# ANZ Java

Wednesday, February 1, 2023 10:59 PM

URL: 202302-anz-java https://1drv.ms/u/s!AknT1SrRpCz-wLEUhesLREpkzkkp4w?e=9QtUn0

http://tiny.cc/anz-java

GIT: https://github.com/vivekduttamishra/anz-java-202302

# C++

Thursday, February 2, 2023 8:46 AM

C = C+1

X++

- C with class
- new C

C ++ --

# Java

Thursday, February 2, 2023 8:54 AM

Java

- **Platform independent**
- **Architectural neutral**
- General purpose
- Object Oriented
- Multi-threaded
- Network
- **secured**
- robust
- high peromance
- **interpreted**

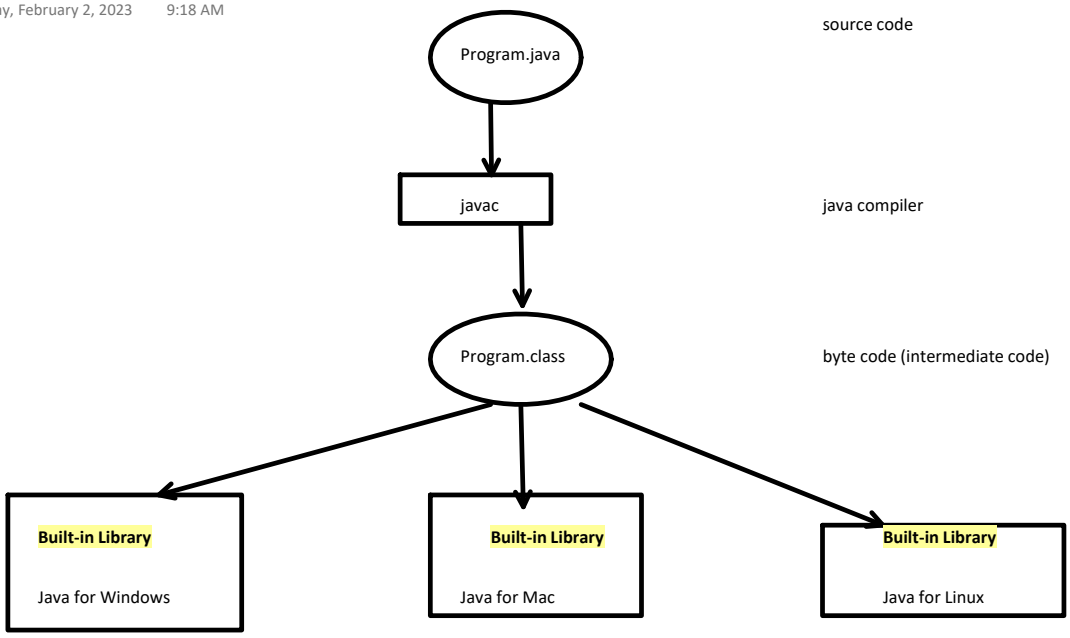
programming language.

Java Promise

- Write Once, Run Anywhere
- No separate code for different OS/Hardware combination.

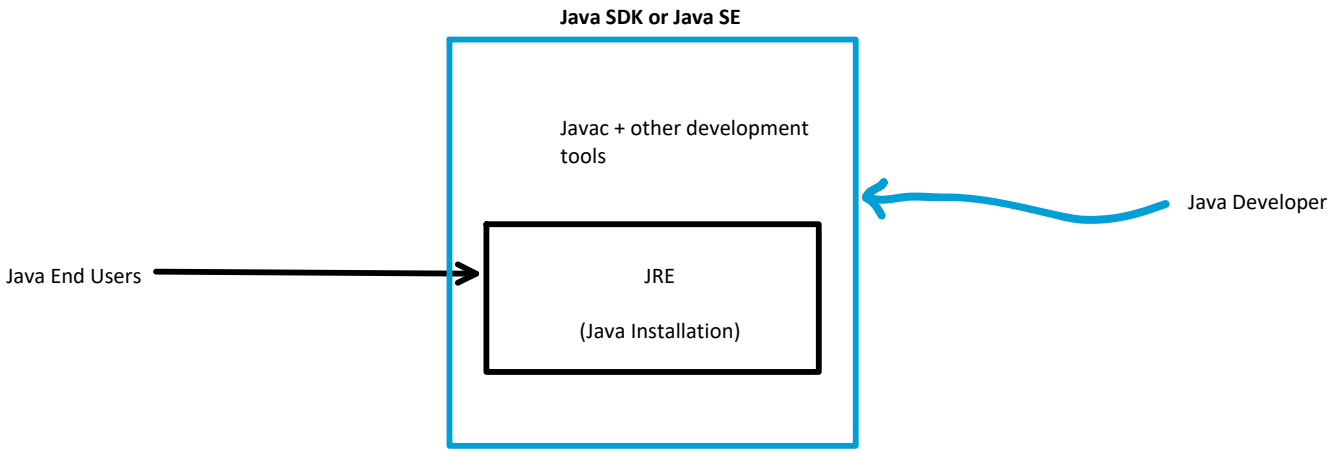
# Java Program Flow

Thursday, February 2, 2023 9:18 AM



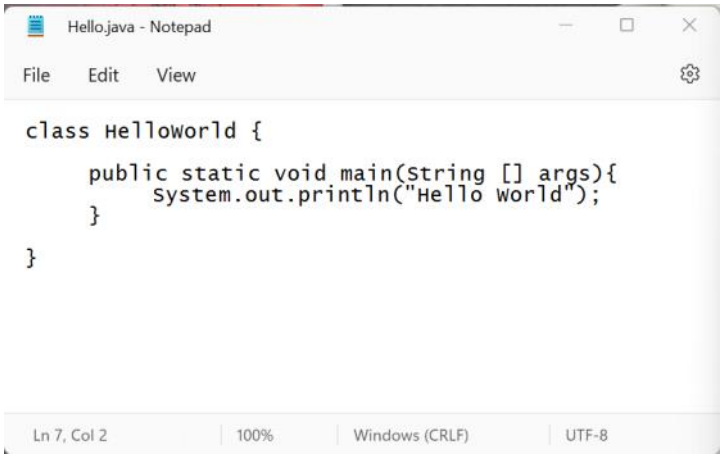
# Installation and Bundles

Thursday, February 2, 2023 9:24 AM



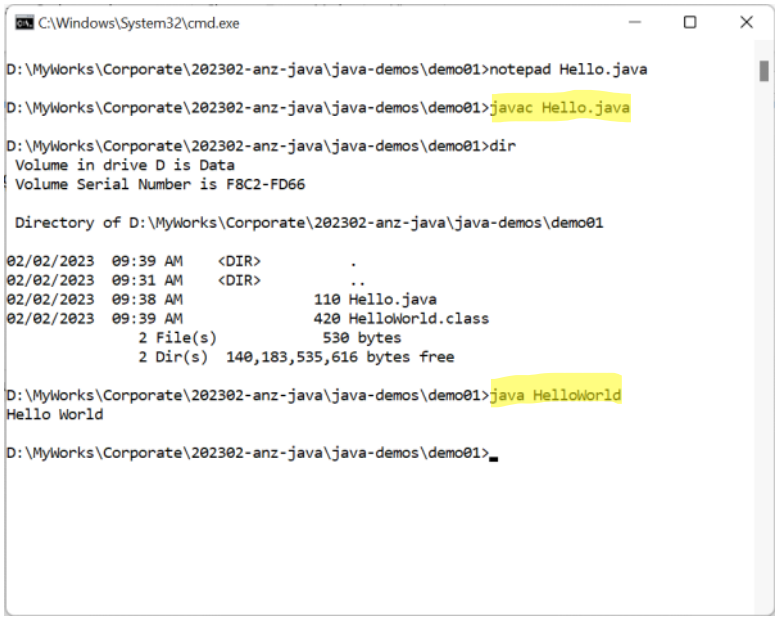
# Hello World

Thursday, February 2, 2023 9:59 AM




- Write a Hello.java
- We need

1. A class
   - It can have any name we like
2. main function
   - match exact signature
3. print statement
   a. match exact singature




## Step #1 compile

- we compile the source file.
- Here we use the full file name in the exact same case with extension

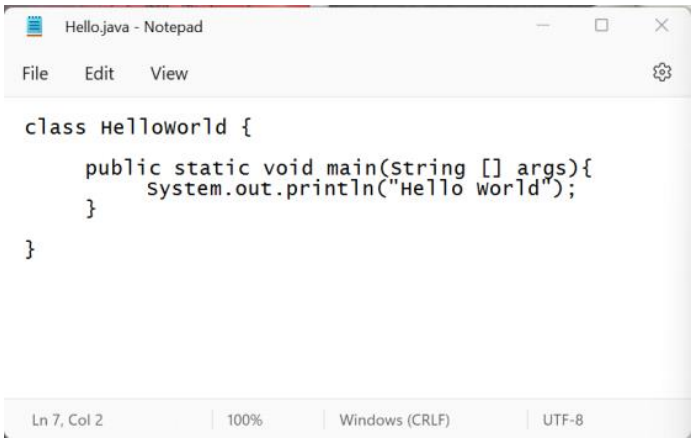
- On success we get
  - A class file with same name as that of class
  - It may not be same as the file name

Step #2 run the program

- we run the class file that contains main
- name is case sensetive without suffixing .class

# Basic Java

Thursday, February 2, 2023 10:34 AM




Anatomy of Java Program

- A Java Program will have one or more classes
  - we need at least one class
- A class may have one or more methods (or functions)
  - Every program should have a "main" function
  - Every class doesn't need main.

- A Java Program is case sensetive.
  - You must be careful about the cases (upper case or lower case)
- Java Keywords
  - There are some special keywords that have special meaning in java
    - example
      - class
      - public
      - static
      - void
    - All keywords are in lower case
  - There are user defined words that represent
    - class name
    - method name
    - variable name
    - Example
      - HelloWorld
    - Few class names are pre defined by Java but are not keywords
      - String
      - System
      - out
      - println
    - main is special
      - It is created by user
      - Java expects you to create it
    - All user defined words can be in any case
      - You must use it in subsequent placed based on orginal defintion.
      - We follow certain naming convention to avoid confusion

## Naming Convention in Java

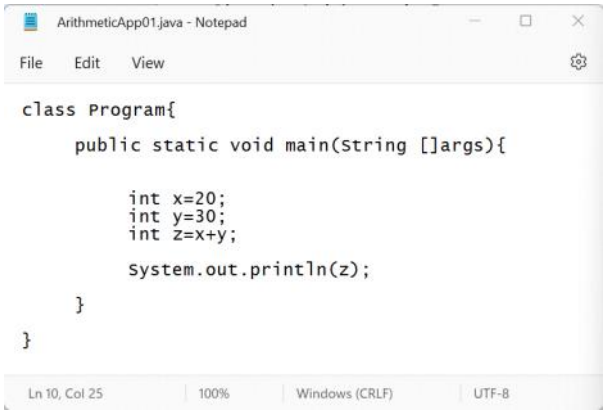
- Class Name
  - Pascal convention
  - Name should begin with upper case
  - If the name is a composite name it each word should begin with upper case
  - No underscores
  - Example
    - class Hello
    - class InterestCalculator

- Method Name/ Field Name / Variable Name
  - Camel case
  - Name should begin with lower case
  - In case of composite word each subsequent word should begin with upper case
  - avoid underscore
  - example
    - calculate()
    - calculateInterest()
    - period
    - interestRate
- package name
  - all lower case

# Simple Arithmetic Program

Thursday, February 2, 2023 10:50 AM

- Write a program to calculate sum of two numbers




## Variable

- To store a value of a particular type and refer it back we need to create a user defined name called variable
  - variable indicates that the value can change later.

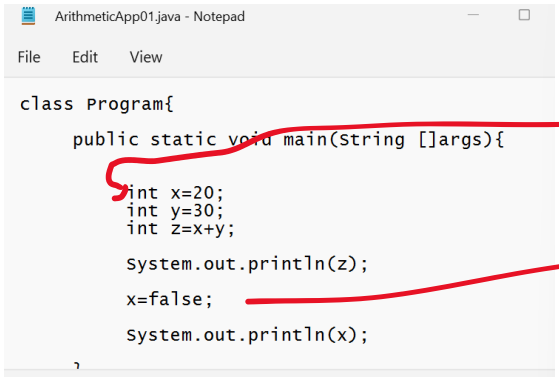
```
int a= 20;  //a is an integer that has current value 20.

char b= '3'; // can hold international character set

double c=20.7;  //can hold non-integer values


boolean d= true;

boolean e= 7>8;  //false
```

- a variables value can change later

```
a = 30;    //change the value to another value

a = a * 10;  //change the value based on the previous value of same
variabel
```

- You can't store wrong type of value in  a variable

```
a="Hello World"; //can't store String in int variable
```




```
D:\MyWorks\Corporate\202302-anz-java\java-demos\simple-demos>javac ArithmeticApp01.java
ArithmeticApp01.java:12: error: incompatible types: boolean cannot be converted to int
                x=false;
                  ^
1 error
```

## Data Types

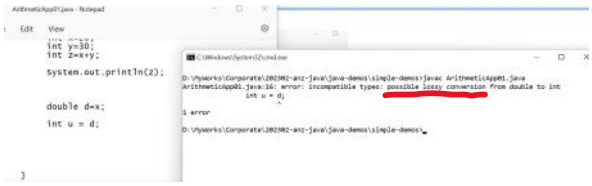
- to store the value in memory we need to create variables
  - variables are memory locations with specific name
  - they are associated with a particular type of value they can hold

- common types
  - int
    - integer
  - float
    - floating point (decimal numbers, single precession)
  - double
    - floating point decimal number, double precession
  - boolean
    - true/false
  - Other less used data types
    - char
      - a unicode char representation
      - represented as a single single quoted letter.
        - 'A'
        - '2'
          - '2' and 2 are different from each other
          - '2' doesn't possess arithematic quality
    - byte
      - represents a single byte
    - short
      - short int
    - long
      - long int

- **String**
  - String is a series of char to represent
    - word
    - sentense
  - It is double qutoed
  - Note String begins with upper case S
    - It is a class and not a keyword
    - It is a predefined class created by Java team

## Compatible and Incompatible type

- Few types are compataible if not same
- an int can be assigned to double without any information loss
  - Java allows this conversion automatically
  - implicit type conversion
- a double may be assigned to int with a loss of information (fraction part)
  - They are compatible but lossy
  - Java doesn't allow this conversion automatically




- we can force such conversion by explicit type casting

```
int u = (int)  d;  //force convert value of 'd' in int before assign
```

- Note here  'd' remains double
- The value of d is converted to int and stored in u

