

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

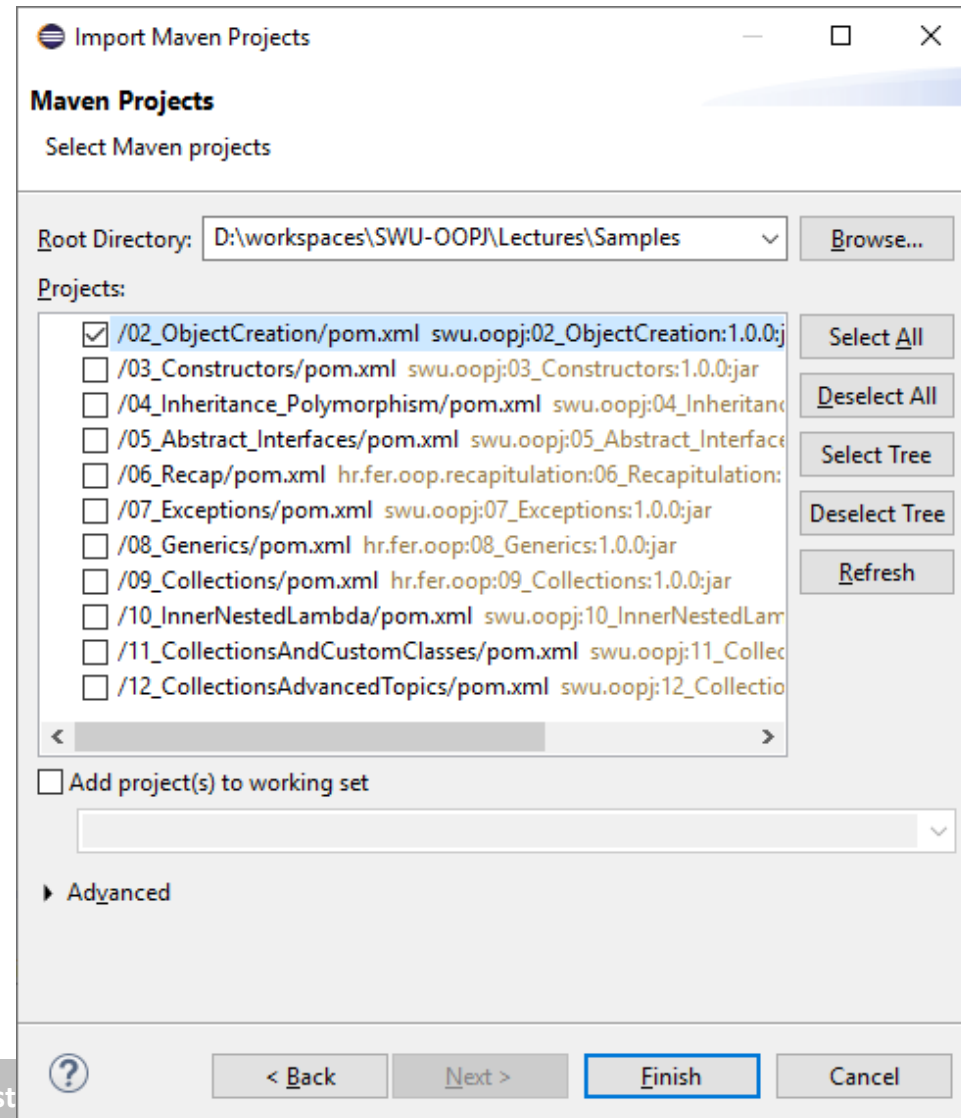
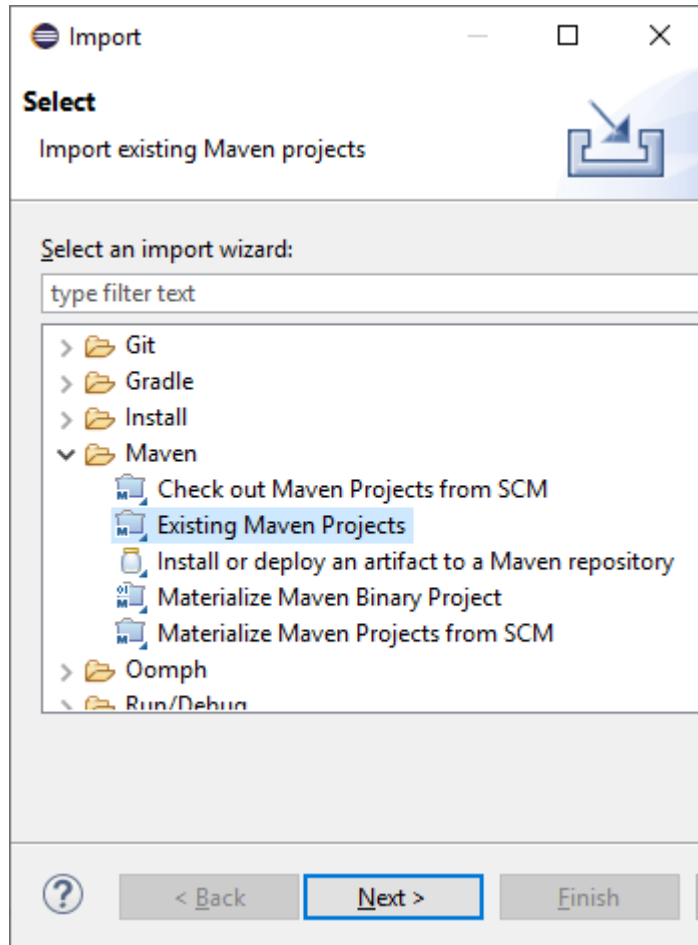
- Introductory examples had used *src* and *bin* folder and no IDE had been used
 - only *src* was included in git repository
- Source code does not contain an IDE's specific project data
 - it differs for Eclipse, Netbeans, etc...
 - new Java project should be created, source code copied, dependencies set up, ... → quite inconvenient
- 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 they do not exist locally
 - Java version that it should be used
 - ...
- Maven project by convention use different folder structure
 - *src* → *src/main/java*
 - *src* may contain also other source file types (resources, tests, ...)
 - *bin* → *target/classes*
 - *target* can contain other binaries, e.g. *target/test-classes*, ...

