Improving structure with inheritance

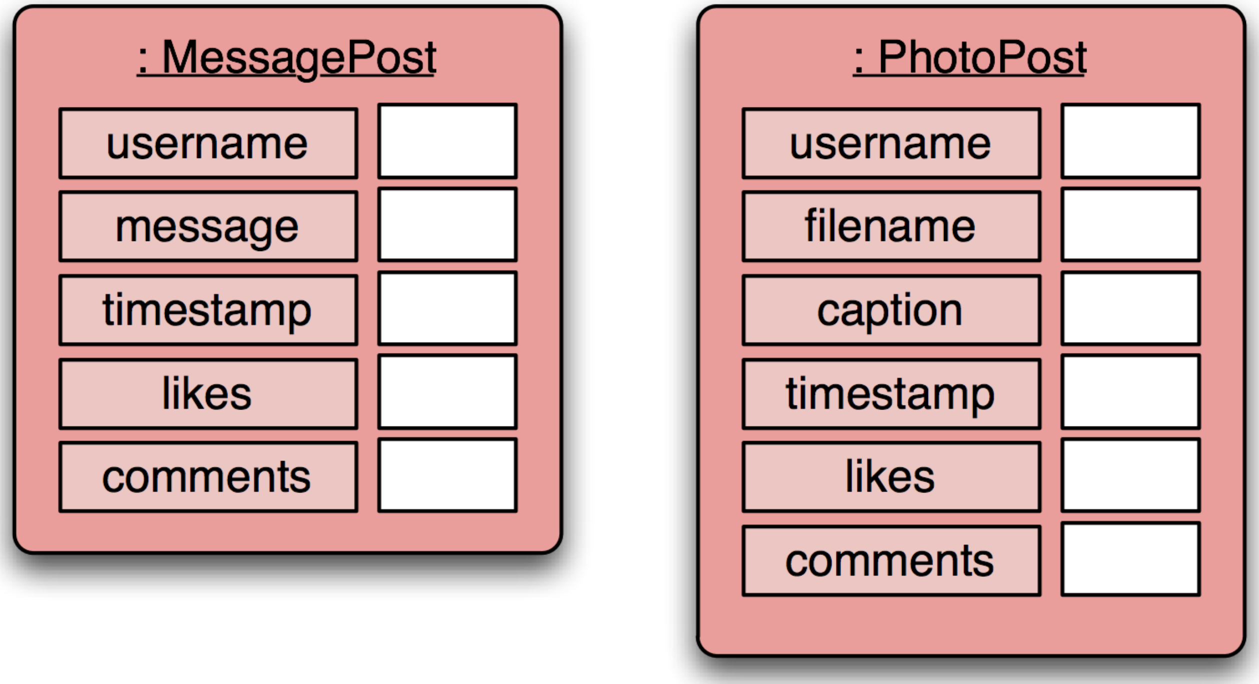
Main concepts to be covered

- Inheritance
- Subtyping
- Substitution
- Polymorphic variables

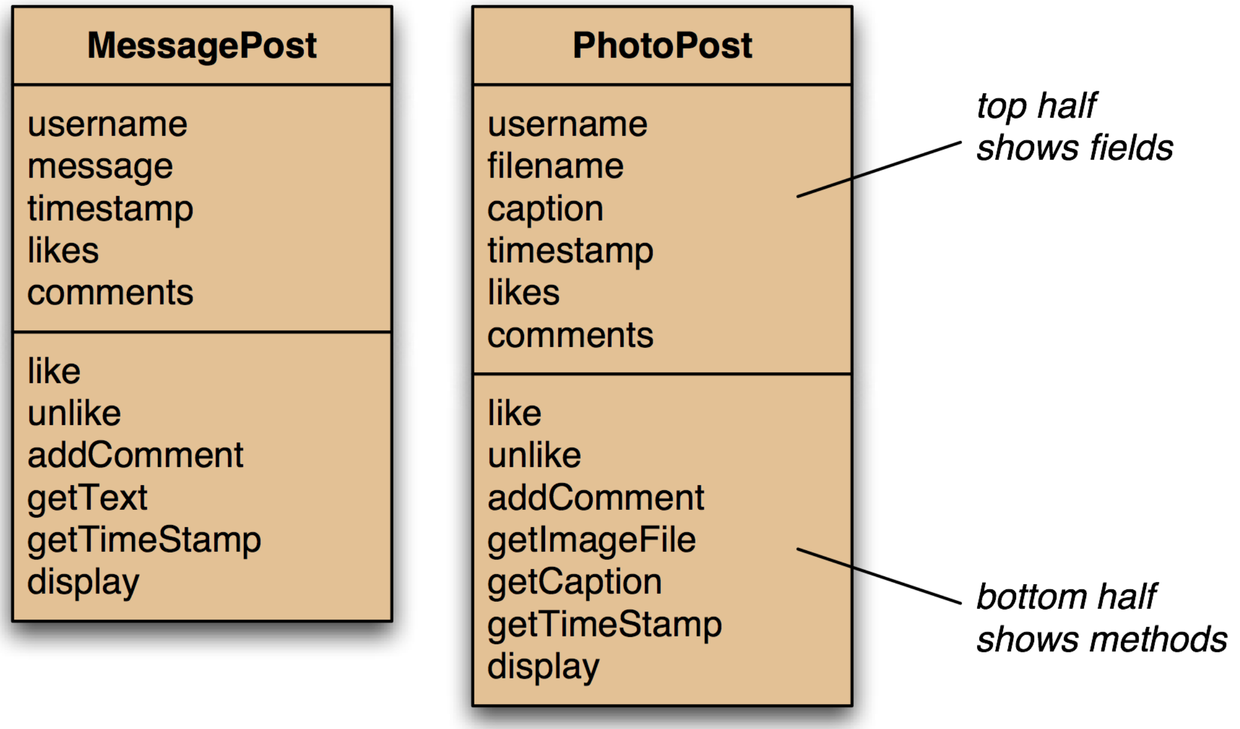
The Network example

- A small, prototype social network.
- Supports a news feed with posts.
- Stores *text posts* and *photo posts*.
  - MessagePost: multi-line text message.
  - PhotoPost: photo and caption.
- Allows operations on the posts:
  - E.g., search, display and remove.

