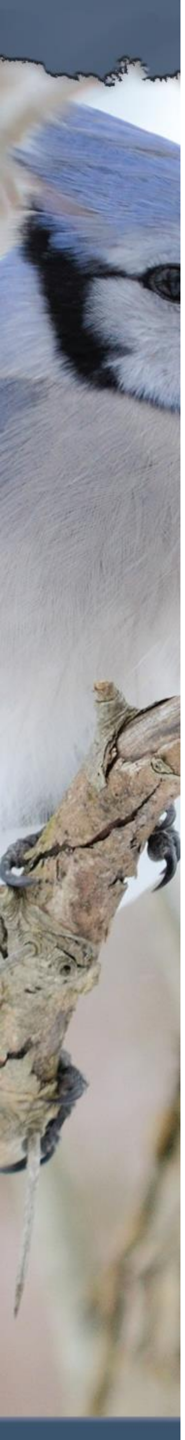
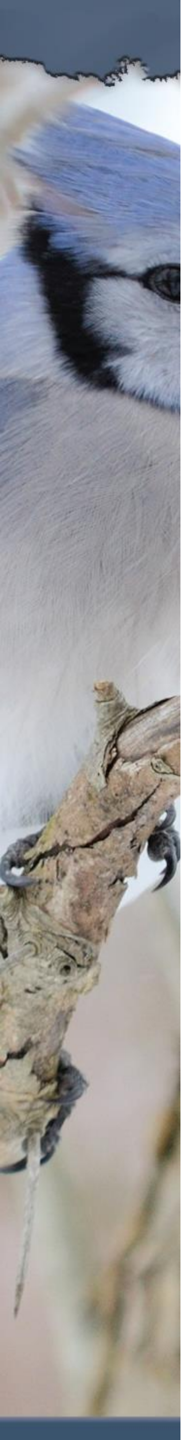