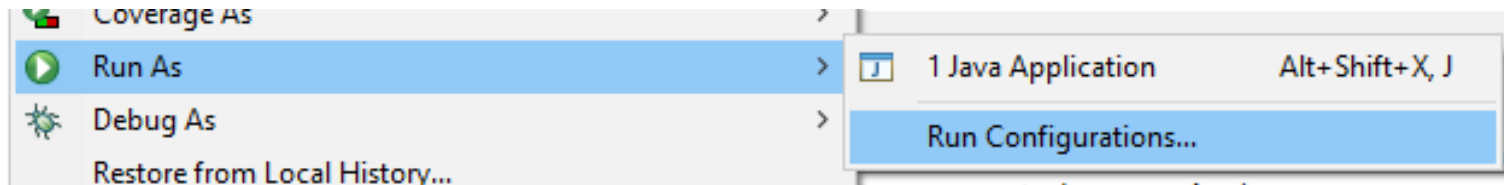
Import Maven project to Eclipse

- Import → Existing Maven Projects → Choose projects to import

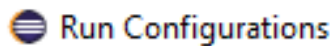


How to enter program arguments in Eclipse

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

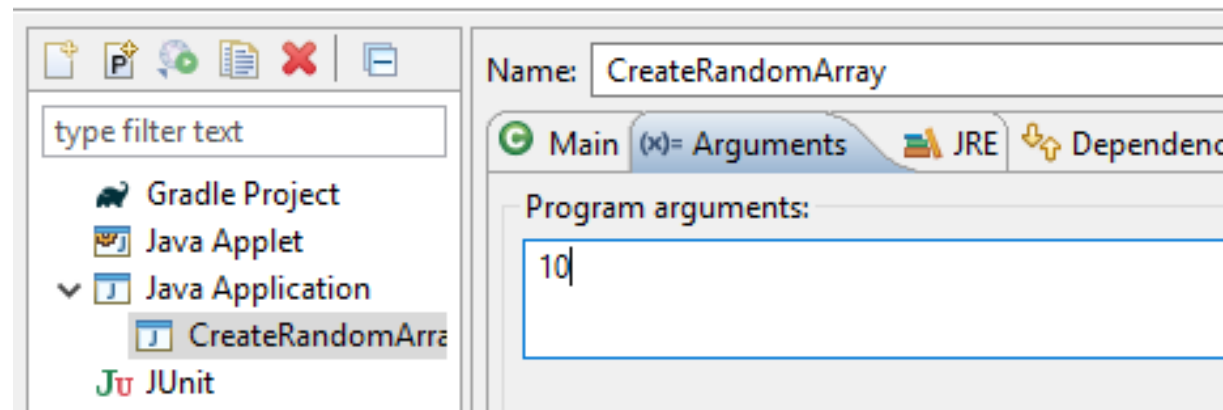


- Enter desired arguments into text field in tab *Arguments*



Create, manage, and run configurations

Run a Java application



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

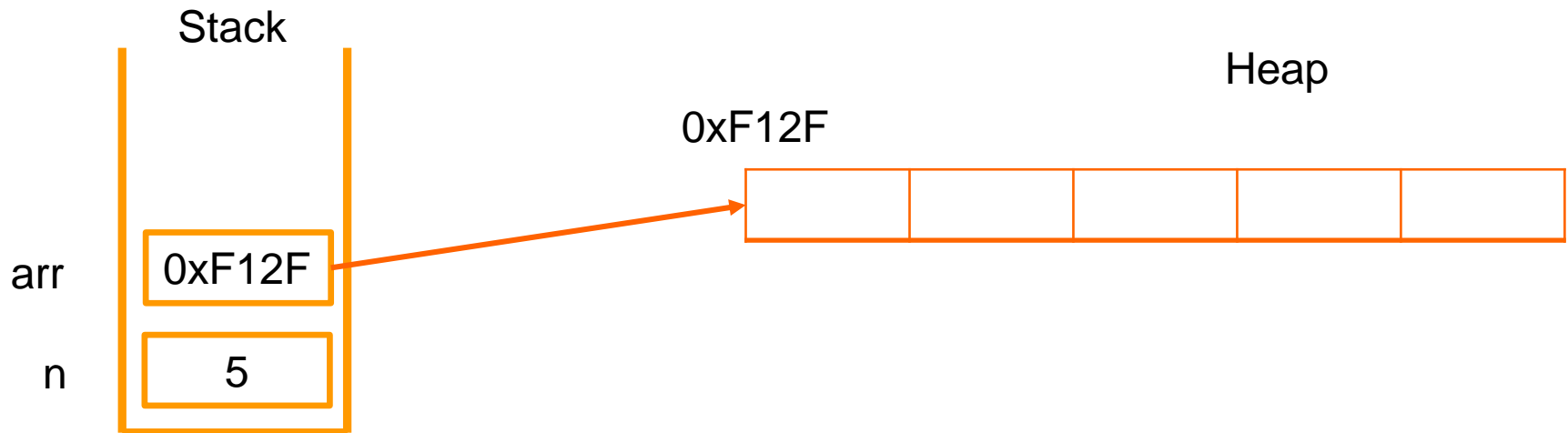


Creating an array in Java

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public static double[] create(int n) { // 1
    double[] arr;                      // 2
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        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

