Object Oriented Programming in Java

2: Objects creation
strings, arrays, program memory organization (stack and heap)

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- The samples and slides are inspired by the Object Oriented Programming course at the University of Zagreb, Faculty of Electrical Engineering and Computing, Zagreb, Croatia.
  - Original materials in Croatian were created by (in alphabetical order): Ivica Botički, Marko Čupić, Mario Kušek, Boris Milašinović, and Krešimir Pripužić under CC-BY-NC-SA licence.
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Importing Java files into an IDE

- Introductory examples had used *src* and *bin* folder and no IDE had been used
  - only *src* was included in git repository
- Source code does not contain an IDE's specific project data
  - it differs for Eclipse, Netbeans, etc…
  - new Java project should be created, source code copied, dependencies set up, … → quite inconvienient
- Solution:
  - use one of uniform build systems supported by majority of IDEs
  - *Apache Maven* is one of the possible choices
    - Alternatives: Gradle, …

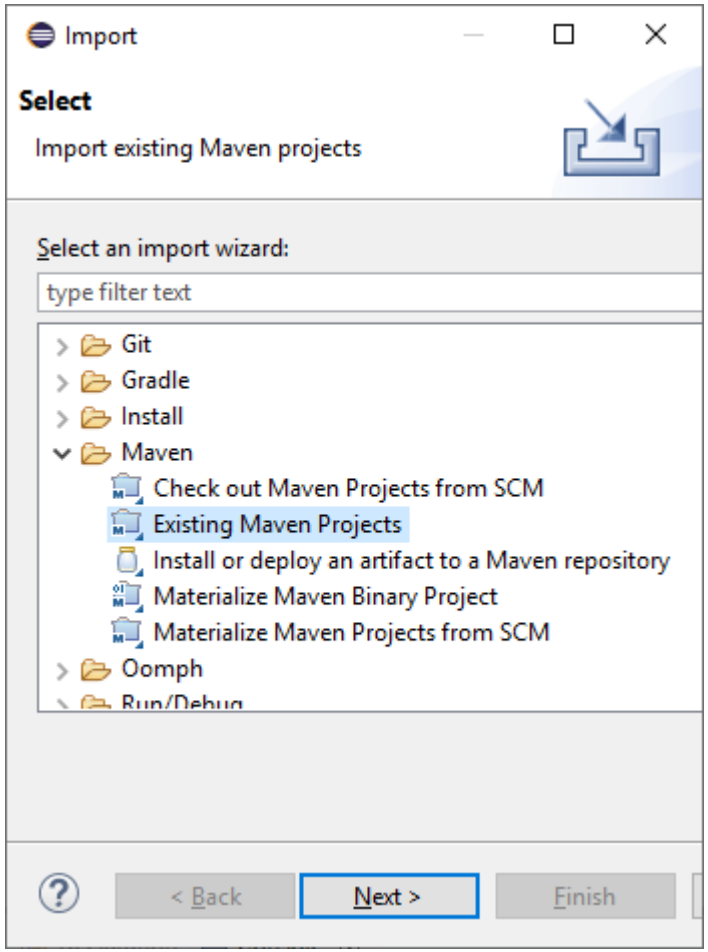
Structure of Maven projects

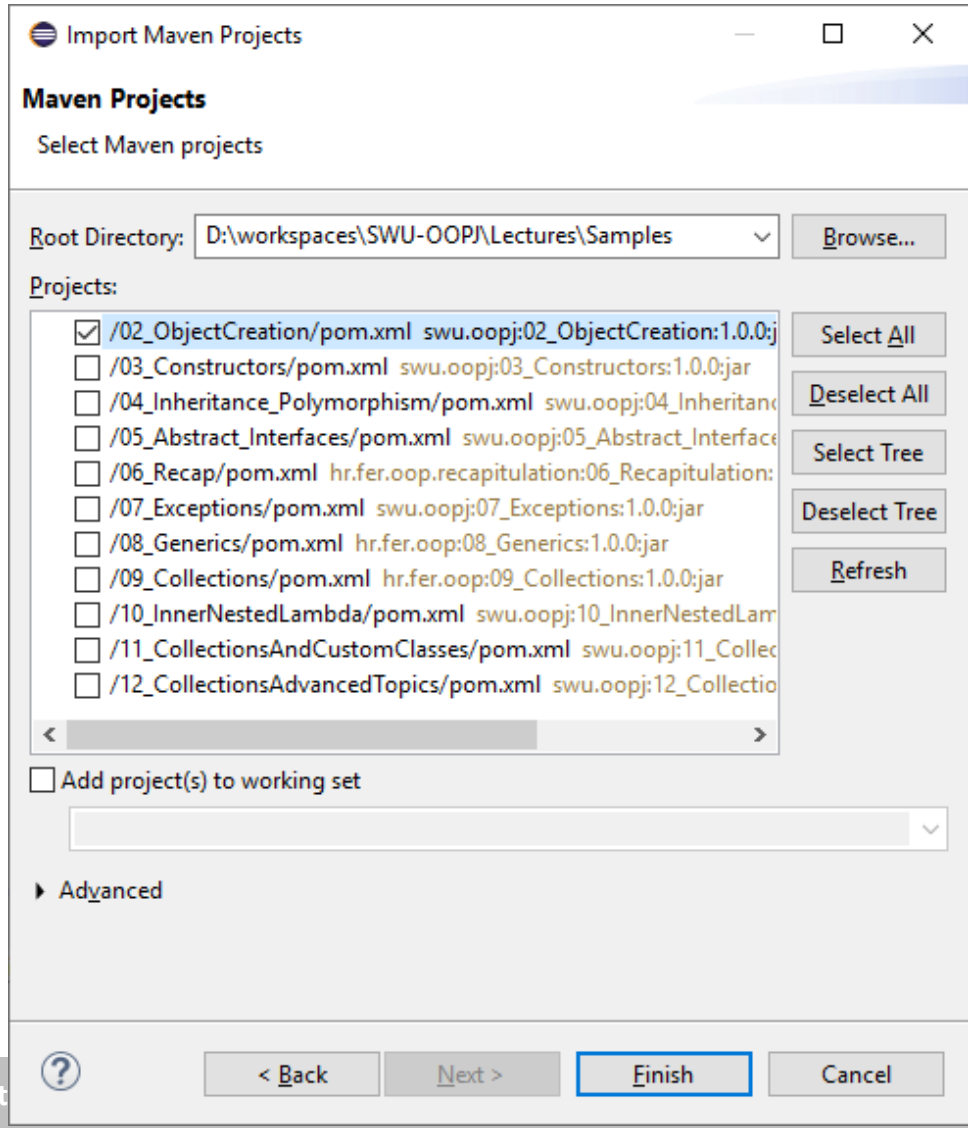
- Project's root folder contains pom.xml that configures
  - project identifiers
    - important for libraries shared at central Maven repository
  - dependencies on third party libraries
    - Maven or IDE downloads them if the do not exists locally
  - Java version that it should be used
  - …

