

**BLM 2562 OBJECT ORIENTED PROGRAMMING – Feb. 2017**  
**Assist. Prof. Dr. Yunus Emre SELÇUK**

**GENERAL INFORMATION**

**SCORING**

- 1st midterm: %20, 13/04/2017
- 2nd midterm: %20, 25/05/2017
- Final exam: %40,
- Project: %15,
- Lab: %15
- **Exam dates can be changed (follow [www.ce.yildiz.edu.tr](http://www.ce.yildiz.edu.tr))**
- The percentages can be changed slightly
- Do not forget what you have learned from the previous term, otherwise penalty points will be deducted from your scores.

**SUGGESTED BOOKS:**

- Java Programming:
  - Java How to Program, Harvey M. Deitel & Paul J. Deitel, Prentice-Hall.
    - 7th ed. or newer
  - Core Java 2 Volume I & II, C. S. Horstmann and G. Cornell, Prentice-Hall.
    - 7th ed. or newer
- UML:
  - UML Distilled, 3rd ed. (2003), Martin Fowler, Addison-Wesley.
- You can refer to any other book of your choice as well.

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**COURSE CONTENTS**

- Introduction of the course.
- Primitives, wrappers, parameters.
- Exception handling
- Working with Files and Streams (Serialization).
- Introduction to generic classes using basic data structures (Lists).
- Introduction to generic classes using basic data structures (Maps).
- Typecasting, Enum classes, Inner classes.
- Introduction to Multithreading
- GUI Programming (with Swing)

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**BLM 2562 OBJECT ORIENTED PROGRAMMING LECTURE NOTES**  
**Assist. Prof. Dr. Yunus Emre SELÇUK**

**PRIMITIVES AND WRAPPERS**

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**PRIMITIVES AND WRAPPERS**

- Primitive type: One unit of information (non-class).
- Wrapper: A class having one primitive number and some useful methods related with that member.
- Natural numbers in Java (Numbers without fractional parts):

Primitive	Meaning	Range	Wrapper
int	Integer (4 bytes)	Lower: - 2.147.483.648 Higher: + 2.147.483.647	Integer
long	Big integer ( 8 bytes)	( $\pm 9,22 \times 10^{18}$ ) <code>long natID = 12345678900L;</code>	Long
short	Small integer ( 2 bytes)	Lower: -32.768 Higher: +32.767	Short
byte	One byte	Lower: -128 Higher: +127	Byte

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## PRIMITIVES AND WRAPPERS

- Real numbers in Java (Numbers with fractional parts):

Primitive	Meaning	Range	Wrapper
double	Large real number	( $\pm 1,79 \cdot 10^{308}$ )	Double
float	Small real number	( $\pm 3,4 \cdot 10^{38}$ )	Float

- Other primitives:

Primitive	Meaning	Range	Wrapper
char	Karakter	'A'-'Z', 'a'-'z', etc. (UTF-16 encoding)	Character
boolean	Mantıksal	false – true	Boolean

- I would also like to remind you the non-primitive type String soon.

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## PRIMITIVES AND WRAPPERS

- Operations with primitives:
  - Arithmetic: + - \* / %.
  - Remember operator precedence
  - ++, --,
  - ++i and i++ differs:  $y * ++z$ ,  $y * z++$
  - Shorthands: += -= \*= /= %=
  - Check the static methods of java.lang.Math: pow, abs, round, ...
  - Binary:
    - Boolean algebra: & | ~ ^ (and or not xor)
    - Shifting: << >>
    - Ex: The rightmost 4<sup>th</sup> bit of n:  $(n \& 8) / 8$  or  $(n \& (1 \ll 3)) \gg 3$

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## PRIMITIVES AND WRAPPERS

- We use wrappers for their useful methods and in cases where primitives cannot be used.
  - Serialization and map indexes are examples of such cases that we will cover in the later weeks.
- The wrappers reside in the java.lang package
- Some useful methods of class Integer (refer to Java API for further methods and more details)
  - `int compareTo(Integer anotherInteger)`
  - `int intValue()`
  - `static int parseInt(String s)`
  - `String toString()`
  - `static String toString(int i)`
  - `static Integer valueOf(String s)`

```
int ilkel1 = 5, ilkel2 = 7;
Integer sarma1, sarma2;
sarma1 = new Integer( ilkel1 );
sarma2 = new Integer( ilkel2 );
System.out.println("Sonuç1:"+sarma1.compareTo(sarma2)); //-1
```

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## PRIMITIVES AND WRAPPERS

- I would also like to remind you the non-primitive type String and some of its methods:
  - `int compareTo(String anotherString)`
  - `int compareToIgnoreCase(String str)`
  - `String concat(String str)` //The + operation
  - `int indexOf (String str) //-1, 0, ...`
    - `"Selçuk".indexOf("ç") = 3`
  - `int indexOf (String str, int fromIndex)`
  - `int length()`
  - `String substring(int m, int n)`
    - Returns characters between positions m and n-1.
      - Because Java (and indexOf) begins counting from 0.
    - `"Selçuk".substring(0,3) = "Sel"`
  - `String toLowerCase()`
  - `String toUpperCase()`
  - `String trim()`
- P.S. Problems with understanding the workings of these methods can mean that we have fundamental problems with the previous term's Object Oriented Concepts course.

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## PRIMITIVES AND WRAPPERS

- More methods of the class String:
  - static String format(String format, Object... args)
    - Format parameter: Similar to C format
    - ... denote any number of parameters

```
double pi = (double)22/7;
System.out.println(String.format("%1.6f", pi));
```
  - int lastIndexOf (String str)
  - int lastIndexOf (String str, int fromIndex)
  - String replace(CharSequence target, CharSequence replacement)
    - CharSequence interface provides uniform, read-only access to many different kinds of char sequences.

```
String last = "The Last Ninja's Last Supper";
String first = last.replace("Last", "First");
System.out.println(first);
```

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## PRIMITIVES AND WRAPPERS

- The primitive version of Enum classes:
  - Sometimes, a variable should only hold a restricted set of values.
  - For example, you may sell pizza in four sizes: small, medium, large, and extra large
    - Of course, you could encode these sizes as integers 1, 2, 3, 4, or characters S, M, L, and X.
    - But that is an error-prone setup. It is too easy for a variable to hold a wrong value (such as 0 or m).
  - Example:
    - Defining a primitive enum (in Size.java):
 

```
public enum Size {
    SMALL, MEDIUM, LARGE, EXTRA_LARGE;
}
```
    - Using in code:
 

```
Size s = Size.MEDIUM;
```
  - In fact, we have defined a class named Size and enforced that only four static instances of that class can be created.
    - You cannot write Size s = Size.Medium or MEDIUM or M ...

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## PRIMITIVES AND METHOD PARAMETERS

- Java uses "call-by-value" calling style when passing primitive parameters to methods.
  - This calling style works in the same way when you pass parameters without pointers in the C/C++ language.
- Java uses "call-by-value-of-references" when passing non-primitive parameters to methods.
  - This calling style is different than the style "call-by-references", i.e. when you pass parameters as pointers in the C/C++ language.
  - Well, this style is very similar to the pointer style, except you cannot change the memory address of object parameters
    - This means that changes to object parameters are permanent, except re-initializing and swapping objects.
- Examine the following code and its output:

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## PRIMITIVES AND METHOD PARAMETERS

```
package oop00;
public class MethodParametersTest1 {
    private Integer wrapI, wrapJ;
    public void ilkelDuzenle( int x ) { x++; }
    public void sarmalayiciDuzenle( Integer x ) { x++; }
    public void ilkelDegistir( int x, int y ) {
        int temp; temp = x; x = y; y = temp;
    }
    public void sarmalayiciDegistir( Integer x, Integer y ) {
        Integer temp; temp = x; x = y; y = temp;
    }
    public void sarmalayiciDegistirAlt(Integer x, Integer y) {
        Integer temp;
        temp = new Integer(x);
        x = new Integer(y);
        y = new Integer(temp);
    }
    public void swapForReal( ) {
        Integer temp = wrapI; wrapI = wrapJ; wrapJ = temp;
    }
    public static void main(String[] args) {
        MethodParameters test = new MethodParameters();
        test.tryMe();
    }
}
```

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## PRIMITIVES AND METHOD PARAMETERS

```
public void tryMe() {
    int count = 3;
    System.out.println("Before : " + count );
    this.ilkelDuzenle(count);
    System.out.println("After: " + count );

    Integer wrap = new Integer( 5 );
    System.out.println("Before : " + wrap );
    this.sarmalayiciDuzenle(wrap);
    System.out.println("After: " + wrap );

    int count1 = 1, count2 = 2;
    System.out.println("Before : " + count1 + ", " + count2 );
    this.ilkelDegistir(count1, count2);
    System.out.println("After: " + count1 + ", " + count2 );

    Integer wrap1 = new Integer( 1 );
    Integer wrap2 = new Integer( 2 );
    System.out.println("Before : " + wrap1 + ", " + wrap2 );
    this.sarmalayiciDegistir(wrap1, wrap2);
    System.out.println("After: " + wrap1 + ", " + wrap2 );

    System.out.println("Before : " + wrap1 + ", " + wrap2 );
    this.sarmalayiciDegistirAlt(wrap1, wrap2);
    System.out.println("After: " + wrap1 + ", " + wrap2 );

    wrapI = 3; wrapJ = 5;
    System.out.println("Before : " + wrapI + ", " + wrapJ );
    this.swapForReal();
    System.out.println("After: " + wrapI + ", " + wrapJ );
}
```

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## PRIMITIVES AND METHOD PARAMETERS

