



Lecture 2

Java SE – Programming

presentation

Java Programming – Software App Development

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Agenda for Lecture 2 – Summary of JSE





Java Standard Edition – Uni- & Multi- dimensional Arrays

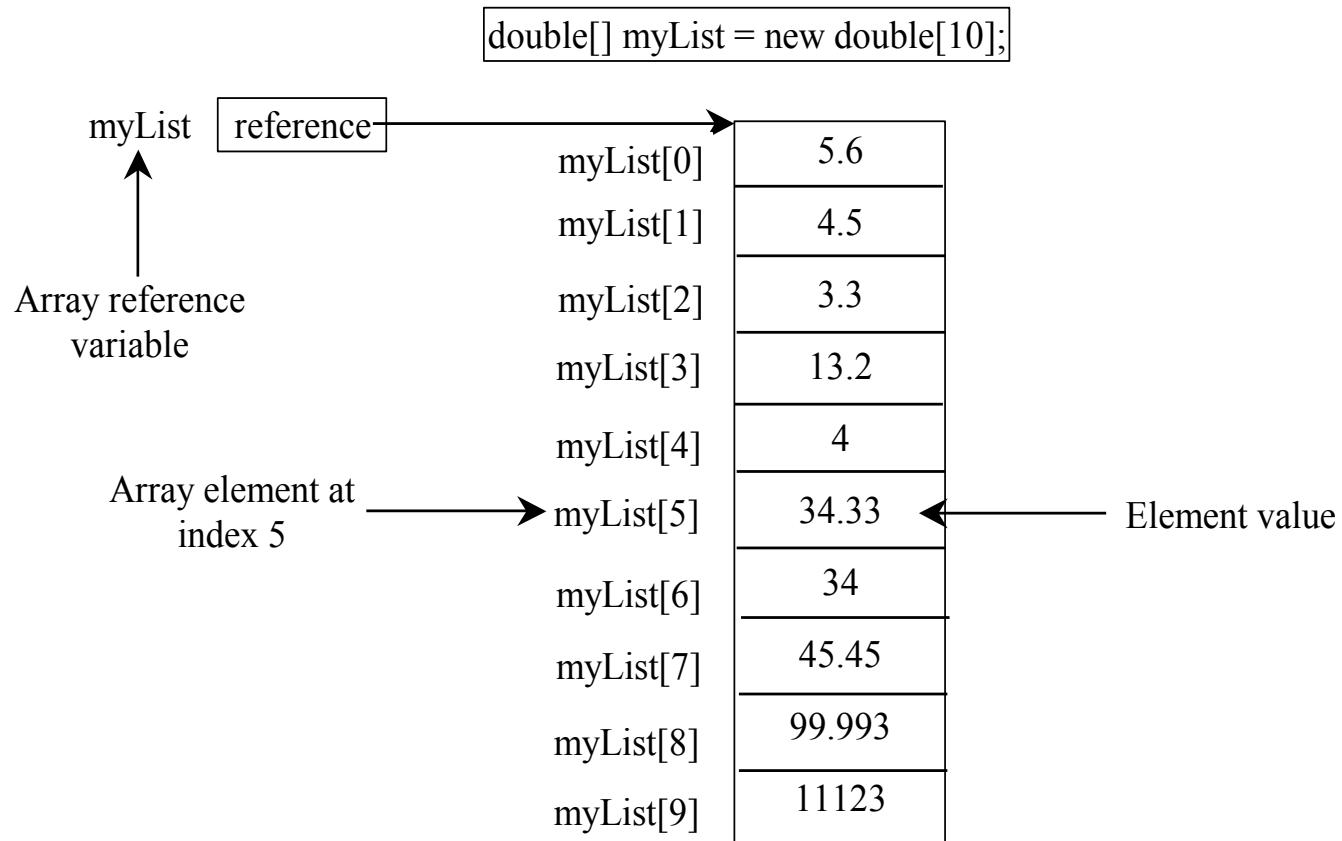
Java Arrays

1.1 Java Arrays – defining and usage

Opening Problem

ASSIGNMENT 03 - Read one hundred numbers, compute their average, and find out how many numbers are above the average.

Array is a data structure that represents a collection of the same types of data.



1.1 Java Arrays – defining and usage

Declaring Array Variables

- `datatype[] arrayRefVar;`

Example: `double[] myList;`

- `datatype arrayRefVar[]; // This style is allowed, but not preferred`

Example: `double myList[];`

Creating Arrays

```
arrayRefVar = new datatype[arraySize];
```

Example:

```
myList = new double[10];
```

`myList[0]` references the first element in the array.

`myList[9]` references the last element in the array.

1.1 Java Arrays – defining and usage

Declaring, creating, initializing Using the Shorthand Notation

```
double[ ] myList = {1.9, 2.9, 3.4, 3.5};
```

This shorthand notation is equivalent to the following statements:

```
double[ ] myList = new double[4];
```

```
myList[0] = 1.9;
```

```
myList[1] = 2.9;
```

```
myList[2] = 3.4;
```

```
myList[3] = 3.5;
```

This shorthand syntax must be in one statement.

1.1 Java Arrays – defining and usage

Printing arrays

```
for (int i = 0; i < myList.length; i++) {  
    System.out.print(myList[i] + " ");  
}
```

Summing all elements

```
double total = 0;  
for (int i = 0; i < myList.length; i++) {  
    total += myList[i];  
}
```

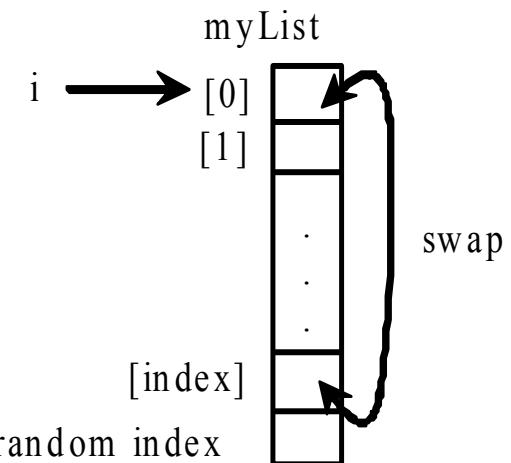
Finding the largest element

```
double max = myList[0];  
for (int i = 1; i < myList.length; i++) {  
    if (myList[i] > max) max = myList[i];  
}
```

1.1 Java Arrays – defining and usage

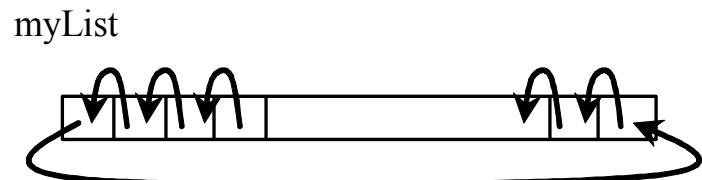
Random shuffling

```
for (int i = 0; i < myList.length; i++) {  
    // Generate an index j randomly  
    int index = (int) (Math.random()  
        * myList.length);  
  
    // Swap myList[i] with myList[j]  
    double temp = myList[i];  
    myList[i] = myList[index];  
    myList[index] = temp;  
}
```



Shifting Elements

```
double temp = myList[0]; // Retain the first element  
  
// Shift elements left  
for (int i = 1; i < myList.length; i++) {  
    myList[i - 1] = myList[i];  
}  
  
// Move the first element to fill in the last position  
myList[myList.length - 1] = temp;
```



1.1 Java Arrays – defining and usage

Enhanced for Loop (for-each loop)

JDK 1.5 introduced a new for loop that enables you to traverse the complete array sequentially without using an index variable. For example, the following code displays all elements in the array *myList*:

```
for (double value : myList)
    System.out.println(value);
```

In general, the syntax is

```
for (elementType value : arrayRefVar) {
    // Process the value
}
```

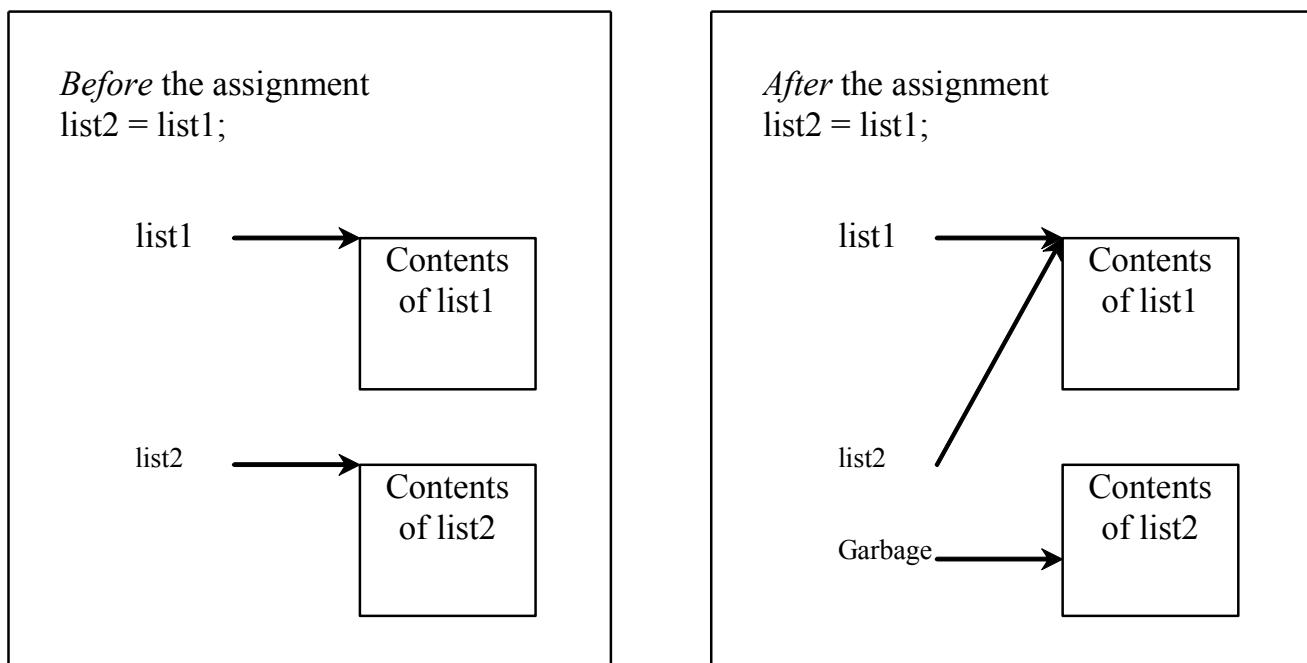
You still have to use an index variable if you wish to traverse the array in a different order or change the elements in the array.

1.1 Java Arrays – defining and usage

Copying Arrays

Often, in a program, you need to duplicate an array or a part of an array. In such cases you could attempt to use the assignment statement (=), as follows:

list2 = list1;



1.1 Java Arrays – defining and usage

Copying Arrays

Using a loop:

```
int[] sourceArray = {2, 3, 1, 5, 10};  
int[] targetArray = new int[sourceArray.length];  
  
for (int i = 0; i < sourceArray.length; i++)  
    targetArray[i] = sourceArray[i];
```

The `arraycopy` Utility

```
arraycopy(sourceArray, src_pos, targetArray, tar_pos,  
length);
```

Example:

```
System.arraycopy(sourceArray, 0, targetArray, 0,  
sourceArray.length);
```

1.1 Java Arrays – defining and usage

Passing Arrays to Methods

```
public static void printArray(int[] array)
{
    for (int i = 0; i < array.length; i++) {
        System.out.print(array[i] + " ");
    }
}
```

Invoke the method

```
int[] list = {3, 1, 2, 6, 4, 2};
printArray(list);
```

Invoke the method

```
printArray(new int[]{3, 1, 2, 6, 4, 2});
```

Anonymous array

1.1 Java Arrays – defining and usage

Pass By Value

Java uses *pass by value* to pass arguments to a method. There are important differences between passing a value of variables of primitive data types and passing arrays.

- For a parameter of a primitive type value, the actual value is passed. Changing the value of the local parameter inside the method does not affect the value of the variable outside the method.
- For a parameter of an array (or reference) type, the value of the parameter contains a reference to an array / object; this reference is passed to the method. Any changes to the array / object that occur inside the method body will affect the original array / object that was passed as the argument.

