

Inheritance

Improving Structure with Inheritance

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Lectures and Labs

- This weeks lectures and labs are based on examples in:
 - Objects First with Java - A Practical Introduction using BlueJ, © David J. Barnes, Michael Kölling (<https://www.bluej.org/objects-first/>)

Topic List



1. Social Network V1
2. Inheritance hierarchies
3. Social Network V2
4. Coding inheritance hierarchies
 - Super and subclasses
 - Using constructors in these hierarchies
5. Social Network V3
 - Deeper hierarchies
 - Advantages of using inheritance
6. Subtyping and Substitution
7. Polymorphic variables / Collections
 - Includes casting, wrapper classes, autoboxing /unboxing

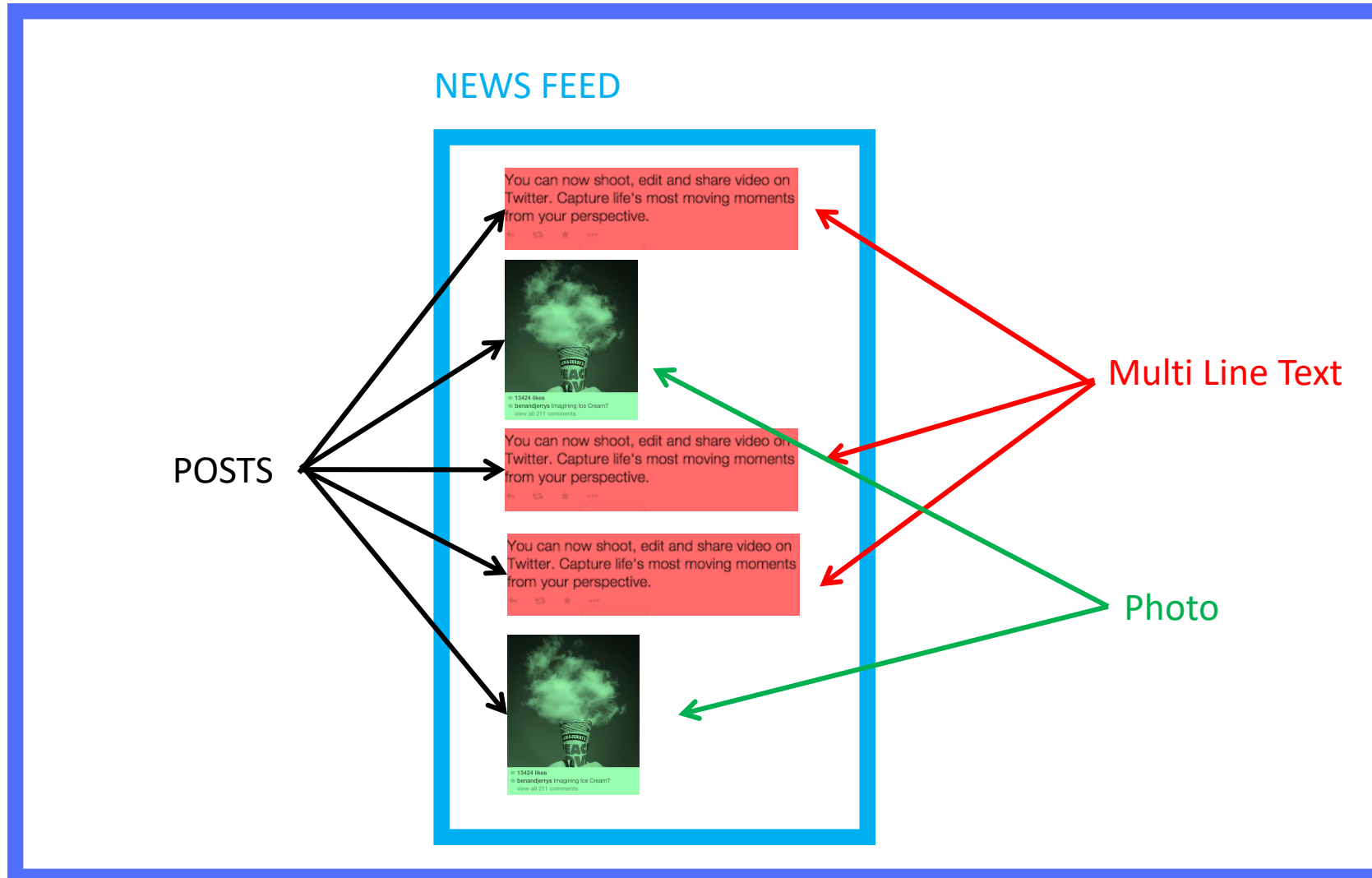
Social Network V1



- A small, prototype SOCIAL NETWORK.
- Supports a **News Feed** with posts.
- **POSTS:**
 - **MessagePost:**
 - multi-line text message.
 - **PhotoPost:**
 - photo and caption.
 - **Operations**
 - e.g., search, display and remove.

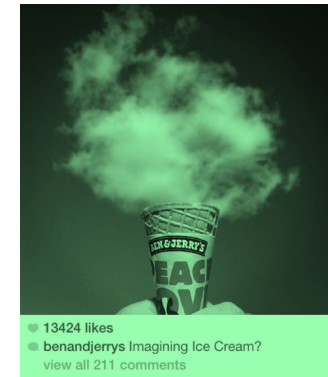
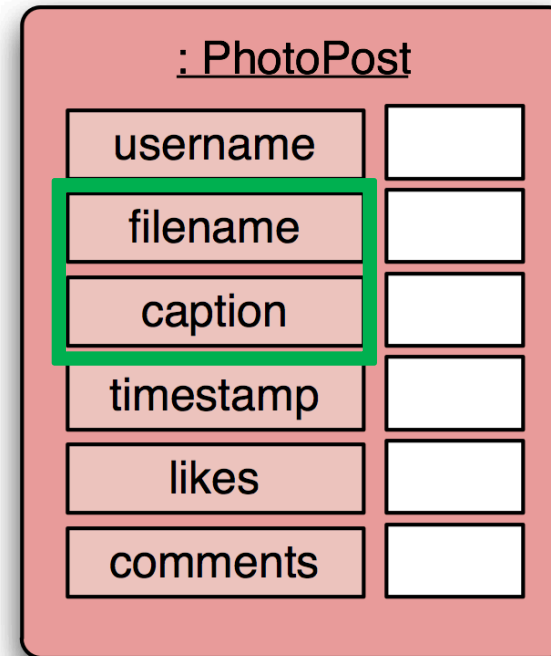
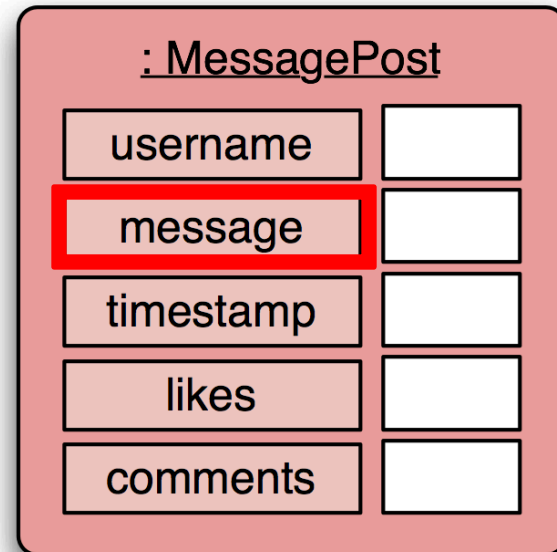


