BBM 102 – Introduction to Programming II

Spring 2017

Classes and Objects in Java

Instructors: Ayça Tarhan, Fuat Akal, Gönenç Ercan, Vahid Garousi
TAs: Selma Dilek, Selim Yılmaz, Selman Bozkır

Today

- Defining Classes, Objects and Methods
- Accessor and Mutator Methods
- Constructors
- Static Members
- Wrapper Classes
- Parameter Passing
- Delegation

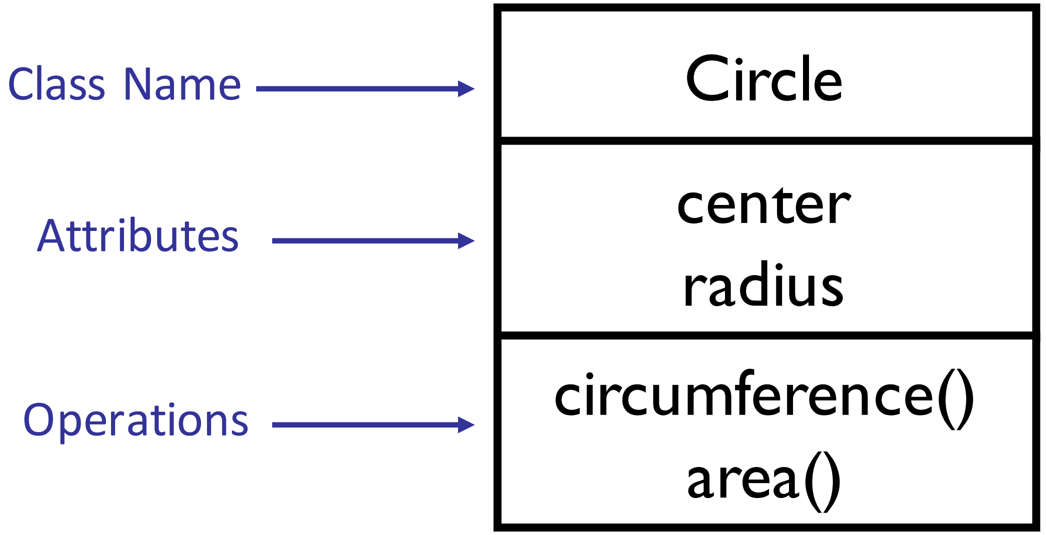
Class and Method Definitions

- Java program consists of objects
  - Objects of class types
  - Objects that interact with one another

- Program objects can represent
  - Objects in real world
  - Abstractions

Java Classes

- A class is a collection of fields (data) and methods (procedure or function) that operate on that data.



Defining a Java Class

- Syntax:

```
class  ClassName{
       [fields declaration]
       [methods declaration]
}
```

- Bare bone class definition:

```
/* This is my first java class.
It is not complete yet. */
class Circle {
    // fields will come here
    // methods will come here
}
```

Adding Fields to Class Circle

- Add fields

```
class Circle {
    public double x, y; // center coordinates
    public double r;    // radius of the circle
}
```

- The fields are also called the ***instance*** variables.
  - Each object, or instance of the class has its own copy of these instance variables

- Do not worry about what *public* means at the moment.
  - Access modifiers (public, private and protected will be covered in the next weeks)

Adding Methods to a Class

- A class with only data fields has no life.
  - Objects created by such a class cannot respond to any messages.

- Methods are declared inside the body of the class.

- The general form of a method declaration is:

```
type MethodName (parameter-list)
{
        Method-body;
}
```

- methodName(parameter-list) part of the declaration is also known as the method signature.
  - Method signatures in a class should be unique!

