Objects First With Java
A Practical Introduction Using BlueJ

Improving structure with inheritance

2.0

Main concepts to be covered

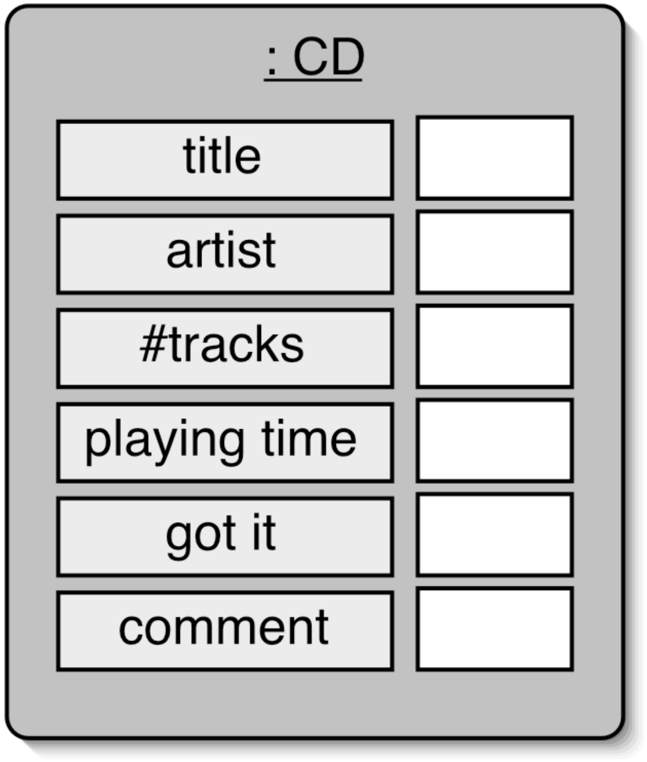
- Inheritance
- Subtyping
- Substitution
- Polymorphic variables

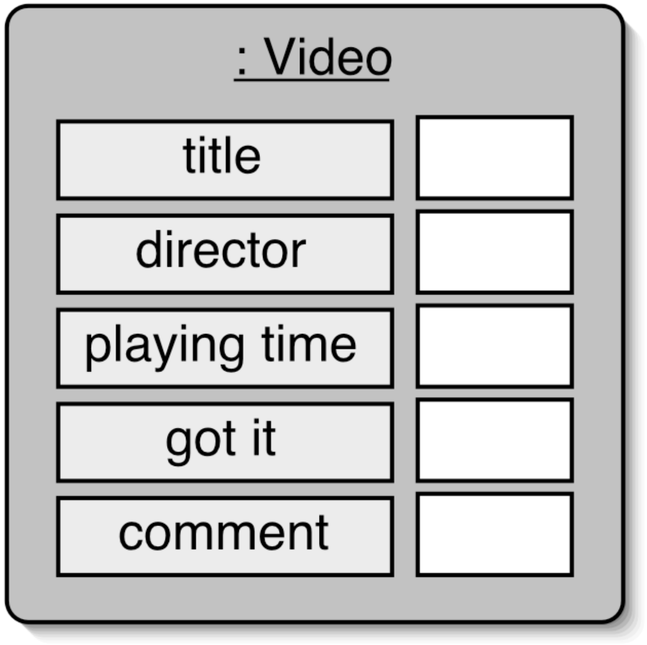
The DoME example

"Database of Multimedia Entertainment"

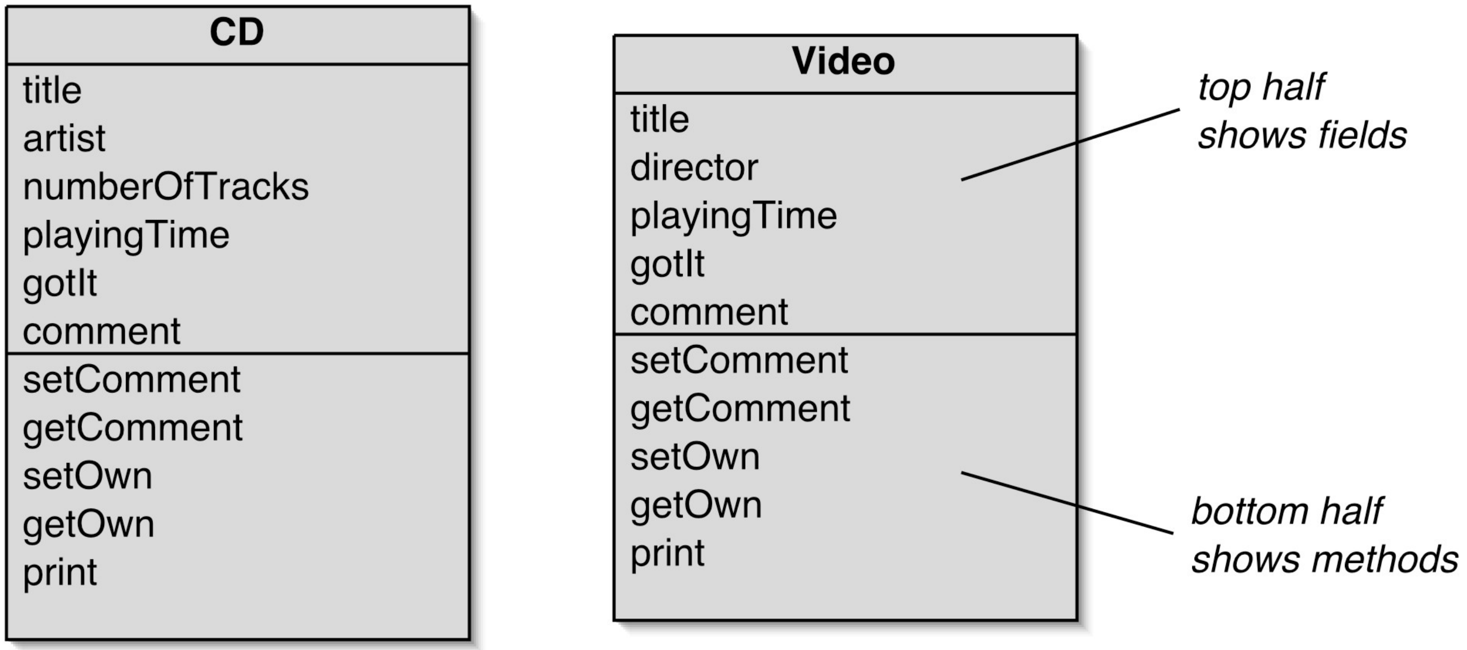
- stores details about CDs and videos
  - CD: title, artist, # tracks, playing time, got-it, comment
  - Video: title, director, playing time, got-it, comment
- allows (later) to make additions or to search for information or to print lists

