Polymorphism

Chapter 9

5TH EDITION

Lewis & Loftus

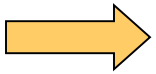
java
Software Solutions

Foundations of Program Design

Polymorphism

- **Polymorphism is an object-oriented concept that allows us to create versatile software designs**
- **Chapter 9 focuses on:**
  - **defining polymorphism and its benefits**
  - **using inheritance to create polymorphic references**
  - **using interfaces to create polymorphic references**
  - **using polymorphism to implement sorting and searching algorithms**
  - **additional GUI components**

Outline



Polymorphic References

Polymorphism via Inheritance

Polymorphism via Interfaces

Sorting

Searching

Event Processing Revisited

File Choosers and Color Choosers

Sliders

Binding

- **Consider the following method invocation:**

when compiling, it doesn't call this doIt, it just makes sure that they have this method defined.

```
obj.doIt();
```

- **At some point, this invocation is *bound* to the definition of the method that it invokes**
- **If this binding occurred at compile time, then that line of code would call the same method every time**
- **However, Java defers method binding until run time -- this is called *dynamic binding* or *late binding***
- **Late binding provides flexibility in program design**

Polymorphism

- **The term *polymorphism* literally means "having many forms"**
- **A *polymorphic reference* is a variable that can refer to different types of objects at different points in time**
- **The method invoked through a polymorphic reference can change from one invocation to the next**
- **All object references in Java are potentially polymorphic**

Polymorphism

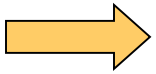
- **Suppose we create the following reference variable:**

```
Occupation job;
```

This doesn't have to point to new Occupation(), it can be any capatible type - which means anything that inherits from it

- **Java allows this reference to point to an `Occupation` object, or to any object of <u>any compatible type</u>**
- **This compatibility can be established using inheritance or using interfaces**
- **Careful use of polymorphic references can lead to elegant, robust software designs**

Outline



Polymorphic References

Polymorphism via Inheritance

Polymorphism via Interfaces

Sorting

Searching

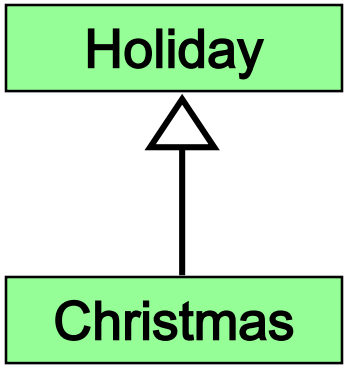
Event Processing Revisited

File Choosers and Color Choosers

Sliders

References and Inheritance

- **An object reference can refer to an object of its class, or to an object of any class related to it by inheritance**
- **For example, if the `Holiday` class is used to derive a class called `Christmas`, then a `Holiday` reference could be used to point to a `Christmas` object**



Christmas is the child

```
Holiday day;
day = new Christmas();
```

this is polymorphic reference - day to point to any of Holiday's children

say that holiday has the method celebrate. christmas extends holiday
holiday has celebrate() method - have fun
but for christmas, celebrate() method - open presents

References and Inheritance

- **Assigning a child object to a parent reference is considered to be a widening conversion, and can be performed by simple assignment**

parent can point to children - the children is considered 'more' cause you are adding additional methods and variables

- **Assigning an parent object to a child reference can be done also, but it is considered a narrowing conversion and must be done with a cast**

(Holiday)Christmas xmas = new Holiday(); this is narrowing - child points to parent object (must be cast)
child reference parent object

- **The widening conversion is the most useful**

Polymorphism via Inheritance

reference - object

- **It is the type of the object being referenced, not the reference type, that determines which method is invoked**
- **Suppose the `Holiday` class has a method called `celebrate`, and the `Christmas` class overrides it**
- **Now consider the following invocation:**