SOCIAL NETWORK



Social Network V1 - Objects

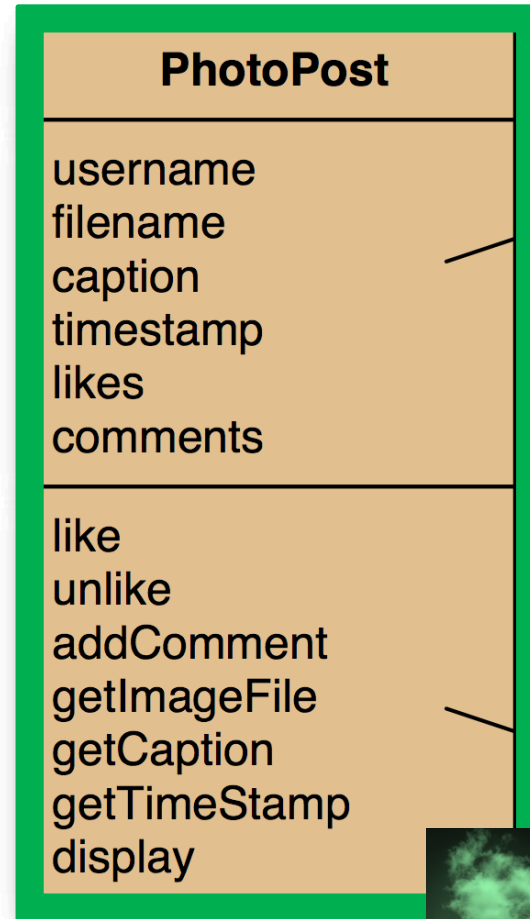
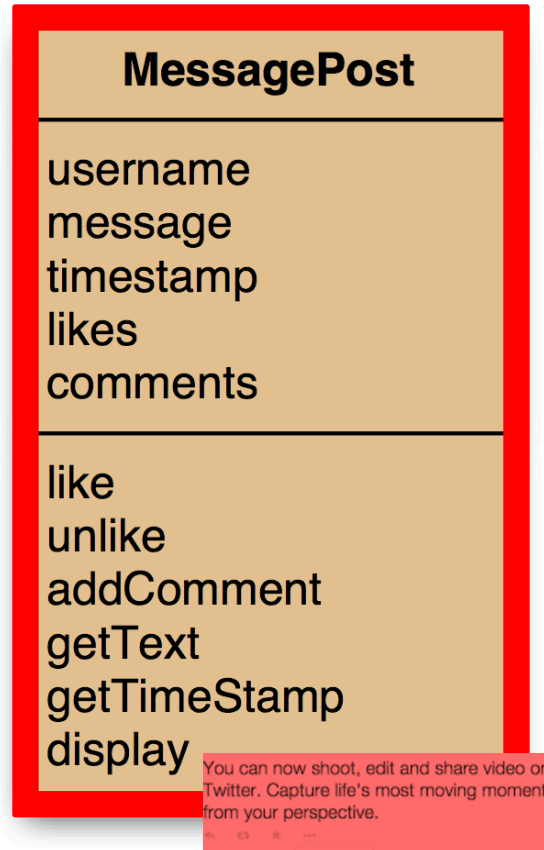
You can now shoot, edit and share video on Twitter. Capture life's most moving moments from your perspective.



MessagePost: multi-line text message.

PhotoPost: photo and caption.