DoME objects





DoME classes
(UML Syntax)

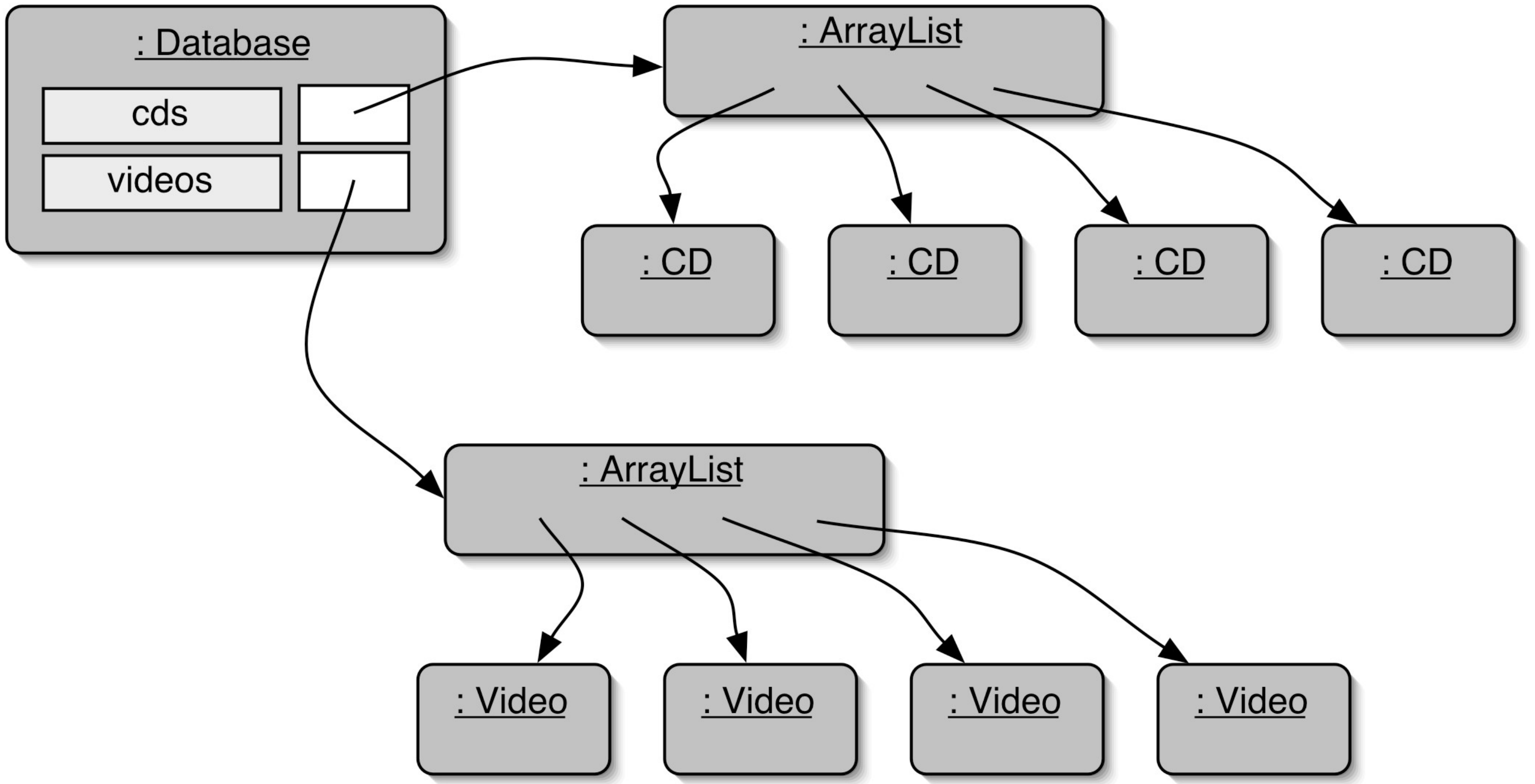


accessor and mutator methods for varying fields (`gotIt, comment`)

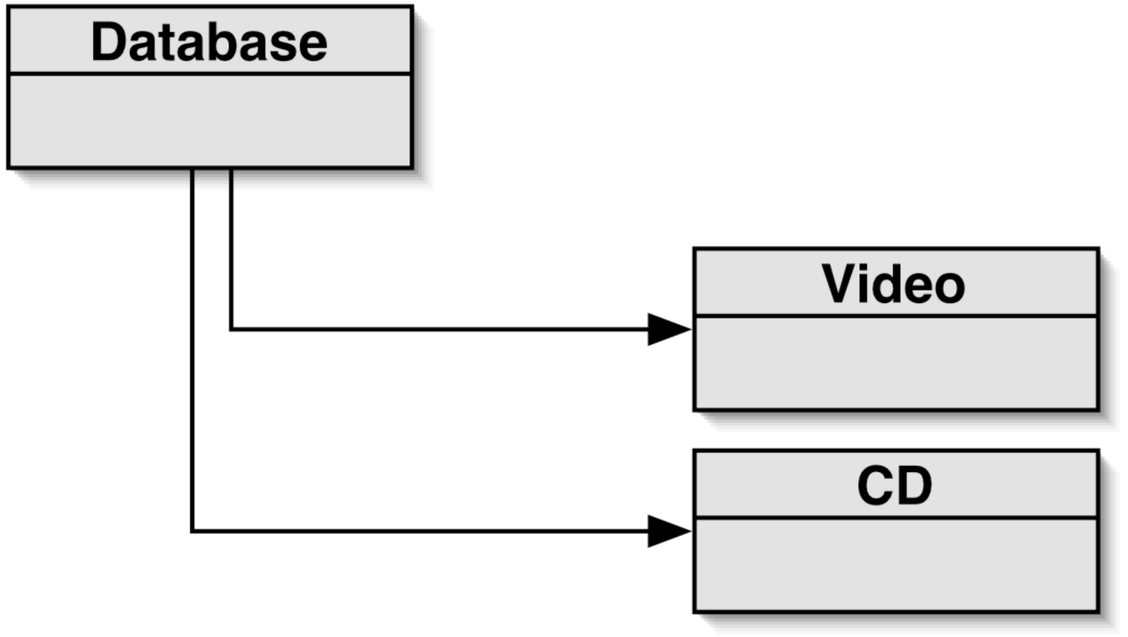
the other fields are set in the constructor