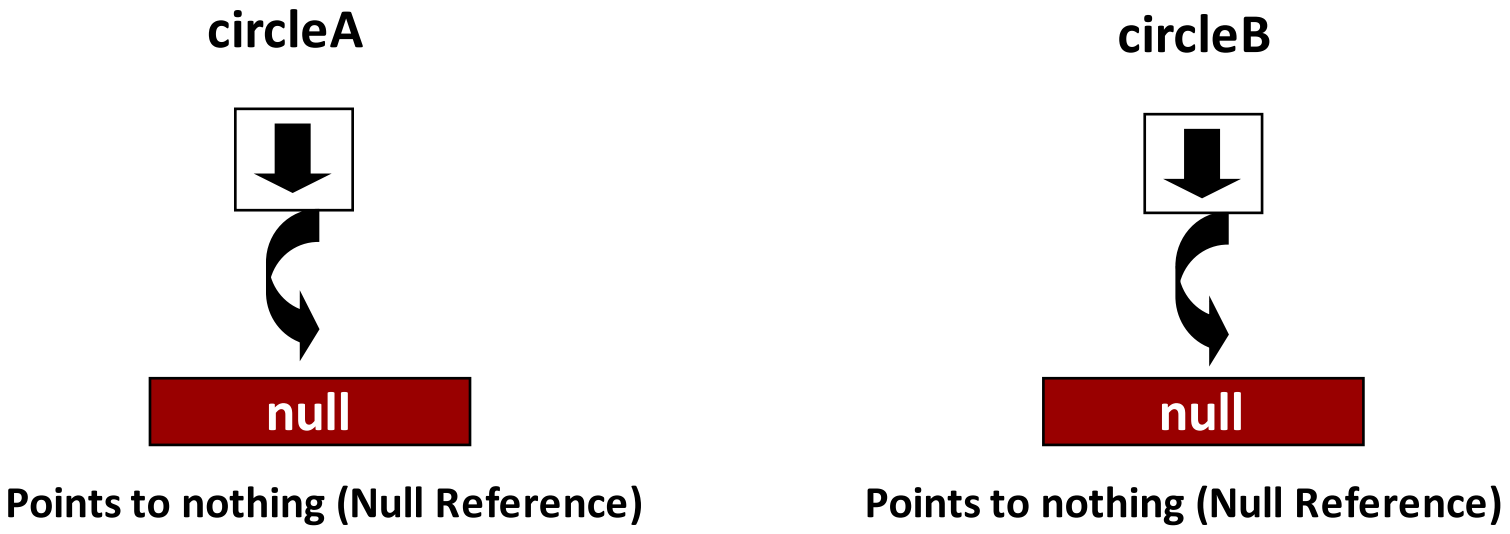
Adding Methods to Class Circle

```
public class Circle {
      public double x, y; // center of the circle
      public double r;    // radius of the circle

      // Method to return circumference
      public double circumference() {
            return 2 * 3.14 * r;
      }

      // Method to return area
      public double area() {
            return 3.14 * r * r;
      }
}
```

Defining Objects of a Class

- A class can be thought as a type
- A variable (object) can be defined as of that type (class)

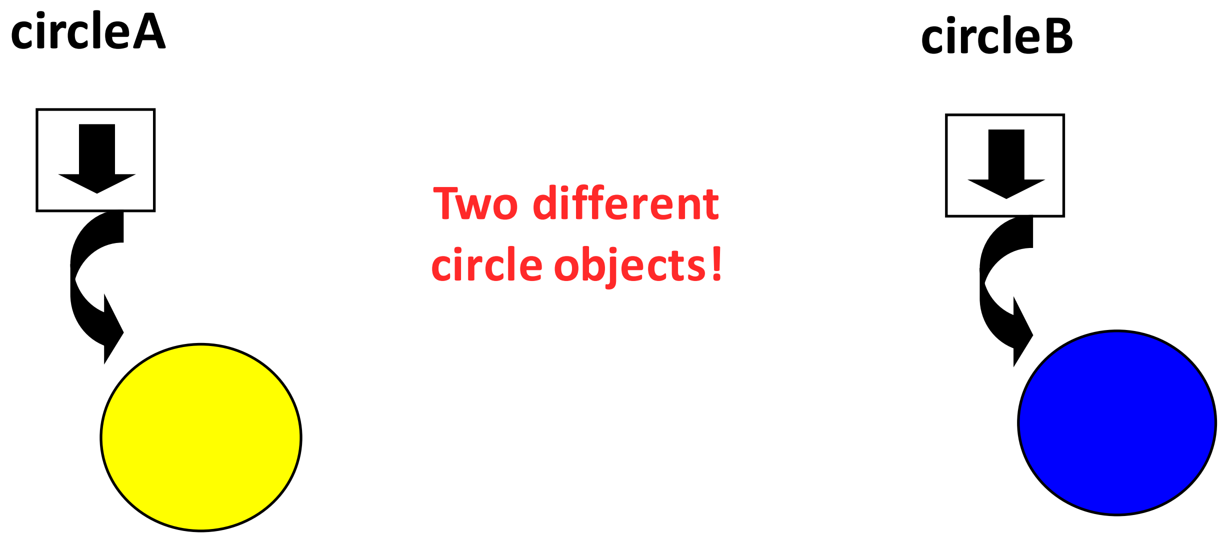
```
Circle circleA, circleB;
```


circleA
null
Points to nothing (Null Reference)
circleB
null
Points to nothing (Null Reference)