Social Network V1 - Classes

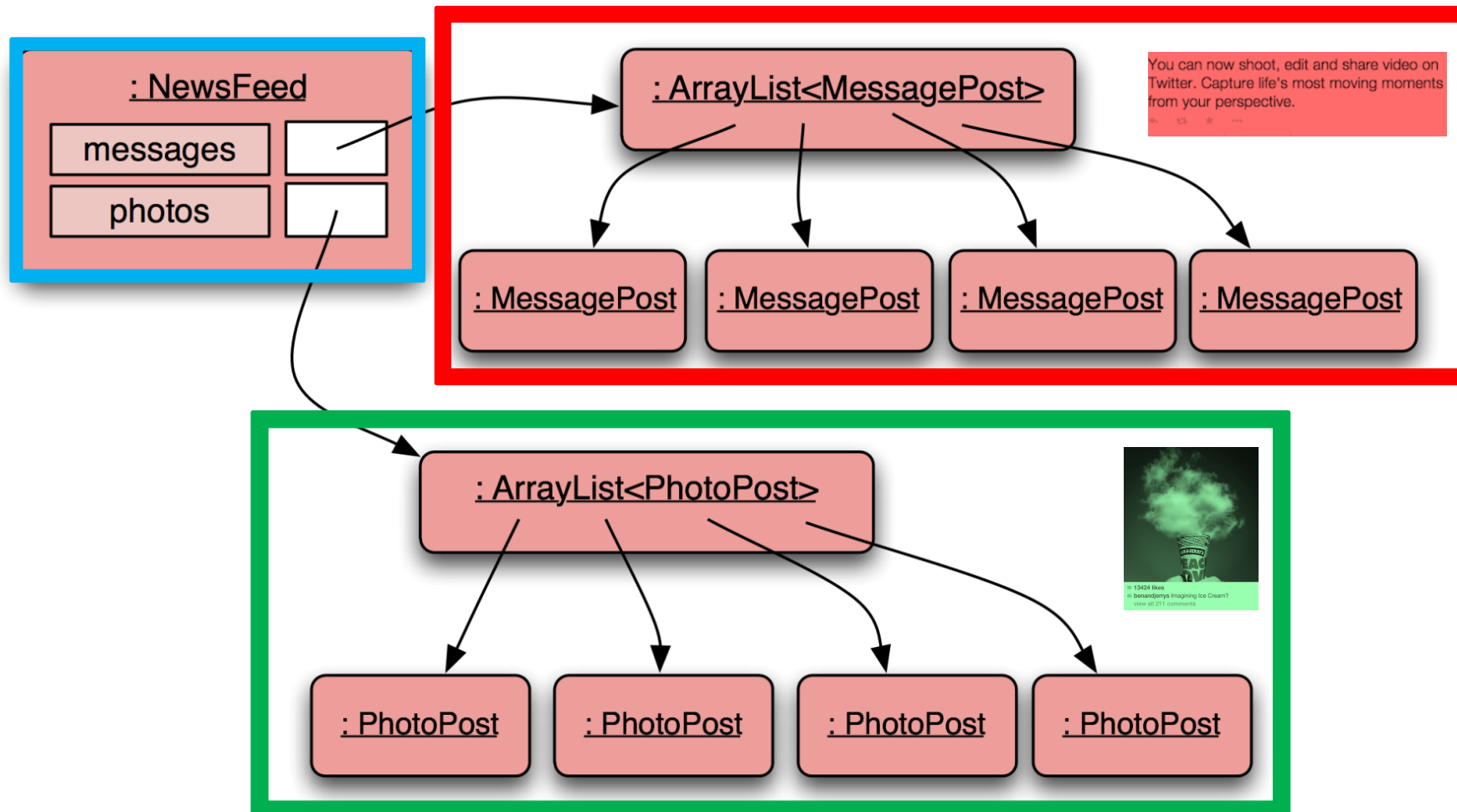


top half shows fields

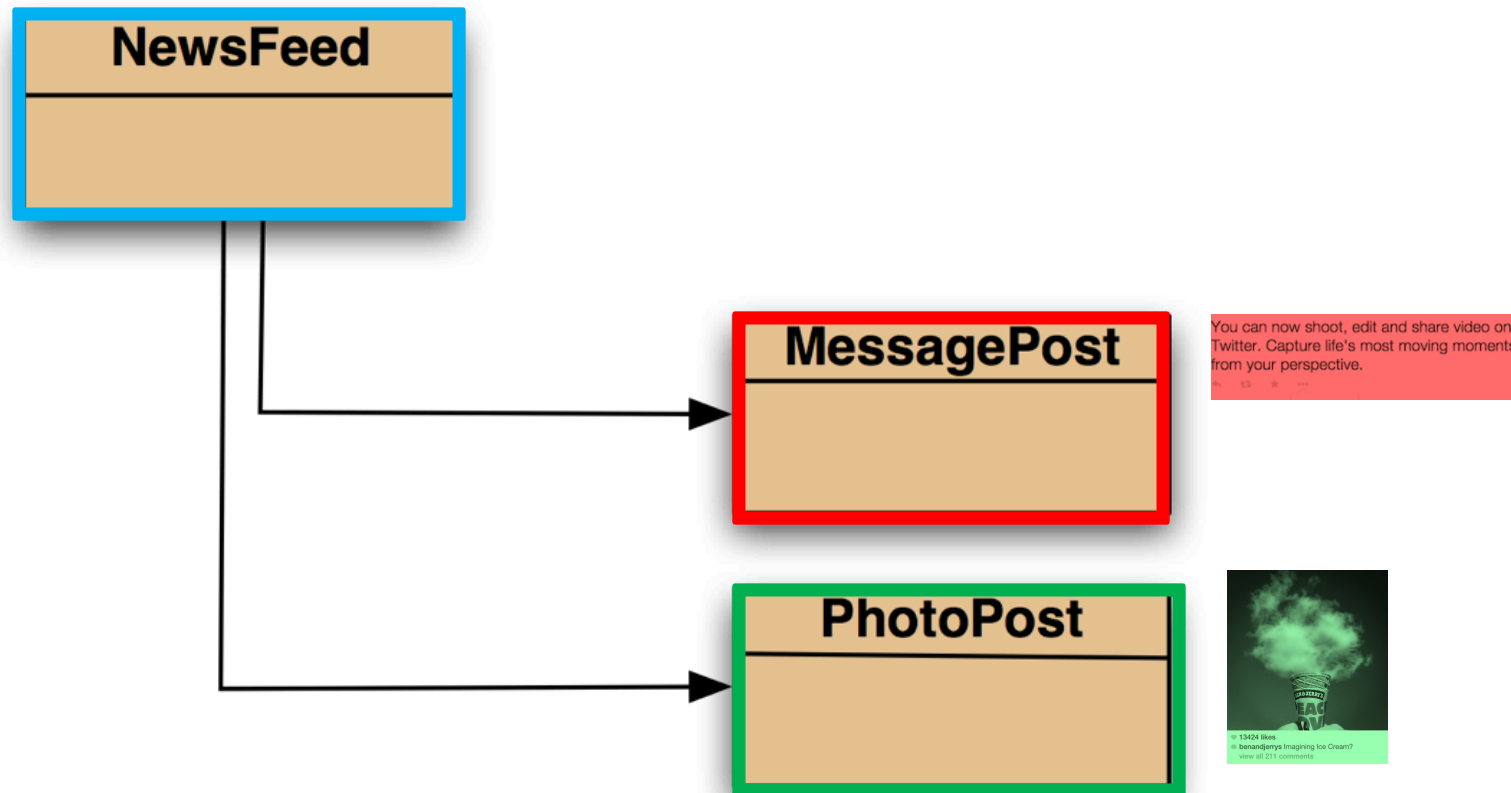
bottom half shows methods



Social Network V1 - Object model



Social Network V1 - Class diagram



MessagePost source code

You can now shoot, edit and share video on Twitter. Capture life's most moving moments from your perspective.

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>();
    }

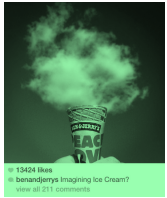
    public void addComment(String text) ...

    public void like() ...

    public void display() ...

    ...
}
```

PhotoPost 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) ...

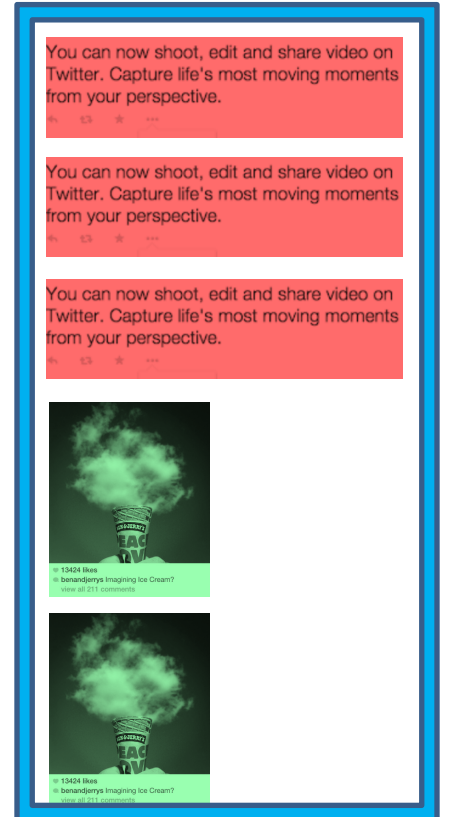
    public void like() ...

    public void display() ...
    ...
}
```

NewsFeed source code

```
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
        }
    }
}
```



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3. Social Network V2

4. Coding inheritance hierarchies

- Super and subclasses
- Using constructors in these hierarchies

5. Social Network V3

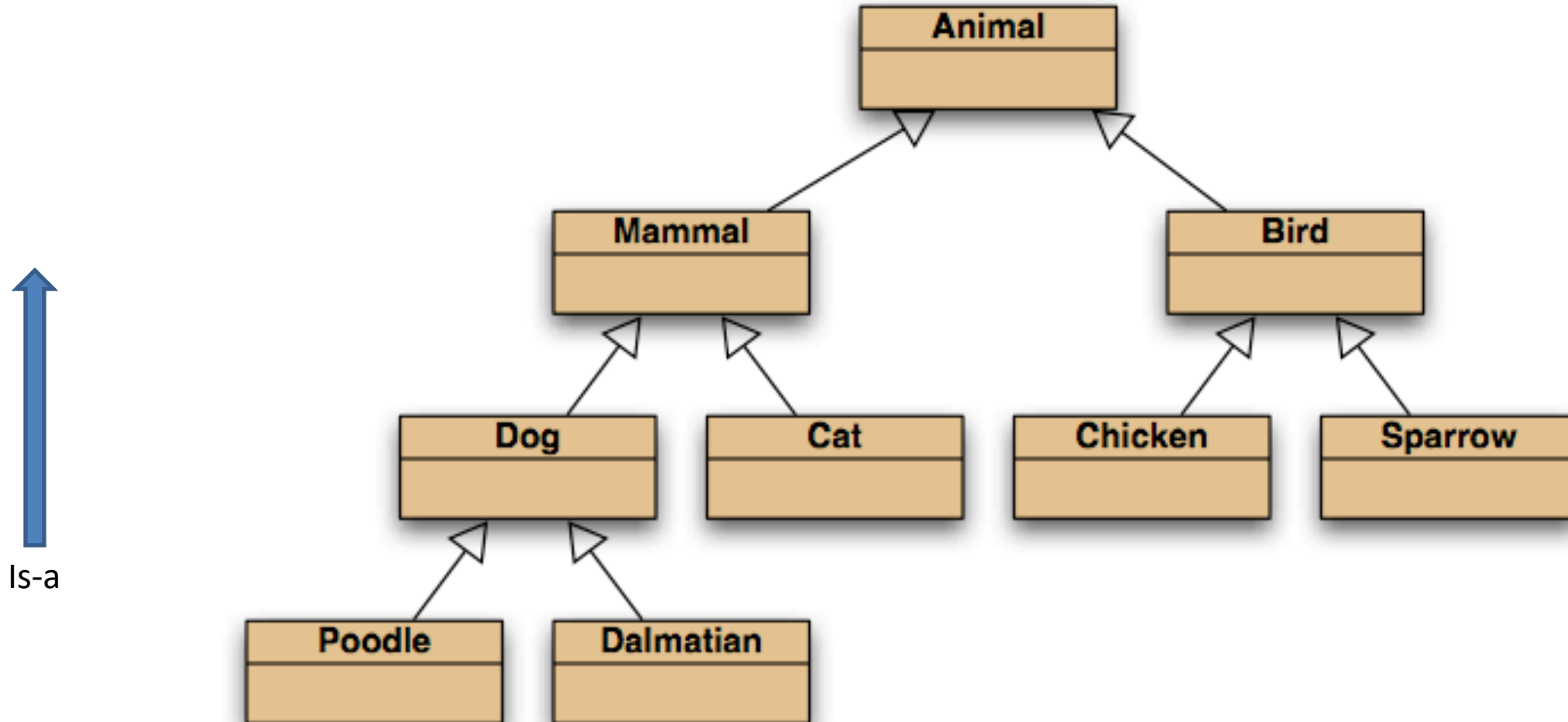
- Deeper hierarchies
- Advantages of using inheritance

