Data Abstraction & Problem Solving with
JAVA
3rd Edition Walls & Mirrors
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Chapter 9

Advanced Java Topics

Inheritance Revisited

- Inheritance
  - Allows a class to derive the behavior and structure of an existing class

Inheritance Revisited

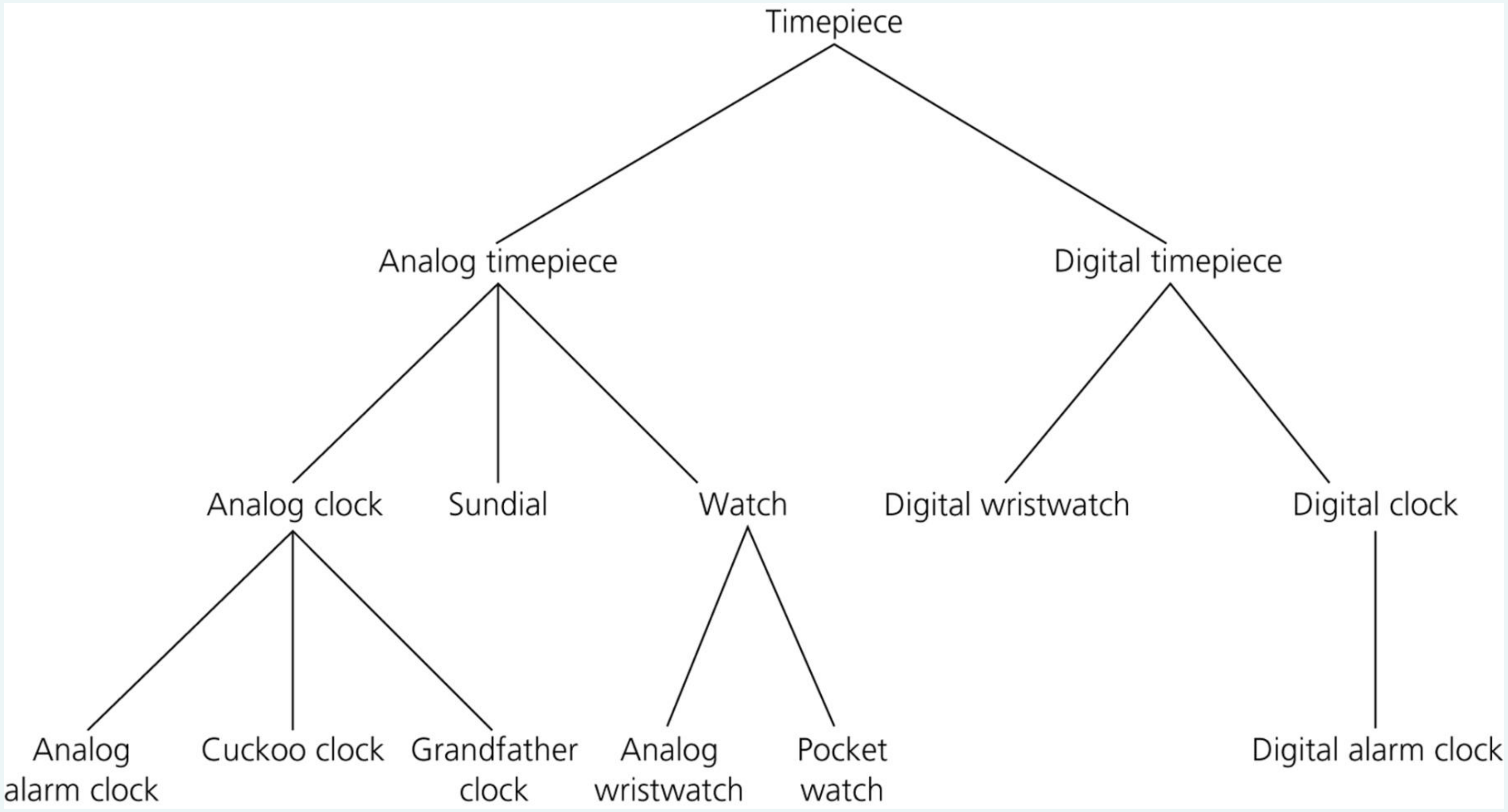


Figure 9-1

Inheritance: Relationships among timepieces

Inheritance Revisited

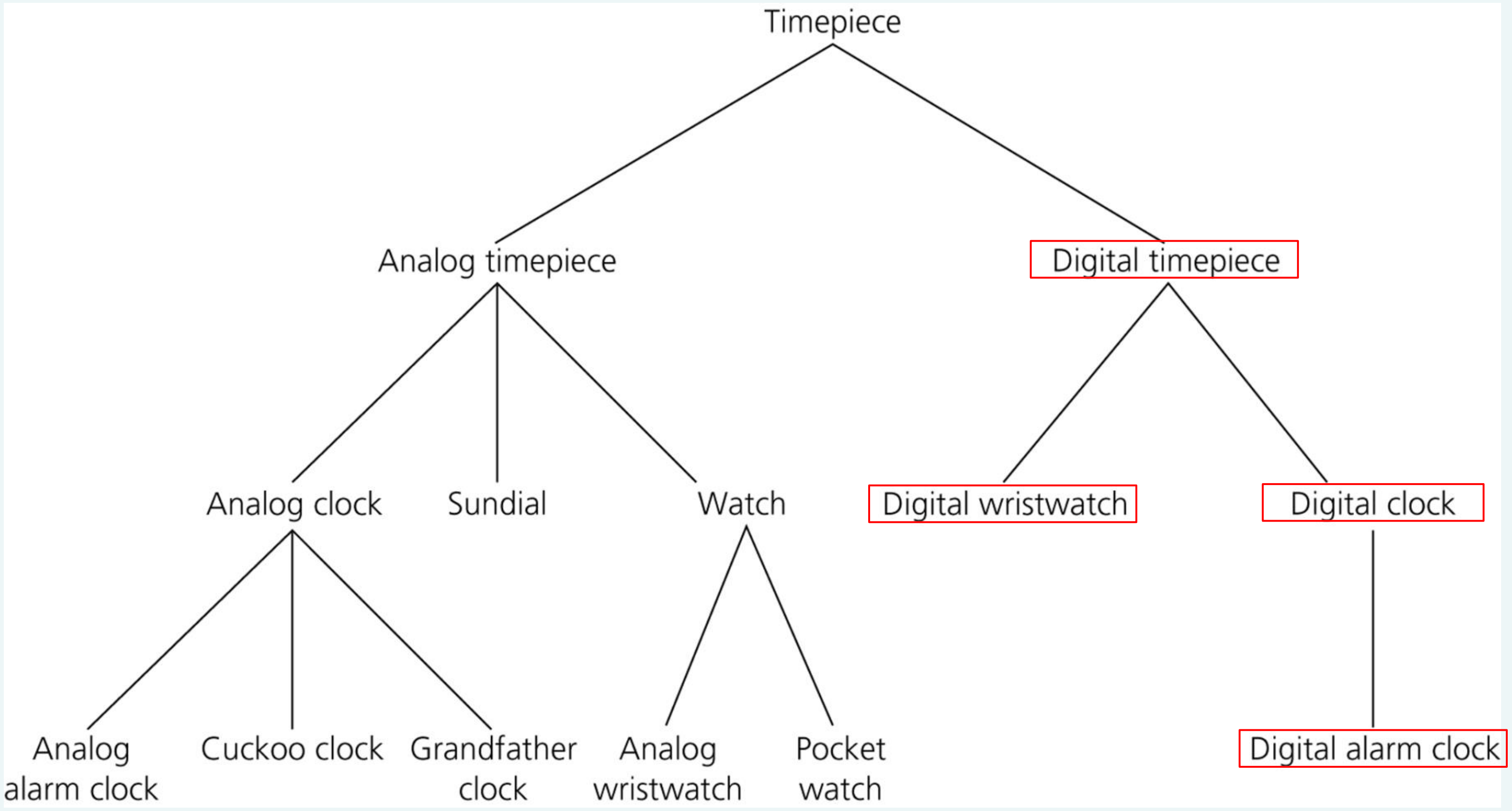


Figure 9-1

Inheritance: Relationships among timepieces

Inheritance Revisited

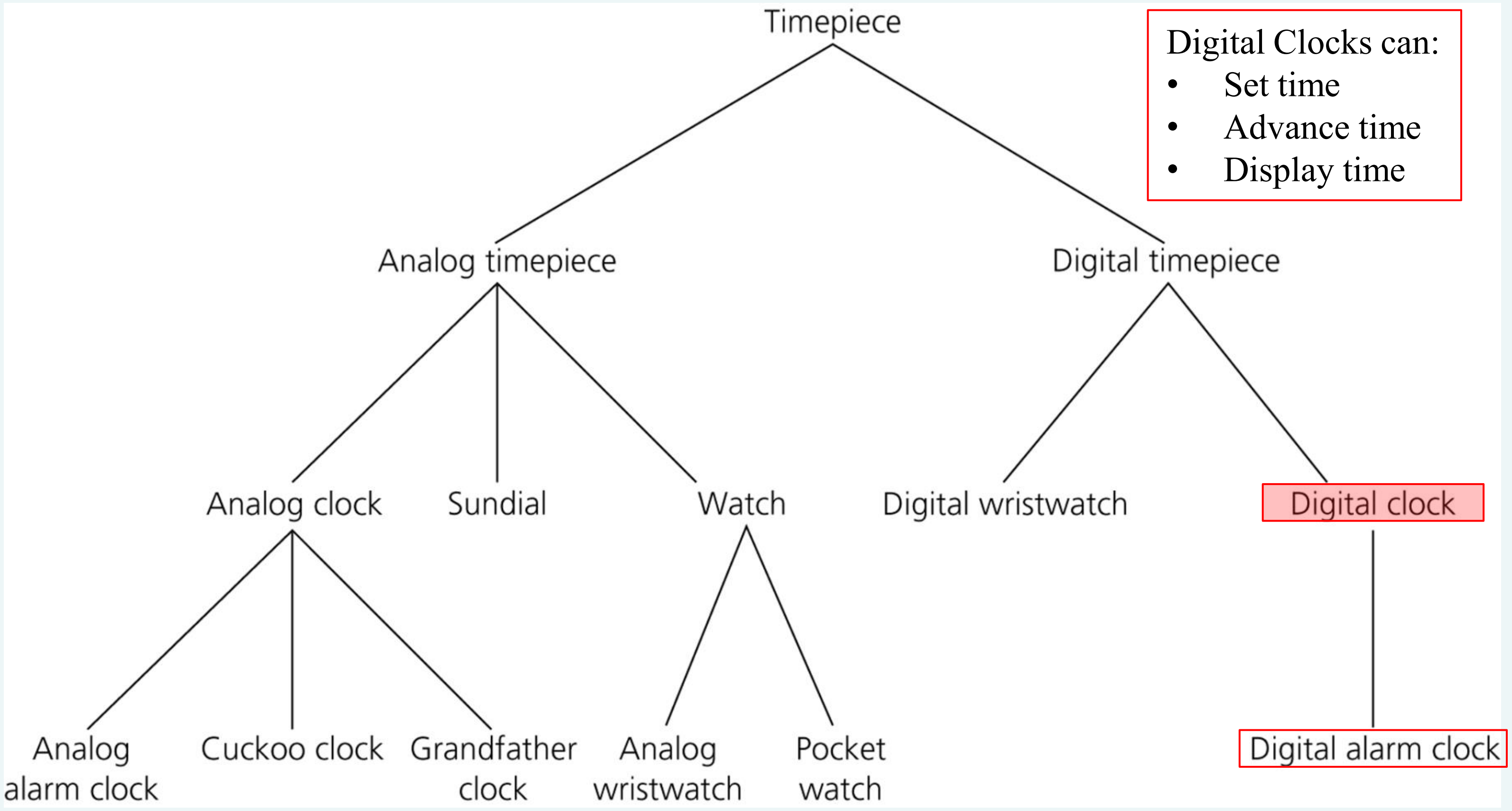
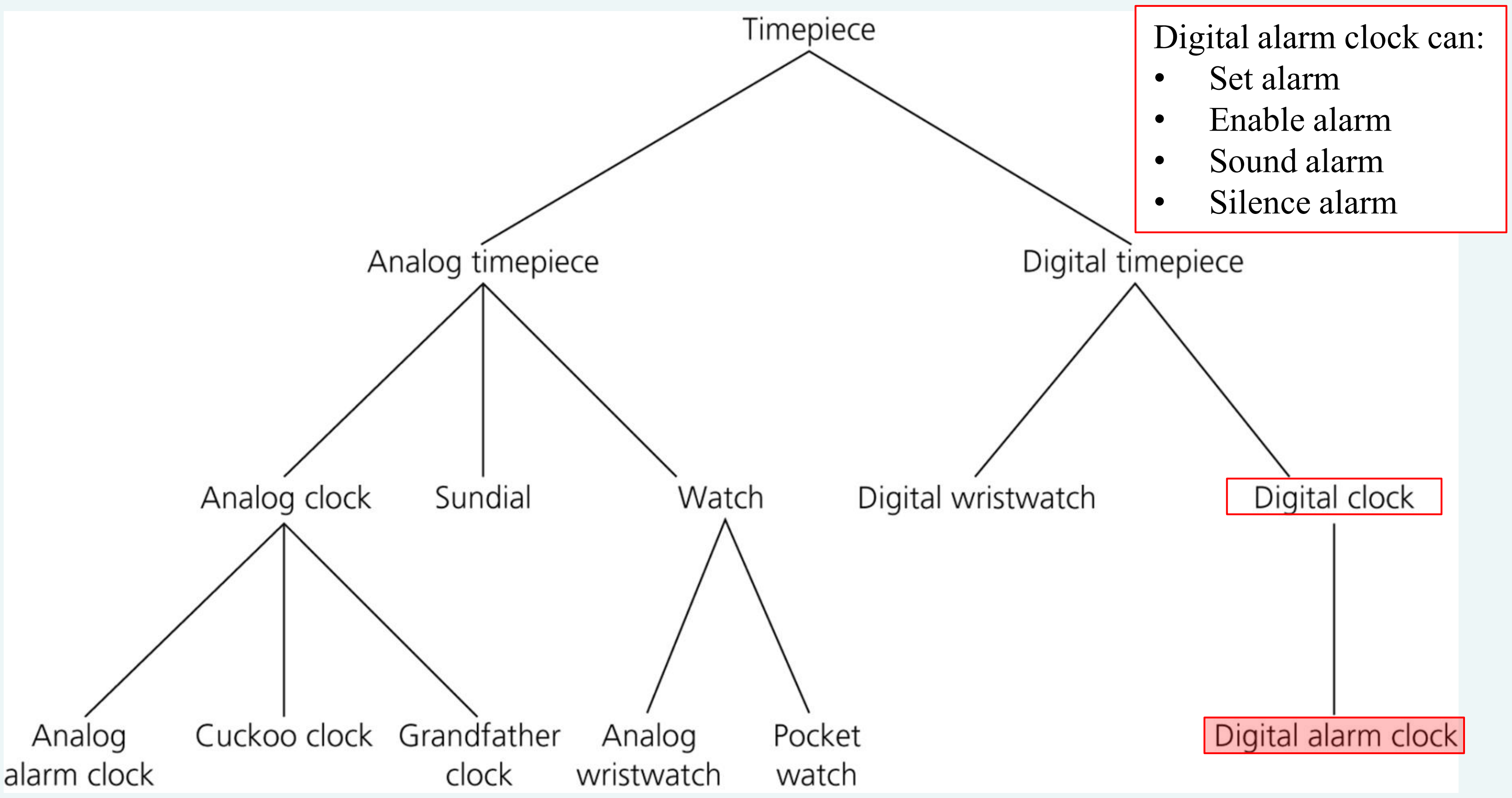