Creating Objects of a Class

- Objects are created by using the **new** keyword

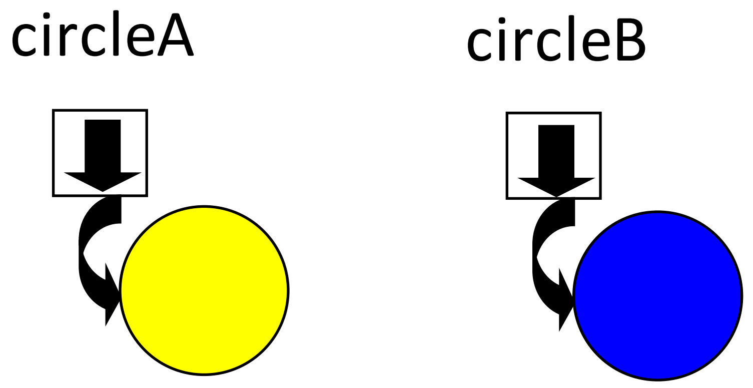
```
Circle circleA;
circleA = new Circle();

Circle circleB = new Circle();
```



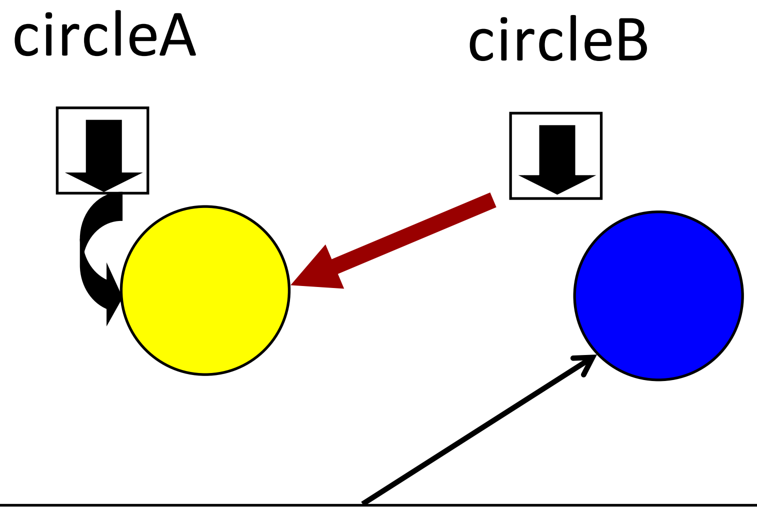
Creating Objects of a Class

```
circleA = new Circle();
circleB = new Circle() ;
circleB = circleA;
```

Before Assignment



After Assignment



This object does not have a reference anymore: inaccessable!

Garbage Collection

- The object which does not have a reference cannot be used anymore.

- Such object becomes a candidate for automatic garbage collection.

- Java collects garbage periodically and releases the memory occupied by such objects to be used in the future.

Using Objects

- Object's data is accessed by using the dot notation

```
Circle circleA = new Circle();

circleA.x = 25.0;
circleA.y = 25.0;
circleA.r = 3.0;
```

- Object's methods are invoked by sending messages

```
double area = circleA.area();
```

Circle Class Alltogether

```
public class Circle {
        public double x, y; // center of the circle
        public double r;    // radius of the circle

        // Methods to return circumference and area
        public double circumference() {
                return 2 * 3.14 * r;
        }
        public double area() {
                return 3.14 * r * r;
        }
        public static void main(String[] args) {
                Circle circleA = new Circle();
                circleA.x = 25.0;
                circleA.y = 25.0;
                circleA.r = 3.0;

                double area = circleA.area();
                System.out.println("Area of the circle is " + area);
        }
}
```