- The output:

```
Before : 3
After: 3
Before : 5
After: 5
Before : 1, 2
After: 1, 2
Before : 1, 2
After: 1, 2
Before : 1, 2
After: 1, 2
Before : 3, 5
After: 5, 3
```

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## PRIMITIVES AND METHOD PARAMETERS

- Examine the following code and its output:

```
package oop00;
public class MethodParametersTest2 {
    public void tryMe( ) {
        int x = 1, y = 2;
        System.out.println("Before : " + x + ", " + y );
        int temp;
        temp = x;
        x = y;
        y = temp;
        System.out.println("After: " + x + ", " + y );

        Integer sarmal = new Integer( 3 );
        Integer sarma2 = new Integer( 5 );
        System.out.println("Before : " + sarmal + ", " + sarma2 );

        Integer gecici = sarmal;
        sarmal = sarma2;
        sarma2 = gecici;
        System.out.println("After: " + sarmal + ", " + sarma2 );
    }
}
```

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## PRIMITIVES AND METHOD PARAMETERS

```
public static void main(String[] args) {
    MethodParametersTest2 test = new MethodParametersTest2 ();
    test.tryMe();
}
```

- The output:

```
Before : 1, 2
After: 2, 1
Before : 3, 5
After: 5, 3
```

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## PRIMITIVES AND METHOD PARAMETERS

- Examine the following code and its output:

```
package oop00;
public class MethodParametersTest3 {
    public static void main(String[] args) {
        int[] dizi = { 1, 2, 3, 4, 5 };
        LowHighSwap.doIt( dizi );
        for( int j = 0; j < dizi.length; j++ )
            System.out.print( dizi[j] + " " );
    }
}
class LowHighSwap {
    static void doIt( int[] z ) {
        int temp = z[ z.length - 1 ];
        z[ z.length - 1 ] = z[ 0 ];
        z[ 0 ] = temp;
    }
}
/* Using static has nothing to do with the
 * "call-by-value-of-references" issue. */
```

- The output:

```
5 2 3 4 1
```

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**BLM 2562 OBJECT ORIENTED PROGRAMMING LECTURE NOTES**  
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**EXCEPTION HANDLING**

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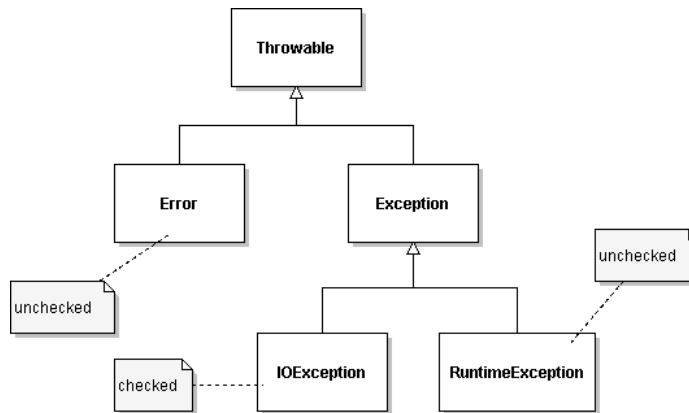
**EXCEPTION HANDLING**

- "If that guy has any way of making a mistake, he will"
  - Murphy's Law
- Some sources of error are:
  - Bugs in JVM
  - Wrong input by the user
  - Buggy code written by us
  - Acts of God
    - A lone and humble programmer cannot control:
      - every aspect of Internet traffic,
      - file access rights,
      - etc.
    - But we should be aware of them and deal with them!
- There are multiple ways of dealing with errors.
  - Boolean returns
  - Form components with error checking mechanisms
  - Exception handling.
- Exception handling is a form of error trapping.

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## EXCEPTION HANDLING

- Each exception is modeled by a class in Java.



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## EXCEPTION HANDLING

- `java.lang.Error`:
  - indicates serious problems that a reasonable application should not try to catch
    - `Depletion of system resources, internal JVM bugs, etc.`
    - `java.lang.UnsupportedClassVersionError`: Can happen when you move your code between different versions of Eclipse.
- `java.lang.RuntimeException`:
  - This is mostly caused by our buggy code
    - `java.lang.NullPointerException`: We have tried to use an uninitialized object
    - `java.lang.IndexOutOfBoundsException`: We have tried to access a non-existent member of an array.
    - etc.
- `java.io.IOException`:
  - Something went wrong during a file operation or a network operation.
  - These operations are always risky, so we must have an alternate plan in case of something goes wrong.
    - If having an alternate plan is a must, then the exception is determined as checked.

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## EXCEPTION HANDLING

- Handling checked exceptions is done by coding a try – catch block.

```
try {
    /* error-prone methods */;
}
catch( AnException e ) {
    /* Dealing with error */
}
```

- A programmer may opt to not handle a checked exception.

- However, someone will eventually handle it!

```
aMethod(...) throws AnException {
    /* error-prone methods */
}
```

- In this case, this someone is the one who calls that aMethod

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## EXCEPTION HANDLING

- It is possible to handle multiple exceptions as well:

```
try {
    /* error-prone methods */;
}
catch( AnException e ) {
    /* Dealing with error */
}
catch( AnotherException e ) {
    /* Dealing with error */
}
```

- About try blocks:

- Each new try block introduces a runtime overhead
- Therefore it's wiser to open one try block with multiple catch blocks

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## EXCEPTION HANDLING

- What should I do in a catch block?
  - Inform the user about the error with the `e.printStackTrace()` method.
  - Log this error
- If this is a very serious error, you may release some resources and make a "clean exit" in the finally block.
  - Scopes of the try block and the finally block are different. Therefore you cannot access the temporary variables/objects defined in the try block from the finally block. Plan your "clean exit" accordingly.
  - The finally block executes whether an exception is thrown or not.

```
try {
    /* error-prone methods */;
}
catch( AnException e ) {
    /* Dealing with error */
}
catch( AnotherException e ) {
    /* Dealing with error */
}
finally {
    /* make a clean exit */
}
```

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## EXCEPTION HANDLING

```
public class ExceptionExample01 {
    MyScreenRenderer graphics;
    MyCADfile myFile;
    //Other methods of this class are omitted
    public void parseMyCADfile( String fileName ) {
        try {
            graphics = new MyScreenRenderer();
            myFile = openFile( fileName );
            MyFigure figs[ ] = myFile.readFromFile( );
            drawFigures( figs );
            myFile.close();
        }
        catch( IOException e ) {
            System.out.println("An IO exception has occurred"+
                               " while opening or reading from file:"+
                               e.toString( ));
            e.printStackTrace( );
            System.exit(1);
        }
        finally {
            graphics.releaseSources();
        }
    }
}
```

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## EXCEPTION HANDLING

- You can create your own Exception classes by :
  - inheriting from IOException if you want your exception to be a checked one,
  - inheriting from RuntimeException if you want an unchecked one.

```
public class MyFileFormatException extends IOException {
    public MyFileFormatException( ) {
        super( );
    } //was required in JDK versions older than 5
    public MyFileFormatException( String errorMessage ) {
        super( errorMessage );
        /* Ayrıca yapmak istediğiniz işler */
    }
}
```

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## EXCEPTION HANDLING

- Throwing an exception:
  - If something terrible may happen during your code, you can throw an exception

```
public class AProgram {
    public void processFile ( ) throws MyFileFormatException{
        some_statements();
        if( an_unexpected_situation )
            throw new MyFileFormatException("... happened");
    }
}
```

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## EXCEPTION HANDLING

- Let's wrap it up all by an example:

```
package oop01;
import java.io.IOException;
/* Eğer RuntimeException'dan türetsek
 * tüm kodlarımız nasıl olacaktı inceleyiniz.
 */
@SuppressWarnings("serial")
public class ImpossibleInfo extends IOException {
    public ImpossibleInfo( String errorMessage ) {
        super(errorMessage);
    }
}
}
```

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## EXCEPTION HANDLING

```
package oop01;
public class Person {
    private String name;
    private int age;

    public Person( String name ) { this.name = name; }
    public String getName( ) { return name; }
    public int getAge( ) { return age; }
    public String toString() {
        return getName() + " " + getAge( );
    }
    public void setAge( int age ) throws ImpossibleInfo {
        if( age < 0 || age > 150 )
            throw new ImpossibleInfo("Impossible age: "+age);
        this.age = age;
    }
}
```

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## EXCEPTION HANDLING

```
package oop01;
import java.util.*;
public class TestExceptions {
    public static void main(String[] args) {
        Scanner in = new Scanner(System.in);
        System.out.print("Enter person's name: ");
        String name = in.nextLine();
        Person insan = new Person(name);
        try {
            System.out.print("Enter age: ");
            int age = in.nextInt();
            insan.setAge(age);
            System.out.println(insan);
        }
        catch (ImpossibleInfo e) {
            e.printStackTrace();
        }
        finally {
            in.close();
        }
    }
}
```

- You can wrap the statement that can cause an exception and the remaining statements with the try block or you can put all statements into the try block.

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**BLM 2562 OBJECT ORIENTED PROGRAMMING LECTURE NOTES**  
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**INTRODUCTION TO GENERIC CLASSES  
AND BASIC DATA STRUCTURES IN JAVA**

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**INTRO. GENERIC CLASSES and DATA STRUCTURES in JAVA**

- Generic programming means to write code that can be reused for objects of many different types.
  - Recent languages such as Java and C# support generics.
  - Generics are, at least on the surface, similar to templates in C++.
- The aim of this section is to make you familiar with the usage of generic classes.
  - We will try to reach this aim by teaching you how to use some of the generic classes that comes with the Java language.
  - We have chosen the examples from the basic data structures in the java.util library.
  - Therefore, an introduction to these data structures exists in the course notes.
- The aim of this section is not to:
  - Teach you how to write your own generic classes.
  - Teach you about data structures.