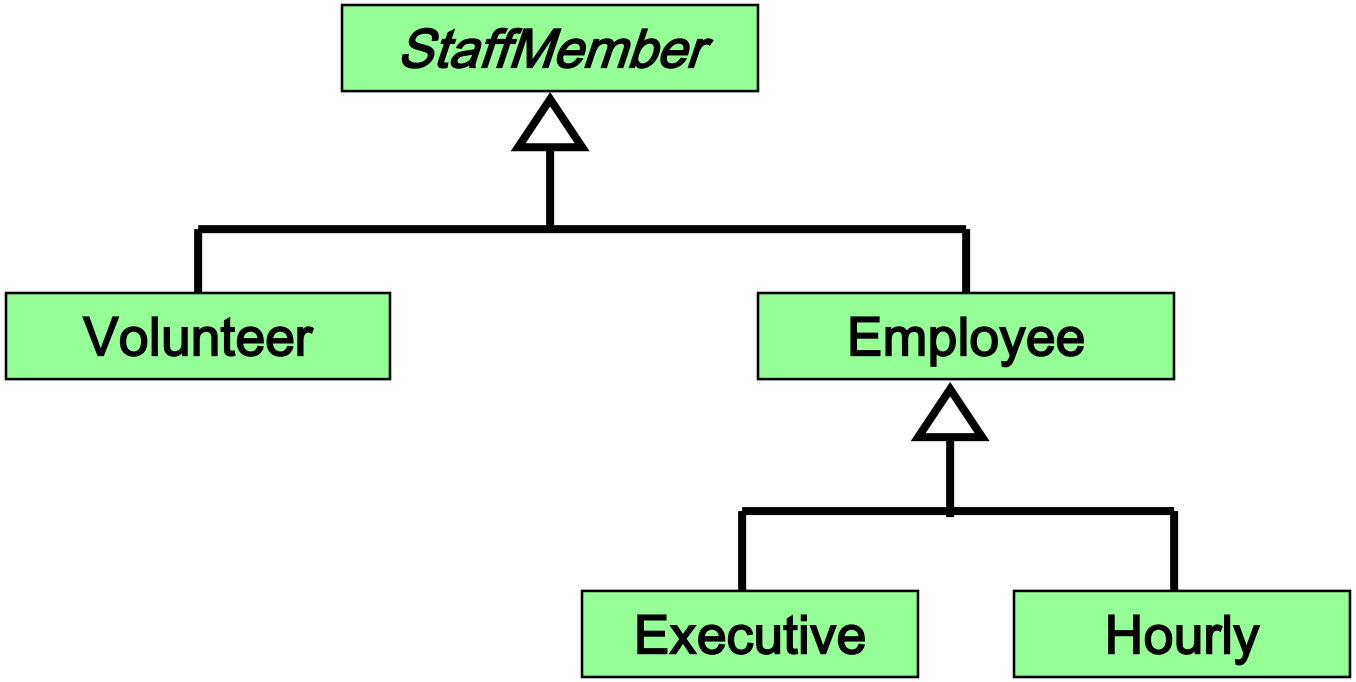
```
day.celebrate();
```

- **If `day` refers to a `Holiday` object, it invokes the `Holiday` version of `celebrate`; if it refers to a `Christmas` object, it invokes the `Christmas` version**

note: a parent reference will call child's overridden method
but if child has a new method: sing_carols the parent can't call that method because the parent does not have that method
the way to get the parent to sing_carols, will have to do a cast:
((Christmas)day).sing_carols

Polymorphism via Inheritance

- **Consider the following class hierarchy:**

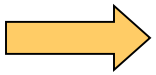


Polymorphism via Inheritance

- **Now let's look at an example that pays a set of diverse employees using a polymorphic method**

- **See `Firm.java` (page 488)**
- **See `Staff.java` (page 489)**
- **See `StaffMember.java` (page 491)**
- **See `Volunteer.java` (page 493)**
- **See `Employee.java` (page 494)**
- **See `Executive.java` (page 495)**
- **See `Hourly.java` (page 496)**

Outline



Polymorphic References

Polymorphism via Inheritance

Polymorphism via Interfaces

Sorting

Searching

Event Processing Revisited

File Choosers and Color Choosers

Sliders

Polymorphism via Interfaces

- **An interface name can be used as the type of an object reference variable**

```
Speaker current;
```

- **The `current` reference can be used to point to any object of any class that implements the `Speaker` interface**
- **The version of `speak` that the following line invokes depends on the type of object that `current` is referencing**

```
current.speak();
```