DoME object model

now the database object, holding two collection objects



UML Class diagram



Collection is omitted

CD source code

[incomplete (comments!)]

```
public class CD {
    private String title;
    private String artist;
    private String comment;

    CD(String theTitle, String theArtist)
    {
     title = theTitle;
     artist = theArtist;
     comment = " ";
    }

    void setComment(String newComment)
    { ... }

    String getComment()
    { ... }

    void print()
    { ... }
    ...
}
```

Video source code

[incomplete (comments!)]

very similar to CD!!

```
public class Video {
   private String title;
   private String director;
   private String comment;

   Video(String theTitle, String theDirect)
   {
    title = theTitle;
    director = theDirect;
    comment = " ";
   }

   void setComment(String newComment)
   { ... }

   String getComment()
   { ... }

   void print()
   { ... }
   ...
}
```

Database source code

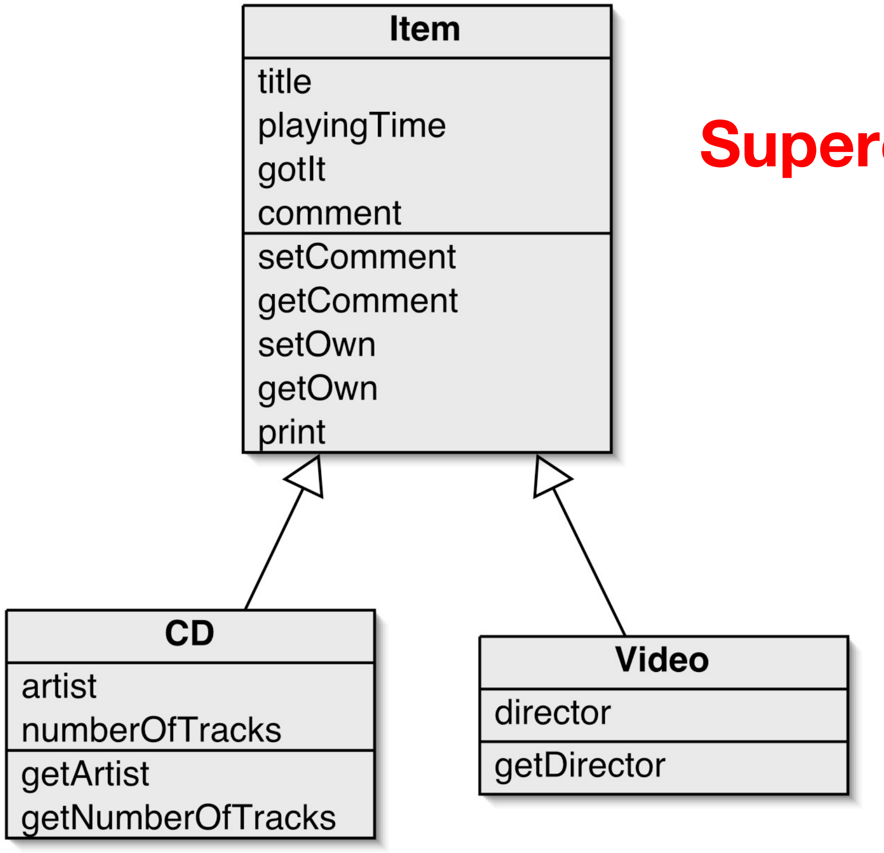
prints a list of all CDs and videos

```
class Database {

   private ArrayList<CD> cds;
   private ArrayList<Video> videos;
   ...

   public void list()
   {
      for(Iterator iter = cds.iterator(); iter.hasNext(); ) {
          CD cd = iter.next();
          cd.print();
          System.out.println();   // empty line between items
       }

      for(Iterator iter = videos.iterator(); iter.hasNext(); ) {
          Video video = iter.next();
          video.print();
          System.out.println();   // empty line between items
       }
   }
}
```

Critique of DoME

- code duplication
  - CD and Video classes very similar (large parts are identical)
  - makes maintenance difficult/more work
  - introduces danger of bugs through incorrect maintenance
- code duplication also in Database class
  - Imagine a third media “VideoGame” – what has to be done?