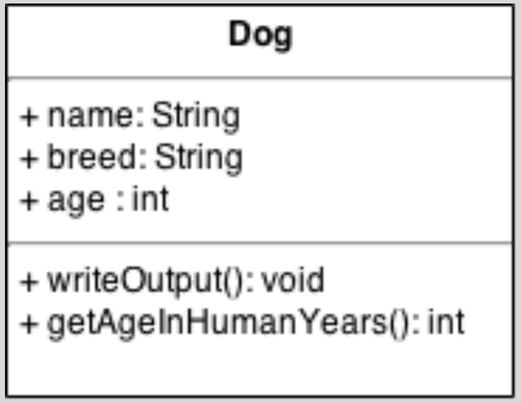
Class Files and Separate Compilation

- Each Java class definition is usually written in a file by itself
  - File begins with the name of the class
  - Ends with .java
- Class can be compiled separately
- Helpful to keep all class files used by a program in the same directory

Java has Two Kinds of Methods

- Methods that <u>return a single item</u>
- Methods that <u>perform some action</u> rather than returning an item
  - void methods

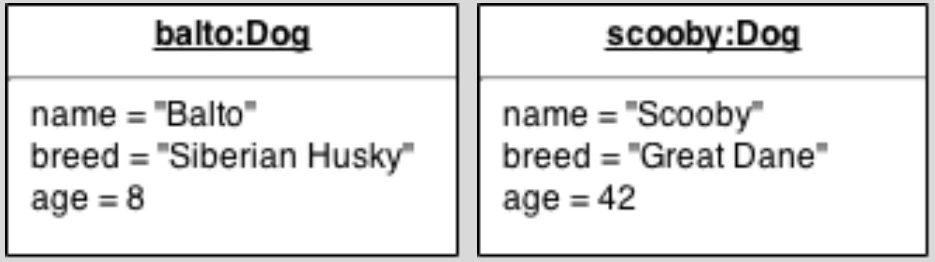
```
public class Dog {
        public String name;             // Instance variables
        public String breed;
        public int age;

        // Method that returns nothing: void method
        public void writeOutput() {
                System.out.println("Name: " + name);
                System.out.println("Breed: " + breed);
                System.out.println("Age in calendar years: " + age);
                System.out.println("Age in human years: " +
                                                getAgeInHumanYears());
        }

        // Method that returns a value
        public int getAgeInHumanYears() {
                int humanAge = 0;
                if (age <= 2) {
                        humanAge = age * 11;
                } else {
                        humanAge = 22 + ((age - 2) * 5);
                }
                return humanAge;
        }
}
```



Example Dog Class

```
public class DogDemo {
   public static void main(String[] args) {
         Dog balto = new Dog();
         balto.name = "Balto";
         balto.age = 8;
         balto.breed = "Siberian Husky";
         balto.writeOutput();

         Dog scooby = new Dog();
         scooby.name = "Scooby";
         scooby.age = 42;
         scooby.breed = "Great Dane";
         System.out.println(scooby.name + " is a " + scooby.breed + ".");
         System.out.print("He is " + scooby.age + " years old, or ");

         int humanYears = scooby.getAgeInHumanYears();
         System.out.println(humanYears + " in human years.");
   }
}
```

DogDemo class contains only a main method.



Program's output

```
Name: Balto
Breed: Siberian Husky
Age in calendar years: 8
Age in human years: 52

Scooby is a Great Dane.
He is 42 years old, or 222 in human years.
```

```
public class Dog {
      public String name;
      public String breed;
      public int age;

      public void writeOutput()  {
            // method body
      }

      public int getAgeInHumanYears()  {
            // method body
      }

      public static void main(String[] args)  {
            Dog balto = new Dog();
            balto.name  = "Balto";
            balto.age  = 8;
            balto.breed  = "Siberian Husky";
            balto.writeOutput();
            ...
      }
}
```

Dog class could contain a main method, too.

Multiple Classes in a Single File

```
class Computer {

  void computer_method() {
    System.out.println("Power gone! Shut down your PC soon...");
  }

  public static void main(String[] args) {
    Computer my = new Computer();
    Laptop your = new Laptop();

    my.computer_method();
    your.laptop_method();
  }
}

class Laptop {
  void laptop_method() {
    System.out.println("99% Battery available.");
  }
}
```

The file *Computer.java* contains two class definitions.

```
$ javac Computer.java
// will generate Computer.class and Laptop.class files.
```

Accessor and Mutator Methods

- A public method that returns data from a private instance variable is called an accessor method, a get method, or a getter.
  - The names of accessor methods typically begin with get.