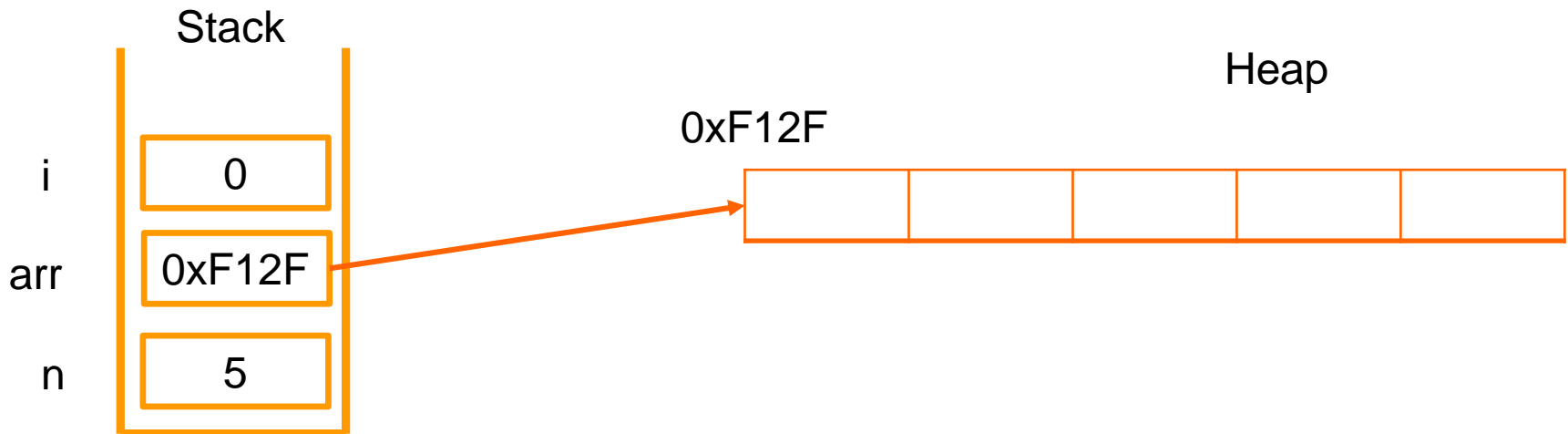


Creating an array in Java

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}
```

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

- step 4 – initial step

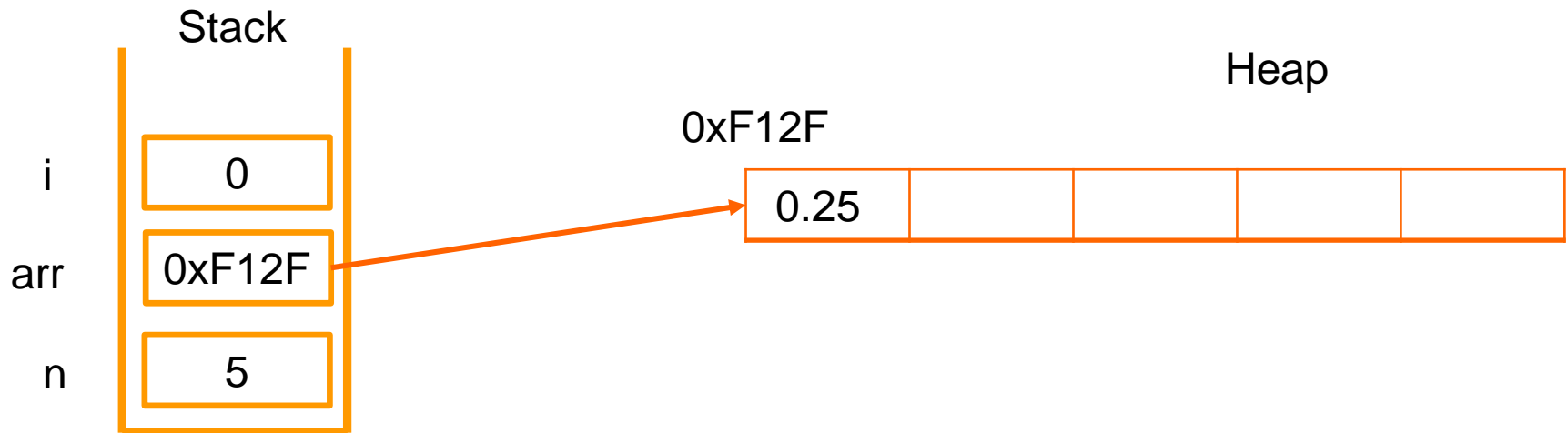


Creating an array in Java

```
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 0, and random number is 0.25

