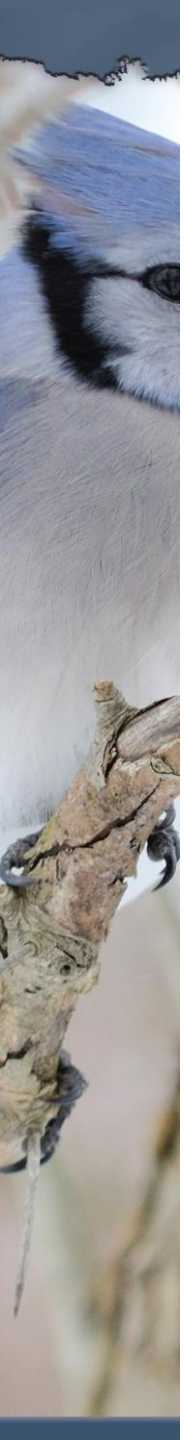
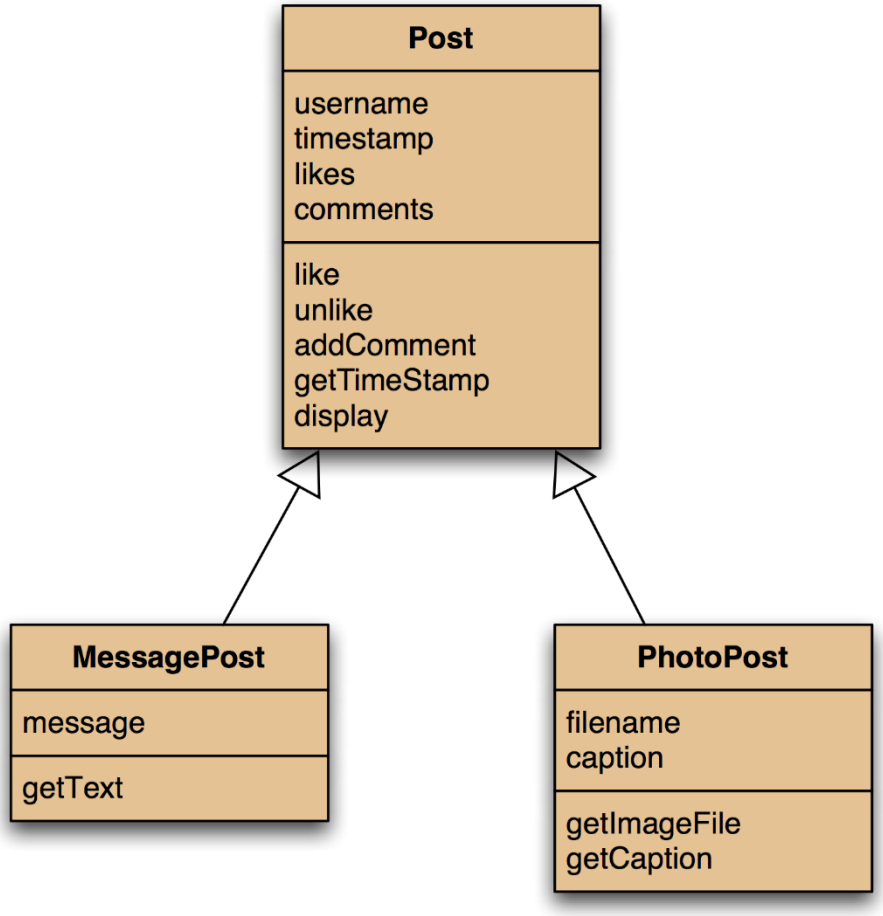