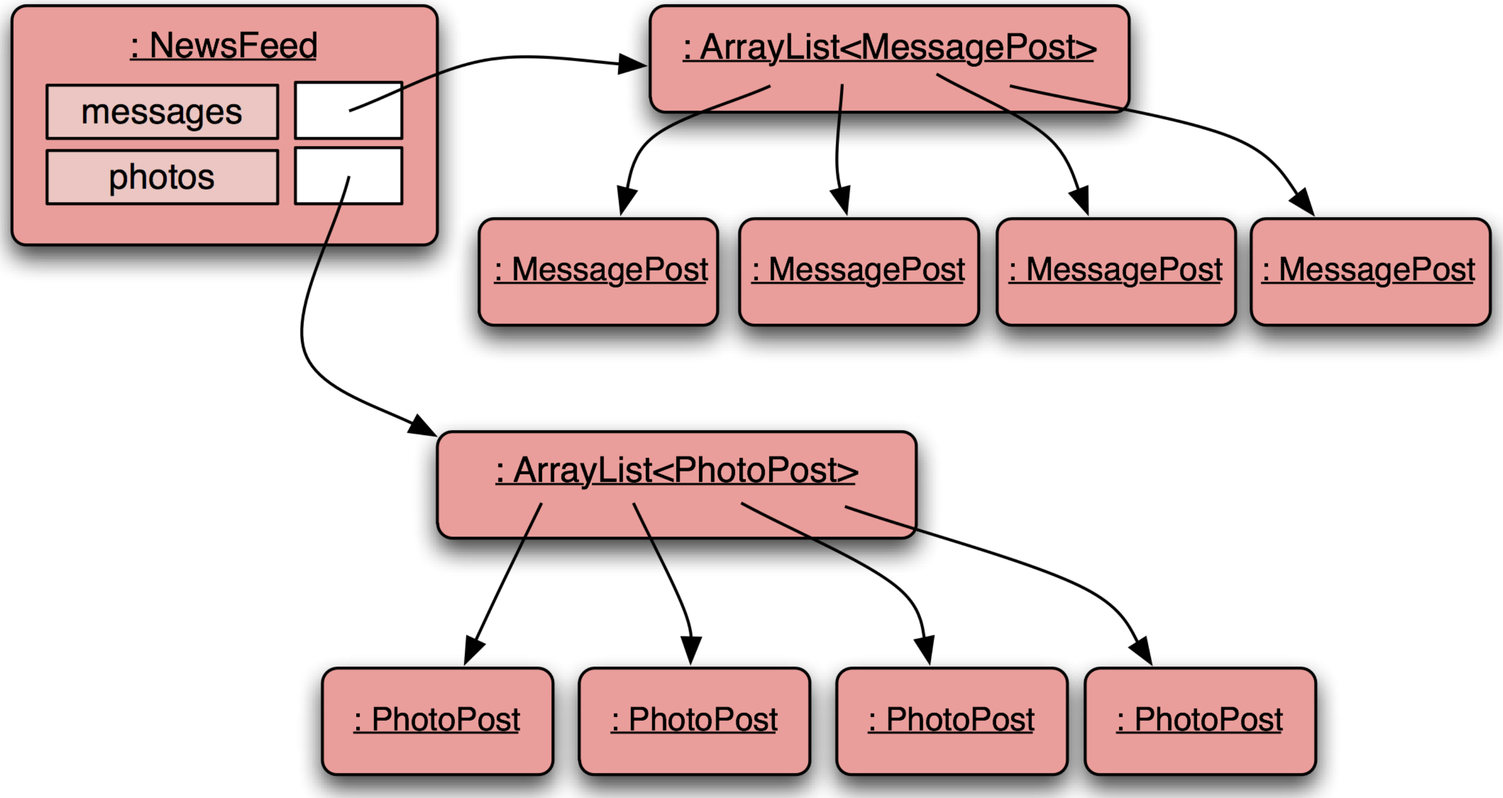
Network objects



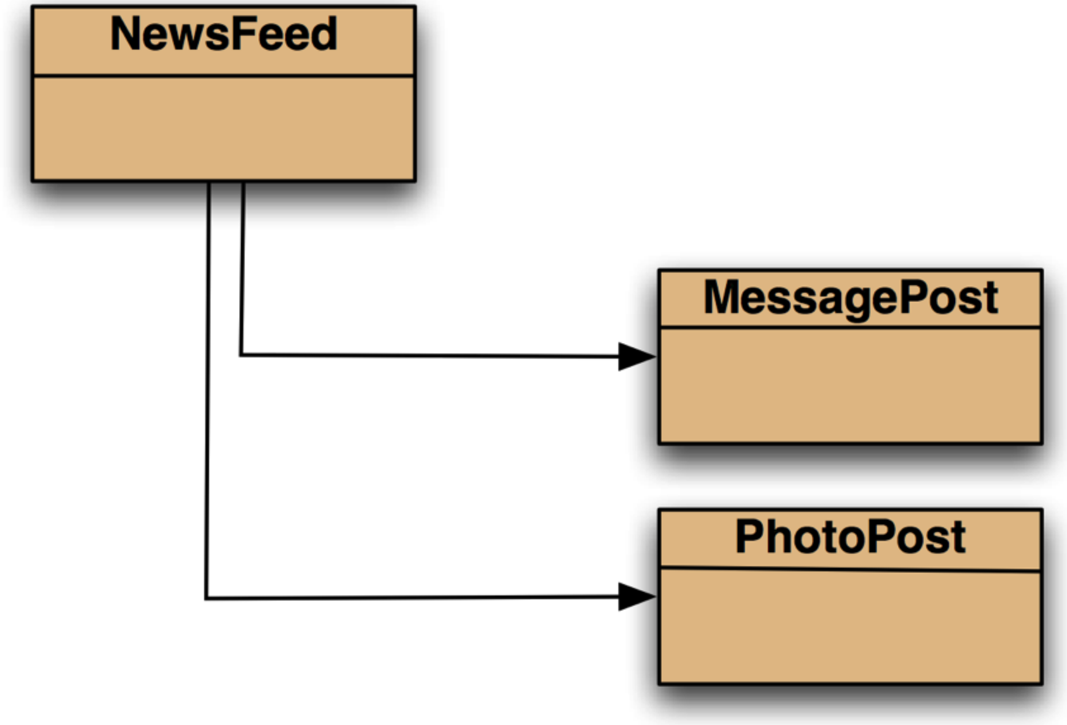
Network classes



Network object model



Class diagram



MessagePost source code

Just an outline

```
public class MessagePost
{
   private String username;
   private String message;
   private long timestamp;
   private int likes;
   private ArrayList<String> comments;

   public MessagePost(String author, String text)
   {
        username = author;
        message = text;
        timestamp = System.currentTimeMillis();
        likes = 0;
        comments = new ArrayList<String>();
   }

   public void addComment(String text) ...

   public void like() ...

   public void display() ...

   ...
}
```

Photo-Post source code

Just an outline

```
public class PhotoPost
{
   private String username;
   private String filename;
   private String caption;
   private long timestamp;
   private int likes;
   private ArrayList<String> comments;

   public PhotoPost(String author, String filename,
                    String caption)
   {