## Print A report including multiple variables

- wat if we want to say
  - sum of 20 and 30 is 50
- Java allows "+" operator between string and anything
  - String + anything => string

```
class Program{
    public static void main(String []args){

        int x=20;
        int y=30;
        int z=x+y;

        System.out.println("sum of "+ x +" and "+ y + " is "+ z);

    }
}
```

```
C:\Windows\System32\cmd.exe

D:\MyWorks\Corporate\202302-anz-java\java-demos\simple-demos>javac ArithmeticApp01.java

D:\MyWorks\Corporate\202302-anz-java\java-demos\simple-demos>java Program
sum of 20 and 30 is 50

D:\MyWorks\Corporate\202302-anz-java\java-demos\simple-demos>
```

```
class Program{
     public static void main(String []args){

          int x=20;
          int y=30;
          int z=x+y;

          String output="sum of "+ x +" and "+ y + " is "+ x + y;

          System.out.println(output);


          System.out.println( "sum of "+ x +" and "+ y + " is "+ (x + y));

     }
}
```

```
C:\Windows\System32\cmd.exe

D:\MyWorks\Corporate\202302-anz-java\java-demos\simple-demos>javac ArithmeticApp01.java

D:\MyWorks\Corporate\202302-anz-java\java-demos\simple-demos>java Program
sum of 20 and 30 is 2030
sum of 20 and 30 is 50

D:\MyWorks\Corporate\202302-anz-java\java-demos\simple-demos>
```

## Statement vs Expression

- An expression can be a
  - simple value
  - arithmetic expression containing variable, constant and operators
- An statement
  - Always ends with a semicolon
  - A statement may be
    - declaring a variable
      - int x=20;
    - calling a method
      - System.out.println(x)
  - A method can take an expression as a parameter
    - It can't take statement as a parameter
    - We can't declare a variable as a method argument

~~System.out.println( int x=20);~~ //Not allowed.

```
System.out.println( x*20); //allowed
```

## White space

- Java considers blank space, tab and enter key or their combination as white space
- Whereever we can have a blank space or an operator, we can add any combination of white space
  - A statement may have multiple blank space, tab or even enter key
  - A statement or a expression may span to multiple lines
  - end is marked with semicolon

- valid statements may look like

```
int a=20;  int b= a

+

30

/2 ;
```

- Note
  - statement 2 (declaration of variable b) begins in same line where first statement ends
  - second statement spans in 4 lines
  - It is acceptable

- Exception to this rule
  - A string doesn't follow white space concept
  - A string must end in the same physical line
  - Invalid statement

```
String address = "A2 202, Ozone Evergreens,
            Haralur Road,
            Bangalore
            560102 "
```

- To represent string with multiple line we use special combination characters to represent single character. This is known as escape sequences
  - \n --> new line (also includes \r)
  - \r —> carriage return
  - \t —> tab
  - \b —> back space
  - \' —> '
  - \" —> "
  - \\ —> \

- To represent the above address properly

```
String address = "A2 202, Ozone Evergreens,\nHaralur Road,\nBangalore\npin\t560102";
```

- To represent a large string in source code we can use string concat

```
address=  "A2 202,\n"+
          "Ozone Evergreens,\n"+
          "Haralur Road,\n"+
          "Bangalore,\n"+
          "pin\t560102";
```

# Java Operators

Thursday, February 2, 2023 12:01 PM

| Operators | Meaning | Associative |
|---|---|---|
| () | | inner to outer (right to left) |
| . | | left to right |
| * , / , %, ~, ! | | left to right |
| +, - | | left to right |
| <,>,<=,>=, ==, != | Relational | left to right |
| && | Boolean and | left to right |
| \|\| | Boolean or | left to right |
| =<br>+=<br>-=<br>*= | assignment | right to left |
| ?: | | |

## Increment and Decrement (Prefix and Post fix)

- when increment/decrement is a independent expression they are exactly same
  - x++;
  - ++x
- when increment/decrement comes as part of another expression
  - prefix is resolved before resolving the expression
  - postfix is resolved after resolving the expression

```
int x=20;

x++; //21
++x; //22
```

```
int y=5;

int z = y++ * 10;  //z will be 5* 10 =50,  y will become 6 later


int k=5;

int l = ++k * 10 ; // first k will become 6 then l with become 6*10 = 60
```

## Integer Operations

```
int x=50;
int y=4;
```

- an operation between 2 int always returns an int
  - It truncates (not rounds) to fractional part
- An operation involving at least one double makes the result double

- 20 * 30 /40
  - 20* 30 = 600
  - 600 / 40 = 15
- 20 + 40 * 4
  - 40 *4 = 160
  - 20+160 = 180
- (20 + 40) * 4
  - 20+40 = 60
  - 60 *4 = 240

## Composite Assignment

- x+=y
  - x= x+y
- x*=y
  - x=x*y
- x=x+1
  - x+=1
  - x++
  - ++x
- x=x-1
  - x-=1
  - x--
  - --x

```
int x=50;
int y=4;

double z= x/ y;

System.out.println(z); //12.5
```

- an operation between 2 int always returns an int
  - It truncates (not rounds) to fractional part
- An operation involving at least one double makes the result double

- z = x / y;
  - x/y => 50/4 = 12~~.5~~ =12
- z= 12
  - z=12.0

## How to get 12.5?

- At least one operand should be double (or casted to double)

- Option#1

```
z= (double)x /y;
```

- Option#2

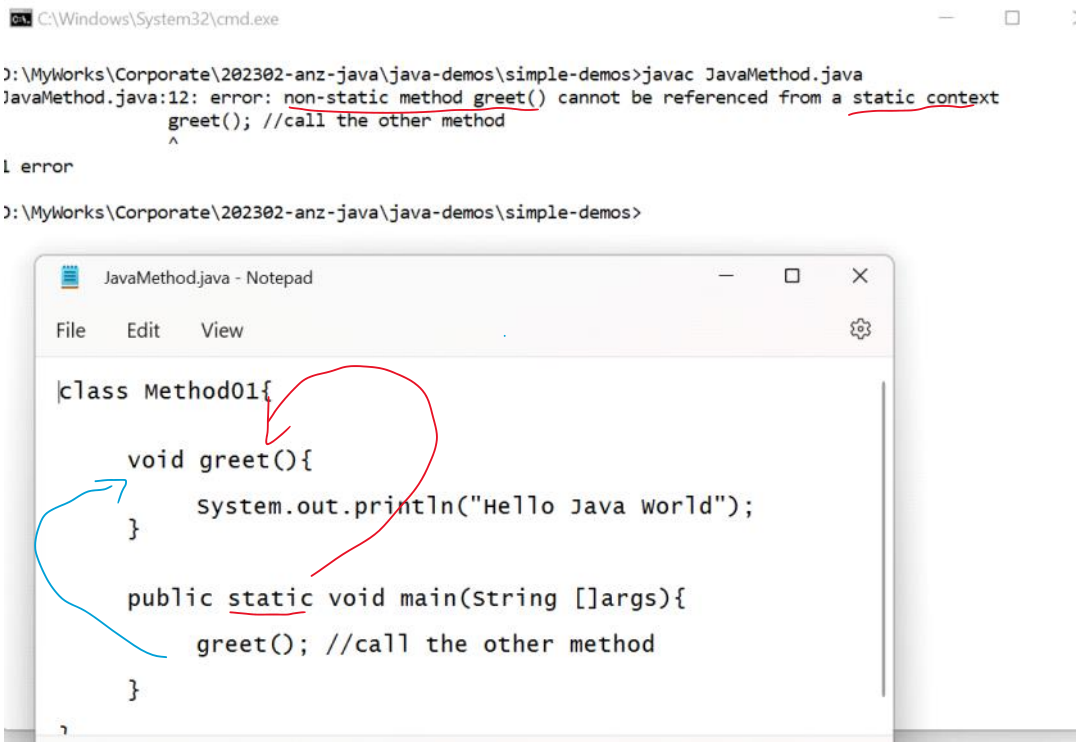
```
z= x*1.0/y;
```

# Java Methods (functions)

Thursday, February 2, 2023 12:45 PM

- methods are independent reusable algorithm
- They have
  - name
  - return type (that can also be void if we don't return anything)
  - can take one or more parameters

## A Method may represent a piece of exeuctable code




- A static main, can't call non-static greet
- main must be static
- We may also mark greet as static
- Why?
  - We will discuss later!

## Working with multiple Methods

```
File  Edit  View
class Method01{

     static void greet(){

          System.out.println("Hello Java World");
     }

     public static void main(String []args){

          greet(); //call the other method
          greet(); // call again
          greet(); //and yet again

     }
}
```

```
C:\Windows\System32\cmd.exe

D:\MyWorks\Corporate\202302-anz-java\java-demos\simple-demos>javac JavaMethod.java

D:\MyWorks\Corporate\202302-anz-java\java-demos\simple-demos>java Method01
Hello Java World

D:\MyWorks\Corporate\202302-anz-java\java-demos\simple-demos>javac JavaMethod.java

D:\MyWorks\Corporate\202302-anz-java\java-demos\simple-demos>java Method01
Hello Java World
Hello Java World
Hello Java World

D:\MyWorks\Corporate\202302-anz-java\java-demos\simple-demos>
```

### Note:

- We have two methods in our program
  - greet
  - main
- Eventhough "greet" is the first method, program always begins with "main"
- "greet" will not work unless it is called explicitly
  - if main never calls it, it doesn't work. just exists
- main may call greet multiple times
- there can be more methods forming a chain
  - main calls method1
  - method1 calls method2
  - ...

## What if  we need to greet someone specific?

- we may pass the name of the person to be greeted as a prameter
- A parameter is like a varible that is created and assigned the value passed.

```
File  Edit  View
class Method01{

     static void greet(String name){

          System.out.println("Hello "+name+", welcome to Java World");
     }

     public static void main(String []args){

          greet(); //call the other method
          greet(); // call again
          greet(); //and yet again

     }
}
```

```
C:\Windows\System32\cmd.exe

D:\MyWorks\Corporate\202302-anz-java\java-demos\simple-demos>javac JavaMethod.java
JavaMethod.java:12: error: method greet in class Method01 cannot be applied to given types;
               greet(); //call the other method
               ^
  required: String
  found:    no arguments
  reason: actual and formal argument lists differ in length
JavaMethod.java:13: error: method greet in class Method01 cannot be applied to given types;
               greet(); // call again
               ^
```

Note

- Here greet expects user to pass a String value
- That string value will be stored in a variable called name.
- greet method may use the name in their code

- But main is not passing the value for name and that is an error here
- Error
  - I couldn't find greet that doesn't take parameter

```
class Method01{

     static void greet(String name){

          System.out.println("Hello "+name+", welcome to Java World");
     }

     public static void main(String []args){

          greet("Vivek"); //call the other method
          greet("Raheem"); // call again
          greet("Venu"); //and yet again

     }
}
```

```
C:\Windows\System32\cmd.exe

D:\MyWorks\Corporate\202302-anz-java\java-demos\simple-demos>javac JavaMethod.java

D:\MyWorks\Corporate\202302-anz-java\java-demos\simple-demos>java Method01
Hello Vivek, welcome to Java World
Hello Raheem, welcome to Java World
Hello Venu, welcome to Java World

D:\MyWorks\Corporate\202302-anz-java\java-demos\simple-demos>
```

- Here we are calling greet multiple times with different values for name
- The supplied values are called arguments
- variable that is created to store argument is known as parameter
- Example
  - parameter is "name"
  - arguments supplied for "name" are
    - "vivek"
    - "rahim"
    - "venu"

## Method chaining

```
File  Edit  View
class Method01{

     static void greet(String name){

          System.out.println("Hello "+name+", welcome to Java World");
     }

     static void goodBye(){
          System.out.println("Good Bye everyone, see you soon");
     }

     public static void main(String []args){

          greetEveryone();

     }

     static void greetEveryone(){

          greet("Vivek"); //call the other method
          greet("Raheem"); // call again
          greet("Venu"); //and yet again
     }
}
```

```
C:\Windows\System32\cmd.exe

D:\MyWorks\Corporate\202302-anz-java\java-demos\simple-demos>javac JavaMethod.java

D:\MyWorks\Corporate\202302-anz-java\java-demos\simple-demos>java Method01
Hello Vivek, welcome to Java World
Hello Raheem, welcome to Java World
Hello Venu, welcome to Java World

D:\MyWorks\Corporate\202302-anz-java\java-demos\simple-demos>
```

1. Program always begins with main()
2. main calls greetEveryone()
3. greetEveryone() calls greet() thrice with different parameters
4. no one calls goodBye() in the call chain that started with main
    a. It never executes
    b. It will not give any compile time error for being unused.
5. Physical order of method definition has no impact.

## Method returning result

```
class Program{



     public static void main(String []args){

          int a= sumSquare(5,3); //
          System.out.println(a);

          int b= sumSquare(4,6);
          System.out.println(b);

     }

     static int sumSquare(int a, int b){

          int c= a+b;

          return c*c;
     }
}
```

```
C:\Windows\System32\cmd.exe

D:\MyWorks\Corporate\202302-anz-java\java-demos\simple-demos>javac JavaMethod02.java
JavaMethod02.java:17: error: invalid method declaration; return type required
       static sumSquare(int a, int b){
              ^
1 error

D:\MyWorks\Corporate\202302-anz-java\java-demos\simple-demos>javac JavaMethod02.java

D:\MyWorks\Corporate\202302-anz-java\java-demos\simple-demos>java Program
64
100

D:\MyWorks\Corporate\202302-anz-java\java-demos\simple-demos>
```

Note

- sumSquare indicates that it is returning a value of type int.
- Before the function ends it must include a return statement with value that we need to return
- The returned may be used in the caller function as expression
    - assigned to a variable
    - included in a forumla
        - int c=sumSquare(5,5)*10;
    - print directly
        - System.out.println(sumSquare(2,3));

- each method has it's own set of variables
- main has
    - a
    - b
- sumSquare ahs
    - a
    - b
    - c
- It is possible that two different method has variables with the same name
    - They belong to different method and are unrelated
    - same name is just a co-incidence

# Statements

Thursday, February 2, 2023 2:27 PM

- every statement ends with a semicolon
- a block of statement is wrapped in braces {}
- Java statements like if, while, for etc can take either a single statement or a block of statements

## If statement

```
if ( boolean_expression){

     statement1;
     statement2;
}


if(boolean_expression)
     single_statement;
```

Important

- block marker is always required in class and method even if they contain single statement
- for loops and branching braces are optional if there is single statement

### If - else

```
if( boolean_expression)
     statement_or_block;
else
     statement_or_block
```

### if -else if

```
if( condition1 )
     do_this;

else   if(condition2)
     do_this
else if (condition 3)
     do_this;
else
     do_this;
```

### while loop

```
while( condition_is_true)
     block_or_statement;
```

### do-while

```
do{
     one_or_more_statement;
}while( condition_is_true);
```

Note

- do-while needs block marker even for a single statement

- do while executes a min of one time before it tests for condition

### standard for loop

- similar to c/c++ etc

```
for( initalization;  condtion;  reinitialization)
     block or statement;
```

- for executes in othe order
    1. runs intialization
    2. checks condition
    3. runs block or statement if conditon is true else exists
    4. runs reinitalization
    5. repeats from step 2

```
for(int i=0; i<10; i++)
    greet();
```

- Note
    - Intialization can declare a new variable here.
    - All the three components are optional in for loop
        - You may or may not provide
            - intialization
                - if it is already done before for loop
            - condition
                - defaults to true
                - if not given it is like run for ever
            - re-inialization
                - if you are doing within the block
        - But the two semicolon inside for () is compulsary

- example for a run for ever for loop

```
for(;;)
    run_for_ever;
```

### Examples

```
void countDown(int x){

    for(;x>0;x--){
        System.out.println(x);
    }

}
```

### Example 2

```
void countDown(int x){

    for(;x>0;){
        System.out.println(x--);
    }

}
```

## How to exit a loop without finishing

- sometimes we need to exit a loop (for/while/do-while) before its natural condition
    - we may have more than one condition and it may be complicated to put all in one place
- we can use "break" statement to exit the loop

- for example break the loop after you get three values that are divisible by 5 while counting in a range
- **IMPORTANT!**
    - **NEVER USE BREAK INSIDE A LOOP WITHOUT A CONDITION**

```
void countRange(int min, int max){


}
```

## Skipping a loop count

- sometimes we may want to skip ramaining statements of a loop under a given condition.
- We may use continue to denote that.
- continue should be conditional
- Let's skip every multiple of 2

## for-each style loop

- will discuss later.