- Maven project by convention use different folder structure
  - *src → src/main/java*
    - src may contains also other source file types (resources, tests, …)
  - *bin → target/classes*
    - *target* can contain other binaries, e.g. target/test-classes, …

Import Maven project to Eclipse

- Import → Existing Maven Projects → Choose projects to import

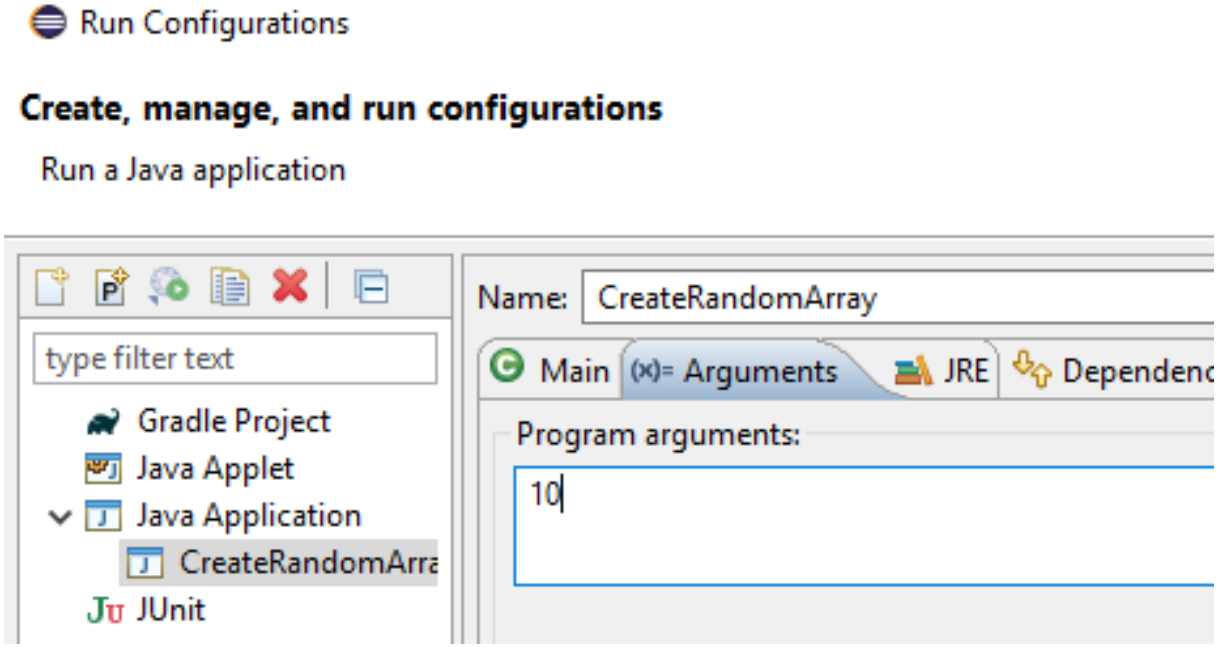




How to enter program arguments in Eclipse

- Right click on the source file containing main program that must be run → Run As → Run Configurations

- Enter desired arguments into text field in tab *Arguments*



Stack and heap

- Stack holds local variables, partial results, enables invocation of functions, recursion, …
  - calling a methods puts method arguments and return address on the program stack
  - method exists “removes” the element from the stack
  - declaring primitive type variable in a method take place on the stacks holding variable value
- Heap keeps other data
  - dynamically allocated data
  - program code
  - classes and methods information
  - constants

Arrays in Java

- Arrays are declared with `type[] variable_name;`
  - Array declaration does not create an array!
  - It create a place (typically 32-bit or 64-bit) on the program stack for declared variable.
    - Variable value would be an address of a continuous block on heap for storing array elements created later with keyword *new*
    - Initially value is *null* meaning that currently that reference does not refer to any object.

Creating an array in Java

```
public static double[] create(int n) { // 1
  double[] arr;                        // 2
  arr = new double[n];                 // 3
  for(int i=0; i<n; i++) {             // 4
       arr[i] = Math.random();         // 5
  }
  return arr;                          // 6
}
```

…02_ObjectCreation/src/main/java/swu/oopj/objectcreation/CreateRandomArray.java

- (Very) simplified memory state after step 1 in case method is called with n=5

Creating an array in Java

```
public static double[] create(int n) { // 1
  double[] arr;                        // 2
  arr = new double[n];                 // 3
  for(int i=0; i<n; i++) {             // 4
       arr[i] = Math.random();         // 5
  }
  return arr;                          // 6
}
```

…02_ObjectCreation/src/main/java/swu/oopj/objectcreation/CreateRandomArray.java

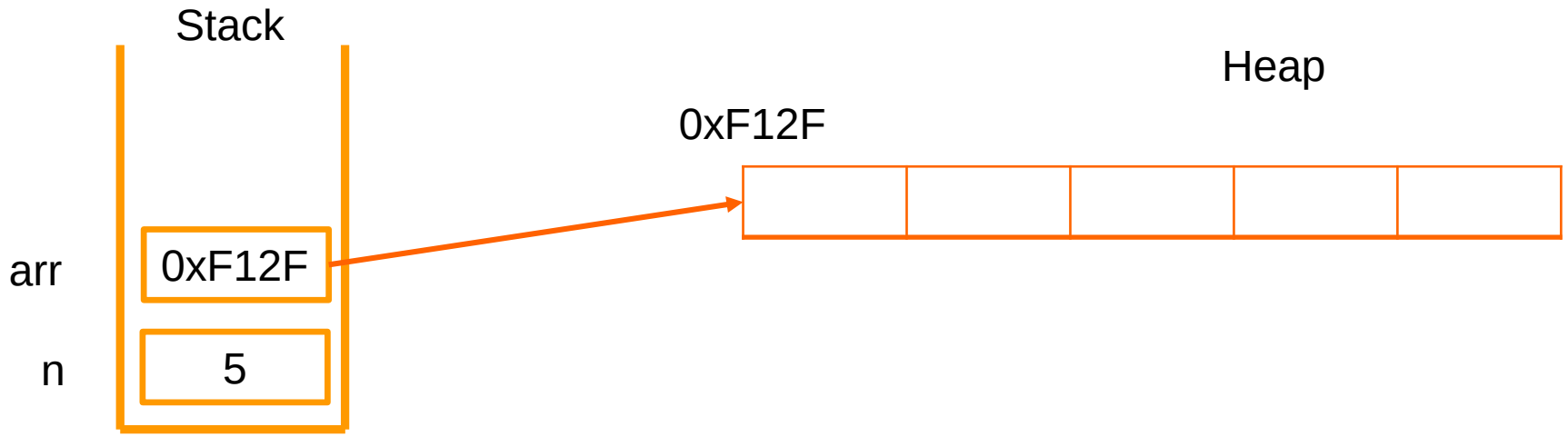
- Simplified memory state after step 2

Creating an array in Java

```
public static double[] create(int n) { // 1
  double[] arr;                        // 2
  arr = new double[n];                 // 3
  for(int i=0; i<n; i++) {             // 4
       arr[i] = Math.random();         // 5
  }
  return arr;                          // 6
}
```