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## INTRO. GENERIC CLASSES and DATA STRUCTURES in JAVA

- Introduction to Data Structures:
  - A data structure is a scheme for organizing data in the memory of a computer
  - In a general sense, any data representation is a data structure.
    - Example: An integer.
  - More typically, a **data structure is** meant to be **an organization for a collection of data items.**
  - The way in which the data is organized affects the performance of a program for different tasks.
  - The choice of data structure and algorithm can make the difference between a program running in a few seconds or many days!
  - Some of the more commonly used data structures include arrays, lists, stacks, queues, heaps, trees, and graphs.

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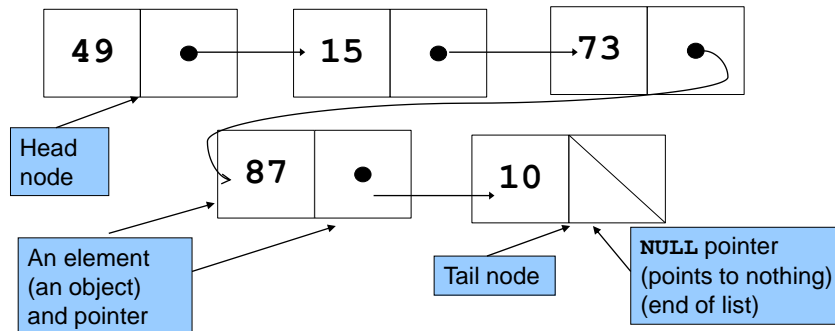
## INTRO. GENERIC CLASSES and DATA STRUCTURES in JAVA

- Introduction to linked lists:
  - Linear collection of self-referential class objects, called nodes
  - Connected by pointer links (transparent to the programming user in Java)
  - The first (head) and last (tail) nodes of the list are accessed via an object reference
  - Traversing between the nodes is done by using using an iterator object obtained from the data structure
    - You may write your own traversal code according to the organization of the data structure.
  - Traversing an entire list is easier (thanks to the for-each loop).

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## INTRO. GENERIC CLASSES and DATA STRUCTURES in JAVA

- An example linked list holding Integer objects:



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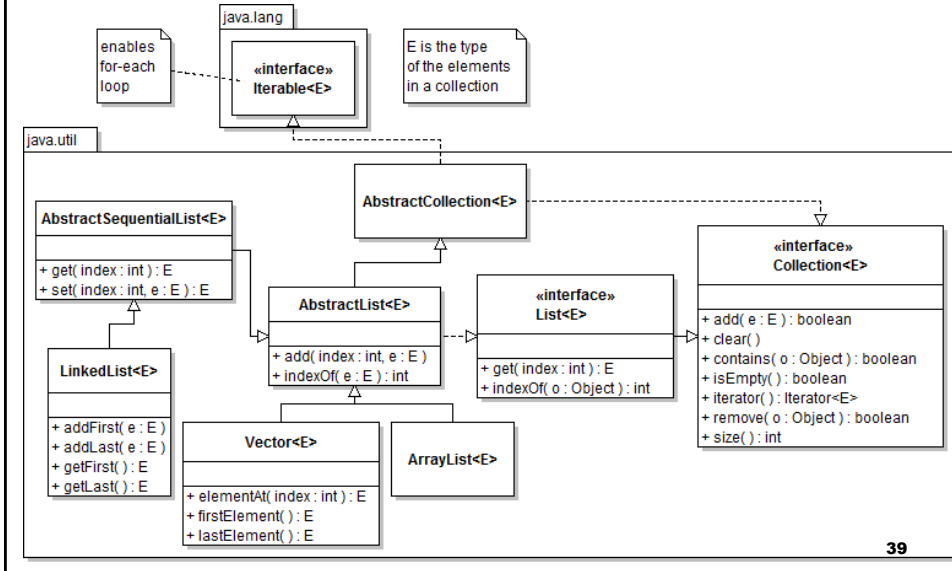
## INTRO. GENERIC CLASSES and DATA STRUCTURES in JAVA

- Advantages of linked lists over arrays:
  - Enlarging a list costs nothing!
  - Insertion and removal of elements to any position is faster.
  - Sorting algorithms work faster on linked lists.
- Advantage of arrays over linked lists:
  - Lists are traversed sequentially where any  $i^{\text{th}}$  member of an array is directly accessible.
- Types of linked lists:
  - Single-linked list: Only traversed in one direction
  - Doubly-linked list: Allows traversals both forwards and backwards
- A list may also be circular.
  - Pointer in the last node points back to the first node (like prayer beads)

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## INTRO. GENERIC CLASSES and DATA STRUCTURES in JAVA

- Part of the inheritance tree of list structures in Java:



## INTRO. GENERIC CLASSES and DATA STRUCTURES in JAVA

- An example list implementation in java: The java.util.ArrayList class
  - Based on arrays, single-linked, thread-unsafe.
  - Initialization:
 

```
ArrayList myList = new ArrayList();
```
- In such definition, the nodes are instances of Object.
  - This makes typecasting mandatory in order to use the node objects.
  - Luckily, support for 'Generic Programming' is introduced in JSE 5.0.
- Generic programming** means to write code that can be reused for objects of many different types.
  - For example, you don't want to program or use separate classes to collect String and File objects.
  - And you don't have to!
    - The single class ArrayList collects objects of any class and constitutes an example of generic programming.
- Example: Creating an ArrayList instance which will contain Person instances
 

```
ArrayList<Person> liste = new ArrayList<Person>();
```

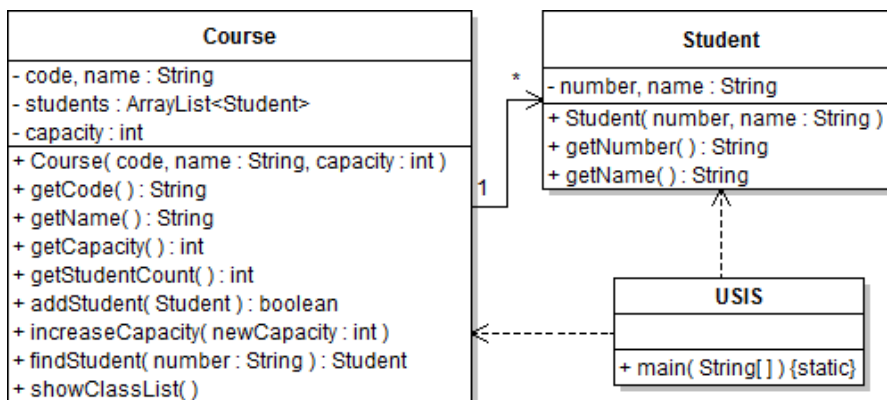
## INTRO. GENERIC CLASSES and DATA STRUCTURES in JAVA

- Fundamental methods of the ArrayList class:
  - `add( <T> object )`: Adds an element (an object of type T) to the end of the list.
  - `<T> get( int i )`: Returns the  $i^{\text{th}}$  element.
  - `int size( )`: Returns the number of elements in this list
  - Remember that the entire list can be easily traversed by using the for-each loop.
- A selection of the other methods of the ArrayList class:
  - `ensureCapacity( int size )`: Increases the capacity of this ArrayList instance, if necessary.
  - `trimToSize( )`: Trims the capacity of this ArrayList instance to be the list's current size.
  - `set( int i, <T> element )`: Replaces the element at the specified position in this list with the specified element.
  - `remove( int i )`: Removes the  $i^{\text{th}}$  element from this list
    - If the current size is less than i, an `IndexOutOfBoundsException` is thrown (unchecked).

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## INTRO. GENERIC CLASSES and DATA STRUCTURES in JAVA

- Let's implement a multiplicity association (1-\*) by using ArrayList



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## INTRO. GENERIC CLASSES and DATA STRUCTURES in JAVA

```
package oop02a;
import java.util.*;

public class Course {
    private String code; private String name; private int capacity;
    private ArrayList<Student> students;

    public Course(String code, String name, int capacity) {
        this.code = code; this.name = name; this.capacity = capacity;
        students = new ArrayList<Student>();
    }
    public String getCode() { return code; }
    public String getName() { return name; }
    public int getCapacity() { return capacity; }
    public int getStudentCount() {
        return students.size();
    }
    public boolean addStudent( Student aStudent ) {
        if( getStudentCount() == capacity ||
            findStudent(aStudent.getNumber()) != null )
            return false;
        students.add(aStudent);
        return true;
    }
}
```

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## INTRO. GENERIC CLASSES and DATA STRUCTURES in JAVA

```
public Student findStudent( String number ) {
    for( Student aStudent : students )
        if( aStudent.getNumber().compareTo(number) == 0 )
            return aStudent;
    return null;
}
public void increaseCapacity( int newCapacity ) {
    if( newCapacity <= capacity )
        return;
    capacity = newCapacity;
}
public void showClassList( ) {
    System.out.println("Class List of "+code+" "+name);
    System.out.println("Student#   Name, Surname");
    System.out.println("-----");
    for( Student aStudent : students )
        System.out.println(aStudent.getNumber() +
            " " + aStudent.getName());
}
}
```

- Please compare this code with the ones you can write by using arrays and see how much cleaner your code has become (show from oop02x).
  - In this example, the member "capacity" exists only for business logic, not for array operations.