Figure 9-1

Inheritance: Relationships among timepieces

Inheritance Revisited



Digital alarm clock can:
- Set alarm
- Enable alarm
- Sound alarm
- Silence alarm

Figure 9-1

Inheritance: Relationships among timepieces

Inheritance Revisited

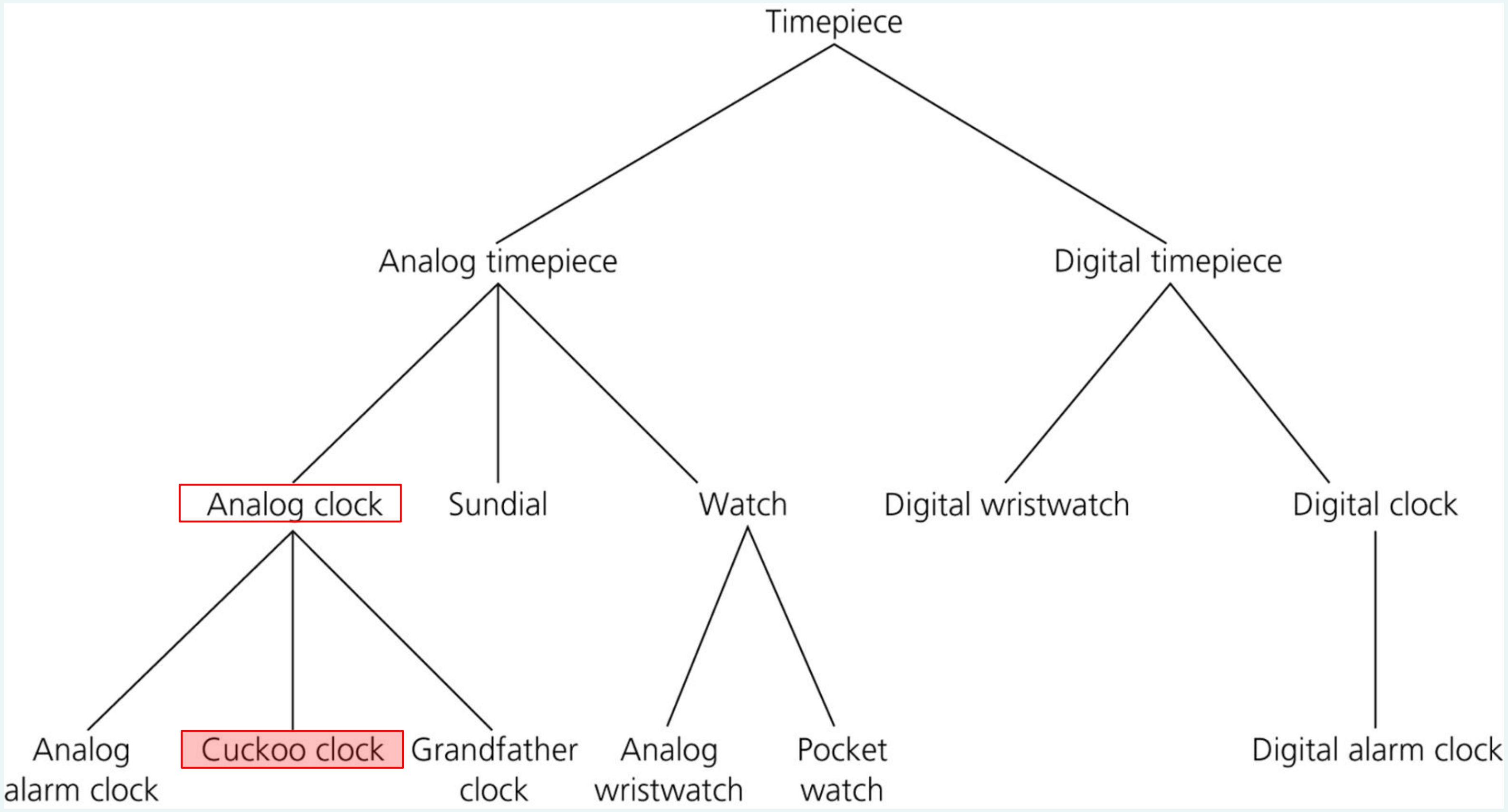


Figure 9-1

Inheritance: Relationships among timepieces

Inheritance Revisited

- Superclass or base class
  - A class from which another class is derived
- Subclass, derived class, or descendant class
  - A class that inherits the members of another class
- Benefits of inheritance
  - It enables the reuse of existing classes
  - It reduces the effort necessary to add features to an existing object

