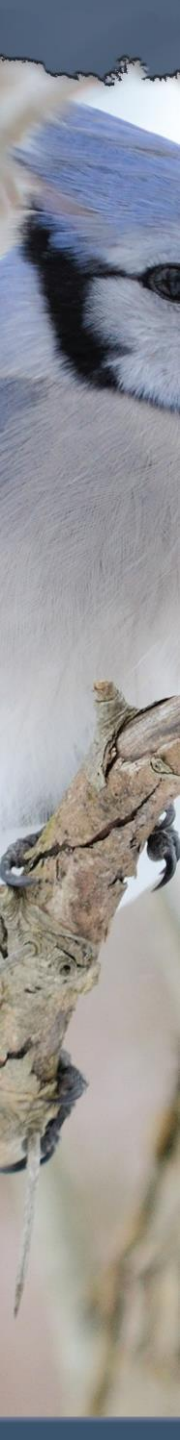
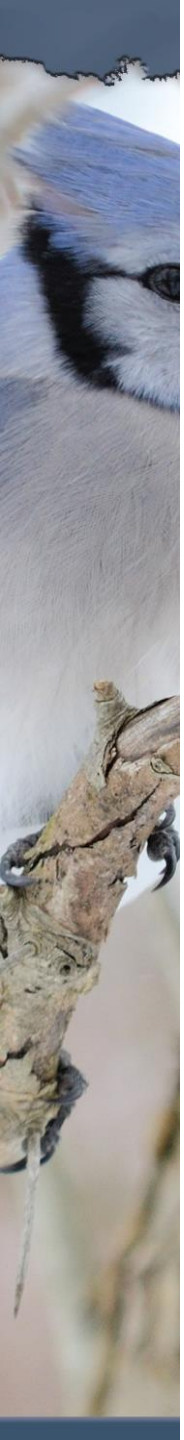


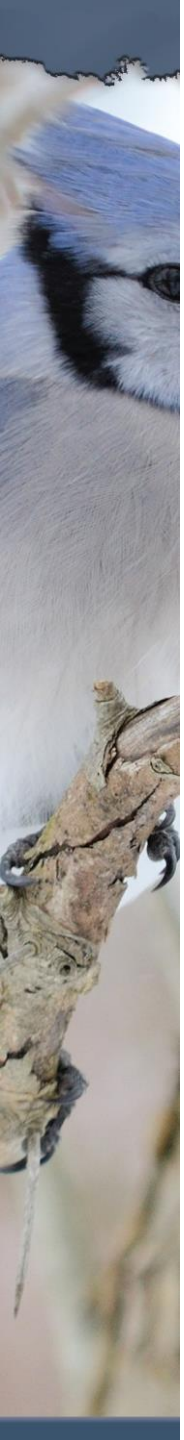
More-Sophisticated Behavior

Using library classes to implement some more advanced functionality



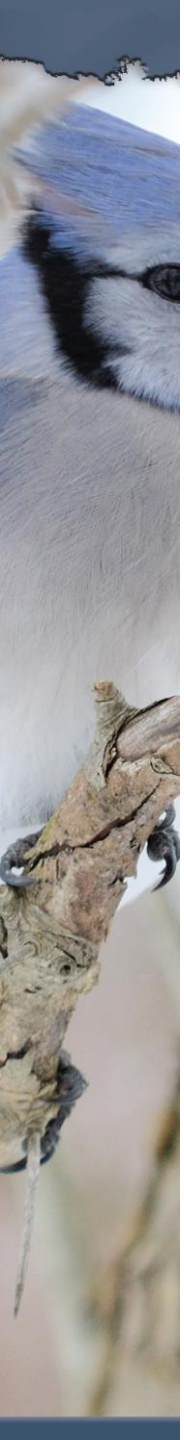
Main concepts to be covered

- Using library classes
- Reading documentation



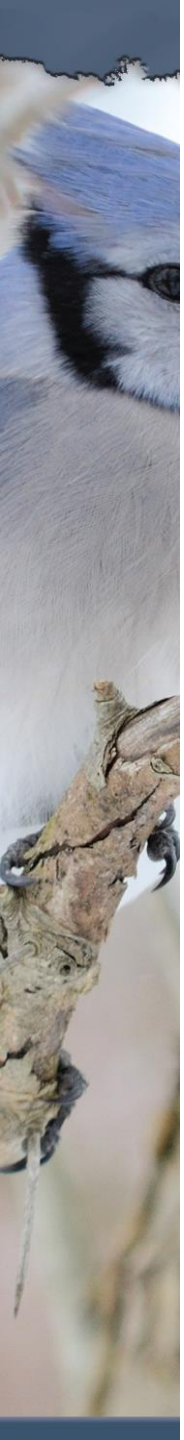
The Java class library

- Thousands of classes
- Tens of thousands of methods
- Many useful classes that make life much easier
- Library classes are often inter-related
- Arranged into packages



Working with the library

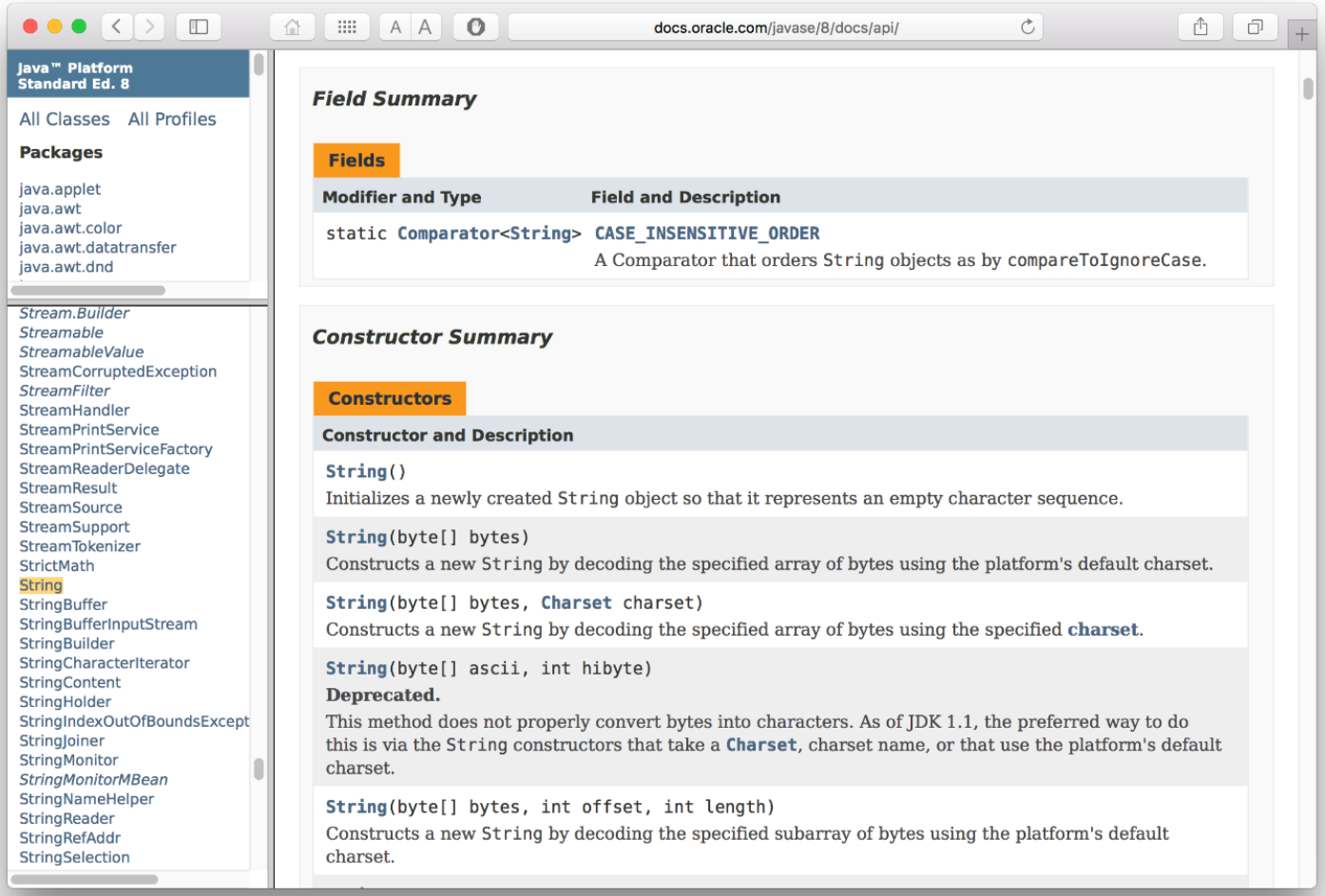
- A competent Java programmer must be able to work with the libraries
- You should:
  - know some important classes by name;
  - know how to find out about other classes
- Remember:
  - we only need to know the *interface*, not the *implementation*



Reading class documentation

- Documentation of the Java libraries in HTML format
- Readable in a web browser
- Class API:
  Application Programmers Interface
- Interface description for all library classes