- A public method that changes the data stored in one or more private instance variables is called a mutator method, a set method, or a setter.
  - The names of mutator methods typically begin with set.

Circle Class with Getters/Setters

```
public class Circle {
        public double x, y; // center of the circle
        public double r;    // radius of the circle

        public double getX() { return x; }
        public void setX(double centerX) { x = centerX; }
        public double getY() { return y; }
        public void setY(double centerY) { y = centerY; }
        public double getR() { return r; }
        public void setR(double radius) { r = radius; }

        // Methods to return circumference and area
        …
}
```

Constructors

- Constructor is a special method that gets invoked "automatically" at the time of object creation.
- Constructor is normally used for initializing objects with default values unless different values are supplied.
- Constructor has the same name as the class name.
- Constructor cannot return values.
- A class can have more than one constructor as long as they have different signature (i.e., different input arguments syntax).

Circle Class with Constructor

```
public class Circle {
        public double x, y; // center of the circle
        public double r;    // radius of the circle

        // Constructor
        public Circle(double centerX, double centerY, double radius) {
                x = centerX;
                y = centerY;
                r = radius;
        }

        // Methods to return circumference and area
        ...
}
```

```
Circle aCircle = new Circle(10.0, 20.0, 5.0);
```

Multiple Constructors

- Sometimes we may want to initialize in a number of different ways, depending on the circumstance.

- This can be supported by having multiple constructors having different input arguments.

Circle Class with Multiple Constructors

```
public class Circle {
        public double x, y; // center of the circle
        public double r;    // radius of the circle

        // Constructor
        public Circle(double centerX, double centerY, double radius) {
                x = centerX;
                y = centerY;
                r = radius;
        }

        public Circle(double radius) {
                x = 0; y = 0; r = radius;
        }

        public Circle() {
                x = 0; y = 0; r = 1.0;
        }

        // Methods to return circumference and area
        ...
}
```

```
Circle aCircle = new Circle(10.0, 20.0, 5.0);
Circle bCircle = new Circle(5.0);
Circle cCircle = new Circle();
```

The Keyword this

- this keyword can be used to refer to the object itself.
- It is generally used for accessing class members (from its own methods) when they have the same name as those passed as arguments.

```
public class Circle {
        public double x, y; // center of the circle
        public double r;    // radius of the circle

        public double getX() { return x; }
        public void setX(double x) { this.x = x; }
        public double getY() { return y; }
        public void setY(double y) { this.y = y; }
        public double getR() { return r; }
        public void setR(double r) { this.r = r; }

        // Methods to return circumference and area
        …
}
```

Static Variables

- Java supports definition of global variables that can be accessed without creating objects of a class.
  - Such members are called Static members.

- This feature is useful when we want to create a variable common to all instances of a class.

- One of the most common example is to have a variable that could keep a count of how many objects of a class have been created.

- Java creates only one copy for a static variable which can be used even if the class is never instantiated.

Using Static Variables

- Define the variable by using the static keyword

```
public class Circle {
    // Class variable, one for the Circle class.
    // To keep number of objects created.
    public static int numCircles;

    // Instance variables, one for each instance
    // of the Circle class.
    public double x,y,r;

    // Constructor
    Circle (double x, double y, double r){
        this.x = x;
        this.y = y;
        this.r = r;
        numCircles++;
    }
}
```

```
Circle circleA = new Circle(10, 12, 20);
// numCircles = 1
Circle circleB = new Circle(5, 3, 10);
// numCircles = 2
```

Instance vs. Static Variables

- *Instance variables*: One copy per object. Every object has its own instance variables.
  - e.g. **`x,y,r`** (center and radius of the circle)

- *Static variables*: One copy per class.
  - e.g. **`numCircles`** (total number of circle objects created)

Static Methods

- A class can have methods that are defined as **static**.
- Static methods can be accessed without using objects. Also, there is **NO** need to create objects.
- Static methods are generally used to group related library functions that don’t depend on data members of its class.
  - e.g., Math library functions.

