CS 112 Introduction to Programming

Summary of Methods; User Input using Scanner

Yang (Richard) Yang
Computer Science Department
Yale University
308A Watson, Phone: 432-6400
Email: yry@cs.yale.edu

Admin

- PS4
  - Part 1: speed and angle interpretation

- Walkthroughs
  - Monday and Tuesday evenings

- Debugging session:
  - Please contribute buggy code to us 😊

- Midterm 1 date: Mar. 3
Recap: StdDraw.show(T)

### Display
- Draw A
- Draw B
- Draw C

### Buffer
- Draw A
- Draw B
- Draw C

Recap: General Method Definition

```java
public static type name(parameters) {
  statements;
  ...
  return expression;
}
```
Summary: Method Definition

- **Why define methods?**
  - Denote structure, eliminate redundancy
  - A method with parameters solves an entire class of similar problems

- **Can you define in the same class multiple methods with the same name?**
  - Yes. This is called **method overloading**, as long as the overloaded methods must have different **signatures**, where the signature of a method is the sequential list of the type of each parameter.

Summary: Method Invocation (I)

- **How does the compiler pick the method to use for overloaded methods?**
  - The compiler picks the method according to signature match.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>double tryMe (int x) {</td>
<td>double tryMe (double x, double y)</td>
<td></td>
</tr>
<tr>
<td>return x + .375;</td>
<td>{</td>
<td></td>
</tr>
<tr>
<td>}</td>
<td>return x * y;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>}</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Invocation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>result = tryMe (25, 4.32)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Summary: Method Invocation (II)

- Corresponding actual argument in the invocation is assigned to the corresponding formal argument

```java
int line = 3;
printNumber(line-1, 5);
```

```java
public static void printNumber(int number, int count)
{
    // equiv: number = 2; count = 5;
    for (int i = 1; i <= count; i++) {
        System.out.print(number);
    }
    System.out.println();
}
```

Formal Arguments are Local Variables

- In Java, a formal argument is a local variable of a method
- The formal argument and the actual argument are different variables, with different memory locations, even if they have the same name.
- When a primitive variable is passed as the actual argument to a formal argument, the value is copied
  - Value copying implies value semantic
  - Implication: modifying the parameter inside the method will not affect the variable passed in.
Value Semantics

int a = 100;
double x = 45.12;

A value variable stores a value of the type of the variable.

Value Variables

int a = 100;
double x = 45.12;
int aa;
Value-Variable Assignment

```c
int a = 100;
double x = 45.12;
int aa;
aa = a;
```

An assignment of one value variable to another value variable copies the value.

Value-Variable Assignment

```c
int a = 100;
double x = 45.12;
int aa;
aa = a;
a = 200;
```

Change the value of one value variable will not change the other.
Exercise: What is the output?

```java
public static void main(String[] args) {
    int x = 23;
    strange(x);
    System.out.println("2. x = " + x);
}

global vars:
args:
  0: int[]
x:
  0: 23

Example: main() start

```
Example: Invocation

```java
public static void main(String[] args) {
    int x = 23;
    strange(x);
    System.out.println("2. x = " + x);
}

public static void strange(int x) {
    x = x + 1;
    System.out.println("1. x = " + x);
}
```

Example: Local update

```java
public static void main(String[] args) {
    int x = 23;
    strange(x);
    System.out.println("2. x = " + x);
}

public static void strange(int x) {
    x = x + 1;
    System.out.println("1. x = " + x);
}
```
Example: Method return

```java
public static void main(String[] args) {
    int x = 23;
    strange(x);
    System.out.println("2. x = " + x);
}
```

```java
public static void strange(int x) {
    x = x + 1;
    System.out.println("1. x = " + x);
}
```

Example: Method return

```java
public static void main(String[] args) {
    int x = 23;
    strange(x);
    System.out.println("2. x = " + x);
}
```
A "Parameter Mystery" problem

```java
public class ParameterMystery {
    public static void main(String[] args) {
        int x = 9;
        int y = 2;
        int z = 5;

        mystery(z, y, x);
        mystery(y, x, z+y);
    }

    public static void mystery(int x, int z, int y) {
        System.out.println(z + " and " + (y - x));
    }
}
```

What is the output?