Inheritance Revisited

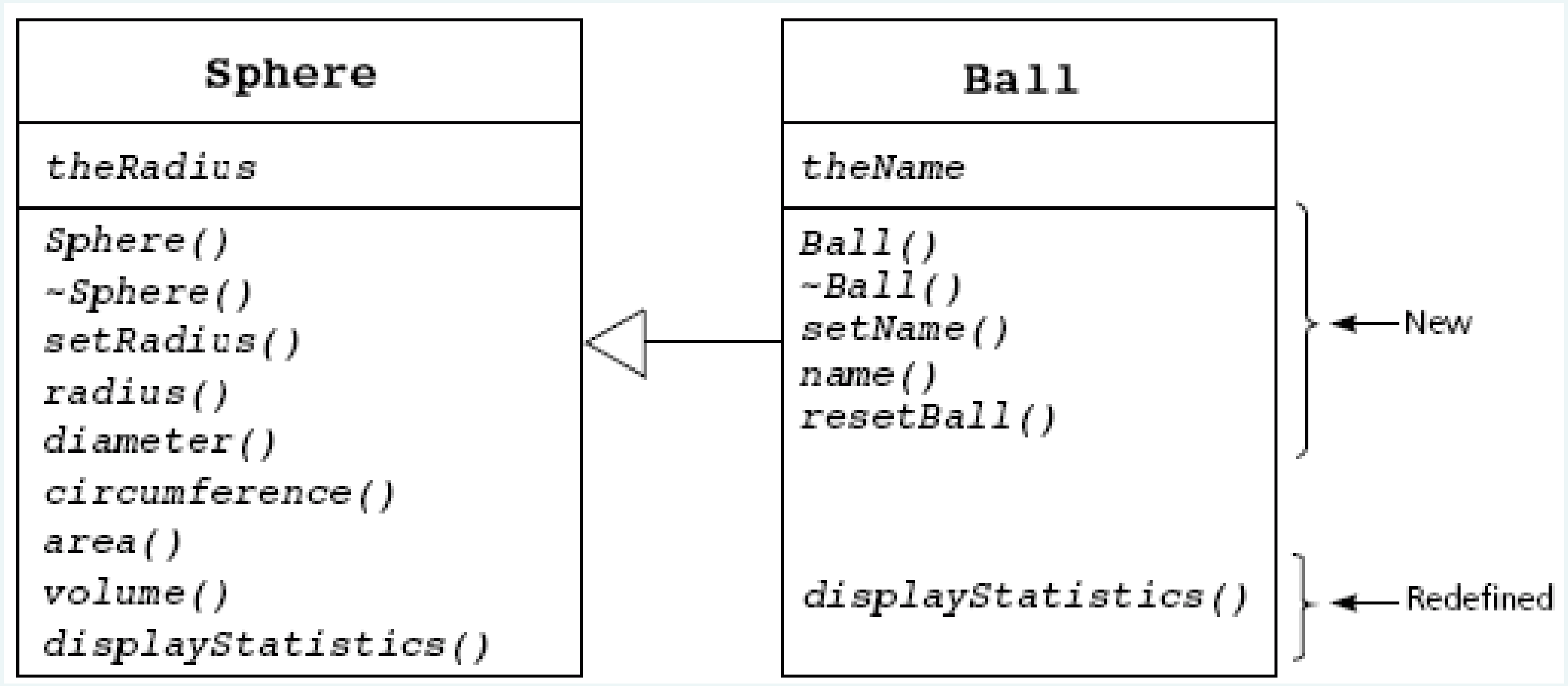


Figure 9-2

The subclass ***Ball*** inherits members of the superclass ***Sphere*** and overrides and adds methods

Inheritance Revisited

- A subclass
  - Can add new members to those it inherits
  - Can override an inherited method of its superclass
    - A method in a subclass overrides a method in the superclass if the two methods have the same declarations

Inheritance Revisited

- A subclass inherits private members from the superclass, but cannot access them directly
- Methods of a subclass can call the superclass's public methods
- Clients of a subclass can invoke the superclass's public methods
- An overridden method
  - Instances of the subclass will use the new method
  - Instances of the superclass will use the original method