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## INTRO. GENERIC CLASSES and DATA STRUCTURES in JAVA

```
package oop02x;
public class Course {
    private String code; private String name; private int capacity, studentCount;
    private Student[ ] students;
    public Course(String code, String name, int capacity) {
        this.code = code; this.name = name; this.capacity = capacity;
        students = new Student[capacity]; studentCount = 0;
    }
    public String getCode() { return code; }
    public String getName() { return name; }
    public int getCapacity() { return capacity; }
    public int getStudentCount() { return studentCount; }
    public boolean addStudent( Student aStudent ) {
        if( studentCount == capacity || findStudent(aStudent.getNumber()) != null )
            return false;
        students[studentCount] = aStudent;
        studentCount++;
        return true;
    }
    public Student findStudent( String number ) {
        for( int i = 0; i < studentCount; i++ )
            if( students[i].getNumber().compareTo(number) == 0 )
                return students[i];
        return null;
    }
}
```

- Continues on the next slide

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## INTRO. GENERIC CLASSES and DATA STRUCTURES in JAVA

- Continued from the next slide

```
public void increaseCapacity( int newCapacity ) {
    if( newCapacity <= capacity )
        return;
    Student[ ] geciciDizi = new Student[ newCapacity ];
    for( int i = 0; i < studentCount; i++ )
        geciciDizi[i] = students[i];
    students = geciciDizi;
    capacity = newCapacity;
}
public void showClassList( ) {
    System.out.println("Class List of "+code+" "+name);
    System.out.println("Student#   Name, Surname");
    System.out.println("-----");
    for( Student aStudent : students )
        if( aStudent != null ) //dizi gerceklemesinde gerekli!
            System.out.println(aStudent.getNumber()+" "+aStudent.getName());
}
}
```

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## INTRO. GENERIC CLASSES and DATA STRUCTURES in JAVA

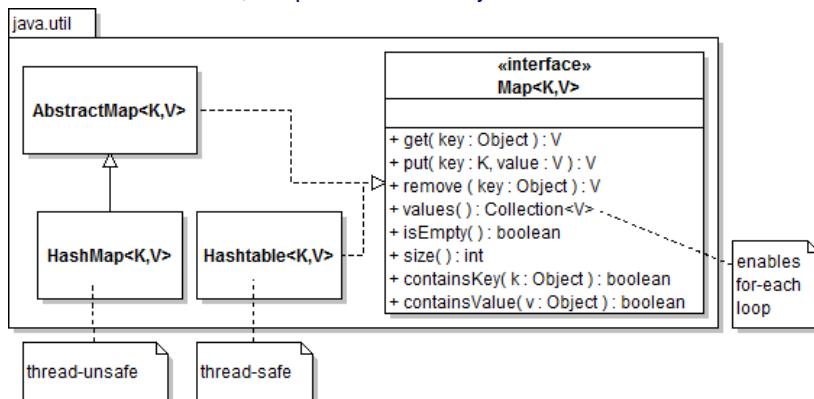
- Now, let's demonstrate and test our code:

```
public class USIS {
    public static void main(String[] args) {
        Course oop = new Course("0112562", "Obj. Or. Prog.", 3);
        Student yasar = new Student("09011034", "Yaşar Nuri Öztürk");
        if( !oop.addStudent(yasar) )
            System.out.println("Problem #1");
        boolean result;
        result = oop.addStudent(yasar);
        if( result == true )
            System.out.println("Problem #2");
        Student yunus = new Student("09011045", "Yunus Emre Selçuk");
        oop.addStudent(yunus);
        Student fatih = new Student("09011046", "Fatih Çıtlak");
        oop.addStudent(fatih);
        Student cemalnur = new Student("09011047", "Cemalnur Sargut");
        if( oop.addStudent(cemalnur) )
            System.out.println("Problem #3");
        if( oop.findStudent("09011046") != fatih )
            System.out.println("Problem #4");
        if( oop.findStudent(fatih.getNumber()) == null )
            System.out.println("Problem #5");
        System.out.println("End of test\n");
        oop.showClassList();
    }
}
```

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## INTRO. GENERIC CLASSES and DATA STRUCTURES in JAVA

- Introduction to map structures:
  - The map data structure lets you to easily reach an existing element according to its unique identifier
    - This operation is also much faster with map structures than with array and list structures
  - Element = value, unique identifier = key



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## INTRO. GENERIC CLASSES and DATA STRUCTURES in JAVA

- A map implementation in Java: The java.util.HashMap class
  - java.util.HashMap<K,V>
    - K: Key, V: Value
- Fundamental methods of the HashMap class :
  - public V get( Object key );
    - Returns the value to which the specified key is mapped.
  - public V put( K key, V value );
    - Associates the specified value with the specified key in this map.
      - I suggest you to obtain the key from the value (by using the necessary get method to access its unique identifier).
      - If a value already exists in the data structure with the given key, the old value is deleted and returned, whereas the new value is inserted into the collection.
  - public Collection<V> values( );
    - Returns a list of all values stored in this table which can easily be traversed by using the for-each loop.
    - At this point, it is not necessary to know the specifics of the generic Collection interface.

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## INTRO. GENERIC CLASSES and DATA STRUCTURES in JAVA

- Let's implement the previous example by using HashMap:

```
package oop02b;
import java.util.*;

public class Course {
    private String code; private String name; private int capacity;
    private HashMap<String, Student> students;

    public Course(String code, String name, int capacity) {
        this.code = code; this.name = name; this.capacity = capacity;
        students = new HashMap<String, Student>();
    }

    public String getCode() { return code; }
    public String getName() { return name; }
    public int getCapacity() { return capacity; }
    public int getStudentCount() {
        return students.size();
    }

    public boolean addStudent( Student aStudent ) {
        if( getStudentCount() == capacity ||
            findStudent(aStudent.getNumber()) != null )
            return false;
        students.put(aStudent.getNumber(), aStudent);
        return true;
    }
}
```

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## INTRO. GENERIC CLASSES and DATA STRUCTURES in JAVA

```

public Student findStudent( String number ) {
    return students.get(number);
}

public void increaseCapacity( int newCapacity ) {
    if( newCapacity <= capacity )
        return;
    capacity = newCapacity;
}

public void showClassList( ) {
    System.out.println("Class List of "+code+" "+name);
    System.out.println("Student#   Name, Surname");
    System.out.println("-----");
    for( Student aStudent : students.values() )
        System.out.println(aStudent.getNumber() +
            " " + aStudent.getName());
}
}

```

- Please compare this code which uses maps with the previous one which uses lists and notice the conveniences for the programmer.

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## INTRO. GENERIC CLASSES and DATA STRUCTURES in JAVA

### TESTING

- We wrote some code, but we didn't test it for bugs. Let's do it:

```

public class USIS {
    public static void main(String[] args) {
        Course oop = new Course("0112562", "Obj. Or. Prog.", 3);
        Student yasar = new Student("09011034", "Yaşar Nuri Öztürk");
        if( !oop.addStudent(yasar) )
            System.out.println("Problem #1");
        if( oop.addStudent(yasar) )
            System.out.println("Problem #2");
        Student yunus = new Student("09011045", "Yunus Emre Selçuk");
        oop.addStudent(yunus);
        Student fatih = new Student("09011046", "Fatih Çıtlak");
        oop.addStudent(fatih);
        Student cemalnur = new Student("09011047", "Cemalnur Sargut");
        if( oop.addStudent(cemalnur) )
            System.out.println("Problem #3");
        if( oop.findStudent("09011046") != fatih )
            System.out.println("Problem #4");
        System.out.println("End of test");
    }
}

```

Why isn't there a package name?

How can we document this new class?

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## INTRO. GENERIC CLASSES and DATA STRUCTURES in JAVA

### SUMMARY OF FUNDAMENTAL DATA STRUCTURE IMPLEMENTATIONS:

- `java.util.LinkedList<E>` implements `List<E>`
  - Faster insertions and deletions
  - Slower random access
  - Doubly-linked (Can be traversed backwards by obtaining a `ListIterator` instance [not to be covered?] ).
- `java.util.ArrayList<E>` implements `List<E>`
  - Slower insertions and deletions
  - Faster random access
- `java.util.Vector<E>` implements `List<E>`
  - Similar to `ArrayList`
  - synchronized
    - Suitable for multi-threaded use, slower in single-threaded use
- `java.util.HashMap<K,V>` implements `Map<K,V>`
  - Used for fast searches by a key (indexed)
- `java.util.Hashtable<K,V>` implements `Map<K,V>`
  - Similar to `HashMap` but synchronized
    - Suitable for multi-threaded use, slower in single-threaded use
  - Attention: Lowercase t in class name `Hashtable`

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This slide is intentionally left blank

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**BLM 2562 OBJECT ORIENTED PROGRAMMING LECTURE NOTES**  
**Assist. Prof. Dr. Yunus Emre SELÇUK**

**TYPECASTING**

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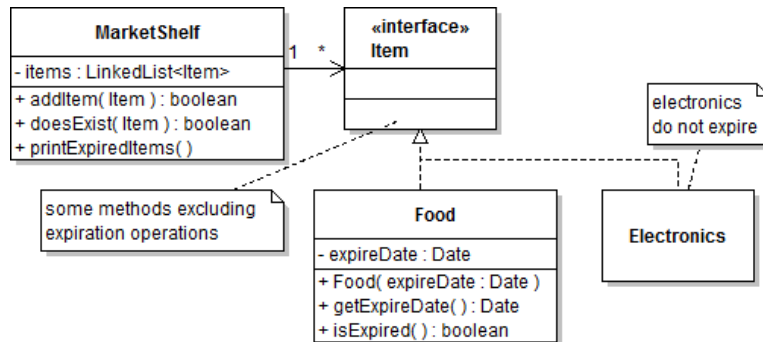
**TYPECASTING**

