More About Objects and Methods

Chapter 5

When an Object Is Required

- Methods called *outside* the object definition require an object to precede the method name
- For example:

```
Oracle myOracle = new Oracle();
//myOracle is not part of the definition code
//for Oracle
...
//dialog is a method defined in Oracle class
myOracle.dialog();
...
```

The "`this.`" Parameter

- `this` refers to the calling object of the method
- Methods called in an class definition file do not need to reference itself
- You may either use "`this.`", or omit it
- For example, if `answerOne()` is a method defined in the class `Oracle`:

```
public class Oracle
{
   … myMethod(…)
   {
   //invoke the answerOne method defined
   this.answerOne();
   answerOne();  //"this" is the default object
   ...
   }
}
```

`null`

- If the compiler requires you to initialize a class variable, you can set it to `null` if you have no other initial value.
- You can use == and != to see if a class variable is equal to `null`, because `null` is used like an address.

Gotcha: Null Pointer Exception

- If you invoke a method using a variable that is initialized to null, you will get an error message that says "Null Pointer Exception".

```
Species specialSpecies = null;
specialSpecies.readInput();
```

Null Pointer Exception

```
Species specialSpecies = new Species();
specialSpecies.readInput();
```

OK

Static Methods

- Some methods don't need an object to do their job
  - For example, methods to calculate logarithm: just pass the required parameters and return the logarithm
- Use the class name instead of an object name to invoke them
- Also called *class methods*
- Static methods are associated with a class—the method behavior is “static”
- Nonstatic methods are associated with an object—the method behavior depends on the object and hence “nonstatic”

Uses for Static Methods

- `main` method—the starting point of a program
- Static methods are commonly used to provide libraries of useful and related methods. Examples:
  - `SavitchIn` defines methods for keyboard input
    - not provided with Java
    - no need to create a `SavitchIn` object
    - methods include `readLineInt`, `readLineDouble`, etc.
    - see the appendix
  - the `Math` class
    - provided with Java
    - no need to create a `Math` object
    - methods include `pow`, `sqrt`, `max`, `min`, etc.
    - more details next

The **Math** Class (p335 4th Ed.)

- Includes constants `Math.PI` (approximately 3.14159) and `Math.E` (base of natural logarithms which is approximately 2.72)
- Includes three similar static methods: `round`, `floor`, and `ceil`
  - All three return whole numbers (although they are type `double`)
  - **`Math.round`** returns the whole number nearest its argument

`Math.round(3.3)` returns `3.0` and `Math.round(3.7)` returns `4.0`

  - **`Math.floor`** returns the nearest whole number that is equal to or less than its argument

`Math.floor(3.3)` returns `3.0` and `Math.floor(3.7)` returns `3.0`

  - **`Math.ceil`** (short for ceiling) returns the nearest whole number that is equal to or greater than its argument

`Math.ceil(3.3)` returns `4.0` and `Math.ceil(3.7)` returns `4.0`

Static Methods

- Declare static methods with the *`static`* modifier, for example:

```
public static double log(double value)
  ...
```

Static/nonstatic methods

```
public class Person
{
   public static void main(String[] args)  // no associated object
   {

   }

   public void setName(String name) // depends on an object
   {

   }
}
```

Static Attributes

- Static attributes are *associated with a class*
  - A constant:
    - `public static final double PI`
  - An attribute shared by all objects in the class
    - `private static int objectCounter`
    - Keep track of how many objects are created
    - Should not be used as “global variables” within the class --- any object can inappropriately modify it
- Non-static attributes are *associated with an object*
  - For describing different objects (instance variables)
    - `private String name`
  - Values are therefore different depending on the object
  - Constants should not be nonstatic, why?

Static Attributes (Variables)

- The `StaticDemo` program in the text uses a static attribute:
  `private static int numberOfInvocations = 0;`
- Similar to definition of a named constant, which is a special case of static variables.
- May be public or private but are usually private for the same reasons instance variables are.
- Only one copy of a static variable and it can be accessed by any object of the class.
- May be initialized (as in example above) or not.
- Can be used to let objects of the same class coordinate.
- Not used in the rest of the text.

Static/nonstatic methods/attributes

```
public class Person
{
   private String _name;      // different for each object
   private static final bool HAS_NOSE = true; // shared constant

   public static void main(String[] args)  // no associated object
   {
   }

   public void setName(String name) // depends on an object
   {
   }
}
```

Static Methods and Attributes

- A static method doesn't have a calling object
  - cannot refer to a (nonstatic) attribute of the class. Why?
  - cannot call a nonstatic method of the class directly
    - unless it creates an object of the class to use as a calling object.