        username = author;
        this.filename = filename;
        this.caption = caption;
        timestamp = System.currentTimeMillis();
        likes = 0;
        comments = new ArrayList<String>();
   }

   public void addComment(String text) ...
   public void like() …
   public void display() …
   ...
}
```

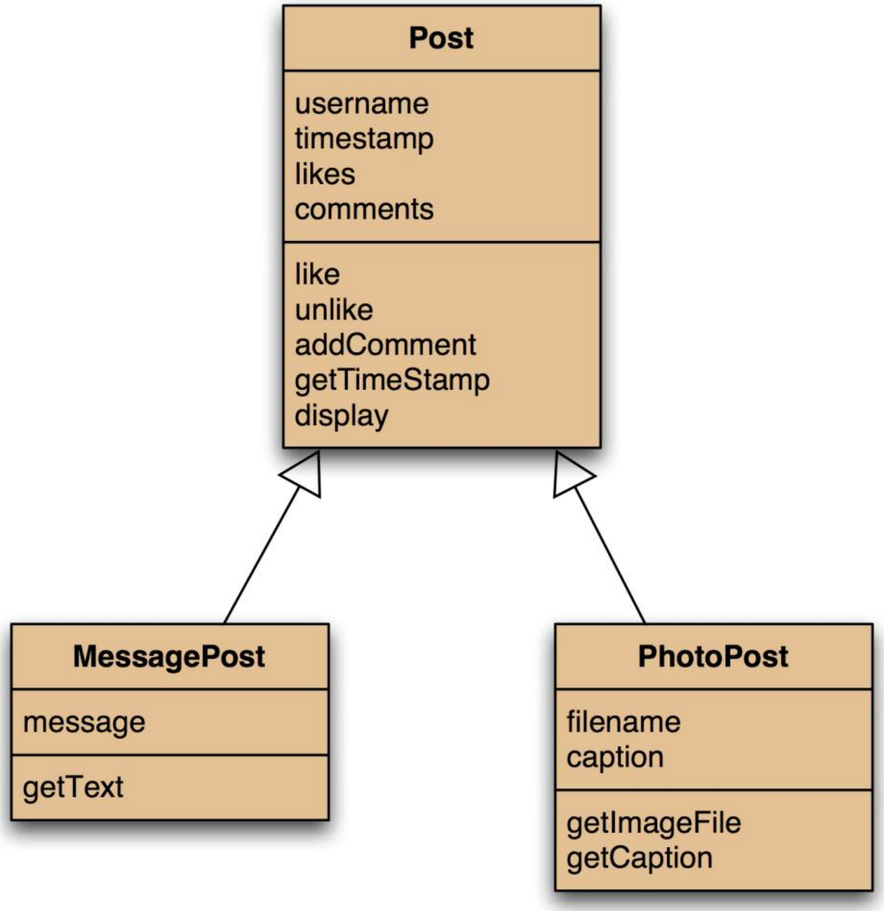
NewsFeed

```
public class NewsFeed
{
   private ArrayList<MessagePost> messages;
   private ArrayList<PhotoPost> photos;
   ...
   public void show()
   {
       for(MessagePost message : messages) {
          message.display();
          System.out.println();  // empty line between posts
       }

       for(PhotoPost photo : photos) {
          photo.display();
          System.out.println();  // empty line between posts
       }
   }
}
```

Critique of Network

- Code duplication:
  - MessagePost and PhotoPost classes very similar (large parts are identical)
  - makes maintenance difficult/more work
  - introduces danger of bugs through incorrect maintenance
- Code duplication in NewsFeed class as well.

