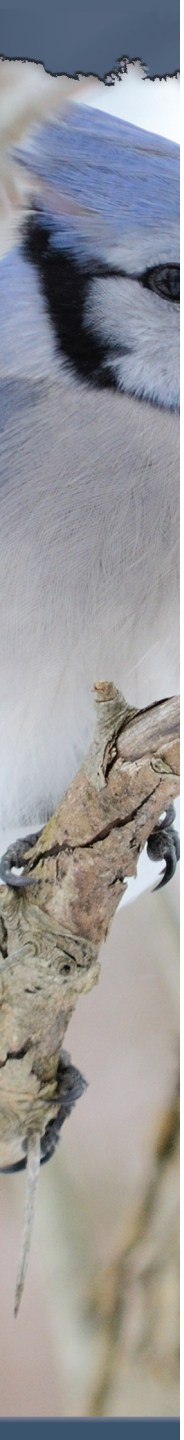


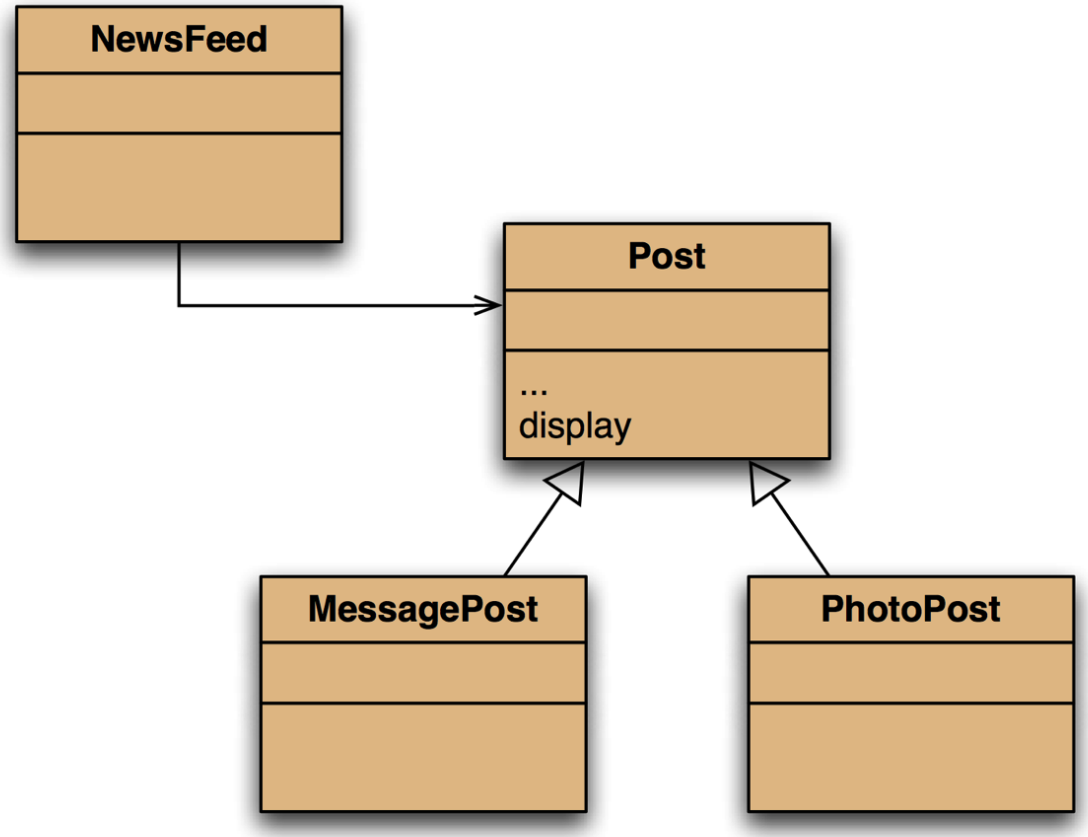
More about inheritance

Exploring polymorphism

Main concepts to be covered

- method polymorphism
- static and dynamic type
- overriding
- dynamic method lookup
- protected access