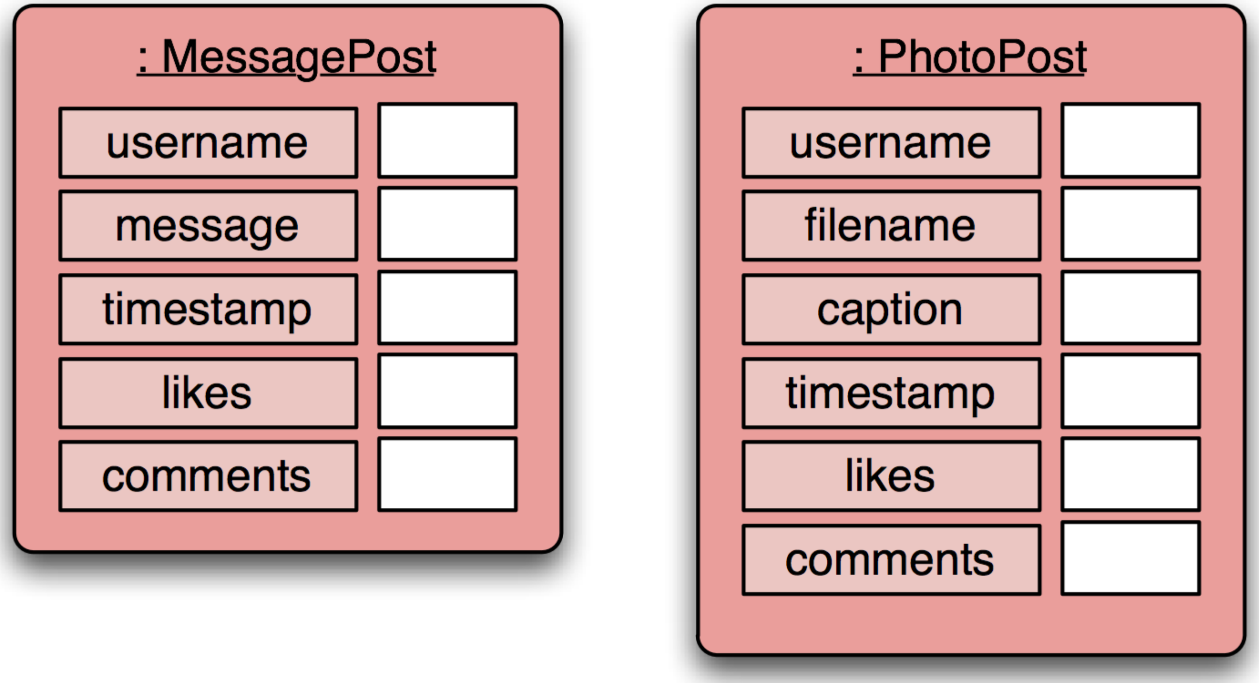
Improving structure with inheritance



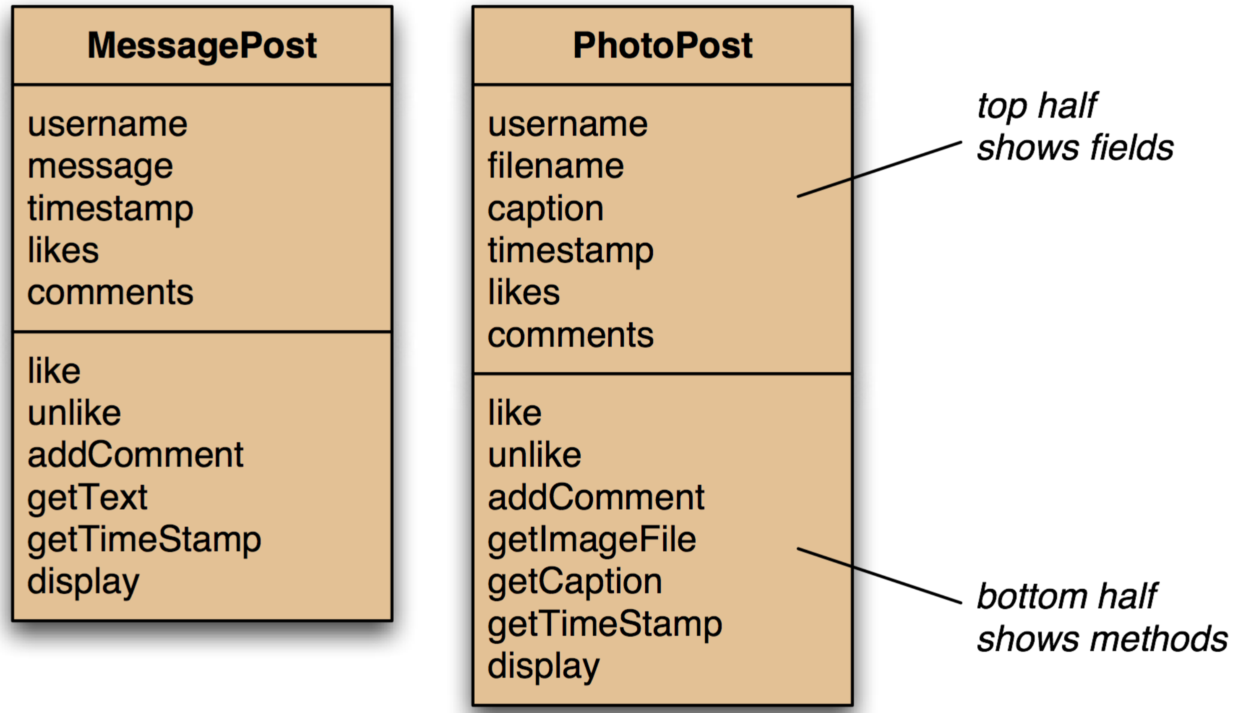
The Network example

- 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

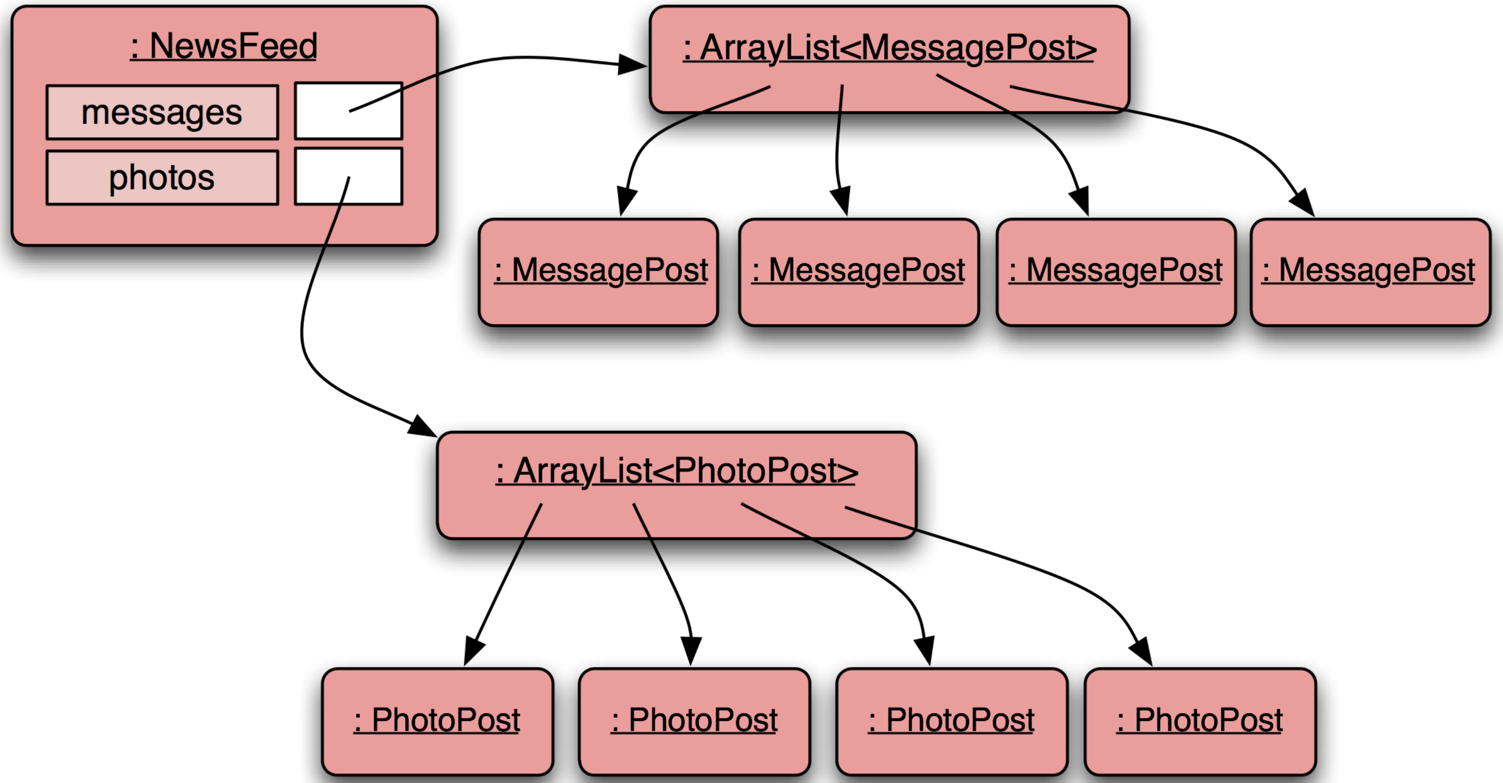
Network objects



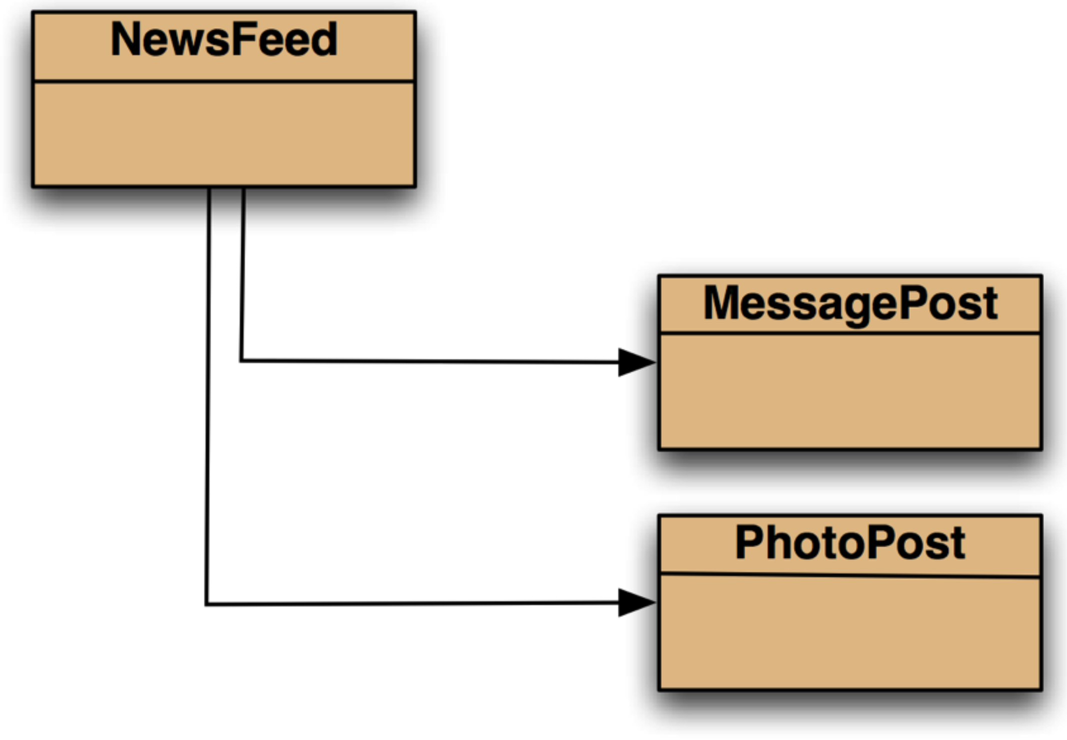
Network classes

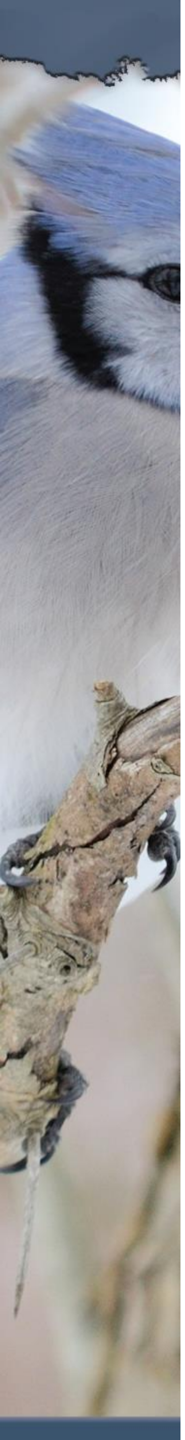


Network object model



Class diagram





Message-Post 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<>();
   }

   public void addComment(String text) ...

   public void like() ...