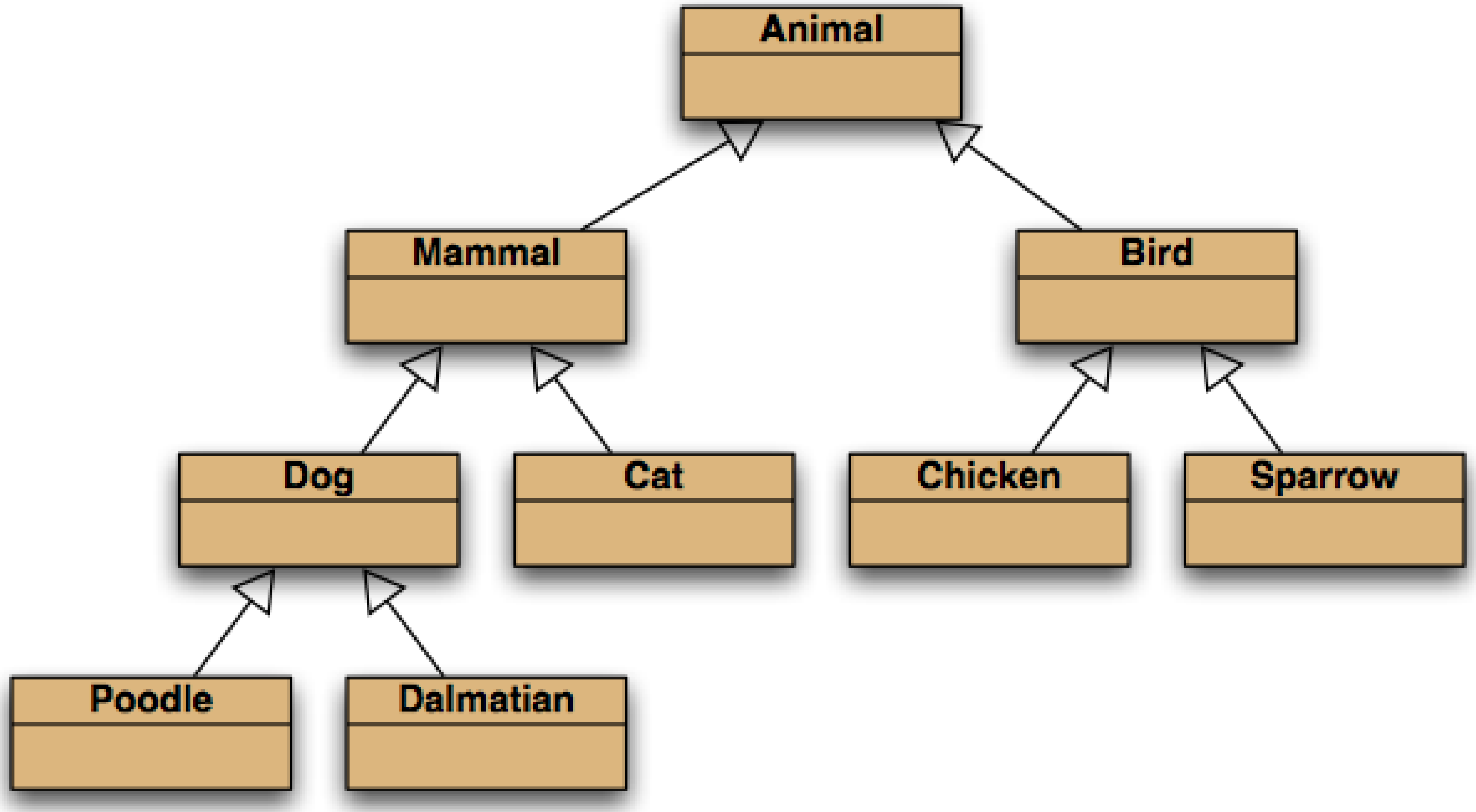
Using inheritance



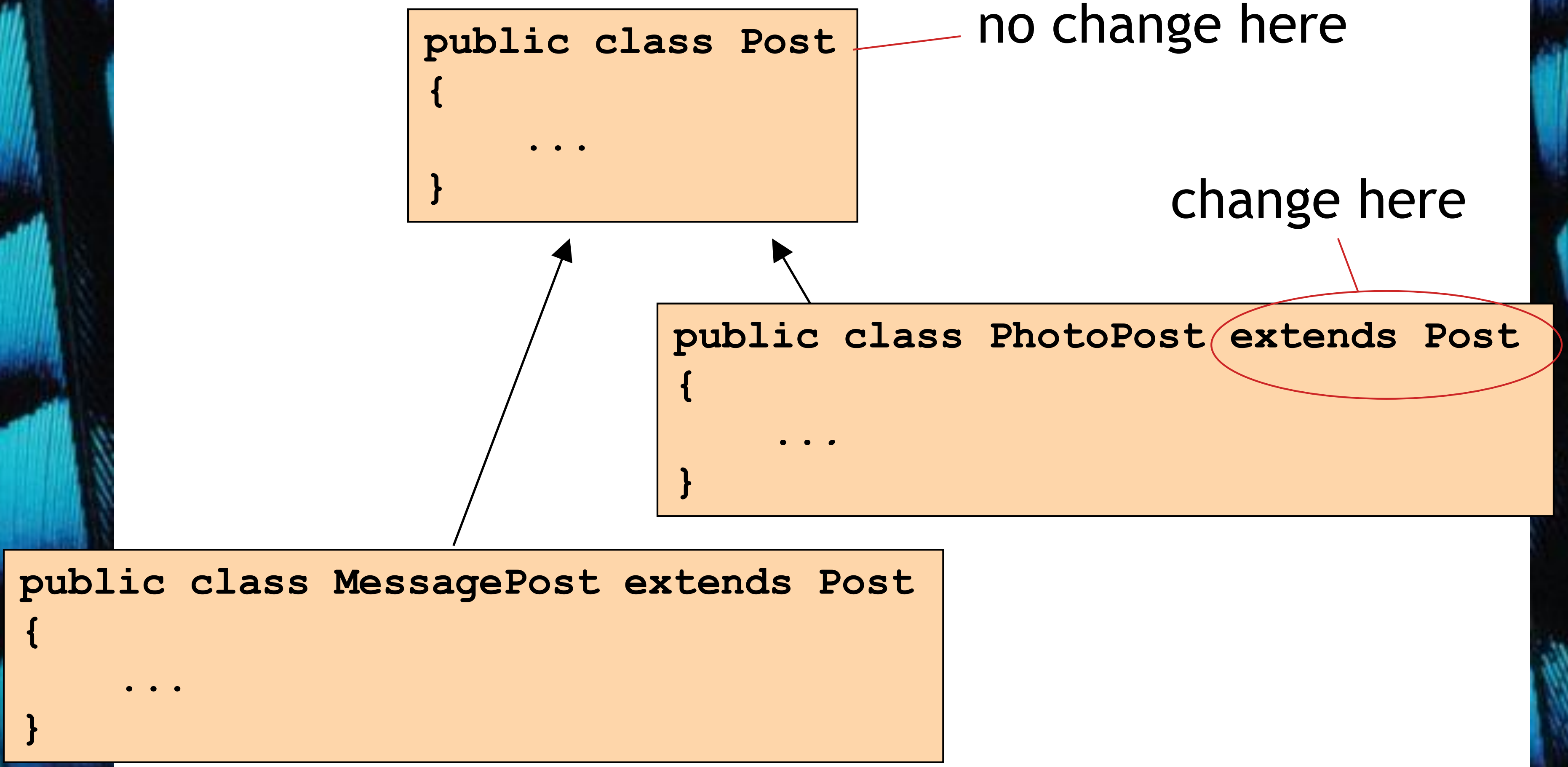
Using inheritance

- define one superclass : **`Post`**
- define subclasses for **`MessagePost`** and **`PhotoPost`**
- the superclass defines common attributes (via fields)
- the subclasses **inherit** the superclass attributes
- the subclasses add other attributes

Inheritance hierarchies



Inheritance in Java



```
public class Post
{
      ...
}
```

no change here

change here

```
public class PhotoPost extends Post
{
      ...
}
```

```
public class MessagePost extends Post
{
      ...
}
```

Superclass

```
public class Post
{
    private String username;
    private long timestamp;
    private int likes;
    private ArrayList<String> comments;

    // constructor and methods omitted.
}
```

Subclasses

```
public class MessagePost extends Post
{
    private String message;

    // constructor and methods omitted.
}