DoME Inheritance
Class Diagram



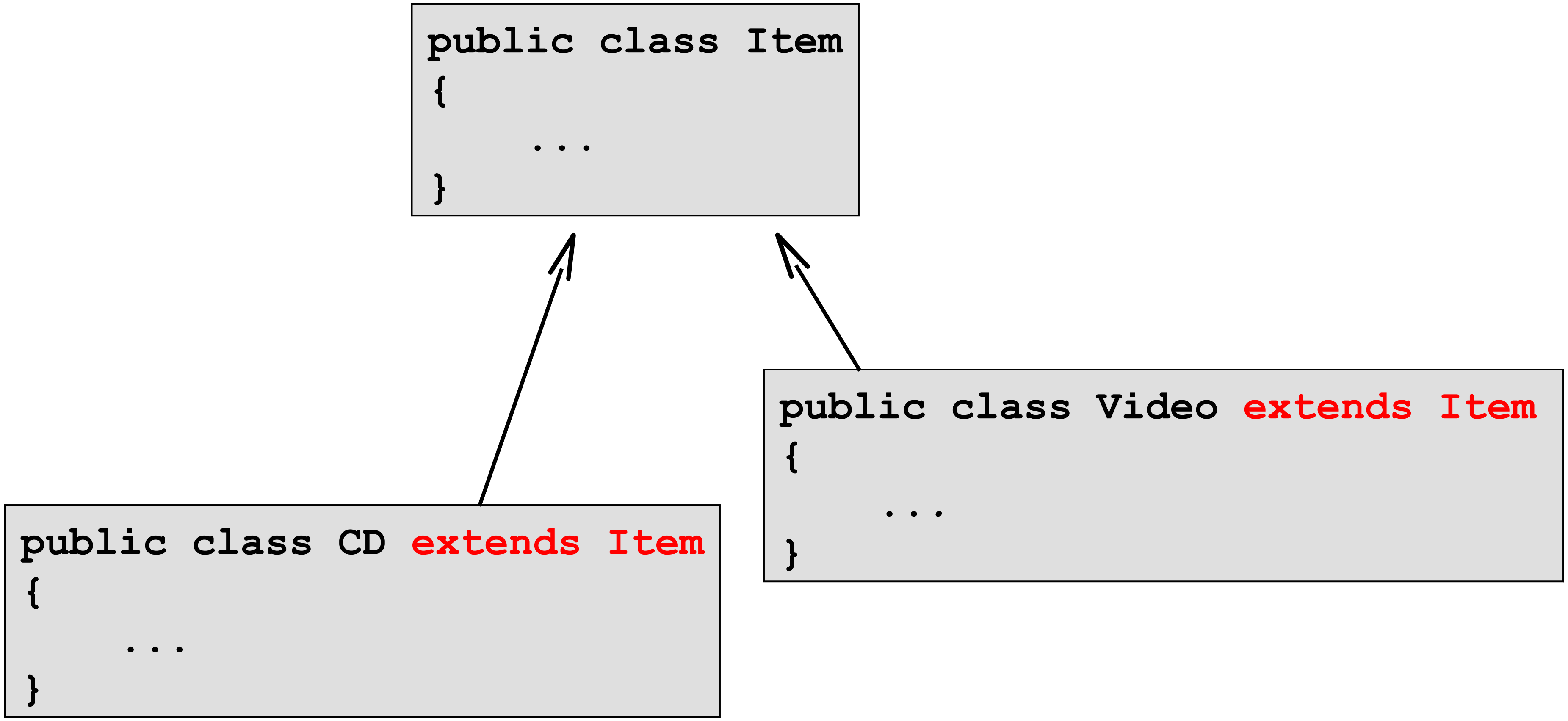
Superclass

Subclass

Inheritance

- define one **superclass** for Item
- define **subclasses** for Video and CD
- the superclass defines common attributes (fields and methods)
- the subclasses **inherit from** or **extend** the superclass
- the subclasses **inherit** the superclass attributes
- the subclasses add their own attributes

Inheritance in Java



```
public class Item
{
      ...
}
```

```
public class CD extends Item
{
      ...
}
```

```
public class Video extends Item
{
      ...
}
```

Superclass

```
public class Item
{
    private String title;
    private int playingTime;
    private boolean gotIt;
    private String comment;

    // constructors and methods omitted.
}
```

object generation possible, but usually not intended

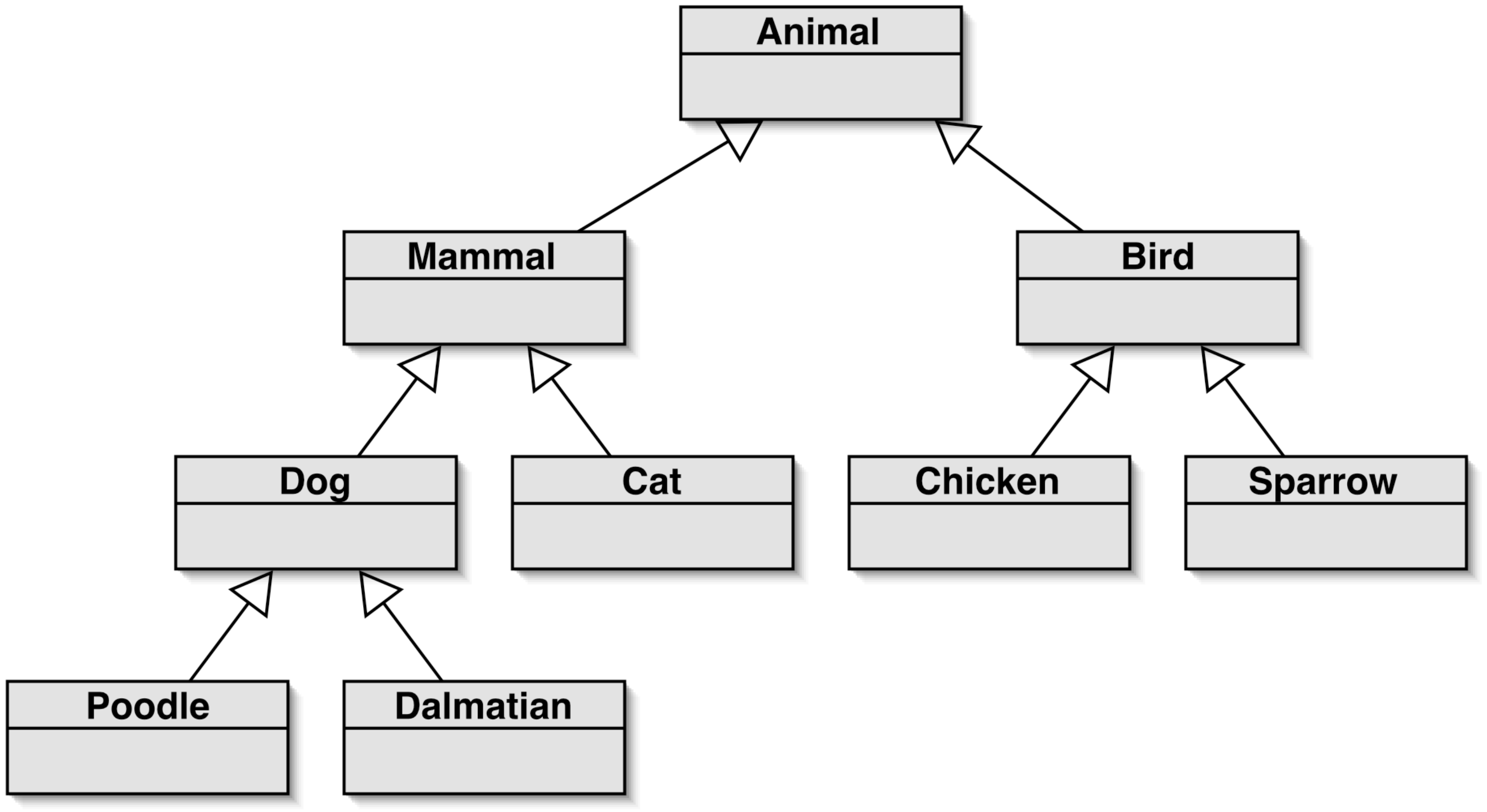
Attention! `private` fields are not visible to the subclass!