Static/nonstatic methods/variables

```
public class Person
{
   private String _name;      // different for each object
   private static final bool HAS_NOSE = true; // shared constant

   public static void main(String[] args)  // no associated object
   {
       _name = "John Jay";        // ???
       setName("John Jay");       // ???
       Person jj = new Person();
       jj.setName("John Jay");
   }
   public void setName(String name) // depends on an object
   {
       this._name = name;     // this. is optional
   }
}
```

Static/nonstatic methods/variables

```
class Person

HAS_NOSE: true

main()


  object jj              object mm              object cc

 _name: "John Jay"      _name: "Mary Mott"     _name: "Chris Card"

 setName()              setName()              setName()
```

Wrapper Classes

- Used to wrap primitive types in a class structure
- All primitive types have an equivalent class
- The class includes useful constants and static methods, including one to convert back to the primitive type

Primitive type	Class type	Method to convert back
`int`	`Integer`	`intValue()`
`long`	`Long`	`longValue()`
`float`	`Float`	`floatValue()`
`double`	`Double`	`doubleValue()`
`char`	`Character`	`charValue()`

Wrapper class example: `Integer`

- Declare an `Integer` class variable:
  `Integer n = new Integer();`
- Convert the value of an `Integer` variable to its primitive type, `int`:
  `int i = n.intValue();//intValue returns an int`
- Some useful `Integer` constants:
  - `Integer.MAX_VALUE` - the maximum integer value the computer can represent
  - `Integer.MIN_VALUE` - the smallest integer value the computer can represent

Wrapper class example: `Integer`

- Some useful `Integer` methods:
  - `Integer.parseInt("123")` to convert a string of numerals to an integer
  - `Integer.toString(123)` to convert an `Integer` to a `String`
- The other wrapper classes have similar constants and methods
- See the text for useful methods for the class `Character` `(p. 341 4th Ed.)`

Usage of wrapper classes

There are some important differences in the code to use wrapper classes and that for the primitive types

Wrapper Class	Primitive Type
variables contain the *address* of the value	variables contain the value
variable declaration example: `Integer n;`	variable declaration example: `int n;`
variable declaration & init: `Integer n = new Integer(0);`	variable declaration & init.: `int n = 0;`
assignment: `n = new Integer(5);`	assignment: `n = 5;`

Designing Methods: Top-Down Design

- In pseudocode, write a list of subtasks that the method must do.
- If you can easily write Java statements for a subtask
  - you are finished with that subtask.
- If you cannot easily write Java statements for a subtask
  - treat it as a new problem and break it up into a list of subtasks.
- Eventually, all of the subtasks will be small enough to easily design and code.
- Solutions to subtasks might be implemented as private helper methods.
- Top-down design is also known as *divide-and-conquer* or *stepwise refinement*.

Programming Tips for Writing Methods

- Apply the principle of encapsulation and detail hiding by using the `public` and `private` modifiers judiciously
  - If the user will need the method
    - declare it `public`
  - If the method is used only within the class definition -- a *helper* method
    - declare it `private`

Testing a Method

- Test programs are sometimes called *driver* programs
- Keep it simple: test only one new method at a time
- If method A uses method B, there are two approaches:
- *Top down*
  - test method A and use a *stub* ("dummy method") for method B
  - A *stub* is a method that stands in for the final version and does little actual work.
    - does something as trivial as printing a message or returning a fixed value (so simple that it can't have bugs).
- *Bottom up*
  - test method B fully before testing A

Java Tip: You Can Put a **main** in Any Class

- Usually **`main`** is by itself in a class definition.
  - **`main`** method NOT in a class that is used to create objects
- Adding a diagnostic **`main`** method to a class
  - easier to test the class's methods.
- When the class is used to create objects
  - the **`main`** method is ignored.
- **`main`** ***must be*** static
  - can't invoke nonstatic methods of the class in **`main`** unless you create an object of the class.

`main()` in Multiple Classes

```
class PersonDriver
{
  public static void main()
  {
    Person jj = new Person();
    doStuff();
  }


  public static void doStuff()
  {
     // …
  }

}
```

```
class Person
{
  private String _name;

  public static void main()
  {
    // for testing Person
    // starting point if Person is run

    // *ignored* if PersonDriver is run

    Person jj = new Person();
  }

  public String getName()
  //…

}
```

Methods with the Same Name

- A method depositing some money to an account
- Allow depositing amounts of different types (e.g. 1.45, "1.45")
- We could:
  - depositDouble(double amount)
  - depositString(String amount)
  - depositDollarsCents(int dollars, int cents)
- Nicer:
  - deposit(double amount)
  - deposit(String amount)
  - deposit(int dollars, int cents)
- "Overloading" a method

Overloading

- The same method name has more than one definition *within the same class*
- Each definition must have a different "signature" (though the same method name)
  - different parameter types
  - different number of parameters
  - different ordering of parameter types
  - return type is **not** part of the signature
    - **cannot** be used to distinguish between two methods with the same name and parameter types
    - If the parameter types are different, return type can be different