   public void display() ...

   ...
}
```

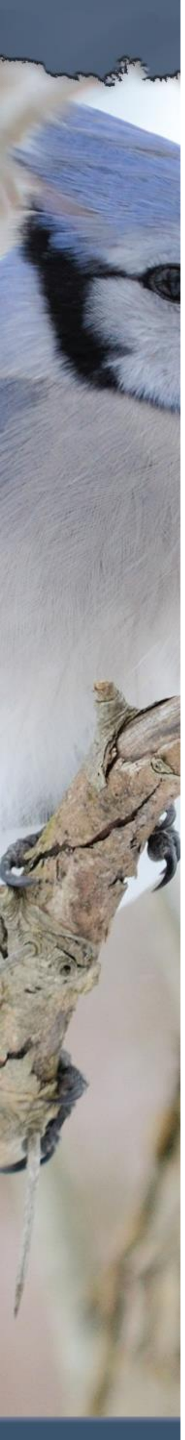
Photo-Post source code

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<>();
   }

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

NewsFeed

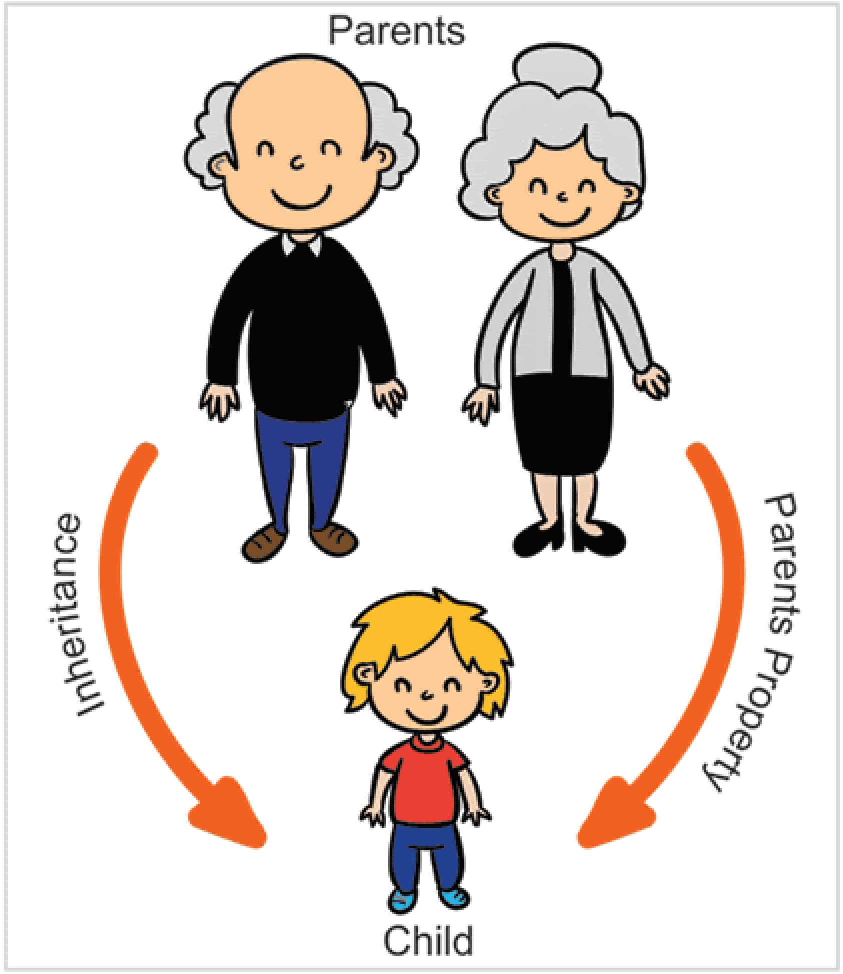
```
public class NewsFeed
{
   private ArrayList<MessagePost> messages;
   private ArrayList<PhotoPost> photos;
   ...
   public void show()
   {
       for(MessagePost message : messages) {
          message.display();
          System.out.println();  // empty line between posts
       }

