13 Methods

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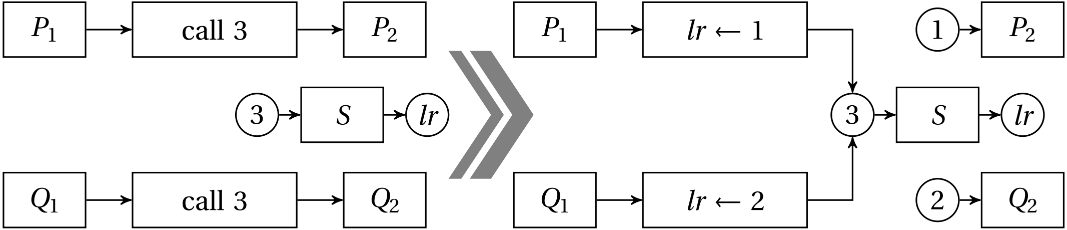
Outline

1. Subroutines, Procedures and Functions
2. Methods
3. Static Methods
4. Local Variables
5. Reading Homework

Subroutines

- A particular task could be performed a number of times on different data values.
- This repeated task is normally implemented as a subroutine.
- A new branching instruction to support subroutines: branching to a location stored in a *variable*, such as a register *lr*.
- **Call**: before we go to the subroutine, we store the location of the next instruction to *lr*.
- **Return**: when the subroutine finishes, we fetch the location from *lr* and go back.



- How about nested subroutine calls?

Procedures, Functions and Methods

- In Java, methods act as subroutines, procedures and functions.
- Subroutines are common groups of statements that are shared in different places.

```
void printBar() { System.out.println("--------"); }
```

- Procedures are subroutines that may formally accept arguments, such that a procedure may be called upon different values.

```
void printBar(int n) {
    for ( int i = 0; i < n; ++i ) System.out.print("-");
    System.out.println();
}
```

- Functions are procedures that may return values.

```
int max(int x, int y) { return x > y ? x : y; }
```

- In mathematics, functions do not have side effects, they just map arguments to results.
- In Java, methods usually have side effects, that they can change variables outside and perform I/O operations.

Defining a Method

- Every method in Java belongs to a class. We must define a method within a class, such as *MyClass*.
- Every method has a signature (header), which mentions the method name, the types of the parameters and the return value.

```
int sumSqr(int x, int y)
```

- A statement block following the method header defines the method body.

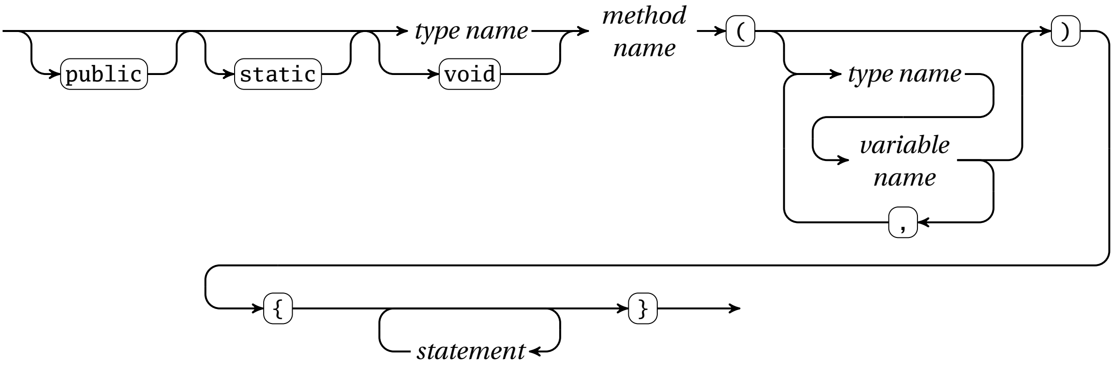
```
{ return sqr(x) * sqr(y); }
```

- The task that the method performs is specified in the block.
- A method returns when the `return` statement is executed, or when the execution reaches the end of the block if the method has no return value, that is, the return type is `void`.

```
void doubleStarBars() {
    for ( int i = 0; i < 80; ++i )
        System.out.print((i+1)%40 == 0 ? "*\n" : "*");
}
```

Syntax Diagram of Method Definitions

method definition



Calling a Method

- A method call starts with an object, say *myObj*, of the class that defines the method, followed by the method name and arguments.

```
int a = 100 + myObj.sumSqr(100, 200);
```

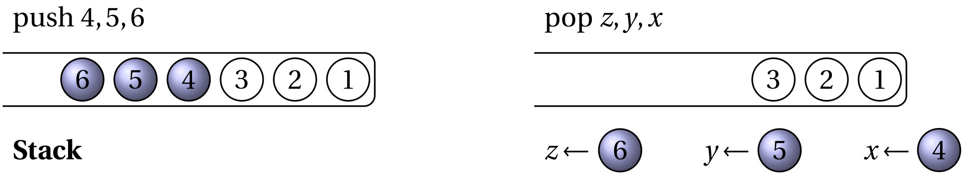
- A method call is an expression, if it returns a value. The value returned is the result of this expression. You can put it anywhere that an expression fits.
- A method with the `void` return type must be called as a statement.

```
myObj.doubleStarBars();
```

- The arguments (100 and 200) are assigned to the parameters (x and y) declared in the signature, they can be used as variables in the method.
- The object (*myObj*) is assigned to an implicit parameter called "`this`", it can be used as a constant in the method to refer to the calling object.
- The result is stored in a special variable, for example, a register r_0, that can be fetched when the method returns.