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'.
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What we want

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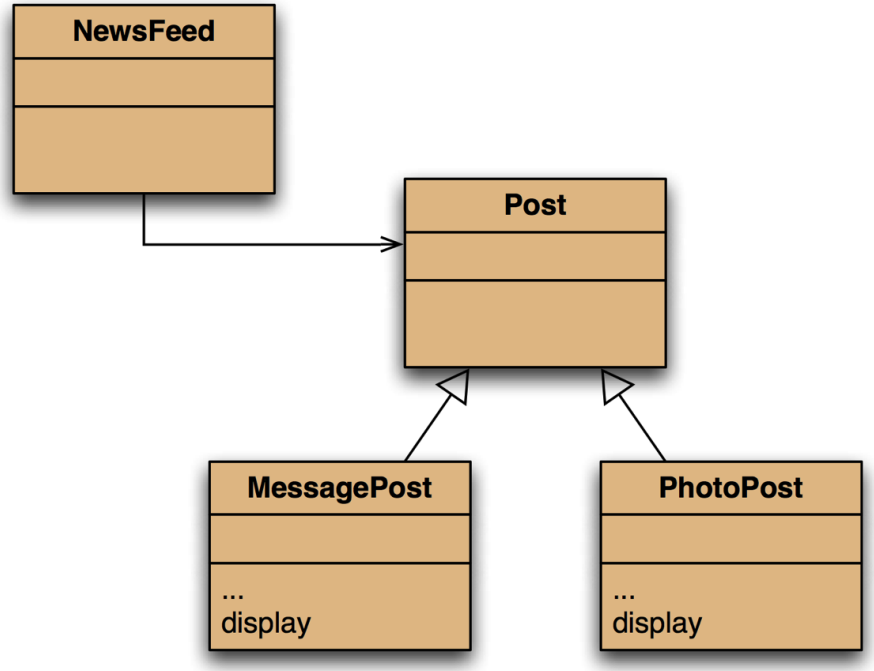
What we have

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

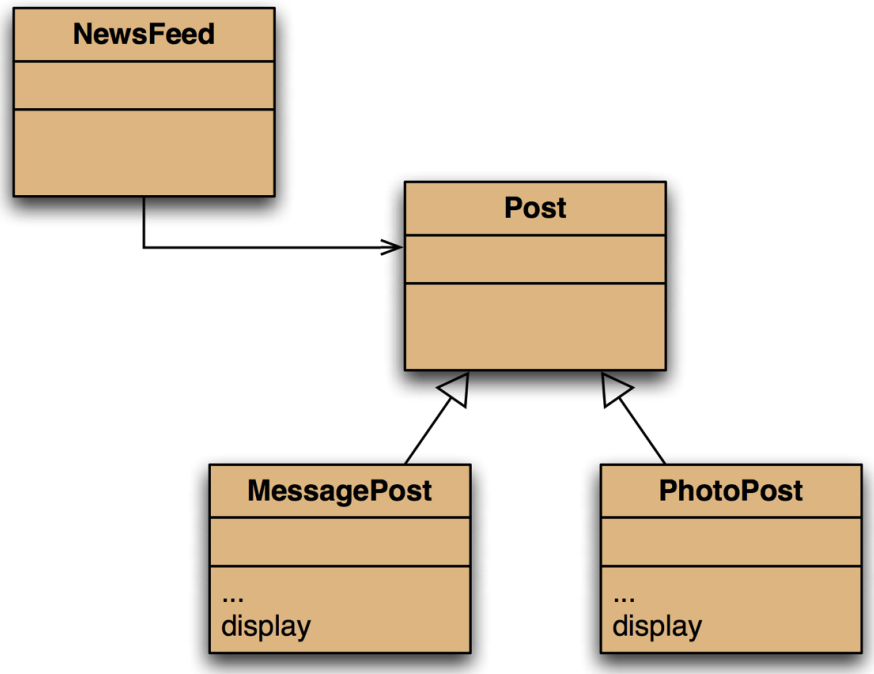


Place **`display`** where it has access to the information it needs.