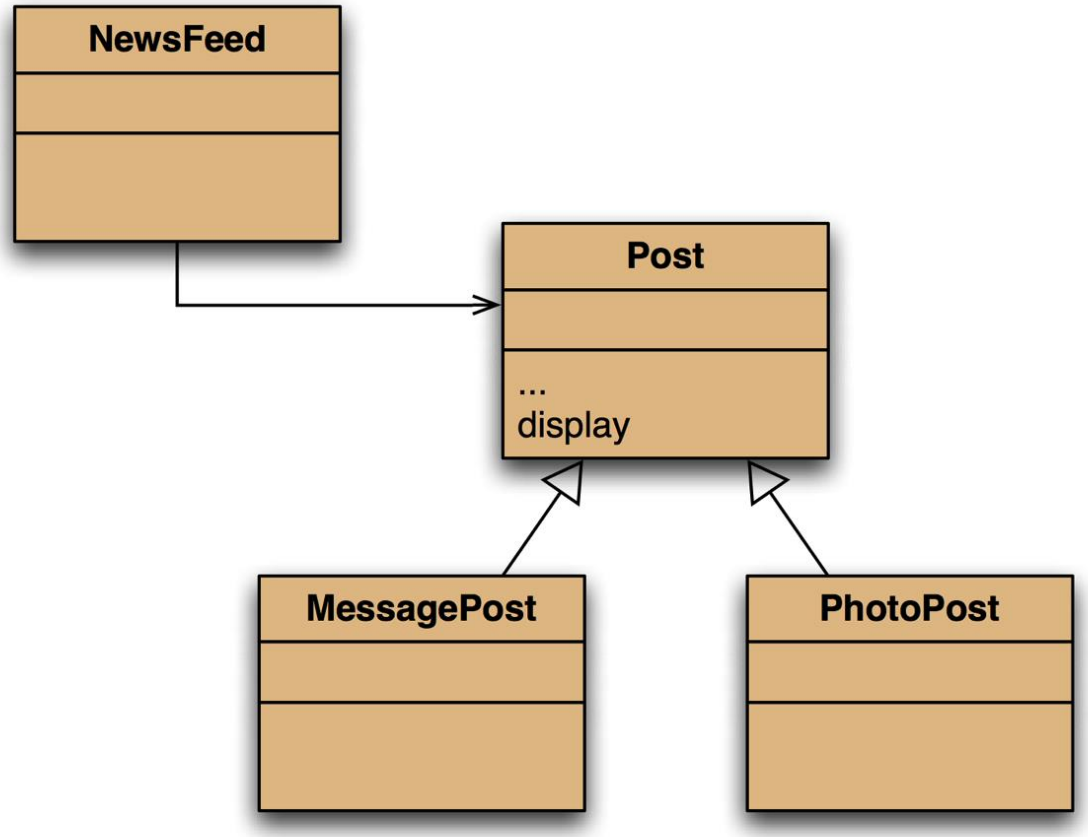
More about inheritance

Exploring polymorphism

The Class Diagram



The inheritance hierarchy



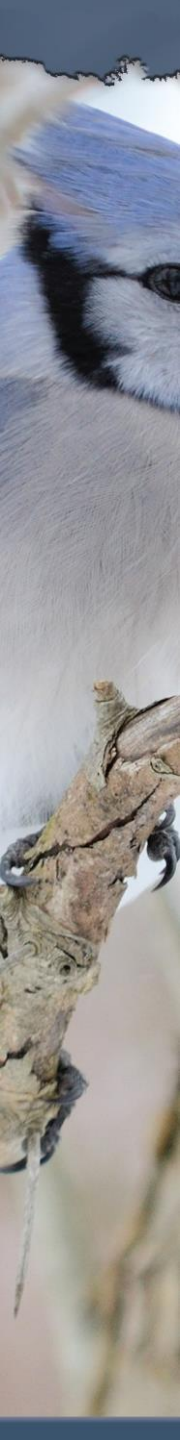
Conflicting output

```
Leonardo da Vinci
Had a great idea this morning.
But now I forgot what it was. Something to do with flying ...
40 seconds ago - 2 people like this.
  No comments.

Alexander Graham Bell
[experiment.jpg]
I think I might call this thing 'telephone'.
12 minutes ago  -  4 people like this.
  No comments.
```

What we want

```
Leonardo da Vinci
40 seconds ago  -  2 people like this.
  No comments.

Alexander Graham Bell
12 minutes ago  -  4 people like this.
  No comments.
```

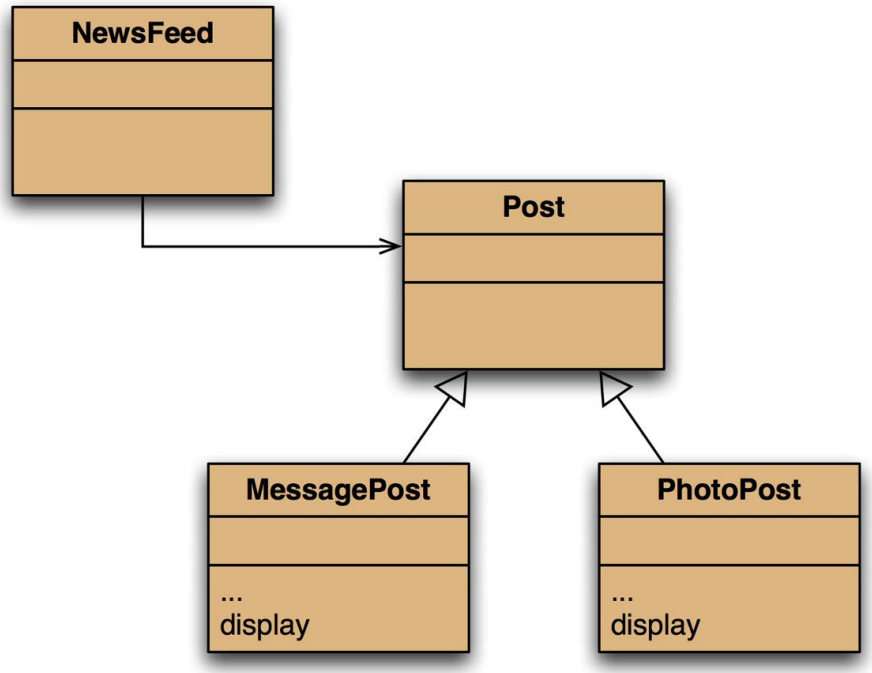
What we have



The problem

- The **`display`** method in **`Post`** only prints the common fields.
- Inheritance is a one-way street:
  - A subclass inherits the superclass fields.
  - The superclass knows nothing about its subclass's fields.

Attempting to solve the problem

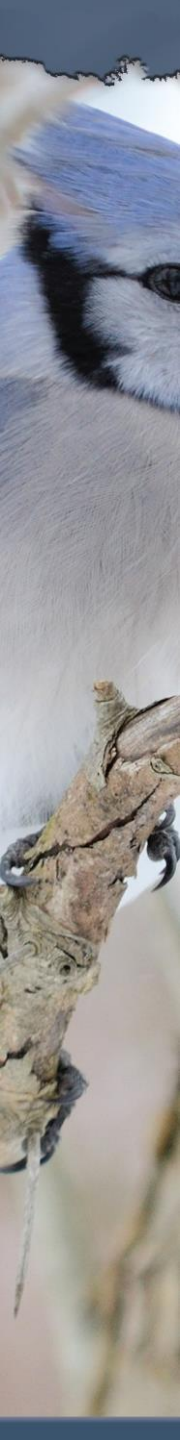


Place **`display`** where it has access to the information it needs.