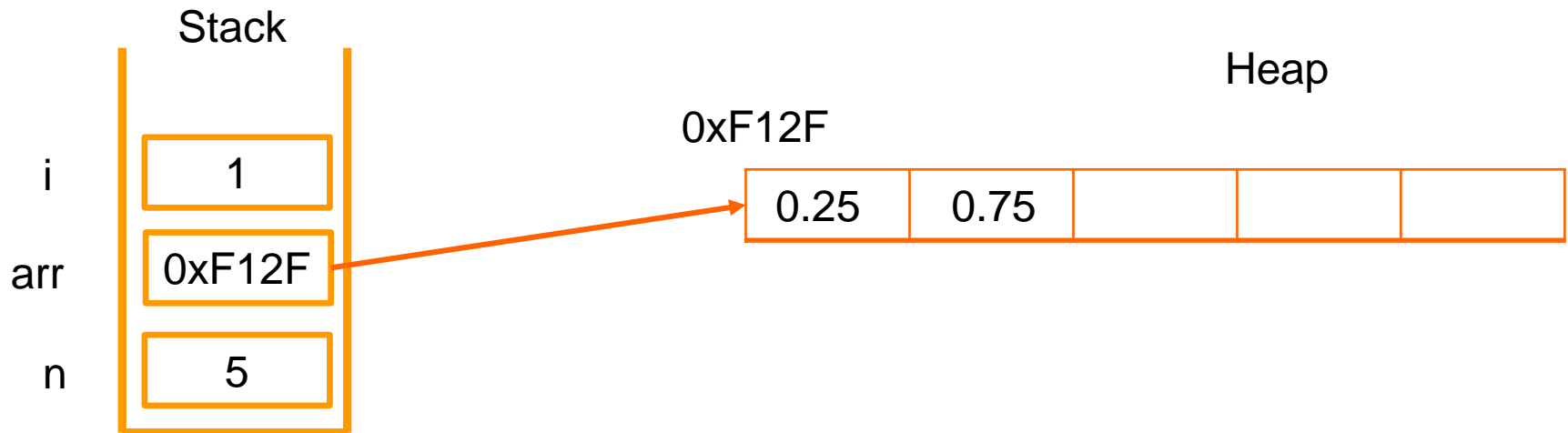


Creating an array in Java

```
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

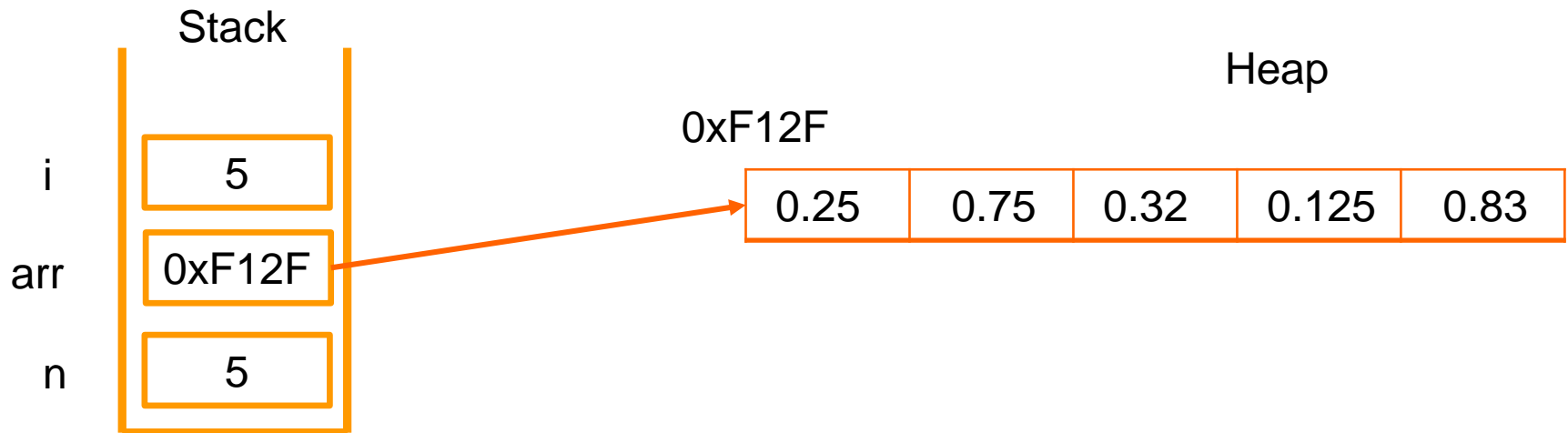


Creating an array in Java

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