```

```
public class PhotoPost extends Post
{
    private String filename;
    private String caption;

    // constructor and methods omitted.
}
```

Inheritance and constructors

```
public class Post
{
    private String username;
    private long timestamp;
    private int likes;
    private ArrayList<String> comments;

    /**
     * Initialise the fields of the post.
     */
    public Post(String author)
    {
        username = author;
        timestamp = System.currentTimeMillis();
        likes = 0;
        comments = new ArrayList<String>();
    }

    // methods omitted
}
```

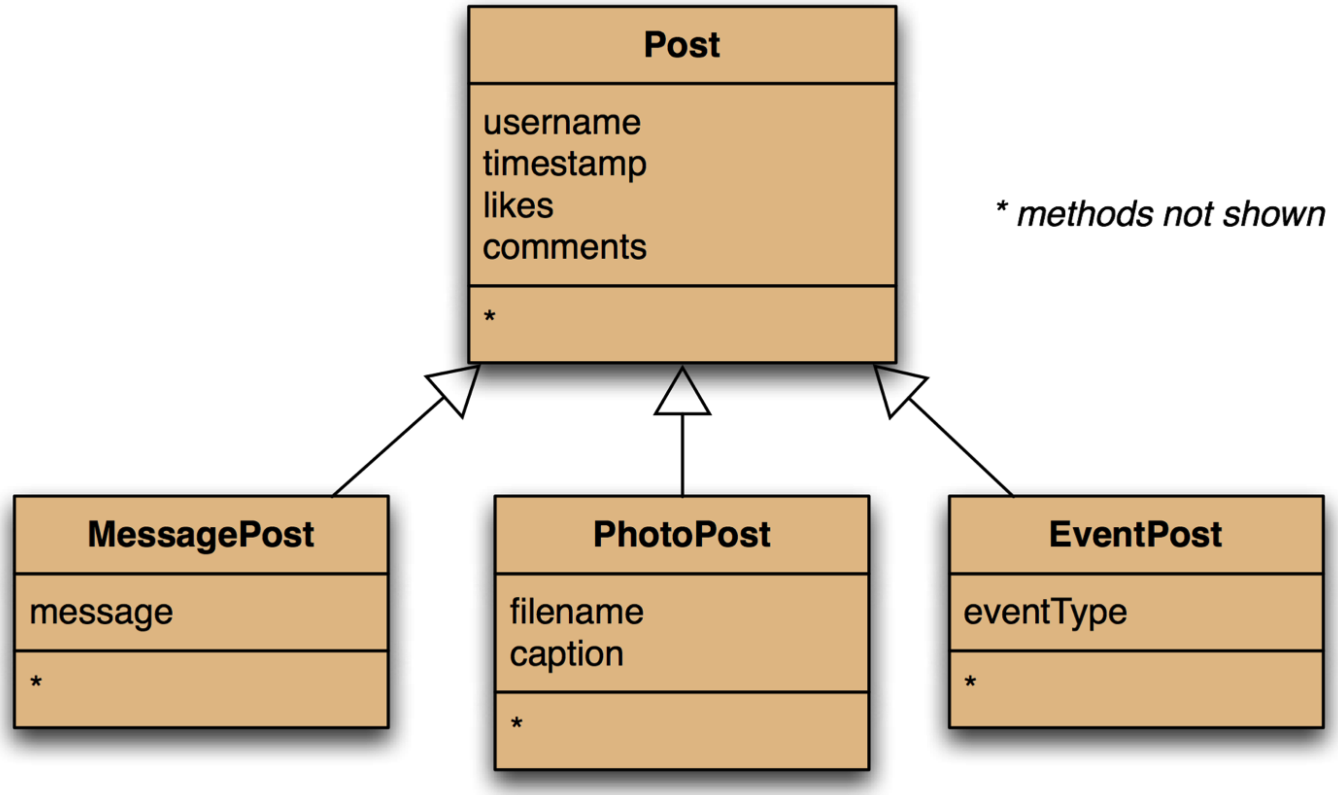
Inheritance and constructors

```
public class MessagePost extends Post
{
    private String message;

    /**
     * Constructor for objects of class MessagePost
     */
    public CD(String author, String text)
    {
        super(author);
        message = text;
    }

    // methods omitted
}
```