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



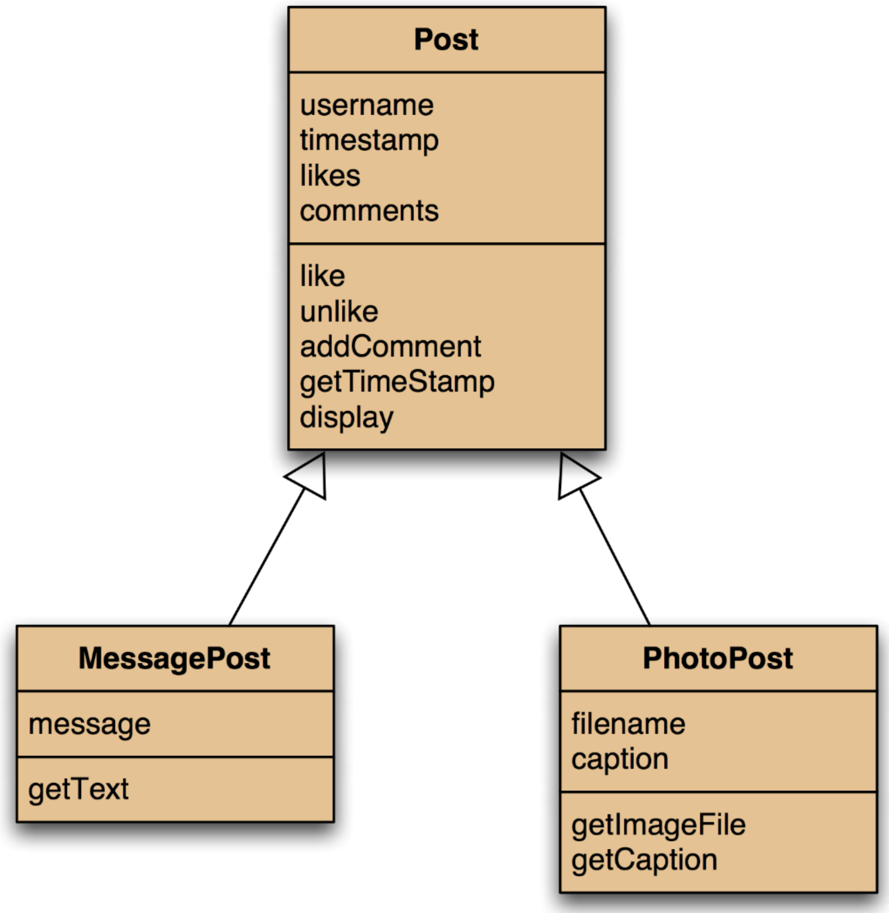
Critique of Network

- Code duplication:
  - **`MessagePost`** and **`PhotoPost`** classes are 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