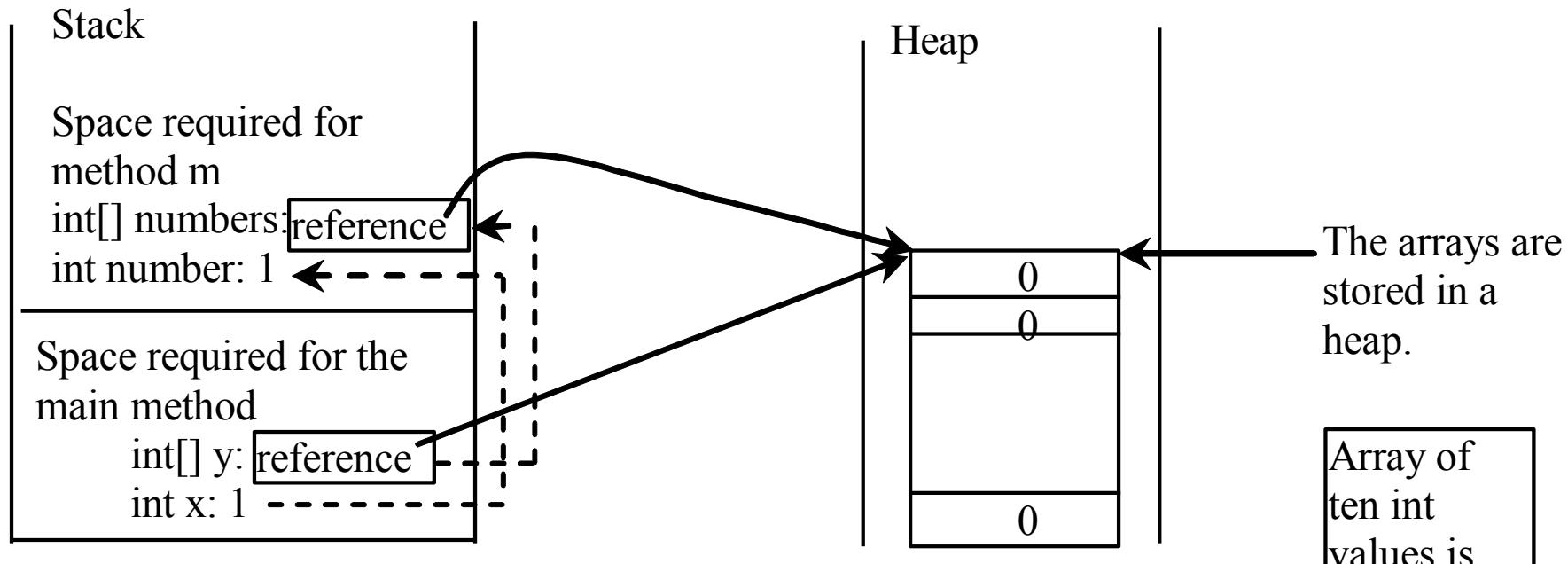
1.1 Java Arrays – defining and usage

Simple Example – Pass by Value

```
public class Test {  
    public static void main(String[] args) {  
        int x = 1; // x represents an int value  
        int[] y = new int[10]; // y represents an array of int  
        values  
  
        m(x, y); // Invoke m with arguments x and y  
  
        System.out.println("x is " + x);  
        System.out.println("y[0] is " + y[0]);  
    }  
  
    public static void m(int number, int[] numbers) {  
        number = 1001; // Assign a new value to number  
        numbers[0] = 5555; // Assign a new value to numbers[0]  
    }  
}
```

1.1 Java Arrays – defining and usage

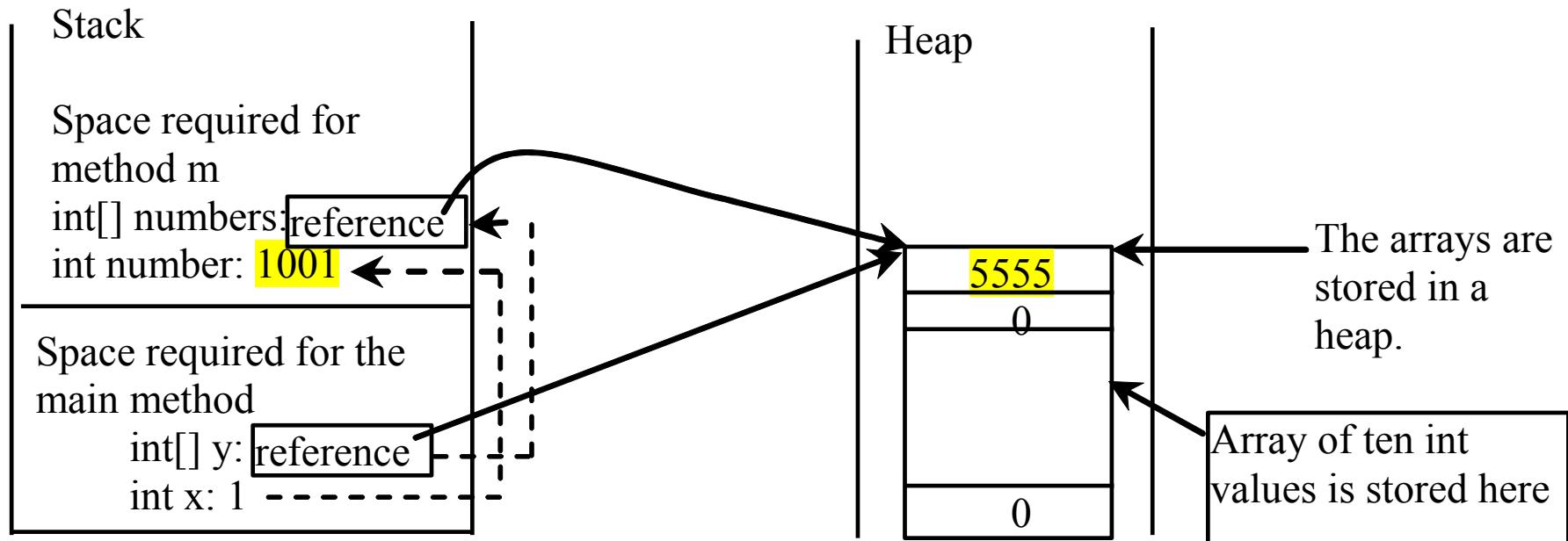
Call Stack – Pass by Value



When invoking `m(x, y)`, the values of `x` and `y` are passed to number and numbers. Since `y` contains the reference value to the array, numbers now contains the same reference value to the same array.

1.1 Java Arrays – defining and usage

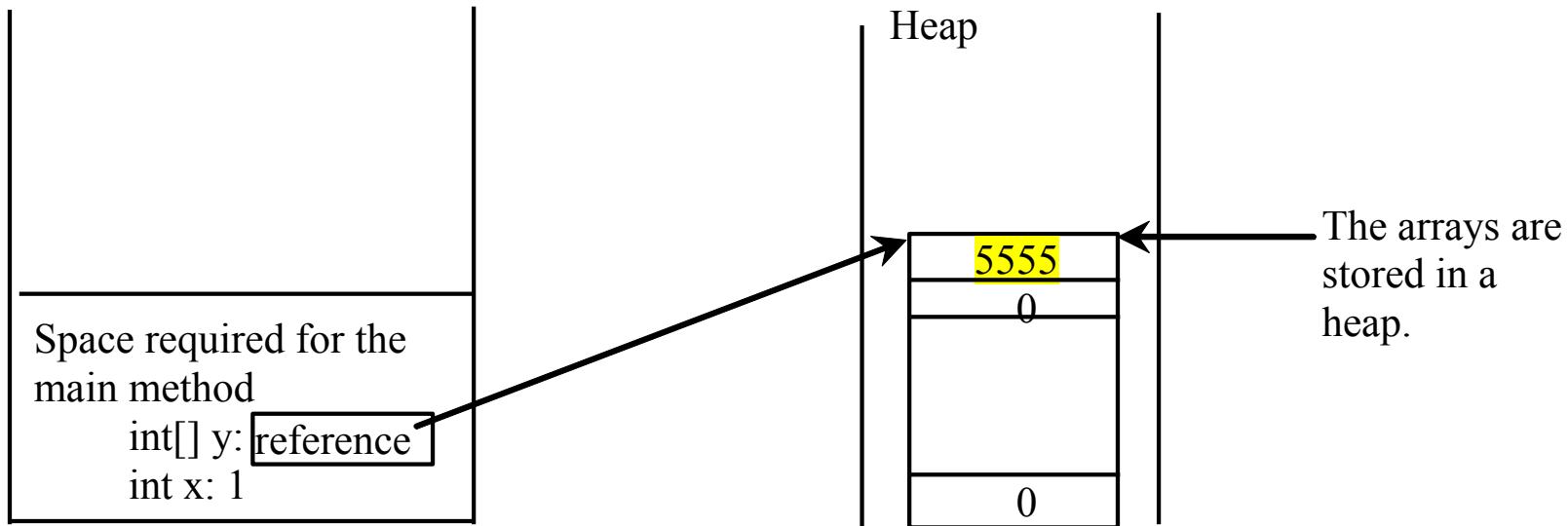
Call Stack – Pass by Value



When invoking `m(x, y)`, the values of `x` and `y` are passed to number and numbers. Since `y` contains the reference value to the array, numbers now contains the same reference value to the same array.

1.1 Java Arrays – defining and usage

Heap – Pass by Value



The JVM stores the array in an area of memory, called *heap*, which is used for dynamic memory allocation where blocks of memory are allocated and freed in an arbitrary order.

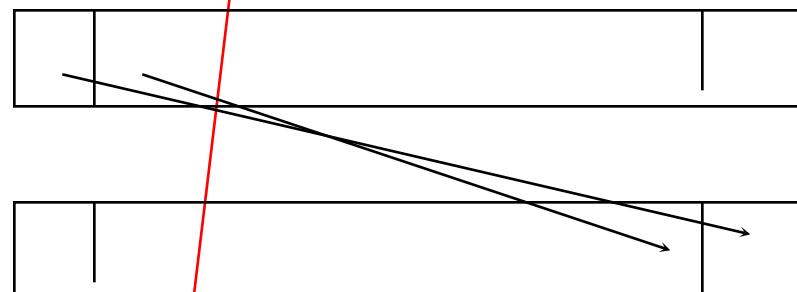
1.1 Java Arrays – defining and usage

Returning an Array from a Method

```
public static int[] reverse(int[] list) {  
    int[] result = new int[list.length];  
  
    for (int i = 0, j = result.length - 1;  
         i < list.length; i++, j--) {  
        result[j] = list[i];  
    }  
  
    return result;  
}
```

list

result



```
int[] list1 = new int[]{1, 2, 3, 4, 5, 6};  
int[] list2 = reverse(list1);
```

1.1 Java Arrays – Trace the reverse Method

```
int[] list1 = {1, 2, 3, 4, 5, 6};  
int[] list2 = reverse(list1);
```

```
public static int[] reverse(int[] list) {  
    int[] result = new int[list.length];  
  
    for (int i = 0, j = result.length - 1;  
         i < list.length; i++, j--) {  
        result[j] = list[i];  
    }  
  
    return result;  
}
```

Declare result and create array

list

1	2	3	4	5	6
---	---	---	---	---	---

result

0	0	0	0	0	0
---	---	---	---	---	---

1.1 Java Arrays – Trace the reverse Method

```
int[] list1 = new int[]{1, 2, 3, 4, 5, 6};  
int[] list2 = reverse(list1);
```

```
public static int[] reverse(int[] list) {  
    int[] result = new int[list.length];  
  
    for (int i = 0, j = result.length - 1;  
         i < list.length; i++, j--) {  
        result[j] = list[i];  
    }  
  
    return result;  
}
```

i = 0 and j = 5

list

1	2	3	4	5	6
---	---	---	---	---	---

result

0	0	0	0	0	0
---	---	---	---	---	---

1.1 Java Arrays – Trace the reverse Method

```
int[] list1 = new int[]{1, 2, 3, 4, 5, 6};  
int[] list2 = reverse(list1);
```

```
public static int[] reverse(int[] list) {  
    int[] result = new int[list.length];  
  
    for (int i = 0, j = result.length - 1;  
         i < list.length; i++, j--) {  
        result[j] = list[i];  
    }  
  
    return result;  
}
```

i (= 0) is less than 6

list

1	2	3	4	5	6
---	---	---	---	---	---

result

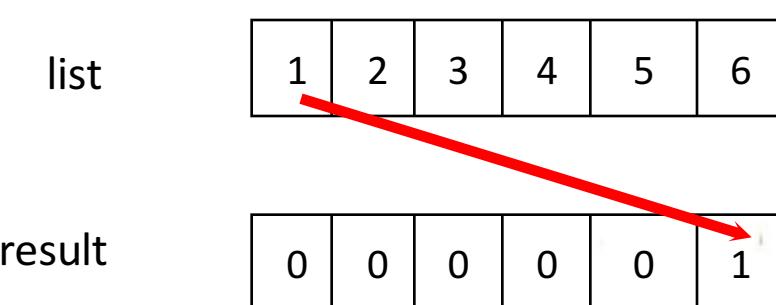
0	0	0	0	0	0
---	---	---	---	---	---

1.1 Java Arrays – Trace the reverse Method

```
int[] list1 = new int[]{1, 2, 3, 4, 5, 6};  
int[] list2 = reverse(list1);
```

```
public static int[] reverse(int[] list) {  
    int[] result = new int[list.length];  
  
    for (int i = 0, j = result.length - 1;  
         i < list.length; i++, j--) {  
        result[j] = list[i];  
    }  
  
    return result;  
}
```

i = 0 and j = 5
Assign list[0] to result[5]