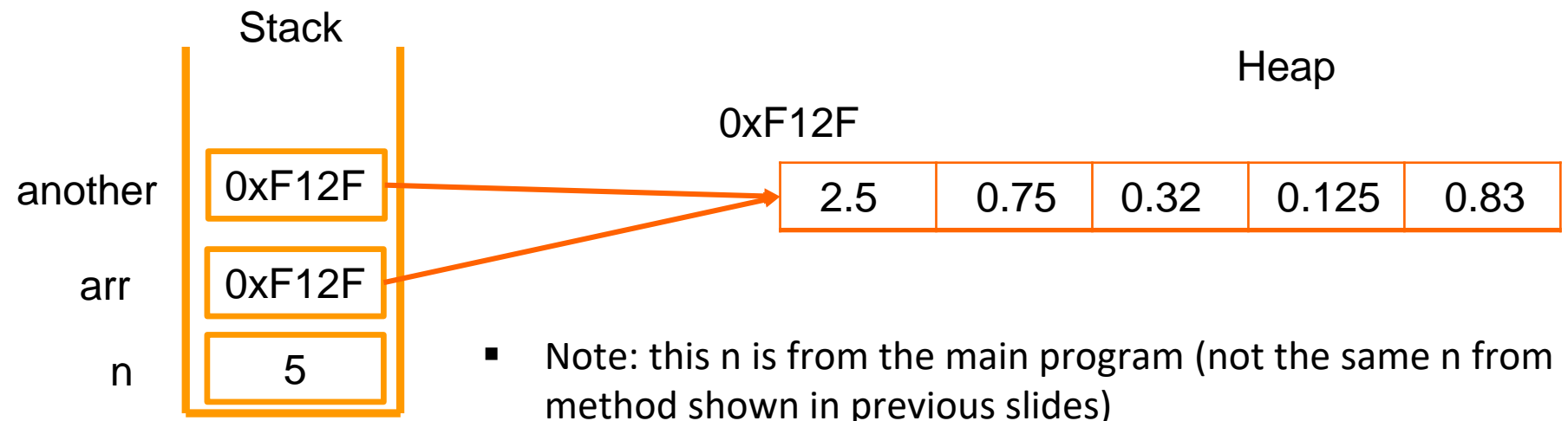


operator = copies values from/to the stack

- 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



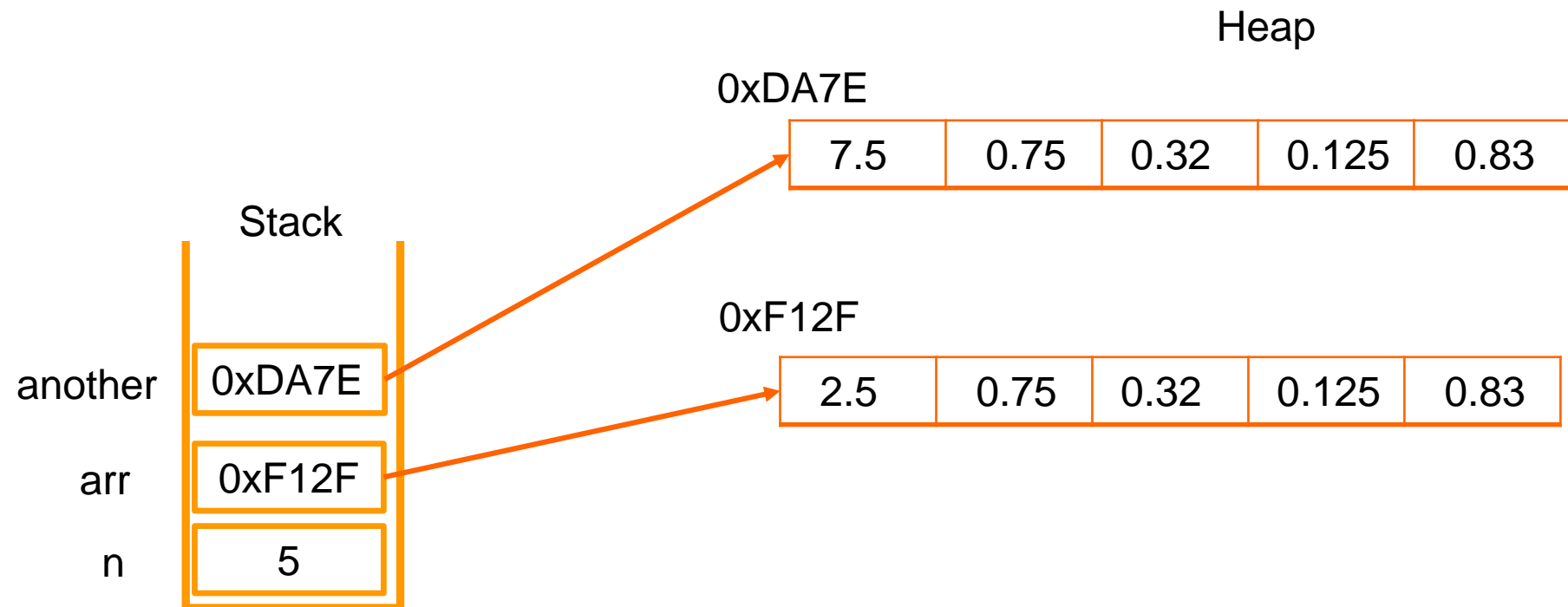
operator = copies values from/to the stack

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