## switch statement

### semantic

```
switch(expression){

     case value_1:
          statement1;
          statement2;
          break;
     case value_2:
          statement1;
          statement2;
          return;

     default:
          statement;


}
```

- A switch can take a expression that can be
  - number
  - string
- the value is matched to each case and and statement under the case is executed
- if no value matches the passed value it goes to default

- we should end each case with break or return
  - return exists the function
- we may use continue in switch case if it is present in some loop.
  - continue continues loop not switch

## Important!

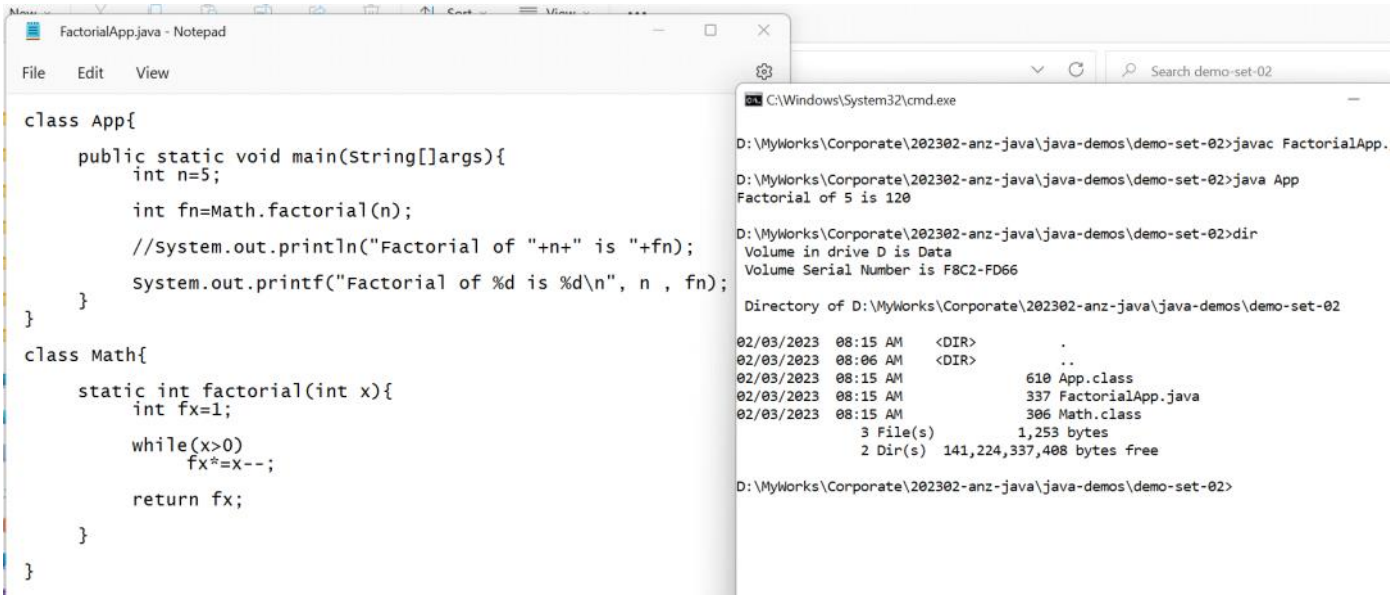
- break and contiue operates on the innermost loop in case of nested loop.
- you may need multiple breaks to come out of all the loops

90360 VIVEK

# Multiple classes

Friday, February 3, 2023 8:16 AM

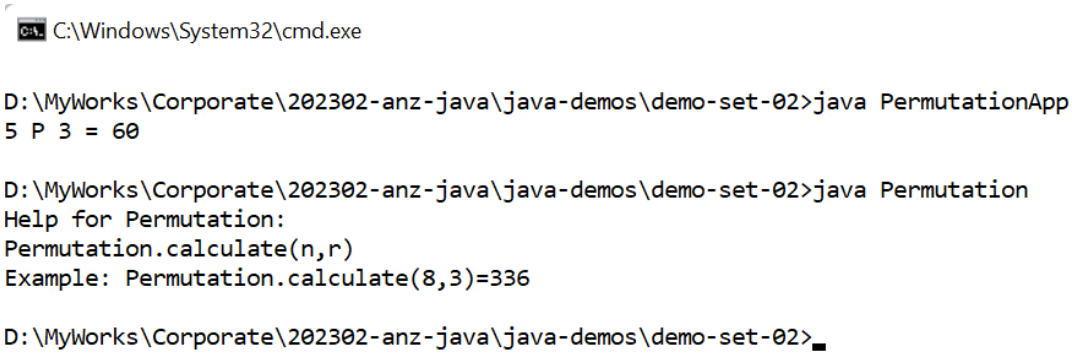
- When we compile a source file it generates one .class file per class (not per file)




## How the Application is build with multiple source file?

- When we compile a source file say PermutationApp.java, java compiler finds it's dependency on class Permutation
- Now Java Compiler looks for a file Permutation.class
  - If present it uses the Permutation.class
- If Permutation.class is not present it looks for a source file with the same name
  - If present, it compiles the source file to get .class file
  - If it is not present, compilation aborts with error
    - IMPORTANT
      - While it is not compulsary to have source file and class file with same name, it is good to have to assist the compilation process.
- If both source file and class file is available, compiler checks for the modification date to find which one is latest
  - In case source file is modified after last compilation, it is recompiled
- IMPORTANT:
  - the source file is used only by java compiler and not by java runtime
  - Java runtime can't compile even if files are out of date.

## Multiple Main class




- We can have multiple main class in different classes
- The one which is invoked with Java command will be caleld
- Use Case
    - A Dictionary class can be used as
        - stand alone dictionary app
        - embedded in Word to spell check.

# Object Oriented Program

Friday, February 3, 2023 8:56 AM

## What is a Program?

Set of instructions given to computer to perform some task.

# Furniture Shop

Friday, February 3, 2023 9:22 AM

## Objects

- Furnitures
  - Chair
    - Material
    - Price
  - Table
  - Bed
- List (Inventory)
- List (Customer)
- Invoice

- Multiple Chairs with similar property and behaviors (purpose)
  - **Each of them will have common set of elements like**
    - **Material**
    - **Price**
  - They may also have different features like
    - recliner
    - drawer
    - (we will not talk about them,yet)

## Creating Object, The Java Way (common in most languages)

- We need a class to represent the idea of an object
- A class will describe what an object will be like
  - It can be considered as template or blueprint
    - **Why do we call it a class then? (pending question)**

- To create an object we need a class (to describe it)

```
class Chair{


}
```

- Now we can create multiple chair objects

```
Chair c1 = new Chair();

Chair c2 = new Chair();
```

- Now a class can contain informations related to the object

```
class Chair{

    int price=2000;

}
```

- Now our chairs can have price

```
Chair c1=new Chair();
Chair c2=new Chari();

System.out.println(c1.price); //2000;
```

- We can also change the price

```
c1.price=5000;
System.out.println(c1.price); //5000;
System.out.println(c2.price); //2000
```

- An object can also have it's own behavior or roles

```
class List{
    int items;
```

## IMPORTANT!

- We, in most cases, would name our class as Singular
  - Chair, not Chairs
- A class is the description for a single Object
- Once we have the design description we can create multiple objects with same idea (class)

Note

- class doesn't have the price variable
  - It has the definion of price which will belong to the chair object

- Both chair object will have their own price
  - so now we have to price variables
    - c1.price
    - c2.price
  - here 2000 is the default price that will be intially assigned to all chairs
  - each chair can individually change it a

- Here addItem is NOT a static method
- Non static methods are referred as object level methods

```
class List{
     int items;
     void addItem( String item){
          items++;
          System.out.println("Item added");
     }

     int size(){
          return items;
     }

}
```

- Here addItem is NOT a static method
- Non static methods are referred as object level methods or instance methods
    - They belong to individual objects
- Most of your methods should be non-static
    - You are writing an object oriented program

- Now we can use these elements

```
List inventory = new List();

inventory.addItem("Chair");
inventory.addItem("Table");


List customers=new List();
customers.addItem("Vivek");

System.out.println( inventory.size()); //2
System.out.println(customers.size()); //1
```

# Assignment 2.1

Friday, February 3, 2023 9:45 AM

- Create a List class
- Add the methods to
  - AddItem
  - RemoveItem
  - Size
- Test the methods with at least two list objects

# Naming Convention

Friday, February 3, 2023 10:30 AM

```
class ClassList{

     int items; //defaults to 0

     void addItem(String item){
          items++;
     }

     void removeItem(String item){
          items--;
     }

     int countItems(){
          return items;
     }

}
```

- This is a working code.
  - But a working code may not be equal to a good code

- Important considerations
  - Class Name doesn't need a Class Prefix
  - We Generally avoid prefix in any code
  - Between Prefix and Suffix prefer suffix
    - avoid both if possible
  - While addItem is a good name
    - Item is redundant suffix
      - in list add means addList
      - It can be avoided in this context
    - we don’t need chairPrice and tablePrice in Chair and table class
      - Both can have price
      - meaning will be clear when we write
        - chair1.price
        - chair2.price
        - table1.price

# Closer Look at the Objects

Friday, February 3, 2023 10:48 AM

```
public static void main(String []args){

	List customerList=new List();
	customerList.add("Vivek");


	List furnitures=new List();
	furnitures.add("Chair");
	furnitures.add("Table");
	furnitures.add("Bed");


	System.out.printf("Total Customers: %d\n", customerList.count());
	System.out.printf("Furntitures: %d\n", furnitures.count());

	Chair c1=new Chair();
	Chair c2=new Chair();

	c1.price=3000;
	System.out.printf("c1.price=%d\tc2.price=%d\n",c1.price,c2.price);


	Bed b1=new Bed();

	Inventory inventory=new Inventory();

	Invoice invoice1=new Invoice();

	Invoice invoice2=new Invoice();


	Table t1=new Table();


	System.out.println(t1);
	System.out.println(b1);
	System.out.println(inventory);
	System.out.println(invoice1);
	System.out.println(invoice2);
```

## List

- A list has three methods
  - add
  - remove
  - count
- It has a property
  - items
- They are interconnected for the same object
  - add increases items count
  - remove declreases the same field
  - count returns the result for the same
- The two lists are different from each other
  - add or customerList and add of furnitures are incrementing different "items" variable
- Similarly we have two Chair with their individual prices

```
Total Customers: 1
Furntitures: 3
c1.price=3000	c2.price=2000
Table@33c7353a
Bed@681a9515
Inventory@3af49f1c
Invoice@19469ea2
Invoice@13221655
```

Note

- We are here printing the entire Object and not some property of Objects
- Java internally prints an object as String with two components separated by "@"
  - Class Name of that object
  - A unique Id or hashcode generated for each individual object
    - By default they will be different for each object
      - Known as hashCode

- This information is also available by calling a special method present in all "objects" called toString
  - Internally System.out.println is implicitly calling toString of the current object

- the hashCode can be checked by using another special method hashCode()

```
System.out.println(t1);
System.out.println(b1);
System.out.println(inventory);
System.out.println(invoice1);
System.out.println(invoice1.toString());
System.out.println(invoice2);
```

- whenever we want to print an object, it internally calls the toString method

## What if I want to print a different information for my object?

## we can write our own toString method

## The Default ToString Behavior

```
customerList List@548c4f57
furntiures List@1218025c
```

After Adding our own toString

```
public String toString(){
     if(items==1)
          return "List of "+items+" item";
     else
          return "List of "+items+" items";
}
```

```
customerList List of 1 item
furntiures List of 3 items
```

# Assignment 2.2

Friday, February 3, 2023 11:06 AM

- Define toString in list that should display the list items

```
List customerList=new List();

customerList.add("Vivek");
customerList.add("Sanjay");

List furntiures=new List();


System.out.println(customerList);
System.out.println(furnitures);
```

Expected Output

[\tVivek\tSanjay\t]

(empty)

# Non Intialized variables

Friday, February 3, 2023 11:17 AM

- We have two types of variables we declare in Java
  - Fields
    - we declare inside the class
    - They represent the property of an object
    - They are by default initalized to
      - null for objects
      - 0 for numbers
      - false for boolean
      - '' for char
  - Method local variables
    - They remain uninialized till you initalize them
    - You can't use them without first initializing them

```
class Program{

    int number; //by default 0
    String name; //by default null;


    void f1(){
        int x; //un-initalized
        String y; //unitialized


        y="Hi";

        System.out.println(y); //works

        System.out.println(x); //fails. not
        intilized

        System.out.println(number); //works 0

        System.out.println(name); //works null

    }

}
```

# Organizing Large Application

Friday, February 3, 2023 11:32 AM

- We have multiple classes in our code
- These classes represent different domain elements
- Furnitures
  - Chair
  - Table
  - Bed
- Generic Data
  - List
- Finance
  - Invoice
  - Inventory