Subclasses

```
public class CD extends Item
{
    private String artist;
    private int numberOfTracks;

    // constructors and methods omitted.
}
```

```
public class Video extends Item
{
    private String director;

    // constructors and methods omitted.
}
```

Inheritance hierarchy



Inheritance and constructors

```
public class Item
{
    private String title;
    private int playingTime;
    private boolean gotIt;
    private String comment;

    /**
     * Initialise the fields of the item.
     */
    public Item(String theTitle, int time)
    {
        title = theTitle;
        playingTime = time;
        gotIt = false;
        comment = "";
    }

    // methods omitted
}
```

Inheritance and constructors

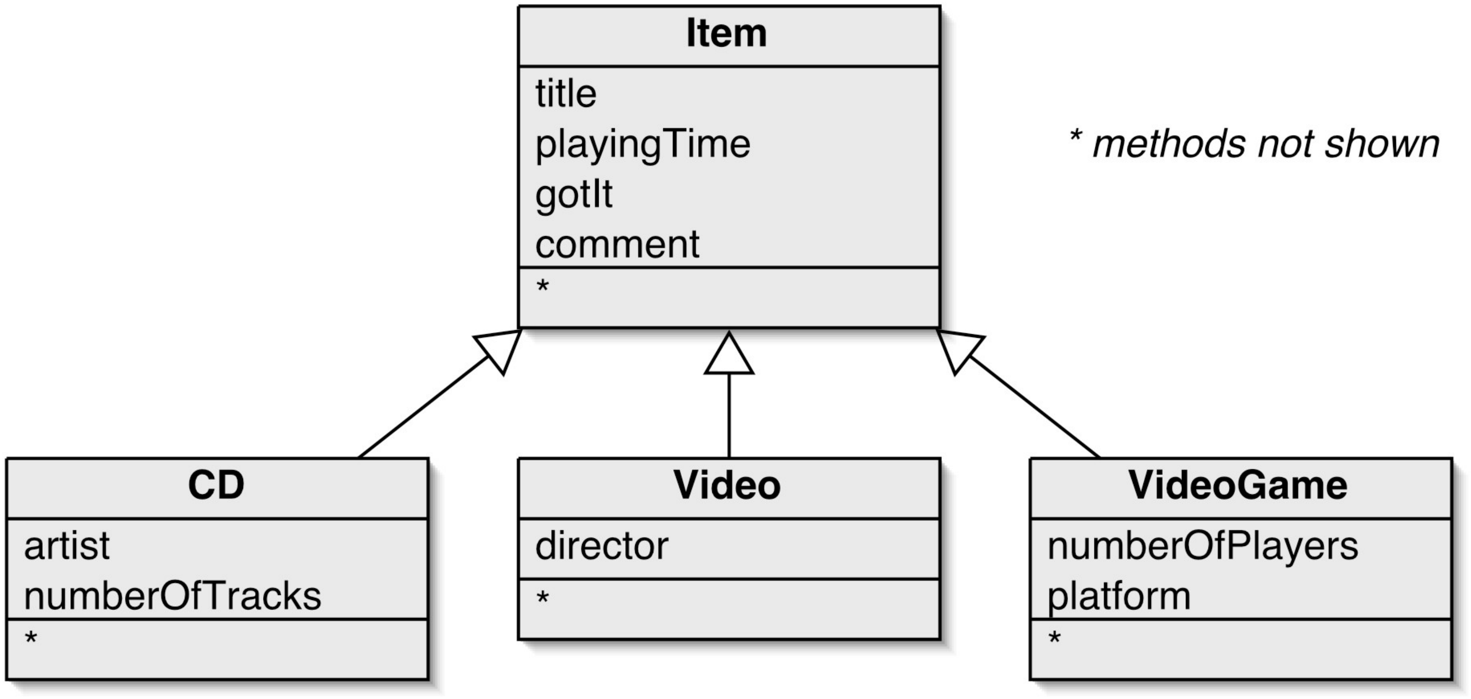
```
public class CD extends Item
{
    private String artist;
    private int numberOfTracks;

    /**
     * Constructor for objects of class CD
     */
    public CD(String theTitle, String theArtist,
              int tracks, int time)
    {
        super(theTitle, time);
        artist = theArtist;
        numberOfTracks = tracks;
    }

    // methods omitted
}
```

privacy also applies between subclasses and their superclass

Superclass constructor call

- Subclass constructors must always contain a 'super' call.
- If none is written, the compiler inserts one (without parameters)
  - works only if the superclass has a constructor without parameters
- Must be the first statement in the subclass constructor.