API Reference

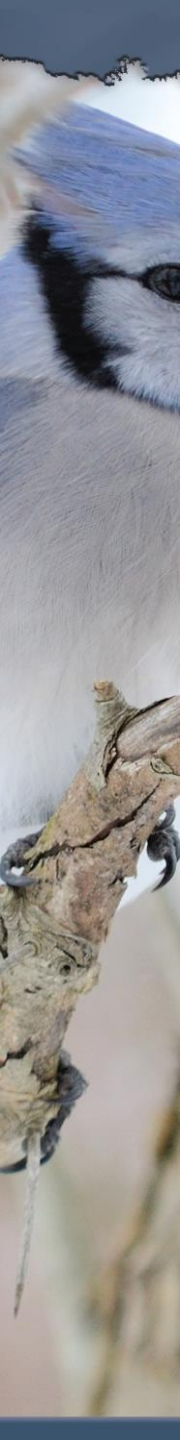


Interface vs implementation

The documentation includes (the WHAT):

- the name of the class
- a general description of the class
- a list of constructors and methods
- return values and parameters for constructors and methods
- a description of the purpose of each constructor and method

→ **the *interface* of the class**



Interface vs implementation

*The documentation **does not** include* (HOW):

- private fields (most fields are private)
- private methods
- the bodies (source code) of methods

→ **the *implementation* of the class**

Debug with Logging

- Print statements require removal before production
- Logging provides a more effective alternative
  - Import classes/interfaces with core logging facilitate

```
import java.util.logging.Logger;
import java.util.logging.Level;
```

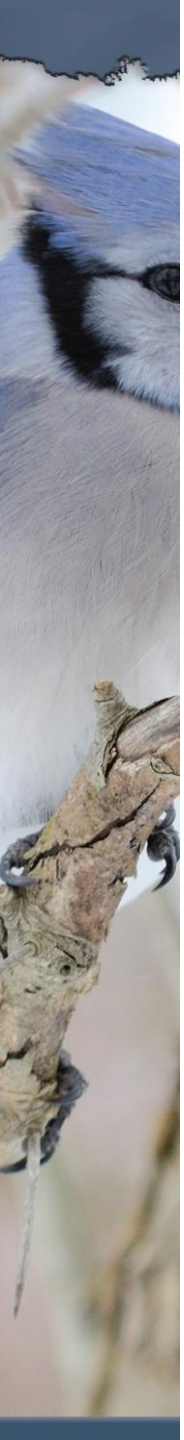
  - Declare and initialize the logger object for a class

```
Logger logger =
Logger.getLogger(ClassName.class.getName());
```

  - Instead of System.out.println statements, now use:

```
void log(Level level, String msg)
logger.log(Level.WARNING, "Name is INVALID");
```

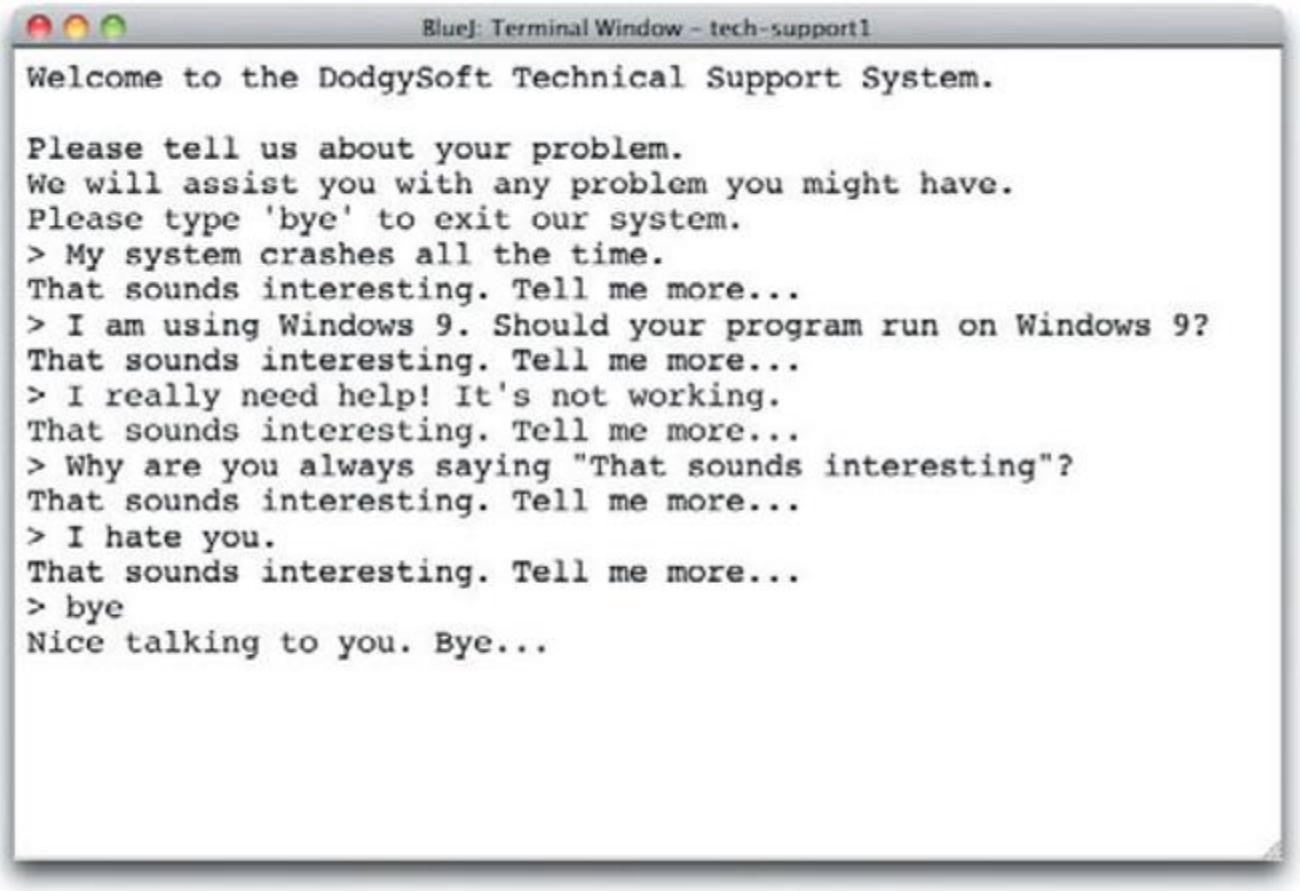
  - Static *Level* constants in descending order:
    - SEVERE (highest value)
    - WARNING
    - INFO
    - CONFIG
    - FINE
    - FINER
    - FINEST (lowest value)



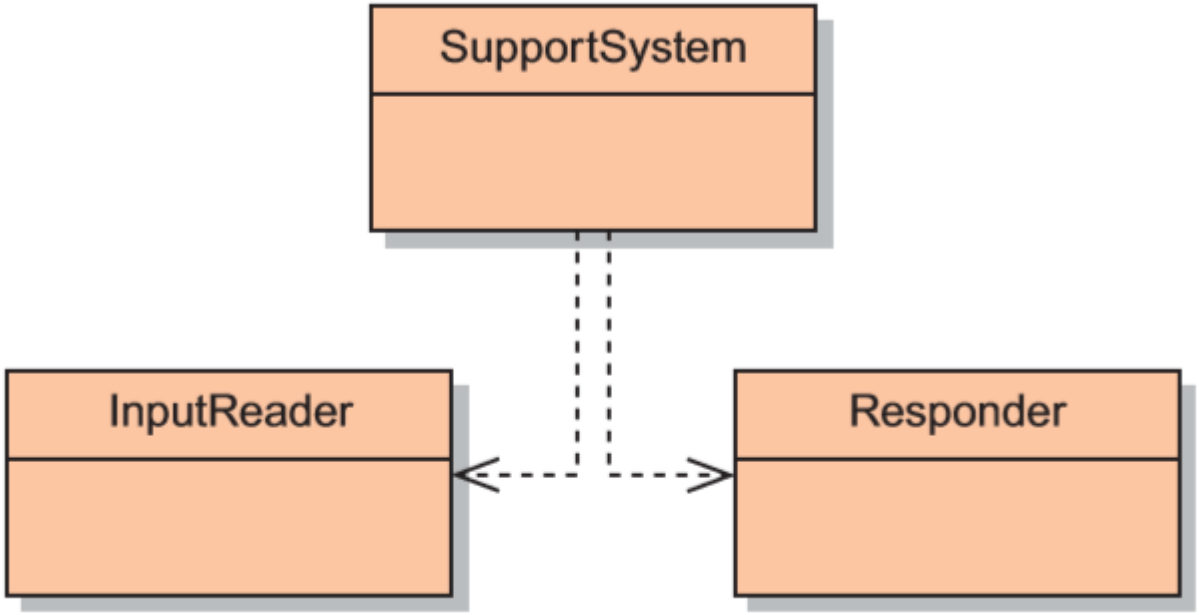
A Technical Support System

- A interactive text dialog system providing technical support for online customers
- Idea based on *Eliza* (AI program) developed by Joseph Weizenbaum (MIT, 1960s)
- *tech-support* project requirements:
  - Technical support system text interface
  - User inputs a technical support question
  - Program generates a response

Interactive text dialog system *tech-support*



Modularization



tech-support project

```
public class SupportSystem
{
    private InputReader reader;
    private Responder responder;

    /**
     * Creates a technical support system.
     */
    public SupportSystem()
    {
        reader = new InputReader();
        responder = new Responder();
    }

    ...
```

Basic structure

- *tech-support* project requirements:
  - Technical support system text interface
  - User inputs a technical support question
  - Program generates a response

```
String input = reader.getInput();
...
String response = responder.generateResponse();
System.out.println(response);
```

Main loop structure

```
boolean finished = false;

while(!finished) {

    do something

    if(exit condition) {
        finished = true;
    }
    else {
        do something more
    }
}
```

A common iteration pattern.