Each subclass has its own version.

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

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.

Compile-time error - **`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();
```

Static and dynamic type

What is the type of c1?

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

What is the type of v1?

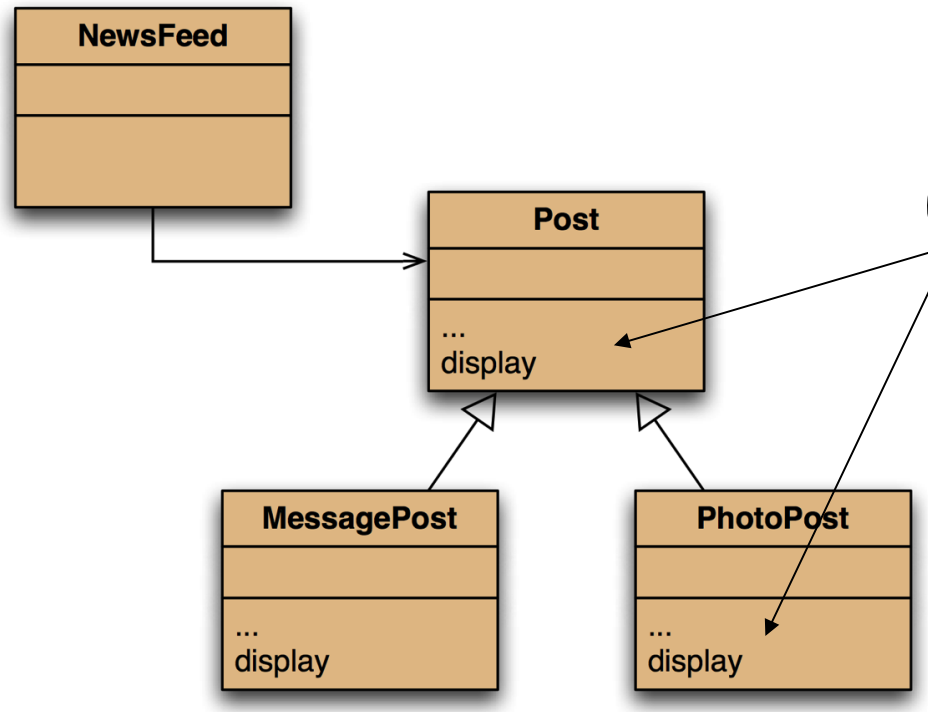
```
Vehicle v1 = new Car();
```

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.
}
```

Overriding: the solution



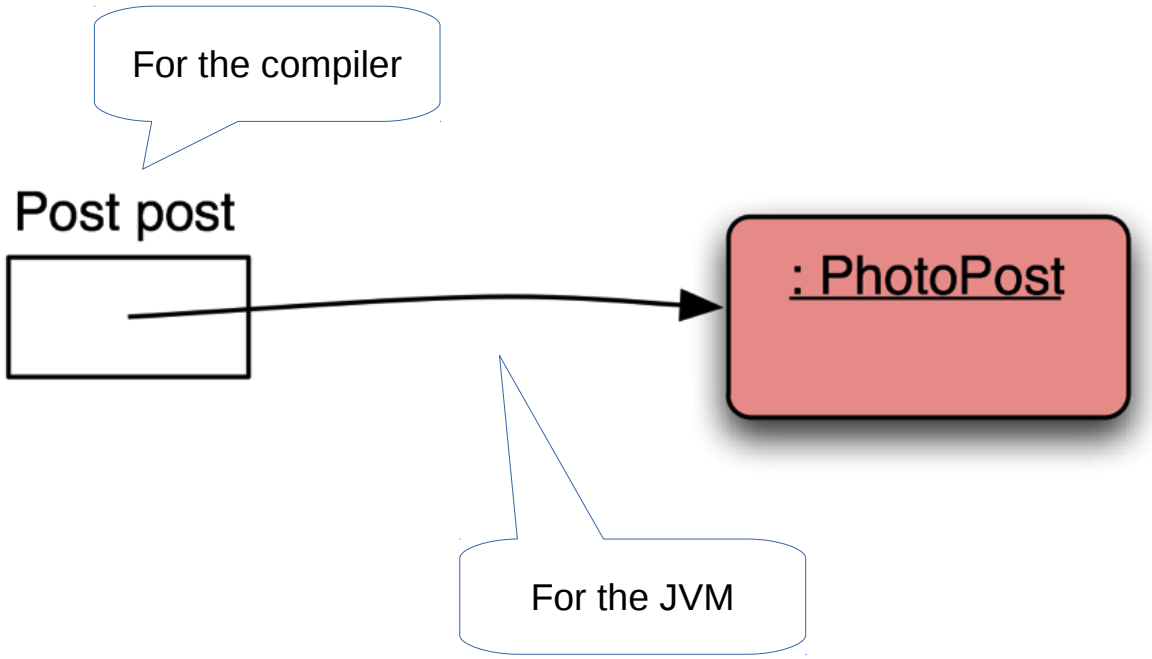
`display` method in *both* super- and subclasses.