Summary: Return

- The **return type** of a method indicates the type of value that the method sends back to the calling location
  - a method that does not return a value has a **void** return type
- The **return statement** specifies the value that will be returned
  - its expression must conform to the return type
Foundational Programming Concepts

any program you might want to write

- objects
- methods and classes
- graphics, sound, and image I/O
- arrays
- conditionals and loops
- Math
- text I/O
- primitive data types
- assignment statements

Outline

- Admin and recap
- Text input using methods from the Scanner class
Interactive Programs

- Interactive programs can be easier to use and have more interesting behavior.
- Interactive programs can be tricky: users are unpredictable and may misbehave.
- Java text input is based on the Scanner class.

Some Scanner Methods

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>nextInt()</td>
<td>Returns an int from source</td>
</tr>
<tr>
<td>nextDouble()</td>
<td>Returns a double from source</td>
</tr>
<tr>
<td>next()</td>
<td>Returns a one-word String from source</td>
</tr>
<tr>
<td>nextLine()</td>
<td>Returns a one-line String from source</td>
</tr>
</tbody>
</table>
Problem of using `Scanner`

- It is common that the same program reads input simultaneously from multiple sources:
  - `System.in` (the opposite of `System.out`)
  - Files, strings, web sites, databases, ...

Design Option I

<table>
<thead>
<tr>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>Scanner.nextInt(&lt;src&gt;)</code></td>
</tr>
<tr>
<td><code>Scanner.nextDouble(&lt;src&gt;)</code></td>
</tr>
<tr>
<td><code>Scanner.next(&lt;src&gt;)</code></td>
</tr>
<tr>
<td><code>Scanner.nextLine(&lt;src&gt;)</code></td>
</tr>
</tbody>
</table>
Design Option II: Objects (briefly)

- **object**: An entity that contains both data and behavior.
  - **data**
    - variables inside the object
  - **behavior**
    - methods offered by the object
  - You interact with the methods; most data are hidden in the object.

Constructing Objects

- An object is created from a **class**

- Constructing (creating) an object by calling the constructor method:
  ```java
  Type objectName = new Type(parameters);
  ```

- Calling an object's method:
  ```java
  objectName.methodName(parameters);
  ```
Packages

- The classes in Java are organized into packages: think of packages as folders, which help you to get organized.
- Some of the packages in Java are:

<table>
<thead>
<tr>
<th>Package</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>java.lang</td>
<td>General support, e.g., Math, String, System</td>
</tr>
<tr>
<td>java.applet</td>
<td>Creating applets for the web</td>
</tr>
<tr>
<td>java.awt</td>
<td>Graphics and graphical user interfaces</td>
</tr>
<tr>
<td>javax.swing</td>
<td>Additional graphics capabilities and components</td>
</tr>
<tr>
<td>java.net</td>
<td>Network communication</td>
</tr>
<tr>
<td>java.util</td>
<td>Utilities</td>
</tr>
<tr>
<td>java.text</td>
<td>Text processing</td>
</tr>
</tbody>
</table>

- Scanner belongs to the java.util package

http://docs.oracle.com/javase/7/docs/api/java/util/Scanner.html

The import Declaration

- When you want to use a class from a non-default / java.lang package, you could use its fully qualified class name, e.g.,
  
  ```java
  java.util.Scanner console;
  ```

  Or you can import the class, then just use the class name
  
  ```java
  // put this at the very top of your program
  import java.util.Scanner;
  ...
  Scanner console;
  ```

- To import all classes in a particular package, you can use the * wildcard character
  
  ```java
  // put this at the very top of your program
  import java.util.*;
  ```
Using **Scanner**

```java
import java.util.Scanner;
...

Scanner console = new Scanner(System.in);

// Typically print a prompt
System.out.print("How old are you? ");

int age = console.nextInt();

System.out.println("You typed " + age);
```

---

**Scanner for System.in**

- Using System.in is to interact using the Terminal:

![Terminal on Mac OS X](image1.png)  
![Terminal on Microsoft Windows](image2.png)
Scanner Example

```java
import java.util.*; // so that I can use Scanner
public class UserScannerInput {
    public static void main(String[] args) {
        Scanner console = new Scanner(System.in);
        System.out.print("Which year will you graduate? ");
        int year = console.nextInt();
        int rYears = year - 2014;
        System.out.println(year + " years remaining at Yale!");
    }
}
```

Console (user input underlined):
Which year will you graduate? 2014
0 years remaining at Yale!