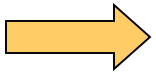
Polymorphism via Interfaces

- **Suppose two classes, `Philosopher` and `Dog`, both implement the `Speaker` interface, providing distinct versions of the `speak` method**
- **In the following code, the first call to `speak` invokes one version and the second invokes another:**

```
Speaker guest = new Philospher();
guest.speak();
guest = new Dog();
guest.speak();
```

11/9/17 end here

Outline



Polymorphic References

Polymorphism via Inheritance

Polymorphism via Interfaces

Sorting

Searching

Event Processing Revisited

File Choosers and Color Choosers

Sliders

Sorting

- ***Sorting*** **is the process of arranging a list of items in a particular order**
- **The sorting process is based on specific value(s)**
  - **sorting a list of test scores in ascending numeric order**
  - **sorting a list of people alphabetically by last name**
- **There are many algorithms, which vary in efficiency, for sorting a list of items**
- **We will examine two specific algorithms:**
  - **Selection Sort**
  - **Insertion Sort**

Selection Sort

- **The approach of Selection Sort:**
  - **select a value and put it in its final place into the list**
  - **repeat for all other values**
- **In more detail:**
  - **find the smallest value in the list**
  - **switch it with the value in the first position**
  - **find the next smallest value in the list**
  - **switch it with the value in the second position**
  - **repeat until all values are in their proper places**

Selection Sort

- **An example:**

```
original:          3   9   6   1   2
smallest is 1:     1   9   6   3   2
smallest is 2:     1   2   6   3   9
smallest is 3:     1   2   3   6   9
smallest is 6:     1   2   3   6   9
```

- **Each time, the smallest remaining value is found and exchanged with the element in the "next" position to be filled**

Swapping

- **The processing of the selection sort algorithm includes the *swapping* of two values**
- **Swapping requires three assignment statements and a temporary storage location:**

```
temp = first;
first = second;
second = temp;
```

Polymorphism in Sorting

- **Recall that an class that implements the `Comparable` interface defines a `compareTo` method to determine the relative order of its objects**
- **We can use polymorphism to develop a generic sort for any set of `Comparable` objects**
- **The sorting method accepts as a parameter an array of `Comparable` objects**
- **That way, one method can be used to sort a group of `People`, or `Books`, or whatever**

Selection Sort

- **The sorting method doesn't "care" what it is sorting, it just needs to be able to call the `compareTo` method**
- **That is guaranteed by using `Comparable` as the parameter type**
- **Also, this way each class decides for itself what it means for one object to be less than another**
- **See `PhoneList.java` (page 502)**
- **See `Sorting.java` (page 503), specifically the `selectionSort` method**
- **See `Contact.java` (page 505)**

Insertion Sort

- **The approach of Insertion Sort:**
  - **pick any item and insert it into its proper place in a sorted sublist**
  - **repeat until all items have been inserted**
- **In more detail:**
  - **consider the first item to be a sorted sublist (of one item)**
  - **insert the second item into the sorted sublist, shifting the first item as needed to make room to insert the new addition**
  - **insert the third item into the sorted sublist (of two items), shifting items as necessary**
  - **repeat until all values are inserted into their proper positions**

Insertion Sort

- **An example:**

```
original:     3    9    6    1    2
insert 9:     3    9    6    1    2
insert 6:     3    6    9    1    2
insert 1:     1    3    6    9    2
insert 2:     1    2    3    6    9
```

- **See `Sorting.java` (page 503), specifically the `insertionSort` method**

Comparing Sorts

- **The Selection and Insertion sort algorithms are similar in efficiency**
- **They both have outer loops that scan all elements, and inner loops that compare the value of the outer loop with almost all values in the list**
- **Approximately n^2 number of comparisons are made to sort a list of size n**
- **We therefore say that these sorts are of *order* n^2**
- **Other sorts are more efficient: *order* $n \log_2 n$**

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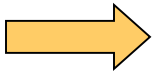
Polymorphism via Inheritance

Polymorphism via Interfaces

Sorting



Searching

Event Processing Revisited

File Choosers and Color Choosers

Sliders

Searching

- **Searching is the process of finding a target element within a group of items called the search pool**
- **The target may or may not be in the search pool**
- **We want to perform the search efficiently, minimizing the number of comparisons**
- **Let's look at two classic searching approaches: linear search and binary search**
- **As we did with sorting, we'll implement the searches with polymorphic `Comparable` parameters**