6. Subtyping and Substitution

7. Polymorphic variables / Collections

- Includes casting, wrapper classes, autoboxing /unboxing

Inheritance hierarchies

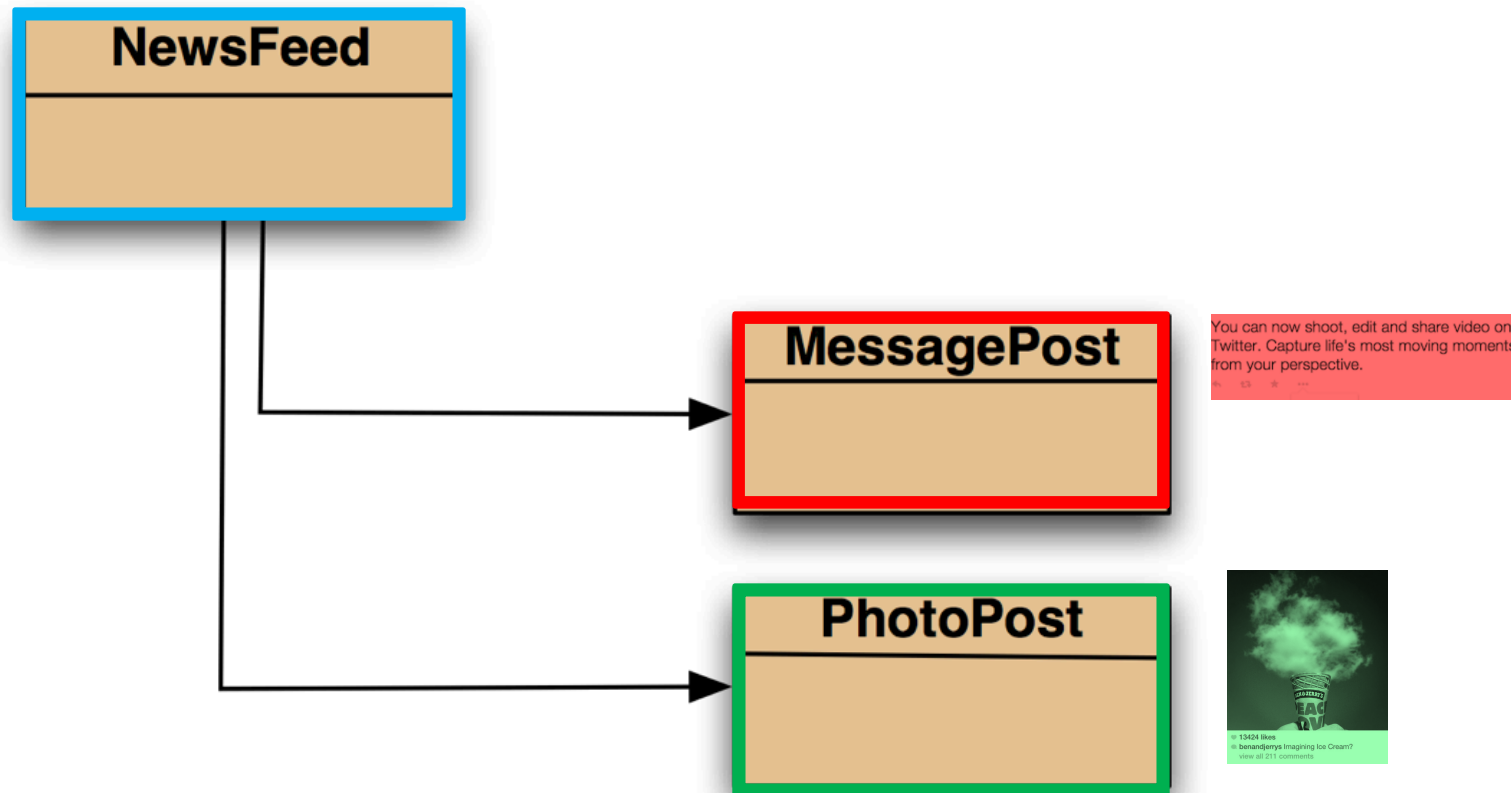


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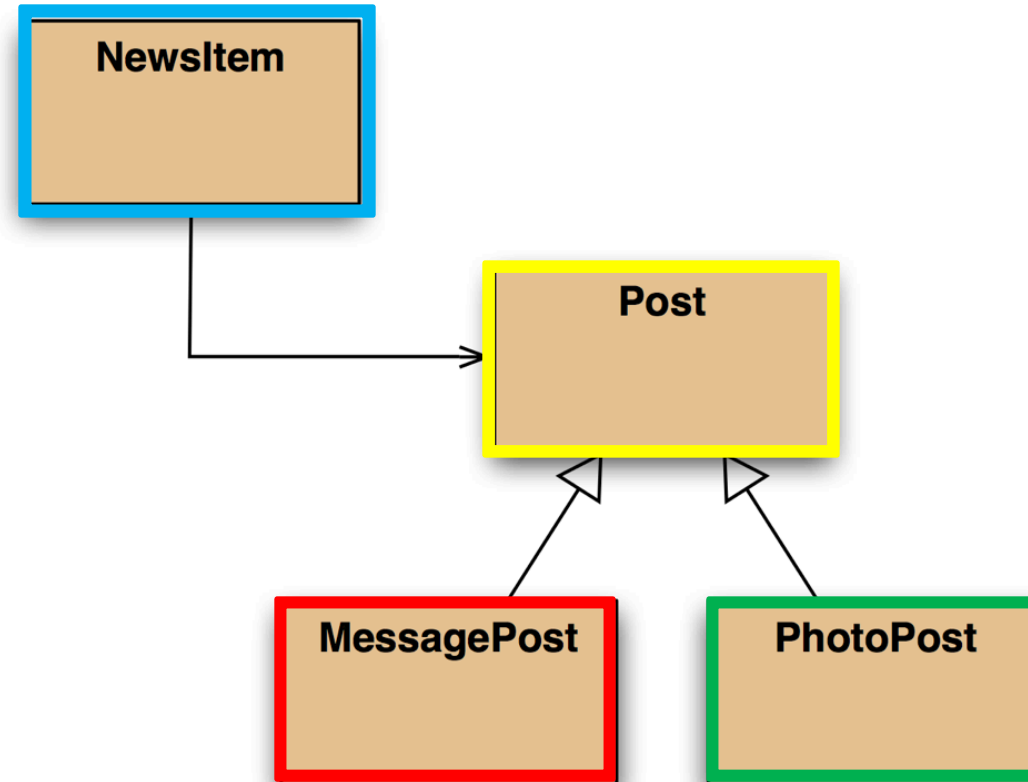
Recap: Social Network V1 - Class diagram



Critique of Social Network V1

- 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.