Each subclass has its own version.

But **`Post`**'s fields are private.

`NewsFeed` cannot find a **`display`** method in **`Post`**.



Static type and dynamic type

- A more complex type hierarchy requires further concepts to describe it.
- Some new terminology:
  - static type
  - dynamic type
  - method dispatch/lookup

Static and dynamic type

What is the type of c1?

```
Car c1 = new Car();
```

What is the type of v1?

```
Vehicle v1 = new Car();
```

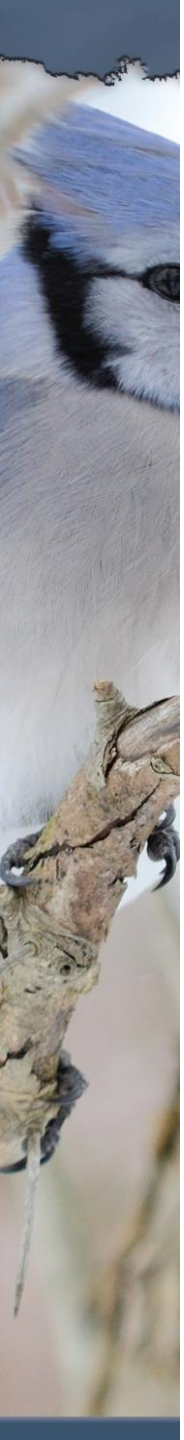
Static and dynamic type

- The declared type of a variable is its *static type*.
- The type of the object a variable refers to is its *dynamic type*.
- The compiler's job is to check for static-type violations.

```
for(Post post : posts) {
    post.display();   // Compile-time error.
}
```

Solution: using `instanceof`

```
public class NewsFeed {

   ...

   public void show() {
      for (Post post : posts) {
         if (post instanceof MessagePost) {
            MessagePost msg = (MessagePost) post;
            msg.display();
         } else if (post instanceof PhotoPost) {
            PhotoPost photo = (PhotoPost) post;
            photo.display();
         }
         System.out.println();
      }
   }

   ...
}
```