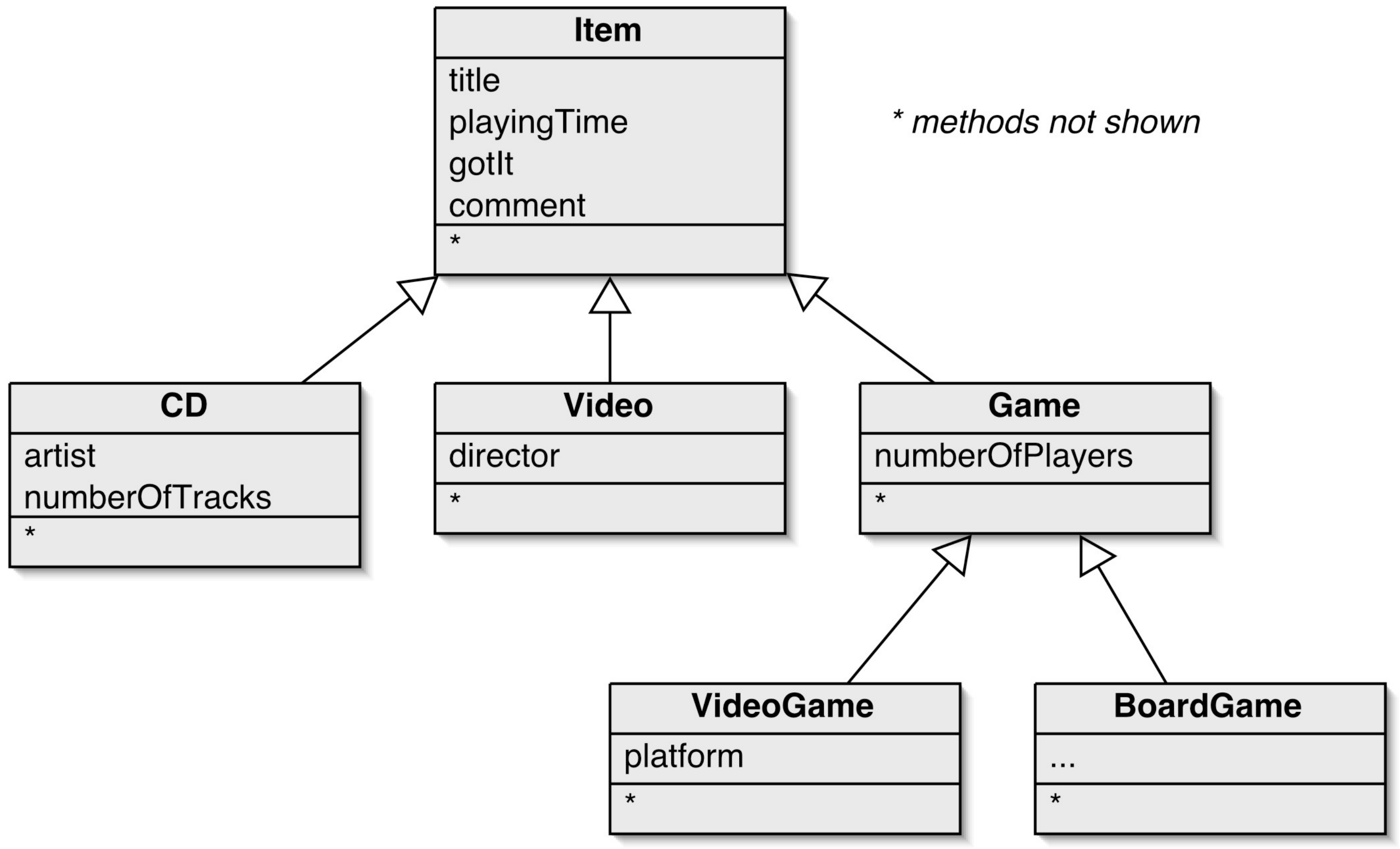
Adding more item types



** methods not shown*

example of code reuse!

Deeper hierarchies



Review (so far)

Inheritance helps with:

- Avoiding code duplication
- Easier maintenance
- Extendibility

New Database

```
public class Database
{
    private ArrayList<Item> items;

    /**
     * Construct an empty Database.
     */
    public Database()
    {
        items = new ArrayList<Item>();
    }

    /**
     * Add an item to the database.
     */
    public void addItem(Item theItem)
    {
        items.add(theItem);
    }
    ...
}
```

avoids code duplication

New Database source code

```
/**
 * Print a list of all currently stored CDs and
 * videos to the text terminal.
 */
public void list()
{
   for(Iterator iter = items.iterator(); iter.hasNext(); ) {
       Item item = (Item)iter.next();
       item.print();
       System.out.println();   // empty line between items
   }
}
```

Subtyping

First, we had:

```
public void addCD(CD theCD)
public void addVideo(Video theVideo)
```

Now, we have:

```
public void addItem(Item theItem)
```

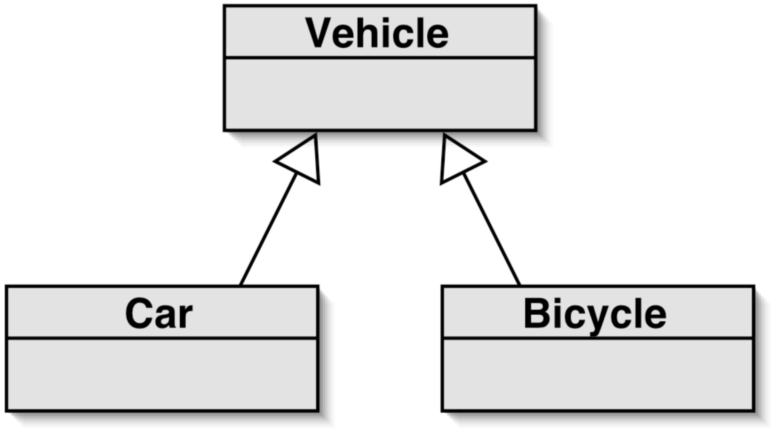
Method call:

```
Video myVideo = new Video(...);
database.addItem(myVideo);
```

Subclasses and Subtyping

- Classes define types.
- Subclasses define subtypes.
- Objects of subclasses can be used where objects of supertypes are required (interface ↔ instance).
  This is called **substitution**.