1.1 Java Arrays – Trace the reverse Method

```
int[] list1 = new int[]{1, 2, 3, 4, 5, 6};  
int[] list2 = reverse(list1);
```

```
public static int[] reverse(int[] list) {  
    int[] result = new int[list.length];  
  
    for (int i = 0, j = result.length - 1;  
         i < list.length; i++, j--) {  
        result[j] = list[i];  
    }  
  
    return result;  
}
```

After this, i becomes 1 and j becomes 4

list

1	2	3	4	5	6
---	---	---	---	---	---

result

0	0	0	0	0	1
---	---	---	---	---	---

1.5 Java Arrays – Trace the reverse Method

```
int[] list1 = new int[]{1, 2, 3, 4, 5, 6};  
int[] list2 = reverse(list1);
```

```
public static int[] reverse(int[] list) {  
    int[] result = new int[list.length];  
  
    for (int i = 0, j = result.length - 1;  
         i < list.length; i++, j--) {  
        result[j] = list[i];  
    }  
  
    return result;  
}
```

i (=1) is less than 6

list

1	2	3	4	5	6
---	---	---	---	---	---

result

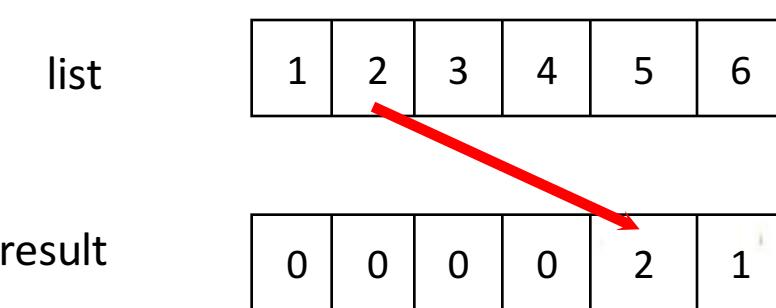
0	0	0	0	0	1
---	---	---	---	---	---

1.1 Java Arrays – Trace the reverse Method

```
int[] list1 = new int[]{1, 2, 3, 4, 5, 6};  
int[] list2 = reverse(list1);
```

```
public static int[] reverse(int[] list) {  
    int[] result = new int[list.length];  
  
    for (int i = 0, j = result.length - 1;  
         i < list.length; i++, j--) {  
        result[j] = list[i];  
    }  
  
    return result;  
}
```

i = 1 and j = 4
Assign list[1] to result[4]



1.1 Java Arrays – Trace the reverse Method

```
int[] list1 = new int[]{1, 2, 3, 4, 5, 6};  
int[] list2 = reverse(list1);
```

```
public static int[] reverse(int[] list) {  
    int[] result = new int[list.length];  
  
    for (int i = 0, j = result.length - 1;  
         i < list.length; i++, j--) {  
        result[j] = list[i];  
    }  
  
    return result;  
}
```

After this, i becomes 2 and
j becomes 3

list

1	2	3	4	5	6
---	---	---	---	---	---

result

0	0	0	0	2	1
---	---	---	---	---	---

1.1 Java Arrays – Trace the reverse Method

```
int[] list1 = new int[]{1, 2, 3, 4, 5, 6};  
int[] list2 = reverse(list1);
```

```
public static int[] reverse(int[] list) {  
    int[] result = new int[list.length];  
  
    for (int i = 0, j = result.length - 1;  
         i < list.length; i++, j--) {  
        result[j] = list[i];  
    }  
  
    return result;  
}
```

i (=2) is still less than 6

list

1	2	3	4	5	6
---	---	---	---	---	---

result

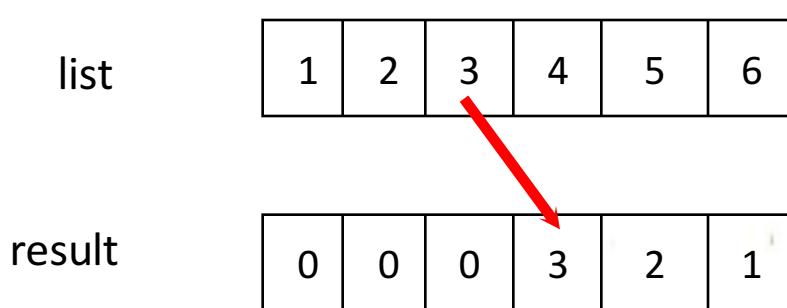
0	0	0	0	2	1
---	---	---	---	---	---

1.1 Java Arrays – Trace the reverse Method

```
int[] list1 = new int[]{1, 2, 3, 4, 5, 6};  
int[] list2 = reverse(list1);
```

```
public static int[] reverse(int[] list) {  
    int[] result = new int[list.length];  
  
    for (int i = 0, j = result.length - 1;  
         i < list.length; i++, j--) {  
        result[j] = list[i];  
    }  
  
    return result;  
}
```

i = 2 and j = 3
Assign list[i] to result[j]



1.1 Java Arrays – Trace the reverse Method

```
int[] list1 = new int[]{1, 2, 3, 4, 5, 6};  
int[] list2 = reverse(list1);
```

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public static int[] reverse(int[] list) {  
    int[] result = new int[list.length];  
  
    for (int i = 0, j = result.length - 1;  
         i < list.length; i++, j--) {  
        result[j] = list[i];  
    }  
  
    return result;  
}
```

After this, i becomes 3 and
j becomes 2

list

1	2	3	4	5	6
---	---	---	---	---	---

result

0	0	0	3	2	1
---	---	---	---	---	---

1.1 Java Arrays – Trace the reverse Method

```
int[] list1 = new int[]{1, 2, 3, 4, 5, 6};  
int[] list2 = reverse(list1);
```

```
public static int[] reverse(int[] list) {  
    int[] result = new int[list.length];  
  
    for (int i = 0, j = result.length - 1;  
         i < list.length; i++, j--) {  
        result[j] = list[i];  
    }  
  
    return result;  
}
```

i (=3) is still less than 6

list

1	2	3	4	5	6
---	---	---	---	---	---

result

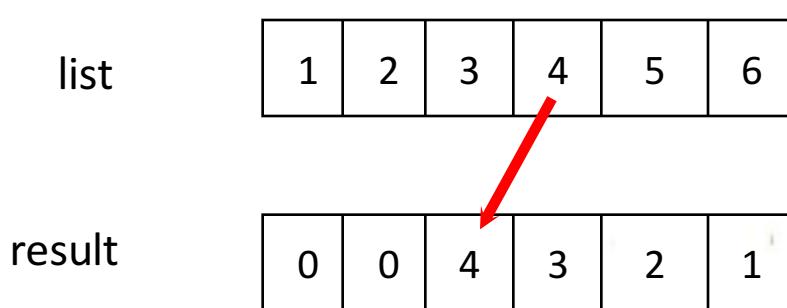
0	0	0	3	2	1
---	---	---	---	---	---

1.1 Java Arrays – Trace the reverse Method

```
int[] list1 = new int[]{1, 2, 3, 4, 5, 6};  
int[] list2 = reverse(list1);
```

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public static int[] reverse(int[] list) {  
    int[] result = new int[list.length];  
  
    for (int i = 0, j = result.length - 1;  
         i < list.length; i++, j--) {  
        result[j] = list[i];  
    }  
  
    return result;  
}
```

i = 3 and j = 2
Assign list[i] to result[j]



1.1 Java Arrays – Trace the reverse Method

```
int[] list1 = new int[]{1, 2, 3, 4, 5, 6};  
int[] list2 = reverse(list1);
```

```
public static int[] reverse(int[] list) {  
    int[] result = new int[list.length];  
  
    for (int i = 0, j = result.length - 1;  
         i < list.length; i++, j--) {  
        result[j] = list[i];  
    }  
  
    return result;  
}
```

After this, i becomes 4 and
j becomes 1

list

1	2	3	4	5	6
---	---	---	---	---	---

result

0	0	4	3	2	1
---	---	---	---	---	---

1.1 Java Arrays – Trace the reverse Method

```
int[] list1 = new int[]{1, 2, 3, 4, 5, 6};  
int[] list2 = reverse(list1);
```

```
public static int[] reverse(int[] list) {  
    int[] result = new int[list.length];  
  
    for (int i = 0, j = result.length - 1;  
         i < list.length; i++, j--) {  
        result[j] = list[i];  
    }  
  
    return result;  
}
```

i (=4) is still less than 6

list

1	2	3	4	5	6
---	---	---	---	---	---

result

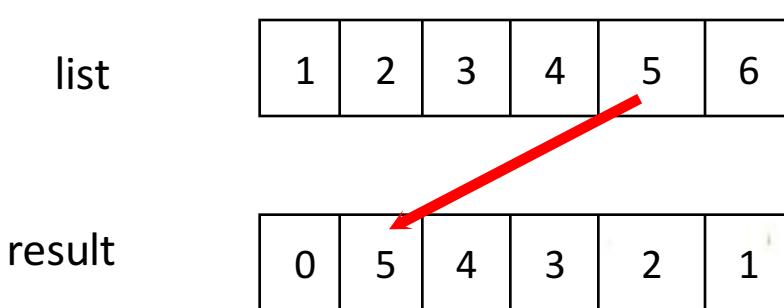
0	0	4	3	2	1
---	---	---	---	---	---

1.1 Java Arrays – Trace the reverse Method

```
int[] list1 = new int[]{1, 2, 3, 4, 5, 6};  
int[] list2 = reverse(list1);
```

```
public static int[] reverse(int[] list) {  
    int[] result = new int[list.length];  
  
    for (int i = 0, j = result.length - 1;  
         i < list.length; i++, j--) {  
        result[j] = list[i];  
    }  
  
    return result;  
}
```

i = 4 and j = 1
Assign list[i] to result[j]



1.1 Java Arrays – Trace the reverse Method

```
int[] list1 = new int[]{1, 2, 3, 4, 5, 6};  
int[] list2 = reverse(list1);
```

```
public static int[] reverse(int[] list) {  
    int[] result = new int[list.length];  
  
    for (int i = 0, j = result.length - 1;  
         i < list.length; i++, j--) {  
        result[j] = list[i];  
    }  
  
    return result;  
}
```

After this, i becomes 5 and
j becomes 0

list

1	2	3	4	5	6
---	---	---	---	---	---

result

0	5	4	3	2	1
---	---	---	---	---	---

1.1 Java Arrays – Trace the reverse Method

```
int[] list1 = new int[]{1, 2, 3, 4, 5, 6};  
int[] list2 = reverse(list1);
```

```
public static int[] reverse(int[] list) {  
    int[] result = new int[list.length];  
  
    for (int i = 0, j = result.length - 1;  
         i < list.length; i++, j--) {  
        result[j] = list[i];  
    }  
  
    return result;  
}
```

i (=5) is still less than 6

list

1	2	3	4	5	6
---	---	---	---	---	---

result

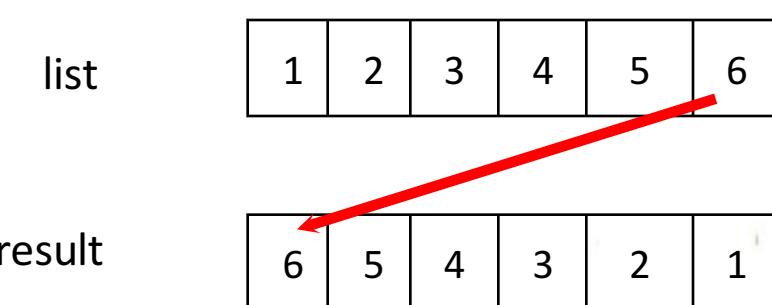
0	5	4	3	2	1
---	---	---	---	---	---

1.1 Java Arrays – Trace the reverse Method

```
int[] list1 = new int[]{1, 2, 3, 4, 5, 6};  
int[] list2 = reverse(list1);
```

```
public static int[] reverse(int[] list) {  
    int[] result = new int[list.length];  
  
    for (int i = 0, j = result.length - 1;  
         i < list.length; i++, j--) {  
        result[j] = list[i];  
    }  
  
    return result;  
}
```

i = 5 and j = 0
Assign list[i] to result[j]