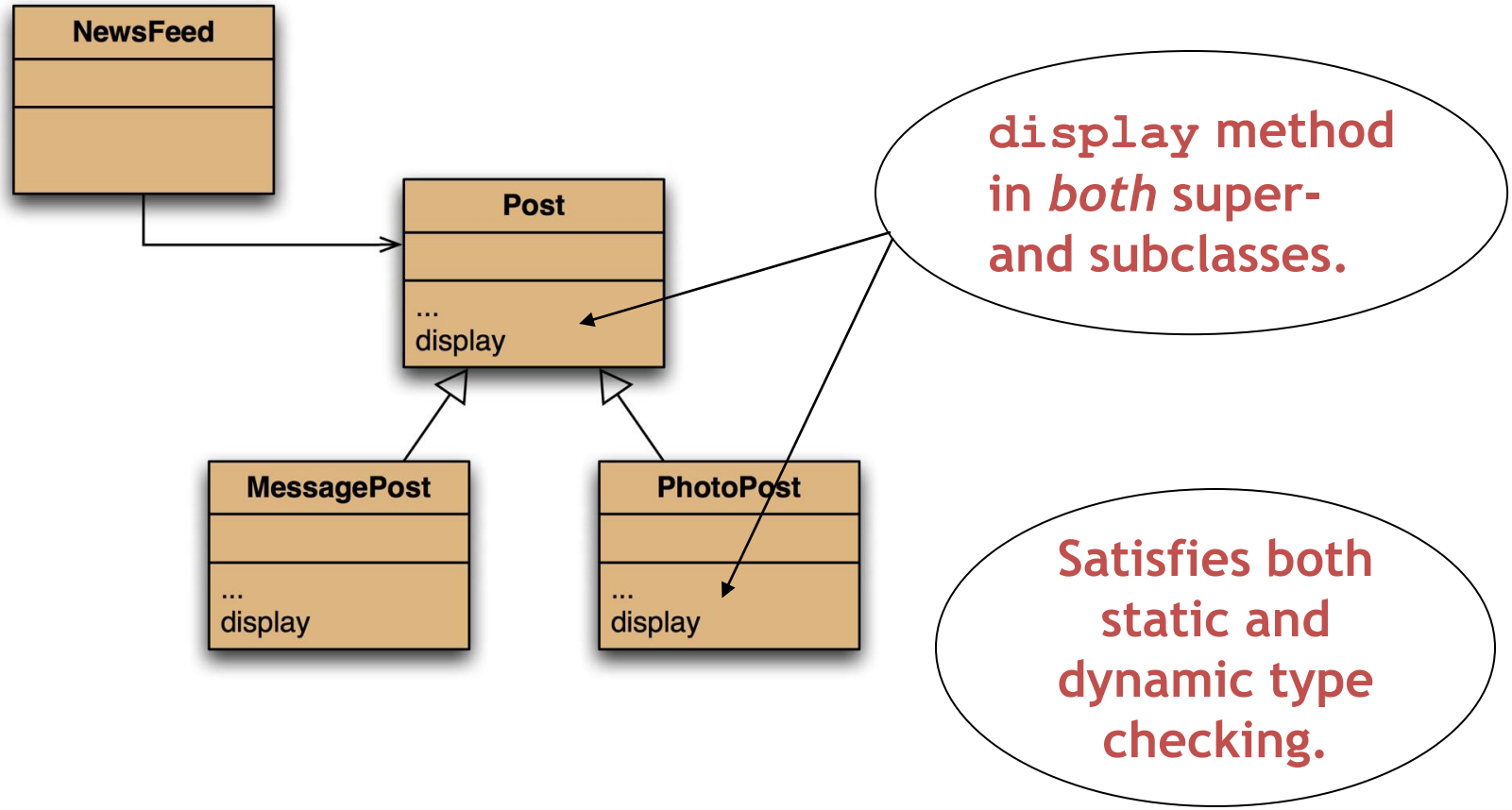


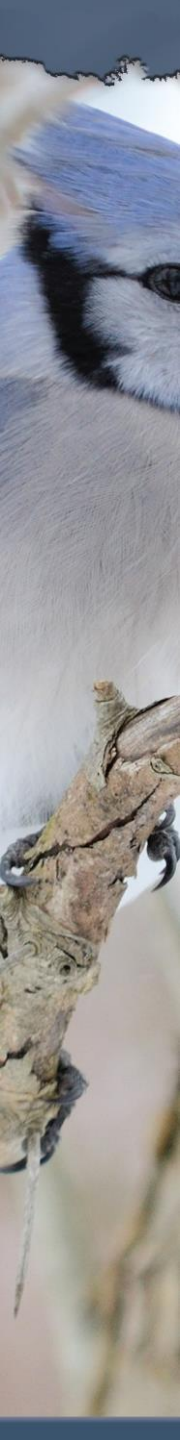
The `instanceof` operator

- Used to determine the dynamic type.
- Recovers ‘lost’ type information.
- Usually precedes assignment with a cast to the dynamic type:

```
if (post instanceof MessagePost) {
    MessagePost msg = (MessagePost) post;
    … access MessagePost methods via msg …
}
```

Overriding: the **better** solution

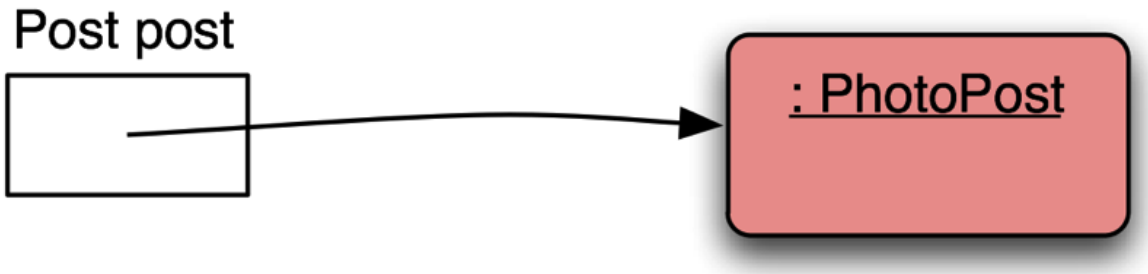




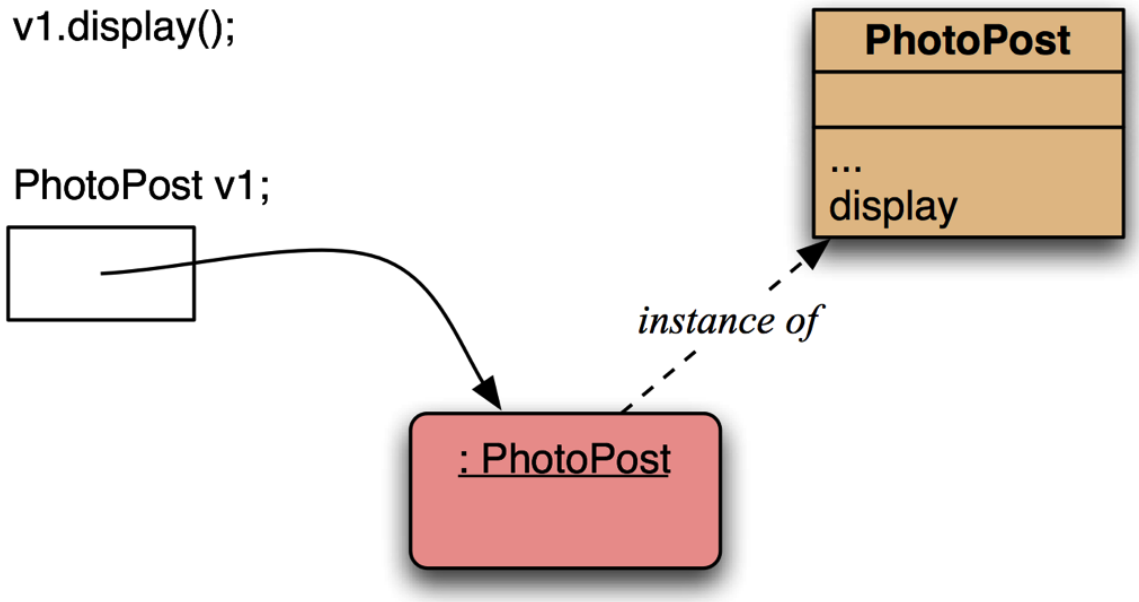
Overriding

- Superclass and subclass define methods with the same signature.
- Each has access to the fields of its class.
- Superclass satisfies static type check.
- Subclass method is called at runtime – it *overrides* the superclass version.
- What becomes of the superclass version?