…02_ObjectCreation/src/main/java/swu/oopj/objectcreation/CreateRandomArray.java

- step 3 - for illustration, suppose that place for array is created at address 0xF12F



Creating an array in Java

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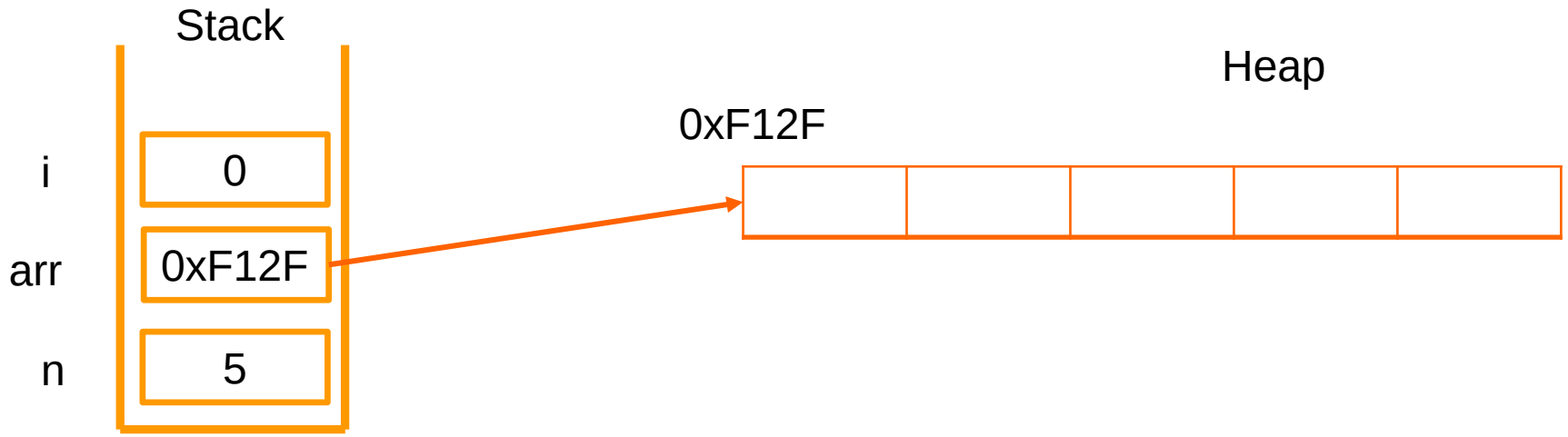
…02_ObjectCreation/src/main/java/swu/oopj/objectcreation/CreateRandomArray.java

- step 4 – initial step



Creating an array in Java

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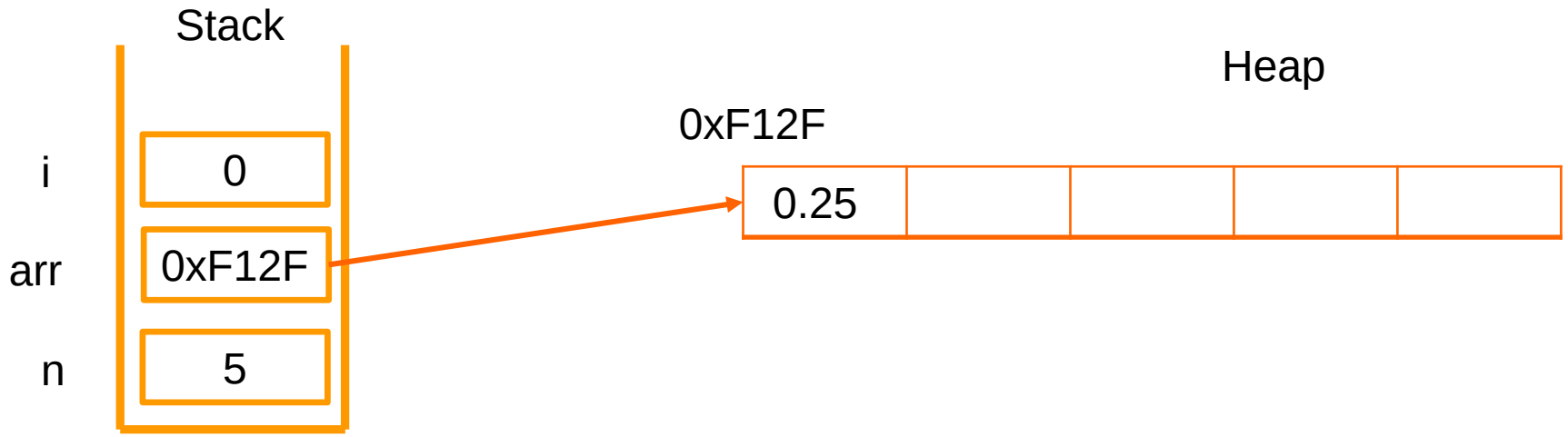
}
```

…02_ObjectCreation/src/main/java/swu/oopj/objectcreation/CreateRandomArray.java

- step 5 – when *i* is 0, and random number is 0.25

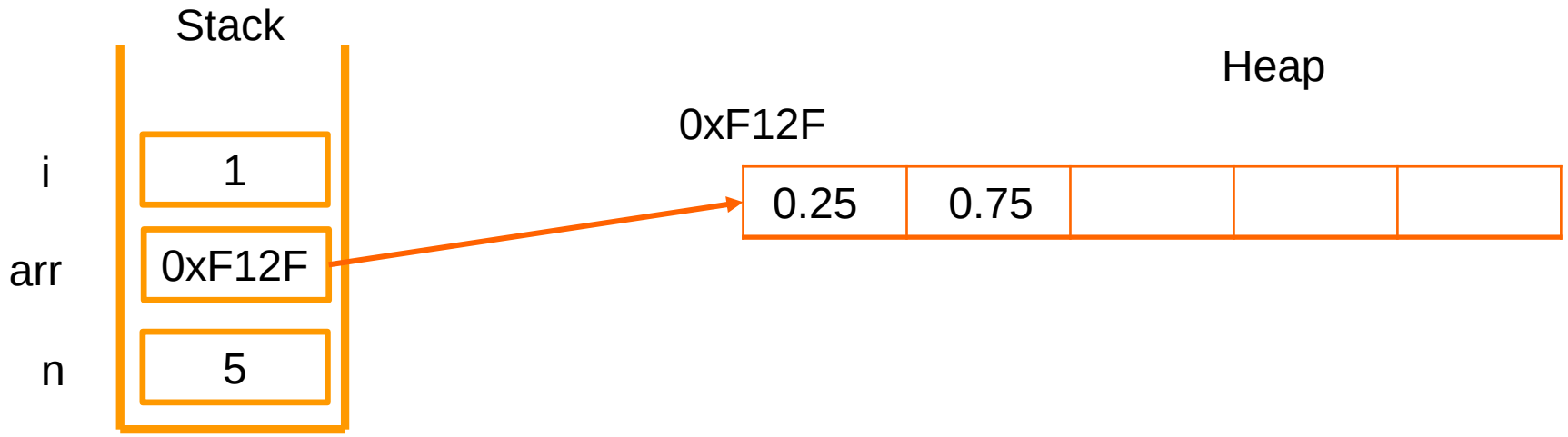


Creating an array in Java