- Remember the following rule of inheritance:
  - An instance of a sub class can be used wherever an instance of its super class is expected.
- This is a type-safe operation and it is done automatically.
  - We can convert a specific object to a more general one without losing any information.
  - Conversion in the opposite direction is risky, therefore it is done manually.
- The Java terminology uses the word "type casting" for converting the type of an object.
- You can make a manual cast from one type to another, according to the following rules:
  - From the interface to the class of the object
  - From the super class to the sub class
- However, this is an unsafe operation and therefore you need to make a check beforehand

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## TYPECASTING

- Example:



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## TYPECASTING

- Coding class MarketShelf:

```

import java.util.*;
public class MarketShelf {
    private LinkedList<Item> items;
    public MarketShelf() {
        items = new LinkedList<Item>();
    }
    public boolean doesExist( Item anItem ) {
        for( Item item : items )
            if( item == anItem )
                return true;
        return false;
    }
    public boolean addItem( Item anItem ) {
        if( doesExist(anItem) )
            return false;
        items.add(anItem);
        return true;
    }
}
  
```

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## TYPECASTING

- Coding class MarketShelf:

```
public void printExpiredItems( ) {
    boolean hasExpiredItem = false;
    System.out.println("Expired item(s): ");
    for( Item item : items ) {
        if( item instanceof Food )
            if( ((Food)item).isExpired() ) {
                hasExpiredItem = true;
                System.out.println(item);
            }
    }
    if( hasExpiredItem == false )
        System.out.println("All items are fresh!");
}
```

- [Checking for type compliance and typecasting](#)

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## TYPECASTING

- Coding class MarketShelf:

```
public static void main( String[] args ) {
    MarketShelf shelf = new MarketShelf();
    Calendar cal = Calendar.getInstance();
    cal.add(Calendar.DAY_OF_MONTH,1);
    Date future = cal.getTime();
    cal.set(Calendar.YEAR, 2010);
    cal.set(Calendar.MONTH, 0); //0: January
    cal.set(Calendar.DATE, 12);
    Date past = cal.getTime();
    shelf.addItem( new Food(past) );
    shelf.addItem( new Food(future) );
    shelf.addItem( new Electronics() );
    shelf.checkForExpiration();
}
```

- [Using java.util.Date and Calendar classes](#)

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## TYPECASTING

- Coding class Food:

```
package oop03b;
import java.util.Date;
public class Food implements Item {
    private Date expireDate;

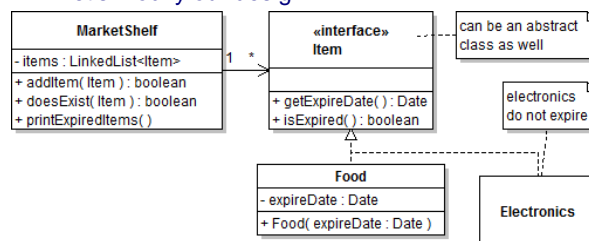
    public Food(Date expireDate) {
        this.expireDate = expireDate;
    }
    public Date getExpireDate() { return expireDate; }
    public boolean isExpired() {
        Date today = new Date();
        if( expireDate.before(today) )
            return true;
        else return false;
    }
    public String toString() {
        return "A food expiring at " + expireDate;
    }
}
```

- [Using java.util.Date class continues](#)

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## TYPECASTING

- Critique of typecasting:
  - Typecasting is a "necessary evil". Use it sparingly.
    - Back in the days where generic classes were not available in Java, we had to make typecasting frequently.
    - Nowadays, we need typecasting only when we make deserialization (topic of the next lecture).
  - We can always make designs without typecasting.
    - Let's modify our design:



- In other cases, we can make good use of abstract classes and polymorphism.
  - In those cases, we are advised to avoid any relationship with the subclasses.

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**BLM 2562 OBJECT ORIENTED PROGRAMMING LECTURE NOTES**  
**Assist. Prof. Dr. Yunus Emre SELÇUK**

**WORKING WITH FILES**

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**WORKING WITH FILES**

**RELATED EXCEPTIONS**

- `java.io.IOException`: Represents I/O exceptions in general.
- `java.io.EOFException` extends `IOException`: Indicates that the end of file or stream has been reached unexpectedly.
- `java.io.FileNotFoundException` extends `IOException`: Indicates that the requested file cannot be found in the given path.
- `java.lang.SecurityException` extends `java.lang.RuntimeException`: Indicates that the requested operation cannot be executed due to security constraints.

**GENERAL INFORMATION ABOUT FILE OPERATIONS**

- File operations are separated into two main groups in Java:
  - File management: Operations such as creating, renaming, deleting files and folders.
  - I/O operations.
- I/O operations are not only done with files but also with different sources such as TCP sockets, web pages, console, etc. Therefore I/O operations:
  - have been separated from file operations
  - coded in the same way for all these different sources.
- This approach is in harmony with the nature of object oriented paradigm. However, the complexity has been increased as a side effect.

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## WORKING WITH FILES

### FILE MANAGEMENT

- Coded by using the java.io.File class which represents both the files and the folders in the hard drive.
- Creating a File object does not mean to create an actual file or folder.
- Creating a File object :
  - Done by using the File( String fileName) constructor.
  - fileName should contain both the path and the name of the file/folder.
    - Full path vs. relative path.
      - Using full path degrades portability
      - Relativity is tricky as well: IDEs may keep source and class files in different folders.
    - Path separator:
      - Windows uses \ (should be denoted as \\ in Strings), Unix uses /.
      - What about portability?
        - public static String File.separator
        - public static char File.separatorChar
  - File( String path, String name) and File( File path, String name ) constructors:
    - Represents a file/folder with the given name in the folder given by the path parameter.

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## WORKING WITH FILES

### FILE MANAGEMENT

- Some methods of the class java.io.File:
  - boolean exists( ); tells whether the file exists or not.
  - boolean isFile( ); returns true if this File object represents a file, false otherwise, i.e. this object represents a folder.
  - File getParentFile( ); Returns the directory where this file/folder resides.
  - String getCanonicalPath( ) throws IOException; Returns the full path of the file/folder, including the file name.
  - boolean canRead( ); Can this application read form this file?
  - boolean canWrite( ); Can this application write to this file?
  - boolean createNewFile( ); Actually creates the file.
  - boolean mkdir( ); Actually creates the folder.
  - boolean mkdirs( ); Actually creates the folder with all necessary parent folders
  - boolean renameTo( File newName ); Renames the file.
  - boolean delete( ); Deletes the file.
- boolean returns: True if the operation is successful.
- You do not have to memorize all those methods.

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## WORKING WITH FILES

### I/O OPERATIONS USING STREAMS

- Any I/O source is represented as stream in Java
  - Files, memory, command prompt, network, etc.
- Binary vs. Text format:
  - Binary I/O is fast and efficient, but it is not easily readable by humans.
  - Text I/O is the opposite.
- Random vs. Sequential access:
  - Sequential access: All records are accessed from the beginning to the end
  - Random access: A particular record can be accessed directly.
  - Disk files are random access, but streams of data from a network are not.
- Java chains streams together for different working styles.
- We will study a mechanism which allows makes it possible to write any object to a stream and read it again later.
  - This process is called serialization in the Java terminology.

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## WORKING WITH FILES

### I/O OPERATIONS USING STREAMS

- Serialization – Output operations:
  - We will write entire objects to a file on disk.
  - The classes of objects to be serialized should implement the `java.io.Serializable` interface.
  - You do not need to do anything else as the `java.io.Serializable` interface does not have any methods.
  - `ObjectOutputStream` and `FileOutputStream` objects are chained together for serialization.
  - Multiple objects can and should be sent to the same stream.

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## WORKING WITH FILES

### I/O OPERATIONS USING STREAMS

- Example record: the class Arkadas

```
public class Arkadas implements java.io.Serializable {
    private static final long serialVersionUID = 1L;
    private String isim, telefon, ePosta;
    public Arkadas( String name ) { this.isim = name; }
    public String getIsim( ) { return isim; }
    public String getTelefon( ) { return telefon; }
    public void setTelefon( String telefon ) {
        this.telefon = telefon;    }
    public String getEPosta( ) { return ePosta; }
    public void setEPosta( String posta ) { ePosta = posta; }
    public String toString( ) {
        return isim + " - " + telefon + " - " + ePosta;
    }
}
```

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## WORKING WITH FILES

### I/O OPERATIONS USING STREAMS

- About the lines beginning with @ :
  - These are special commands called “annotations”.
  - They work at the “meta” level, i.e. they contain “information about information”.
  - They give information to the IDE, compiler, another programme, etc. about this program.
  - We have used the annotation mechanism to remove the warnings.
  - In fact, warnings must be taken into consideration. In the previous examples, we have disabled these warnings with annotations.
  - In the example above, we didn’t use annotation as the warning is directly related with our current subject.
- About “marking interfaces”:
  - The java.io.Serializable interface does not include any methods to be implemented. This interface is used only for marking/highlighting the classes where its instances are to be serialized.

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## WORKING WITH FILES

### I/O OPERATIONS USING STREAMS

- About the serialVersionUID member:
  - private static final long serialVersionUID = 1L;
  - We can give a particular version instead of 1, or we can have the IDE to generate a unique identifier automatically.
  - If we do not code this member, we can hide the related warning with the @SuppressWarnings("serial") command.
  - What does this member mean?
    - There will be applications which save and load objects from different sources.
    - In time, the source code of the classes of these objects may change, as well as the source code of the aforementioned applications.
    - Different versions of all those classes can exist together. In order to avoid incompatibilities, we need a versioning mechanism.
    - This mechanism is implemented by giving a different (and possibly increasing) serial number to classes and by checking this serial in the applications.