Satisfies both static and dynamic type checking.

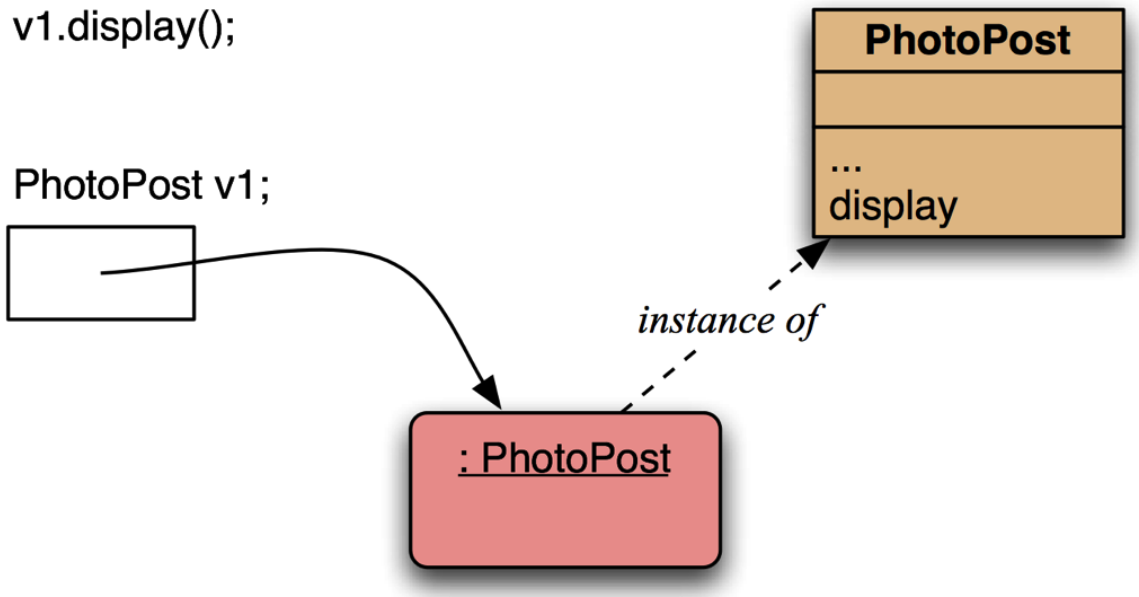
Overriding

- 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