```
public static double[] create(int n) { // 1
  double[] arr;                        // 2
  arr = new double[n];                 // 3
  for(int i=0; i<n; i++) {             // 4
       arr[i] = Math.random();         // 5
  }
  return arr;                          // 6
}
```

…02_ObjectCreation/src/main/java/swu/oopj/objectcreation/CreateRandomArray.java

- step 5 – when *i* is 1, and random number is 0.75



Creating an array in Java

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       arr[i] = Math.random();         // 5
  }
  return arr;                          // 6
}
```
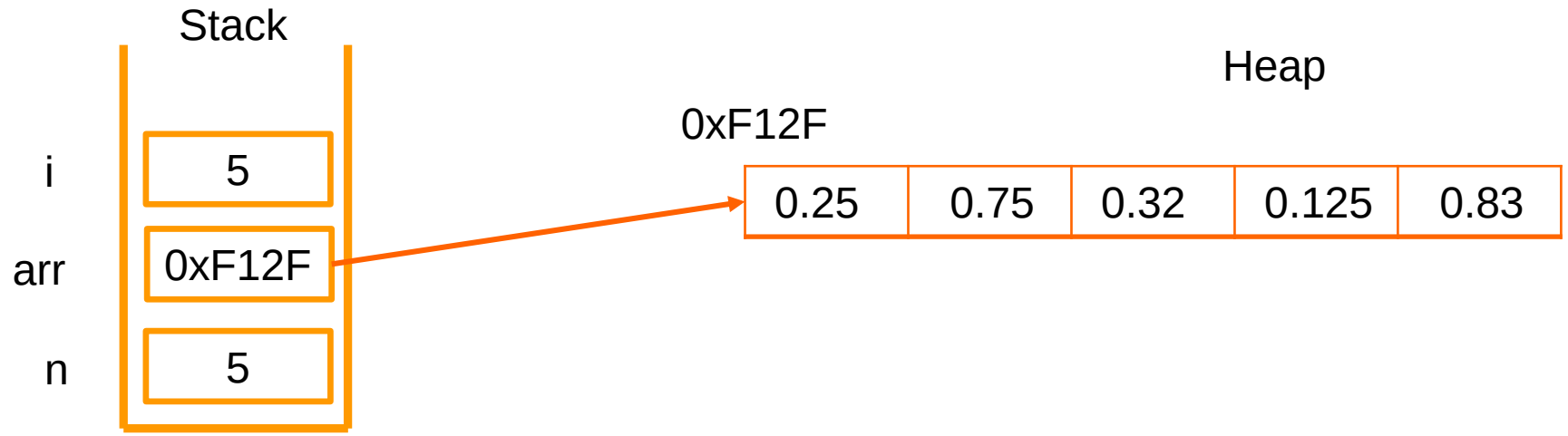

…02_ObjectCreation/src/main/java/swu/oopj/objectcreation/CreateRandomArray.java

- step 6 – what `return arr` means → it returns value 0xF12F

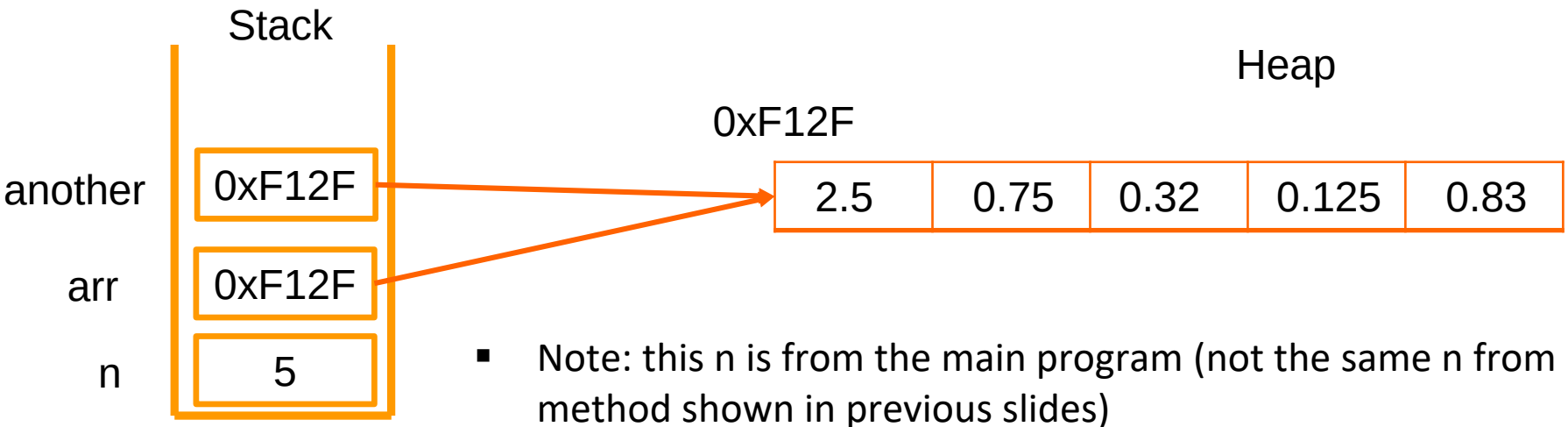


operator = copies values from/to the stack

- operator copy values on the stack and does not clone a data

```
double[] arr = create(n);
double[] another = arr; //what happens here?
another[0] = 2.5;
System.out.printf("#1 = %.4f %.4f %n", arr[0], another[0]);
```