1.1 Java Arrays – Trace the reverse Method

```
int[] list1 = new int[]{1, 2, 3, 4, 5, 6};  
int[] list2 = reverse(list1);
```

```
public static int[] reverse(int[] list) {  
    int[] result = new int[list.length];  
  
    for (int i = 0, j = result.length - 1;  
         i < list.length; i++, j--) {  
        result[j] = list[i];  
    }  
  
    return result;  
}
```

After this, i becomes 6 and
j becomes -1

list

1	2	3	4	5	6
---	---	---	---	---	---

result

6	5	4	3	2	1
---	---	---	---	---	---

1.1 Java Arrays – Trace the reverse Method

```
int[] list1 = new int[]{1, 2, 3, 4, 5, 6};  
int[] list2 = reverse(list1);
```

```
public static int[] reverse(int[] list) {  
    int[] result = new int[list.length];  
  
    for (int i = 0, j = result.length - 1;  
         i < list.length; i++, j--) {  
        result[j] = list[i];  
    }  
  
    return result;  
}
```

i (=6) < 6 is false. So exit the loop.

list

1	2	3	4	5	6
---	---	---	---	---	---

result

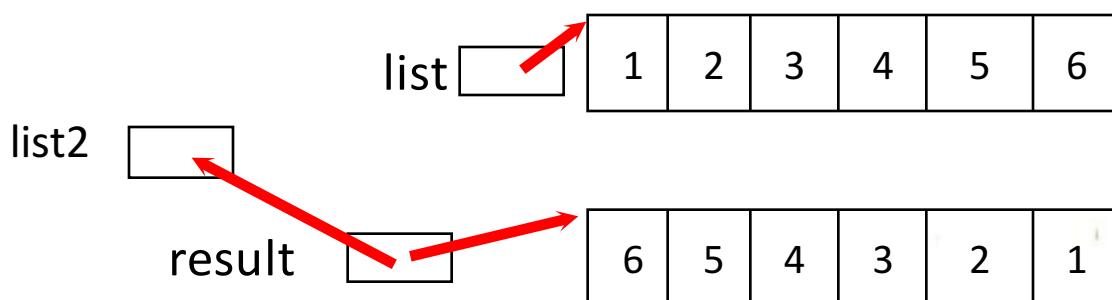
6	5	4	3	2	1
---	---	---	---	---	---

1.1 Java Arrays – Trace the reverse Method

```
int[] list1 = new int[]{1, 2, 3, 4, 5, 6};  
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```

```
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    for (int i = 0, j = result.length - 1;  
         i < list.length; i++, j--) {  
        result[j] = list[i];  
    }  
  
    return result;  
}
```

Return result

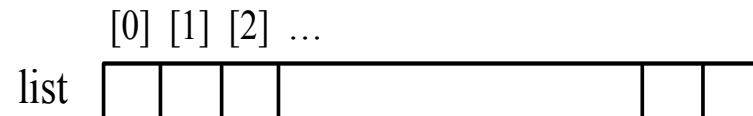


1.1 Java Arrays

Searching Arrays

Searching is the process of looking for a specific element in an array; for example, discovering whether a certain score is included in a list of scores. Searching is a common task in computer programming. There are many algorithms and data structures devoted to searching. In this section, two commonly used approaches are discussed, *linear search* and *binary search*.

```
public class LinearSearch {  
    /** The method for finding a key in the list */  
    public static int linearSearch(int[] list, int key) {  
        for (int i = 0; i < list.length; i++)  
            if (key == list[i])  
                return i;  
        return -1;  
    }  
}
```



key Compare key with list[i] for i = 0, 1, ...

1.1 Java Arrays

Linear Search

The linear search approach compares the key element, key, *sequentially* with each element in the array list. The method continues to do so until the key matches an element in the list or the list is exhausted without a match being found. If a match is made, the linear search returns the index of the element in the array that matches the key. If no match is found, the search returns -1.

1.1 Java Arrays

Linear Search Animation

Key

List

3

6	4	1	9	7	3	2	8
---	---	---	---	---	---	---	---

3

6	4	1	9	7	3	2	8
---	---	---	---	---	---	---	---

3

6	4	1	9	7	3	2	8
---	---	---	---	---	---	---	---

3

6	4	1	9	7	3	2	8
---	---	---	---	---	---	---	---

3

6	4	1	9	7	3	2	8
---	---	---	---	---	---	---	---

3

6	4	1	9	7	3	2	8
---	---	---	---	---	---	---	---

1.1 Java Arrays

From Idea to Solution – Linear Search

```
/** The method for finding a key in the list */
public static int linearSearch(int[] list, int key) {
    for (int i = 0; i < list.length; i++)
        if (key == list[i])
            return i;
    return -1;
}
```

Trace the method

```
int[] list = {1, 4, 4, 2, 5, -3, 6, 2};
int i = linearSearch(list, 4); // returns 1
int j = linearSearch(list, -4); // returns -1
int k = linearSearch(list, -3); // returns 5
```

1.1 Java Arrays

Binary Search

For binary search to work, the elements in the array **must already be ordered (SORTED)**. Without loss of generality, assume that the array is in ascending order.

e.g., 2 4 7 10 11 45 50 59 60 66 69 70 79

The binary search first compares the key with the element in the middle of the array.

For objects / references a Comparable<E> interface must be implemented in class E.

Binary Search, cont.

Consider the following three cases:

- If the key is less than the middle element, you only need to search the key in the first half of the array.
- If the key is equal to the middle element, the search ends with a match.
- If the key is greater than the middle element, you only need to search the key in the second half of the array.

1.1 Java Arrays

Binary Search

Key

List

8

1	2	3	4	6	7	8	9
---	---	---	---	---	---	---	---

8

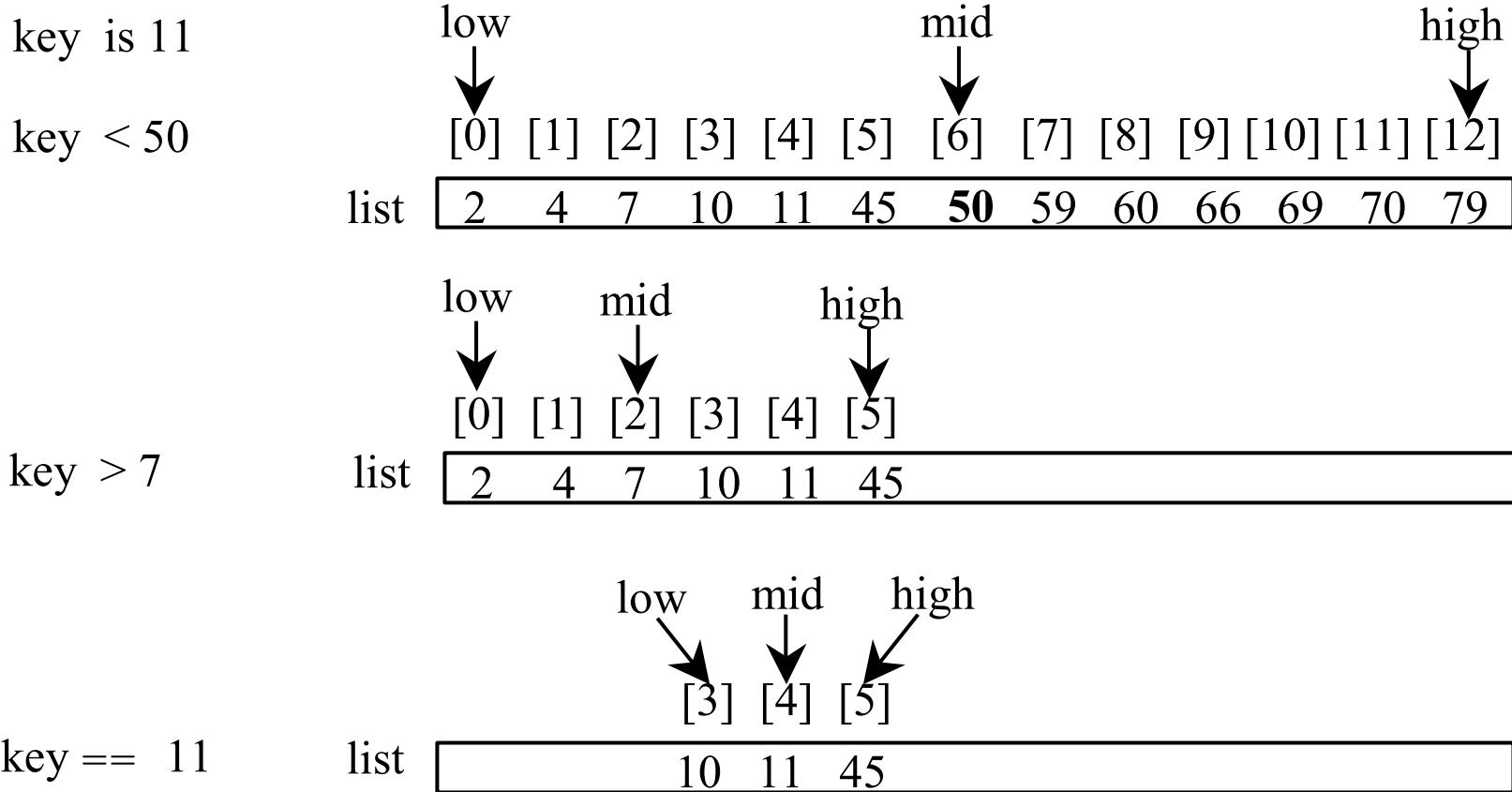
1	2	3	4	6	7	8	9
---	---	---	---	---	---	---	---

8

1	2	3	4	6	7	8	9
---	---	---	---	---	---	---	---

1.1 Java Arrays

Binary Search, cont.



1.1 Java Arrays

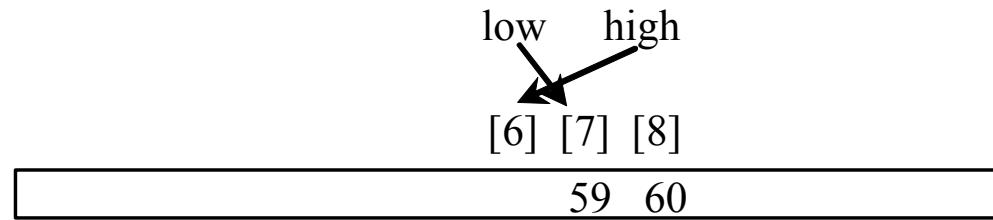
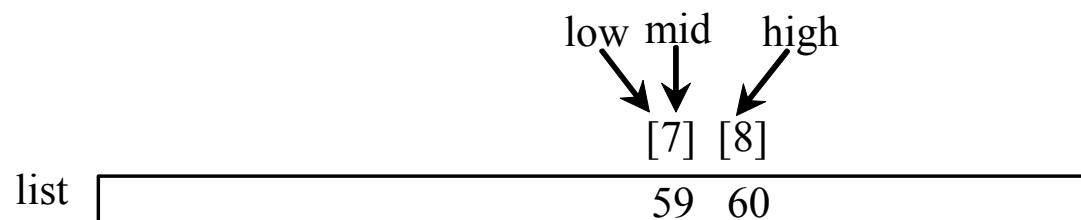
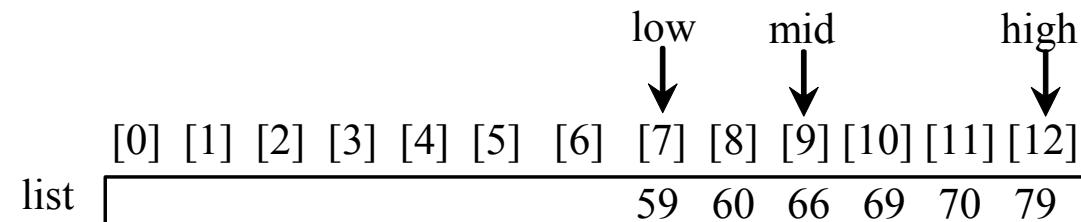
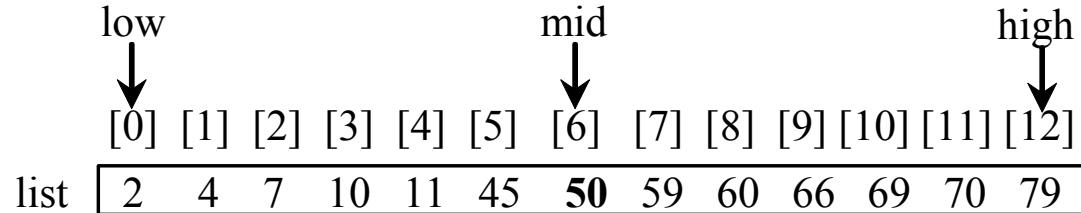
Binary Search, cont.

key is 54

key > 50

key < 66

key < 59



1.1 Java Arrays

Binary Search, cont.

The binarySearch method returns the index of the element in the list that matches the search key if it is contained in the list. Otherwise, it returns

-insertion point - 1.

The insertion point is the point at which the key would be inserted into the list.

1.1 Java Arrays

From Idea to Solution – Binary Search

```
/** Use binary search to find the key in the list */
public static int binarySearch(int[] list, int key) {
    int low = 0;
    int high = list.length - 1;

    while (high >= low) {
        int mid = (low + high) / 2;
        if (key < list[mid])
            high = mid - 1;
        else if (key == list[mid])
            return mid;
        else
            low = mid + 1;
    }

    return -1 - low;
}
```

1.1 Java Arrays

The **Arrays.binarySearch** Method

Since binary search is frequently used in programming, Java provides several overloaded `binarySearch` methods for searching a key in an array of `int`, `double`, `char`, `short`, `long`, and `float` in the `java.util.Arrays` class. For example, the following code searches the keys in an array of numbers and an array of characters.