Signature

- combination of method name and number/types/order of parameters
- `equals(Species)` has a different signature than `equals(String)`
  - same method name, different parameter types
- *`myMethod(1)`* has a different signature than *`myMethod(1, 2)`*
  - same method name, different number of parameters
- *`myMethod(10, 1.2)`* has a different signature than *`myMethod(1.2, 10)`*
  - same method name and number of parameters, but different order of parameter types

Overloading and Argument Type

- Accidentally using the wrong datatype as an argument can invoke a different method
- For example, see the `Pet` class in the text
  - `set(int age)` sets the pet's age
  - `set(double weight)` sets the pet's weight
  - You want to set the pet's weight to 6 pounds:
    - `set(6.0)` works as you want because the argument is type `double`
    - `set(6)` will set the *age* to 6, not the weight, since the argument is type `int`

Overloading and Method Matching

- `set(String name, int age, double weight)`

- `obj.set("Lassie", 3, 40.1);`
- `obj.set("Lassie", 3.1, 40.1);`
- `obj.set("lassie", 3, 40);`
- `obj.set("Lassie", 3.1, 40);`
- `obj.set("Lassie", 40, 3);`

Gotcha: Overloading and Automatic Type Conversion

- If Java does not find a signature match, it attempts some automatic type conversions, e.g. `int` to `double`
- An unwanted version of the method may execute
- In the text Pet example of overloading:
  What you want: name "Cha Cha", age 3, and weight 10
  - `set(String name, int age, double weight)`
  - But you make two mistakes:
    1. you reverse the age and weight numbers, and
    2. you fail to make the weight a type double.
  - `set("Cha Cha", 10, 3)` does not do what you want
    - it sets the pet's age = 10 and the weight = 3.0
  - Why?
    - `set` has no definition with the argument types `String`, `int`, `int`
    - However, it does have a definition with `String`, `int`, `double`, so it promotes the last number, 3, to 3.0 and executes the method with that signature

Gotcha: You Cannot Overload Based on the Returned Type

- Compiler will not allow two methods with same name, same types and number of parameters, but different return types in the same class:

```
public double getWeight()

public char getWeight()
```

Can't have both in the same class

- In a situation like this you would have to change the name of one method or change the number or types of parameters.

Constructors

- A *constructor* is a special method
  - Initialize attributes
- Automatically called when an object is created using `new`
- Has the same name as the class
- Often overloaded (more than one constructor for the same class definition)
  - different versions to initialize all, some, or none of the instance variables
  - each constructor has a different signature (a different number or sequence of argument types)

Defining Constructors

- Constructor headings do not include a return type
- *default constructor*
  - constructor with no parameters.
- If no constructor is provided
  - Java automatically creates a default constructor.
- If *any* constructor is provided
  - *no* constructors are created automatically.

Programming Tip

- Include a constructor that initializes *all* attributes.
- Include a constructor that has no parameters
  - *default constructor*

Constructor Example from `PetRecord`

```
public class PetRecord
{
   private String name;
   private int age; //in years
   private double weight; //in pounds
. . .
   public PetRecord(String initialName)
   {
      name = initialName;
      age = 0;
      weight = 0;
   }
```

Initializes three instance variables: `name` from the parameter and `age` and `weight` with default initial values.

Sample use:
`PetRecord pet1 = new PetRecord("Eric");`

Using Constructors

- Using the `Pet` class in text:
  `Pet myCat = new Pet("Calvin", 5, 10.5);`
  - this calls the `Pet` constructor with `String`, `int`, `double` parameters
- Changing values of attributes after you have created an object
  - `set` methods should be provided for this purpose

Programming Tip: You Can Use Other Methods in a Constructor

```
public PetRecord(String initialName,
          int initialAge, double initialWeight)
{
   name = initialName;
   if ((initialAge < 0) || (initialWeight < 0))
   {
      System.out.println("Error…");
   }
   else
   {
      age = initialAge;
      weight = initialWeight;
   }
}
```

- less method invocation overhead

- shorter
- possibly more consistent with other constructors and methods

```
public PetRecord(String initialName,
   int initialAge, double initialWeight)
{
   set(initialName, initialAge, initialWeight);
}
```

Types of Constructors

1. Default Constructor
   - Default values for attributes
   - Overriding the one provided by Java
   - Defining: `public Person()`
   - Using: `new Person();`
2. Regular Constructor
   - Initial values for attributes are passed in as parameters
   - Defining: `public Person(String name, int age, …)`
   - Using: `new Person("John", 12, …);`
3. Copy Constructor
   - Make a copy of the object passed in as the parameter
   - Copy the attribute values from the object in the parameter
   - Defining: `public Person(Person original)`
   - Using: `new Person(mark);`