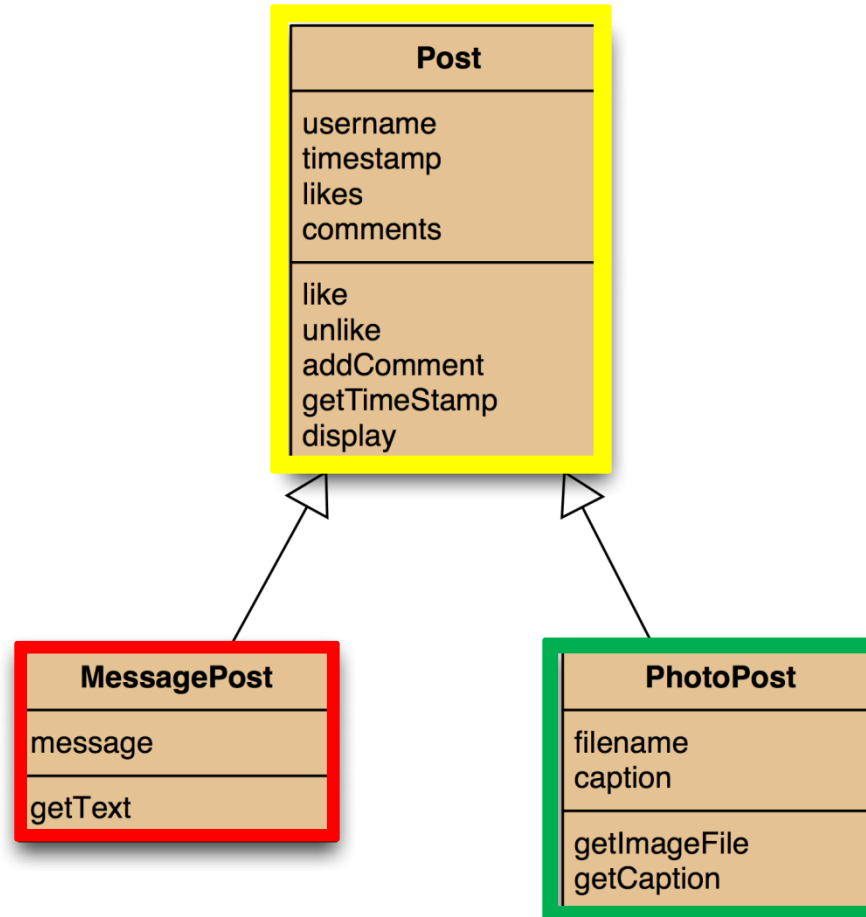
Social Network V2 - Class diagram



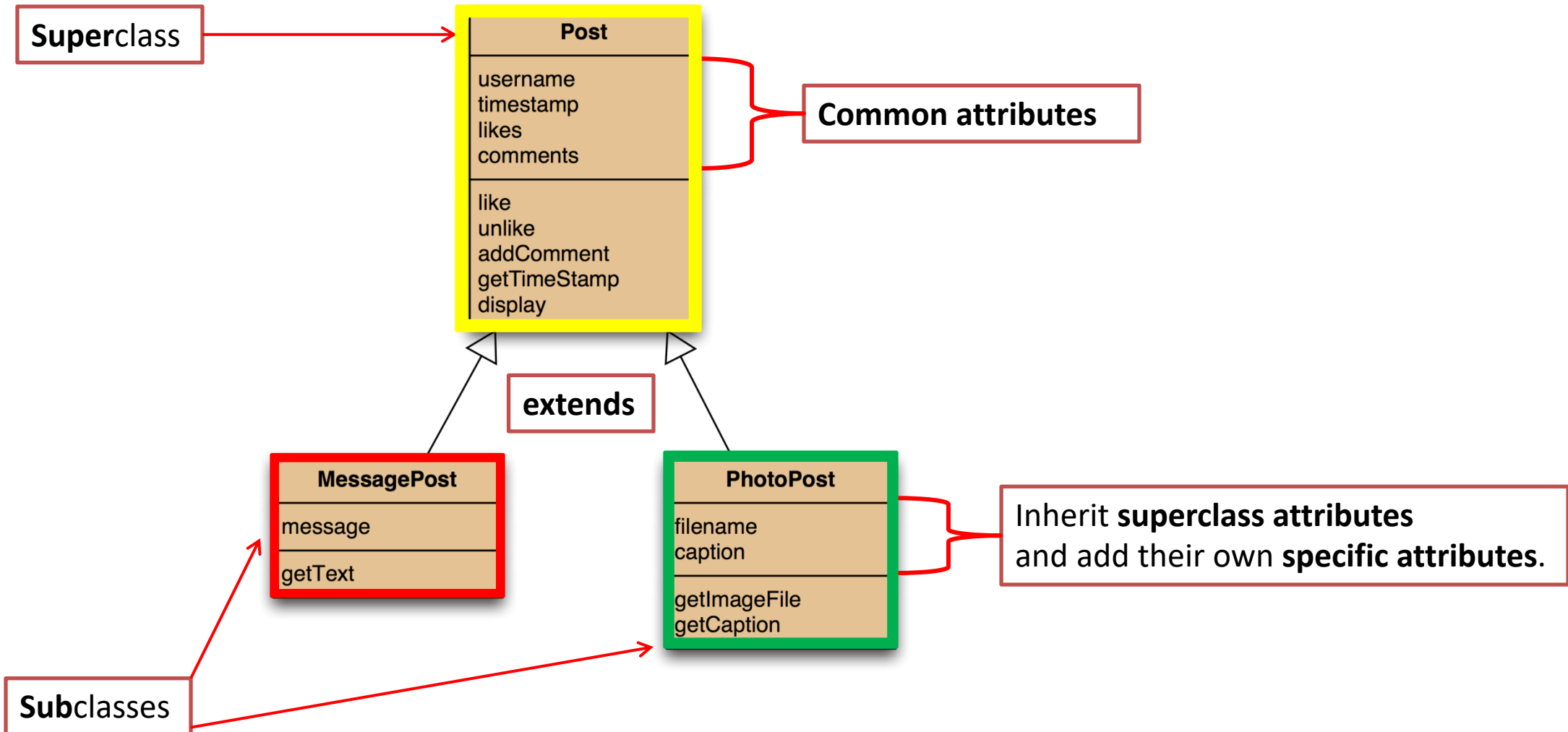
You can now shoot, edit and share video on Twitter. Capture life's most moving moments from your perspective.



Social NetworkV2 - Using inheritance



Social NetworkV2 - Using inheritance



Social Network V2 – Inheritance Summary

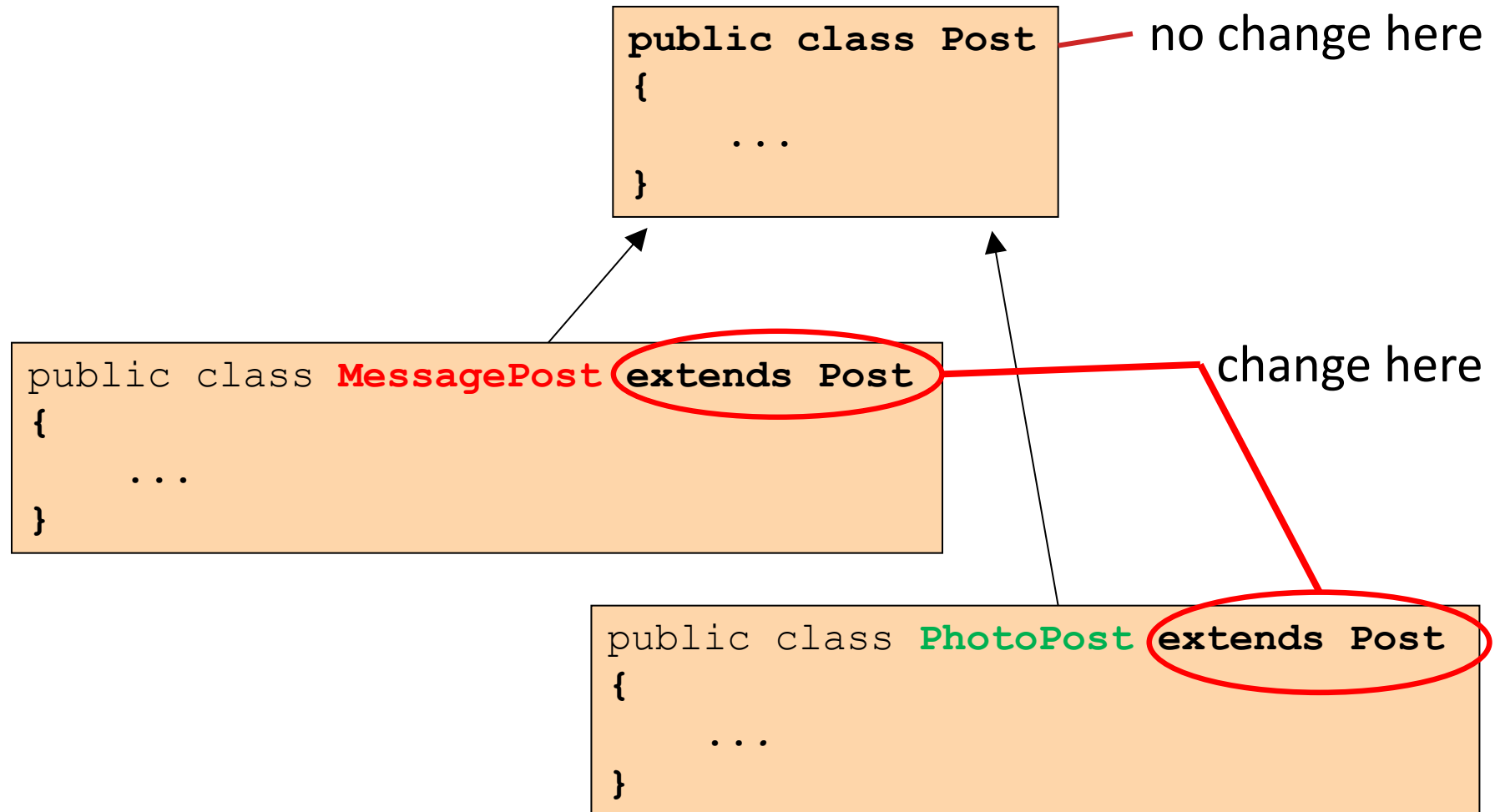
- define one **superclass**
 - **Post**
- define **subclasses** for
 - **MessagePost**
 - **PhotoPost**
- the **superclass**
 - defines common attributes (via fields)
- the **subclasses**
 - **inherit** the superclass attributes (fields)
 - add other specific attributes (fields)

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 - Using **constructors** in these hierarchies
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Inheritance in Java - **extends**



Superclass

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

    // constructor and methods omitted.
}
```

we define common fields in superclass

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.
}
```

we add subclass fields; inherit superclass fields
subclass objects will have all fields

Inheritance and Constructors

- superclass

```
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

- subclass

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

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

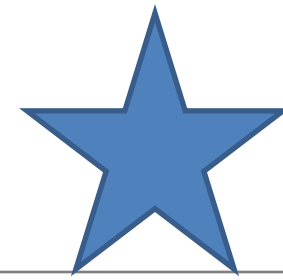
    // methods omitted
}
```



subclass: must call superclass constructor!

Must take values for all fields that we want to initialise.