Inheritance Revisited

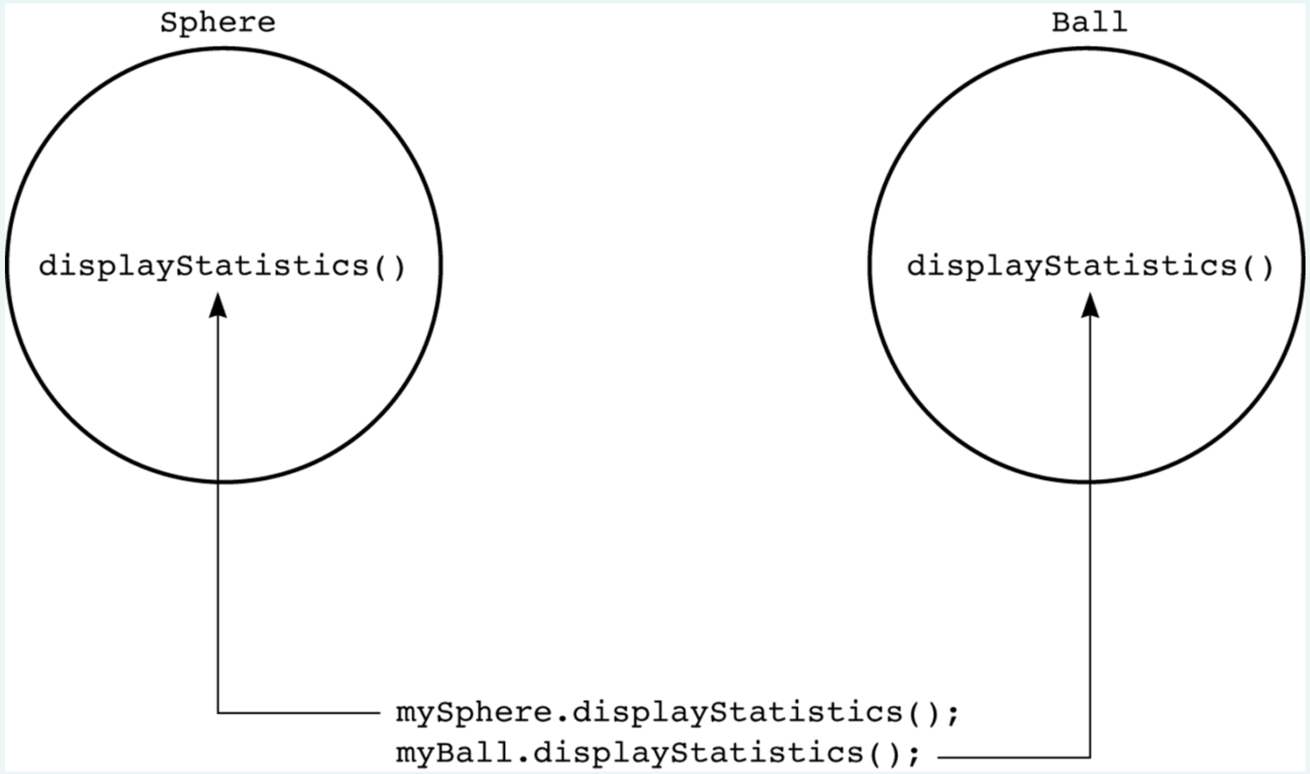


Figure 9-3

An object invokes the correct version of a method

Java Access Modifiers

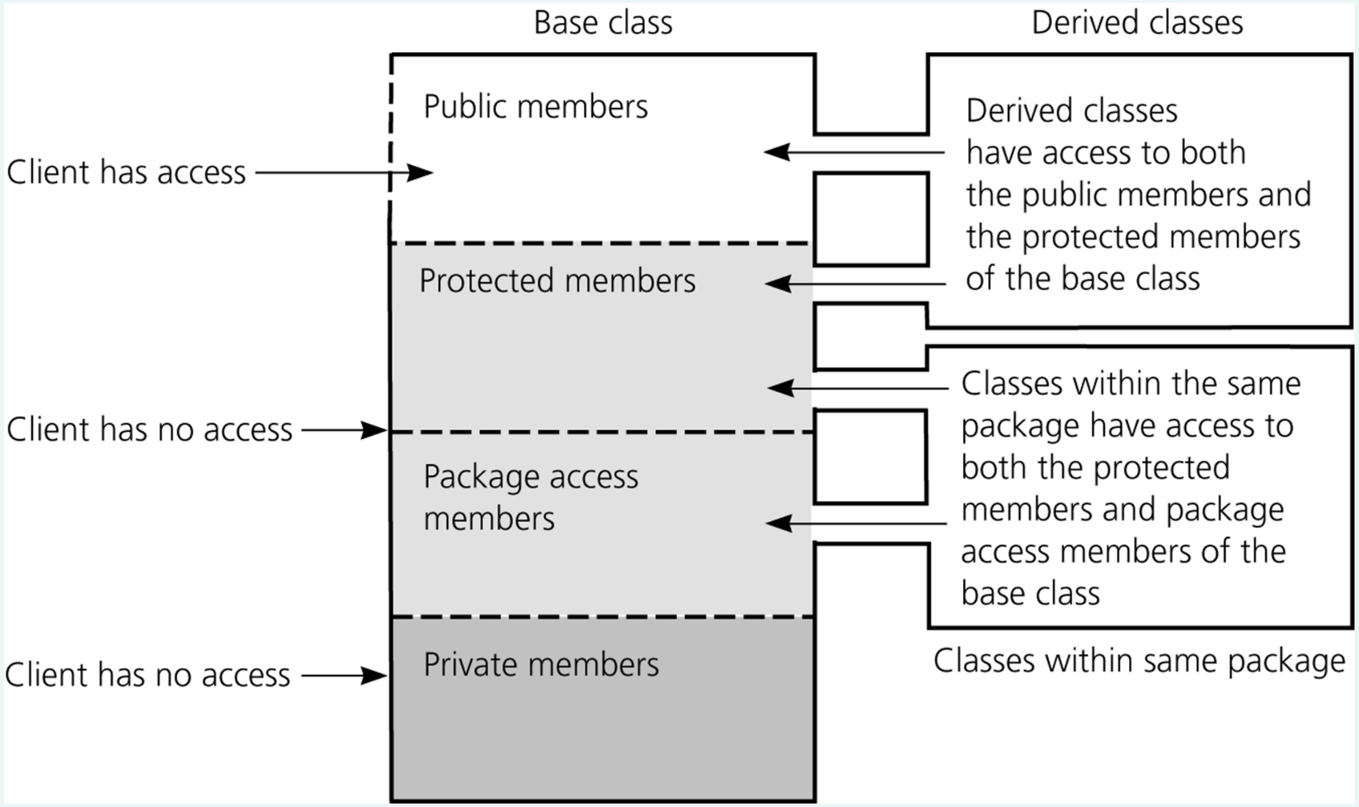

Base class
Derived classes
Public members
Client has access
Derived classes have access to both the public members and the protected members of the base class
Protected members
Client has no access
Package access members
Classes within the same package have access to both the protected members and package access members of the base class
Client has no access
Private members
Classes within same package

Figure 9-4

Access to public, protected, package access, and private members of a class by a client and a subclass

Java Access Modifiers

- Membership categories of a class
  - Public members can be used by anyone
  - Members declared without an access modifier (the default) are available to
    - Methods of the class
    - Methods of other classes in the same package
  - Private members can be used only by methods of the class
  - Protected members can be used only by
    - Methods of the class
    - Methods of other classes in the same package
    - Methods of the subclass

Is-a and Has-a Relationships

- Two basic kinds of relationships
  - Is-a relationship
  - Has-a relationship

Is-a Relationship

- Inheritance should imply an is-a relationship between the superclass and the subclass
- Example:
  - If the class `Ball` is derived from the class `Sphere`
    - A ball is a sphere

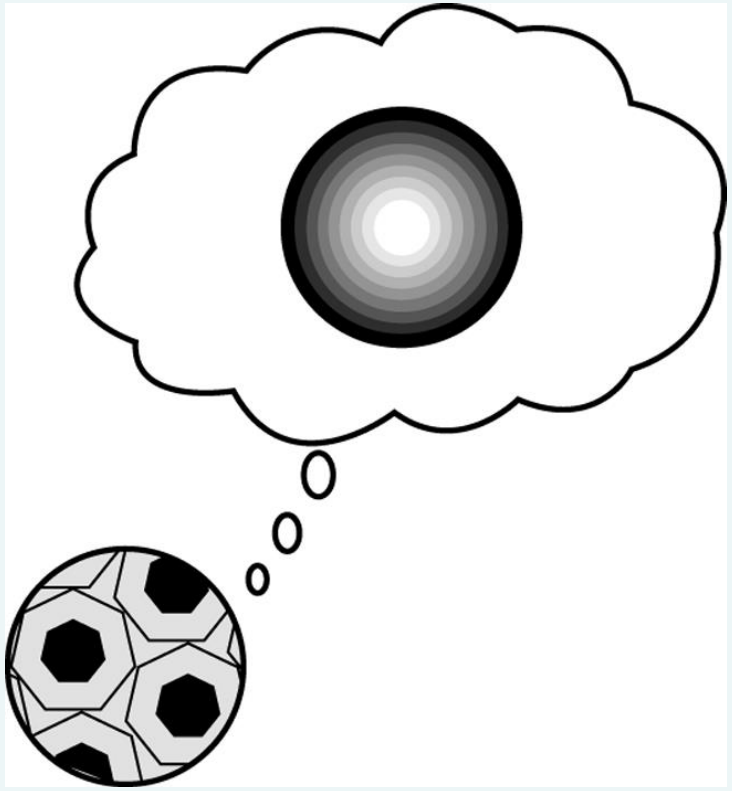


Figure 9-5

A ball "is a" sphere

Is-a Relationship

- Object type compatibility
  - An instance of a subclass can be used instead of an instance of the superclass, but not the other way around