SupportSystem class

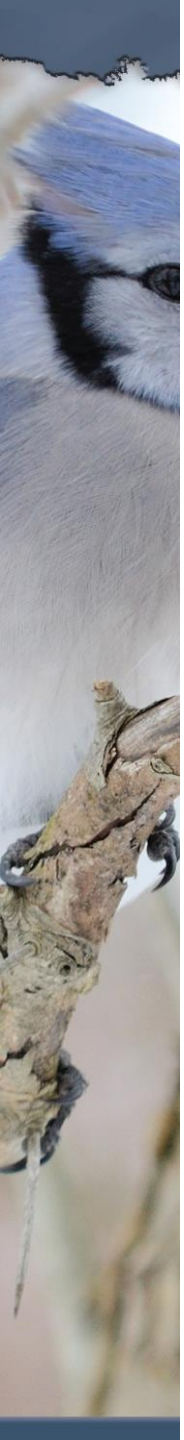
```
public void start()
{
   boolean finished = false;

   printWelcome();
   while(!finished) {
     String input = reader.getInput();

     if(input.startsWith("bye")) {
        finished = true;
     }
     else {
        String response = responder.generateResponse();
        System.out.println(response);
     }
   }
   printGoodbye();
}
```

** ***input*** is ignored by ***Responder*** in this version

The exit condition

```
String input = reader.getInput();

if(input.startsWith("bye")) {
    finished = true;
}
```

- Where does '**`startsWith`**' come from?
- What is it?
- What does it do?
- How can we find out?



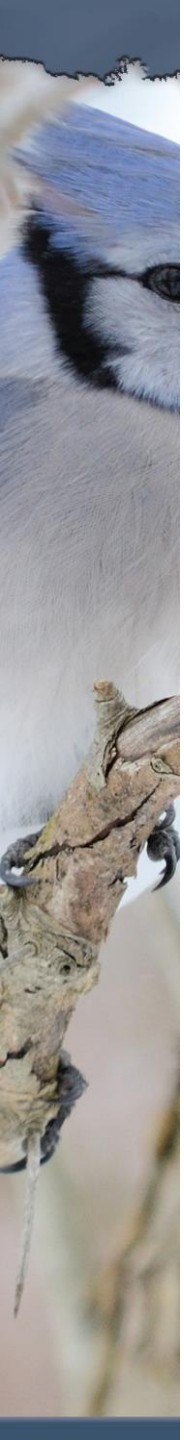
Documentation for **startsWith**

- **`startsWith`**
  - **`public boolean startsWith(String prefix)`**
- Tests if this string starts with the specified prefix
- Parameters:
  - **`prefix`** - the prefix
- Returns:
  - **true** - if the String startsWith the prefix
  - **false** – otherwise the String does not

Methods from `String`

- `boolean contains(char c)`
- `boolean endsWith(String s)`
- `int indexOf(String s)`
- `int indexOf(String s, int i)`
- `String substring(int b)`
- `String substring(int b, int e)`
- `String toUpperCase( )`
- `String trim( )`
  - Beware: strings are *immutable*!

(when invoking its methods, but may be mutated with the assignment operator)



Immutable `String`

String method

```
String toUpperCase()
```

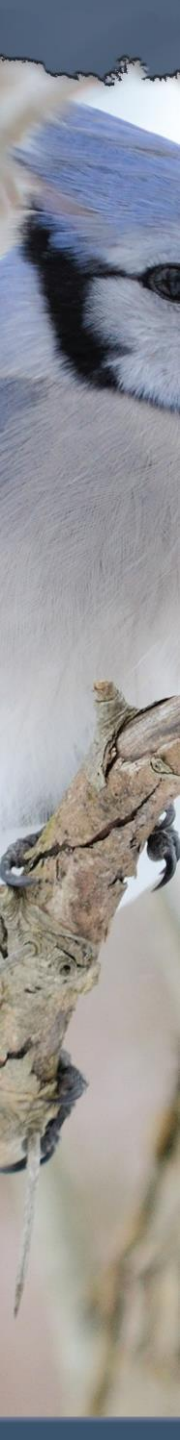
Incorrect use

```
input.toUpperCase();
```

Correct use

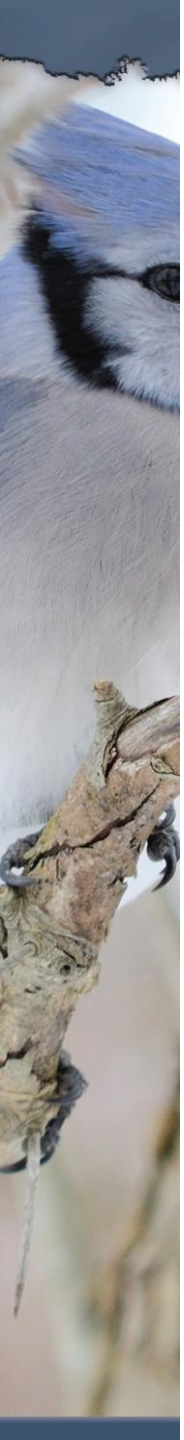
```
input = input.toUpperCase();
```

```
if(input.toUpperCase().contains())
```



Using library classes

- Classes organized into packages
- Classes from the library must be *imported* using an **`import`** statement (except classes from **`java.lang`**)
- They can then be used like classes from the current project



Packages and import

- Single classes may be imported:

```
import java.util.ArrayList;
```

- Whole packages can be imported:

```
import java.util.*;
```

- Importation does NOT involve source code insertion

Using Random

- The library class **`Random`** can be used to generate random numbers

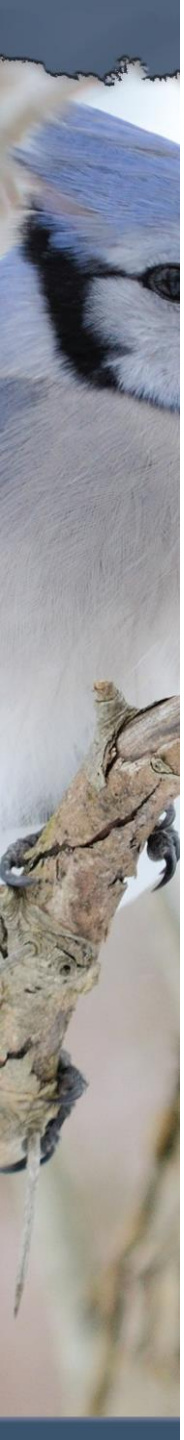
```
import java.util.Random;
...
Random rand = new Random();
...
int num = rand.nextInt();
int value = 1 + rand.nextInt(100);
int index = rand.nextInt(list.size());
```

Selecting a random response

```
private Random randomGenerator;
private ArrayList<String> responses;

public Responder()
{
    randomGenerator = new Random();
    responses = new ArrayList<String>();
    fillResponses();
}

private void fillResponses()
{
    …fill ArrayList responses with a selection of response strings…
}

public String generateResponse()
{
    int index = randomGenerator.nextInt(responses.size());
    return responses.get(index);
}
```

Fill *ArrayList* of responses

```
private ArrayList<String> responses;

public Responder()
{
   randomGenerator = new Random();
   responses = new ArrayList<String>();
   fillResponses();
}

public void fillResponses()
{
   responses.add("That sounds odd. Could you describe \n" + "that problem in more detail?");
   responses.add("No other customer has ever \n" + "complained about this before. \n" +
                 "What is your system configuration?");
   responses.add("That's a known problem with Vista." + "Windows 7 is much better.");
   responses.add("I need a bit more information on that.");
   responses.add("Have you checked that you do not \n" + "have a dll conflict?");
   responses.add("That is explained in the manual. \n" + "Have you read the manual?");
   responses.add("Your description is a bit \n" + "wishy-washy. Have you got an expert \n" +
                 "there with you who could describe \n" + "this more precisely?");
   responses.add("That's not a bug, it's a feature!");
   responses.add("Could you elaborate on that?");
}
```



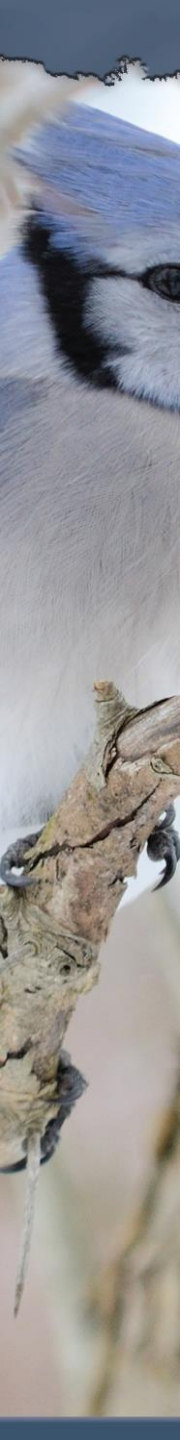
Parameterized (Generic) classes

- The documentation includes provision for *a type parameter*:
  - **`ArrayList<E>`**
- These type names reappear in the parameters and return types:
  - **`E get(int index)`**
  - **`boolean add(E e)`**