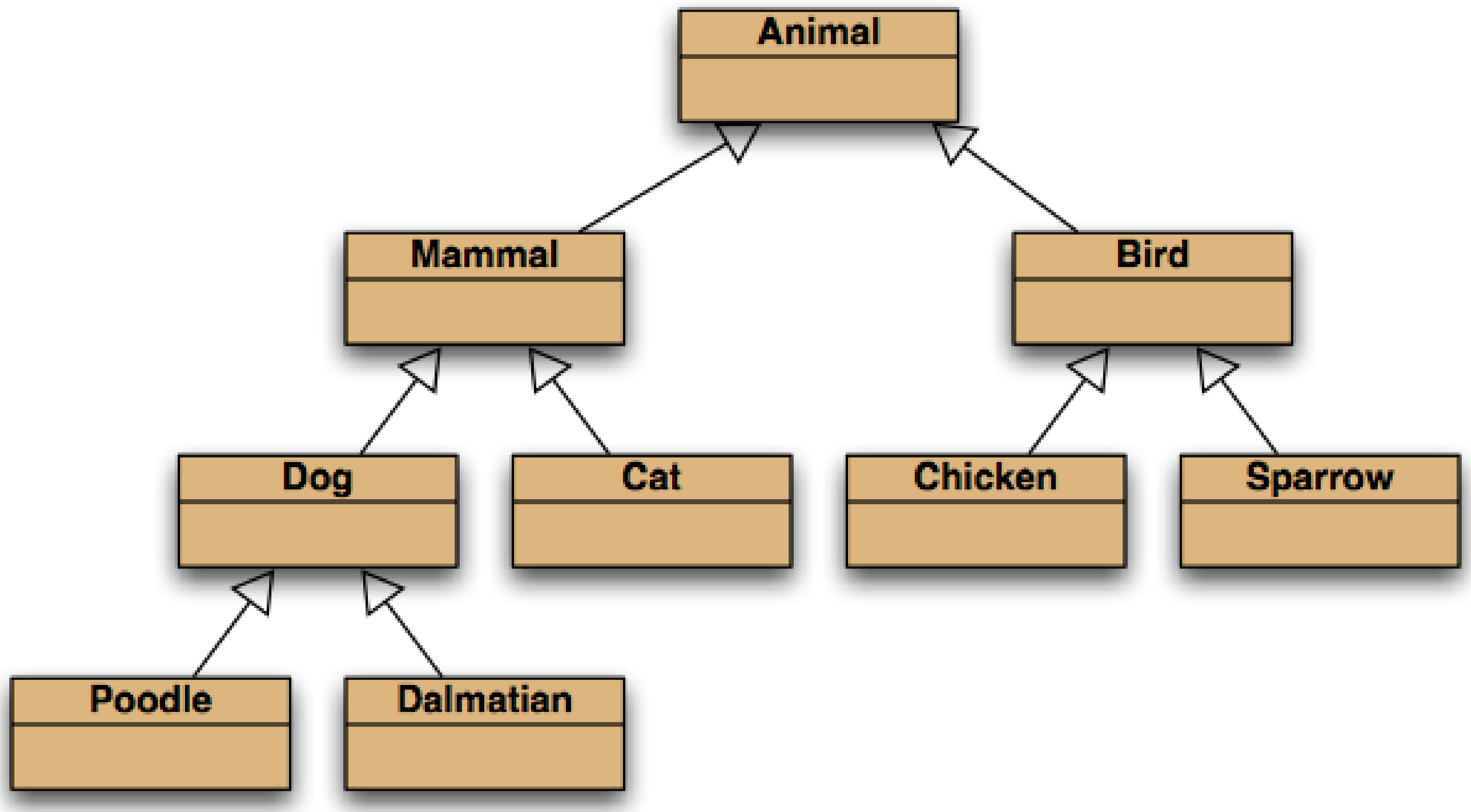
Using inheritance



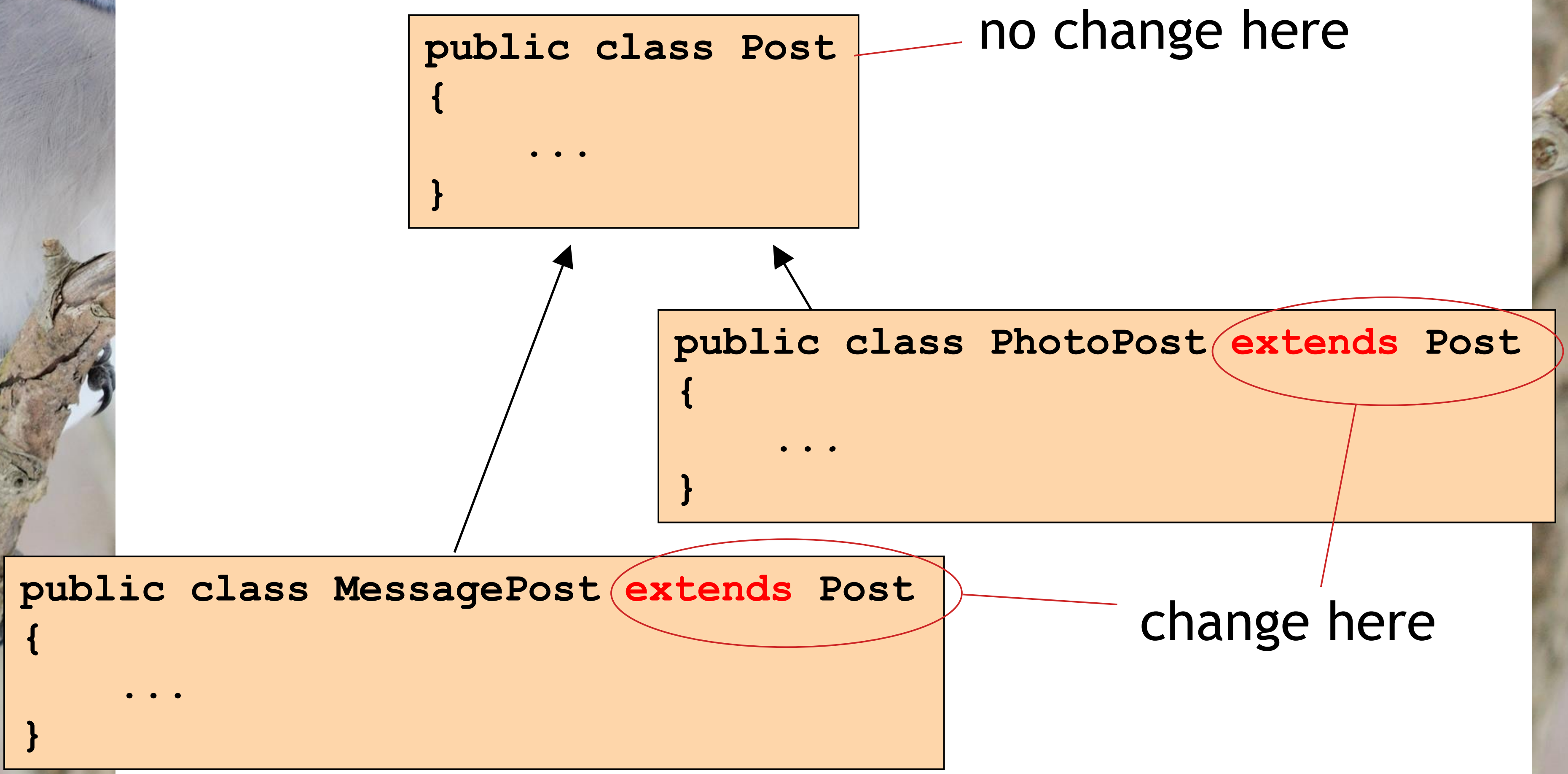
Using inheritance

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

Inheritance hierarchies



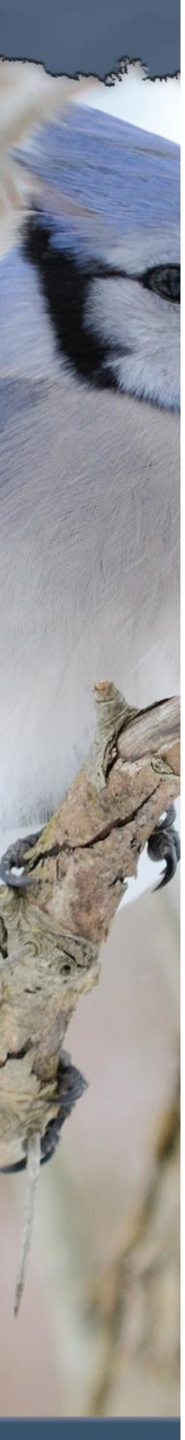
Inheritance in Java



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

```
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

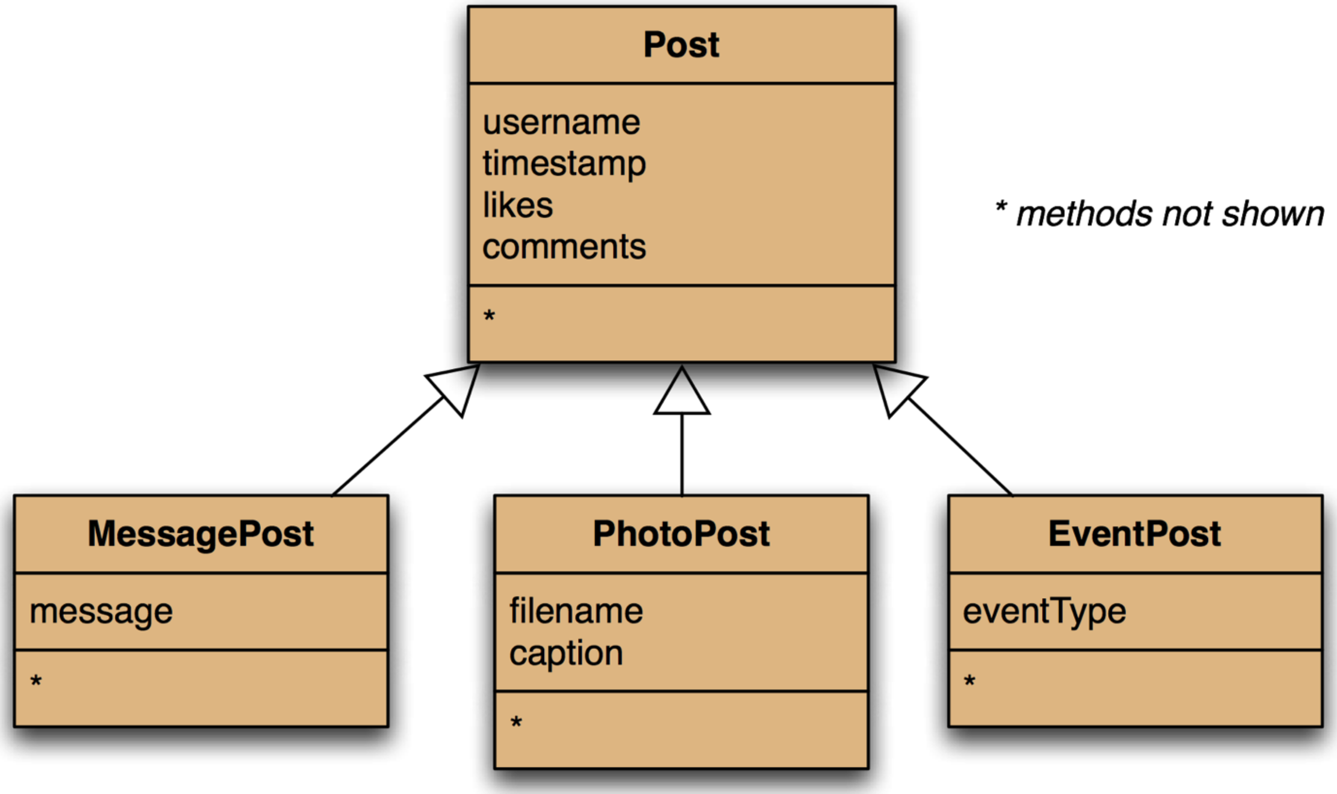
```
public class MessagePost extends Post
{
    private String message;