Subtyping and assignment



subclass objects may be assigned to superclass variables - but not the other way round!

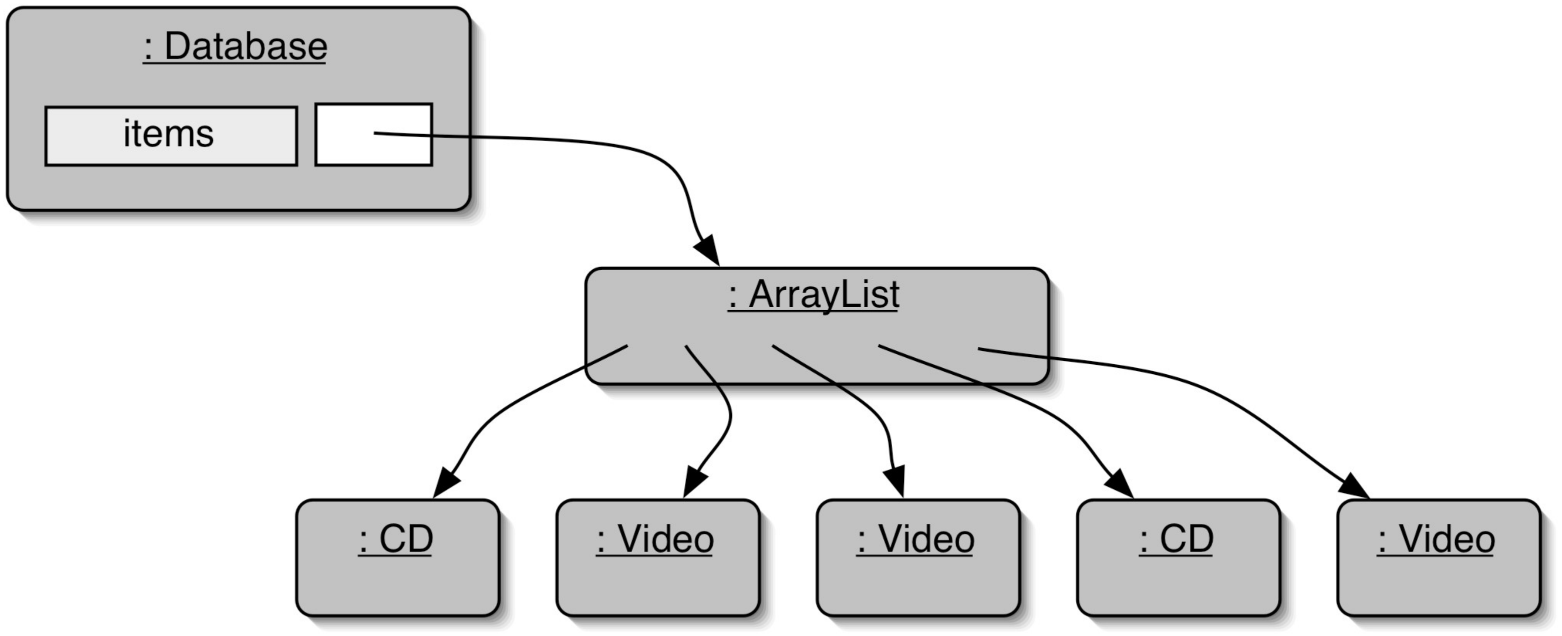
```
Vehicle v1 = new Vehicle();
Vehicle v2 = new Car();
Vehicle v3 = new Bicycle();
```

Subtyping and parameter passing

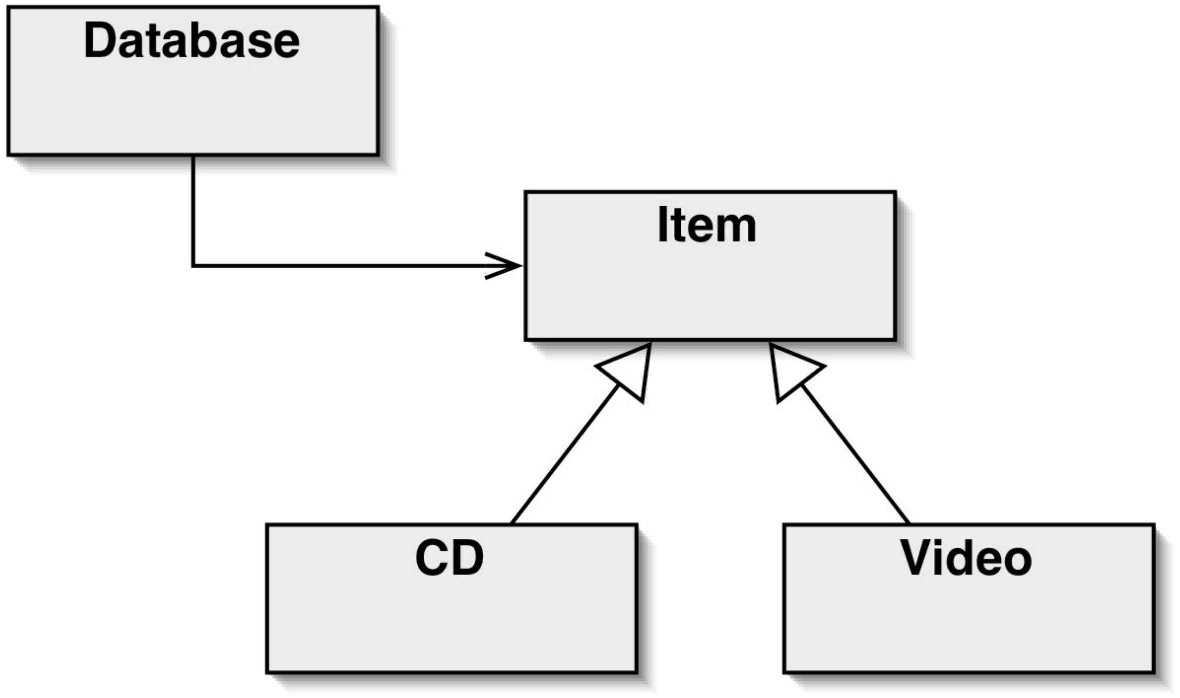
```
public class Database
{

    public void addItem(Item theItem)
    {
        ...
    }
}

Video video = new Video(...);
CD cd = new CD(...);

database.addItem(video);
database.addItem(cd);
```

subclass objects may be passed to superclass parameters - but not the other way round!