Parameterized classes

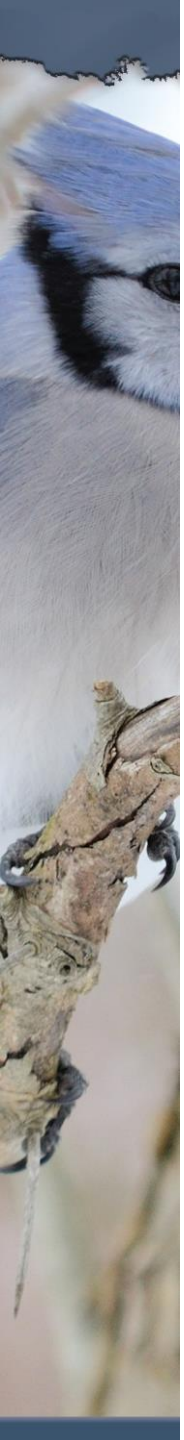
- The types in the documentation are placeholders for the types we use in practice

- An `ArrayList<TicketMachine>` actually has methods:
  - `TicketMachine get(int index)`
  - `boolean add(TicketMachine e)`



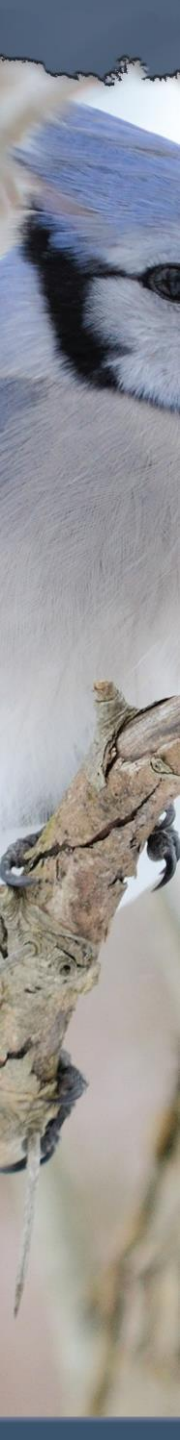
Review

- Java has an extensive class library
- A good programmer must be familiar with the library
- The documentation tells us what we need to know to use a class (its interface)
- Some classes are parameterized with additional types
  - Parameterized classes are also known as *generic classes* or *generic types*



Further library classes

Using library classes to implement some more advanced functionality



Main concepts to be covered

- Further library classes:
  - **`Set`** – avoiding duplicates
  - **`Map`** – creating associations
- Writing documentation:
  - **`javadoc`**

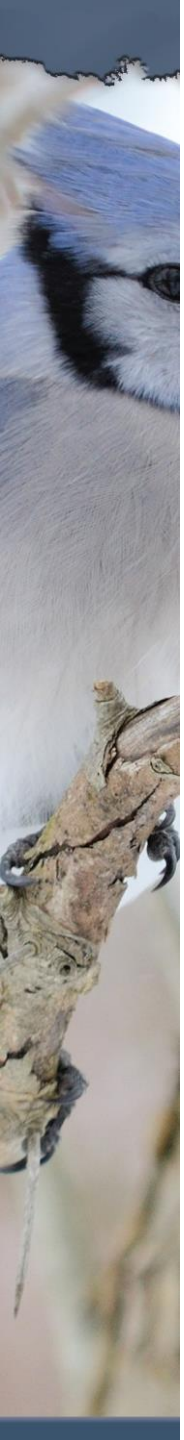
Using sets

```
import java.util.HashSet;

...
HashSet<String> mySet = new HashSet<String>();

mySet.add("one");
mySet.add("two");
mySet.add("three");

for(String element : mySet) {
    do something with element
}
```

Compare with code for an `ArrayList`!

ArrayList vs. HashSet

- **Similarities**
  - Contain a collection of objects
  - Add objects (.add method)
  - Remove objects (.remove method)
  - Number of elements (.size method)
  - Iterator ability (.iterator method)
- **Differences**
  - HashSet objects are unique, while an ArrayList can have duplicate objects
  - HashSet objects are not ordered, while ArrayList objects are ordered

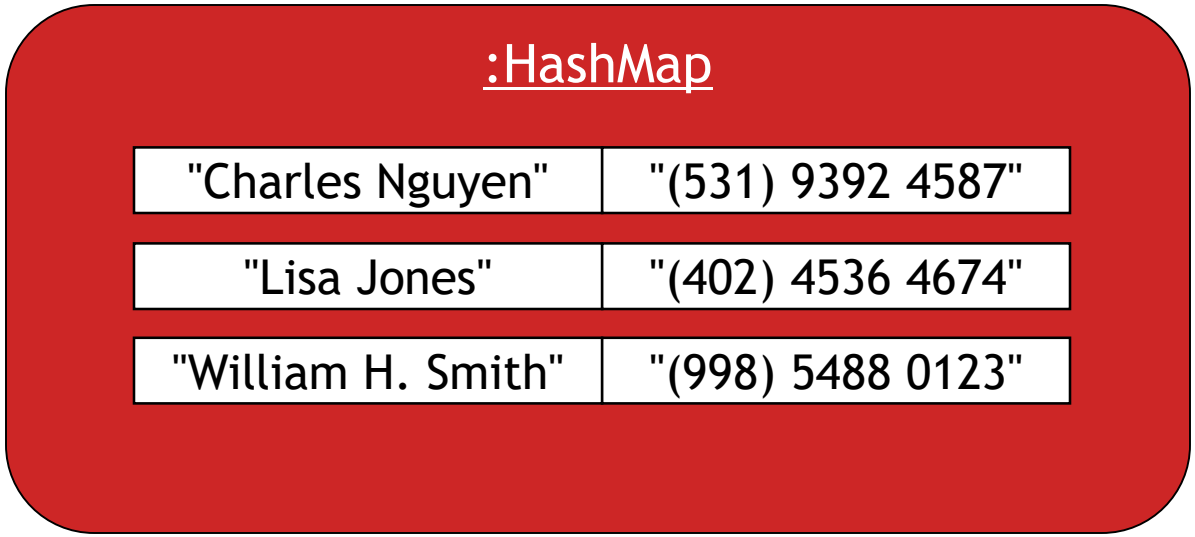


Maps

- Maps are flexible-sized collections that contain:
  - value pairs each with its own object type
  - each pair consists of a key and a value
- Uses the key to easily lookup the value
  - instead of using an integer index
- For example, a telephone book:
  - name and phone number pair
- Reverse-lookup of key using value
  - not so easy

Using maps

- A map with strings as keys and values



Using maps .*put* and .*get*

Declaration and creation of *contacts* HashMap:

```
HashMap<String, String> contacts =
                    new HashMap<String, String>();
```

HashMap .*put* method inserts an entry:

```
contacts.put("Charles Nguyen", "(531) 9392 4587");
contacts.put("Lisa Jones", "(402) 4536 4674");
contacts.put("William H. Smith", "(998) 5488 0123");
```

HashMap .*get* method retrieves the value :

```
String number = contacts.get("Lisa Jones");
System.out.println(number);
```

Does *HashMap* have an *iterator* method?

Using maps in *TechSupport*

```
private HashMap <String, String> responseMap;
        :
responseMap = new HashMap<String, String>();
        :
responseMap.put("slow",
   "I think this has to do with your hardware. \n" +
   "Upgrading your processor should solve all " +
   "performance problems. \n" + "Have you got a problem
   with our software?");
responseMap.put("bug",
   "Well, you know, all software has some bugs. \n" +
   "But our software engineers are working very " +
   "hard to fix them. \n" + "Can you describe the
   problem a bit further?");
responseMap.put("expensive",
   "The cost of our product is quite competitive. \n" +
   "Have you looked around and " + "really compared our
   features?");
```

TechSupport response map

Responses in an ArrayList of String:

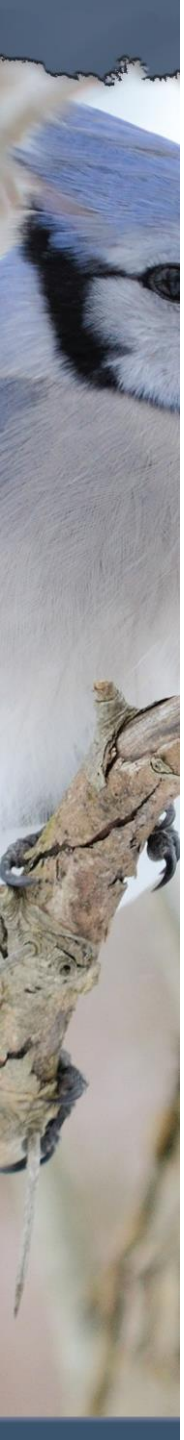
```
public String generateResponse()
{
    int index = randomGenerator.nextInt(responses.size());
    return responses.get(index);
}
```

Using a HashMap:

```
public String generateResponse(String word)
{
     String response = responseMap.get(word);

     if(response != null)  {
          return response;
     }
     else  {
          return pickDefaultResponse();
     }
}
```