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

    // methods omitted
}
```

- **Subclass must call superclass constructor!**
- **Must take values for all fields that we want to initialize!**

Superclass constructor call

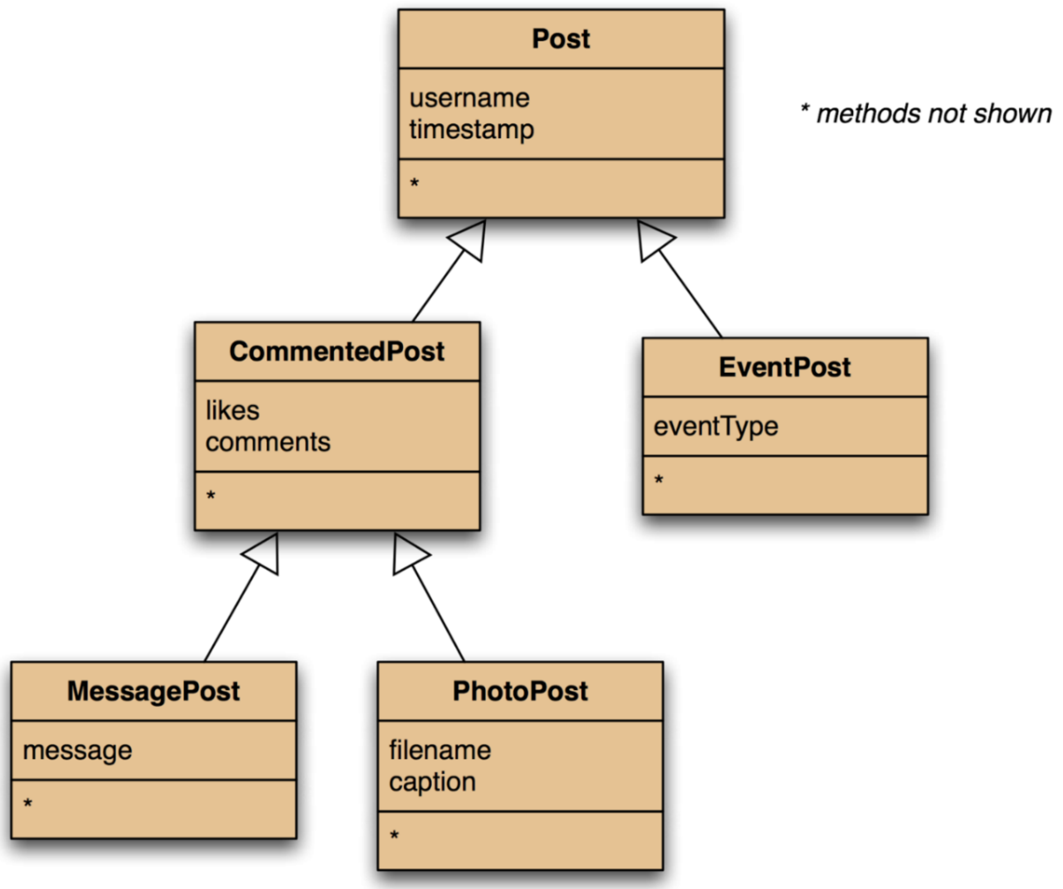
- Subclass constructors must always contain a *super* call
- If none is written, the compiler inserts one (without parameters)
  - only compiles if the superclass has a constructor without parameters
- Must be the first statement in the subclass constructor

Adding more item types

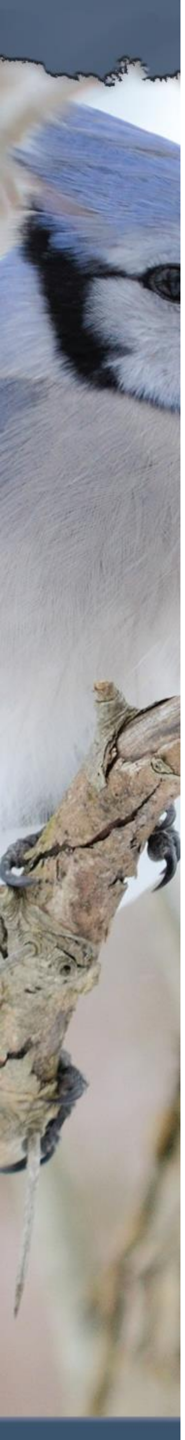


** methods not shown*

Deeper hierarchies



Abstract classes serve solely as a superclass and are not intended to be used to create instances.



Review (so far)

Inheritance (so far) helps with:

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

```
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);
    }
    ...
}
```

Revised NewsFeed source code

avoids code duplication in the client class!

No longer a *messages* AND *photos* ArrayLists!!

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 ...
    }
}
```

Now only 1 loop in the show method!!

Subtyping

First, we had:

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

Now, we have:

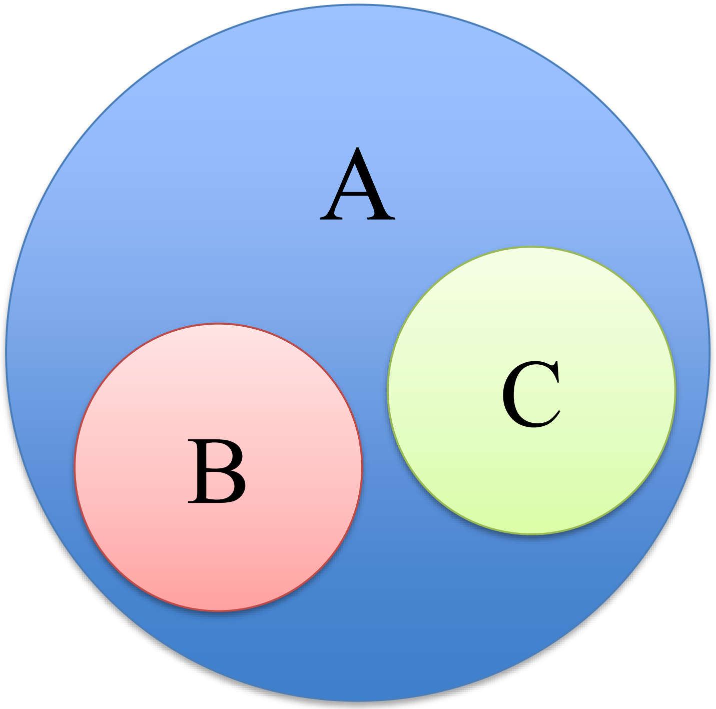
```
public void addPost(Post post)
```

We call this method with:

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

PhotoPost* is a subtype of *Post

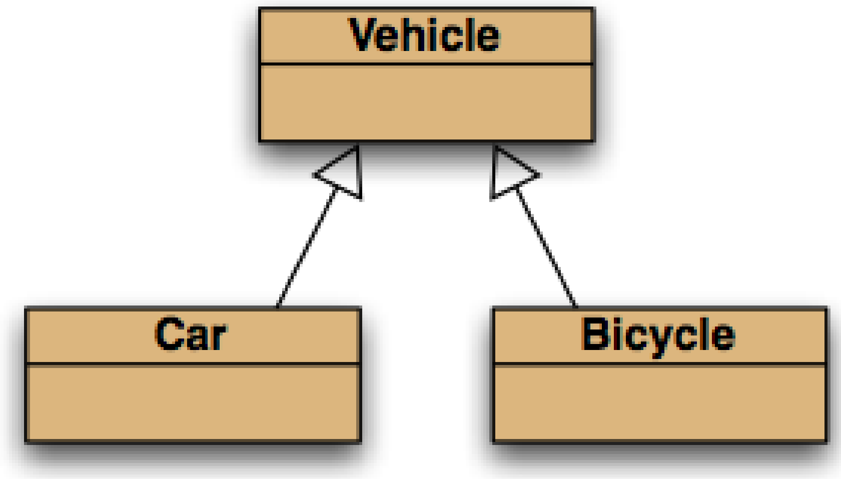
Subclasses and subtyping



Subclasses and subtyping

- Classes define types
- Subclasses define *subtypes*
- Objects of subclasses can be used where objects of supertypes are required … called **substitution**
- But supertypes may NOT be used in place of a subtype

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

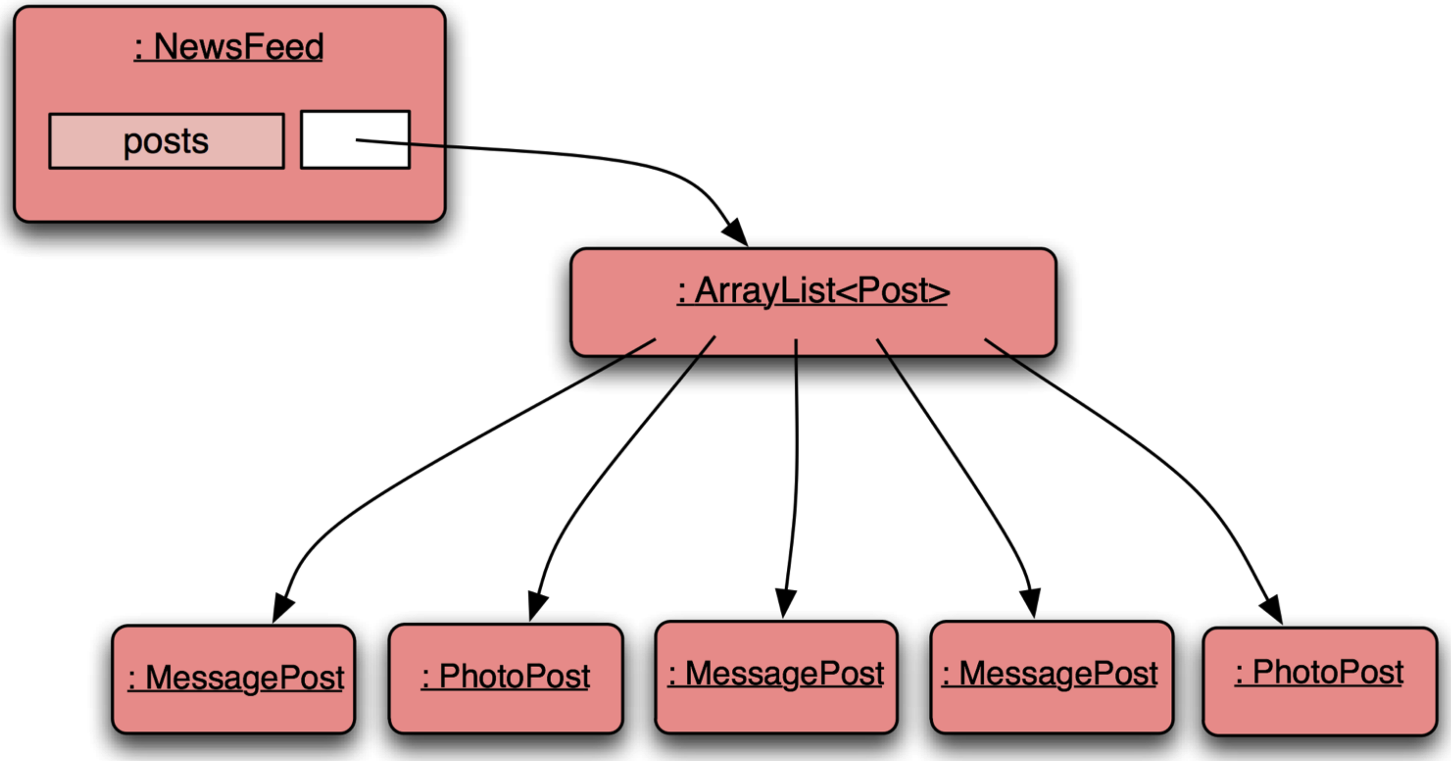
```
public class NewsFeed
{

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

subclass objects may be used as actual parameters for the superclass

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

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

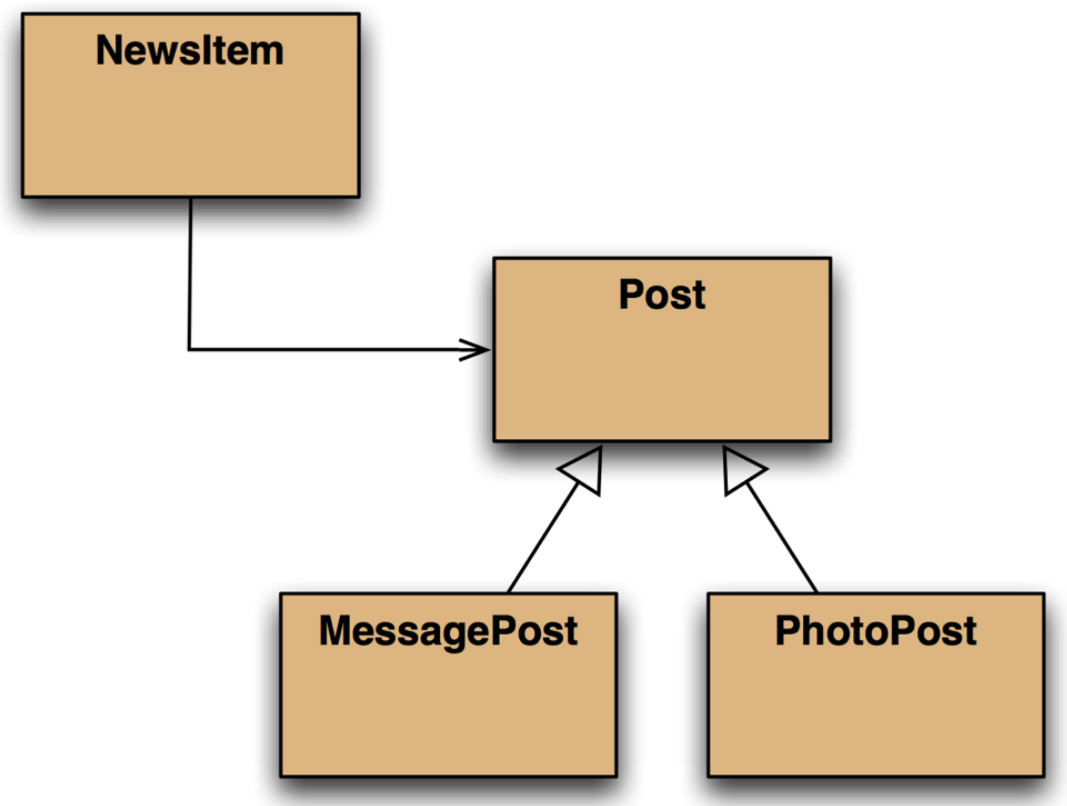
PhotoPost* & *MessagePost* are both subtypes of *Post

Object diagram



***NewsFeed* object can hold a single or mixed collection of supertype *Post* and subtypes PhotoPost/MessagePost**

Class diagram



***NewsItem* now only knows about *Post* rather than the subclasses**

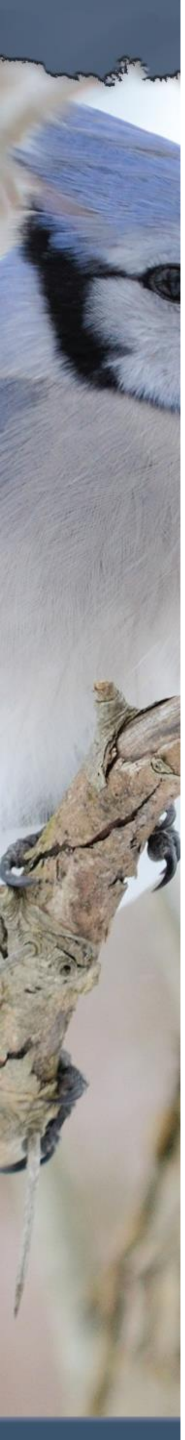
Polymorphic variables

- Object variables in Java are **polymorphic** (many shapes)
  - Can hold objects of more than one type

- Can hold objects of the declared type, or of subtypes of the declared type