Superclass constructor call

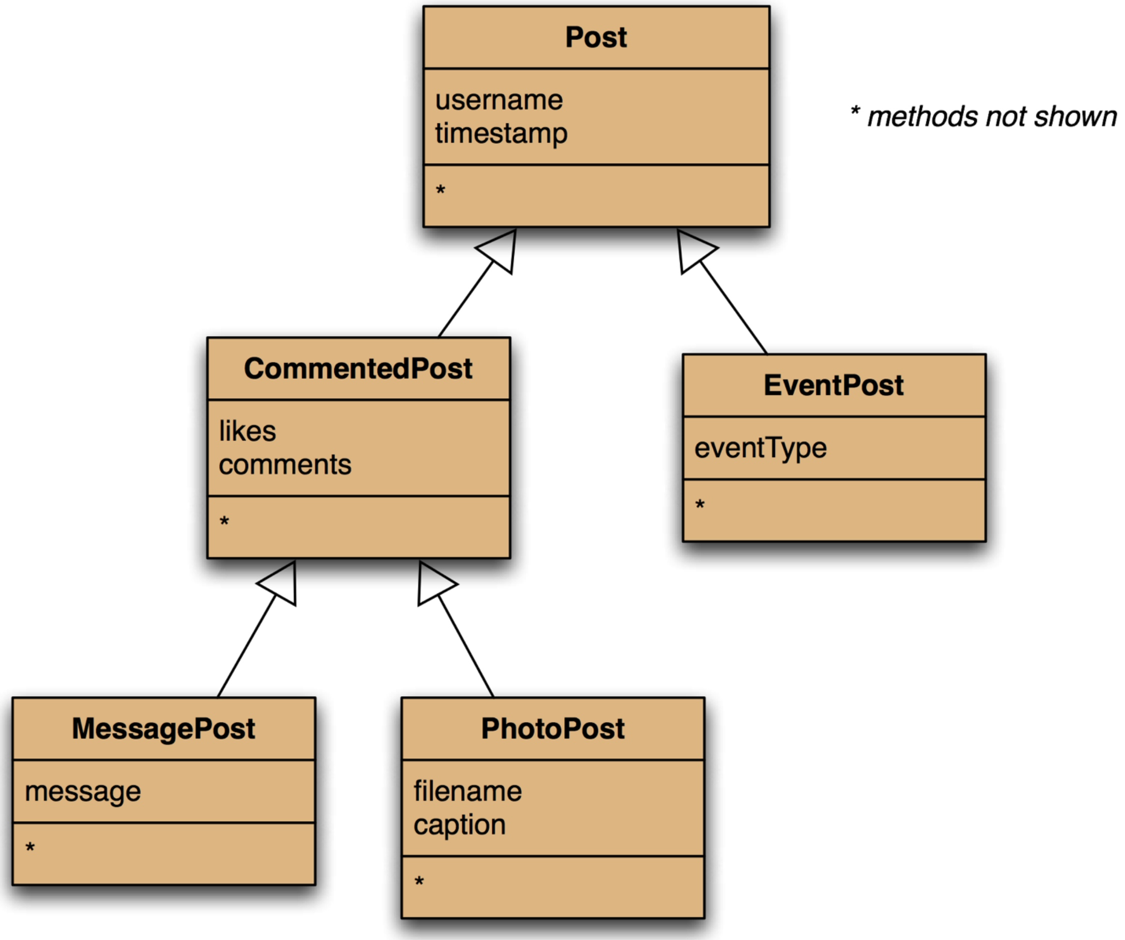
- Subclass constructors must always contain a 'super' call.
- If none is written, the compiler inserts one (without parameters)
  - works only, if the superclass has a constructor without parameters
- Must be the first statement in the subclass constructor.

Adding more item types



** methods not shown*

Deeper hierarchies



Review (so far)

Inheritance (so far) helps with:

- Avoiding code duplication
- Code reuse
- Easier maintenance
- Extendibility

Revised NewsFeed source code

```
public class NewsFeed
{
    private ArrayList<Post> posts;

    /**
     * Construct an empty news feed.
     */
    public NewsFeed()
    {
        posts = new ArrayList<Post>();
    }

    /**
     * Add a post to the news feed.
     */
    public void addPost(Post post)
    {
        posts.add(post);
    }
    ...
}
```

avoids code duplication in the client class!

New NewsFeed source code

```
/**
 * Show the news feed. Currently: print the
 * news feed details to the terminal.
 * (Later: display in a web browser.)
 */
public void show()
{
   for(Post post : posts) {
       post.display();
       System.out.println(); // Empty line ...
   }
}
```

Subtyping

First, we had:

```
public void addMessagePost(
                MessagePost message)
public void addPhotoPost(
                PhotoPost photo)
```

Now, we have:

```
public void addPost(Post post)
```

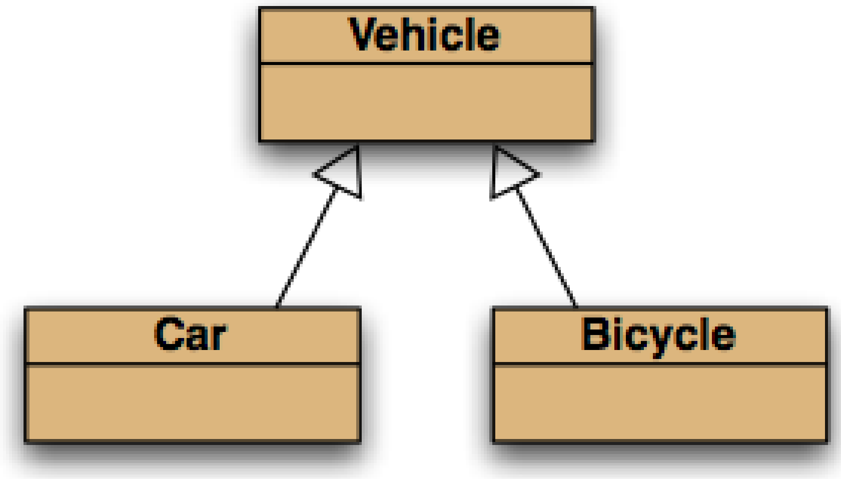
We call this method with:

```
PhotoPost myPhoto = new PhotoPost(...);
feed.addPost(myPhoto);
```