Has-a Relationships

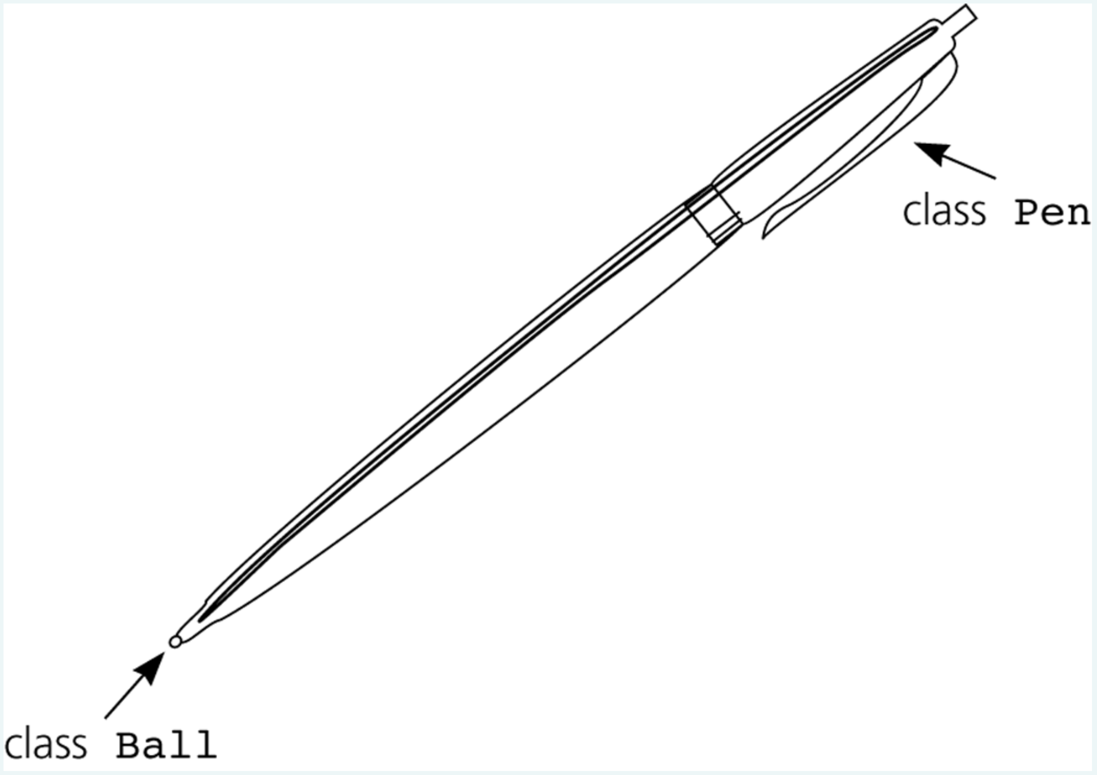


Figure 9-6

A pen “has a” or

“contains a” ball

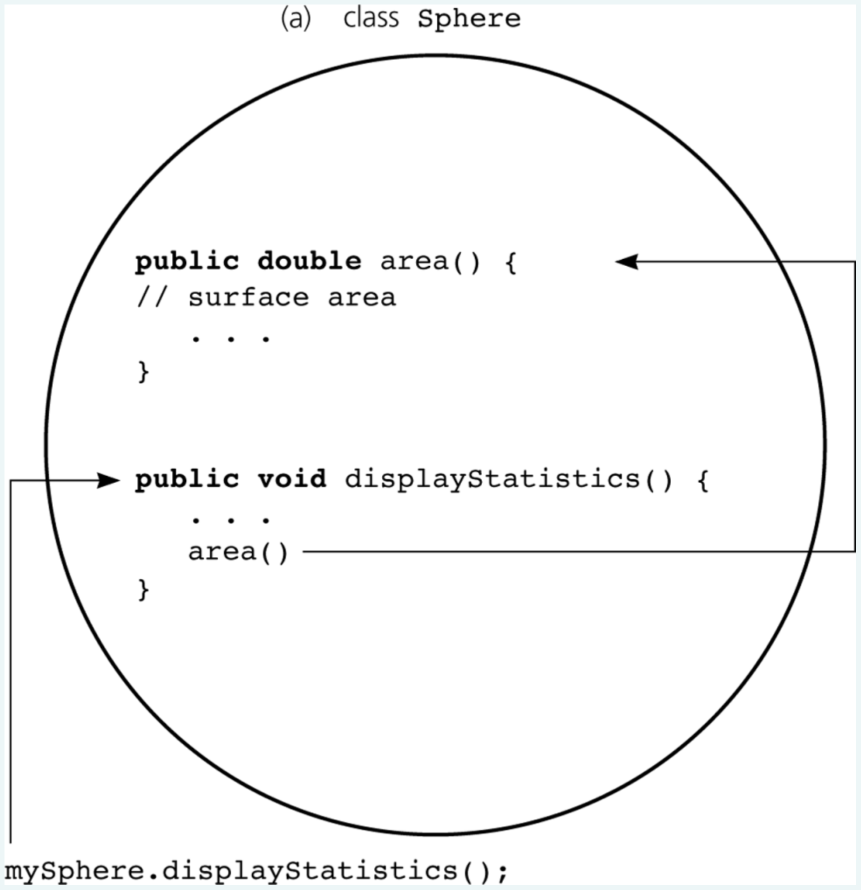
Has-a Relationships

- Has-a relationship
  - Also called containment
  - Cannot be implemented using inheritance
    - Example: To implement the has-a relationship between a pen and a ball
      - Define a data field `point` – whose type is `Ball` – within the class `Pen`

Dynamic Binding and Abstract Classes

- A polymorphic method
  - A method that has multiple meanings
  - Created when a subclass overrides a method of the superclass
- Late binding or dynamic binding
  - The appropriate version of a polymorphic method is decided at execution time