- We don't want to keep all our files at one place
- Generally we may not want to incoude our source file in distribution
- How do we organize
  - Source and class files separately
  - Each domain related classes separately

## Folder Based Organization

- we can create separate folder for
  - src
    - should contain .java files
  - class
    - should contain .class files

- Inside both these folders we can have sub folders representing domains
  - furntiures
  - data
  - finance

### Our Project src structure

```
D:.
└───src
    │   FurnitureApp.java
    │
    ├───data
    │       List.java
    │
    ├───finance
    │       Inventory.java
    │       Invoice.java
    │
    └───furnitures
            Bed.java
            Chair.java
            Table.java
```

## Will the compilation work?

```
C:\Windows\System32\cmd.exe

D:\MyWorks\Corporate\202302-anz-java\java-demos\demo04\src>javac FurnitureApp.java
FurnitureApp.java:6: error: cannot find symbol
                List customerList=new List();
                ^
  symbol:   class List
  location: class FurnitureApp
FurnitureApp.java:6: error: cannot find symbol
                List customerList=new List();
                                  ^
  symbol:   class List
  location: class FurnitureApp
FurnitureApp.java:10: error: cannot find symbol
                List furnitures=new List();
```

### Problem

- Java doesn't know where to go looking for classes (source or bytecode)

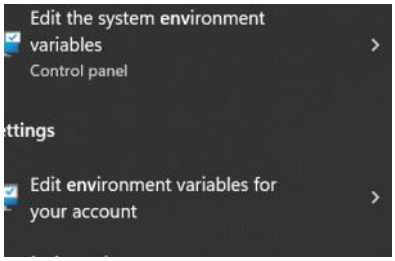
## Solution : CLASSPATH

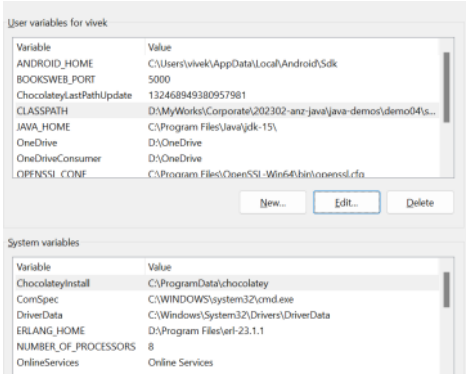
- Just like environment variable PATH that helps us locate executable files (eg. java, javac), java uses a system environment variable CLASSPATH to look for all the paths where classes are likely to be present
- A class path can maintain a list of PATH separated by
  - ; in windows OS
  - : in linux and MAC
  - These are as per the OS convention
- To make our design work we need to include all folders where we expect the path

### Setting class path

- There are multiple ways to set the CLASSPATH

### Option#1 In the environement setting of your system




```
D:\MyWorks\Corporate\202302-anz-java\java-demos\demo04\src>echo %classpath%
D:\MyWorks\Corporate\202302-anz-java\java-demos\demo04\src\furnitures;D:\MyWorks\Corporate\202302-anz-java\java-demos\de
mo04\src\data;D:\MyWorks\Corporate\202302-anz-java\java-demos\demo04\src\finance

D:\MyWorks\Corporate\202302-anz-java\java-demos\demo04\src>javac FurnitureApp.java
```

```
Volume serial number is F8C2-FD66
D:.
└───src
    │   FurnitureApp.class
    │   FurnitureApp.java
    │
    ├───data
    │       List.class
    │       List.java
    │
    ├───finance
    │       Inventory.class
    │       Inventory.java
    │       Invoice.class
    │       Invoice.java
    │
    └───furnitures
            Bed.class
            Bed.java
            Chair.class
            Chair.java
            Table.class
            Table.java
```

### A Small Snag

```
D:\MyWorks\Corporate\202302-anz-java\java-demos\demo04\src>dir
 Volume in drive D is Data
 Volume Serial Number is F8C2-FD66

 Directory of D:\MyWorks\Corporate\202302-anz-java\java-demos\demo04\src

02/03/2023  11:47 AM    <DIR>          .
02/03/2023  11:36 AM    <DIR>          ..
02/03/2023  11:47 AM    <DIR>          data
```

### Why are we unable to find class file present in the current directory?

- By default Java/javac searches for class (both source/bytecode) in the current working directory

```
 Directory of D:\MyWorks\Corporate\202302-anz-java\java-demos\demo04\src

02/03/2023  11:47 AM    <DIR>          .
02/03/2023  11:36 AM    <DIR>          ..
02/03/2023  11:47 AM    <DIR>          data
02/03/2023  11:47 AM    <DIR>          finance
02/03/2023  11:47 AM             1,783 FurnitureApp.class
02/03/2023  11:31 AM             1,092 FurnitureApp.java
02/03/2023  11:47 AM    <DIR>          furnitures
               2 File(s)          2,875 bytes
               5 Dir(s)  141,212,073,984 bytes free

D:\MyWorks\Corporate\202302-anz-java\java-demos\demo04\src>java FurnitureApp
Error: Could not find or load main class FurnitureApp
Caused by: java.lang.ClassNotFoundException: FurnitureApp
```

current directory?

- By default Java/javac searches for class (both source/bytecode) in the current working directory
- Once CLASSPATH is set it searches only in the directories mentioned in the classpath
  - they stop searching in current folder

## Solution

- We can always ask java to search in current directory by adding "." path in the CLASSPATH

## Aside

- appending value to existing environment variable like class path

### Windows

```
set CLASSPATH = %CLASSPATH%;.\something
```

### Linux/Mac

```
set CLASSPATH = $CLASSPATH:./something
```

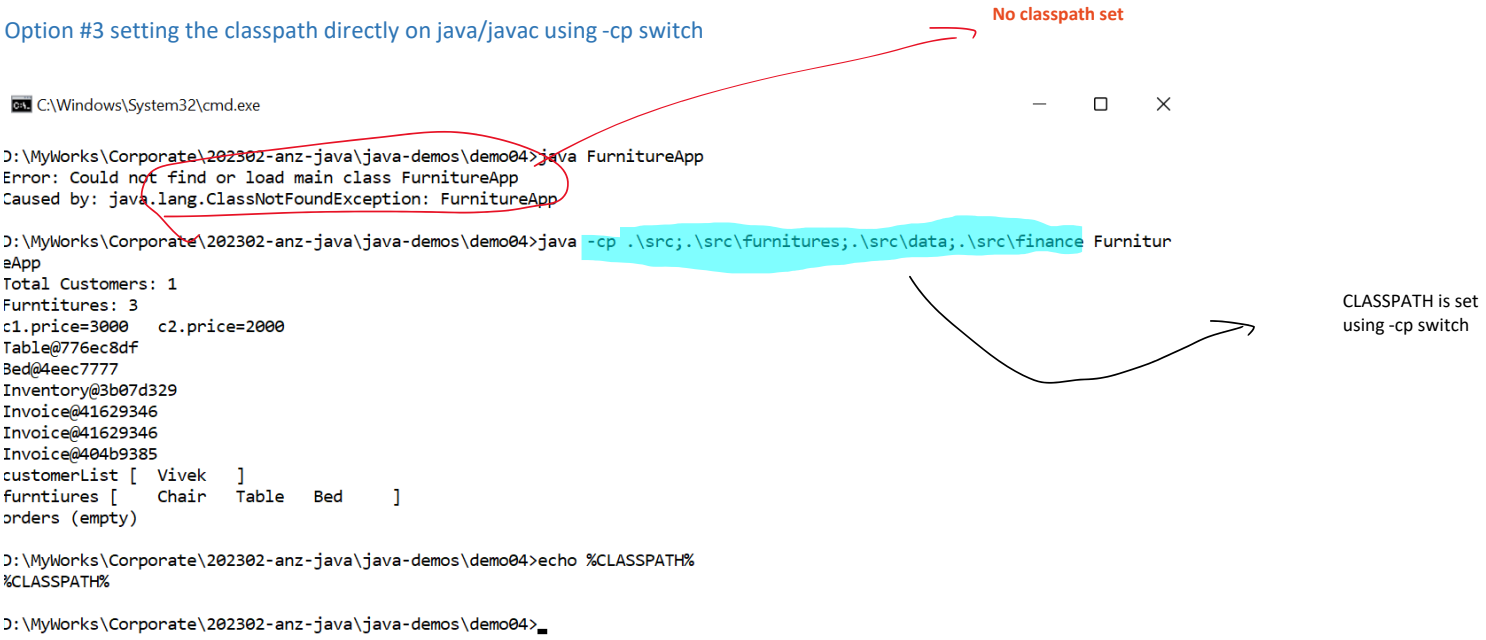
## Why we shouldn't set classpath at the system level?

- we may have many applications
- Each will need its own classpath
  - they may conflict with each other

## Option#2  creating classpath at application level

- we can declare the classpath directly on the command window
- Problem
  - we need to set the classpath everytime we open a command window
- Solution
  - Use a batch file / shell script

## Option #3 setting the classpath directly on java/javac using -cp switch




## How to separate source and class files in different folders

| | | | | |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |

# Class name conflict

Friday, February 3, 2023 12:27 PM

## What is a Table?

| | | | | |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |

Or

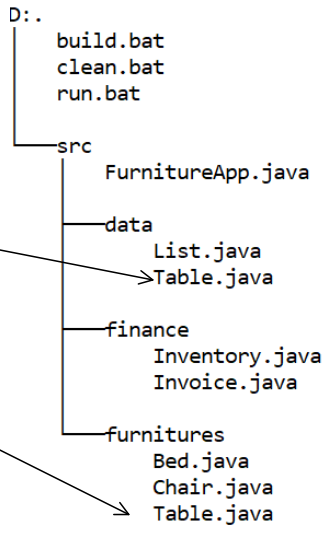
Data Table

Furniture Table

## Do we ever need both the table in the same application?

## Which Table is referred here?

```
Table t1=new Table();

System.out.println(t1);
```




## How will java decide which table to use?

- Java reads the class path in sequence in which it defined
- In our example we include "data" folder before "furnitures" folder

```
set APP_ROOT=.
set SRC=%APP_ROOT%\src
set CLASSES=%APP_ROOT%\classes
set CP=%CLASSES%\data;%CLASSES%\finance;%CLASSES%\furnitures
javac  -d %CLASSES%\data  %SRC%\data\*.java
javac -d %CLASSES%\finance  %SRC%\finance\*.java
javac  -d %CLASSES%\furnitures %SRC%\furnitures\*.java
javac -d %CLASSES% -cp %CP%  %SRC%\FurnitureApp.java
```

- As such it will be using data table and NOT furniture table
- A classpath search stops the moment a candidate class is located.

## How to use both Table in the same class

- we can't keep them in same folder
- classpath will check the first folder only

# Java Packages

Friday, February 3, 2023 12:39 PM

- Java Package is a logical grouping of classes and (sub) packages
- We can create packages like

- furnitures
  - Chair
  - Table
  - Bed
- data
  - List
  - Table
- finance
  - Invoice
  - Inventory

## What is the difference between a package and folder

- A package is a "java" concept, folder is an "os" feature
- A package name will be used within the java program, folders appear only externally in classpath
- A package will still be using folder structure
  - A package is not a folder
  - A packages lives inside a folder

## How do we create a package

- we can designate any folder as a package
  - we may designated a nested folder structure as nested package
- The package appears in the source code

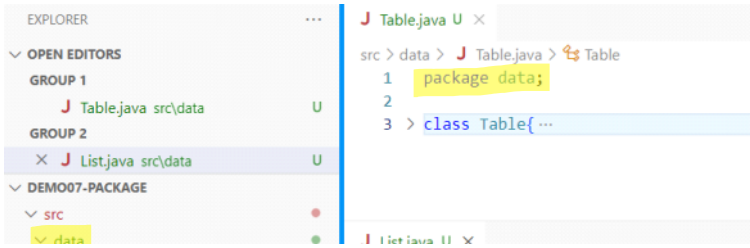
```
src
    FurnitureApp.java

    data
        List.java
        Table.java

    finance
        Inventory.java
        Invoice.java

    furnitures
        Bed.java
        Chair.java
        Table.java
```

- Here we have designated following folder as packages
  - data
  - finance
  - furnitures
- A package becomes language concpet and doesn't appear in classpath

- we are not considering "src" as package
  - src is a container path for packages
  - This folder will appear in the CLASSPATH

- Why is "src" not a package?
  - Because we don't want

### Step 1 Designating Package for Class




- package "data" should match the immeidate folder structure
  - more important for .class file than .java file
- if we chose to name our package as src.data
  - src package will contain subpackage data
- In our example data is package, src is container path for the package.


- If we chose to name our package as src.data
  - src package will contain subpackage data
- In our example data is package, src is container path for the package.