Using Static Methods

```
class Comparator {
        public static int max(int a, int b) {
                if (a > b)
                        return a;
                else
                        return b;
        }

        public static String max(String a, String b) {
                if (a.compareTo(b) > 0)
                        return a;
                else
                        return b;
        }
}
```

```
// Max methods are directly accessed using ClassName.
// NO Objects created.
System.out.println(Comparator.max(5, 10));
System.out.println(Comparator.max("ANKARA", "SAMSUN"));
```

More Static Methods: The Math Class

- It is like including libraries in C language
- It contains standard mathematical methods
  - They are all static
  - Java.lang.Math

```
Math.pow(2.0, 3.0)     // 8
Math.max(5, 6)         // 6
Math.round(6.2)        // 6
Math.sqrt(4.0)         // 2.0
```

Object Cleanup (Destructor)

- Recall: Memory deallocation is automatic in Java
  - No dangling pointers and no memory leak problem.
- Java allows to define **finalize** method, which is invoked (if defined) just before the object destruction.
- This presents an opportunity to perform record maintenance operation or clean up any special allocations made by the user.
- The finalize method will be called by the Garbage Collector, but when this will happen is not deterministic. Try to avoid finalize.

```
protected void finalize() throws IOException {
   Circle.numCircles = Circle.numCircles--;
   System.out.println(“Number of circles:”+ Circle.num_circles);
}
```

Wrapper Classes

- Each of Java's primitive data types has a class dedicated to it.
  - **B**oolean, **B**yte, **C**haracter, **I**nteger, **F**loat, **D**ouble, **L**ong, **S**hort
  - These are known as wrapper classes, because they "wrap" the primitive data type into an object of that class.
  - They contain useful predefined constants and methods
  - The wrapper classes are part of the java.lang package, which is imported by default into all Java programs.
  - Since Java 5.0 we have autoboxing and unboxing.

```
// Defining objects of wrapper class
Integer x = new Integer(33);
Integer y = 33; // Autoboxing
int yInt = y; // Unboxing

// Convert string to an integer
String s = "123”;
int i = Integer.parseInt(s);

//Converting from hexadecimal to decimal
Integer hex2Int = Integer.valueOf("D", 16);
```

Parameter Passing

- Method parameters which are objects are passed by reference.
- Copy of the reference to the object is passed into method, original value unchanged (e.g. circleB parameter in next slide)

```
public class ReferenceTest {

    public static void main (String[] args){
        Circle c1 = new  Circle(5, 5, 20);
        Circle c2 = new Circle(1, 1, 10);
        System.out.println ( “c1 Radius = “ + c1.getRadius());
        System.out.println ( “c2 Radius = “ + c2.getRadius());

        parameterTester(c1, c2);

        System.out.println ( “c1 Radius = “ + c1.getRadius());
        System.out.println ( “c2 Radius = “ + c2.getRadius());
    }

    public static void parameterTester(Circle circleA, Circle circleB){
        circleA.setRadius(15);
        circleB = new Circle(0, 0, 100);

        System.out.println ( “circleA Radius = “ + circleA.getRadius());
        System.out.println ( “circleB Radius = “ + circleB.getRadius());
    }

}
```

```
c1 Radius =  20.0
c2 Radius = 10.0
circleA Radius = 15.0
circleB Radius = 100.0
c1 Radius =  15.0
c2 Radius = 10.0
```

Delegation

- Ability for a class to delegate its responsibilities to another class.
- A way of making an object invoking services of other objects through containership.

Using Delegation

```
public class Point {
        private double xCoord;
        private double yCoord;

        public double getXCoord(){
                return xCoord;
        }
        public double getYCoord(){
                return yCoord;
        }
}
```

```
public class Circle {
        private Point center;
        public double getCenterX(){
                return center.getXCoord();             // Delegation
        }
        public double getCenterY(){
                return center.getYCoord();             // Delegation
        }
}
```

Summary

- Classes, objects, and methods are the basic components used in Java programming.
- Constructors allow seamless initialization of objects.
- Classes can have static members, which serve as global members of all objects of a class.
- Objects can be passed as parameters and they can be used for exchanging messages.
- We will continue next week with encapsulation
  - which helps in protecting data from accidental or wrong usage and also offers better security for data.

Acknowledgments

- The course material used to prepare this presentation is mostly taken/adopted from the list below:
  - Java - An Introduction to Problem Solving and Programming, Walter Savitch, Pearson, 2012.
  - Rajkumar Buyya, University of Melbourne.