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## WORKING WITH FILES

### I/O OPERATIONS USING STREAMS

- An application for writing the objects to a file (serialization/output):

```
import java.util.*;
import java.io.*;
public class ArkadasOlustur {
    public static void main(String[] args) {
        Integer arkadasSayisi;
        Arkadas[] arkadaslar;
        Scanner giris = new Scanner( System.in );
        System.out.println("Bu program arkadaşlarınızın iletişim " +
            "bilgilerini diskteki bir dosyaya kaydeder.");
        System.out.print("Kaç arkadaşınızın bilgisini gireceksiniz? ");
        arkadasSayisi = giris.nextInt( );
        giris.nextLine( );
        arkadaslar = new Arkadas[arkadasSayisi];
        for( int i = 0; i < arkadasSayisi; i++ ) {
            System.out.print((i+1)+". arkadaşınızın ismi nedir? ");
            arkadaslar[i] = new Arkadas( giris.nextLine() );
            System.out.print("Bu arkadaşınızın telefonu nedir? ");
            arkadaslar[i].setTelefon( giris.nextLine() );
            System.out.print("Bu arkadaşınızın e-posta adresi nedir? ");
            arkadaslar[i].setEPosta( giris.nextLine() );
        }
    }
}
```

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## WORKING WITH FILES

### I/O OPERATIONS USING STREAMS

- Serialization example (cont'd):

```

try {
    String dosyaAdi = "arkadaslar.dat";
    ObjectOutputStream yazici = new ObjectOutputStream(
        new FileOutputStream( dosyaAdi ) );
    yazici.writeObject( arkadasSayisi );
    for( Arkadas arkadas : arkadaslar )
        yazici.writeObject( arkadas );
    yazici.close();
    System.out.println("Girilen bilgiler " + dosyaAdi +
        " adlı dosyaya başarıyla kaydedildi.");
}
catch( IOException e ) {
    System.out.println("Dosyaya kayıt işlemi sırasında"+
        " bir hata oluştu.");
    e.printStackTrace();
}
}

```

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## WORKING WITH FILES

### I/O OPERATIONS USING STREAMS

- Deserialization – Input operations:
  - We will read entire objects form a file on disk.
  - ObjectInputStream and FileInputStream objects are chained together for deserialization.
  - Typecasting is required as the objects read from a stream comes as instances of the class Object.
  - If these objects are to be stored in an array, we need to know how many objects there will be.
    - In the data structures that may grow dynamically, we are not faced with this inconvenience.

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## WORKING WITH FILES

### I/O OPERATIONS USING STREAMS

- An application for reading the objects from a file (deserialization/input):

```
import java.io.*;

public class ArkadasGoster {
    public static void main( String[] args ) {
        String dosyaAdi = "arkadaslar.dat";
        try {
            ObjectInputStream okuyucu = new ObjectInputStream(
                new FileInputStream( dosyaAdi ) );
            Integer kayitSayisi = (Integer)okuyucu.readObject();
            for( int i = 0; i < kayitSayisi; i++ ) {
                Arkadas arkadas = (Arkadas) okuyucu.readObject();
                System.out.println(arkadas);
            }
            okuyucu.close();
        }
    }
}
```

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## WORKING WITH FILES

### I/O OPERATIONS USING STREAMS

- Deserialization example (cont'd):

```
catch( IOException e ) {
    System.out.println("Dosya okuma işlemleri sırasında " +
        " bir hata oluştu.");
    e.printStackTrace();
}
catch( ClassNotFoundException e ) {
    System.out.println("Okunan kayıtları işlerken " +
        "bir hata oluştu.");
    e.printStackTrace();
}
}
}
```

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## WORKING WITH FILES

### I/O OPERATIONS USING STREAMS

- More on object streams:
  - There is no safe and efficient way to determine whether the end of a stream has been reached. Therefore we couldn't use a while loop such as:

```
try {
    ObjectInputStream okuyucu = new ObjectInputStream(
        new FileInputStream( dosyaAdi ) );
    Arkadas arkadas = (Arkadas) okuyucu.readObject();
    while okuyucu.hasNext() {
        System.out.println(arkadas);
        arkadas = (Arkadas) okuyucu.readObject();
    }
    okuyucu.close();
}
```

→ Does not work! Removed in JDK8.

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## WORKING WITH FILES

### I/O OPERATIONS USING STREAMS

- There is a method, `int ObjectInputStream.available()`, but this is somewhat buggy
  - <http://www.coderanch.com/t/378141/java/java/EOF-ObjectInputStream>
- Moreover, `readObject()` doesn't return null at EOF
  - <http://stackoverflow.com/questions/2626163/java-fileinputstream-objectinputstream-reaches-end-of-file-eof>
- You can code a solution by letting the exception to happen, and terminate the loop in the catch block.
  - However, exception handling is not invented for altering the program flow.
- A better alternative to writing the data object count beforehand is to use only one container object which stores references all the data objects.
  - This container object will be a **data structure**, such as a list or a map.
    - However, the objects in the container must implement the `java.io.Serializable` interface.
    - Will be shown in the next slide.
  - If there is a relation  $A \rightarrow B$ , both A and B must implement the `java.io.Serializable` interface.

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## WORKING WITH FILES

### I/O OPERATIONS USING STREAMS

- Serializing data structures:

```
package oop04b;
import java.util.*;
import java.io.*;
@SuppressWarnings("resource")
public class ArkadasOlustur {
    public static void main(String[] args) {
        LinkedList<Arkadas> arkadaslar = new LinkedList<Arkadas>();
        Scanner giris = new Scanner( System.in );
        System.out.println("Bu program arkadaşlarınızın iletişim " +
            " bilgilerini diskteki bir dosyaya kaydeder.");
        System.out.print("Kaç arkadaşınızın bilgisini gireceksiniz? ");
        int arkadasSayisi = giris.nextInt( );
        giris.nextLine( );
        for( int i = 0; i < arkadasSayisi; i++ ) {
            System.out.print((i+1)+". arkadaşınızın ismi nedir? ");
            Arkadas arkadas = new Arkadas( giris.nextLine() );
            System.out.print("Bu arkadaşınızın telefonu nedir? ");
            arkadas.setTelefon( giris.nextLine() );
            System.out.print("Bu arkadaşınızın e-posta adresi nedir? ");
            arkadas.setEPosta( giris.nextLine() );
            arkadaslar.add(arkadas);
        }
    }
}
```

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## WORKING WITH FILES

### I/O OPERATIONS USING STREAMS

- Serializing data structures (cont'd):

```
try {
    String dosyaAdi = "arkadaslarAlt.dat";
    ObjectOutputStream yazici = new ObjectOutputStream(
        new FileOutputStream( dosyaAdi ) );
    yazici.writeObject( arkadaslar );
    yazici.close();
    System.out.println("Girilen bilgiler " + dosyaAdi +
        " adlı dosyaya başarıyla kaydedildi.");
}
catch( IOException e ) {
    System.out.println("Dosyaya kayıt işlemi sırasında"+
        " bir hata oluştu.");
    e.printStackTrace();
}
}
```

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## WORKING WITH FILES

### I/O OPERATIONS USING STREAMS

- Deserializing data structures:

```
package oop04b;
import java.io.*;
import java.util.*;
public class ArkadasGoster {
    public static void main( String[] args ) {
        String dosyaAdi = "arkadaslarAlt.dat";
        try {
            ObjectInputStream okuyucu = new ObjectInputStream(
                new FileInputStream( dosyaAdi ) );
            @SuppressWarnings("unchecked")
            LinkedList<Arkadas> arkadaslar =
            (LinkedList<Arkadas>)okuyucu.readObject();
            for( Arkadas arkadas : arkadaslar ) {
                System.out.println(arkadas);
            }
            okuyucu.close();
        }
    }
}
```

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## WORKING WITH FILES

### I/O OPERATIONS USING STREAMS

- Deserializing data structures (cont'd.):

```
        catch( IOException e ) {
            System.out.println("Dosya okuma işlemleri sırasında " +
                " bir hata oluştu.");
            e.printStackTrace();
        }
        catch( ClassNotFoundException e ) {
            System.out.println("Okunan kayıtları işlerken " +
                "bir hata oluştu.");
            e.printStackTrace();
        }
    }
}
```

- What about working with text files or working in other modes?
  - Refer to Vol.II of Core Java 8th ed. or any other book of your choice.
  - Hint: PrintWriter and InputStreamReader streams are available for text output and input.

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## BLM 2562 OBJECT ORIENTED PROGRAMMING LECTURE NOTES

### Assist. Prof. Dr. Yunus Emre SELÇUK

#### ENUM CLASSES

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#### ENUM CLASSES

- The primitive enum we have learned is in fact a class definition.
- Each member of an enum is an instance of that class.
- There cannot be any other members of an enum except the ones that are already defined.
- An enum type can member fields, methods and constructors as any other regular classes.
- The constructor of an enum class must be private.
- Example:

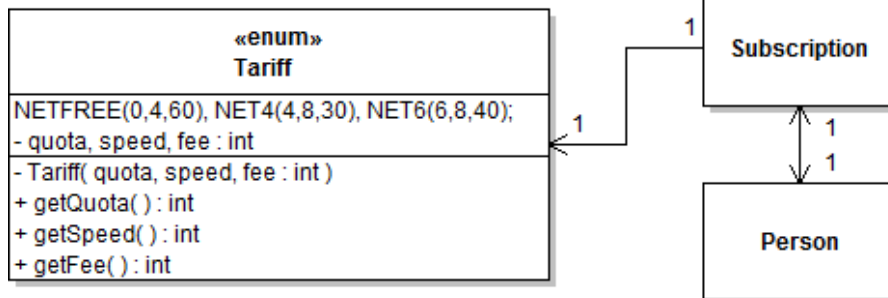
```
package oop05a;
public enum Tariff {
    NETFREE(0,4,60), NET4(4,8,30), NET6(6,8,40);
    private int quota, speed, fee;
    private Tariff( int quota, int speed, int fee ) {
        this.quota = quota; this.speed = speed; this.fee = fee;
    }
    public int getQuota() { return quota; }
    public int getSpeed() { return speed; }
    public int getFee() { return fee; }
}
```

This must be the first line of code!