Dynamic Binding and Abstract Classes

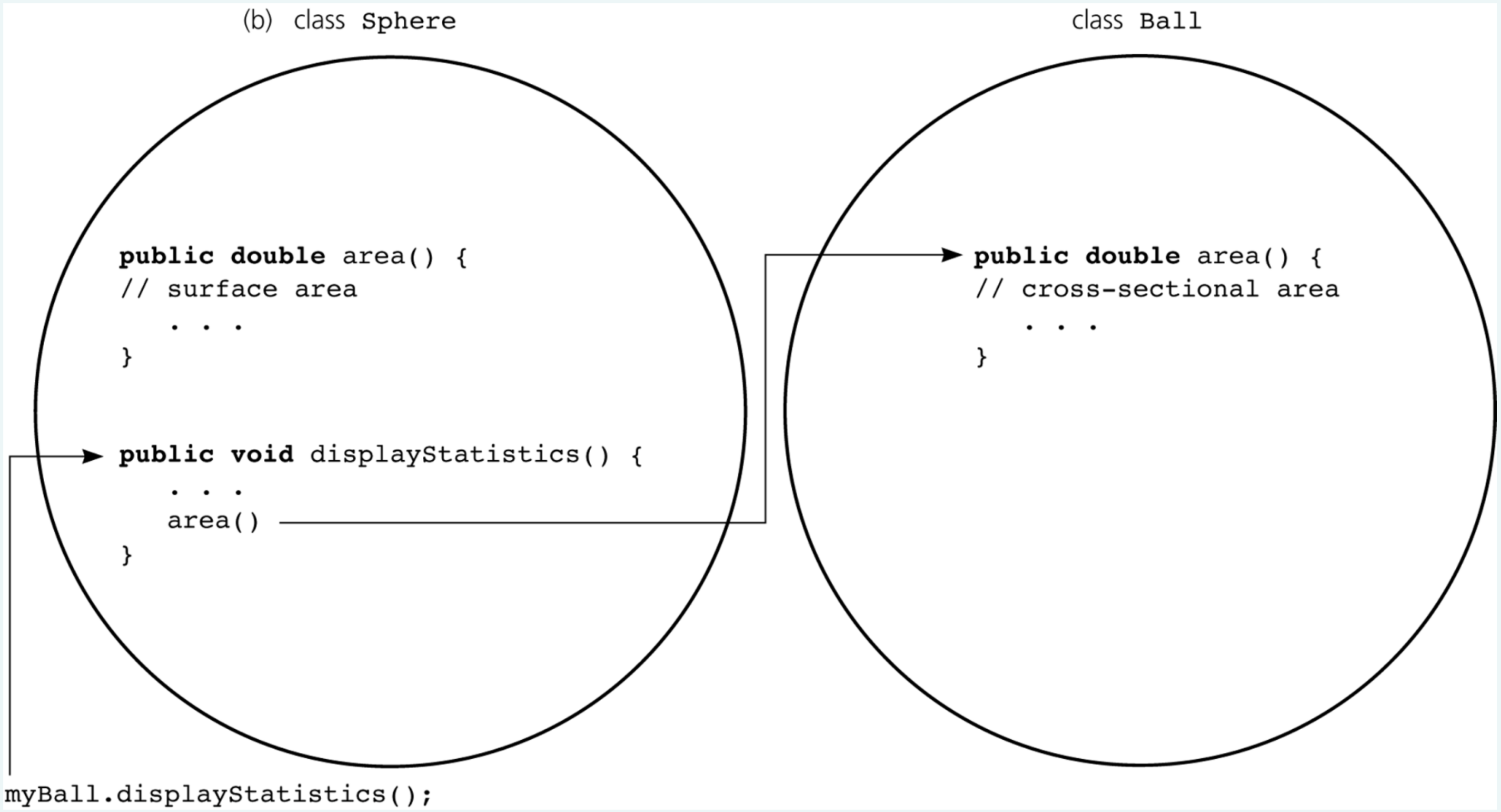


```
public double area() {
// surface area
    . . .
}

public void displayStatistics() {
    . . .
    area()
}

mySphere.displayStatistics();
```

Figure 9-7a

area is overridden: a) ***mySphere.DisplayStatistics( )*** calls ***area*** in ***Sphere***

Dynamic Binding and Abstract Classes



```
public double area() {
// surface area
    . . .
}

public void displayStatistics() {
    . . .
    area()
}
```

```
public double area() {
// cross-sectional area
    . . .
}
```

```
myBall.displayStatistics();
```

Figure 9-7b

area is overridden: b) ***myBall.displayStatistics( )*** calls ***area*** in ***Ball***

Dynamic Binding and Abstract Classes

- Controlling whether a subclass can override a superclass method
  - Field modifier `final`
    - Prevents a method from being overridden by a subclass
  - Field modifier `abstract`
    - Requires the subclass to override the method
- Early binding or static binding
  - The appropriate version of a method is decided at compilation time
  - Used by methods that are `final` or `static`

Dynamic Binding and Abstract Classes

- Overloading methods
  - To overload a method is to define another method with the same name but with a different set of parameters
  - The arguments in each version of an overloaded method determine which version of the method will be used

Please open file *carrano_ppt09_B.ppt* to continue viewing chapter 9.

Chapter 9 (continued)

Advanced Java Topics

Abstract Classes

- Example
  - CD player and DVD player
    - Both involve an optical disk
    - Operations
      - Insert, remove, play, record, and stop such discs

Abstract Classes

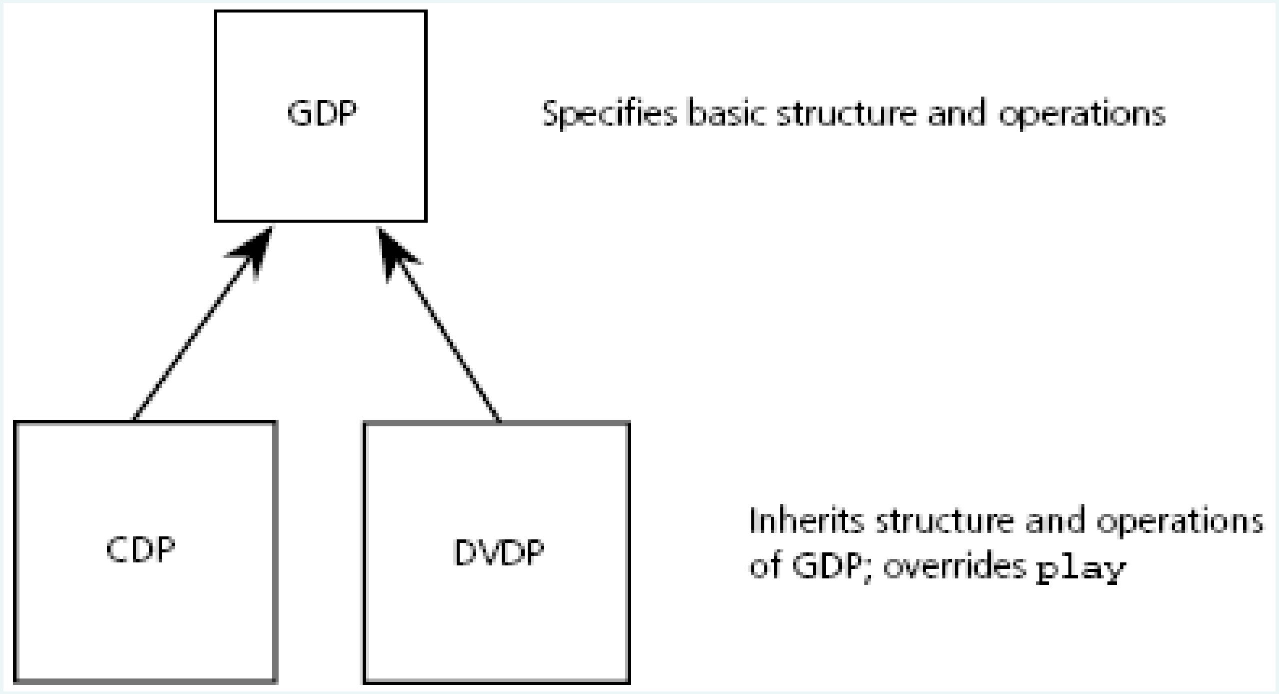

GDP
Specifies basic structure and operations
CDP
DVDP
Inherits structure and operations of GDP; overrides play

Figure 9-8

CDP and DVDP have an abstract base class GDP

Abstract Classes

- Abstract classes
  - An abstract class is used only as the basis for subclasses
    - It defines a minimum set of methods and data fields for its subclasses
  - An abstract class has no instances
  - An abstract class should, in general, omit implementations except for the methods that
    - Provide access to private data fields
    - Express functionality common to all of the subclasses

Abstract Classes

- Abstract classes (Continued)
  - A class that contains at least one abstract method must be declared as an abstract class
  - A subclass of an abstract class must be declared abstract if it does not provide implementations for all abstract methods in the superclass