…02_ObjectCreation/…/CreateRandomArray.java

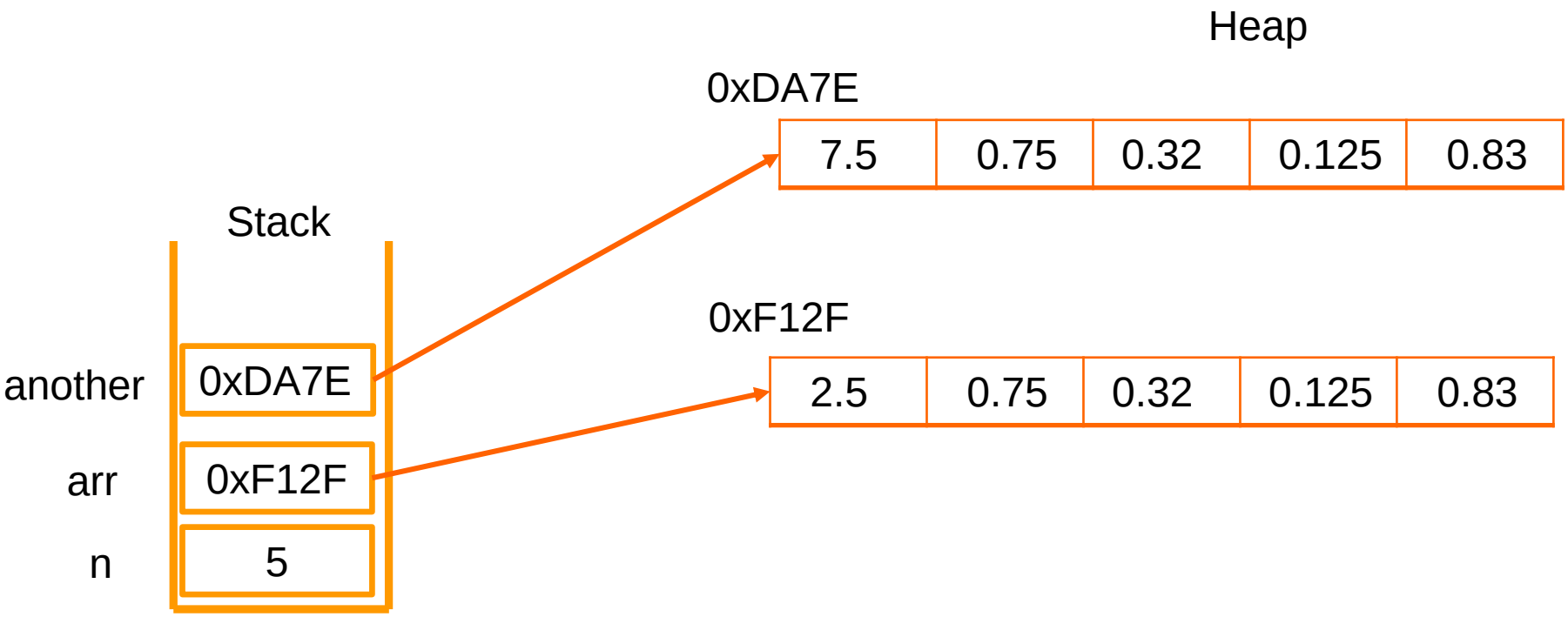


- Note: this n is from the main program (not the same n from method shown in previous slides)

operator = copies values from/to the stack

- operator copy values on the stack and does not clone a data

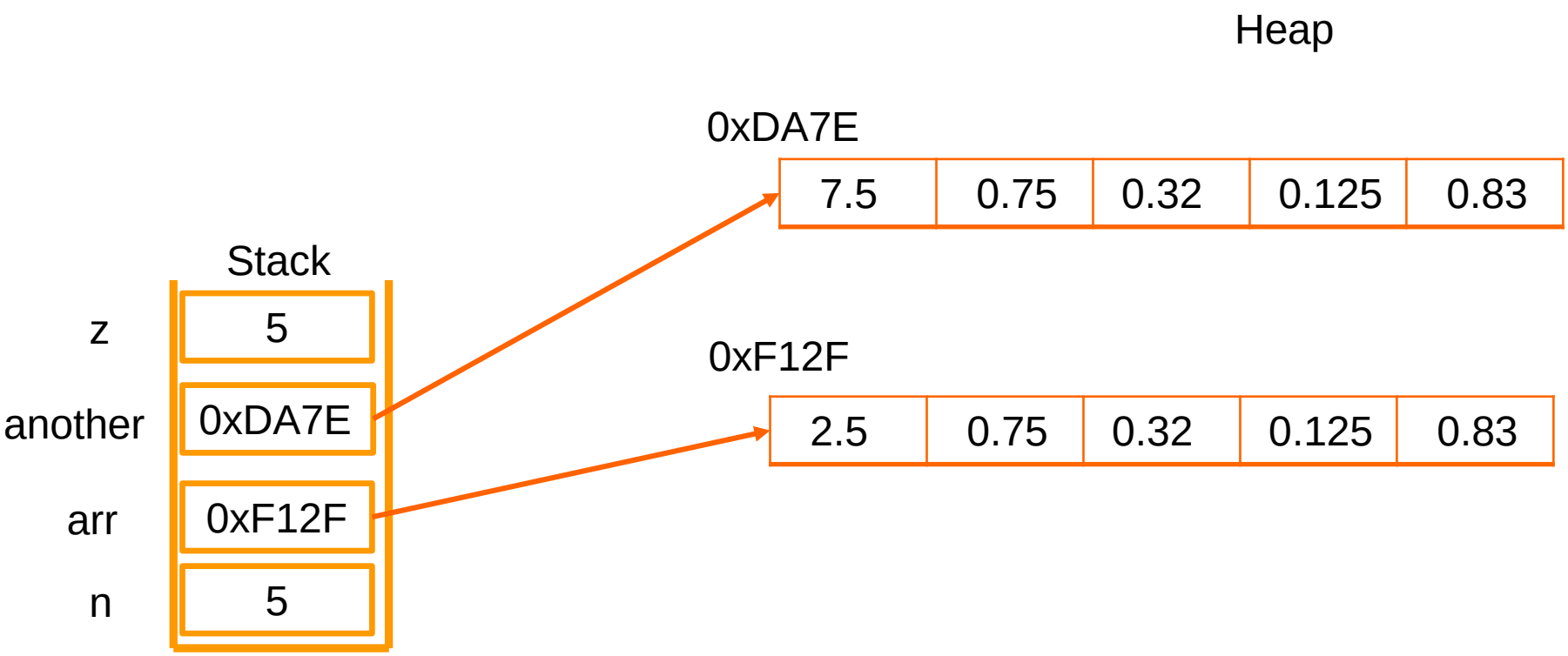
```
another = arr.clone(); //what happens here?
another[0] = 7.5;
System.out.printf("#2 = %.4f %.4f %n", arr[0], another[0]);
```