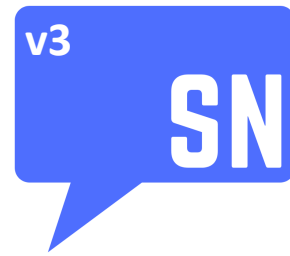
Superclass constructor call



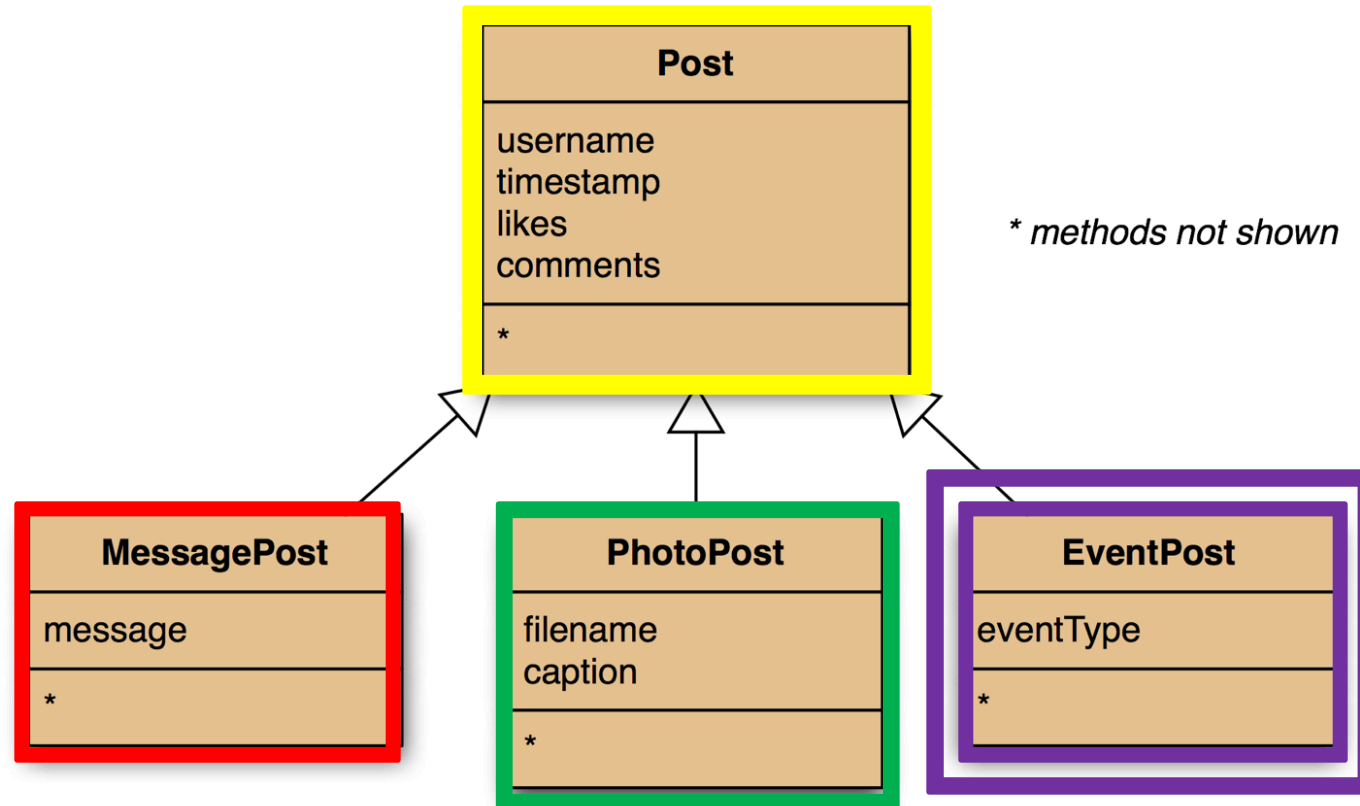
- Subclass constructors must always contain a '**super**' call.
- If none is written, the compiler inserts one (without parameters)
 - works only, if the superclass has a constructor without parameters
- '**super**' call must be the first statement in the subclass constructor.

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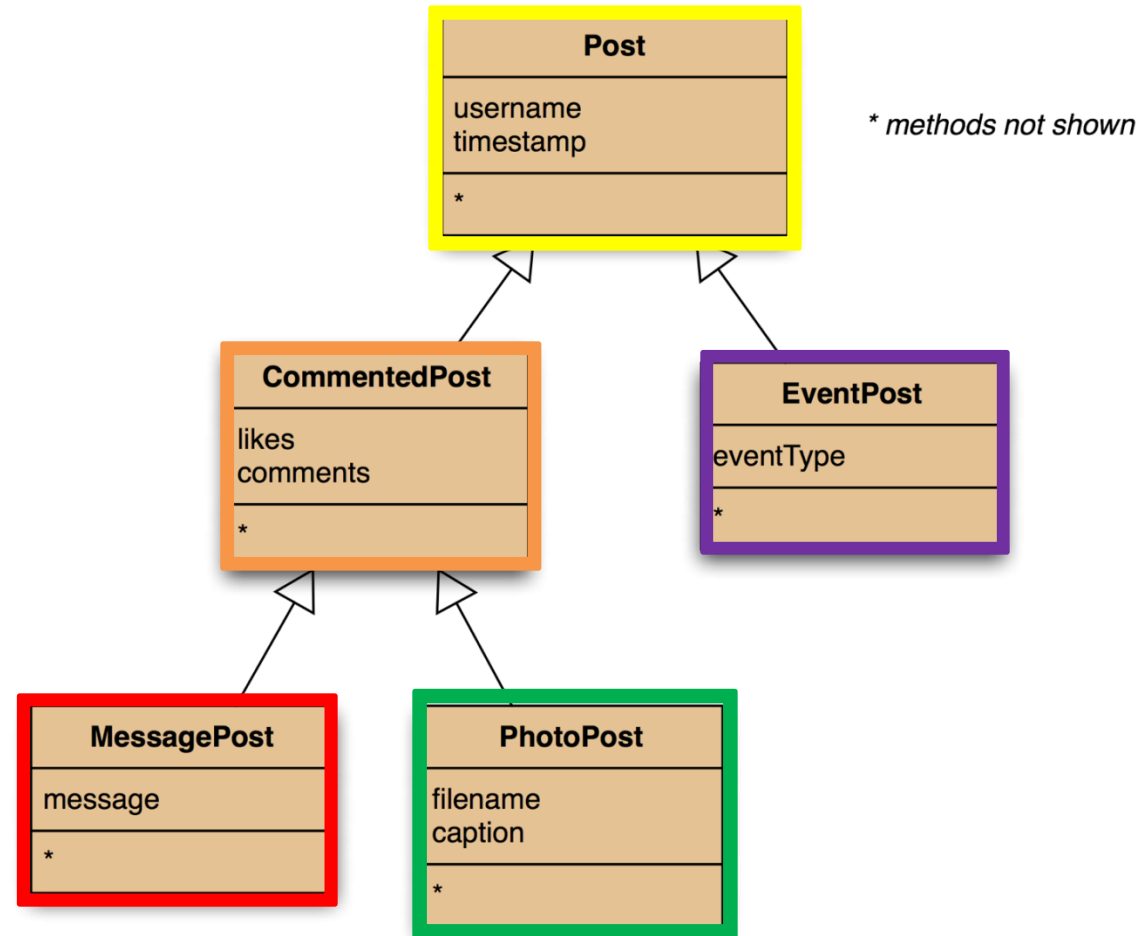
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Social Network V3 - Adding more item types



Social Network V3 - Deeper hierarchies



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Advantages of inheritance

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


*Code is simplified
&
code duplication
in the client class is avoided!*

```
/**
 * Show the news feed. Currently: print the
 * news feed details to the terminal.
 */

public void show()
{
    for(Post post : posts) {
        post.display();
        System.out.println(); // Empty line ...
    }
}
```

REVISED NewsFeed source code

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Subtyping

First, we had:

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

Now, we have:

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

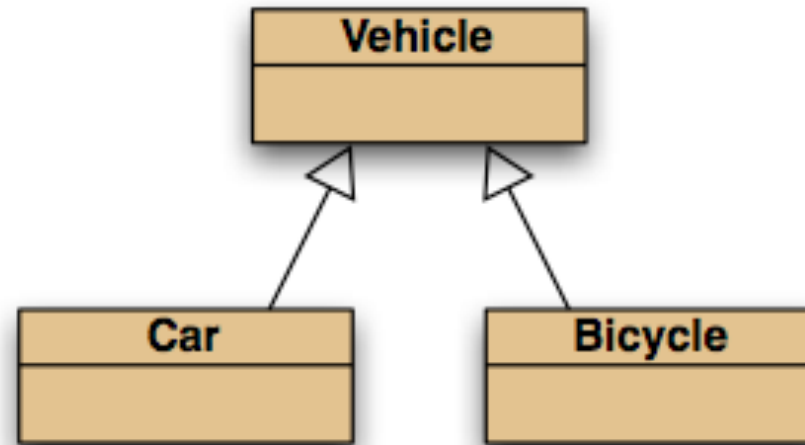
We call this method with:

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

Subclasses and subtyping

- Classes define *types*.
- Subclasses define *subtypes*.
- **Substitution:**
 - objects of *subclasses* can be used where objects of *supertypes* are required.