## Compiling Classes from a Package

```
D:\MyWorks\Corporate\202302-anz-java\java-demos\demo07-package>javac -d .\classes .\src\data\*.java

D:\MyWorks\Corporate\202302-anz-java\java-demos\demo07-package>tree/f
Folder PATH listing for volume Data
Volume serial number is F8C2-FD66
D:.
    build.bat
    clean.bat
    run.bat

├───classes
│   └───data
│           List.class
│           Table.class
```

- even when we have marked to store compiled classes to "classes" folder because they belong to a package "data" compiler generates the package folder and stores it

## Step 2 Using classes from a Package

- Now we don't have a non-packaged (global) class like
  - Chair
  - Table
  - List
- We have classes like
  - furnitures.Chair
  - furnitures.Table
  - data.Table

Note

- Now we have two distinctly identifiable Tables
  - furnitures.Table
  - data.Table

```
D:\MyWorks\Corporate\202302-anz-java\java-demos\demo07-package>javac -cp .\classes\data -d .\classes .\src\FurnitureApp.
java
.\src\FurnitureApp.java:6: error: cannot access List
                List customerList=new List();
                ^
  bad class file: .\classes\data\List.class
    class file contains wrong class: data.List
    Please remove or make sure it appears in the correct subdirectory of the classpath.
1 error

D:\MyWorks\Corporate\202302-anz-java\java-demos\demo07-package>
```

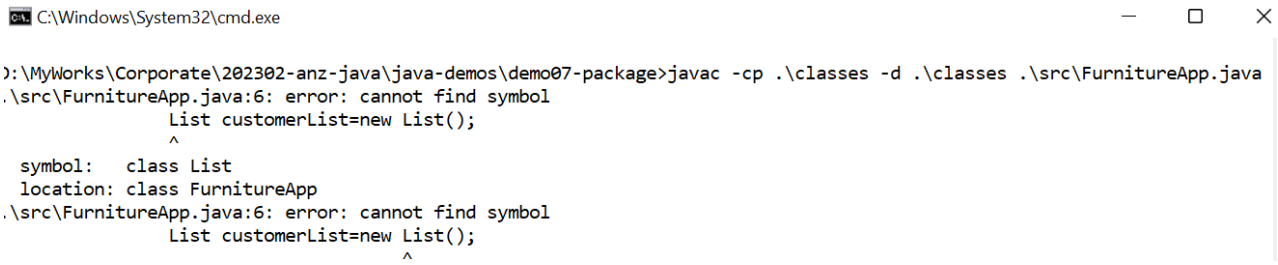
## Problem

- classpath includes "data" as sub folder
- compiler enters this folder and tries to search for package "data" which is not present

## Solution

- package name shouldn't be part of classpath
- parent of package should be part of classpath
  - classpath  is used for searching both
    - class
    - package

## Problem 2




- Now It is searching for List class in classes folder
  - It doesn't exist
- In fact we don't have a global List class
  - we have data.List

### Solution 2.1 (Step 2.1)  using package qualified names

## Problem #3

```
D:\MyWorks\Corporate\202302-anz-java\java-demos\demo07-package>javac -cp .\classes -d .\classes .\src\FurnitureApp.jav
.\src\FurnitureApp.java:6: error: List is not public in data; cannot be accessed from outside package
                data.List customerList=new data.List();
                     ^
.\src\FurnitureApp.java:6: error: List is not public in data; cannot be accessed from outside package
                data.List customerList=new data.List();
                                           ^
.\src\FurnitureApp.java:10: error: List is not public in data; cannot be accessed from outside package
                data.List furnitures=new data.List();
                     ^
.\src\FurnitureApp.java:10: error: List is not public in data; cannot be accessed from outside package
                data.List furnitures=new data.List();
```

- So far all our classes belonged to an unamed global package
- They all belonged to same family and can access each other without problem
- Now List belongs to a different package "data" and can't be accessed outside the package unless it is marked public
  - same goes true for list members
    - add
    - remove
    - count

```
public static void main(String []args){

    data.List customerList=new data.List();
    customerList.add(item: "Vivek");

    data.List furnitures=new data.List();
    furnitures.Table t1=new furnitures.Table();
    data.Table t2=new data.Table();
```

## Advantage

- We can access both Tables
  - data.Table
  - furnitures.Table
- We have smaller class paths
  - we don't need packages folders to be part of classpath
- Easy compile and run
  - we just need one class path
  - It can compile all dependency classes propely
- Auto organization of classes in right package folders

### Problem

- We need to include the package qualified name everywhere
- When we have many classes (we always have many classes) package qualified names becomes difficult

## Option 2.2  import statement

- we can import a particular pakcage contents (classes) directly so that we can use them without qualfiying the packae name

```
import finance.*; //get all the classes from finance packae

class FurnitureApp{


    public static void main(String []args){


        Invoice i1=new Invoice();
        Invoice i2=new Invoice();
        Inventory inventory=new Inventory();

        System.out.println(i1);
        System.out.println(i2);
        System.out.println(inventory);
```

Note

- import "*" can import all classes from a pacakge not the sub packages
- there is nothing like *.*
- Once imported you can use all the classes from there

## Problem with * import

- We generally avoid importing the entire package
- If we import all package with "*" it will be problem similar to not having package

```
    Table t1=new Table();
```

```
C:\Windows\System32\cmd.exe

D:\MyWorks\Corporate\202302-anz-java\java-demos\demo07-package>build
.\src\FurnitureApp.java:20: error: reference to Table is ambiguous
                Table t1=new Table();
                ^
  both class furnitures.Table in furnitures and class data.Table in data match
.\src\FurnitureApp.java:20: error: reference to Table is ambiguous
                Table t1=new Table();
                         ^
  both class furnitures.Table in furnitures and class data.Table in data match
2 errors
```

## Option #3  importing a class selectively from a package

- you may specify which class you want to import

```
import finance.*; //get all the classes from finance packae
import data.*;
import furnitures.*;

import furnitures.Table;


class FurnitureApp{


    public static void main(String []args){


        Invoice i1=new Invoice();
        Invoice i2=new Invoice();
        Inventory inventory=new Inventory();

        List customerList=new List();
        List furnitures=new List();

        Table t1=new Table();
```

## What if we need both Tables

- In such cases we need to use one of the reference explicitly as fully qualified name

```
import furnitures.Table;

class FurnitureApp{


    public static void main(String []args){


        Invoice i1=new Invoice();
        Invoice i2=new Invoice();
        Inventory inventory=new Inventory();

        List customerList=new List();
        List furnitures=new List();

        Table t1=new Table();   //furnitures.Table

        data.Table t2=new data.Table(); //explicit selection
```

## Recommendation

- Java best practice guidelines recommends importing classes rather than package.*

## What is the possibility that two different prorammer will create a package with same name and have same class inside it

- High possibility
- Package is a bundle of related classes
- If package name is same chances are we will create classes also in the same way

## What is the possibility that we need packages created by two developers in the same project

- folder
- package

- **src**
  - class App
  - **vivek**
    - **data**
      - class List

        - class Tree
    - **furnitures**
        - class Chair
- **sanjay**
    - **data**
        - class Search
        - class Table
        - class List

## How do I access both Tree and Search class?

- we can have both src\sanjay and src\vivek in CLASSPATH
- Now we have a **single package (logical entity) called data** which holds
    - List
    - Tree
    - Search
    - Table
    - List

- When we see multiple package definitions they merge as a single logical unit

### compilation

```
$ javac -d .\classes -cp .\src\vivek;.\src\sanjay;.\src App.java
```

Run

```
$ java -cp .\classes  App
```

### What if I want to access List?

- Here it will access the List from that package folder which appears first in CLASSPATH

### How do I access both the List?

- There is NO Java WAY.

## Takeaway

- Contents inside two classes never conflict
    - class acts as boundry
    - Two classes can have field and methods with same name
- Class names may conflict
- This conflict can be resolved using packages
- Package names don't conflict. They merge
- When we have two package folders (same package) with same class, then we have  a problem that can't be resolved
    - whichever folder is first in the list will be used.
    - other is unreachable

## Solution

- to avoid conflict within the package, we use the concept of nested package
- generally we use outer package as identity space (identification of the creator)
    - Example
        - package vivek.data
        - package sanjay.data
- What is the possiblity of name conflict between vivek.data and sanjay.data
    - vivek and sanjay are very common names and most likely will conflict

## Package naming convention

- A package should always be nested
- The outer most package (generally 2) defines identity
    - conventionally we use reverse domain as unique identity

        - in.conceptarchitect
        - org.apache
        - com.anz
    - starting third level package we may use for logical grouping

- example
    - in.conceptarchitect.commons.data
    - in.conceptarchitect.commons.finance
    - in.conceptarchitect.app.furnitureapp.furnitures
    - in.co.sanjay.data

# Distribution

Friday, February 3, 2023 3:01 PM

- A java project will have typically hundreds of classes in dozens of packages and sub packages (folders and sub folders)yste
- Distributing files this way is goint to be difficult
- Java provides a simpler alternative

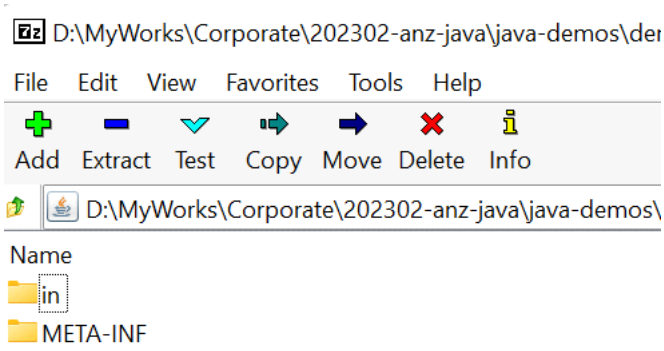
## Jar file

- Jar stands fro Java Archive
- Concept is similar to a zip file
- You bundle the class and package in a single file
- Java can run the application without uncompressing this file
- It improves performance as you will have fewer I/O tor ead the archive

## To create a Jar file

```
jar -cf  ..\app.jar  .
```

- create a jar file including all files and folder and sub folder from current folder
- the jar file should be saved as ..\app.jar




- A jar contains all my files
- It also include some Meta information needed by Java

## Running the program from Jar

- we can just use the jar file as class path

## Manifest

- can include any information realated to jar as key value pair
- we need to create our own manifest file and add the information
- information provided by us shall be merged in actual manifest

# Recursive Function

Monday, February 6, 2023 9:19 AM

- A Recursive Function is a Function Calling Itself
- Sometimes a large and complex algorithm can be broken up into some other term of itself
- Example

- Factorial of 5

5 x 4 x 3 x 2 x 1

Factorial of 4

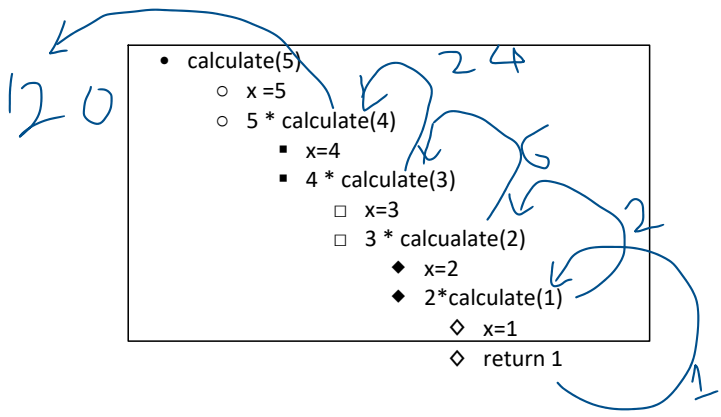
- Now we can say

5! = 5 * 4!

- Programmetically we can write

Factorial.java

```
package in.concpetarchitect.maths;

public class Factorial {

    int calculate(int x) {
        if(x<=1)
            return 1;
        else
            return x* calculate(x-1);
    }

}
```




## How many x we have?

- There are 5 different "x" variable present in memory at this point in time
  - each x is different from each other
- a new set of variables are created each time a method is called
  - a new set of parameters
  - a new set of all local variables declared within the method
- A class level field (static) is created only once
- An object level (non-static) field is created per object

## Important Note

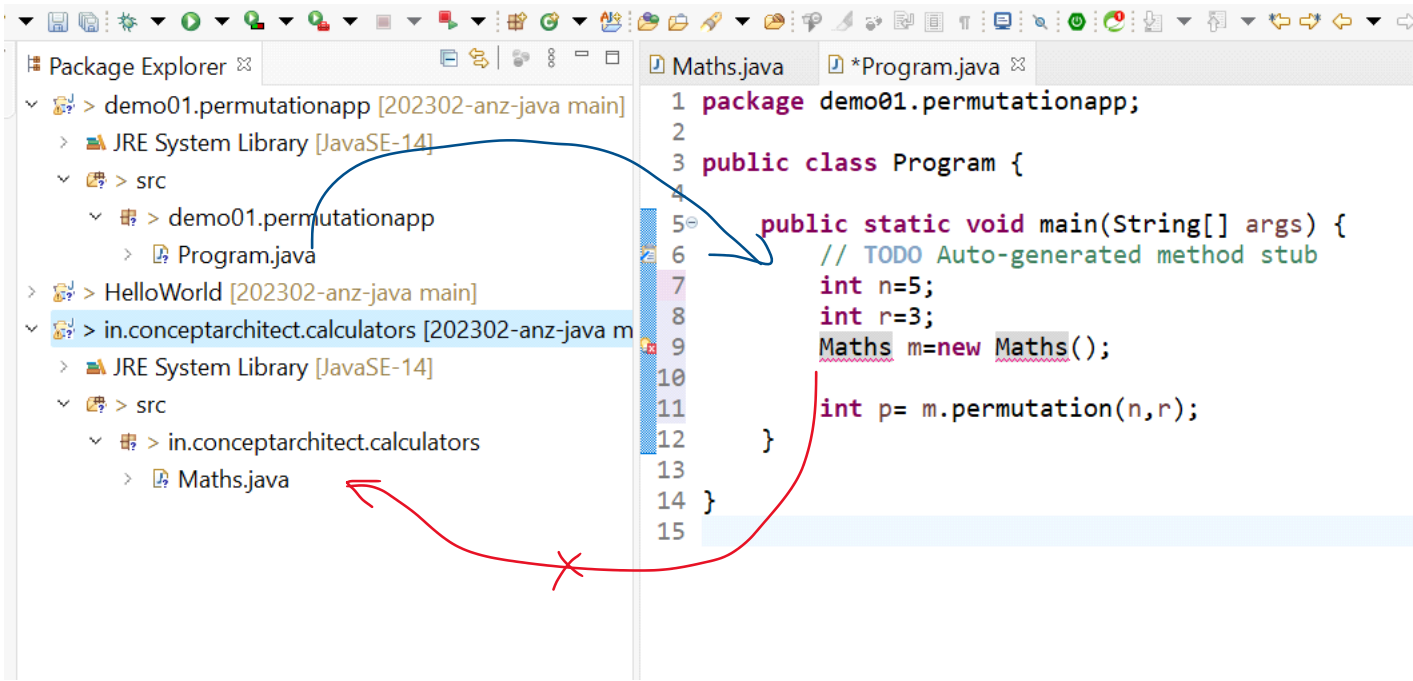
- for every recursive function there should be at least two returns
- One recursive return (that is why it is recursive function)
- One non-recursive direct return
  - If we don't have a direct return the method may enter infinite loop causing "stack overflow error"

# Using class from other eclipse Project

Monday, February 6, 2023 10:24 AM

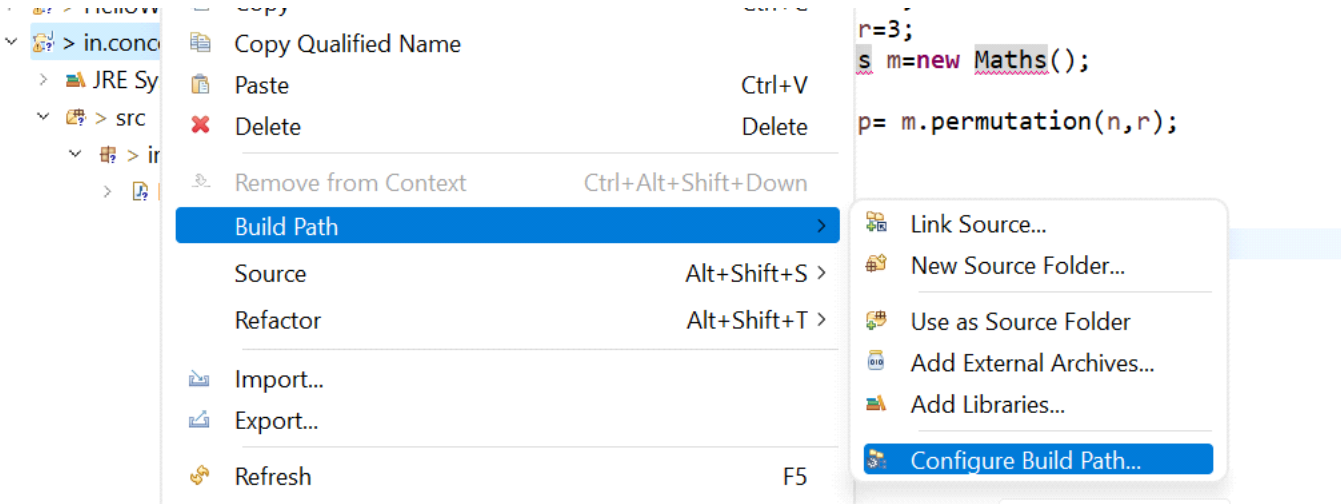
## How do I access class from other projects