`public static` Attributes

- `static`: associated with a class
- `public`: access from any class
- `public static` *`type name`*`;`
  - "Global variables"
  - **Bad**: points will be deducted unless they are well justified
  - Laziness is not a good reason, use parameters and return values for communication among methods
- `public static final` *`type name`*`;`
  - "Global constants"
  - Good: if the "constants" could be used by any class
  - `Math.PI`

`private static` Attributes

- `static:` associated with the class
- `private:` access only by the class
- `private static` *`type name`*`;`
  - "Semi-global variables"
  - Access by any object in the class
  - **Not ok**: points will be deducted; needs to be well justified
  - Laziness is not a good reason
- `private static final` *`type name`*`;`
  - "Semi-global constants"
  - Good: constants used by any object in the class

`static` Attributes (class level)

	`static`	`static final`
`public`	Global variables: **bad** (need very good justifications)	Global constants
`private`	Semi-global variables within a class: **not OK** (need good justifications)	Semi-global constants within a class

Non-static Attributes (object level)

	(non-static)	`final`
`public`	**Bad**	**Not ok** (lack information hiding)
`private`	Good: encapsulation and information hiding	Good if you intend each object has a different constant that does not change in its lifespan (the value must be set in the constructor)

`private final` (non-static) Attributes

```
public class Person
{
  private final String _name;
  private       int    _age;

  public Person(String name, int age)
  {
     _name = name; // assignment must be in constructor
                   // not in a method
     _age = age;
  }
}
```

Gotcha: Privacy Leaks

- Using attributes of a class type takes special care
- Unlike primitive types, object identifiers contain the object's address, not its value
  - returning an object gives back the address, so the called method has direct access to the object
  - the object is "unprotected" (usually undesirable)
- One solution: stick to returning primitive types (`int`, `char`, `double`, `boolean`, `etc.`) or `String`
- Another solution: use `private final` for values that should not be changed
- Use copy constructor, and return a copy of the object
- *cloning*, see Appendix 8 (outside this course)

What is actually private in `class Presidency`?

```
public class Presidency
{
  private Person _president, _vp;

  public Presidency(String p, String vp)
  { _president = new Person(p);
    _vp = new Person(vp); }

  public Person getPresident()
  { return _president; }
```

```
public class Person
{
  private String _name;

  public Person(String name)
  { _name = name; }

  public void setName(String name)
  { _name = name; }
```

```
public class Demo
{
  public static void main(String[] args)
  {
     Presidency  pres42 = new Presidency("Bush", "Cheney");
     Person w = pres42.getPresident();
     pres42.print();
     w.setName("Kerry");
     pres42.print();
  }
}
```

Objects at Different Levels

```
pres42 (class Presidency)

  private _president: @address123
  private _vp: @address456

@address123 (class Person)     @address456 (class Person)

  _name: "Bush"                  _name: "Cheney"
```

Packages

- A way of grouping and naming a collection of related classes
  - they serve as a *library* of classes
  - they do not have to be in the same directory as your program
- The first line of each class in the package must be the keyword `package` followed by the name of the package:
  `package general.utilities;`
- To use classes from a package in a program put an `import` statement at the start of the file:
  `import general.utilities.*;`
  - note the "`.*`" notation

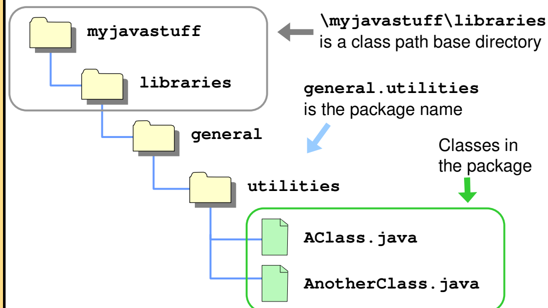
Package Naming Conventions

- Use lowercase
- The name is the pathname with subdirectory separators ("\" or "/", depending on your system) replaced by dots
- For example, if the package is in a directory named "utilities" in directory "general", the package name is:
  `general.utilities`

Package Naming Conventions

- Pathnames are usually relative and use the `CLASSPATH` environment variable
- For example, if:
  `CLASSPATH=c:javastuff\libraries`, and your directory `utilities` is in `c:javastuff\libraries`, then you would use the name:
  `utilities`
  - the system would look in directory `c:javastuff\libraries` and find the `utilities` package

A Package Name



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Summary
Part 1

- A method definition can use a call to another method of the same class
- *static* methods can be invoked using the class name (or an object name)
- Top-down design method simplifies program development by breaking a task into smaller pieces
- Test every method in a program in which it is the only untested method

Summary
Part 2

- Each primitive type has a corresponding wrapper class
- *Overloading:* a method has more than one definition in the same class (but the number of arguments or the sequence of their data types is different)
  - one form of polymorphism
- *Constructor:* a method called when an object is created (using `new`)
  - *default constructor:* a constructor with no parameters