What Really Happen?

- The registers to store return addresses and return values are *lr* and r_0 in all method calls.
- What if we call another method while we are in a method, just like calling *sqr* in *sumSqr*?
- What if we call a method having x as a parameter from a method that declares x as a variable?
- All these issues can be solved by saving the duplicate variables to a stack when entering a subroutine,
- And, restoring the duplicate variables from the stack when leaving the subroutine.



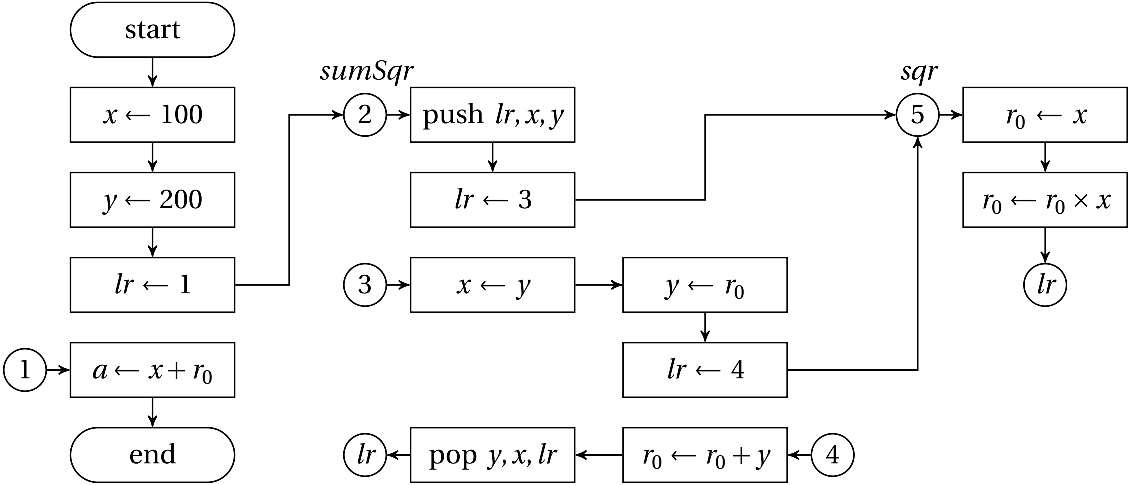
push $4, 5, 6$

Stack

pop z, y, x

$z \leftarrow 6$ $y \leftarrow 5$ $x \leftarrow 4$

Preserving Variables for Nested Method Calls



start

$x \leftarrow 100$

$y \leftarrow 200$

$lr \leftarrow 1$

1 $a \leftarrow x + r_0$

end

sumSqr

2 push lr, x, y

$lr \leftarrow 3$

3 $x \leftarrow y$

$y \leftarrow r_0$

$lr \leftarrow 4$

4 $r_0 \leftarrow r_0 + y$

pop y, x, lr

lr

sqr

5 $r_0 \leftarrow x$

$r_0 \leftarrow r_0 \times x$

lr

Static Methods

- Usually, a method must be called upon an object instance of the class defining the method. Such a method is called an *instance* method. For examples,

```
int i = scanner.nextInt();
int ch = r.read();
```

- The object instance is passed to the method via an implicit parameter "`this`" of the type of the class.
- If a method does not need the object instance (`this`), it can be declared `static`.

```
public static int multiply(int x, int y) { return x * y; }
```

- A static method can be called with the class name `MyClass.multiply(10,20)` rather than the object instance of the class.
- If you call a method within the defining class, you can omit the prefix. For instance methods, "`this`" is the default prefix, for static methods, the class name is the default prefix.

Local Variables

- Variables declared in a block is local to the block and its inner blocks.
- Outer blocks cannot see variables declared in inner blocks.

```
{ int o = 2; { int i = o;✔... } { int x = i;✘... } int y = i;✘... }
```

- Two parallel blocks cannot see variables declared in the other block.
- Variables declared inside the method body are local to the method.
- A name can be used in different blocks for different variables at the same time, inner names hide outer names.
- Where a variable is visible is called its *scope*.
- Each time the execution enters a block, a new set of local variables of the block is created, they are destroyed when the execution leaves the block.
- Method parameters are local variables with the widest scope in the method.

Reading Homework

Textbook

- Section 6.1–6.5, 6.9.

Internet

- Subroutine (`http://en.wikipedia.org/wiki/Subroutine`).
- Local variable (`http://en.wikipedia.org/wiki/Local_variable`).

Self-test

- 5.1 – 5.14, 5.19 – 5.20 (`http://tiger.armstrong.edu/selftest/selftest9e?chapter=5`).