Dividing Strings

```
public HashSet<String> getInput()
{
    System.out.print("> ");
    String inputLine =
        reader.nextLine().trim().toLowerCase();

    String[ ] wordArray = inputLine.split(" ");
    HashSet<String> words = new HashSet<String>();

    for(String word : wordArray) {
        words.add(word);
    }
    return words;
}
```



String .*split*

`String[ ] split(String regex)`

Splits this string around matches of the given regular expression

```
String[] wordArray = inputLine.split(" ");
```

Splits *inputLine* around the regular expression of “ ”

Regular Expressions

“ ” – space

“\t” - tab

“\\s” - any white space

“[\t]” – space or tab(grouping)

“[\t]+” – space or tab(one or more)

Using *regex*

String.split( )

```
String[] wordArray =
originalString.split("[  \t]+");
```

Splits original String around (one or more) spaces or tabs

```
String[] wordArray =
originalString.split("\\s+");
```

Splits original String around (one or more) of ANY white space

String.trim( ).replaceAll( )

```
String  newString =
oldString.trim( ).replaceAll("\\s+", " ");
```

Removes ALL occurrences of leading and trailing spaces with .trim
AND
Replaces ALL (one or more) white spaces with just a SINGLE space

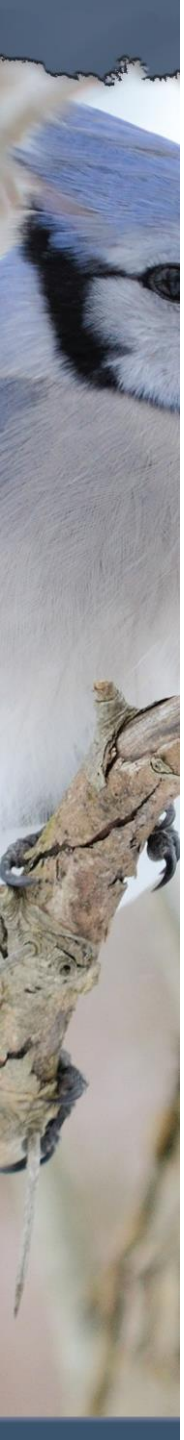
TechSupport input set

Input using an String:

```
String input = reader.getInput();
       :
String response = responder.generateResponse();
```

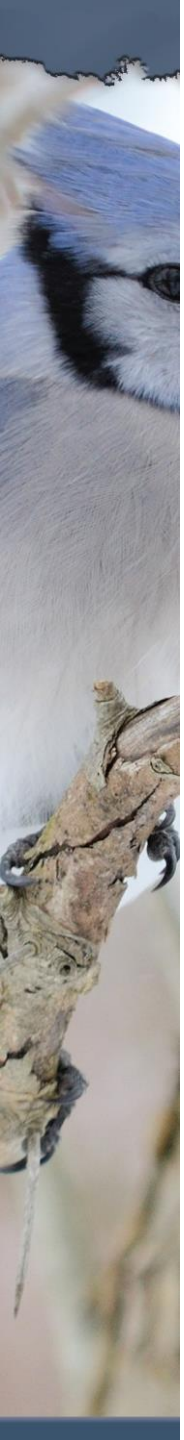
Split input words into a HashSet of String:

```
HashSet<String> input = reader.getInput();
       :
String response = responder.generateResponse(input);
       :
public String generateResponse(HashSet<String> words)
{
    for(String word : words)  {
        String response = responseMap.get(word);
        if(response != null)  {
            return response;
        }
    }
    return pickDefaultResponse();
}
```



`List`, `Map` and `Set`

- Alternative ways to group objects
- Varying implementations available:
  - **List: ArrayList, LinkedList**
  - **Set: HashSet, TreeSet**
- **`HashMap`** is unrelated to **`HashSet`**, & **`HashSet`** is closer to **`ArrayList`**
- Name consist of 2 parts “Array” “List”
  - 2nd word – collection type (List, Map, Set)
  - 1st word – how it is implemented



Collections and primitive types

- Generic collection classes can be used with all class/object types
- But what about *primitive types* such as **`int`**, **`boolean`**, etc…
- Suppose we want an **`ArrayList`** of **`int`**?

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:

Primitive 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

```
int i = 18;
Integer iwrap = i;
…
int value = iwrap;
```

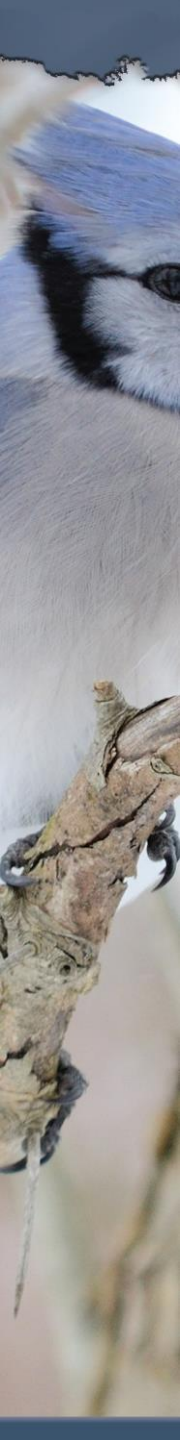
Autoboxing and unboxing

```
private ArrayList<Integer> markList;
...
public void storeMark(int mark)
{
    markList.add(mark);
}
```

autoboxing

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

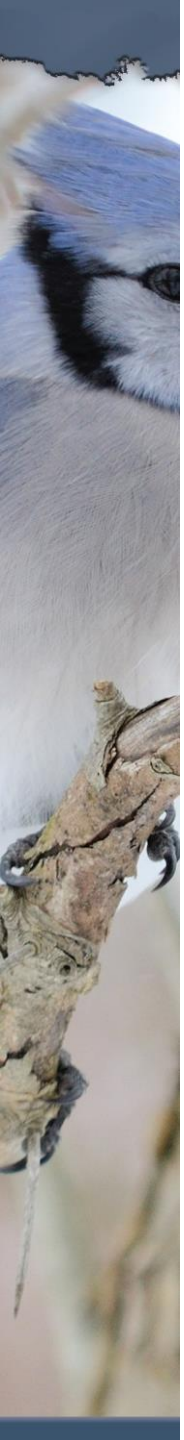
unboxing



Class variables and Constants

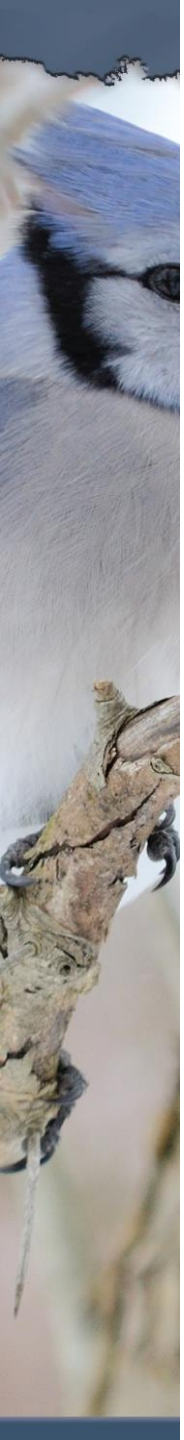
Class variables

- A class variable is shared between ALL instances/objects of the class
- It is a field stored in the class and exists independent of any instances
- Designated by the `static` keyword
- Public static variables are accessed via the class name (NOT object name)
  - `Thermometer.boilingPoint`



Constants

- A variable, once set, can have its value fixed
- Designated by the **`final`** keyword
  - **`final int SIZE = 10;`**
- Final *fields* must be set in their declaration or the constructor
- Combining **`static`** and **`final`** is common