- By default eclipse will search the classes within the project itself
- ctrl+space or ctrl+shift+o will not get details from other projects within or outside the workspace

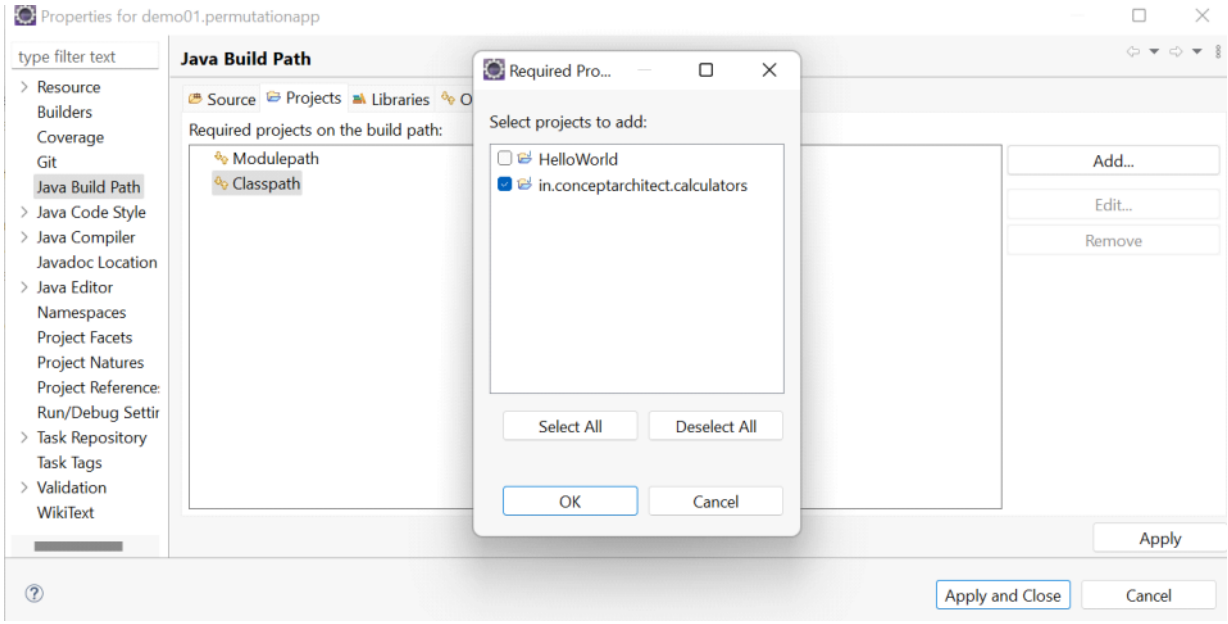



## Adding Reference of One Project in another

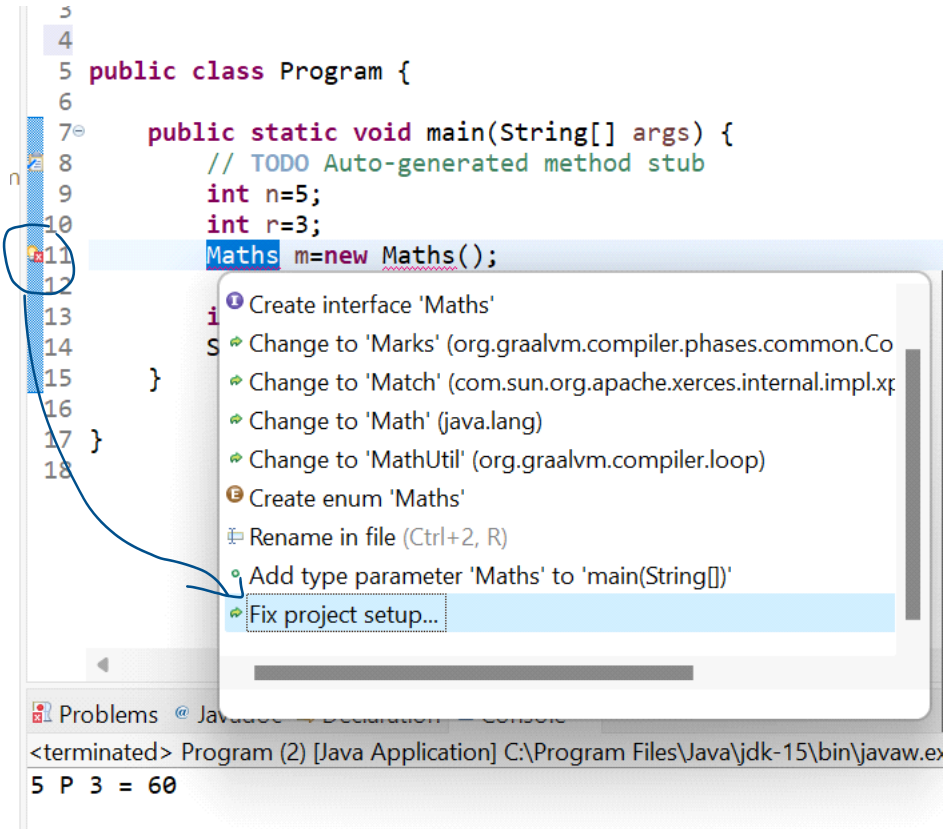
1. Right click project and select the option

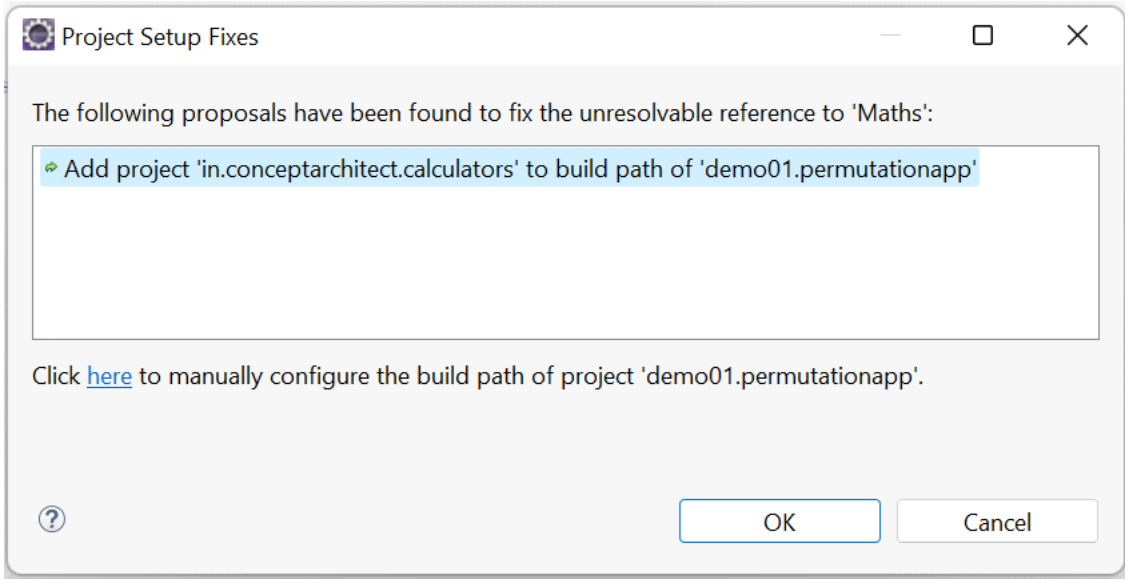


2. Select the Project in the build-path




## Alternative Option

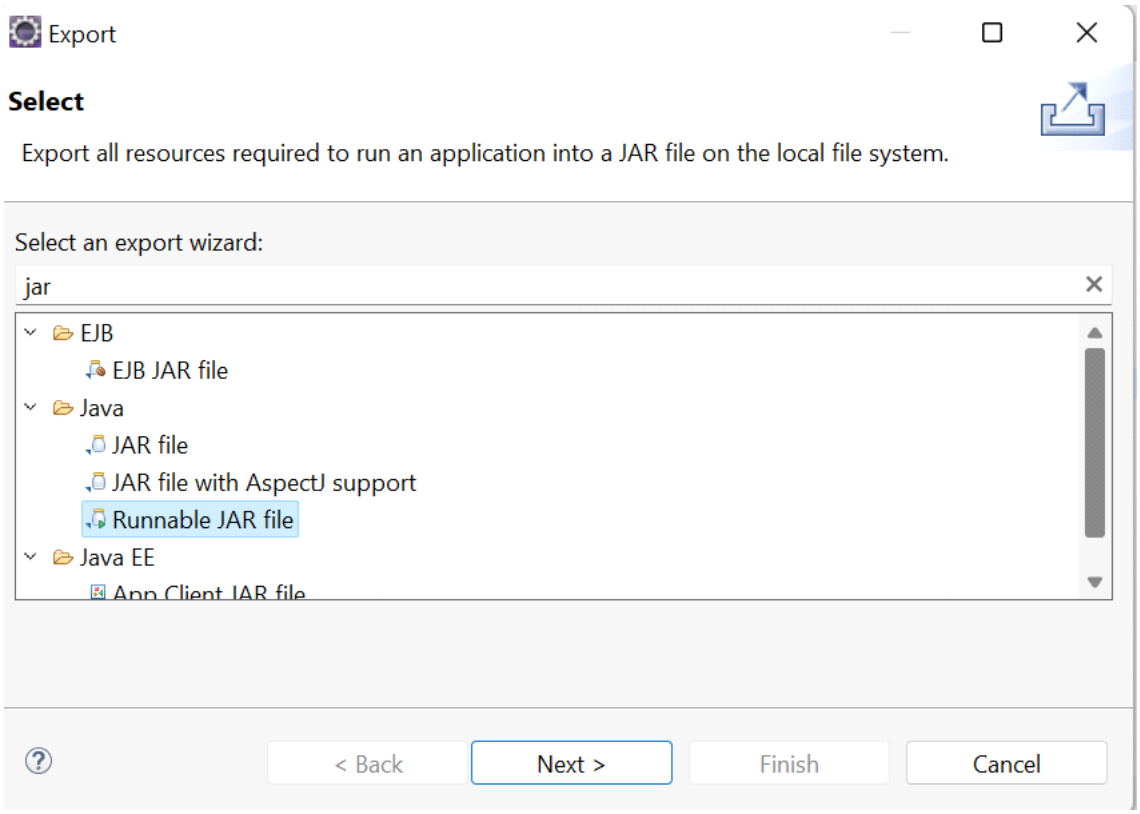



Project Setup Fixes
The following proposals have been found to fix the unresolvable reference to 'Maths':
Add project 'in.conceptarchitect.calculators' to build path of 'demo01.permutationapp'
Click here to manually configure the build path of project 'demo01.permutationapp'.
OK
Cancel

# Creating jar from eclipse

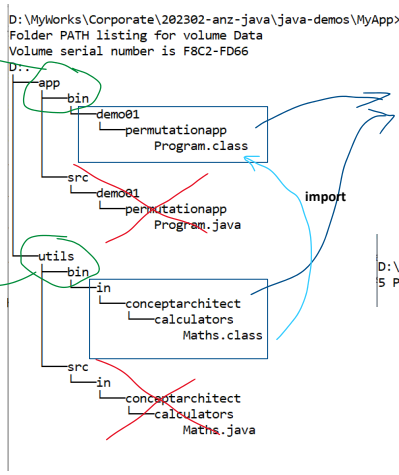
Monday, February 6, 2023 10:36 AM

1. File —> export



# Understanding Runtime Classpath

Monday, February 6, 2023 10:55 AM




import

## ClassPath

- classpath is the path where Java searches for it's class
  - Since Package is a prefix for class, classpath also searches for packages

## Package

- Although we have a physical directory here, they are considered as Java Package
  - And when we see them as package, we don't see them as normal OS level folder

```
D:\MyWorks\Corporate\202302-anz-java\java-demos\MyApp>java -cp .\app\bin;.\utils\bin demo01.permutationapp.Program
5 P 3 = 60
```

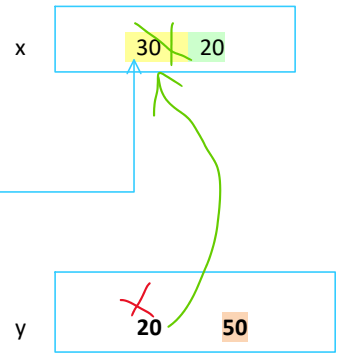
# Primitive Type (Value type) Memory allocation

Monday, February 6, 2023 11:38 AM

```
int x;   //memory is allocated for 1 int. It may not be initialized yet
```

x = 30;

int y=20; //memory allocated and initalzed to gether




## Assigning another value to a variable

```
x=y;
```

- current value of y is copied to X. But they are not related any further

```
y=50;
```

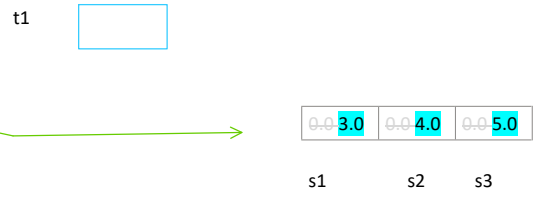
- replaces the value of y from 20 to 50
- No change in the value of x, which is unrelated

# Object (Ref type) Memory Allocation

Monday, February 6, 2023 11:35 AM

```
Triangle t1;

t1= new Triangle();

t1.setSides(3,4,5);
testTriangle(t1);


Triangle t2=new Triangle();
t2.setSides(1, 1, 1);
testTriangle(t2);
```

- creates a reference (pointer) for a triangle object.
  - Triangle object doesn't exist yet
  - No memory allocated to store s1,s2,s3 at this stage




- **new Triangle() is when we allocated the memory for actual object**
  - **The memory is allocated for all non-static fields declared in class**
  - **They are initialized all to 0 (in binary)**
    - **numbers —> 0**
    - **booleann —> false**
    - **object references —> null**

- **values are modified from original state**

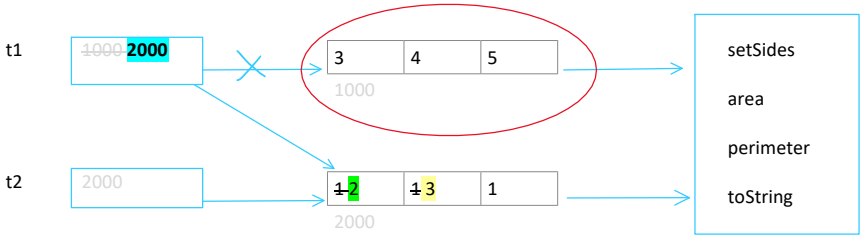
## IMPORTANT NOTE

- Memory is only allocated for non-static fields declared inside the calss
- No memory is allocated at this stage for
  - Methods of the class
    - A common copy is used for all objects
  - Any method parameter or method local
    - They are allocated when you call the method
  - Any class field marked static
    - A single copy is stored in memory
    - More on this later.