operator = copies values from/to the stack

- operator copy values on the stack and does not clone a data

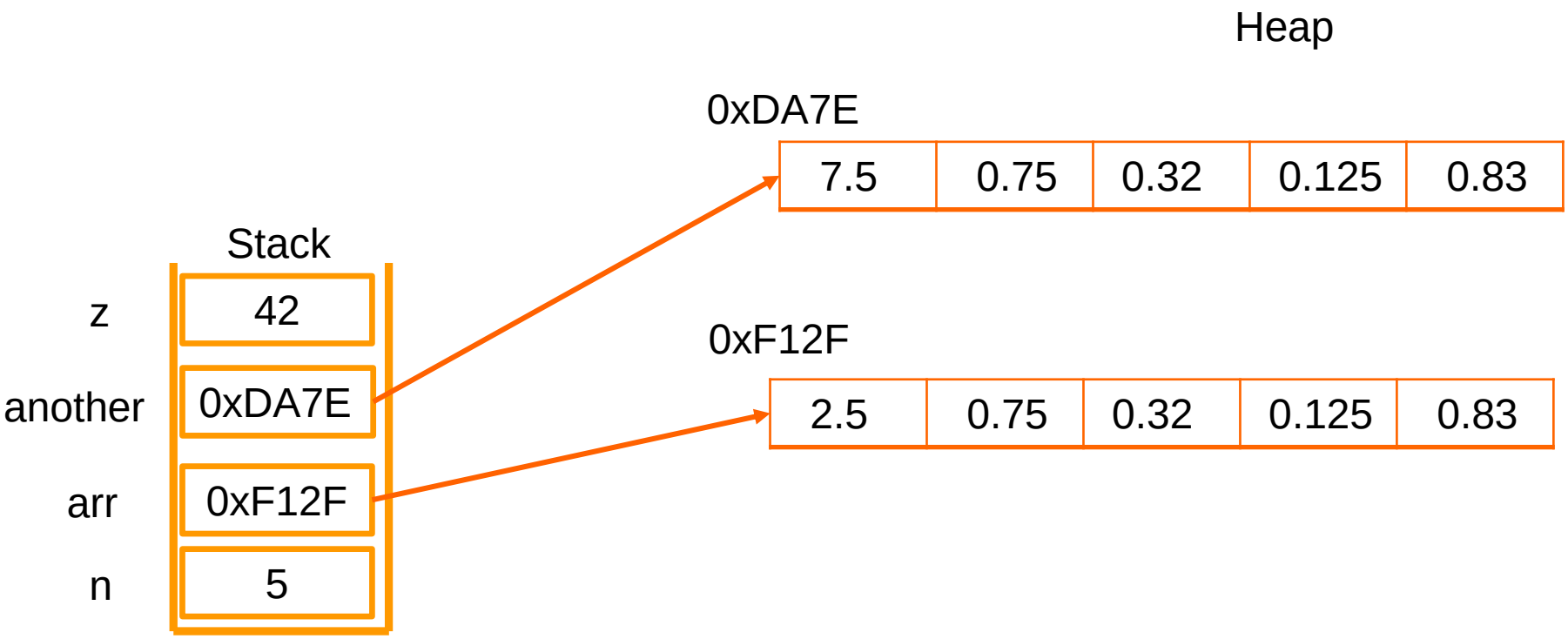
```
int z = n;
```



operator = copies values from/to the stack

- operator copy values on the stack and does not clone a data

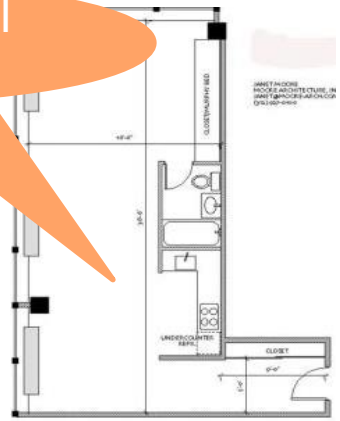
```
z = 42;
System.out.printf("#3 = %d %d %n", n, z);
```



Classes and objects

- A class is a definition from which new objects would be created
  - like a blueprint or template
  - defines common properties (variables and methods) that objects of the group would poses
- An object is one instance of a class.

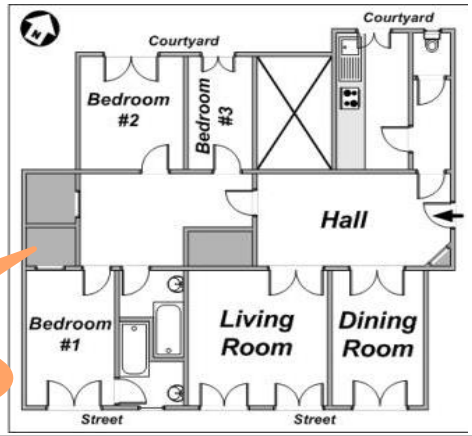
Class: Small Apartment



Objects – instances of *LargeApartment*

Objects – instances of *SmallApartment*

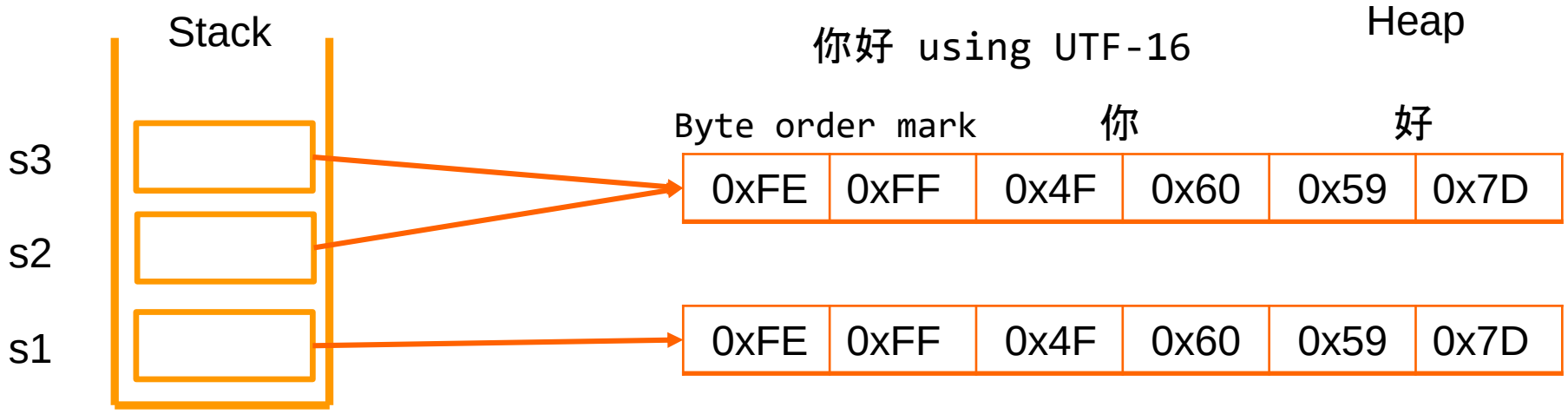
Class: Large Apartment



Strings in Java

- String is sequence of characters
  - *char* is primitive type, *String* is class
  - Instance of string stores characters as bytes (depends of encoding)
- Variables of type *String* are references!
  - new strings (objects) are created using operator *new*