Distinct static and dynamic types

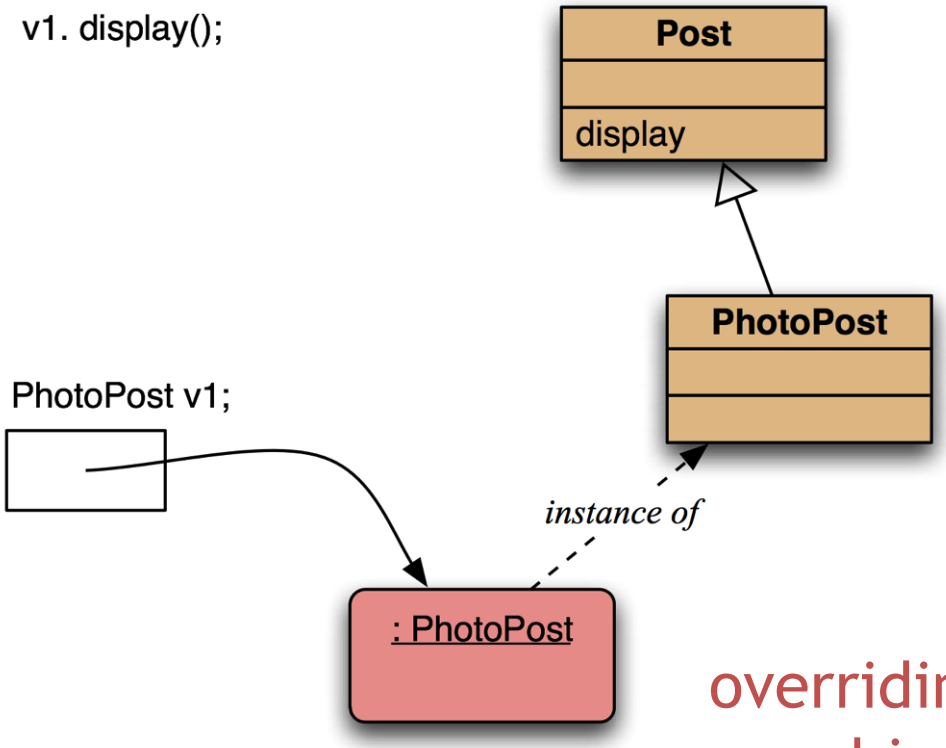


Method lookup



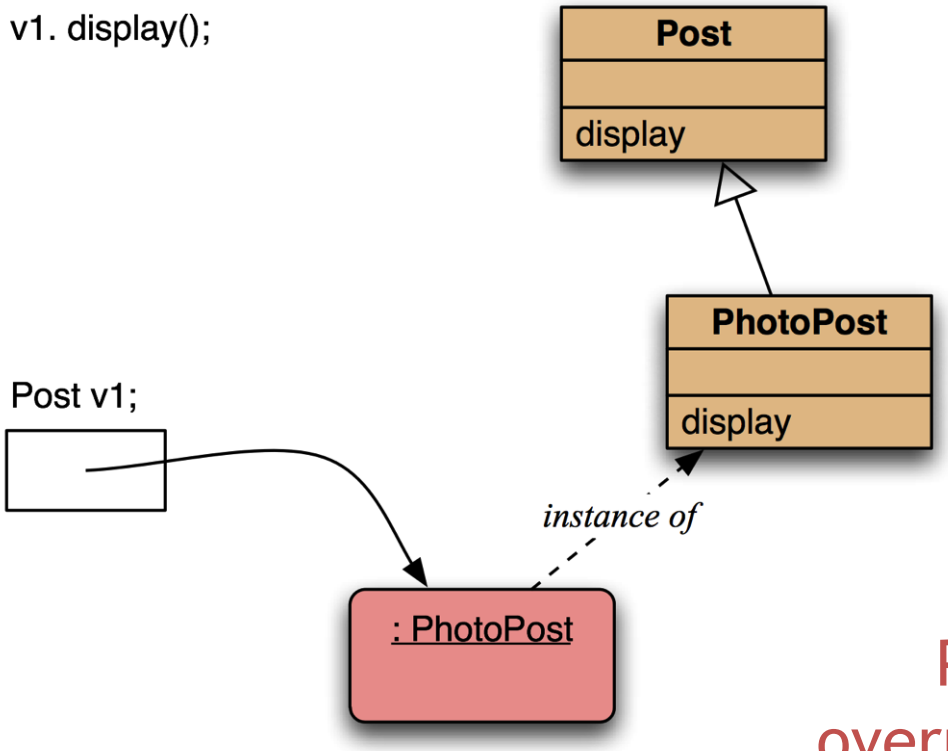
No inheritance or polymorphism.
The obvious method is selected.

Method lookup

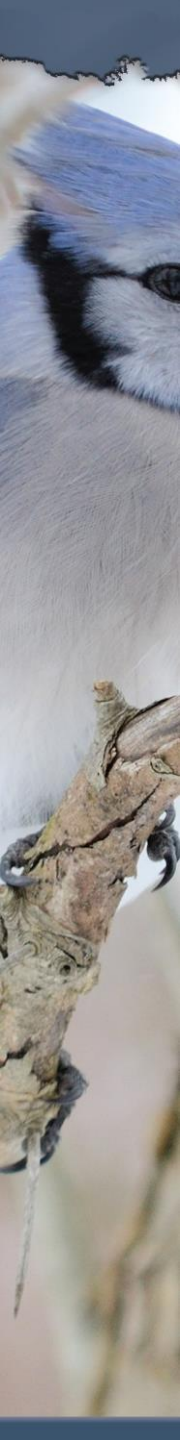


Inheritance but no overriding. The inheritance hierarchy is ascended, searching for a match.