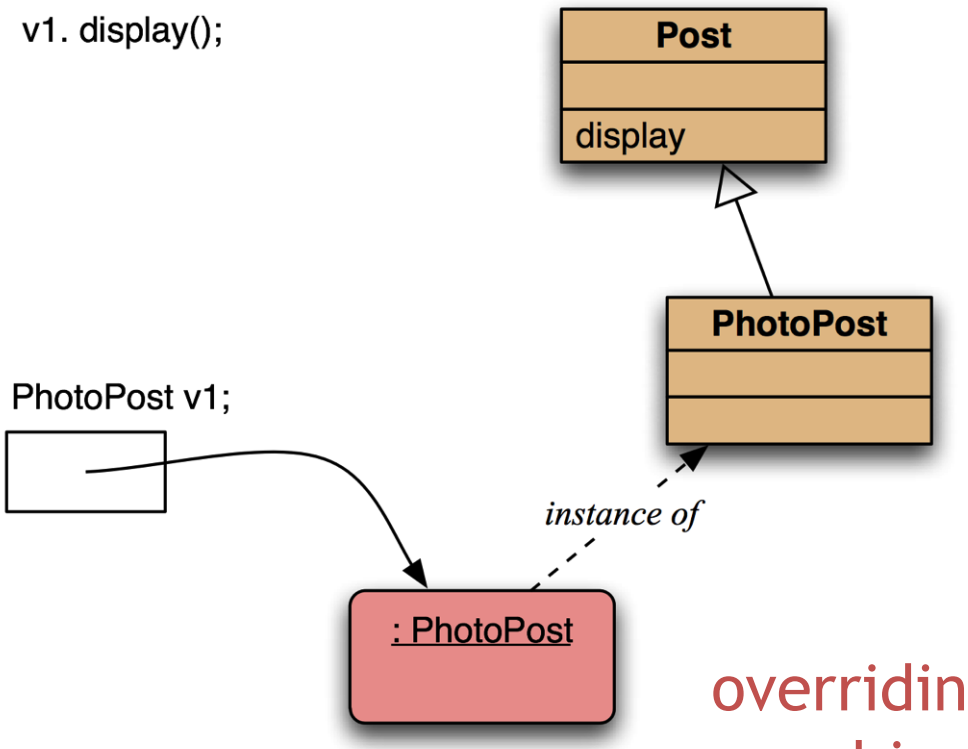


Method lookup



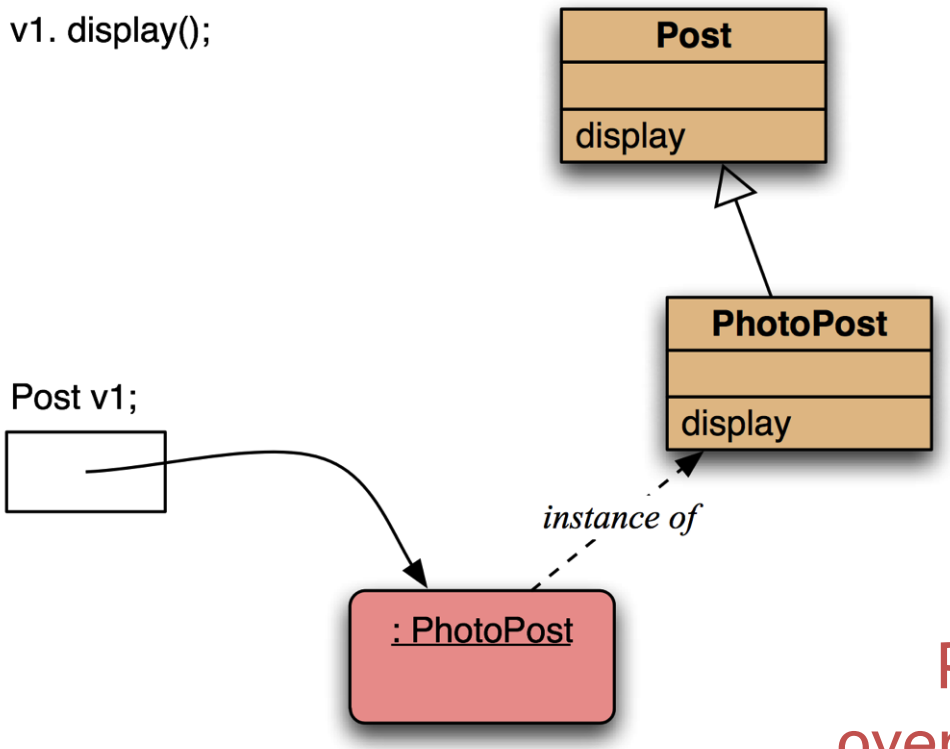
No inheritance or polymorphism.
The obvious method is selected.