```
int[] list = {2, 4, 7, 10, 11, 45, 50, 59, 60, 66, 69, 70, 79};  
System.out.println("Index is " +  
    java.util.Arrays.binarySearch(list, 11));
```

Return is 4

```
char[] chars = {'a', 'c', 'g', 'x', 'y', 'z'};  
System.out.println("Index is " +  
    java.util.Arrays.binarySearch(chars, 't'));
```

Return is -4 (insertion point is
3, so return is -3-1)

For the `binarySearch` method to work, the array must be pre-sorted in increasing order.

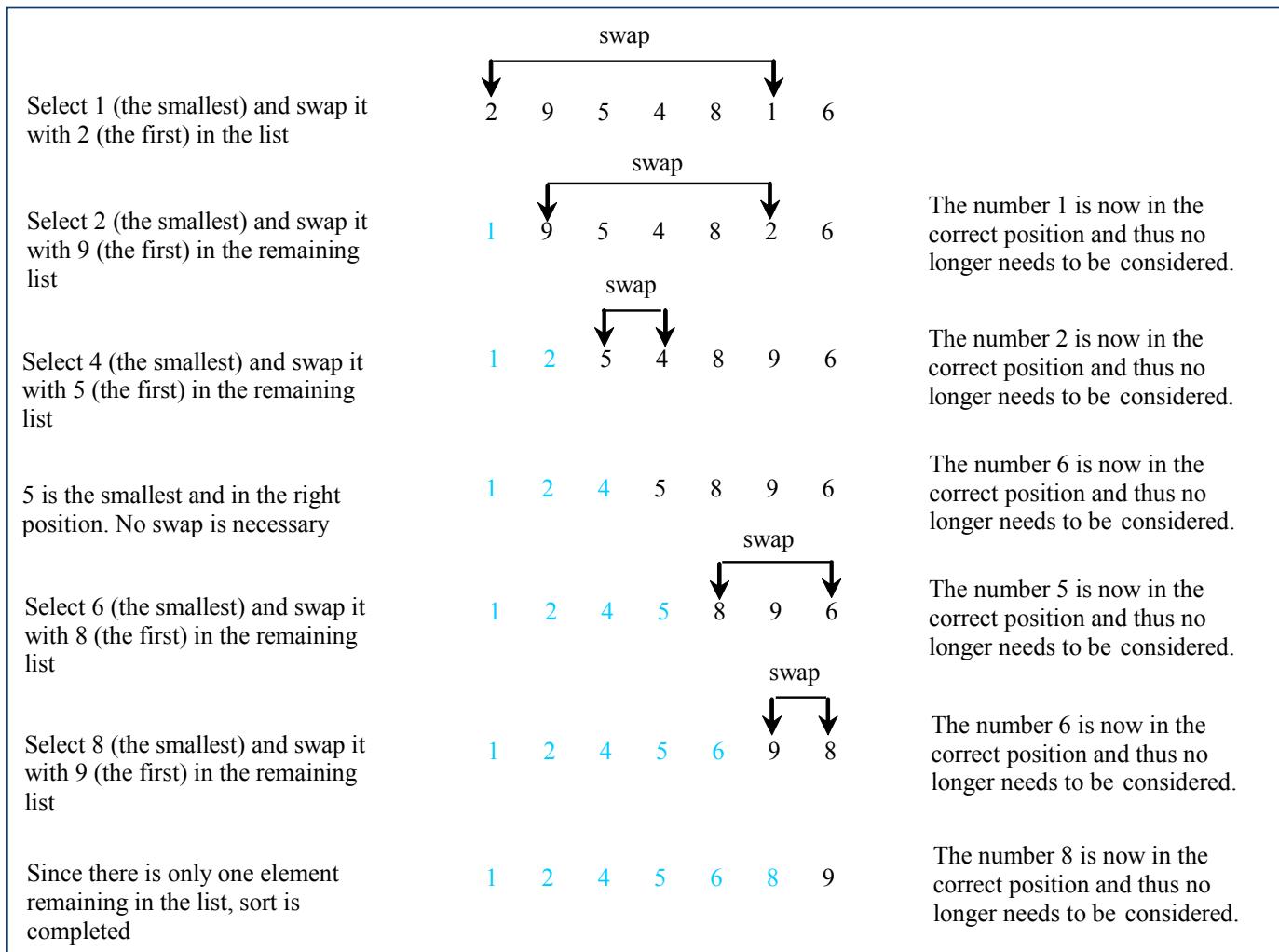
1.1 Java Arrays

Sorting Arrays

Sorting, like searching, is also a common task in computer programming. Many different algorithms have been developed for sorting. Mainly are used two simple, intuitive sorting algorithms: *selection sort* and *insertion sort*.

1.1 Java Arrays – Selection Sort

Selection sort finds the largest number in the list and places it last. It then finds the largest number remaining and places it next to last, and so on until the list contains only a single number. Figure shows how to sort the list {2, 9, 5, 4, 8, 1, 6} using selection sort.



1.1 Java Arrays – Selection Sort

From Idea to Solution - Selection Sort

```
for (int i = 0; i < list.length; i++)  
{  
    select the smallest element in list[i..listSize-1];  
    swap the smallest with list[i], if necessary;  
    // list[i] is in its correct position.  
    // The next iteration apply on list[i..listSize-1]  
}
```

list[0] list[1] list[2] list[3] ... list[10]

...

list[0] list[1] list[2] list[3] ... list[10]

1.5 Java Arrays – Selection Sort

```
for (int i = 0; i < listSize; i++)  
{  
    select the smallest element in list[i..listSize-1];  
    swap the smallest with list[i], if necessary;  
    // list[i] is in its correct position.  
    // The next iteration apply on list[i..listSize-1]  
}
```

Expand

```
double currentMin = list[i];  
  
for (int j = i; j < list.length; j++) {  
    if (currentMin > list[j]) {  
        currentMin = list[j];  
    }  
}
```

1.1 Java Arrays – Selection Sort

```
for (int i = 0; i < listSize; i++)  
{  
    select the smallest element in list[i..listSize-1];  
    swap the smallest with list[i], if necessary;  
    //list[i] is in its correct position.  
    //The next iteration apply on list[i..listSize-1]  
}
```

Expand

```
double currentMin = list[i];  
int currentMinIndex = i;  
for (int j = i; j < list.length; j++) {  
    if (currentMin > list[j]) {  
        currentMin = list[j];  
        currentMinIndex = j;  
    }  
}
```

1.1 Java Arrays – Selection Sort

```
for (int i = 0; i < listSize; i++)  
{  
    select the smallest element in list[i..listSize-1];  
    swap the smallest with list[i], if necessary;  
    //list[i] is in its correct position.  
    //The next iteration apply on list[i..listSize-1]  
}
```

Expand



```
if (currentMinIndex != i) {  
    list[currentMinIndex] = list[i];  
    list[i] = currentMin;  
}
```

1.1 Java Arrays – Selection Sort – Wrap it in a Method

```
/** The method for sorting the numbers */

public static void selectionSort(double[] list) {
    for (int i = 0; i < list.length; i++) {
        // Find the minimum in the list[i..list.length-1]
        double currentMin = list[i];
        int currentMinIndex = i;
        for (int j = i + 1; j < list.length; j++) {
            if (currentMin > list[j]) {
                currentMin = list[j];
                currentMinIndex = j;
            }
        }
        // Swap list[i] with list[currentMinIndex] if necessary;
        if (currentMinIndex != i) {
            list[currentMinIndex] = list[i];
            list[i] = currentMin;
        }
    }
}
```

Invoke it

selectionSort(yourList)

1.1 Java Arrays – Sort

The **Arrays.sort** Method

Since sorting is frequently used in programming, Java provides several overloaded sort methods for sorting an array of int, double, char, short, long, and float in the `java.util.Arrays` class. For example, the following code sorts an array of numbers and an array of characters.

```
double[] numbers = {6.0, 4.4, 1.9, 2.9, 3.4, 3.5};  
java.util.Arrays.sort(numbers);
```

```
char[] chars = {'a', 'A', '4', 'F', 'D', 'P'};  
java.util.Arrays.sort(chars);
```

1.2 Java Arrays – Multidimensional Arrays

Motivations: Thus far, you have used one-dimensional arrays to model linear collections of elements. You can use a two-dimensional array to represent a matrix or a table. For example, the following table that describes the distances between the cities can be represented using a two-dimensional array.

Distance Table (in miles)

	Chicago	Boston	New York	Atlanta	Miami	Dallas	Houston
Chicago	0	983	787	714	1375	967	1087
Boston	983	0	214	1102	1763	1723	1842
New York	787	214	0	888	1549	1548	1627
Atlanta	714	1102	888	0	661	781	810
Miami	1375	1763	1549	661	0	1426	1187
Dallas	967	1723	1548	781	1426	0	239
Houston	1087	1842	1627	810	1187	239	0

1.2 Java Arrays – Multidimensional Arrays

Declare/Create Two-dimensional Arrays

```
// Declare array ref var  
dataType[][] refVar;
```

```
// Create array and assign its reference to variable  
refVar = new dataType[10][10];
```

```
// Combine declaration and creation in one statement  
dataType[][] refVar = new dataType[10][10];
```

```
// Alternative syntax  
dataType refVar[][] = new dataType[10][10];
```

1.2 Java Arrays – Multidimensional Arrays

Two-dimensional Array Illustration

0	1	2	3	4
1				
2				
3				
4				

```
matrix = new int[5][5];
```

matrix.length? 5

matrix[0].length? 5

0	1	2	3	4
1				
2				
3				
4				

```
matrix[2][1] = 7;
```

0	1	2
1	2	3
2	4	5
3	7	8
	10	11
	11	12

```
int[][] array = {  
    {1, 2, 3},  
    {4, 5, 6},  
    {7, 8, 9},  
    {10, 11, 12}  
};
```

array.length? 4

array[0].length? 3

1.2 Java Arrays – Multidimensional Arrays

Declaring, Creating, and Initializing Using Shorthand Notations

You can also use an array initializer to declare, create and initialize a two-dimensional array. For example,

```
int[][] array = {  
    {1, 2, 3},  
    {4, 5, 6},  
    {7, 8, 9},  
    {10, 11, 12}  
};
```

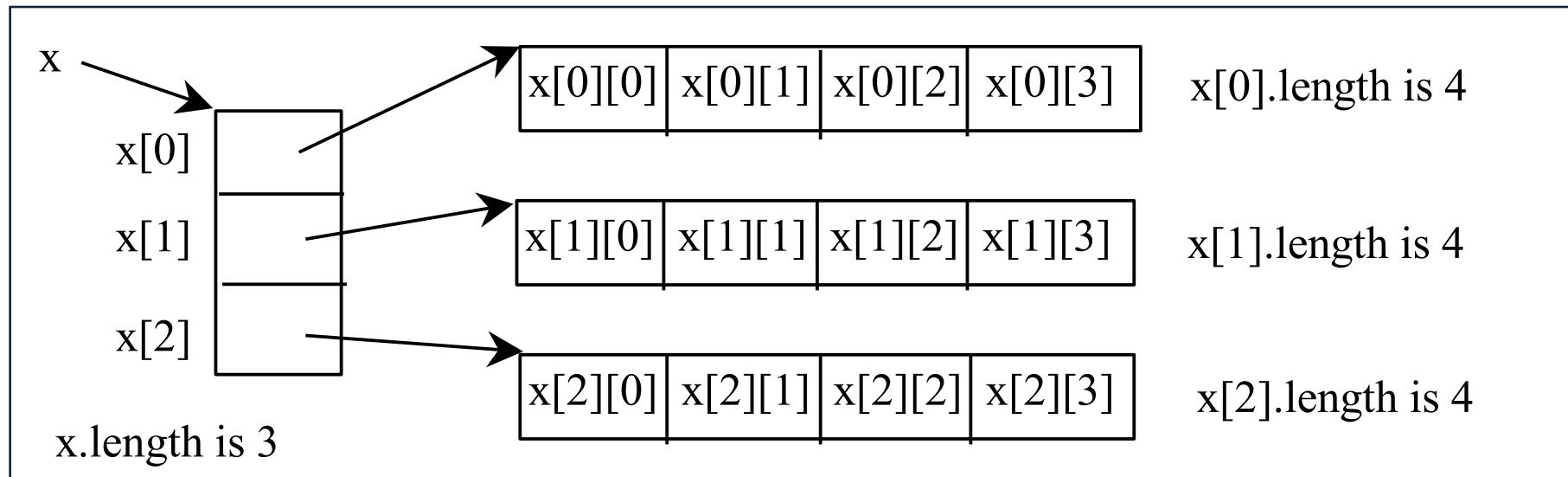
Same as