Object diagram



Class diagram



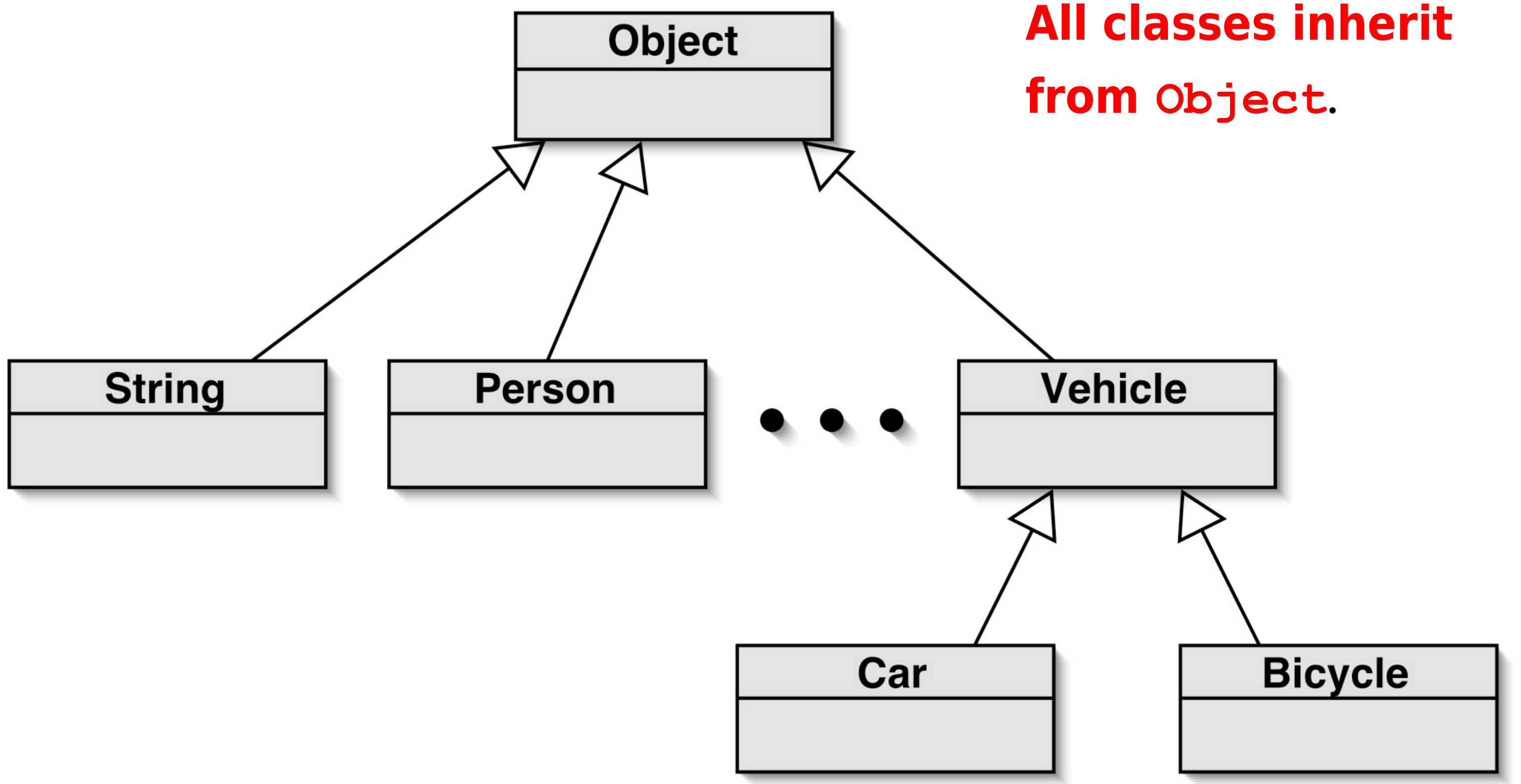
Polymorphic variables

- `Object:` a superclass for all objects
- `Object` variables in Java are **polymorphic**.

  (They can hold objects of more than one type.)

- They can hold objects of the declared type, or of subtypes of the declared type.

The Object class



All classes inherit from `Object`.

Polymorphic collections

- All collections are polymorphic.
- The elements are of type `Object`.

```
public void add(Object element)

public Object get(int index)
```

Casting revisited

- Can assign subtype to supertype.
- Cannot assign supertype to subtype!

```
Video v1 = myList.get(1);
```
error!

- Casting fixes this:

```
Video v1 = (Video) myList.get(1);
```

only if the element has type Video – otherwise runtime error

Wrapper classes

- All objects can be entered into collections...
- ...because collections accept elements of type Object...
- ...and all classes are subtypes of Object.
- Great! But what about simple types?

Wrapper classes

- Simple types (int, char, *etc*) are not objects. They must be wrapped into an object!
- Wrapper classes exist for all simple types:

simple type	*wrapper class*
int	Integer
float	Float
char	Character
…	…

Wrapper classes

```
Collection<Object> myCollection;
myCollection = new ArrayList<Object>();

int i = 18;
Integer iwrap = new Integer(i);

myCollecton.add(iwrap);
...

Integer element = (Integer)myCollection.get(0);
int value = element.intValue()
```

wrap the int value

add the wrapper

retrieve the wrapper

unwrap

Review

- Inheritance allows the definition of classes as extensions of other classes.
- Inheritance
  - avoids code duplication
  - allows code reuse
  - simplifies the code
  - simplifies maintenance and extending
- Variables can hold subtype objects.
- Subtypes can be used wherever supertype objects are expected (substitution).