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## ENUM CLASSES

- Example:



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## ENUM CLASSES

- Creating and using an enum object:

```

public class Test {

    public static void main(String[] args) {
        Tariff tariff4 = Tariff.NET4;
        Person yunus = new Person("Yunus Emre");
        yunus.subscribeTo(tariff4);
        Person berkin = new Person("Berkin Gülay");
        berkin.subscribeTo(Tariff.NETFREE);
        System.out.println(yunus);
        System.out.println(berkin);
    }
}
  
```

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**BLM 2562 OBJECT ORIENTED PROGRAMMING LECTURE NOTES**  
**Assist. Prof. Dr. Yunus Emre SELÇUK**

**INNER CLASSES**

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**INNER CLASSES**

- You can code a class within a class.
  - An **inner class** is coded within an **outer class**.
- An inner class can:
  - Access all members of the outer class, including the private ones.
  - Be hidden from other classes of the same package, if defined as private.
  - It is frequently used in form of **anonymous inner classes** in GUI programming.
    - Anonymous = without a name!
- You cannot:
  - define a static method in a an inner class.
- An example: Person and Employee classes

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## INNER CLASSES

```
package oop05b;
public class Person {
    private String name;
    public Person( String name ) { this.name = name; }
    @SuppressWarnings("unused")
    private class Employee { //begin inner class
        private int salary;
        public Employee( int salary ) { this.salary = salary; }
        public int getSalary() { return salary; }
        public void setSalary(int salary) { this.salary = salary; }
        public String toString( ) { return name + " " + salary; }
    } //end inner class
    public static void main( String[] args ) {
        Employee[] staff = new Employee[3];
        Person kisi;
        kisi = new Person("Osman Pamukoğlu");
        staff[0] = kisi.new Employee( 10000 );
        kisi = new Person("Nihat Genç");
        staff[1] = kisi.new Employee( 7500 );
        kisi = new Person("Barış Müstecaplıoğlu");
        staff[2] = kisi.new Employee( 6000 );
        for( Employee eleman: staff )
            System.out.println( eleman );
    }
}
```

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## INNER CLASSES

- Previous example is a demonstration of how to:
  - define an inner class
  - access the outer object from the inner object
- The inner class in the previous example is private.
  - Therefore, it is hidden from all classes, including the ones within the same package.
  - Which means, the Person.main method cannot be moved to any other class.
- The next example will show how to access a public inner class from any other class.

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## INNER CLASSES

```
package oop05c;

public class Person {
    private String name;
    public Person( String name ) { this.name = name; }

    public class Employee {
        private int salary;
        public Employee( int salary ) { this.salary = salary; }
        public int getSalary() { return salary; }
        public void setSalary(int salary) { this.salary = salary; }
        public String toString( ) { return name + " " + salary; }
    }
}
```

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## INNER CLASSES

```
package oop05c;

//this import is absolutely necessary
import oop05c.Person.Employee;

public class TestInnerClassDirectly {
    public static void main( String[] args ) {
        Employee[] staff = new Employee[3];
        Person kisi;
        kisi = new Person("Osman Pamukoğlu");
        staff[0] = kisi.new Employee( 10000 );
        kisi = new Person("Nihat Genç");
        staff[1] = kisi.new Employee( 7500 );
        kisi = new Person("Barış Müstecaplıoğlu");
        staff[2] = kisi.new Employee( 6000 );
        for( Employee eleman: staff )
            System.out.println( eleman );
    }
}
```

- PS: Instead of the import statement, you can write Person.Employee wherever necessary

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## INNER CLASSES

- This example shows how to access a private inner class from any other class:
  - By using a public method of the outer class
  - Meanwhile, we have to access the inner object from the outer object

```
package oop05d;
public class Person {
    private String name;
    private Employee employee;
    public Person(String name) { this.name = name; }
    public void enlist( int salary ) {
        employee = new Employee( salary );
    }
    public String toString( ) {
        String mesaj = name;
        if( employee != null )
            mesaj += " " + employee.getSalary( );
        return mesaj;
    }
    @SuppressWarnings("unused")
    private class Employee {
        private int salary;
        public Employee( int salary ) { this.salary = salary; }
        public int getSalary() { return salary; }
        public void setSalary(int salary) { this.salary = salary; }
    }
}
```

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## INNER CLASSES

```
package oop05d;
public class TestInnerClassViaOuterClass {
    public static void main(String[] args) {
        Person[] staff = new Person[3];
        staff[0] = new Person( "Polat Alemdar" );
        staff[0].enlist( 10000 );
        staff[1] = new Person( "Memati Baş" );
        staff[1].enlist( 7000 );
        staff[2] = new Person( "Abdülhey Çoban" );
        staff[2].enlist( 5000 );
        for( Person insan: staff )
            System.out.println( insan );
    }
}
```

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**BLM 2562 OBJECT ORIENTED PROGRAMMING LECTURE NOTES**  
**Assist. Prof. Dr. Yunus Emre SELÇUK**

**INTRODUCTION TO MULTITHREADING**

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**INTRODUCTION TO MULTITHREADING**

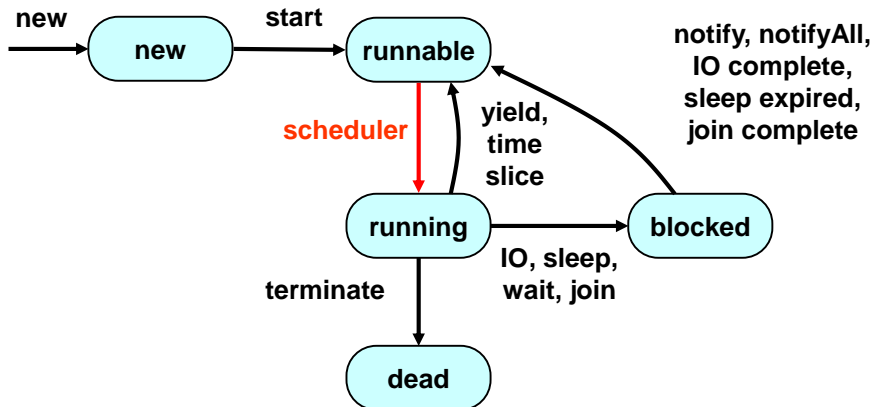
- Multitasking, multiple processes and multithreading:
  - Multitasking is the ability to have more than one program working at the same time.
  - Nowadays, you are likely to have a computer with its CPU having multiple cores.
  - Each core can execute one or more tasks, i.e. processes, depending on the CPU architecture.
  - A process can sometimes be divided into threads that may run in parallel, i.e. concurrently running sub-processes.
    - If there are enough hardware resources, i.e. cores, the time it takes to complete a process will drop significantly.
  - However, this increase in the performance will not be in the order of the available cores.
    - The concurrently running threads will sooner or later need to synchronize with each other.
    - Moreover, creating a process or a thread takes some execution time as well.
- I have done significant simplifications while giving you this introduction!

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## INTRODUCTION TO MULTITHREADING

- A state diagram showing the possible states of a thread and transitions between those states:



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## INTRODUCTION TO MULTITHREADING

- How should a thread wait?
  - If a thread is unable to continue its task because of an obstacle, that thread should wait until the obstacle has been removed.
    - Obstacle: The needed information has not arrived from: the network, another thread, the user, etc.
  - You should not do "**busy waiting**", i.e. executing dummy instructions such as running empty loops for 10.000 times.
  - Instead, you should put that thread into the blocked state by using the sleep command.
  - A sleeping thread, unlike a busy waiting one, does not consume system resources.
  - A sleeping thread is at risk of becoming unable to awake.
    - You must catch the `java.lang.InterruptedException`, which is a checked exception.

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## INTRODUCTION TO MULTITHREADING

- Procedure for running a task in a separate thread:
  1. Place the code for the task into the run method of a class that implements the Runnable interface.
  2. Create an object of your class
  3. Create a Thread object from the Runnable
  4. Start the thread by using Thread.start method (do not call the run method directly)
- Do not code your own threads by inheriting from the Thread class.
  - Otherwise you will lay your only inheritance right to waste.
- Let's make a demonstration with a nonsense application about people watching a match:
  - Each person will shout for the team they support when he or she becomes excited.
  - There is a possibility for each person to become excited in 0-1000 ms.
  - Each person become exhausted after shouting 10 times.

