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Lecture 4: Methods
a.k.a. function a.k.a. procedures

Contents

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1 Motivation: why use methods?

- modularizing code
- reusing code
- easier debugging

2 Defining Methods

syntax:

```
    modifiers returnType methodName ( list-of-parameters )
    {
      method body
    }
```

returnType can be any of the data types that we learned so far, or `void;` `void` methods do not return a value

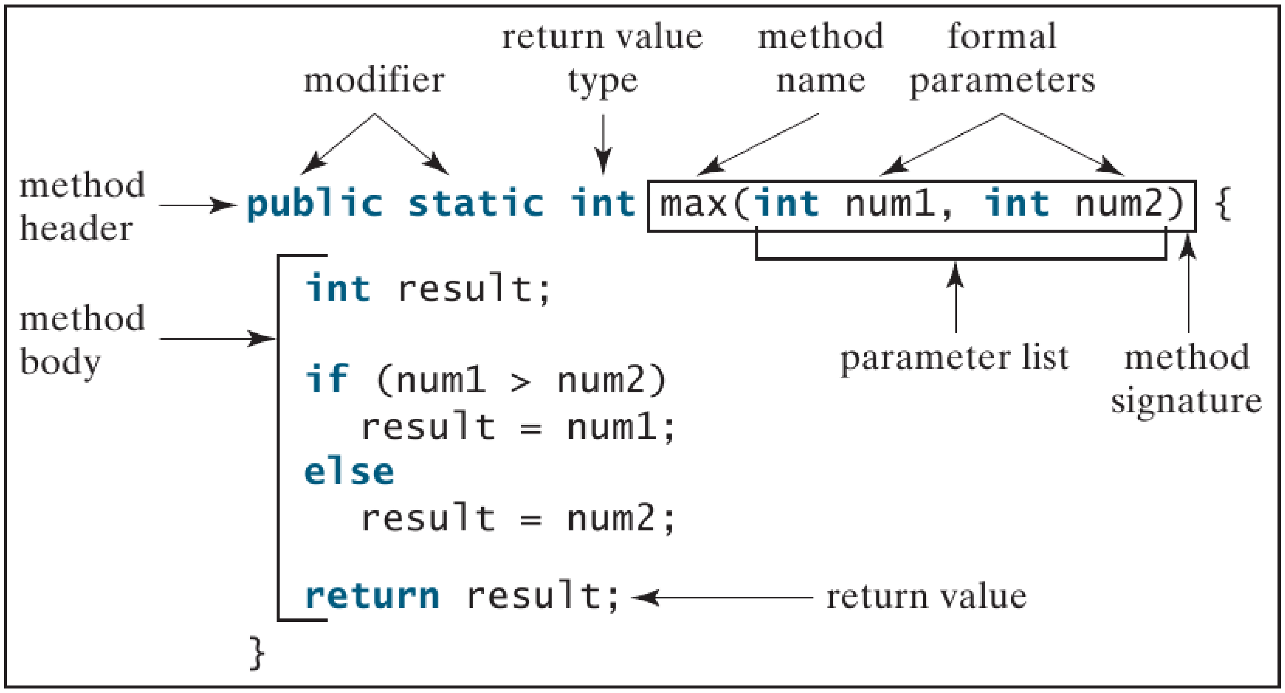
list-of-parameter is a comma separated list of the form:

```
        type1 var1, type2 var2, ..., typeN varN
```

modifiers specify how the method can be accessed (for now will will always use `public static`)

methodName has to follow the naming rules for identifier

Define a method



```
public static int max(int num1, int num2) {
    int result;

    if (num1 > num2)
       result = num1;
    else
       result = num2;

    return result;
}
```

3 Calling Methods

Calling a method results in executing the code in that method.

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- value returning methods are used like values, for example,

```
int smaller = min ( num1, num2 );
```

- void methods are use like statements (in fact, you used these already), for example,

```
System.out.println("Hello world");
```

Syntax:

```
methodName( list-of-arguments );
```

Activation record = activation frame - information about a method that contains: values of parameters and (local) variables. Whenever a method is called an activation record is placed in the area of memory called **stack**.

Source code: `HelloWorld.java` program demonstrates several very simple functions (all are related to hello world message).

`DecimalToBinary.java` program uses the decimal to binary conversion that we developed in the previous lecture, but this time it is a method.

`NumberProperties.java` program has several methods that given a number determine if the number is even, odd, prime and also display the binary version (the last is accomplished by reusing the method defined in `DecimalToBinary.java` file).

4 Passing Parameters by Values

- When the function is called, the values/variables specified in the list-of-arguments must match the list-of-parameters from the function definition in
  - order,
  - number,
  - compatible type.
- In Java all parameters are **passed to methods by value**. This means that the values of the argument variables are copied to variables specific to the method.