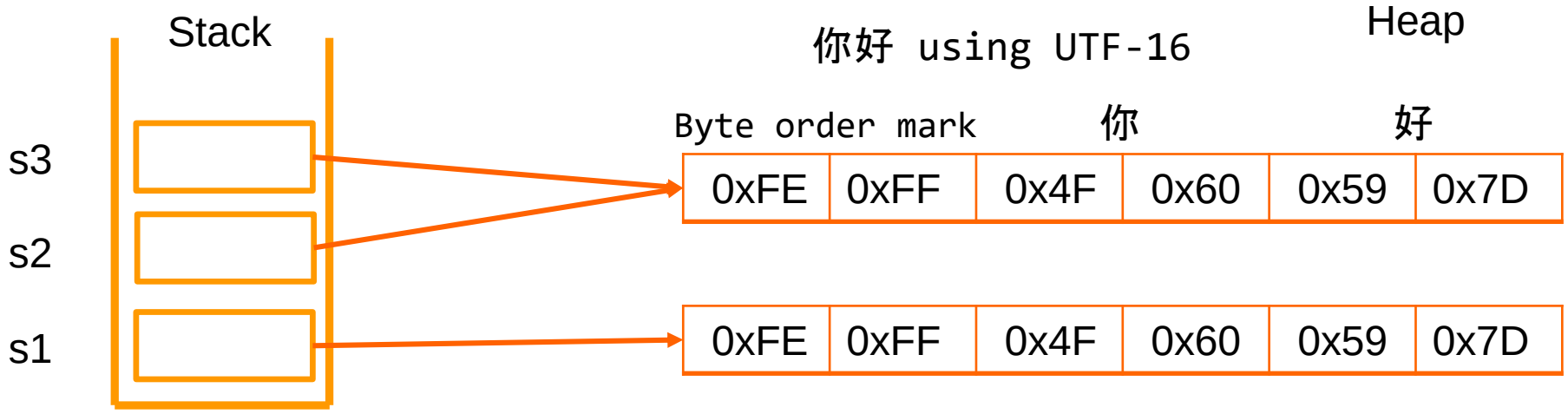
```
String s1 = new String("你好"); //Nǐ hǎo
String s2 = new String("你好"); //Nǐ hǎo
String s3 = s2;
```



Comparing strings (1)

- Operator == compares stack values!
  - *s2 == s3* is *true*
  - s1 == s2 is *false*

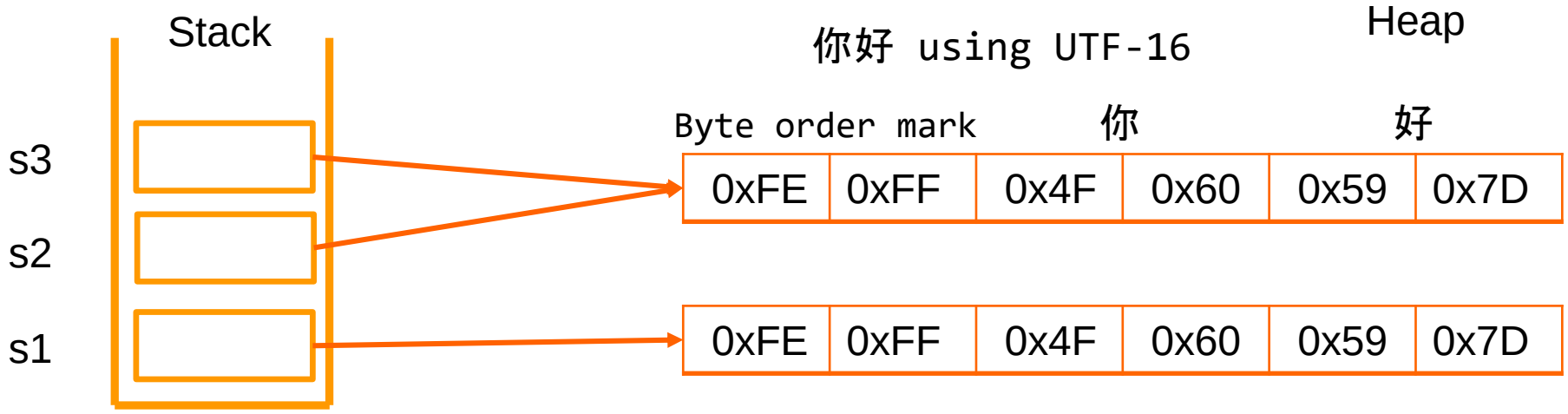
```
String s1 = new String("你好"); //Nǐ hǎo
String s2 = new String("你好"); //Nǐ hǎo
String s3 = s2;
```



Comparing strings (2)

- How to compare content?
  - *s2.equals(s3)* is *true*
  - *s1.equals(s2)* is *true*