```
for(Post post : posts)
{
        post.display();
        System.out.println();
}
```

Variables of supertype *Post* may hold objects of subtypes PhotoPost/MessagePost



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:

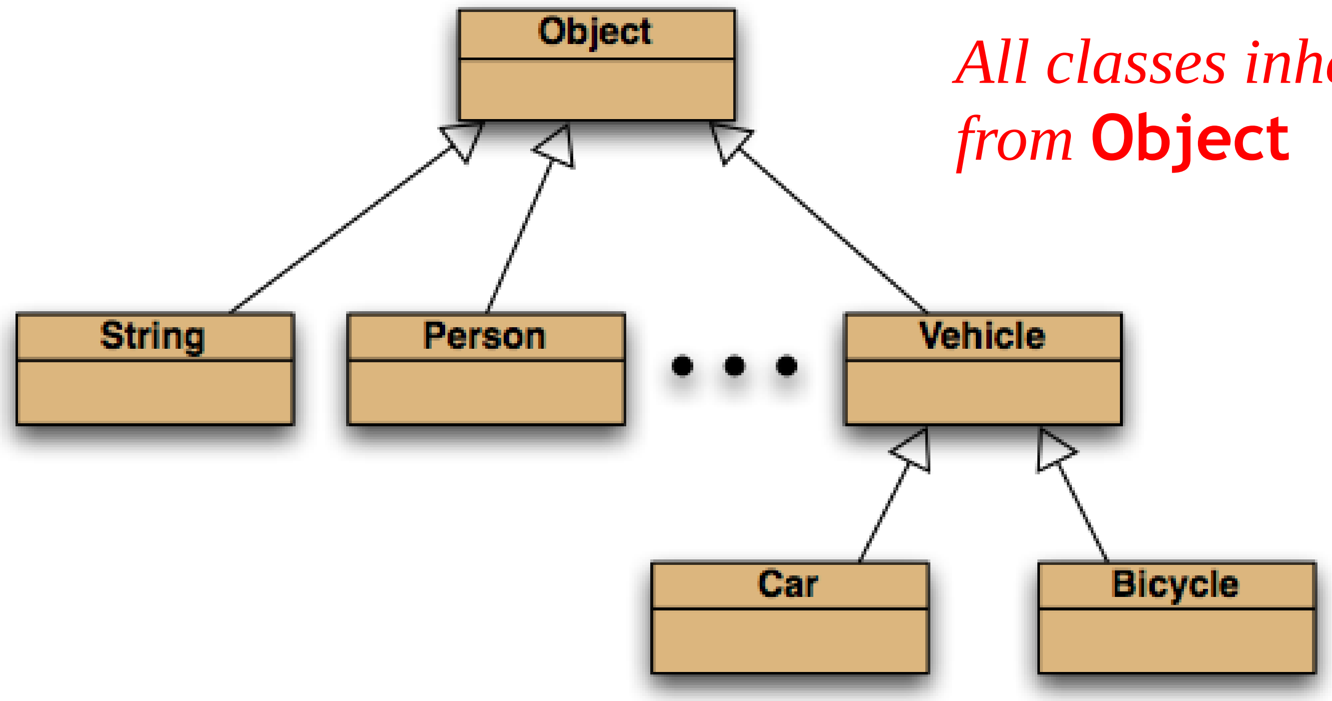
```
c = (Car) v;
```

(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**

***Object* class from Java standard library**

Polymorphic collections

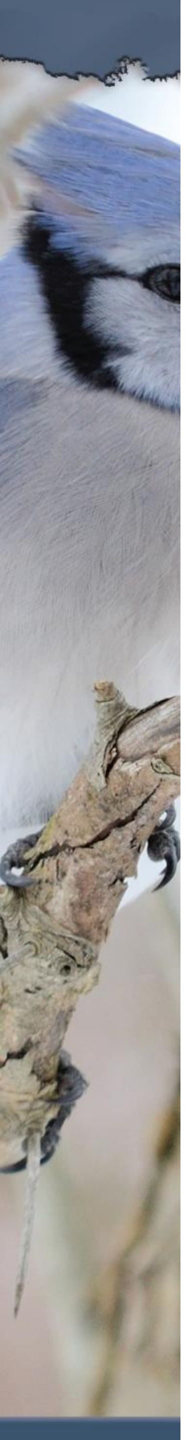
- All collections are polymorphic
- The elements could simply be of type `Object`

```
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



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)