Subtyping and assignment



*subclass objects
may be assigned to
superclass variables*

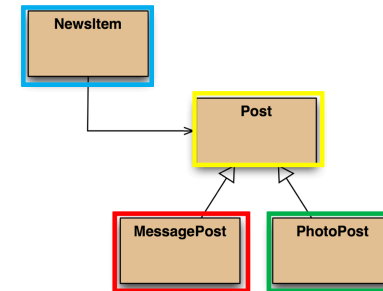
```
Vehicle v1 = new Vehicle();  
Vehicle v2 = new Car();  
Vehicle v3 = new Bicycle();
```


Subtyping and parameter passing

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

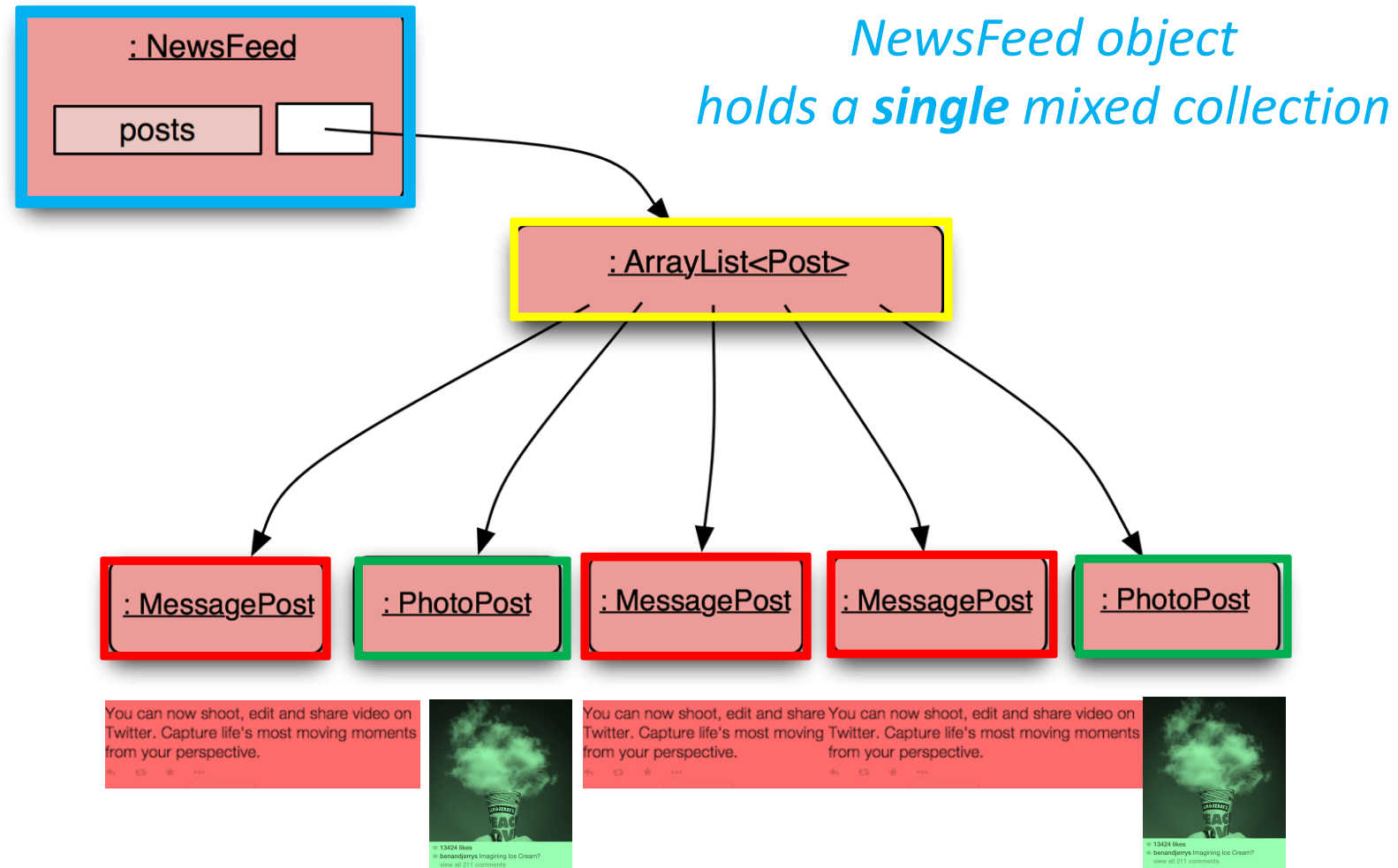
```
PhotoPost photo = new PhotoPost(...);
MessagePost message = new MessagePost(...);
```

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



subclass objects may be used as actual parameters when a superclass is required.

Social Network V2 - Object diagram



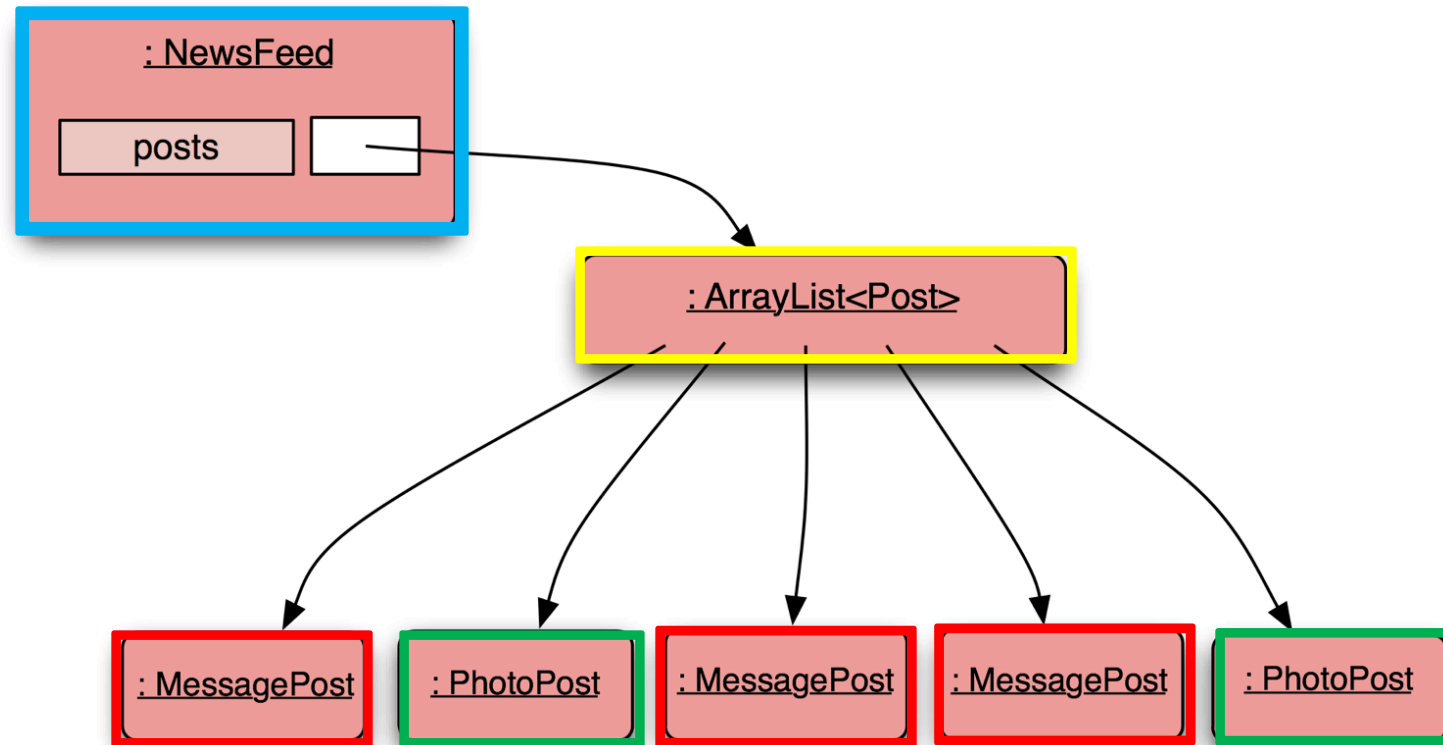
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- 7. Polymorphic**
 - a) Variables
 - b) Collections
 - casting, wrapper classes, autoboxing /unboxing

7 a) Polymorphic variables

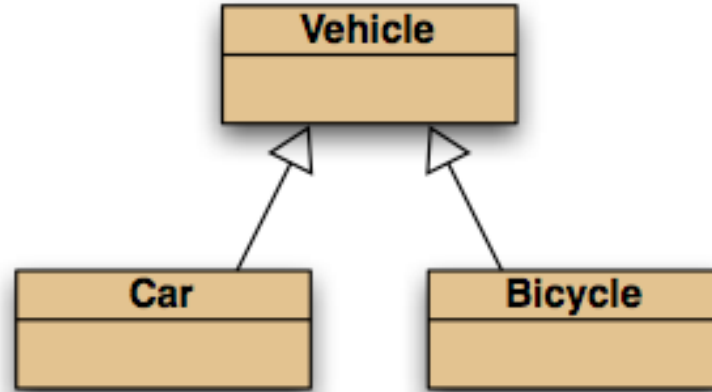
- Object variables in Java are **polymorphic**
 - They can hold objects of
 - i. more than one **type**
 - ii. the declared **type**
 - iii. **subtypes** (*of the declared type*).