UserScannerInput.java

Scanner Example 2

- The Scanner can read multiple values from one line.

```java
import java.util.*; // so that I can use Scanner
public class ScannerMultiply {
    public static void main(String[] args) {
        Scanner console = new Scanner(System.in);
        System.out.print("Please type two numbers: ");
        int num1 = console.nextInt();
        int num2 = console.nextInt();
        int product = num1 * num2;
        System.out.println("The product is "+ product);
    }
}
```

Output (user input underlined):
Please type two numbers: 8 6
The product is 48

ScannerMultiply.java
Scanning Details

- The OS will not send input to Scanner constructed using System.in until user hits enter
- `nextInt()`, `nextDouble()`, `next()` are token based scanning methods
  - skip whitespace (spaces, tabs, new lines) until find first non-white space, collect input into a token until a whitespace, send token to the method to interpret: the following white space remains
  - How many tokens appear on the following line of input?
    23  John Smith   42.0  "Hello world"  $2.50  "  19"
- `nextLine()` collects any input character into a string until the first new line and discards the new line

ScannerTokenDiff.java

Practice: Scanner Fun

- Please try out ScannerFun.java

ScannerFun.java
Input from File

There are two approaches

- Create a scanner with src as a file (more later)

- Redirect a file as standard input (command line)
  %java PlotUSA < USA.txt
### Design Issue

- **What value to return when a token is not the type the scanner expects**

  ```java
  System.out.print("What is your age? ");
  int age = console.nextInt();
  
  Output:
  What is your age? Timmy
  ```

### Token and Exception

- **When a token is not the type that the scanner expects, since no reasonable (non-ambiguous) return value, Scanner throws an exception (panic)**

  ```java
  System.out.print("What is your age? ");
  int age = console.nextInt();
  
  Output:
  What is your age? Timmy
  ```

  ```java
  java.util.InputMismatchException
  at java.util.Scanner.nextInt(Unknown Source)
  at java.util.Scanner.nextInt(Unknown Source)
  ...
Why Not a “Smarter” nextInt()?

- For example, continue to scan the input to find the integer?

- Design principle: design of basic methods should **KISS (Keep It Simple and Stupid)**

---

Problem: How to avoid crash when user gives wrong input?
The **if** statement

Executes a block of statements only if a test is true

```java
if (test) {
    statement;
    ...
    statement;
}
```

- Example:
  ```java
  if (grade >= 90.0 && grade <= 100) {
      System.out.println("It is an A.");
  }
  ```

The **if/else** Statement

- An **else clause** can be added to an **if** statement to make it an **if-else statement**:
  ```java
  if (test) {
      statement1;
  } else {
      statement2;
  }
  ```
- If the condition is true, statement1 is executed; if the condition is false, statement2 is executed
- One or the other will be executed, but not both
The if/else Statement

- Example:

```java
if (gpa >= 2.0 && gpa <= 3.8) {
    System.out.println("Welcome to Middle Univ.!");
} else {
    System.out.println("Application denied.");
}
```

Backup Slides
**Practice: Loan Calculator**

- Design a loan program to compute the monthly amortization table of a fixed-rate loan

http://en.wikipedia.org/wiki/Mortgage_calculator


**Rules of Fixed-Rate Loan**

- Assume N periods (e.g., 120 months)

- For each period, borrower pays interest on the remaining owed (principal) at the fixed rate

- At the end of N's period, the remaining principal goes to 0
## Fixed-Rate Loan Calculation Alg.

- **Alg. focuses on**
  - owed (principal)  \( p \)
  - monthly payment  \( m \)
  - monthly interest rate  \( r \)

Owed at initiation:  \( p \)

Owed after 1 month:  \((1 + r)p - m\)

Owed after 2 month:  \((1 + r)[(1 + r)p - m] - m\)

\[= (1 + r)^2 p - [1 + (1 + r)]m\]

Owed after 3 month:  \((1 + r)[(1 + r)^2 p - [1 + (1 + r)]m] - m\)

\[= (1 + r)^3 p - [1 + (1 + r) + (1 + r)^2]m\]

### Mapping Loop Variable

- **p**: principal
- **m**: monthly payment
- **r**: monthly interest rate

Owed after \( N \) month:  \((1 + r)^N p - [(1 + (1 + r) + \ldots + (1 + r)^{N-1})]m\)

apply  \(1 + x + \ldots + x^{N-1} = \frac{x^N - 1}{x - 1}\)

Owed after \( N \) month:  \((1 + r)^N p - \frac{(1 + r)^N - 1}{r} m\)

Payoff loan after \( N \) month =>  \((1 + r)^N p - \frac{(1 + r)^N - 1}{r} m = 0\)

\[\frac{(1 + r)^N - 1}{r} m = (1 + r)^N p\]

\[m = \frac{r(1 + r)^N}{(1 + r)^N - 1} p\]