## Working with multiple Objects

- all objects share same set of methods

```
Triangle t1= new Triangle();
t1.setSides(3,4,5);

Triangle t2=new Triangle();
t2.setSides(1,1,1);
```




## Assigning One Object to another

```
t1=t2;
```

- Here the reference to t2 will be copied to t1
  - It will not copy the object contents
  - Just the reference
- At this stage both t1 and t2 are referring to same object
  - Triangle<1,1,1>

## What happens to Object Triangle<3,4,5>?

- In self managed codes (like c/c++) this is considered as a memory leak
  - This object has no reference and it can't be used.
  - It will remain in memory forever (till the app is running)
  - They memory can't be re-used
  - We MUST free the memory by deleting the object before this type of assignment

    - It will not copy the object contents
    - Just the reference
- At this stage both t1 and t2 are referring to same object
    - Triangle<1,1,1>

### If we change any one, it changes both

```
t1.s1=2;
t2.s2=3;
```

Actually we have just one object here which is referred by two different references

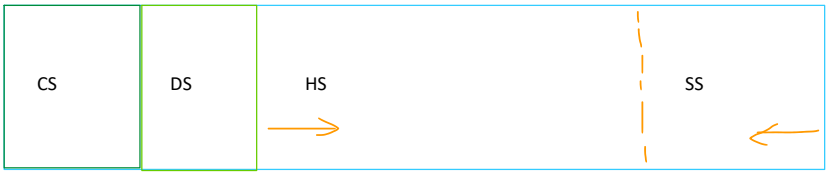
- Any change by any reference changes the same object.
- both t1 and t2 will have the same hashcode as they are the same object

    - It will remain in memory forever (till the app is running)
    - They memory can't be re-used
    - We MUST free the memory by deleting the object before this type of assignment

- In Managed languages like (Java/C++/Python/JavaScript/…)

    - The runtime has a process called "garbage collection"
    - The process frees memory at un undeterministic interval
    - All the un-referenced memory may be freed by garbage collector by it's own strategy or convinience
        - It is a complex and evolving process
        - It involves several generations
        - garbage collection typically works when
            - we start to run out of memory
            - when system resources are comparatively free/idle
        - Even when garbage collector runs there is no surity that it will free all the memory.
            - It may free just one generation of memory
    - Java has a API to force garbage collection
        - This api can initiate garbage collection
            - Even this api doesn't gurantee IMMEDIATE
                - It is meant to be suggestive not authoratative
                - although gernerally it is IMMEDIATE
        - In MOST cases it is not recommened to interfere in the process.

## Memory Layout of a typically Application




- Code Segment
    - stores your logic
        - class methods
- Data Segment
    - Stores static and const values
- Heap Segment
    - Stores dynamically allocated memory
    - "new"
- Stack Segment
    - Stores method locals and parameter
- There is no hard division between Stack and Heap
    - They grow towards each other dynamically

## Java Heap Management

- Java Heap Management works on assumptions that
    - An object either dies very young or lives to grow old.
        - there will be many object created within a method call and are not used once the call is over.
        - Few objects are required throughout application and may live for entire life

- Java Garbage collection has generation model
    - Gen 0
    - Gen 1
    - Gen 2
    - …

- All objects are always created on Gen1 Heap
    - few will be dead long before garbage collection
    - other may live on.
- When garbage collectors starts it starts for a particular generation (not for everyone)
    - Gen1 garbage collector may start when gen0 heap is (almost) full
    - It checks for all living objects (not dead ones)
        - It moves all the surviving object to gen 1
            - Note address will change and that is why java never gives the address to program
            - All the references to this object is automatically changed to new address

        - All the dead objects are removed and gen 0 is now completely empty
    - Same thing will happen to gen1 and gen2

# Triangle Revisited

Monday, February 6, 2023 1:23 PM

```
Triangle t3=new Triangle();
t3.setSides(2,4,8);
testTriangle(t3);
```

- As per java we have a valid object referred by t3.
- But we can't create a triangle with dimension 2,4,8
- Geometrically (domain rule) for a valid triangle
  - sum of every two sides must be greater than the third.

## How do I model a valid Triangle?

- we need to incorporate the triangle rule in the domain object.

### Approach #1

- validate value before assigning and display error message otherwise

```
3  public class Triangle {
4
5      double s1,s2,s3;
6
7      void setSides(double x, double y, double z) {
8          if(x>0 && y>0 && z>0 && x+y>z && y+z>x && x+z>y) {
9              s1=x;
10             s2=y;
11             s3=z;
12         } else {
13             //what to do when user enters wrong info?
14             System.out.println("invalid sides");
15         }
16     }
17
18
19     double perimeter() {
20         return s1+s2+s3;
21     }
```

- indicates we have error

### Error display may not always be best option

- This display doesn't prevent permieter calculation.
- Any value returned will essentially be wrong as invalid triangle shouldn't have a perimeter.

- perimeter function has no knowledge of any message displayed by setSides.

### Approach #2 set a flag (indicator) to mark triangle valid or invalid

```
3  public class Triangle {
4
5      double s1,s2,s3;
6      boolean valid;
7
8      void setSides(double x, double y, double z) {
9          if(x>0 && y>0 && z>0 && x+y>z && y+z>x && x+z>y) {
10             s1=x;
11             s2=y;
12             s3=z;
13             valid=true;
14         } else {
15             //what to do when user enters wrong info?
16             //System.out.println("invalid sides");
17             valid=false;
18         }
19     }
20
21
22     double perimeter() {
23         if(valid)
24             return s1+s2+s3;
25         else
26             return Double.NaN;
27     }
```

- Here we have a Triangle Object
- When we setSides it also internally sets a valid flag to specify if triangle is valid or not
- other behavior of this triangle respects "valid" status and returns expected answers for valid and invalid scenario.

### Binding of Data and Behavior (Encapsulation)

- In this object the triangle states (s1,s2,s3,valid) are interconnected.
- setSide sets the values as per the requirement
- area() and perimeter() are also connected to the same triangle rule and represents proper domain model
- internally all the states and behavior together represent Triangle
- **Encapsulation is more about defininig a responsibility.**

## But what if client is not reasonable/responsible?

```
//t1 is a valid triangle
//What if I change one of it's side making it invalid
t1.s1=100;  //the valid flag is not changed.

testTriangle(t1);
```

```
Triangle <100.0,4.0,5.0>
Perimeter: 109.0               Area: NaN
```

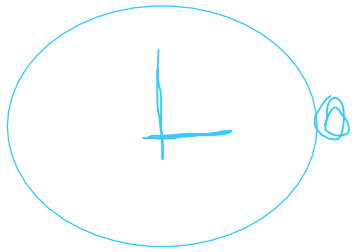
- we may bypass setSides and change values directly
- Now s1 has changed but valid flag is not reset

```
//t3 is invalid (sides are 0,0,0)
//but we can change the valid field

t3.valid=true; //a simple lie.
testTriangle(t3);
```

```
Triangle <0.0,0.0,0.0>
Perimeter: 0.0          Area: 0.0
```

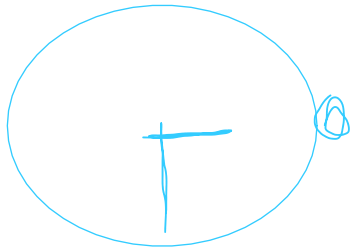
- here Triangle was marked invalid by setSide
- But we can unmark it by resetting valid flag from outside the Triangle object

## Encapsulation recommends protection against unwanted changes.



- In our code we should not allow anyone to access my state (data) directly
- It should change using authorized behavior model.

## Scope Rules



Why do we need a time changing knob and not manually shift hand?

- Ideally when min hand moves the hour hand too should move

- public
  - —> accessible by everyone
- (package)/no scope
  - —> accessible by everyone within the same package
- private
  - accessible only within the class and not outside
- protected
  - to be disucssed later.

```
//t1 is a valid triangle
//What if I change one of it's side making it inval
t1.s1=100;  //the valid flag is not changed.

testTriangle(t1);


//t3 is invalid (sides are 0,0,0)
//but we can change the valid field

t3.valid=true; //a simple lie.
testTriangle(t3);
```

- with private s1 and valid no body can temper with this information
- This information will be set only using right set of values

## Problem —> what if we need to see the value

```
private static void testTriangle(Triangle triangle) {
    System.out.println(triangle);
    if(triangle.valid) {
        System.out.print("Perimeter: "+triangle.perimete
        System.out.println("Area: "+triangle.area());
    }
    System.out.println();
}
```

- Now outsiders can't even see if triangle is valid or not
- It is a valid use case.

## Solution —> define a method to return the valid/invalid status

- we should allow only checking for the information and not changing it.

```
private double s1,s2,s3;
private boolean valid;

public boolean isValid() {
    return valid;
}
```

- Here we can check the validity but not change from outside

## A little refactor

- let's change the valid flag to invalid flag

Wh

## Problem — What if we never call setSides?

```
28        Triangle t4=new Triangle();
29
30        testTriangle(t4);
31
```

- triangle by default is "valid"
- if no side is set it may consider side 0 to be valid

## When is the triangle created : Line 12 or Line 14?

```
12        t1= new Triangle();
13
14        t1.setSides(3,4,5);
15
16
17        testTriangle(t1);
```

- If Triangle is created on Line 12
  - what are the sides of triangle on line 13?
  - can a "valid" triangle exists with side 0?
- If Triangle is created on Line 14
  - What was the value of "t1" on line 13?
  - what is we can t1.perimeter() on line 13?

## Right answer

- There are two creations here
- Java Object is created on Line 12
  - memory is allocated
  - but the object is not a geometrical triangle
  - it is not usable yet.
- Geometrical triangle is not ready till line 14 is called
  - This is where domain object is created
- Real Problem
  - There are two ideas
    - java object
    - domain object
  - There creations are no in sync
    - there is a gap

## Object Oriented Concept —> Constructor

- constructor is a special class method with same name as that of class

```
Triangle t= new Triangle();

|                    |————————> constructor of the class object
|
|
|————————————————————> class name
```

- The two are same name but different concepts

- This method has no return type but returns the newly created object

- This method is called for creating the object with new
- Every class contains a default nothing doing constructor
- We can define our own constructor that replaced the default one.
  - if we define a constructor the default will be removed.
- Our constructor can take multiple arguments
  - We can have overloaded constructor
    - multiple constructor taking different number or type of parameter

# Assignment 3.1

Monday, February 6, 2023 2:24 PM

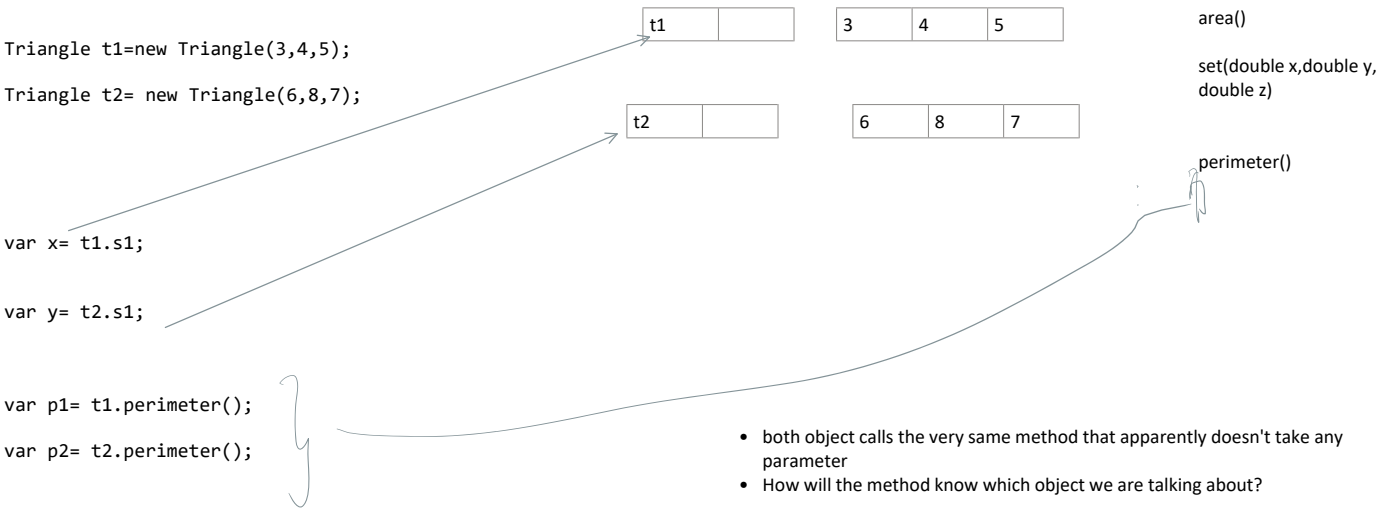
- Create a model for a Bank Account
- We should have following information
    - name
    - account number
    - balance
    - interest rate
    - password

- It should support following operations
    - deposit
        - should reject negative amount
    - withdraw
        - should fail for
            - negative amount
            - access withdrawal
            - invalid password
    - credit interest
        - gives one month interest with formula
            - balance = balance*rate/1200
    - to string
        - to show the account object as string

- Write a test app to work with bank account

# 'this'

Tuesday, February 7, 2023 8:25 AM




- both object calls the very same method that apparently doesn't take any parameter
- How will the method know which object we are talking about?