Linear Search

- **A linear search begins at one end of a list and examines each element in turn**
- **Eventually, either the item is found or the end of the list is encountered**
- **See `PhoneList2.java` (page 510)**
- **See `Searching.java` (page 511), specifically the `linearSearch` method**

Binary Search

- **A *binary search* assumes the list of items in the search pool is sorted**
- **It eliminates a large part of the search pool with a single comparison**
- **A binary search first examines the middle element of the list -- if it matches the target, the search is over**
- **If it doesn't, only one half of the remaining elements need be searched**
- **Since they are sorted, the target can only be in one half of the other**

Binary Search

- **The process continues by comparing the middle element of the remaining *viable candidates***
- **Each comparison eliminates approximately half of the remaining data**
- **Eventually, the target is found or the data is exhausted**
- **See `PhoneList2.java` (page 510)**
- **See `Searching.java` (page 511), specifically the `binarySearch` method**

Outline

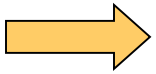
Polymorphic References

Polymorphism via Inheritance

Polymorphism via Interfaces

Sorting

Searching



Event Processing Revisited

File Choosers and Color Choosers

Sliders

Event Processing

- **Polymorphism plays an important role in the development of a Java graphical user interface**
- **As we've seen, we establish a relationship between a component and a listener:**

```
JButton button = new JButton();
button.addActionListener(new MyListener());
```

- **Note that the `addActionListener` method is accepting a `MyListener` object as a parameter**
- **In fact, we can pass the `addActionListener` method any object that implements the `ActionListener` interface**

Event Processing

- **The source code for the `addActionListener` method accepts a parameter of type `ActionListener` (the interface)**
- **Because of polymorphism, any object that implements that interface is compatible with the parameter reference variable**
- **The component can call the `actionPerformed` method because of the relationship between the listener class and the interface**
- **Extending an adapter class to create a listener represents the same situation; the adapter class implements the appropriate interface already**

Outline

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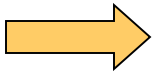
Polymorphism via Interfaces

Sorting

Searching

Event Processing Revisited



File Choosers and Color Choosers

Sliders

Dialog Boxes

- **Recall that a dialog box is a small window that "pops up" to interact with the user for a brief, specific purpose**
- **The `JOptionPane` class makes it easy to create dialog boxes for presenting information, confirming an action, or accepting an input value**
- **Let's now look at two other classes that let us create specialized dialog boxes**

File Choosers

- **Situations often arise where we want the user to select a file stored on a disk drive, usually so that its contents can be read and processed**
- **A *file chooser*, represented by the `JFileChooser` class, simplifies this process**
- **The user can browse the disk and filter the file types displayed**
- **See `DisplayFile.java` (page 518)**

Color Choosers

- **In many situations we want to allow the user to select a color**
- **A *color chooser* , represented by the `JColorChooser` class, simplifies this process**
- **The user can choose a color from a palette or specify the color using RGB values**
- **See `DisplayColor.java` (page 521)**

Outline

Polymorphic References

Polymorphism via Inheritance

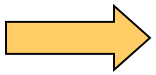
Polymorphism via Interfaces

Sorting

Searching

Event Processing Revisited

File Choosers and Color Choosers



Sliders

Sliders

- **A slider is a GUI component that allows the user to specify a value within a numeric range**
- **A slider can be oriented vertically or horizontally and can have optional tick marks and labels**
- **The minimum and maximum values for the slider are set using the `JSlider` constructor**
- **A slider produces a *change event* when the slider is moved, indicating that the slider and the value it represents has changed**

Sliders

- **The following example uses three sliders to change values representing the color components of an RGB value**
- **See `SlideColor.java` (page 524)**
- **See `SlideColorPanel.java` (page 525)**

Summary

- **Chapter 9 has focused on:**
  - **defining polymorphism and its benefits**
  - **using inheritance to create polymorphic references**
  - **using interfaces to create polymorphic references**
  - **using polymorphism to implement sorting and searching algorithms**
  - **additional GUI components**