Method lookup

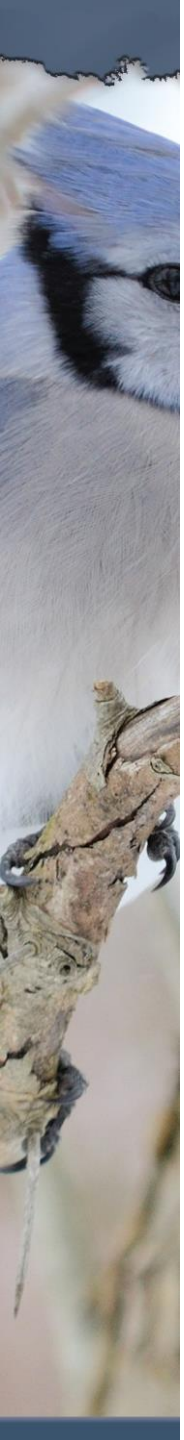


Polymorphism and overriding. The 'first' version found is used.



Method lookup summary

- The variable is accessed.
- The object stored in the variable is found.
- The class of the object is found.
- The class is searched for a method match.
- If no match, the superclass is searched.
- This is repeated until a match is found, or the class hierarchy is exhausted.
- Overriding methods take precedence – they override inherited copies.

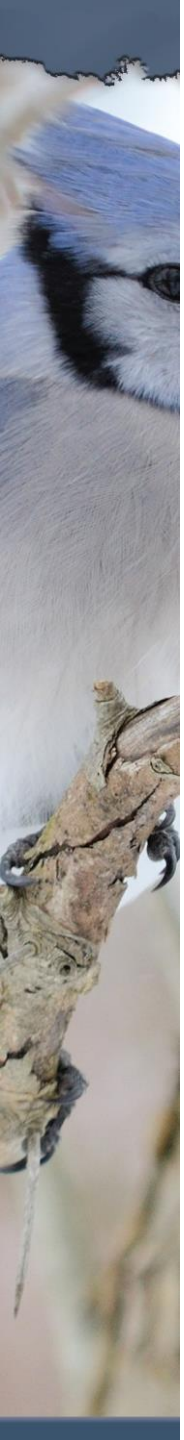


Super call in methods

- Overridden methods are hidden ...
- ... but we often still want to be able to call them.
- An overridden method *can* be called from the method that overrides it.
  - **`super.method(...)`**
  - Compare with the use of **`super`** in constructors.

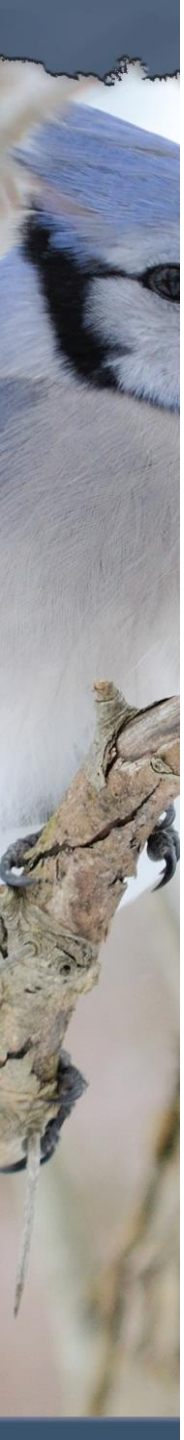
Calling an overridden method

```
@Override
public void display()
{
    super.display();
    System.out.println(" [" +
                       filename +
                       "]");
    System.out.println(" " + caption);
}
```



Method polymorphism

- A polymorphic variable can store objects of varying types.
- We have been discussing *polymorphic method dispatch*.
- Method calls are polymorphic.
  - The actual method called depends on the dynamic object type.

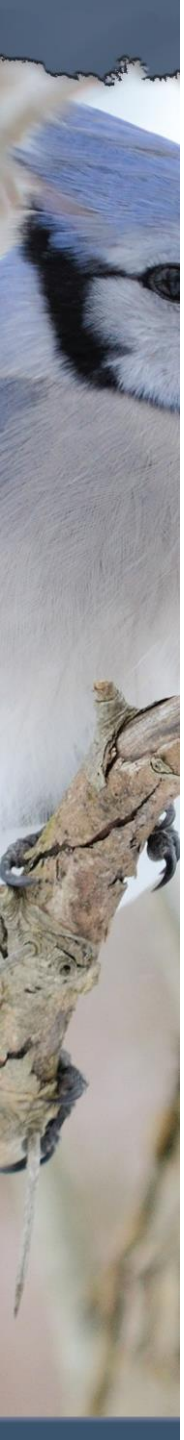


The `Object` class's methods

- Methods in **`Object`** are inherited by all classes.
- Any of these may be overridden.
- The **`toString`** method is commonly overridden:
  - **`public String toString()`**
  - Returns a string representation of the object.