What is the output of the following code?

```
public class Increment {
  public static void main(String[] args) {
    int x = 1;
    System.out.println("Before the call, x is " + x);
    increment(x);
    System.out.println("after the call, x is " + x);
  }

  public static void increment(int n) {
    n++;
    System.out.println("n inside the method is " + n);
  }
}
```

5 Overloading Methods

Overloading methods - defining multiple methods with the same name, but different signatures. A **signature** of a method consists of its name and its parameter list.

How would you write a method that determines max of its two parameters? How would you write a method that determines max of its three parameters?

Source Code: `MaxOverloaded.java` demonstrates three methods all of which are called max, but their parameter lists are different.

6 Scope of Variables

scope of variable the part of the program in which the variable can be referenced (used)

local variable = variable with local scope - variable declared inside a method; method parameters are also local variables

block scope - variable defined inside a block of code (code surrounded by curly braces { }) can be references only within that block; nested blocks cannot have repeating variables

Example 1: When blocks are not nested, the variable name can be reused.

```
public static void main(String[] args) {
  ...
  {
    int x = 5;
    System.out.printf("%d",x);
  }
  {
    int x = 7;
    System.out.printf("%d",x);
  }
...
}
```

Example 2: If blocks are nested, the re-declaring a variable with the same name will cause a compile-time error.

```
public static void main(String[] args) {
  ...
  {
    int x = 5;
    System.out.printf("%d",x);
    {
      int x = 7;
      System.out.printf("%d",x);
    }
  }
...
}
```

7 Method Abstraction and Stepwise Refinement

These are probably the most important concepts regarding Java programming that you learned so far.

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Method abstraction - a person (a client/programmer/user) can use a method without knowing its implementation. The only thing needed should be the method's signature (method name, list of parameters), its return type and its documentation. The author of the method can change its implementation and, as long as the header of the method remains the same, the client code does not need to be modified.

Stepwise refinement - when writing a large program, one should use a divide and conquer approach to decompose the problem into subproblems, which then get decomposed into smaller subproblems and so on, until the final set of problems is of manageable size. What is manageable size? The "small problems" should be easily described as a single task and should be easily turned into simple methods or few lines of code.

Example problem: Simulate a single game of craps. Craps is a dice game. The rules of our simplified version of the game follow.

step1: Roll two dice and check their sum. If the sum is 2, 3, or 12 (called craps), the player loses and the game ends. If the sum is 7 or 11, the player wins and the game ends. If the sum is any other number (i.e., 4, 5, 6, 8, 9 or 10, called point) that value is saved and the dice are rolled again (see step 2).

step 2: Roll the dice and check their sum. If the sum is 7, the player loses and the game ends. If the sum is equal to point, the player wins and the game ends. If the sum is any other number, the step 2 is repeated.

Stepwise refinement of the problem:

Version 1: play the game of craps

Version 2: play the game of craps

- perform first roll (according to rules described in step 1)
- if the game continues, perform second roll (according to rules described in step 2)
- if the game continues, perform third roll (according to rules described in step 2)
- ...

Version 3: play the game of craps

- perform first roll (according to rules described in step 1)
  - roll two dice and compute their sum
  - determine next step based on the sum
- if the game continues, perform second roll (according to rules described in step 2)
  - roll two dice and compute their sum
  - determine next step based on the sum
- if the game continues, perform third roll (according to rules described in step 2)
  - roll two dice and compute their sum
  - determine next step based on the sum
- ...

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Version 4: play the game of craps

- perform first roll (according to rules described in step 1)
  - roll two dice and compute their sum
    - roll the first dice
    - roll the second dice
    - compute sum
  - determine next step based on the sum
    - if sum is 2, 3, or 12 player looses, game ends
    - if sum is 7 or 11, player wins, game ends
    - otherwise save the sum as `point`
- if the game continues, perform second roll (according to rules described in step 2)
  - roll two dice and compute their sum
    - roll the first dice
    - roll the second dice
    - compute sum
  - determine next step based on the sum
    - if sum is equal to seven, player looses, game ends
    - if sum is equal to `point`, player wins, game ends
- if the game continues, perform third roll (according to rules described in step 2)
  - roll two dice and compute their sum
    - roll the first dice
    - roll the second dice
    - compute sum
  - determine next step based on the sum
    - if sum is equal to seven, player looses, game ends
    - if sum is equal to `point`, player wins, game ends
- ...

Version 5: play the game of craps

- perform first roll (according to rules described in step 1)
  - roll two dice and compute their sum
    - roll the first dice
    - roll the second dice
    - compute sum
  - determine next step based on the sum
    - if sum is 2, 3, or 12 player looses, game ends
    - if sum is 7 or 11, player wins, game ends
    - otherwise save the sum as `point`

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- repeat, as long as the game does not end
  - perform a roll (according to rules described in step 2)
    - roll two dice and compute their sum
      - roll the first dice
      - roll the second dice
      - compute sum
  - determine next step based on the sum
    - if sum is equal to seven, player looses, game ends
    - if sum is equal to `point`, player wins, game ends