```
another = arr.clone(); //what happens here?
```

```
another[0] = 7.5;
```

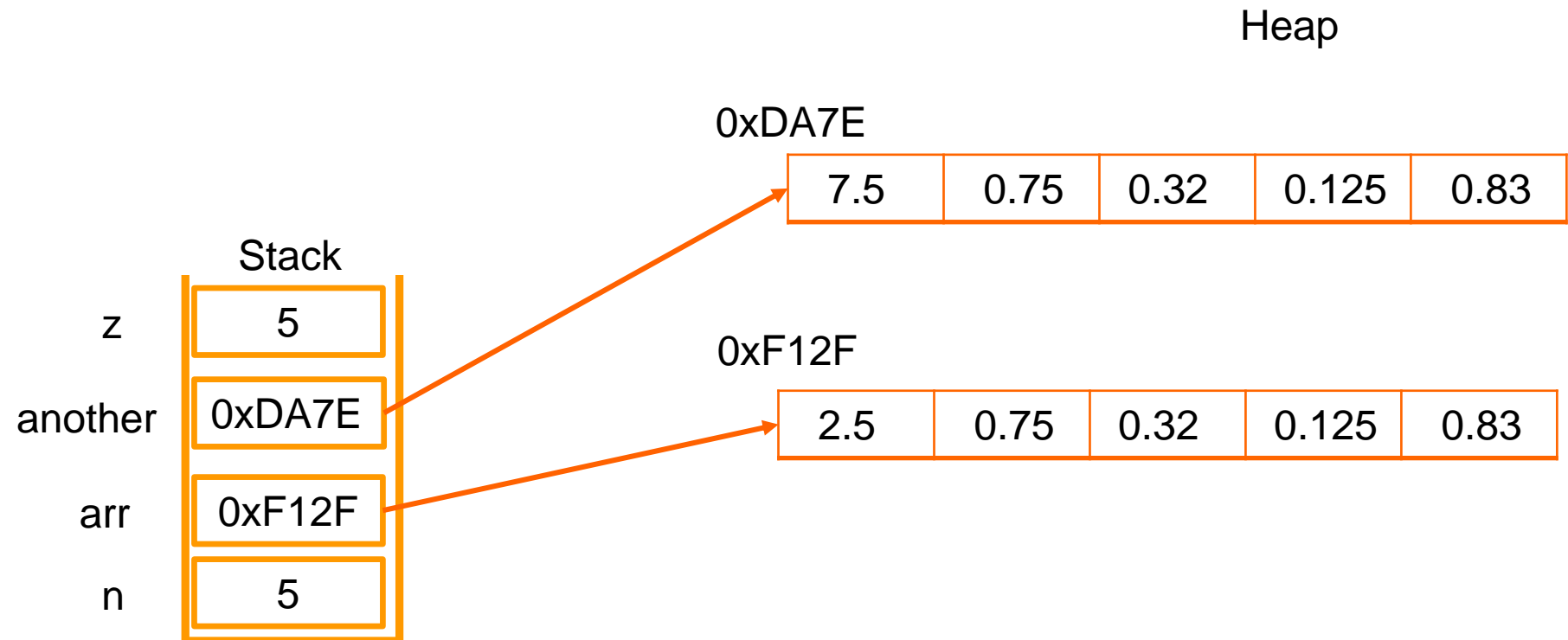
```
System.out.printf("#2 = %.4f %.4f %n", arr[0], another[0]);
```



operator = copies values from/to the stack

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

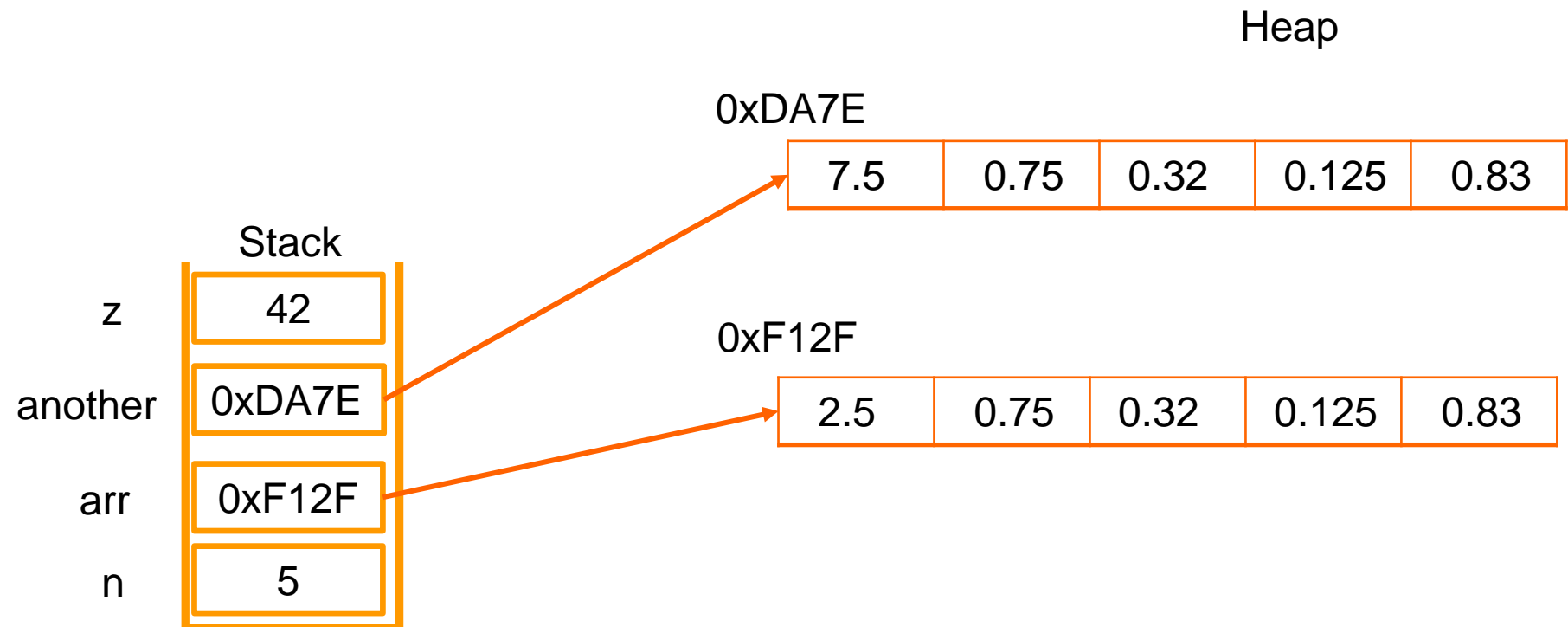
```
int z = n;
```



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

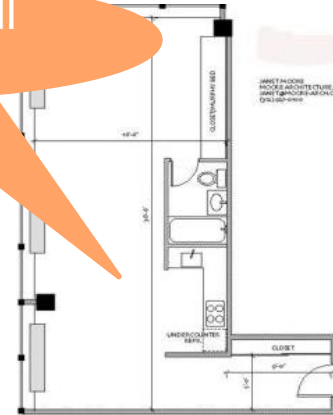
- A class is a definition from which new objects would be created
 - like a blueprint or template
 - defines common properties (variables and methods) that objects of the group would poses