Social Network V2 – polymorphic ArrayList of Post



Casting

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



We can assign **subtype** to **supertype** (note arrow direction)!

```
v = c;
```

```
// correct (car is-a vehicle)
```

But we cannot assign a **supertype** to **subtype** (cannot go against the arrows)!

```
c = v;
```

```
// compile-time error!
```

Without (CASTING)

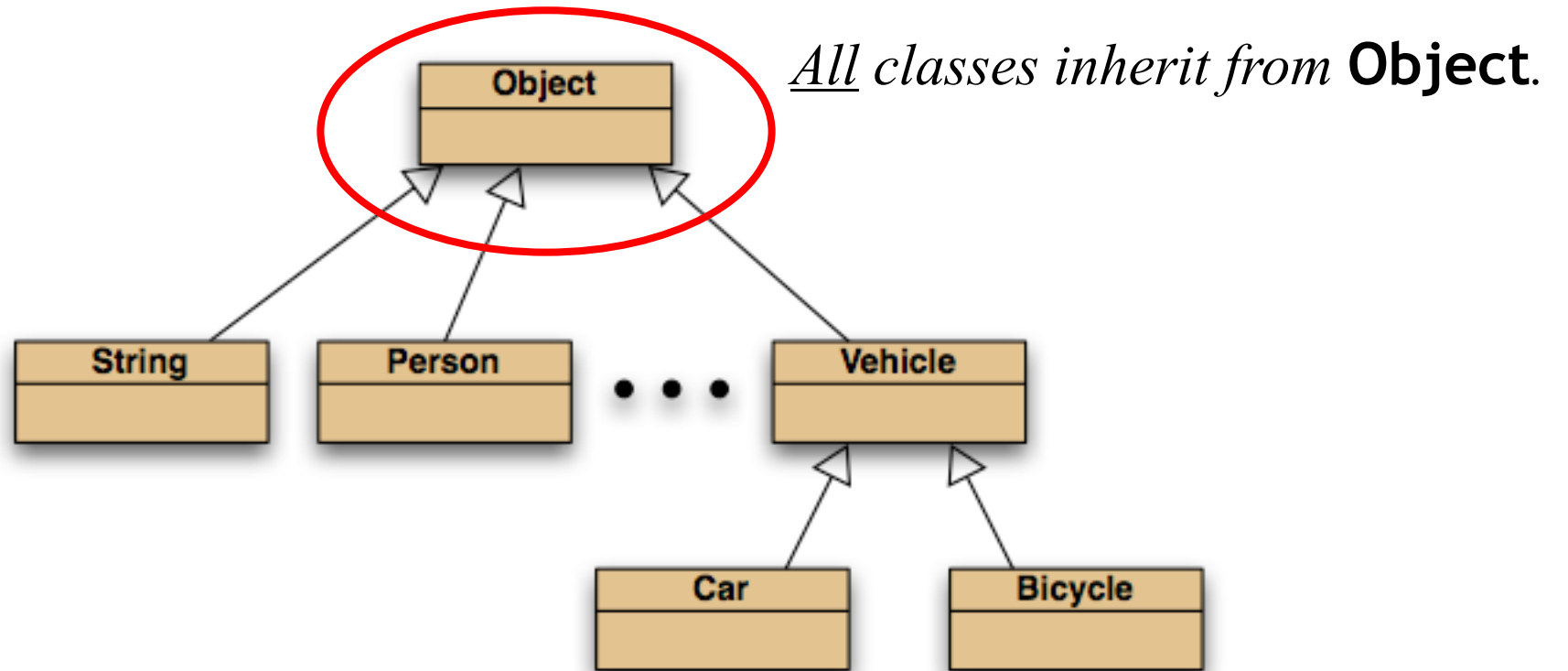
```
c = (Car) v;
```

```
//casting...correct (only 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




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7. Polymorphic

- a) Variables
 - b) Collections
 - Casting
 - wrapper classes,
 - autoboxing /unboxing
- 

7 b) 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...
 - we typically use a type parameter with the collection.

7 b) Polymorphic collections

- With a type parameter the degree of polymorphism:

ArrayList<Post> is **limited**.

- 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**

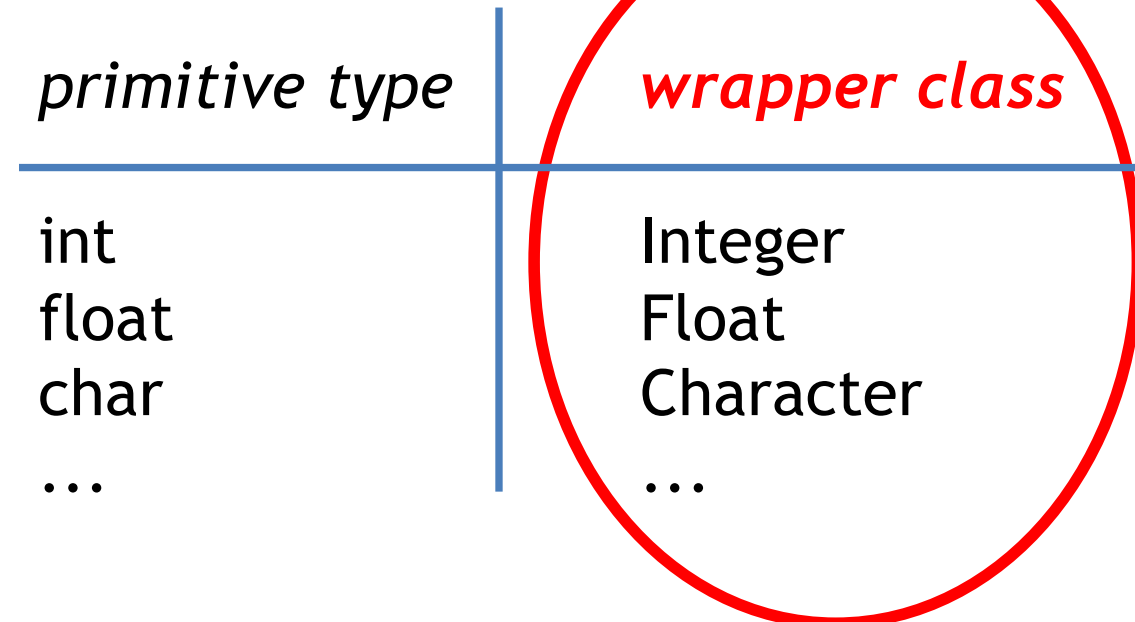
- Potentially, **all** objects can be entered into collections
 - because collections can accept elements of type **Object**
 - and all classes are subtypes of **Object**.
- Great! But what about *the primitive types*:
int, boolean, etc.?

Wrapper classes

- Primitive types are not object types.

Primitive-type values must be wrapped in objects, to be stored in a collection! 

- **Wrapper classes** exist for all primitive types:



Note that there is no simple mapping rule from primitive name to wrapper name!

Wrapper classes

```
int i = 18;
```

```
Integer iwrap = new Integer(i); ←———— wrap the value
```

...

```
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

i.e. we don't have to worry about explicitly wrapping `mark` above

```
int firstMark = markList.get(0);
```

unboxing

Or explicitly unwrapping the first mark in the list `markList.get(0)`

Summary

- if you use **collections** (e.g. ArrayList, Map, Set, etc.) **of a primitive type** (int, long, boolean, char, float, double), you will need to use **wrapper classes** (Integer, Boolean, Character, Float, Double) in the declaration of the collection
e.g. `private ArrayList<Integer> markList;`
- To add an int to this ArrayList of integers, we would **wrap** the **int** by using the **Integer()** constructor method.
- To remove an int from this ArrayList of integers, we would **unwrap** the **int** by using the **intValue()** method of the Integer wrapper class.
- **Autoboxing** and **unboxing** removes the need to use the wrap and unwrap methods in the wrapper class as it's handled automatically.
 - However it is **less efficient** than doing it explicitly. If performance becomes an issue, you would revert to explicitly using the wrapping and unwrapping methods rather than relying on autoboxing and unboxing.

Summary

- a) Polymorphic Variables
- b) Polymorphic Collections
 - casting,
 - wrapper classes,
 - autoboxing /unboxing

**Any
Questions?**



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).