```
int[][] array = new int[4][3];  
array[0][0] = 1; array[0][1] = 2; array[0][2] = 3;  
array[1][0] = 4; array[1][1] = 5; array[1][2] = 6;  
array[2][0] = 7; array[2][1] = 8; array[2][2] = 9;  
array[3][0] = 10; array[3][1] = 11; array[3][2] = 12;
```

1.2 Java Arrays – Multidimensional Arrays

Lengths of Two-dimensional Arrays

```
int[][] x = new int[3][4];
```



1.2 Java Arrays – Multidimensional Arrays

Ragged Arrays

Each row in a two-dimensional array is itself an array. So, the rows can have different lengths. Such an array is known as *a ragged array*. For example,

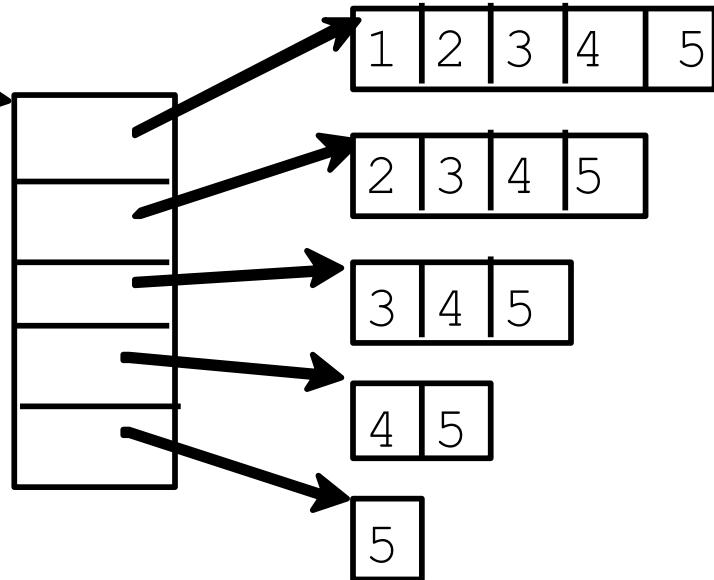
```
int[][] matrix = {  
    {1, 2, 3, 4, 5},  
    {2, 3, 4, 5},  
    {3, 4, 5},  
    {4, 5},  
    {5}  
};
```

```
matrix.length is 5  
matrix[0].length is 5  
matrix[1].length is 4  
matrix[2].length is 3  
matrix[3].length is 2  
matrix[4].length is 1
```

1.2 Java Arrays – Multidimensional Arrays

Ragged Arrays

```
int[][] triangleArray = {  
    {1, 2, 3, 4, 5},  
    {2, 3, 4, 5},  
    {3, 4, 5},  
    {4, 5},  
    {5}  
};
```



Section Conclusion

Fact: **Java is natural**

In few **samples** it is simple to remember:
selections, loops, methods, arrays – it is like
in C/C++ syntax.





Java OOP

Java OOP & JSE



2. Summary of Java SE - OOP

Analogy with C++ and it will be reloaded in next lecture

What is a class?

What is a package of classes in Java?

What is an object / instance?

How many bytes has an object inside JVM?

Why do we need clone, equals and hash methods?

Demo & memory model for the **Certificate** Java class

2. Summary of Java SE - OOP

DEMO: Java Arrays demo and other samples + Java Libraries: JARs

Section Conclusions

Object Oriented Programming in Java – class, object, object's deep vs. shallow copy, interface, interface as type, abstract class, inheritance, polymorphism.

Class is used to encapsulate attributes (fields | features | characteristics) and methods (behavior | ‘interface’) in order to produce instances / objects.

Object is a instance of a class with certain values for attributes and with same methods class for all the generated instances.

In OOP there are two major relationships: “has a” (composition) and “is a” (inheritance)

Object Oriented Programming
for easy Java sharing



**Repositories: Git, Build Automation: ANT / Maven / Gradle, DevOps Continuous Build
Integration: Jenkins, Deployment in Cloud: Docker vs. IaaS VMs**

Advanced SW Eng. & DevOps Topics

3.1 Java Library

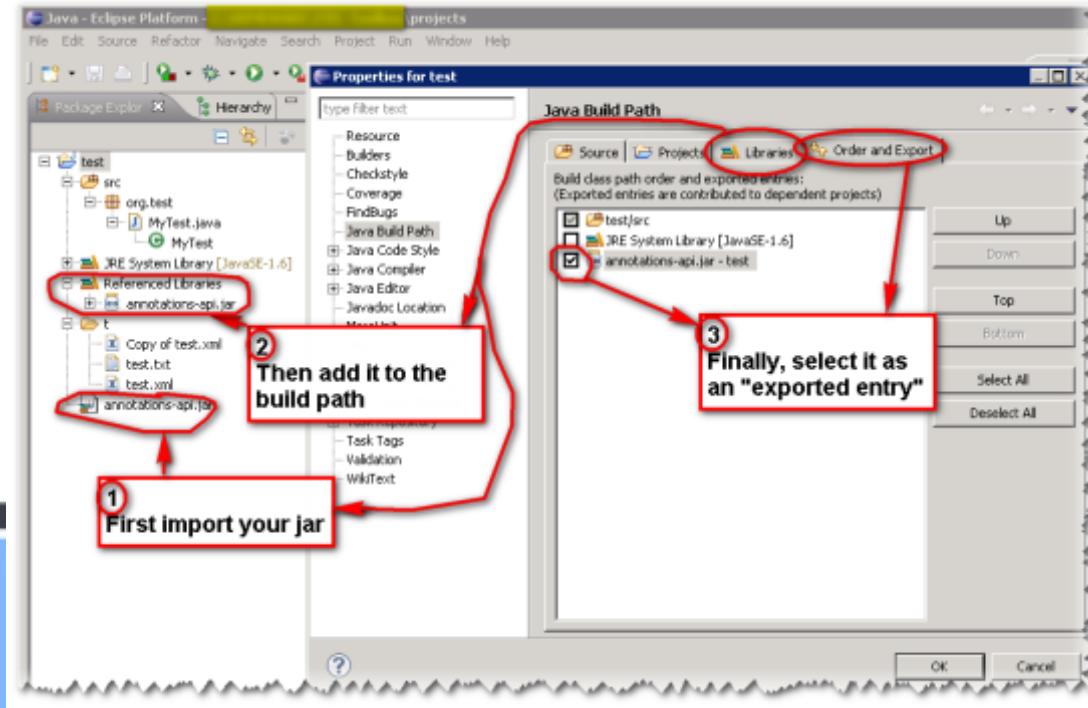
What is a **Java library**?

What are the advantages and disadvantages of Java libraries?

How can be solved in Java multiple dependencies or inclusions of the same class in the compilation phase? How were solved these problems in C/C++?

How should be created a Java library and how should be used – command line vs. IDE?

```
>jar -cvf archive_name.jar files_names_to_compress  
>javac -classpath .:archive_name.jar *.java  
>java -classpath .:archive_name.jar file_with_main_class
```



3.2 Build Automation: Apache ANT

Optional steps to build the lectures with Gradle – all lectures are independent by any Build

Automation system (e.g. Gradle, MVN, ANT, etc.) and the labs are projects in Eclipse IDE:

Apache ANT is a Java based build tool from Apache Software Foundation. Apache Ant's build files are written in XML and they take advantage of being open standard, portable and easy to understand.

Features:

- Ant is the most complete Java build and deployment tool available.
- Ant is platform neutral and can handle platform specific properties such as file separators.
- Ant can be used to perform platform specific tasks such as modifying the modified time of a file using 'touch' command.
- Ant scripts are written using plain XML. If you are already familiar with XML, you can learn Ant pretty quickly.
- Ant is good at automating complicated repetitive tasks.
- Ant comes with a big list of predefined tasks.
- Ant provides an interface to develop custom tasks.
- Ant can be easily invoked from the command line and it can integrate with free and commercial IDEs.

3.2 Build Automation: Apache ANT

```
<project>

    <target name="clean">
        <delete dir="build"/>
    </target>

    <target name="compile">
        <mkdir dir="build/classes"/>
        <javac srcdir="src" destdir="build/classes"/>
    </target>

    <target name="jar">
        <mkdir dir="build/jar"/>
        <jar destfile="build/jar/HelloWorld.jar" basedir="build/classes">
            <manifest>
                <attribute name="Main-Class" value="oata.HelloWorld"/>
            </manifest>
        </jar>
    </target>

    <target name="run">
        <java jar="build/jar/HelloWorld.jar" fork="true"/>
    </target>

</project>
```

ant compile jar run

3.2 Build Automation: Apache ANT

While having a look at the buildfile, we will see some similar steps between Ant and the java-only commands:

java-only	Ant
md build\classes javac -sourcepath src -d build\classes src\oata\HelloWorld.java echo Main-Class: oata.HelloWorld>mf md build\jar jar cfm build\jar\HelloWorld.jar mf -C build\classes . java -jar build\jar\HelloWorld.jar	<mkdir dir="build/classes"/> <javac srcdir="src" destdir="build/classes"/> <!-- automatically detected --> <!-- obsolete; done via manifest tag --> <mkdir dir="build/jar"/> <jar destfile="build/jar/HelloWorld.jar" basedir="build/classes"> <manifest> <attribute name="Main-Class" value="oata.HelloWorld"/> </manifest> </jar> <java jar="build/jar/HelloWorld.jar" fork="true"/>

ant compile

ant jar

ant run

3.2 Build Automation: Apache MVN - Maven

Optional steps to build the lectures with Gradle – all lectures are independent by any Build Automation system (e.g. Gradle, MVN, ANT, etc.) and the labs are projects in Eclipse IDE:

Apache Maven (MVN) is a software project management and comprehension tool. Based on the concept of a project object model (POM), Maven can manage a project's build, reporting and documentation from a central piece of information. Using maven we can build and manage any Java based project.

Features:

- Maven uses **Convention over Configuration**, which means developers are not required to create build process themselves. Developers do not have to mention each and every configuration detail. Maven provides sensible default behavior for projects. When a Maven project is created, Maven creates default project structure. Developer is only required to place files accordingly and he/she need not to define any configuration in **pom.xml**.
- Simple project setup that follows best practices.
- Consistent usage across all projects.
- Dependency management including automatic updating.

3.2 Build Automation: Apache MVN - Maven

Apache Maven (MVN) Features:

- A large and growing repository of libraries.
- Extensible, with the ability to easily write plugins in Java or scripting languages.
- Instant access to new features with little or no extra configuration.
- **Model-based builds** – Maven is able to build any number of projects into predefined output types such as jar, war, metadata.
- **Coherent site of project information** – Using the same metadata as per the build process, maven is able to generate a website and a PDF including complete documentation.
- **Release management and distribution publication** – Without additional configuration, maven will integrate with your source control system such as CVS and manages the release of a project.
- **Backward Compatibility** – You can easily port the multiple modules of a project into Maven 3 from older versions of Maven. It can support the older versions also.
- **Automatic parent versioning** – No need to specify the parent in the sub module for maintenance.
- **Parallel builds** – It analyzes the project dependency graph and enables you to build schedule modules in parallel. Using this, you can achieve the performance improvements of 20-50%.
- **Better Error and Integrity Reporting** – Maven improved error reporting, and it provides you with a link to the Maven wiki page where you will get full description of the error.

3.2 Build Automation: Apache MVN - Maven

Creating a Project

You will need somewhere for your project to reside, create a directory somewhere and start a shell in that directory. On your command line, execute the following Maven goal:

```
1. mvn archetype:generate -DgroupId=com.mycompany.app -DartifactId=my-app -DarchetypeArtifactId=maven-archetype-quickstart -DinteractiveMode=false
```

If you have just installed Maven, it may take a while on the first run. This is because Maven is downloading the most recent artifacts (plugin jars and other files) into your local repository. You may need to execute the command a couple of times before it succeeds. This is because the remote server may time out before your downloads are complete. Don't worry, there are ways to fix that.

You will notice that the generate goal created a directory with the same name given as the artifactId. Change into that directory.