Class constants

- **`static`** - class variable
- **`final`** - constant

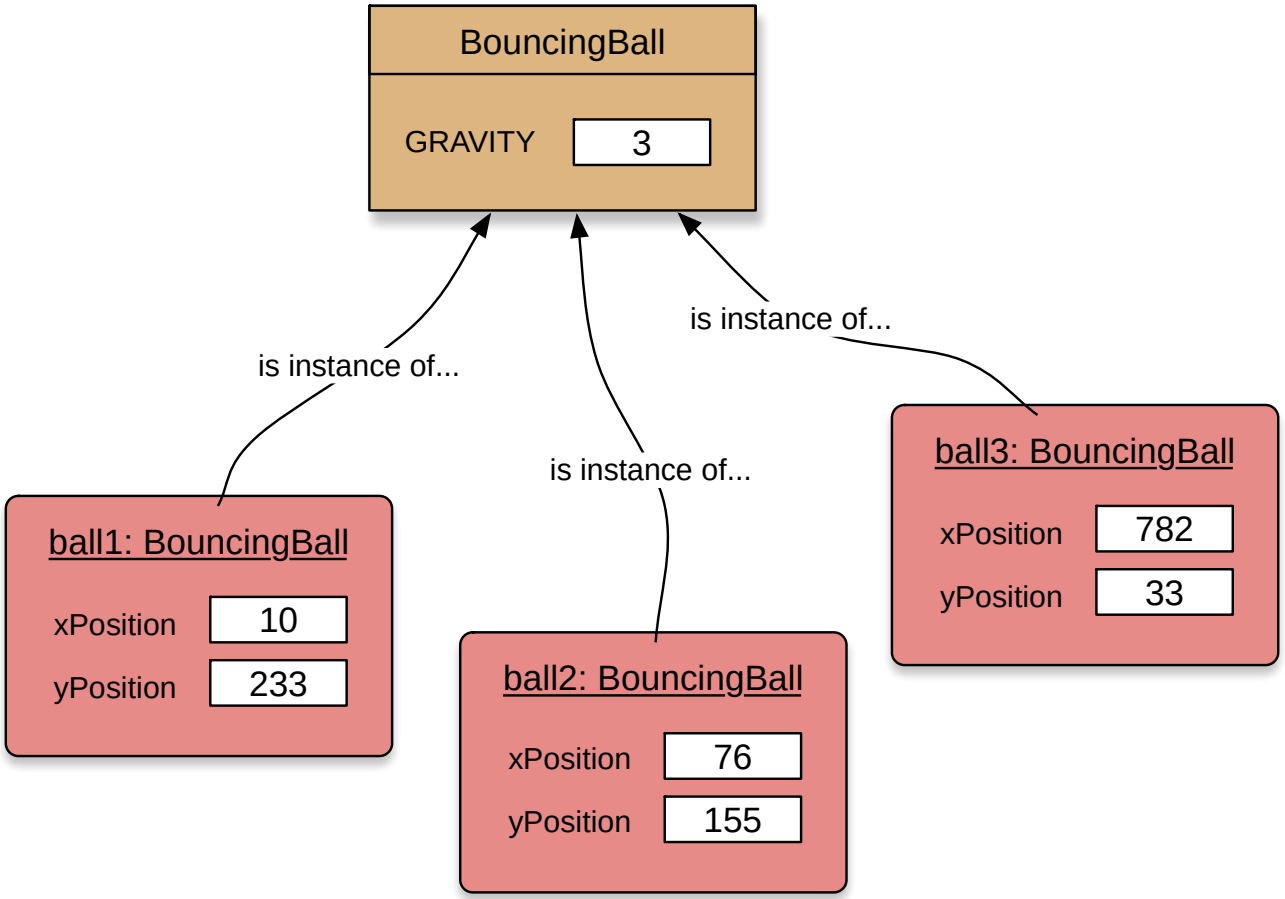
```
private static final int GRAVITY = 3;
```

- Public visibility is less of an issue with **`final`** fields
- Upper-case names often used for class constants:

```
public static final int BOILING_POINT = 100;
```

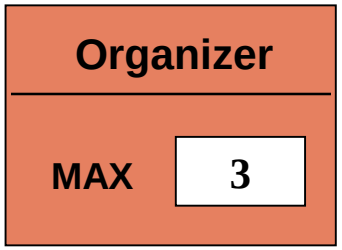
Class constants

```
private static final int GRAVITY = 3;

private int xPosition;
private int yPosition;
```

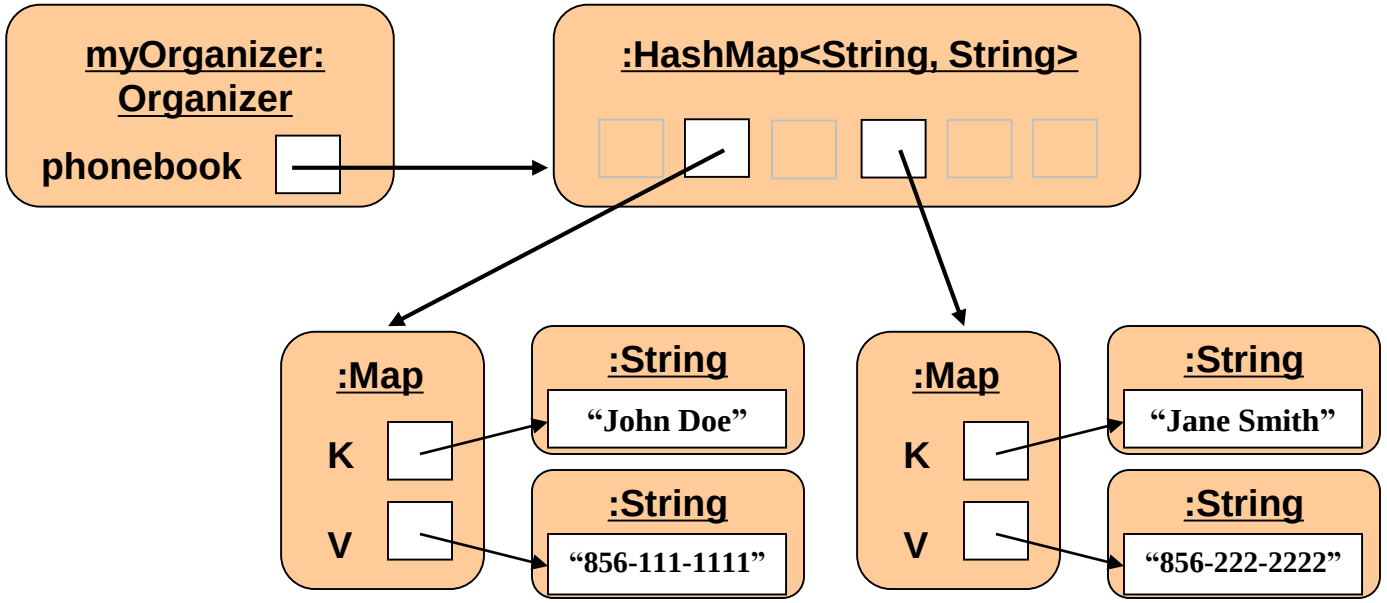


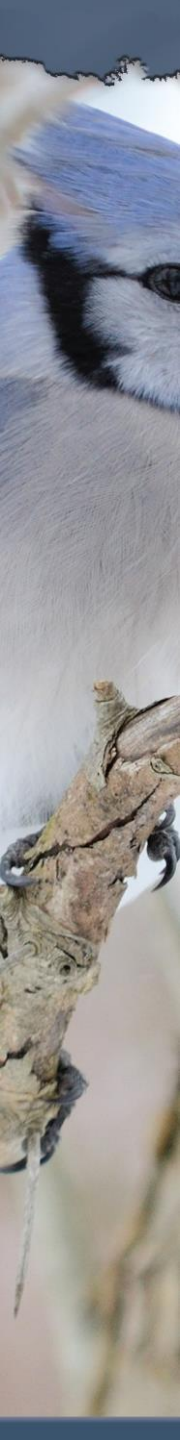
HashMap diagrams

```
private static final int MAX = 3;
```



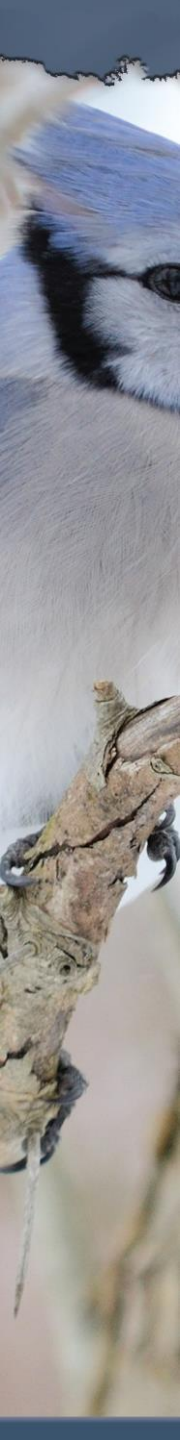

```
private HashMap<String, String> phonebook;
```





Class Methods

- So far, only used *instance methods*
  - invoked on an instance(object) of a class
- However, *class methods* are different
  - may be invoked WITHOUT a class object
- Similar to class variables in that the class methods BELONG to the class
  - having the class is enough to invoke it



Class methods

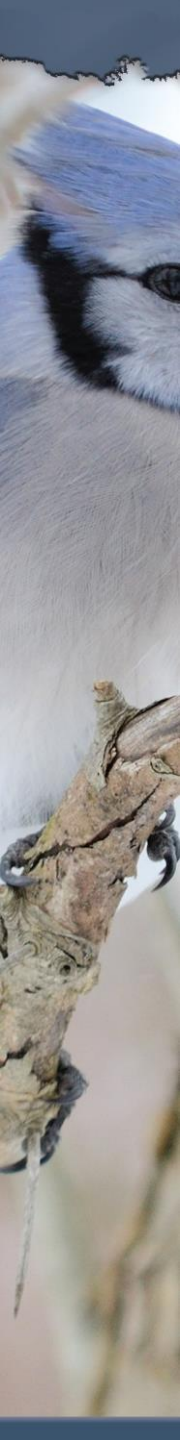
- A **`static`** method belongs to its class rather than the instances:

```
public static int getDaysThisMonth()
```

- Static methods are invoked via their class name:

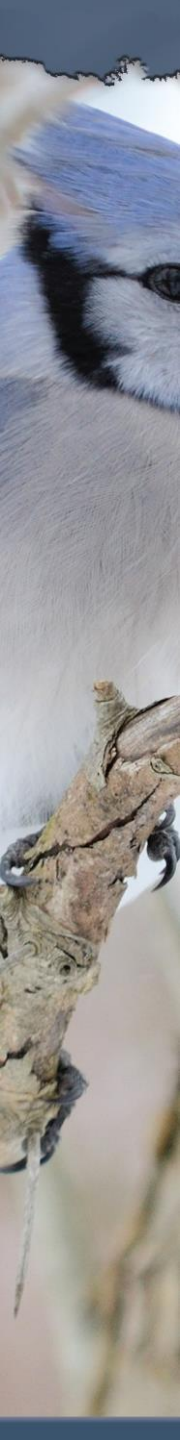
```
int days = Calendar.getDaysThisMonth();
```

There is NO object so the name of class is used before the dot!