Overriding `toString` in `Post`

```
public String toString()
{
    String text = username + "\n" +
                  timeString(timestamp);
    if(likes > 0) {
        text += " - " + likes + " people like this.\n";
    }
    else {
        text += "\n";
    }
    if(comments.isEmpty()) {
        return text + " No comments.\n";
    }
    else {
        return text + " " + comments.size() +
               " comment(s). Click here to view.\n";
    }
}
```



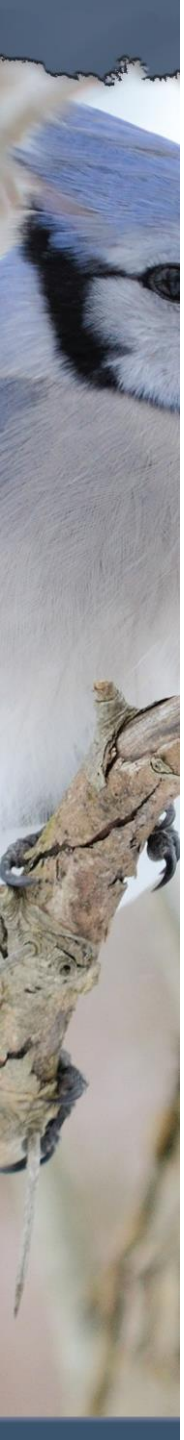
Overriding `toString`

- Explicit print methods can often be omitted from a class:

```
System.out.println(post.toString());
```

- Calls to **`println`** with just an object automatically result in **`toString`** being called:

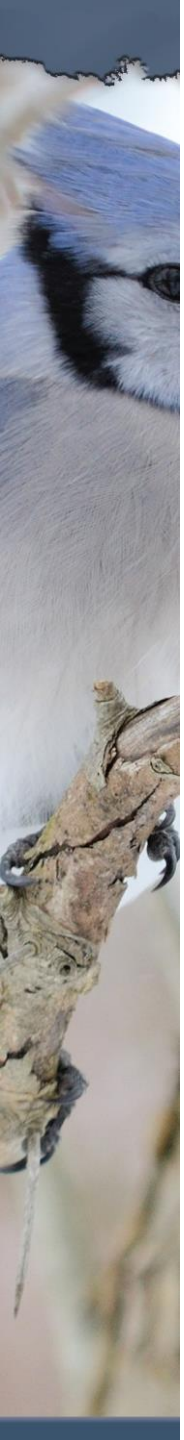
```
System.out.println(post);
```



StringBuilder

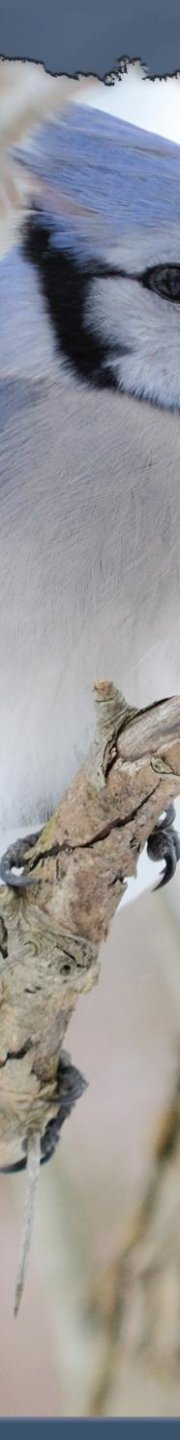
- Consider using **StringBuilder** as an alternative to concatenation:

```
StringBuilder builder = new StringBuilder();
builder.append(username);
builder.append('\n');
builder.append(timeString(timestamp));
…
return builder.toString();
```



Object equality

- What does it mean for two objects to be ‘the same’?
  - Reference equality.
  - Content equality.
- Compare the use of `==` with **`equals()`** between strings.



Overriding `equals`

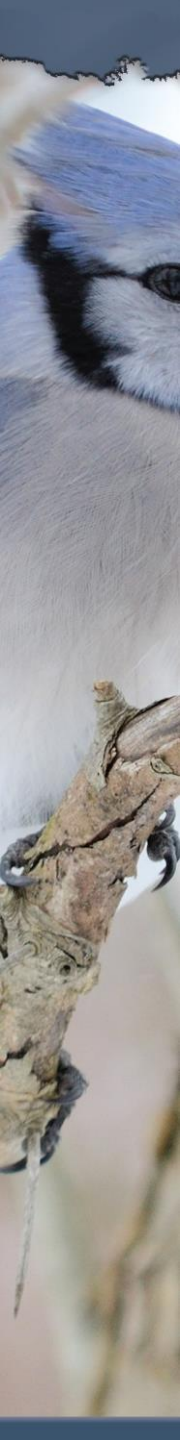
```
public boolean equals(Object obj)
{
    if(this == obj) {
        return true;
    }
    if(!(obj instanceof ThisType)) {
        return false;
    }
    ThisType other = (ThisType) obj;
    … compare fields of this and other
}
```

Overriding `equals` in `Student`

```
public boolean equals(Object obj)
{
    if(this == obj) {
        return true;
    }
    if(!(obj instanceof Student)) {
        return false;
    }
    Student other = (Student) obj;
    return name.equals(other.name) &&
           id.equals(other.id) &&
           credits == other.credits;
}
```