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

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- The variable is accessed.

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Method lookup summary

- The variable is accessed.
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- 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

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

Method polymorphism

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

The `instanceof` operator

- Used to determine the dynamic type.
- Identifies ‘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 …
}
```

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`

```
@Override
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`

```
@Override
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`

```
@Override
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.
 */
@Override
public int hashCode() {
    int result = 17;
    result = 37 * result + name.hashCode();
    result = 37 * result + id.hashCode();
    result = 37 * result + credits;
    return result;
}
```

Overriding

- Overriding method cannot reduce access.

Superclass method	Subclass method
package-private	package-private **`protected`** **`public`**
`protected`	**`protected`** **`public`**
`public`	**`public`**

- **`private`** methods cannot be overridden.

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

`private` « package-private « **`protected`** « **`public`**

same class	same class same package	same class same package subclass	same class same package subclass any class

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.

A word about final

- A **`final`** method is un-overridable.

```
class Souper {
    public final void tinyPerfectMethod() {…}
}

class Sub extends Souper {
    @Override
    public void tinyPerfectMethod() {…}
}
```

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Compiler error

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Compiler error

- A **`private`** method is un-overridable.
- But a subclass may have a method with the same signature.

A word about final

- A **`final`** class is un-subclassable

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public final class Souper {
    …
}

 class Sub extends Souper {
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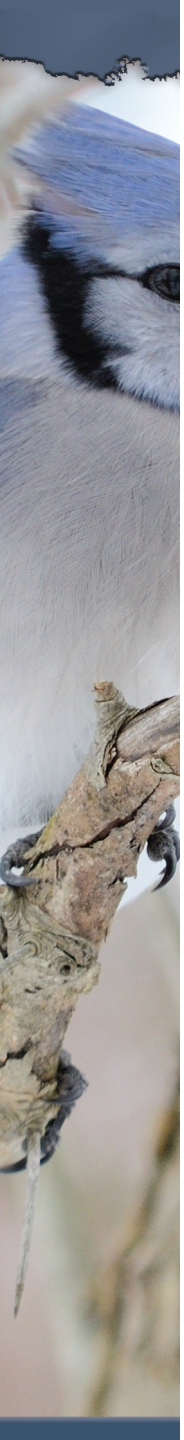
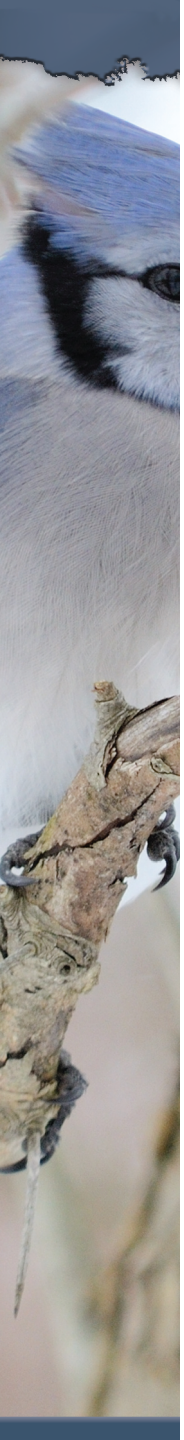


final classes



final classes

- It takes effort to prepare a class to be subclassed.
- Most classes are not suitable and should be declared final.
- String, Boolean, Integer, Math are all declared final.

final classes

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- Most classes are not suitable and should be declared final.
- String, Boolean, Integer, Math are all declared final.
- Classes with only private constructors cannot be subclassed.

final can ensure objects are fully-built

```
class Defective {
    private List<String> messages;
    Defective() {
        Oops - forgot to instantiate messages
    }

    private void obscure() {
        if (some rare condition) {
            messages.add("Stuff happened");
        }
    }
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Code crashes on execution

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final can ensure objects are fully-built

Compiler error - better than runtime crash

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