Java Interfaces Revisited

- A Java interface
  - Specifies the common behavior of a set of classes
  - Common uses
    - Facilitate moving from one implementation of a class to another
      - A client can reference a class's interface instead of the class itself
    - Specify behaviors that are common to a group of classes

Java Interfaces Revisited

- Inheritance can be used to define a subinterface
- The Java API provides many interfaces and subinterfaces
  - Example: `java.util.Iterable`
    - An iterator is a class that provides access to another class that contains many objects

The ADTs List and Sorted List Revisited

- `BasicADTInterface`
  - Can be used to organize the commonalities between the ADT list and the ADT sorted list
  - `ListInterface`
    - A new interface based on `BasicADTInterface`

Implementation of the ADT Sorted List That Used the ADT List

- Operations
  - `createSortedList()`
  - `isEmpty():boolean {query}`
  - `size():integer {query}`
  - `sortedAdd(in newItem:ListItemType) throw ListException`
  - `sortedRemove(in anItem:ListItemType) throw ListException`
  - `removeAll()`
  - `get(in index:integer) throw ListIndexOutOfBoundsException`
  - `locateIndex(in anItem:ListItemType):integer {query}`

Implementations of the ADT Sorted List That Use the ADT List

- A sorted list is a list
  - With an additional operation, `locateIndex`
- A sorted list has a list as a member

Java Generics: Generic Classes

- ADT developed in this text relied upon the use of `Object` class
- Problems with this approach
  - Items of any type could be added to same ADT instance
  - ADT instance returns objects
    - Cast operations are needed
    - May lead to class-cast exceptions
- Avoid this issues by using Java generics
  - To specify a class in terms of a data-type parameter

Generic Wildcards

- Generic classes are not necessary related
- Generic `?` wildcard
  - Stands for unknown data type
- Example

```
public void process(NewClass<?> temp) {
  System.out.println("getData() => " +
   temp.getData());
} // end process
```

Generic Classes and Inheritance

- You can use inheritance with a generic class or interface
- Method overriding rules
  - Declare a method with the same parameters in the subclass
  - Return type is a subtype of all the methods it overrides
- It is sometimes useful to constrain the data-type parameter to a class or one of its subclasses or an implementation of a particular interface
  - To do so, use the keyword `extends`

Abstract Classes

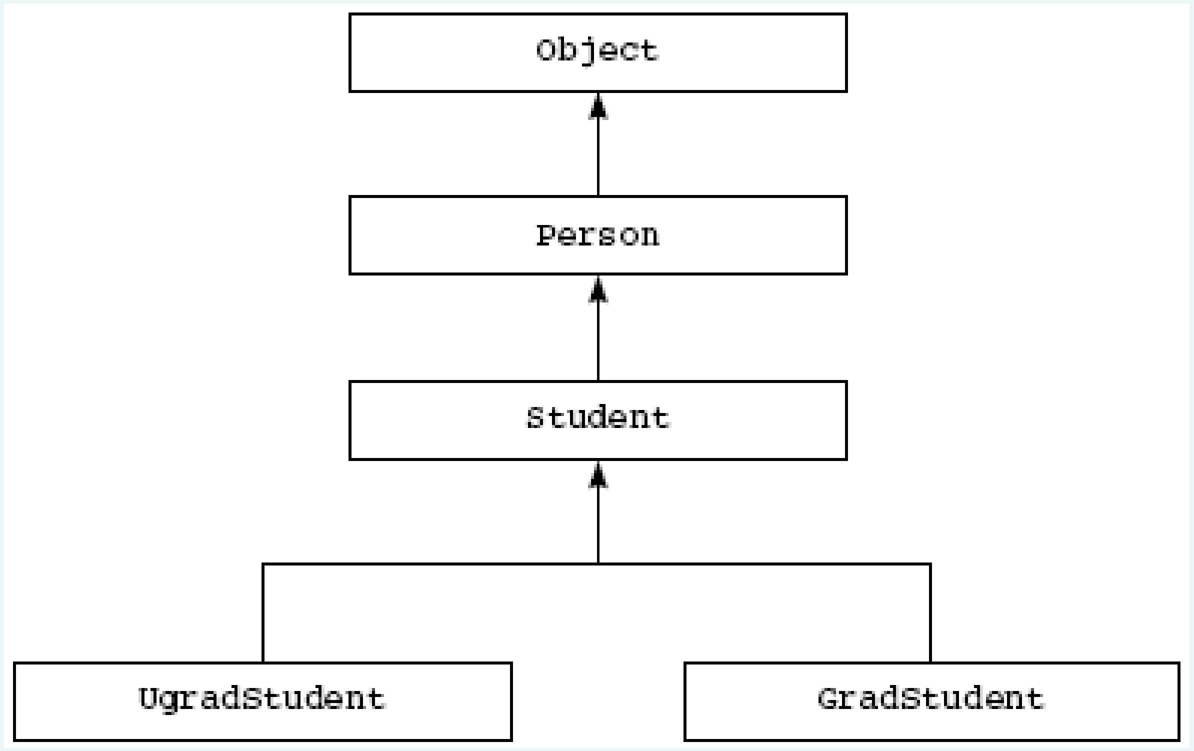


Figure 9-10

Sample class hierarchy

Generic Methods

- Method declarations can also be generic
  - Methods can use data-type parameters
- Generic methods are invoked like regular non-generic methods
- Example

```
public static <T extends Comparable<? super
  T>>
void sort(ArrayList<T> list) {
  // implementation of sort appears here
} // end sort
```

Iterators

- Iterator
  - Object that can access a collection of objects one object at a time
  - Traverses the collection of objects
- JCF defines generic interface `java.util.Iterator`
  - And a subinterface `ListIterator`

Iterators

- Defining our own Iterator class
- Implement an iterator interface
  - At a minimum, include methods for next( ), hasNext( ) and remove( ).
  - If you don't want to remove( ), you may leave method body empty.
- MyListIterator example
  - Maintain lastItemIndex to keep track of where iterator is between calls to iterator methods.
  - Initialize in constructor; increment inside next( ).

Summary

- A subclass inherits all members of its previously defined superclass, but can access only the public and protected members
- Subclasses and superclasses
  - A subclass is type-compatible with its superclass
  - The relationship between superclasses and subclasses is an is-a relationship
- A method in a subclass overrides a method in the superclass if they have the same parameter declarations

Summary

- An abstract method in a class is a method that you can override in a subclass
- A subclass inherits
  - The interface of each method that is in its superclass
  - The implementation of each nonabstract method that is in its superclass
- An abstract class
  - Specifies only the essential members necessary for its subclasses
  - Can serve as the superclass for a family of classes

Summary

- Early (static) binding: compiler determines at compilation time the correct method to invoke
- Late (dynamic) binding: system determines at execution time the correct method to invoke
- When a method that is not declared `final` is invoked, the type of object is the determining factor under late binding
- Generic classes enable you to parameterize the type of a class's data
- Iterators provide an alternative way to cycle through a collection of items