- An object is one instance of a class.



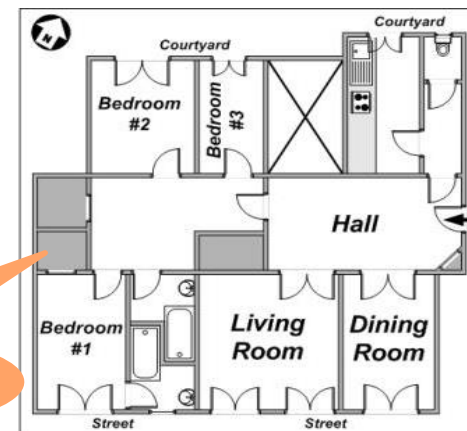
Objects – instances of
SmallApartment

Objects –
instances of
LargeApartment

Class: Small
Apartment



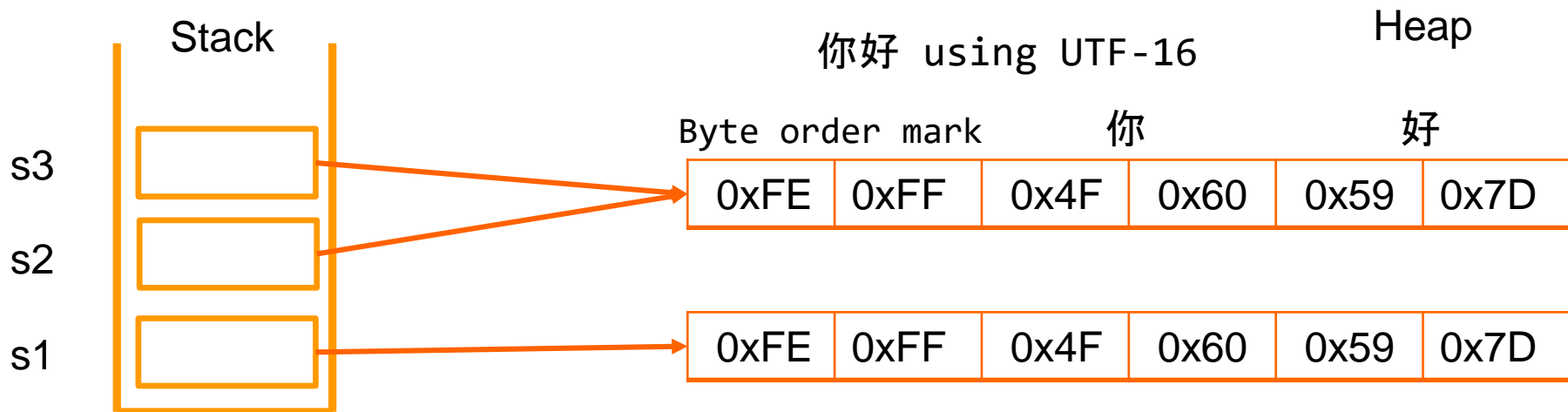
Class: Large
Apartment



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*

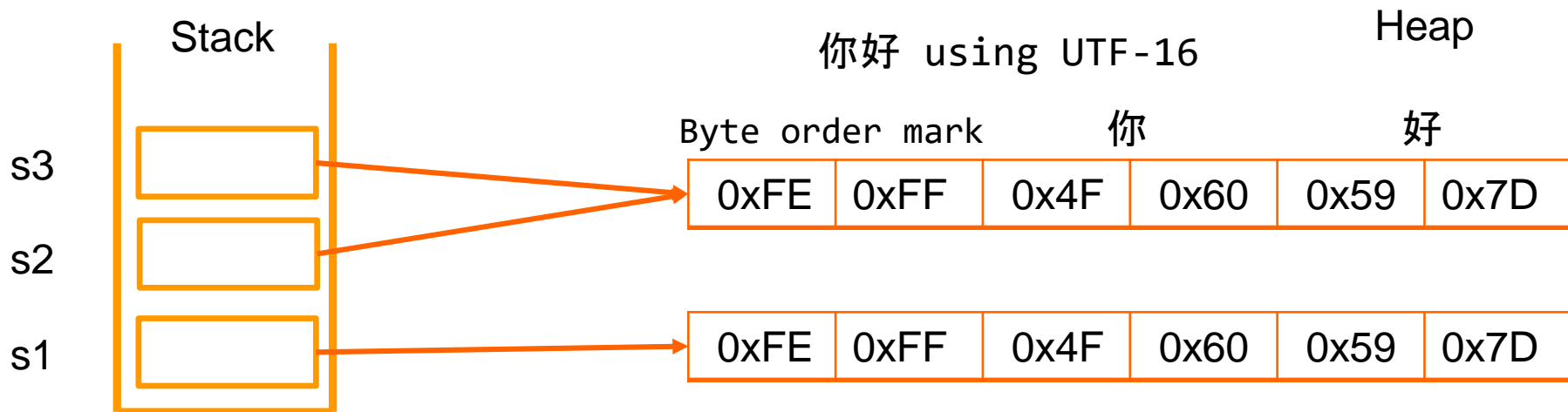
```
String s1 = new String("你好"); //Nǐ hǎo  
String s2 = new String("你好"); //Nǐ hǎo  
String s3 = s2;
```



Comparing strings (1)

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

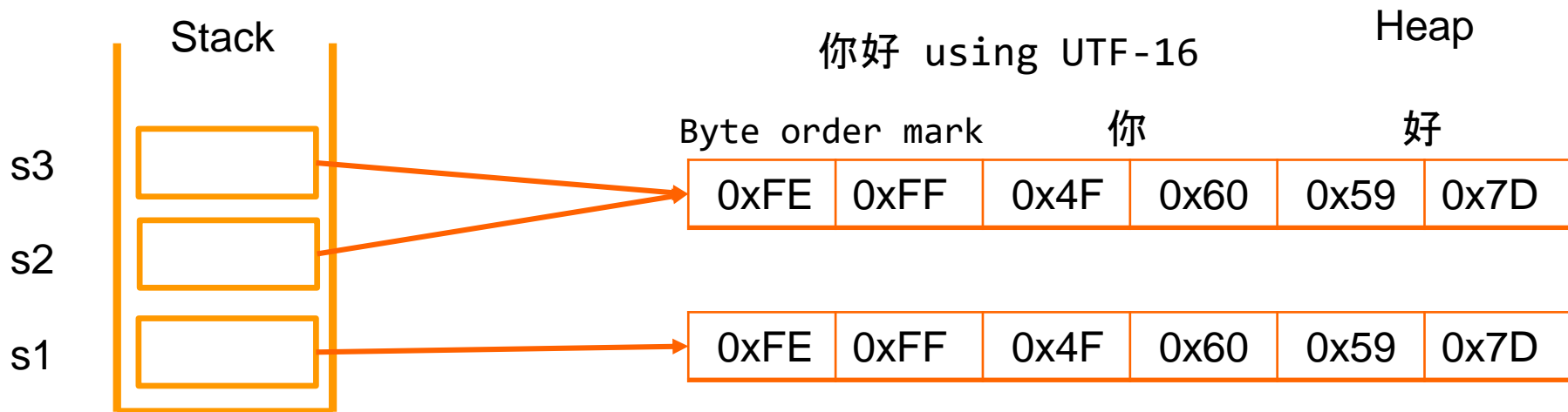
```
String s1 = new String("你好"); //Nǐ hǎo  
String s2 = new String("你好"); //Nǐ hǎo  