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## INTRODUCTION TO MULTITHREADING

```
package oop06a;
import java.util.Random;

public class SoccerFan implements Runnable {
    public final static int STEPS = 10;
    public final static int DELAY = 1000;
    private String teamName, shoutPhrase;

    public SoccerFan( String teamName, String shoutPhrase ) {
        this.teamName = teamName;
        this.shoutPhrase = shoutPhrase;
    }

    public void run() {
        Random generator = new Random();
        try {
            for( int i = 0; i < STEPS; i++ ) {
                System.out.println( teamName + " " + shoutPhrase );
                Thread.sleep( generator.nextInt(DELAY) );
            }
        } catch (InterruptedException e) {
            e.printStackTrace();
        }
    }
}
```

1. Place the code for the task into the run method of a class that implements the Runnable interface.

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## INTRODUCTION TO MULTITHREADING

3. Create a Thread object from the Runnable

```
package oop06a;

public class Match {
    public static void main(String[] args) {
        Thread aThread;
        aThread = new Thread( new SoccerFan("G.S.", "Rulez!") );
        aThread.start();
        aThread = new Thread( new SoccerFan("G.S.", "is the champ!") );
        aThread.start();
        aThread = new Thread( new SoccerFan("F.B.", "is no.1!") );
        aThread.start();
        aThread = new Thread( new SoccerFan("F.B.", "is the best!") );
        aThread.start();
    }
}
```

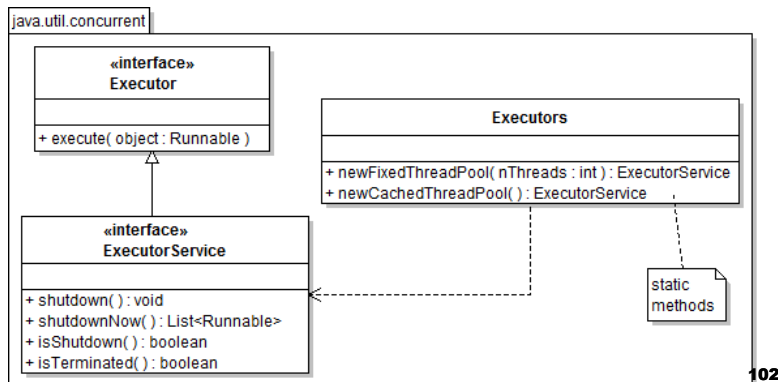
2. Create an object of your class

4. Start the thread by using Thread.start

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## INTRODUCTION TO MULTITHREADING

- Thread pools:
  - Running a small number of tasks in separate threads is acceptable.
  - But do not forget that actual processing units in a typical CPU is rather low, and creating a thread has also a processing cost.
  - Therefore, if you are to execute a large number of tasks, you should use a thread pool instead.
  - Java provides the following interfaces and classes for this purpose:



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## INTRODUCTION TO MULTITHREADING

- `java.util.concurrent.ExecutorService`:
  - `public void shutdown( )` :
    - Shuts down the executor, but allows the tasks currently in the pool to be completed. New threads are not accepted to the pool.
    - We need to use this method for a safe ending.
  - `public List<Runnable> shutdownNow( )`
    - Shuts down immediately, stops the unfinished threads and returns them in a list.
  - `public boolean isShutdown( )`:
    - Returns true if the executor is shut down.
  - `public boolean isTerminated( )`:
    - Returns true if all the tasks in the pool are terminated.
    - Can be used in the main method for waiting the threads to be finished
- `java.util.concurrent.Executor`:
  - `public void execute( Runnable object )` : Executes the given task
- `java.util.concurrent.Executors`:
  - `public static ExecutorService newFixedThreadPool( nThreads : int )`
    - Creates a thread pool that reuses a fixed number of threads
  - `public static ExecutorService newCachedThreadPool( )`
    - Creates a thread pool that creates new threads as needed, but will reuse previously constructed threads when they are available **103**

## INTRODUCTION TO MULTITHREADING

- Let's modify our previous example to be run in a pool.
  - The `SoccerFan` class will not be changed.
  - Try using a fixed pool with different sizes!

```
package oop06a;
import java.util.concurrent.*;
public class MatchWithPool {
    public static void main(String[] args) {
        ExecutorService pool = Executors.newCachedThreadPool( );
        pool.execute( new SoccerFan("G.S.", "Rulez!") );
        pool.execute( new SoccerFan("G.S.", "is the champ!") );
        pool.execute( new SoccerFan("F.B.", "is no.1!") );
        pool.execute( new SoccerFan("F.B.", "is the best!") );
        pool.shutdown( );
    }
}
```

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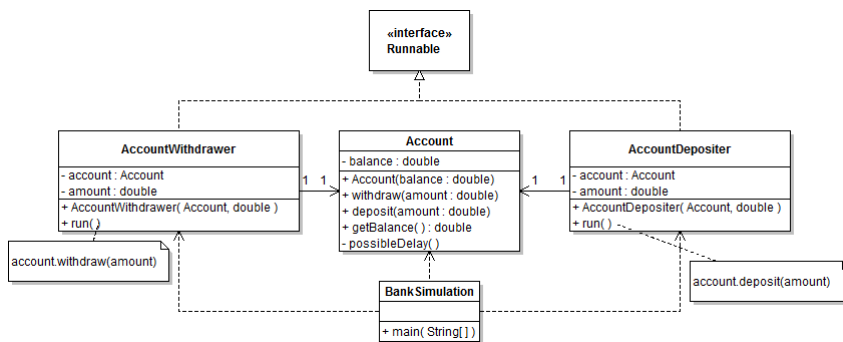
## INTRODUCTION TO MULTITHREADING

- Race condition:
  - In most practical multithreaded applications, two or more threads need to share access to the same data.
  - What happens if two threads have access to the same object and each calls a method that modifies the state of the object?
    - As you might imagine, the threads can step on each other's toes!
    - Depending on the order in which the data were accessed, corrupted objects can result.
  - Such a situation is often called a race condition.

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## INTRODUCTION TO MULTITHREADING

- Thread synchronization is needed to avoid race conditions.
  - Consider the following example:



- This class diagram is descriptive enough, however, let's write the code and execute it.

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## INTRODUCTION TO MULTITHREADING

```
package oop06b;
public class Account {
    private double balance;
    public Account(double balance) { this.balance = balance; }
    public double getBalance() { return balance; }
    public void withdraw( double amt ){
        double curBal = getBalance();
        possibleDelay( );
        balance = curBal - amt;
    }
    public void deposit( double amt ){
        double curBal = getBalance();
        possibleDelay( );
        balance = curBal + amt;
    }
    private void possibleDelay( ) {
        try { Thread.sleep(5); }
        catch (InterruptedException e) { e.printStackTrace(); }
    }
}
```

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## INTRODUCTION TO MULTITHREADING

```
package oop06b;
public class AccountDepositer implements Runnable {
    private Account account;
    private double amount;
    public AccountDepositer(Account account, double amount) {
        this.account = account; this.amount = amount;
    }
    public void run() {
        account.deposit(amount);
    }
}

package oop06b;
public class AccountWithdrawer implements Runnable {
    private Account account;
    private double amount;
    public AccountWithdrawer(Account account, double amount) {
        this.account = account; this.amount = amount;
    }
    public void run() {
        account.withdraw(amount);
    }
}
```

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## INTRODUCTION TO MULTITHREADING

```
package oop06b;
import java.util.concurrent.*;
public class BankSimulation {
    public static void main(String[] args) {
        Account anAccount = new Account(0);
        System.out.println("Before: "+anAccount.getBalance());
        ExecutorService executor = Executors.newCachedThreadPool( );
        for( int i = 0; i < 100; i++ ) {
            AccountDepositer task=new AccountDepositer(anAccount,1);
            executor.execute(task);
        }
        for( int i = 0; i < 50; i++ ) {
            AccountWithdrawer task=new AccountWithdrawer(anAccount,1);
            executor.execute(task);
        }
        executor.shutdown();
        while( !executor.isTerminated() );
        System.out.println("After: "+anAccount.getBalance());
    }
}
```

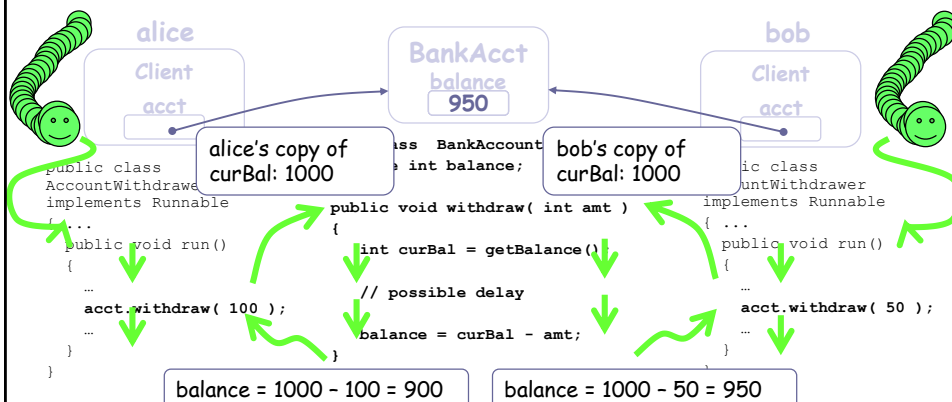
- What did you expect? What did you get?

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## INTRODUCTION TO MULTITHREADING

- What can happen if two threads tried to withdraw from a BankAccount at the same time?

\*note: each thread has its own copy of local variables and parameters, but *fields* are shared between threads



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## INTRODUCTION TO MULTITHREADING

- How can we prevent such a race?
  - We determine the methods which can lead to a race and label them with the keyword `synchronized`.
  - Only one thread can execute a synchronized method, others wait.

```
package oop06c;
public class Account {
    private double balance;
    public Account(double balance) { this.balance = balance; }
    public synchronized void withdraw( double amt ) {
        double curBal = getBalance();
        possibleDelay( );
        balance = curBal - amt;
    }
    public synchronized void deposit( double amt ) {
        double curBal = getBalance();
        possibleDelay( );
        balance = curBal + amt;
    }
    public double getBalance() { return balance; }
    public void possibleDelay( ) { /*same as the previous one */ }
}
```

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## INTRODUCTION TO MULTITHREADING

- Other classes stay the same.
- Output:
 

```
Before: 0.0
After: 50.0
```
- About the data structures and multithreading:
  - Remember the data structures section: Some data structures are thread-safe, i.e. `synchronized`
  - `Vector<E>` and `Hashtable<K,V>`
  - Use those data structures when multithreading is to be used.

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