```
1. cd my-app
```

Under this directory you will notice the following [standard project structure](#).

```
1. my-app
2. |-- pom.xml
3. `-- src
4.   |-- main
5.   |   |-- java
6.   |   |   |-- com
7.   |   |   |   |-- mycompany
8.   |   |   |   |   |-- app
9.   |   |   |   |   |   |-- App.java
10.  |   |-- test
11.  |       |-- java
12.  |           |-- com
13.  |               |-- mycompany
14.  |                   |-- app
15.  |                       |-- AppTest.java
```

The `src/main/java` directory contains the project source code, the `src/test/java` directory contains the test source, and the `pom.xml` file is the project's Project Object Model, or POM.

3.2 Build Automation: Apache MVN - Maven

The POM

The pom.xml file is the core of a project's configuration in Maven. It is a single configuration file that contains the majority of information required to build a project in just the way you want. The POM is huge and can be daunting in its complexity, but it is not necessary to understand all of the intricacies just yet to use it effectively. This project's POM is:

```
1. <project xmlns="http://maven.apache.org/POM/4.0.0" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
2.   xsi:schemaLocation="http://maven.apache.org/POM/4.0.0 http://maven.apache.org/xsd/maven-4.0.0.xsd">
3.   <modelVersion>4.0.0</modelVersion>
4.
5.   <groupId>com.mycompany.app</groupId>
6.   <artifactId>my-app</artifactId>
7.   <version>1.0-SNAPSHOT</version>
8.   <packaging>jar</packaging>
9.
10.  <name>Maven Quick Start Archetype</name>
11.  <url>http://maven.apache.org</url>
12.
13.  <dependencies>
14.    <dependency>
15.      <groupId>junit</groupId>
16.      <artifactId>junit</artifactId>
17.      <version>4.8.2</version>
18.      <scope>test</scope>
19.    </dependency>
20.  </dependencies>
21. </project>
```

mvn clean build
mvn package

java -cp target/my-app-1.0-SNAPSHOT.jar com.mycompany.app.App

3.3 Build Automation: Gradle

Optional steps to build the lectures with Gradle – all lectures are independent by any Build Automation system (e.g. Gradle, MVN, ANT, etc.) and the labs are projects in Eclipse IDE:

Gradle is an advanced general purpose **build management system** based on Groovy.

Features:

- It supports automatic download and configuration of project dependencies (libraries).
- It supports Maven and Ivy (ANT) repositories for retrieving project dependencies, allowing reuse of the artifacts of existing build systems.
- It supports multi-project and multi-artifact builds.

(Optional full Gradle presentation @ISM – Cyber-Security Master – www.ism.ase.ro, by Marius Popa @ Oracle)

<https://gradle.org/install/>

<https://plugins.gradle.org/>

<https://github.com/jabedhasan21/java-hello-world-with-gradle/blob/master/README.md>

<https://www.tutorialspoint.com/gradle/index.htm>

3.3.1. Gradle Intro and Basics

Projects and tasks in **Gradle**:

- A Gradle build consists of one or more projects.
- A **project** using Gradle describes its build via a **build.gradle** file. **build.gradle** file is located in the root folder of the project. **build.gradle** file is based on a *Domain Specific Language* (DSL) written in Groovy.
- **build.gradle** build file defines a project and its tasks.
- A **task** represents a piece of work which a build performs.

```
task hello {  
    doLast {  
        println 'Hello Gradle'  
        println 'Project name: ' + rootProject.name  
    }  
}
```

```
mepopa@MEPOPA-RO /d/work/P006_IoT_GW/GradleTraining  
$ gradle project  
:projects  
-----  
Root project  
-----  
Root project 'GradleTraining'  
No sub-projects  
To see a list of the tasks of a project, run gradle <project-path>:tasks  
For example, try running gradle :tasks  
BUILD SUCCESSFUL  
Total time: 3.676 secs
```

```
mepopa@MEPOPA-RO /d/Work/P006_IoT_GW/GradleTraining  
$ gradle hello  
:hello  
Hello Gradle  
Project name: GradleTraining  
BUILD SUCCESSFUL  
Total time: 3.162 secs
```

3.3.2. Installing and configuring Gradle

- **Requirement:** JDK (Java Development Kit) installation.
- **Installing:** Download the latest release of Gradle from <http://gradle.org/gradle-download/> | <https://gradle.org/install/> for the usage on the command line. Add the /bin folder to PATH environment variable.
- **Gradle daemon:** avoid starting the Java virtual machine for every build. Usage: `org.gradle.daemon=true` in `gradle.properties` in the `${HOME}/.gradle`; Executing gradle with the `--daemon` parameter on the command line or `gradle --stop` to stop it.
- Set specific JVM options: `GRADLE_OPTS` environment variable. Eg. `export GRADLE_OPTS=-Xmx1024m` defines 1 GB as maximum heap size.

3.3.3. Gradle plug-ins

- Plug-ins extend Gradle core functionality. Extension to Gradle adding some preconfigured tasks.
- Gradle ships with a number of plug-ins (**java**), and custom plug-ins can be developed.
- Adding a plug-in in ***build.gradle*** file: **apply plugin: 'pluginname'** (Eg. **apply plugin: 'java'**).
- Registry for Gradle plug-ins: <https://plugins.gradle.org/>.

3.3.3. Gradle plug-ins

build.gradle

```
task hello {  
    doLast {  
        println 'Hello Gradle'  
        println 'Project name: ' + rootProject.name  
    }  
}
```

```
mepopa@MEPOPA-RO /d/Work/P006_IoT_GW/GradleTraining  
$ gradle tasks  
:tasks  
  
-----  
All tasks runnable from root project  
  
Build Setup tasks  
init - Initializes a new Gradle build. [incubating]  
wrapper - Generates Gradle wrapper files. [incubating]  
  
Help tasks  
components - Displays the components produced by root project 'GradleTraining'. [incubating]  
dependencies - Displays all dependencies declared in root project 'GradleTraining'.  
dependencyInsight - Displays the insight into a specific dependency in root project 'GradleTraining'.  
help - Displays a help message.  
model - Displays the configuration model of root project 'GradleTraining'. [incubating]  
projects - Displays the sub-projects of root project 'GradleTraining'.  
properties - Displays the properties of root project 'GradleTraining'.  
tasks - Displays the tasks runnable from root project 'GradleTraining'.  
  
Other tasks  
hello  
  
To see all tasks and more detail, run gradle tasks --all  
To see more detail about a task, run gradle help --task <task>  
  
BUILD SUCCESSFUL  
  
Total time: 3.418 secs
```

build.gradle

```
apply plugin: 'java'  
task hello {  
    doLast {  
        println 'Hello Gradle'  
        println 'Project name: ' + rootProject.name  
    }  
}
```

```
mepopa@MEPOPA-RO /d/Work/P006_IoT_GW/GradleTraining  
$ gradle tasks  
:tasks  
  
-----  
All tasks runnable from root project  
  
Build tasks  
assemble - Assembles the outputs of this project.  
build - Assembles and tests this project.  
buildDependents - Assembles and tests this project and all projects that depend on it.  
buildNeeded - Assembles and tests this project and all projects it depends on.  
classes - Assembles classes 'main'.  
jar - Assembles a jar archive containing the main classes.  
testClasses - Assembles classes 'test'.  
  
Build Setup tasks  
init - Initializes a new Gradle build. [incubating]  
wrapper - Generates Gradle wrapper files. [incubating]  
  
Documentation tasks  
javadoc - Generates Javadoc API documentation for the main source code.
```

```
mepopa@MEPOPA-RO /d/Work/P006_IoT_GW/GradleTraining  
$ gradle tasks  
:tasks  
  
-----  
All tasks runnable from root project  
  
Build tasks  
assemble - Assembles the outputs of this project.  
build - Assembles and tests this project.  
buildDependents - Assembles and tests this project and all projects that depend on it.  
buildNeeded - Assembles and tests this project and all projects it depends on.  
classes - Assembles classes 'main'.  
jar - Assembles a jar archive containing the main classes.  
testClasses - Assembles classes 'test'.  
  
Build Setup tasks  
init - Initializes a new Gradle build. [incubating]  
wrapper - Generates Gradle wrapper files. [incubating]  
  
Help tasks  
components - Displays the components produced by root project 'GradleTraining'. [incubating]  
dependencies - Displays all dependencies declared in root project 'GradleTraining'.  
dependencyInsight - Displays the insight into a specific dependency in root project 'GradleTraining'.  
help - Displays a help message.  
model - Displays the configuration model of root project 'GradleTraining'. [incubating]  
projects - Displays the sub-projects of root project 'GradleTraining'.  
properties - Displays the properties of root project 'GradleTraining'.  
tasks - Displays the tasks runnable from root project 'GradleTraining'.  
  
Verification tasks  
check - Runs all checks.  
clean - Deletes the build directory.  
test - Runs the unit test.  
  
Other tasks  
hello  
  
Rules  
Pattern: clean<taskName> - Cleans the output files of a task.  
Pattern: build<ConfigurationName> - Assembles the artifacts of a configuration.  
Pattern: upload<ConfigurationName> - Assembles and uploads the artifacts belonging to a configuration.  
  
To see all tasks and more detail, run gradle tasks --all  
To see more detail about a task, run gradle help --task <task>  
  
BUILD SUCCESSFUL  
  
Total time: 5.03 secs
```

3.3.4. Gradle dependency management

- Managing the classpath of Gradle projects: adding JAR files, directories or other projects to the build path of the application.
- Automatic download of Java library dependencies, specifying the dependency in Gradle build file.
- A Java library is identified by Gradle via its project's **groupId:artifactId:version** (also known as **GAV** in Maven).
- Adding a dependency: new entry in the dependency section in ***build.gradle*** file.

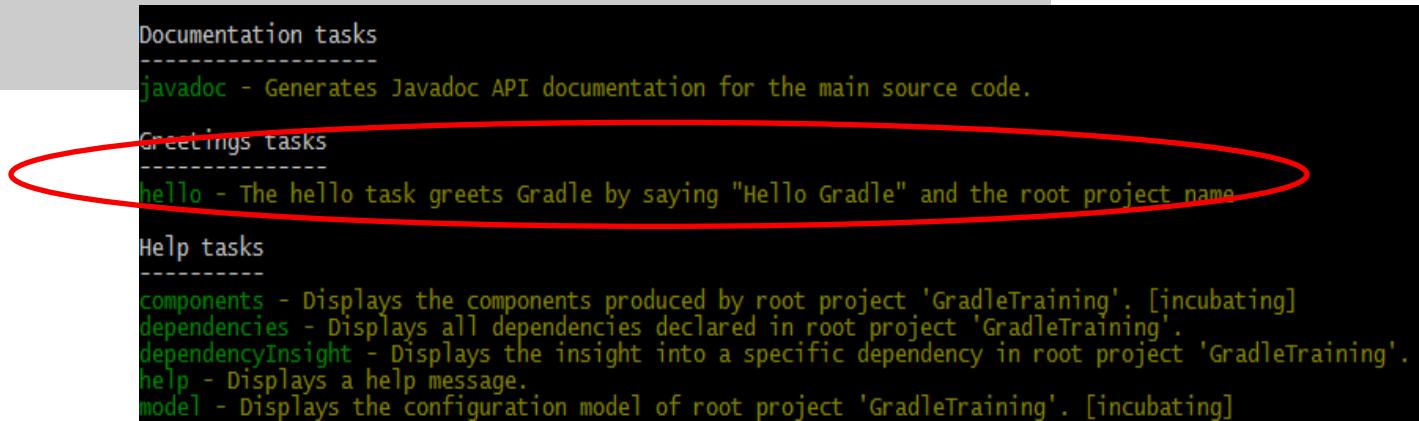
```
repositories {  
    jcenter()  
}  
  
dependencies {  
    compile fileTree(dir: 'libs',  
    include: ['*.jar'])  
    testCompile 'junit:junit:4.12'  
}
```

```
mepopa@MEPOPA-RO /d/Work/P006_IoT_GW/GradleTraining  
$ gradle clean build  
:clean UP-TO-DATE  
:compileJava UP-TO-DATE  
:processResources UP-TO-DATE  
:classes UP-TO-DATE  
:jar  
:assemble  
:compileTestJava UP-TO-DATE  
:processTestResources UP-TO-DATE  
:testClasses UP-TO-DATE  
:test UP-TO-DATE  
:check UP-TO-DATE  
:build  
  
BUILD SUCCESSFUL  
  
Total time: 4.357 secs
```

3.3.5. Gradle tasks

- Default Gradle tasks: tasks for introspection of Gradle itself (eg. task **tasks**).
- Custom Gradle tasks: tasks created by developers (eg. task **hello**). Running the **gradle tasks** task, the **hello** task will be listed under **Other tasks**. Tasks without a group are considered as private tasks. Groups can be applied with the **group** property and a description can be applied by using the **description** property .