String s3 = s2;
```



Comparing strings (2)

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

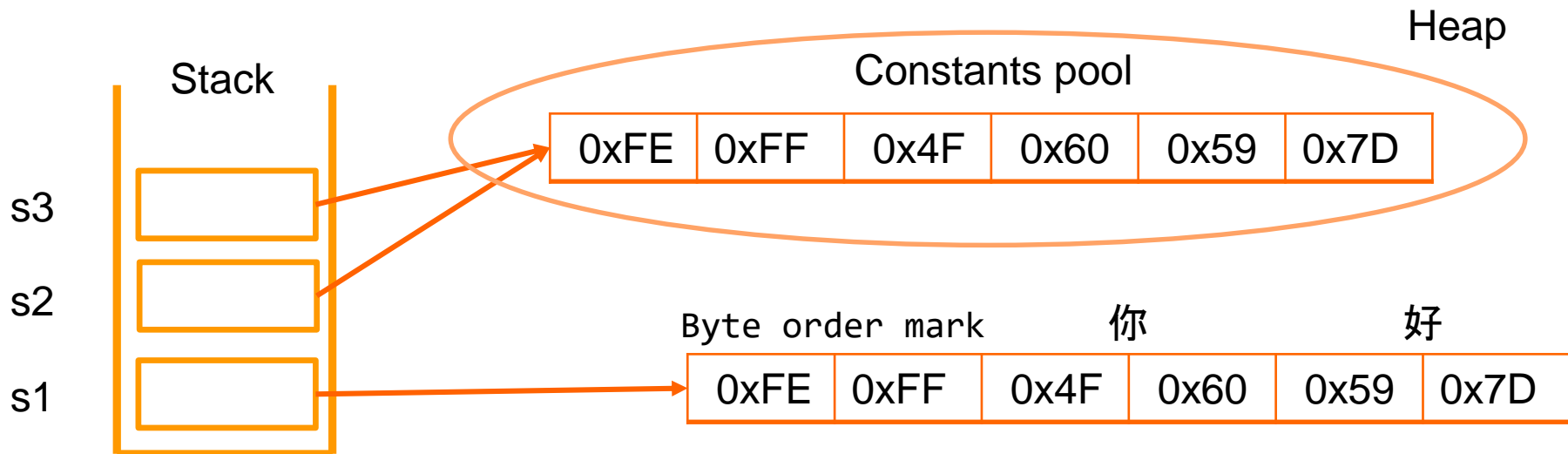
```
String s1 = new String("你好"); //Nǐ hǎo  
String s2 = new String("你好"); //Nǐ hǎo  
String s3 = s2;
```



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*

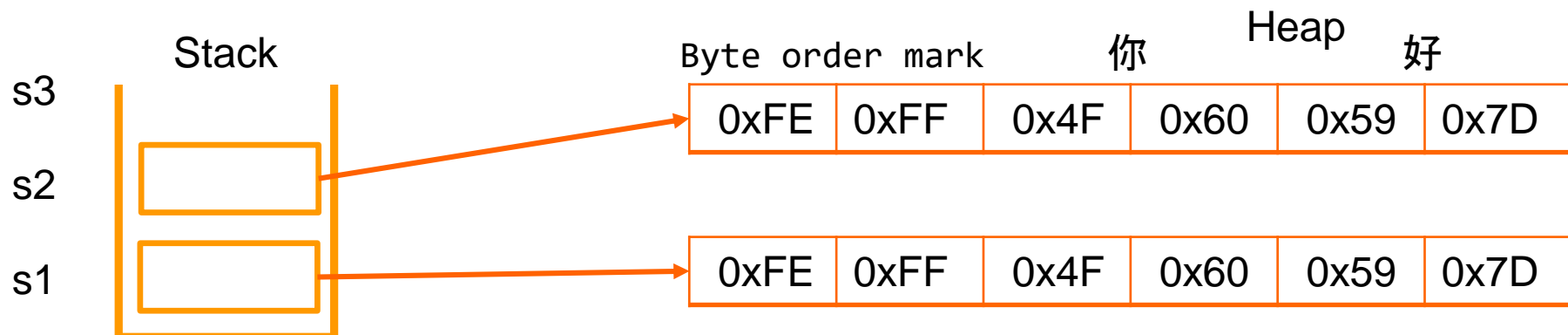
```
String s1 = new String("你好"); //Nǐ hǎo  
String s2 = "你好"; //Nǐ hǎo  
String s3 = "你好";
```



Instance methods

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



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
 - Too 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);
}
```