Subclasses and subtyping

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

Subtyping and assignment



subclass objects may be assigned to superclass variables

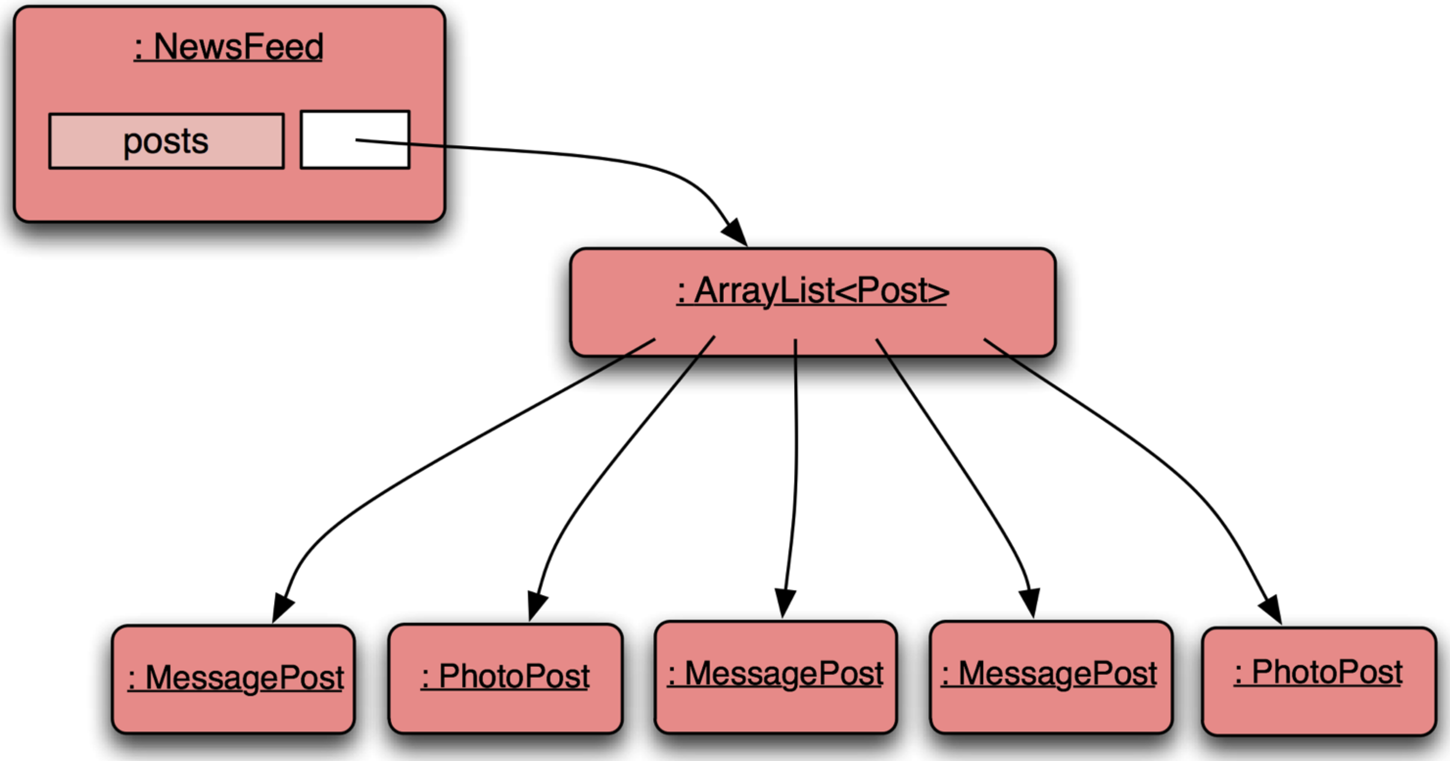
```
Vehicle v1 = new Vehicle();
Vehicle v2 = new Car();
Vehicle v3 = new Bicycle();
```

Subtyping and parameter passing

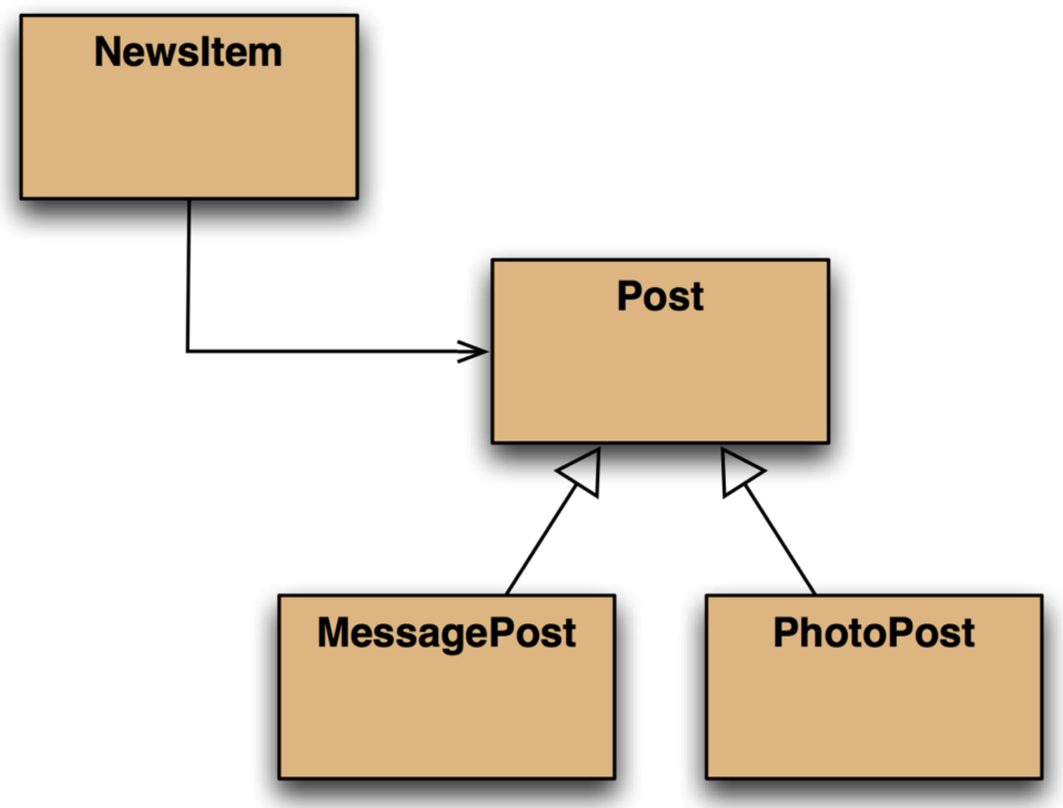
```
public class NewsFeed
{

    public void addPost(Post post)
    {
        ...
    }
}

PhotoPost photo = new PhotoPost(...);
MessagePost message = new MessagePost(...);

feed.addPost(photo);
feed.addPost(message);
```