```
task hello {  
  
    group 'greetings'  
    description 'The hello task greets Gradle by  
saying "Hello Gradle" and the root project name'  
  
    doLast {  
        println 'Hello Gradle'  
        println 'Project name: ' + rootProject.name  
    }  
}
```



3.3.6. Building Java projects

- Java plug-in: provides tasks to **compile** Java source code, run **unit tests**, create **Javadoc** and create a **JAR** file.
- Default project layout:
 - Java source code: **src/main/java**.
 - Java tests: **src/test/java**.
- Different project structure: **sourceSets**.
- Start the build: **gradle build** for **HelloWorld.java**.

```
sourceSets {  
    main {  
        java {  
            srcDir 'src'  
        }  
    }  
    test {  
        java {  
            srcDir 'test'  
        }  
    }  
}
```

```
mepopa@MEPOPA-R0 /d/work/P006_IoT_GW/GradleTraining  
$ gradle build  
T am not invoked, but I always get printed  
:compileJava  
:processResources UP-TO-DATE  
:classes  
:jar  
:assemble  
:compileTestJava UP-TO-DATE  
:processTestResources UP-TO-DATE  
:testClasses UP-TO-DATE  
:test UP-TO-DATE  
:check UP-TO-DATE  
:build  
  
BUILD SUCCESSFUL  
Total time: 5.434 secs
```

3.4 Jenkins/Hudson – DevOps Build Automation

```
export JAVA_HOME=/opt/software/java/jdks/jdk1.8.0_161
export CLASSPATH=.:$JAVA_HOME/jre/lib
export CATALINA_HOME=/opt/software/apache-tomcat-9.0.4
export
PATH=.:$JAVA_HOME/bin:$CATALINA_HOME/bin:/usr/local/sbin:/usr/local/bin:/usr/sbin:/usr/
bin:/sbin:/bin:/usr/games
```

```
cd $CATALINA_HOME
bin/startup.sh
```

```
http://127.0.0.1:8080
http://127.0.0.1:8080/jenkins/
```

```
bin/shutdown.sh
```

The screenshot shows the Jenkins dashboard interface. On the left, there is a sidebar with links: New Item, People, Build History, Manage Jenkins, My Views, Credentials, and New View. The main area displays a table of build items. One item is listed: 'buildAndRunC02'. The table has columns for Status (S), Workstation (W), Name, Last Success, Last Failure, and Last Duration. The 'Name' column is sorted by name. The 'Last Success' and 'Last Failure' columns show the date and time of the last successful and failed builds respectively. Below the table, there are links for 'Legend', 'RSS for all', 'RSS for failures', and 'RSS for just latest builds'. At the bottom, there are two sections: 'Build Queue' (which is empty) and 'Build Executor Status' (which shows 1 Idle and 2 Idle executors).

S	W	Name	Last Success	Last Failure	Last Duration
blue circle icon	cloud icon	buildAndRunC02	22 hr - #7	22 hr - #5	7.5 sec

Icon: S M L

Legend RSS for all RSS for failures RSS for just latest builds

Build Queue

No builds in the queue.

Build Executor Status

1 Idle
2 Idle

3.4 Jenkins/Hudson – DevOps Build Automation

buildAndRunC02 Config [Jenkins] - Mozilla Firefox

LibreOffice Writer

127.0.0.1:8080/jenkins/job/buildAndRunC02/configure

General Source Code Management Build Triggers Build Environment **Build** Post-build Actions

Execute shell

```
cd /home/stud/jenkinsworkspace
if [ ! -d "./javase" ]; then
    # Control will enter here if $DIRECTORY doesn't exist.
    git clone https://github.com/critoma/javase.git
fi

cd ./javase
git pull

export JAVA_HOME=/opt/software/java/jdks/jdk1.8.0_161
export PATH=$JAVA_HOME/bin:/usr/local/sbin:/usr/local/bin:/usr/sbin:/usr/
export CLASSPATH=.:$JAVA_HOME/jre/lib
export JSE=/home/stud/jenkinsworkspace/javase/lectures

cd $JSE/c02/src
javac eu/ase/ooparrays/Student.java
javac eu/ase/ooparrays/ProgMainOopArrays.java

# full JAR deployment
jar -cmvf ./META-INF/MANIFEST.MF ../student.jar eu/ase/ooparrays/*.class
rm eu/ase/ooparrays/*.class

java -jar ../student.jar eu/ase/ooparrays/ProgMainOopArrays
rm ../student.jar
```

Save Apply

Plain Text ▾ Tab Width: 8 ▾ Ln 203, Col 1 ▾ INS

3.5 Deployment: Std. OS vs. VMs vs. Docker Containers

Docker image:

<https://hub.docker.com> | <https://hub.docker.com/r/critoma/ubuntu-java-node-py-dev/>

Install Docker in Linux (similar steps used for Windows):

<https://docs.docker.com/engine/installation/linux/docker-ce/ubuntu/#install-from-a-package>

<https://download.docker.com/linux/ubuntu/dists/xenial/pool/stable/amd64/>

sudo dpkg -i /path/to/package.deb

sudo docker run hello-world

docker search critoma

docker pull critoma/ubuntu-java-node-py-dev

docker run -it critoma/ubuntu-java-node-py-dev

Resources:

https://www.tutorialspoint.com/docker/docker_architecture.htm

https://www.tutorialspoint.com/docker/docker_containers_and_shells.htm

<https://docs.docker.com/install/linux/docker-ce/ubuntu/>

<https://docs.docker.com/engine/installation/linux/linux-postinstall/>

<https://docs.docker.com/get-started/>

<https://docs.docker.com/get-started/part2/>

<https://docs.docker.com/get-started/part6/>

<https://www.digitalocean.com/community/tutorials/how-to-install-and-use-docker-on-ubuntu-16-04>

<https://www.digitalocean.com/community/tutorials/how-to-remove-docker-images-containers-and-volumes#purging-all-unused-or-dangling-images,-containers,-volumes,-and-networks>

<https://www.digitalocean.com/community/tutorials/how-to-install-node-js-on-ubuntu-16-04>

<http://fabiorehm.com/blog/2014/09/11/running-gui-apps-with-docker/>

<https://github.com/fgrehm/docker-eclipse>

<http://fabiorehm.com/blog/2014/09/11/running-gui-apps-with-docker/>

<https://stackoverflow.com/questions/19234831/where-are-docker-images-stored-on-the-host-machine>

3.5 Deployment: Std. OS vs. VMs vs. Docker Containers

<https://hub.docker.com/r/critoma/ubuntu-java-node-py-dev/>

https://hub.docker.com/r/critoma/ubuntu-java-node-py-dev/ 

Oracle / Sun Java / Android / OSGI Python JavaScript - Node.js... Apple Swift / Objecti... Cloud (AWS EC2 Iaa... IoT / Embedded / JC... Security - Viruses -... Git Gradle - Groovy

 Dashboard Explore Organizations Create  critoma

PUBLIC REPOSITORY

critoma/ubuntu-java-node-py-dev

Last pushed: 10 days ago

[Repo Info](#) [Tags](#) [Collaborators](#) [Webhooks](#) [Settings](#)

Short Description 

ubuntu-java-node-py-dev, Linux Ubuntu 16.04, Java 8 and 9, NodeJs, Python 2 and 3

Docker Pull Command 

docker pull critoma/ubuntu-java-node-

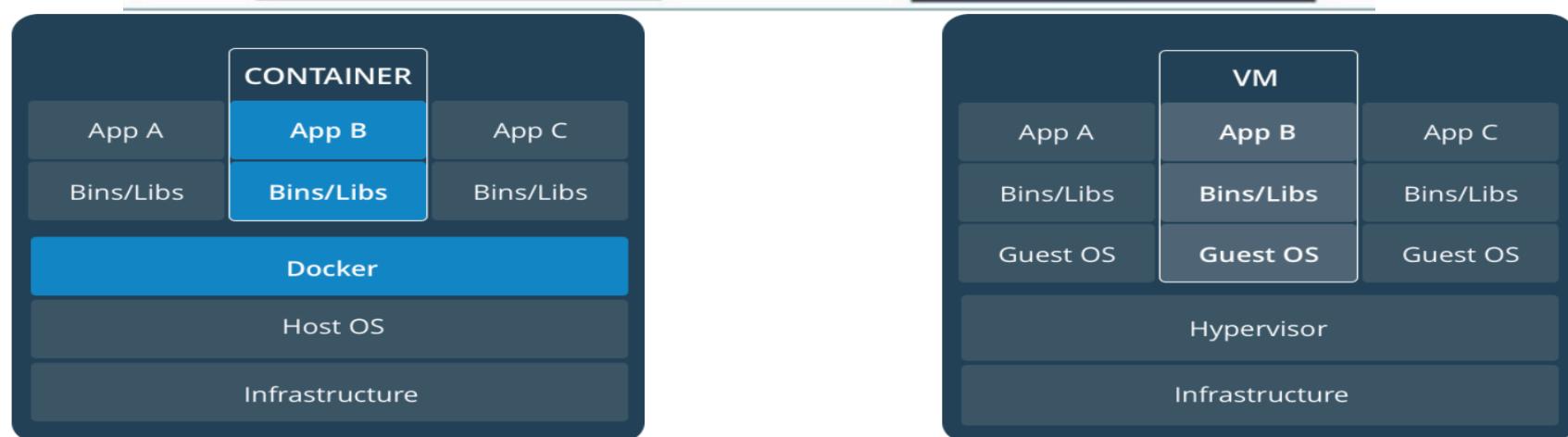
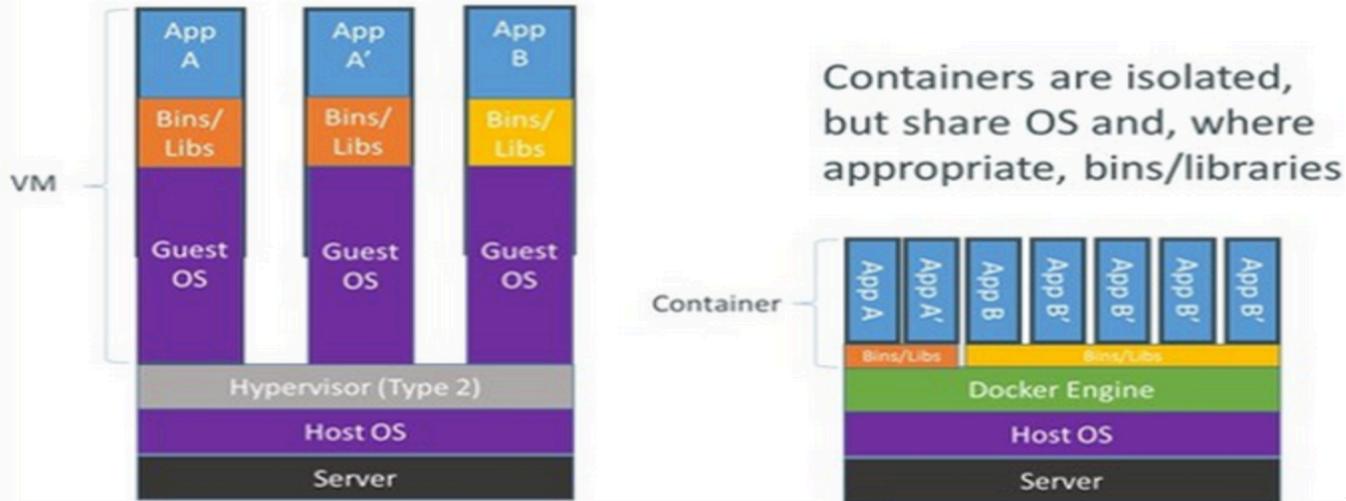
Full Description 

Ubuntu 16.04 Xenial with:
Nodejs
Java
Python

Owner  critoma

3.5 Deployment: Std. OS vs. VMs vs. Docker Containers

Containers vs. VMs



Download Oracle VM VirtualBox OVA:

https://drive.google.com/drive/folders/1SI7uzNPbQ3YsFo3_sbkE3R5lf2f1psZO?usp=sharing

Download Docker Container: <https://hub.docker.com/r/critoma/ubuntu-java-node-py-dev/>



Questions & Answers!





Thanks!



Java Application Development
End of Lecture 2 – summary of Java SE