Overriding `hashCode` in `Student`

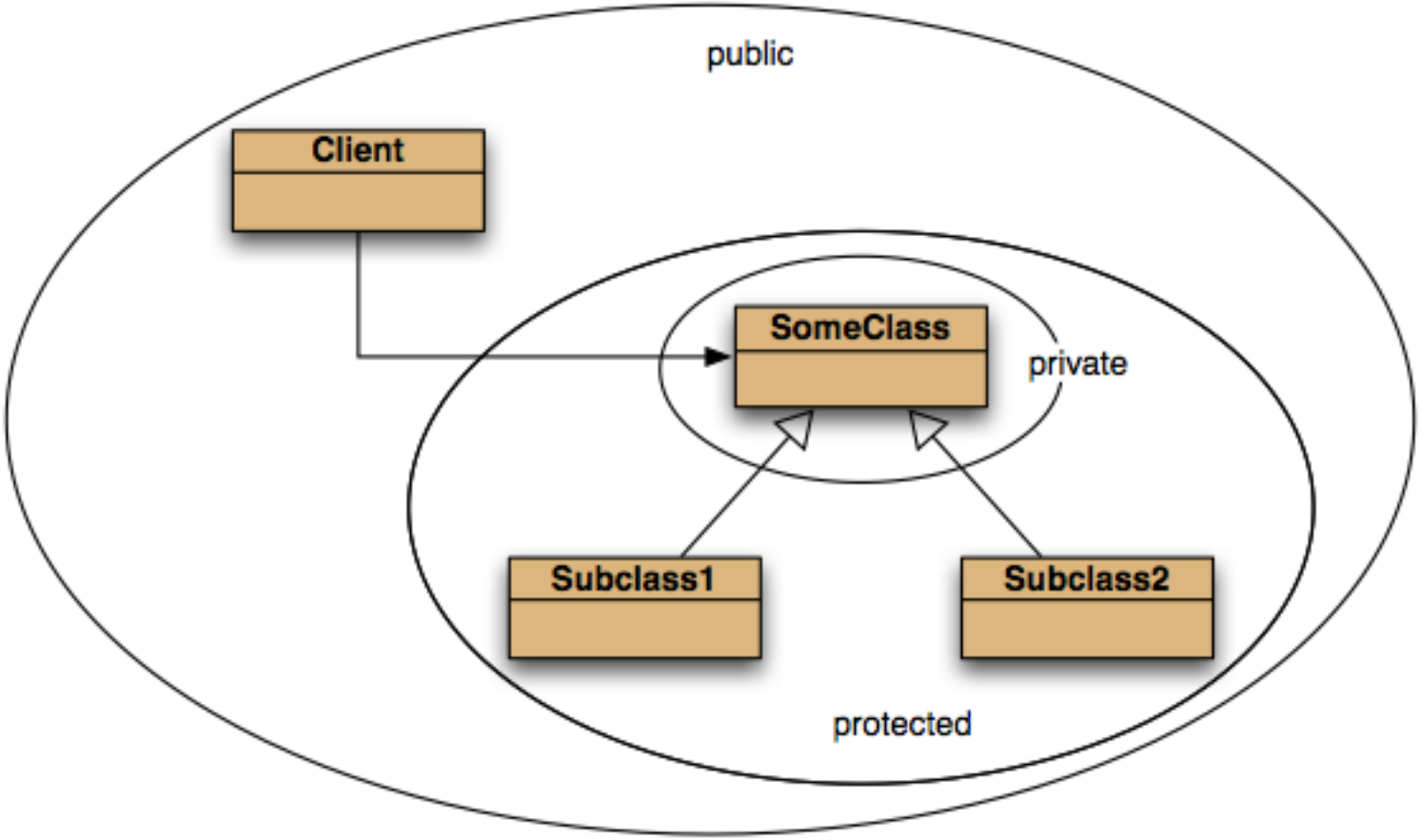
```
/**
 * Hashcode technique taken from
 * Effective Java by Joshua Bloch.
 */
public int hashCode()
{
    int result = 17;
    result = 37 * result + name.hashCode();
    result = 37 * result + id.hashCode();
    result = 37 * result + credits;
    return result;
}
```



Protected access

- Private access in the superclass may be too restrictive for a subclass.
- The closer inheritance relationship is supported by *protected access*.
- Protected access is more restricted than public access.
- We still recommend keeping fields private.
  - Define protected accessors and mutators.

Access levels



Let's Do Some Exercises!

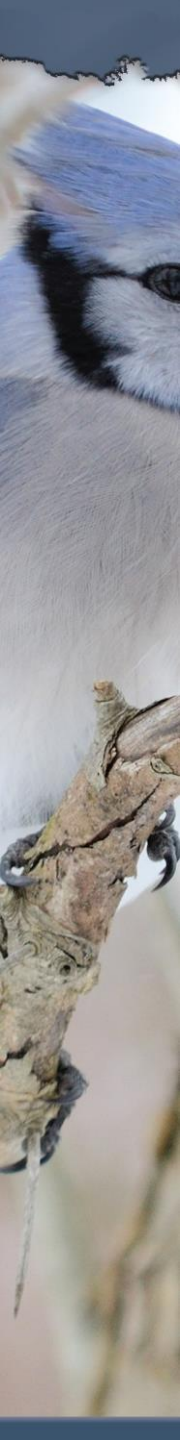
- Exercises 11.11, 11.12 → page 414

Exercise 11.11 Assume that you see the following lines of code:

```
Device dev = new Printer();
dev.getName();
```

Printer is a subclass of **Device**. Which of these classes must have a definition of method **getName** for this code to compile?

Exercise 11.12 In the same situation as in the previous exercise, if both classes have an implementation of **getName**, which one will be executed?



Review

- The declared type of a variable is its static type.
  - Compilers check static types.
- The type of an object is its dynamic type.
  - Dynamic types are used at runtime.
- Methods may be overridden in a subclass.
- Method lookup starts with the dynamic type.
- Protected access supports inheritance.