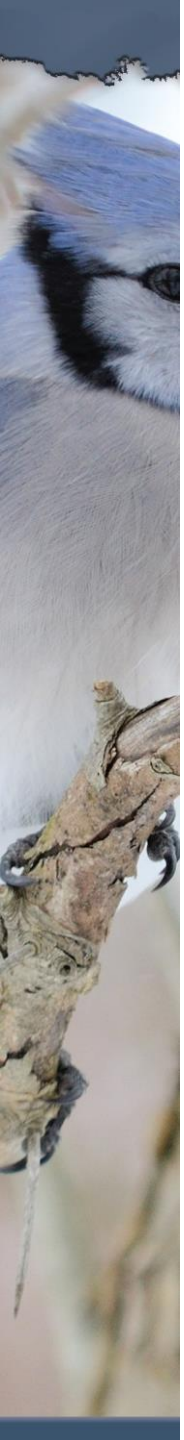
Limitations of class methods

- A static method exists independent of any instances.
- Therefore:
  - They cannot access instance fields within their class
  - They cannot call instance methods within their class



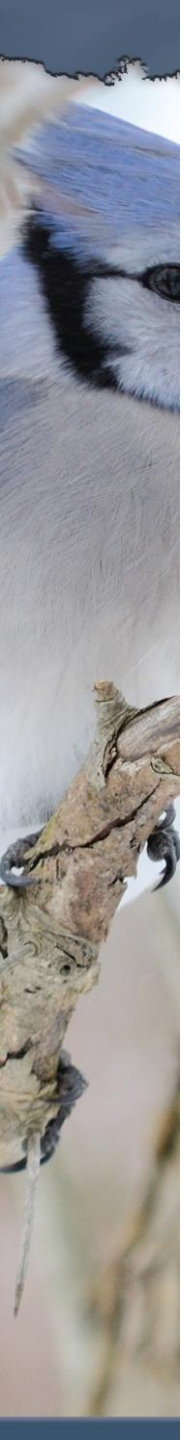
Review

- Class variables belong to their class rather than its instances
- Class methods belong to their class rather than its instances
- Class variables are used to share data among instances
- Class methods are prohibited from accessing instance variables and methods

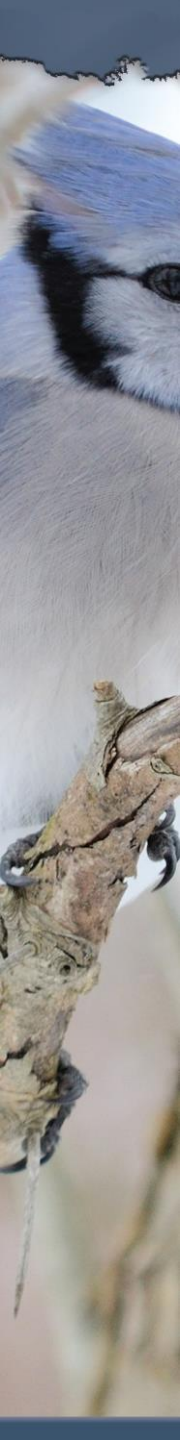


Review

- The values of **`final`** variables are fixed
- They must be assigned at declaration or in the constructor (for fields)
- **`final`** and **`static`** are unrelated concepts, but they are often used together

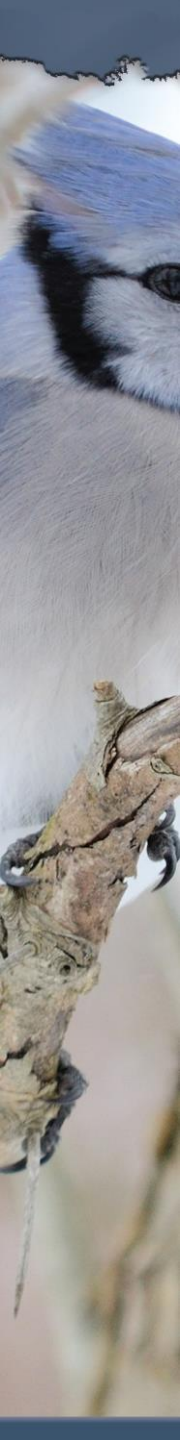


Further Advanced Material



Polymorphic collection types

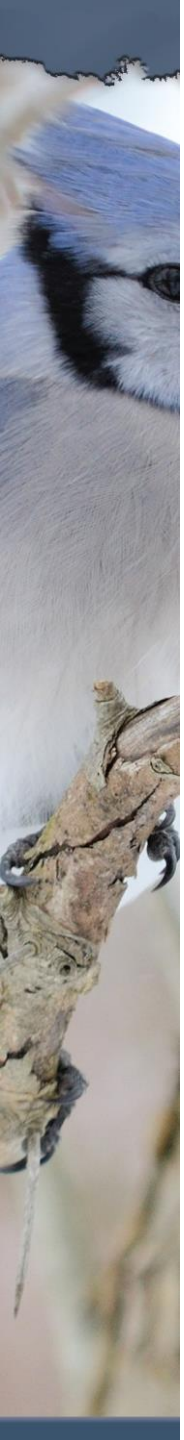
- Different collection classes offer similar interfaces:
  - **`ArrayList`** and **`LinkedList`**
  - **`HashSet`** and **`TreeSet`**
- Types exist which capture those similarities:
  - **`List`**
  - **`Set`**



Polymorphic collection types

- *Polymorphism* allows us to ignore the more specific type in most cases
- Create objects of the *specific* type
- BUT declare variables of the more *general* type:

```
List<Track> tracks = new LinkedList<>();

Map<String, String> responseMap =
                                new HashMap<>();
```

The Stream `collect` method

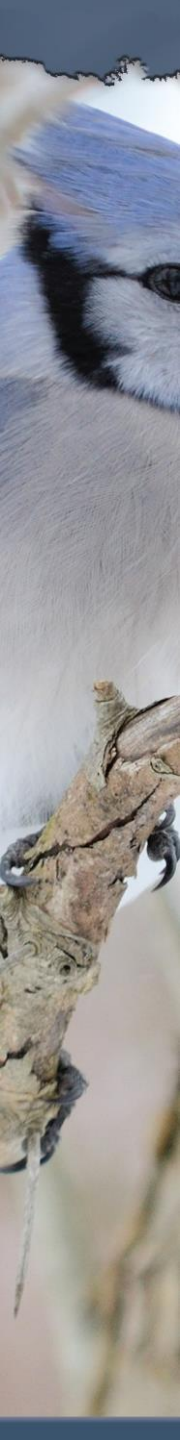
- Used to create a new collection object at the end of a pipeline
- The **`collect`** method takes a **`Collector`** parameter that accumulates elements of the stream
- We often use the polymorphic collection types for the result

Collecting a filtered stream

```
public List<Sighting> getSightingsOf(String animal)
{
    return sightings
            .stream()
            .filter(record -> animal.equals(
                                record.getAnimal()))
            .collect(Collectors.toList());
}
```

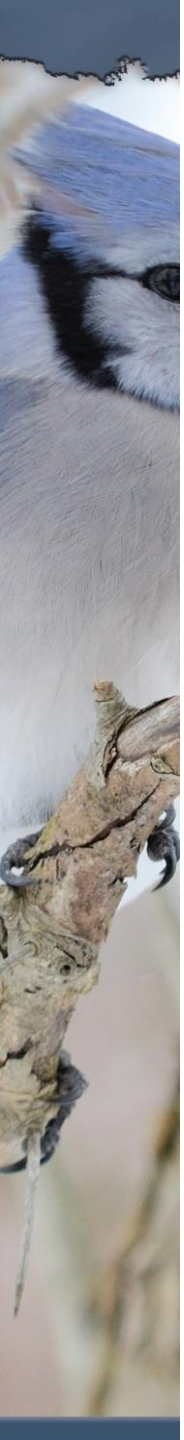
`java.util.stream.Collectors`

static `toList` method returns a generic `Collector` object



Writing class documentation

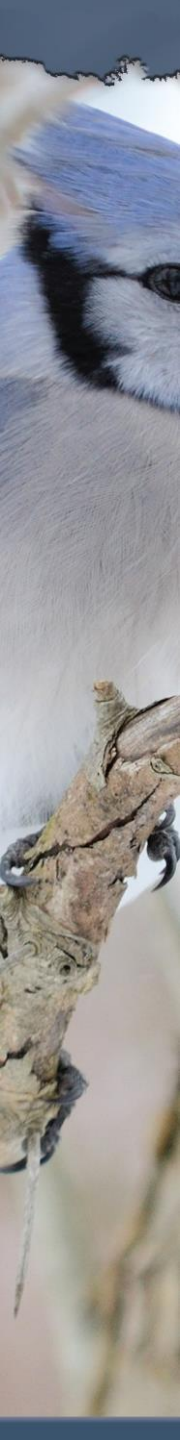
- User classes should be documented the same way library classes are
- Others should be able to use your class without reading the implementation
- Make your class a potential library class



Elements of documentation

Documentation for a class should include:

- the class name
- a comment describing the overall purpose and characteristics of the class
- a version number (@version)
- the authors' names (@author)
- documentation for each constructor and each method



Elements of documentation

The documentation for each constructor and method should include:

- the name of the method
- the return type (@return)
- the parameter names and types (@param)
- a description of the purpose and function of the method
- a description of each parameter
- a description of the value returned

javadoc

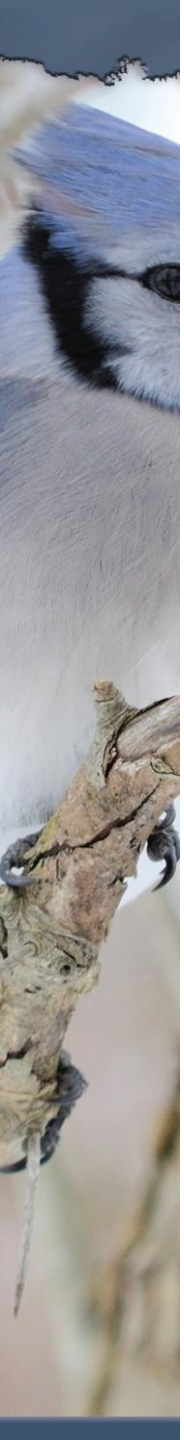
Class comment:

```
/**
 * The Responder class represents a response
 * generator object. It is used to generate an
 * automatic response.
 *
 * @author      Michael Kölling and David J. Barnes
 * @version     1.0  (2011.07.31)
 */
```

javadoc

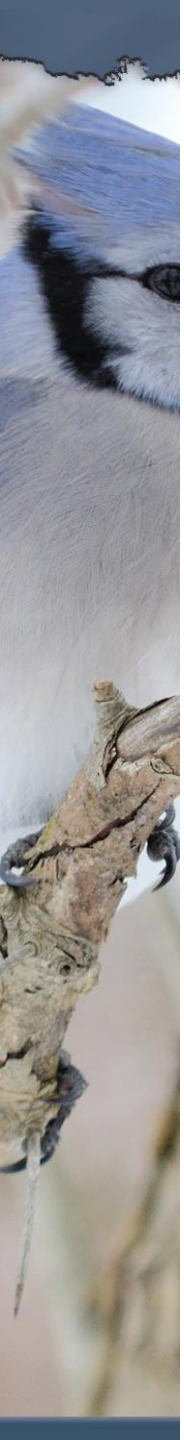
Method comment:

```
/**
 * Read a line of text from standard input (the text
 * terminal), and return it as a set of words.
 *
 * @param   prompt  A prompt to print to screen.
 * @return  A set of Strings, where each String is
 *          of the words typed by the user
 */
public HashSet<String> getInput(String prompt)
{
    ...
}
```



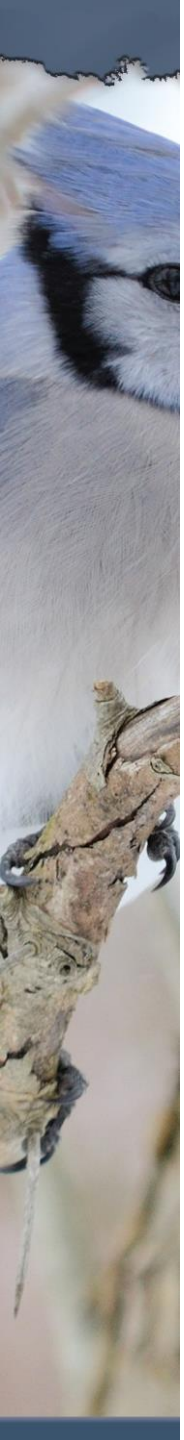
Public vs private

- Public elements are accessible to objects of other classes
  - Fields, constructors and methods
- Fields should NOT be public
  - Keeps the integrity of the field
- Private elements are accessible only to objects of the same class
- Only methods that are intended for other classes should be public



Information hiding

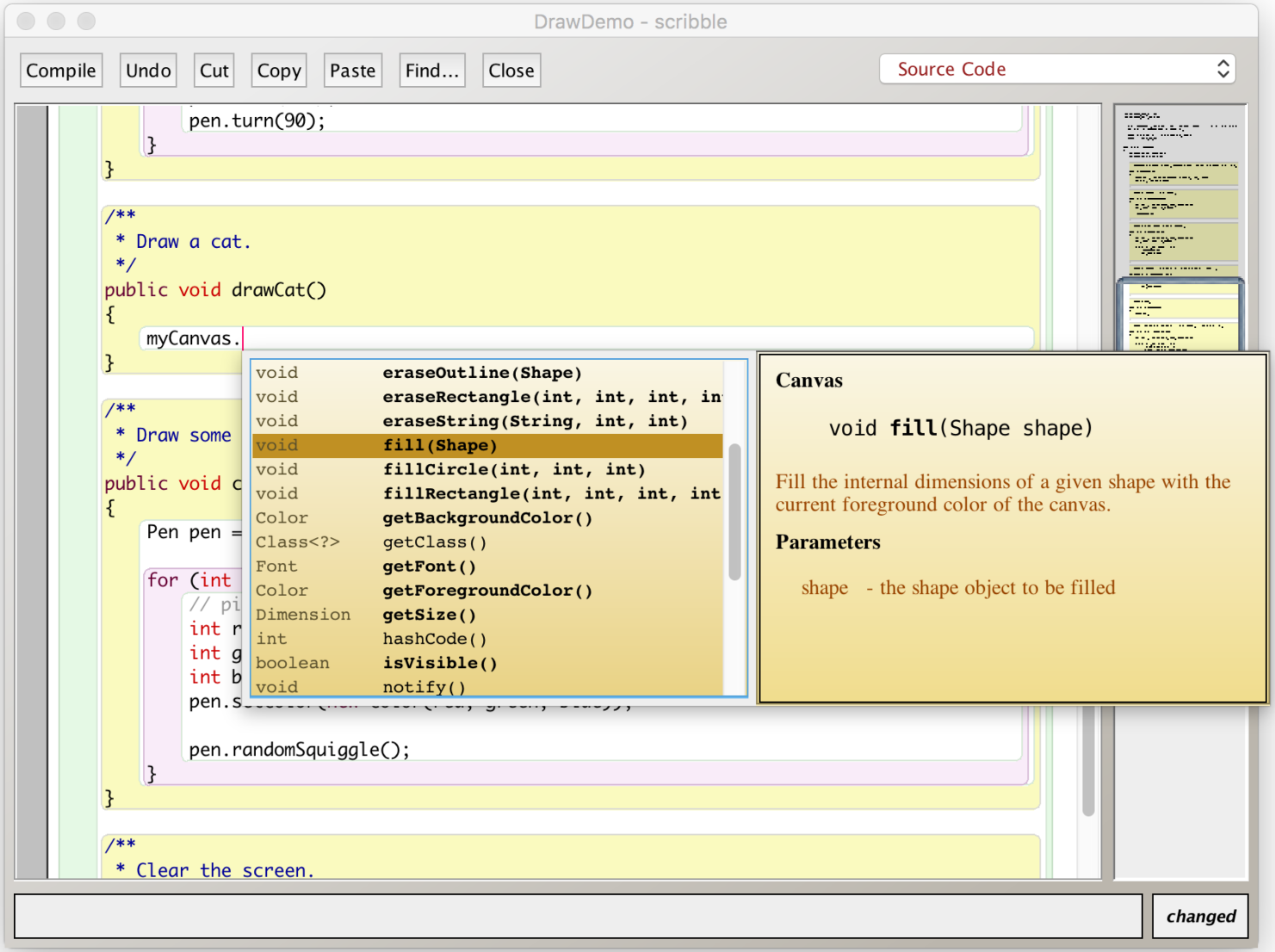
- Data belonging to one object is hidden from other objects (abstraction)
- Know what an object can do, but NOT necessarily how it does it
- Information hiding increases the level of *independence* (modularization)
- Independence of modules is important for large systems and maintenance (loose coupling)

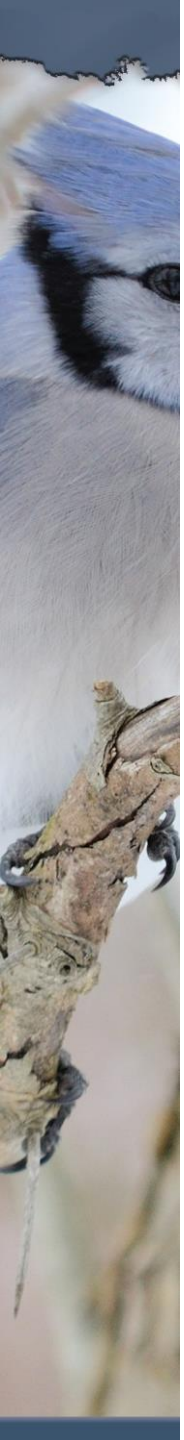


Code completion

- The BlueJ editor supports lookup of methods
- Use Ctrl-space after a method-call dot to bring up a list of available methods
- Use *Return* to select a highlighted method

Code completion in BlueJ





Review

- Java has an extensive class library
- A good programmer must be familiar with the library
- The documentation tells us what we need to know to use a class (interface)
- The implementation is hidden (information hiding)
- Classes are documented so that the interface can be read on its own (class comment, method comments)