subclass objects may be used as actual parameters for the superclass

Object diagram



Class diagram



Polymorphic variables

- 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.

Casting

- We can assign subtype to supertype …
- … but we cannot assign supertype to subtype!

```
Vehicle v;
Car c = new Car();
v = c;   // correct
c = v;   // compile-time error!
```

- Casting fixes this:

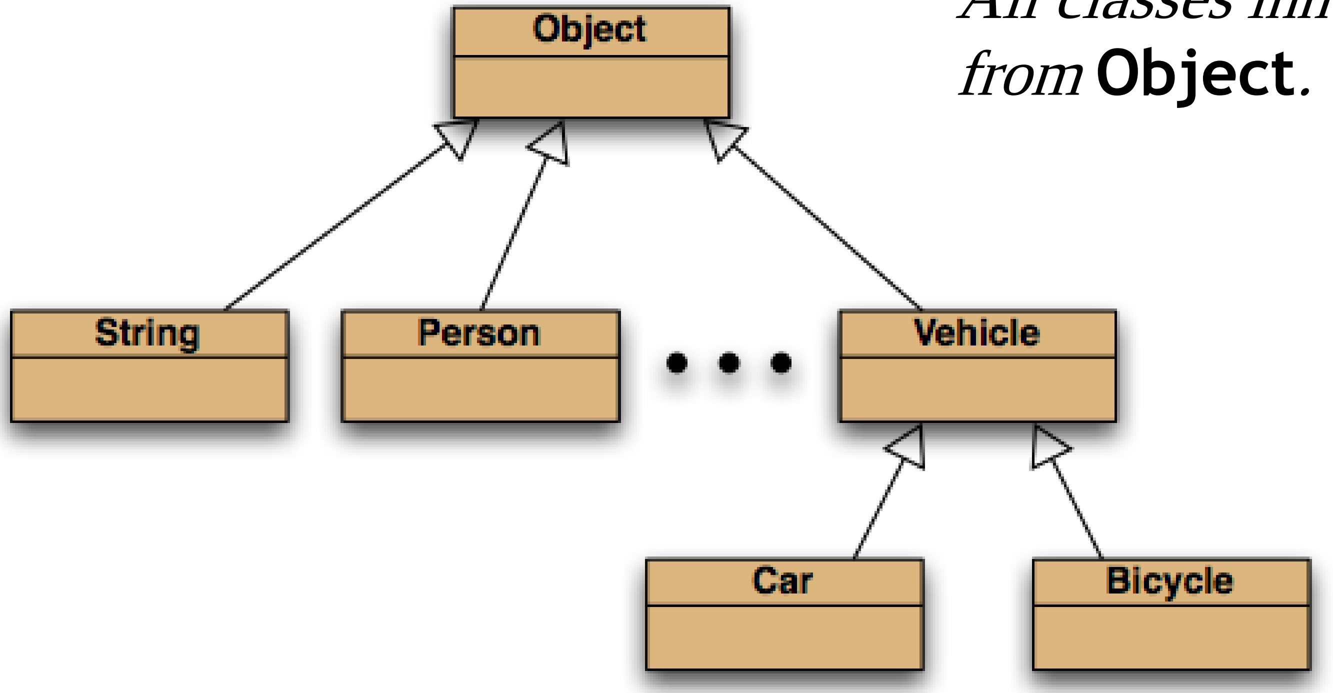
```
c = (Car) v;
```

(only ok if the vehicle really is a Car!)

Casting

- An object type in parentheses.
- Used to overcome 'type loss'.
- The object is not changed in any way.
- A runtime check is made to ensure the object really is of that type:
  - `ClassCastException` if it isn't!
- Use it sparingly.

The Object class



All classes inherit from **Object**.

Polymorphic collections

- All collections are polymorphic.
- The elements could simply be of type **`Object`**.

```
public void add(Object element)

public Object get(int index)
```

- Usually avoided by using a type parameter with the collection.

Polymorphic collections

- A type parameter limits the degree of polymorphism: **`ArrayList<Post>`**
- Collection methods are then typed.
- Without a type parameter, **`ArrayList<Object>`** is implied.
- Likely to get an *“unchecked or unsafe operations”* warning.
- More likely to have to use casts.

Collections and primitive types

- Potentially, all objects can be entered into collections ...
- ... because collections can accept elements of type **`Object`** ...
- ... and all classes are subtypes of **`Object`**.
- Great! But what about *the primitive types*: **`int`**, **`boolean`**, etc.?

Wrapper classes

- Primitive types are not objects types. Primitive-type values must be wrapped in objects to be stored in a collection!
- Wrapper classes exist for all primitive types:

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

Wrapper classes

wrap the value

```
int i = 18;
Integer iwrap = new Integer(i);
…
int value = iwrap.intValue();
```

unwrap it

In practice, *autoboxing* and *unboxing* mean we don't often have to do this explicitly

Autoboxing and unboxing

```
private ArrayList<Integer> markList;

…

public void storeMark(int mark)

{

    markList.add(mark);     autoboxing

}
```

```
int firstMark = markList.remove(0);     unboxing
```

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).