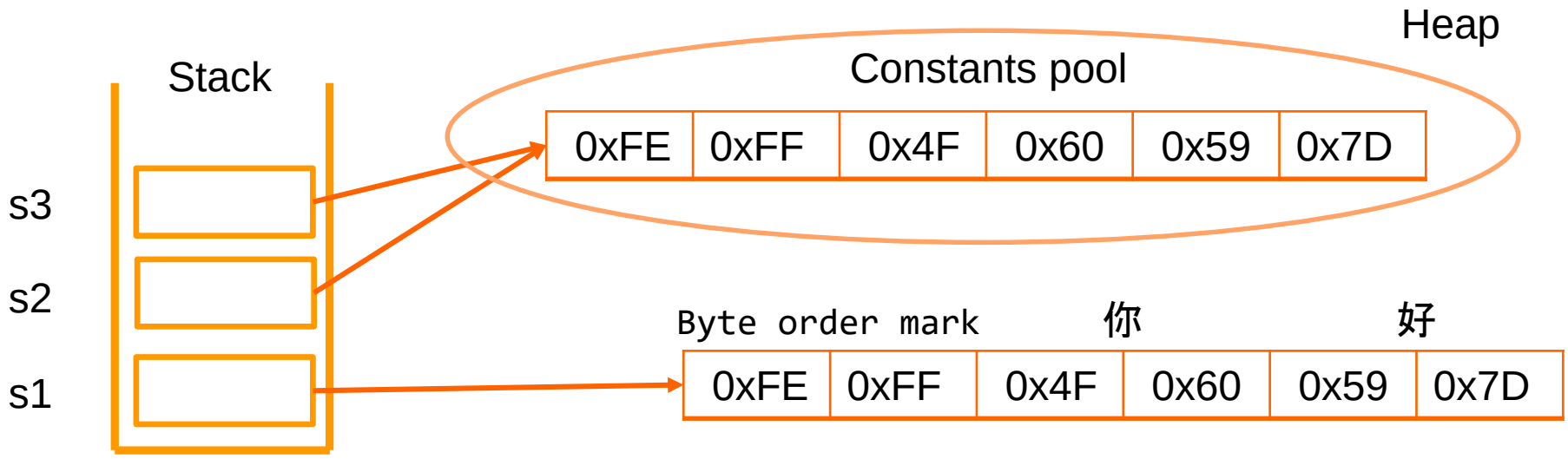
```
String s1 = new String("你好"); //Nǐ hǎo
String s2 = new String("你好"); //Nǐ hǎo
String s3 = s2;
```



Comparing strings (3)

- Note: all constants strings are stored only once in memory
  - only *new* creates a new string (may be copy of an existing one)
  - *s2 == s3* is *true and* s1 == s2 is *false*
  - *s2.equals(s3)* is *true* and *s1.equals(s2)* is *true*

```
String s1 = new String("你好"); //Nǐ hǎo
String s2 = "你好"; //Nǐ hǎo
String s3 = "你好";
```

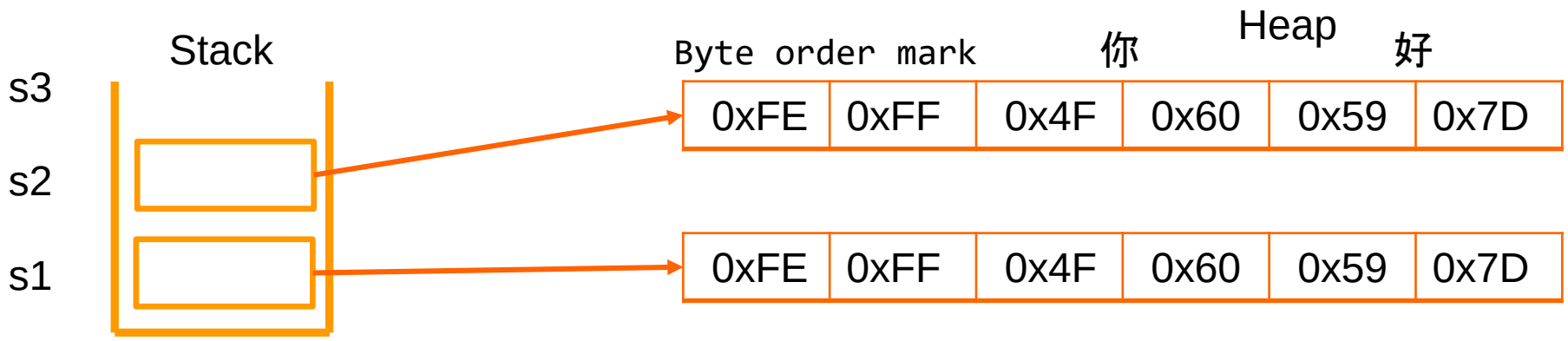


Instance methods

```
String s1 = new String("你好");
char c = s1.charAt(0); // 你
String s2 = new String("你好");
boolean b = s2.equals(s1)
```

- Notice the difference between
  - *s2.equals(s3), s1.charAt(0)*

  and some method calls from previous presentation (T1)
  - *Math.abs, Integer.parseInt, Taylor.ePowerX*
- Methods like *equals* and *charAt* from *String* are instance methods
  - needs an object of its class to be run, and access the object's content
- Static methods can be run even if there is no object of that type
  - more about it in the next presentation (T3)



String methods

- Class *String* has many usable methods from strings manipulation
  - e.g. finding or getting substrings, changing case, replacing parts, …
- String is immutable
  - all methods for string manipulation returns a new string

```
String text = "The quick brown fox jumps over lazy dogs.";
String upperCase = text.toUpperCase();
System.out.println("Upper case text: " + upperCase);
System.out.println("Replacing fox with wolf: "
       + text.replace("fox", "wolf"));
int position = text.indexOf("quick");
System.out.println("quick starts at index: " + position);
System.out.println(text.substring(position, position + 15));
System.out.println("Original: " + text);
```

- Inspect and run the code from the sample and try some other string methods

…02_ObjectCreation/…/WorkingWithStrings.java

Strings concatenation

- Operator + for String could be used for concatenation
  - can be used in combination with numbers or other objects
    - possible due to autoboxing and existence of toString method (explained in some of later presentations)

```
String text = "The quick " + "brown ";
text += "fox jumps over ";
text += 3;
text += " lazy dogs.";
System.out.println(text);
```

…02_ObjectCreation/…/WorkingWithStrings.java

- Note: Do not forget that strings are immutable
  - in case of many concatenations use *StringBuilder* instead

Object lifecycle

- What happens with objects on heap
  - allocated with operator *new*,
  - or e.g. with new strings created during use of various methods from class *String*?
  - memory leaks?
- No need to worry (to much) - *Java* has *Garbage collector (GC)*
  - GC would remove objects that are not referenced any more.
    - Unknown when GC is run (not related to variable scope)
  - *finalize* method is run before cleaning an object
    - in most cases, there is no need for this method
  - To many unnecessary allocated objects causes GC to run more often and may incur performance penalties
    - thus, e.g. StringBuilder is more appropriate if there is lot of concatenations

Standard input/output

…02_ObjectCreation/…/ReadFromStandardInput.java

- System.out.println, System.out.printf for writing to std. output
  https://docs.oracle.com/en/java/javase/11/docs/api/java.base/java/util/Formatter.html#syntax
- Class Scanner for reading from system input

```
Scanner sc = new Scanner(System.in);
System.out.println("Please enter an integer number");
int x = sc.nextInt();
System.out.println("Entered: " + x);
System.out.println("Now, enter a floating point number");
double y = sc.nextDouble();
System.out.println("Entered: " + y);
System.out.println("Enter several lines. Use Q or q to quit.");
while(sc.hasNextLine()) {
        String line = sc.nextLine();
        if (line.equalsIgnoreCase("Q")) break;
        System.out.println(line);
}
```