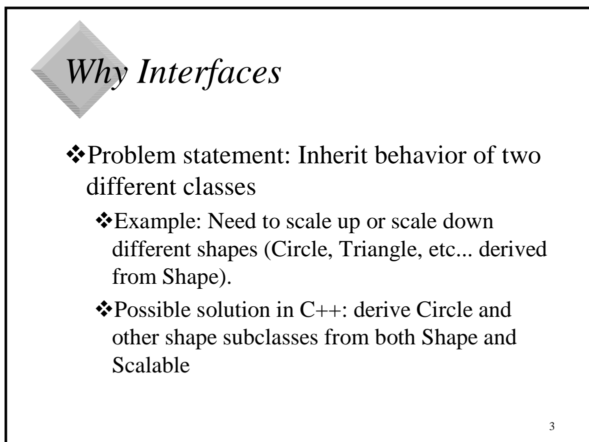

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Superclasses

☹A class in Java can have only one superclass

☹Java does not have multiple inheritance

☺The solution: Java provides **interfaces** as the way to capture behavior of more than one class

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What is an Interface?

- **Interface** - a promise (a contract) of a class to implement certain methods with specified return type and a list of arguments.
- Another way to implement polymorphism (using interface type instead of superclass type) *without requiring the use of inheritance!*
- Compiler **requires** implementing interfaces however it is concerned about signatures only. The actual implementation does not matter
- Interface is a preferred way of implementing callback methods

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Example

```
class Circle extends Shape
{ Point center;
  Integer radius;
}
public interface Scalable
{
  public void changeScale(int percent);
}
class ScalableCircle extends Circle implements
  Scalable
{
// changeScale() method must be implemented here
  public void changeScale(int percent){. . .};
}
```

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Interfaces vs. Classes (similarities)

- A variable can be declared using *either* its **class** type *or* its **interface** type:

```
Scalable c = new ScalableCircle();
```

- Both can be extended:

```
public interface Readable
{
  public String read();
}
public interface Searchable extends Readable
{
  public int findPosition();
}
```

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Interfaces vs. Classes (differences)

- Interfaces cannot specify static methods
- Interfaces cannot have instance variables
- Interfaces cannot be instantiated using `new`
- One class may implement multiple interfaces

```
public class Word implements Searchable,
  Replaceable
{
  public int findPosition(Searchable s) {...}
  public void replace(Replaceable w1,
                      Replaceable w2) {...}
}
```

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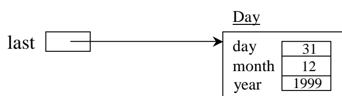
Cloning

- Also referred to as “deep copy”
- By default, Java does “shallow copy”

```
Day last = new Day(1999, 12, 31);
```



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Cloning

- ❖Also referred to as "deep copy"
- ❖By default, Java does "shallow copy"

```
Day last = new Day(1999, 12, 31);
Day d = last;
```

	Day	
last →	day	31
d →	month	12
	year	1999

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Cloning

- ❖Also referred to as "deep copy"
- ❖By default, Java does "shallow copy"

```
Day last = new Day(1999, 12, 31);
Day d = last;
d.advance(1);      //also changed last!
```

	Day	
last →	day	1
d →	month	1
	year	2000

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Correct Solution

```
public class Day implements Cloneable
{    . . .
  public Object clone()
  {
    return new Day(day, month, year);
  }
  private int day;
  private int month;
  private int year;
}
```

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Cloning (deep copy)

```
Day last = new Day(1999, 12, 31);
```


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Cloning (deep copy)

```
Day last = new Day(1999, 12, 31);
Day d = (Day) last.clone();
```


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Cloning (deep copy)

```
Day last = new Day(1999, 12, 31);
Day d = (Day) last.clone();
d.advance(1);  //OK, last is unaffected!
```


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Problems with = (shallow copy)

```
Employee al = new Employee("Al", 50000,
  new Day(1988, 8, 18));
Employee bob = (Employee) al.clone();
bob.setName("Bob");
bob.setSalary(75000);
bob.setHireDay(1999, 9, 19);
```

- Is there a problem with the above code?!
  - We just changed Al's hire date, as well as Bob's!

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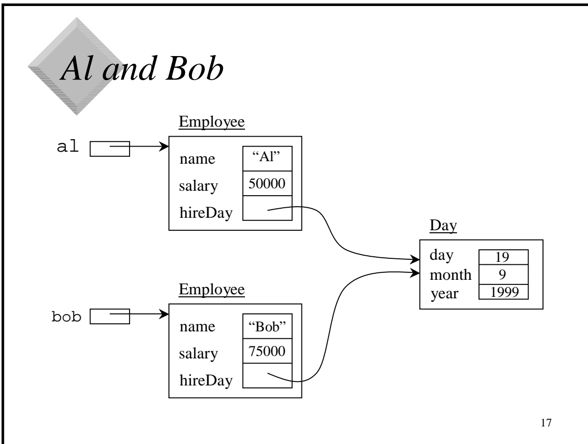
Al and Bob



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The `Cloneable` Interface

- Solution: implement the `Clonable` interface
  - and override the `clone()` method

```
public class Employee implements Cloneable
{ ...
  public Object clone()
  {   try
      {   Employee e = (Employee) super.clone();
          e.hireDay = (Day) hireDay.clone();
          return e;
      }   catch (CloneNotSupportedException e)
      {   return null; }
  }
}
```

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The `Cloneable` Interface

- User code cannot call the `clone()` method unless the class implements the `Cloneable` interface (else an exception is thrown)
  - Thus `Cloneable` is called a *tagging interface*
- The `Object` class does not implement the `Cloneable` interface
  - It merely provides a `protected clone()` method as a convenience to implementors (subclasses)

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Implementing Callbacks in Java

- **Callback** - a method that gets called when a certain event or action occurs.
- Examples:
  - Mouse click - mouseClicked()
  - Timer expiration - timerExpired()
  - Window closing - windowClosed()
- C++ uses function pointers to implement callbacks
- Java does not have function pointers. Interfaces are used to specify the callback function signature without specifying the class it belongs to.

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Timer Code Examples

```
interface TimerListener
{ public void timeElapsed(Timer t); }

class AlarmClock implements TimerListener
{ AlarmClock()
  {   t = new Timer(this);
      t.setDelay(100);  // 100 millisec.
  }
  public void timeElapsed(Timer t)
  {   if(t.getTime() >= wakeUpTime)
        wakeUp.play();
  }
  Timer t; ...
}
```

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Timer Implementation

```
class Timer extends Thread
{ Timer(TimerListener tl)
  {   listener = tl; }
  ...
  Public void run()
  {   while (true)
      {  sleep(interval);
         listener.timeElapsed(this);
      }
  }
  private TimerListener listener;
}
```

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Inner classes (Java 1.1)

- **Inner class** - a class defined inside another class
- Invisible to other classes
- Has an implicit reference to the “outer” class (not available to other code, even in same package!)
- Can access private data of the outer class
- Inner classes are always private
- Translated into a separate file with the name OuterClass$InnerClass.class
- Can be anonymous (useful for callbacks, etc.)

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Property Editor Code Example

- Review the code in the example file:
  `PropertyTest.java`

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Homework Assignment

- ❖Improve the ShapeBox example:
  - ❖implement a Movable interface for all shapes
  - ❖implement a Scalable interface for all shapes
  - ❖test it using “draw”, “move”, “scaleUp”, and “scaleDown” commands

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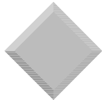

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