## 'this' reference

- every object method gets an additional parameter 'this' when invoked
- this always refers to the invoking object
- You can conceptually understand that all our object methods are actually like a global method and are slightly modified by the compiler (conceptual view)

```
class Triangle{

    double s1,s2,s3;

    public double perimeter(){

        return s1+s2+s3;
    }

}


class Program{

    public static void main(String []args){

        Triangle t1=new Triangle(3,4,5);
        Triangle t2= new Triangle(4,4,4);

        var p1=t1.perimeter();
        var p2=t2.perimeter();
    }

}
```

```
//conceptual view

class Triangle{

    double s1,s2,s3;


    public static double perimeter(Triangle this){

        return this.s1+this.s2+this.s3;
    }
}



class Program{

    public static void main(String []args){

        Triangle t1=new Triangle(3,4,5);
        Triangle t2= new Triangle(4,4,4);

        var p1=Triangle.perimeter(t1); //t1.perimeter();
        var p2=Triangle.perimeter(t2); //t2.perimeter();
    }

}
```

# Banking Model

Tuesday, February 7, 2023 8:51 AM

```
public void withdraw(double amount,String password) {
    if(amount<0)
        System.out.println("withdraw failed for negative amount");
    else if(amount>balance)
        System.out.println("insufficient balance");
    else if(!this.password.equals(password))
        System.out.println("invalid credentials");
    else {
        balance-=amount;
        System.out.println("Please collect your cash");
    }

}
```

- ATM can't see or understand message present on the server
- A function can't see what the called function prints
- They share information using
  - parameter
  - return

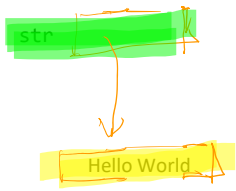
- printed on the server
- we expect to see the message on the ATM
- When it succeeds we just don't want the message "please collect your cash"
  - we want the cash

# String class

Tuesday, February 7, 2023 11:18 AM

- String is not a premitive type. It is a class
  - It has reference types.
- Although String is not a primitive type, it is a core language feature and Java gives some additional feature to String that we can't define for our class

```
String str;

str="Hello World";
```

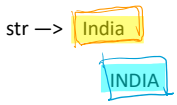



- Java allocates memory just sufficient to store the current string.
- Reference refers to it.

## String is java is immutable

- A String object can't be modified after it has been created.
- Any modification to a String requires
  - Creation of a new String object
  - My old reference can now refer to new String object

```
String str="India";

str.toUpperCase(); //creates a new String at a new memory location
```

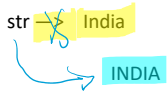



- Note
  - str is still referring to "India"
  - The newly created string is not referenced anywhere and will eventually be garbage collected.

## Modifying existing String (reference)

- while we can't  modify the string object we can modify the reference to refer to new String

```
String str="India";

str=str.toUpperCase();
```

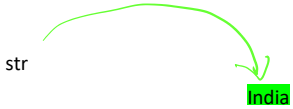



- Note
  - str now refers to modified String "INDIA"
  - the original String "India" is now not referred and shall be eventually garbage collected

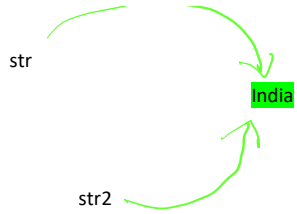
## Why immutability is importan!

- Since Strings are not modiafle after creation, java can reuse a String object internally

```
String str="India";
```



```
String str="India";

String str2="India";
```




- compiler realizes that we have same String so instead of storing it twice both reference can refer to the same
- we are sure neither can change it.

## == vs equals

- Java String contains a method to compare String content
  - equals()
    - return true/false
- This is different from == operator

- == operator compares the references
  - if rerefernce is same the value will naturally be same
- .equals compares actual value
  - compare actual characters
  - It is possible that I have two different Strings with same content at two different places.
    - == wll return false
    - .equals will return true

- We prefer .equals over == for String comparision
  -

- equals indicate that two objects have same value
  - tests for value equals (equivalent)
  -
- == indicate that the two references refer to same object
  - indicates they are exactly same.

### compares

- compares compares two String to find how different they are from each other
- It returns the difference for first mis-match character to indicate which comes first in dictionary (unicode sequence)

```
String str1="India";

String str2="Indonasia";


int diff = str1.compareTo(str2); // unicode difference of 'i' - 'o' = -6
```

- result interpetation
  - 0 —> equals
  - negative —> first string comes first in dictionary/alphabatic sequence
  - positive —> first string comes later in the sequence

## Case Sensetive tests

- Normally Strings are case sensetive
  - `"India".equals("INDIA")  –> false`
  - `"India".compareTo("INDIA")  -->  'n' -'N' = 32`

- We have case insensetive comparsions
  - "India".equalsIgnoreCase("INDIA") —> true
  - "India".comparesToIgnoreCase("INDIA") —> 0

## Common String class methods

| Method Name | Purpose | Example |
|---|---|---|

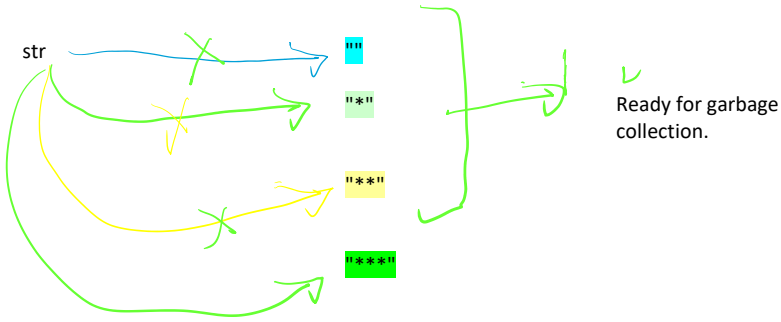
| | | |
|---|---|---|
| length() | returns length of string | |
| equals | true/false | |
| equalsInoreCase | | |
| compareTo | | |
| compareToIgnoreCase | | |
| toUpperCase | convert to upper case | |
| toLowerCase | | |
| charAt | returns character at a given position | |
| indexOf | searches one string inside another and returns the index of match, -1 if not found | "Indian".indexOf("ia") —> 3<br>"Indian".indexOf("is") —> -1 |
| replace | replace a given substring with another in another string. It replaces first match | var s="India is my country. I love India";<br>s.replace("India","Bharat"); |
| substring | extracts a string from another String using index and length<br><br>* return string starting from a given index and of specified lenfth | var s="India is my country. I love India";<br>var x= s.substring(12,7) -->"country"<br><br>• return string starting 12th index and including 7 characters |
| format | • static method<br>• creates a new String based on the formatter and arguments supplied | |

# String Building

Tuesday, February 7, 2023 11:45 AM

## How String concat works?

```
String str= "";

str+="*";

str+="*";

str+="*";
```




## Problem

- If we have a large String maniuplation, using standard Java String can have extreme performance issue

```
String str="";

for(int i=0;i<10000;i++)
     str+="*";
```

- If you need large amount of String maniuplation consider to use the class StringBuilder

## StringBuilder

- StringBuilder is a class that has methods to maniuplate  a memory chunk inplace
- It increases memory as per requirement in optimized manner
- Once you have completed the manipulation you can get the final string by calling toString() on the builder object.

# Array

Tuesday, February 7, 2023 12:04 PM

- Array is an Object (reference type) that can hold multiple values accessible by index
  - An array of "int" is still an Object and not a premitive type

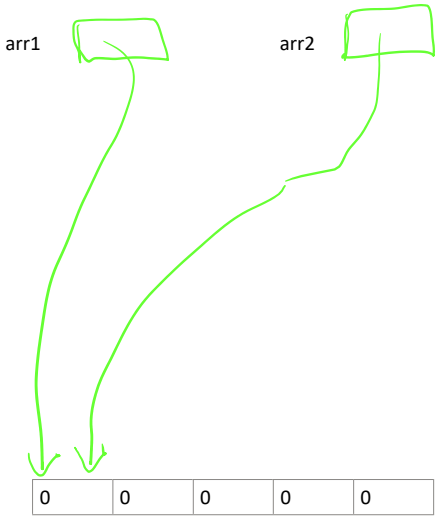
## Step #1 create an array of int

option#1

```
int [] arr1 ;
```

option#1

```
int arr2 [];
```




## Note

- both the above options are identical
- They create a reference that will refer to an actual array later.
- The size is not specified
  - size belongs to array object and not array reference

## Step #2 create the array object

- here we need to spcifiy the size of the array
  - the maximum value it can store

```
arr1 = new int [5];
```

- We created an array of int
- It can store 5 int
- currently the values are all 0.

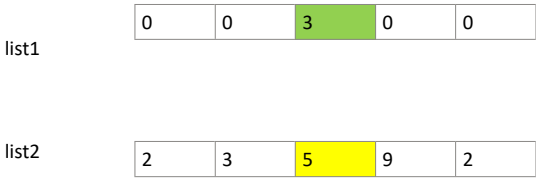
```
arr2=arr1;
```

- now arr2 also refers to the array object
- No values duplicated
- No second array created.

## Creating Array reference and Object together

### Option#1

```
int [] list1 = new int [5] ; //array of 5 items all are 0

int  list2 []  = {2,3,5,9,2};  //aray of 5 items with specified values
```




## Array Access using index

```
list1[2]=3;

System.out.println( list2[2] ); //5
```

## Accessing Array Elements using standard for loop

```
for( var i=0; i< list1.length; i++){
     System.out.println(list1[i]);
     list1[1]*=10;
}
```

- Note:
  - int String length() is a method
  - in array it is like a field

## Accessing Array Elements (Readonly) using Foreach loop

```
for( var value : list2){

     System.out.printf("%d ",value);

}

//expected output

2   3  9 2 6
```

Note:

- value is the value of list
- it is given one by one
- We don't get index
- we can't modify array element by assigning anything to the value

# Problem with traditional Test

Tuesday, February 7, 2023 1:34 PM

## 1. It is based on print output

- print output is for human eye consumption
- you get an output on the screen
  - there is no way to confirm or deny if what you is what you expected.
- we must manual maintain a track of what I expect

## 2. Multiple Test will have multiple output on the same screen

- It is difficult to draw a boundry as to which test printed what message on the output
  - you may get a bunch of true/false
    - which message is associated with which test?

## 3. Tests may interfere with each other

- offen test will be working against an objet and may result in
  - false positive
    - test passes despite having an actual bug
      - bug was not detected
  - false negative
    - test fails desptie having no bug

1. This test is assuming that total balance in the account is amount

2. However an unrelated test has added Rs 100 to the test object, just violating my assumption and poluting the test data with unexpected value

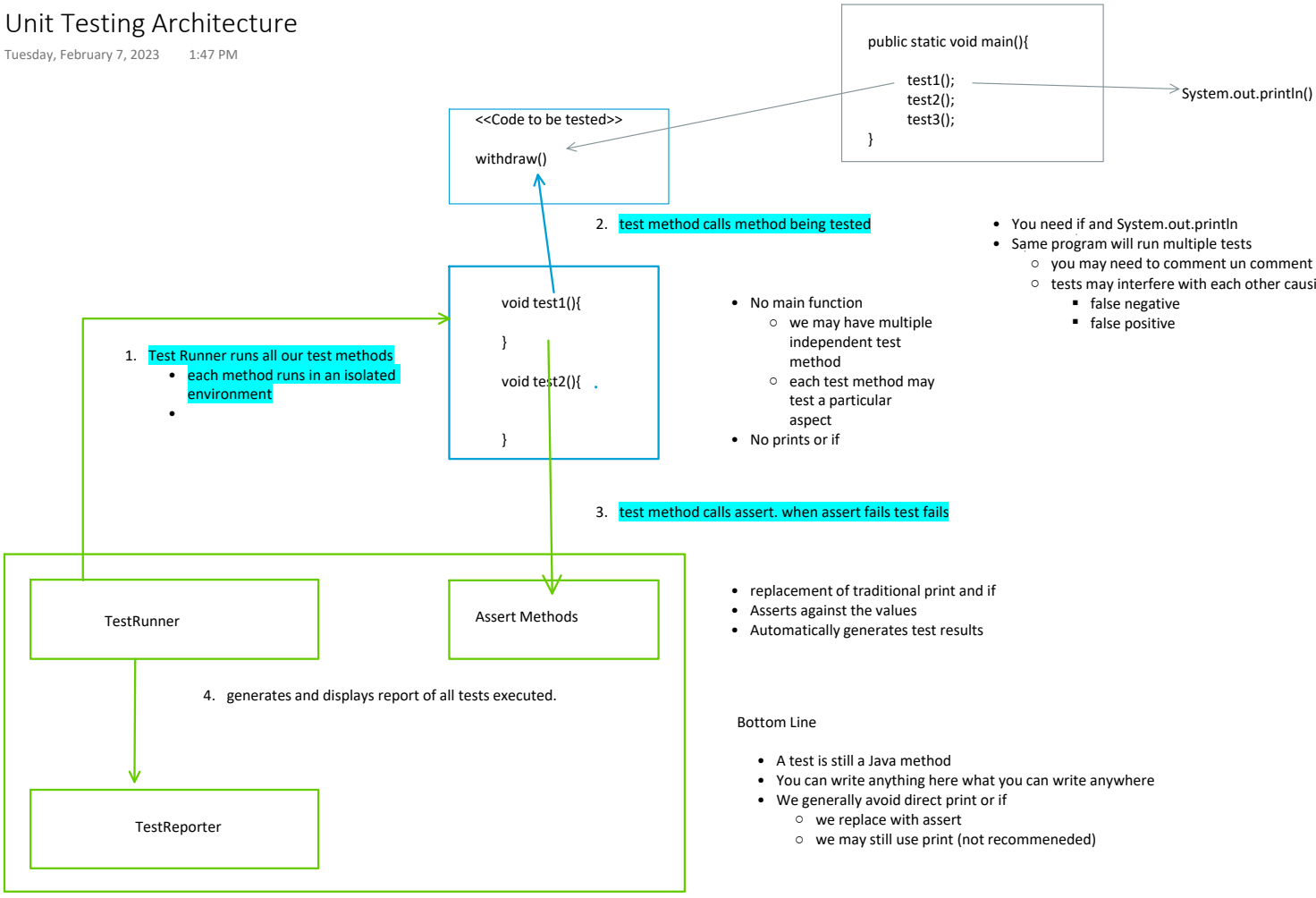
```
public static void main(String[] args) {
    // TODO Auto-generated method stub
    String password="p@ss";
    var amount=20000;
    var a1=new BankAccount(1, "Vivek", password, amount, 12);


    depositTests("Deposit fails for negative amount", a1, -1, false);
    depositTests("Deposit succeeds for positive non zero amount",a1,100,true);

    withdrawTests("Withdraw should fail for negative amount",a1,-1,password, BankingStatus.invalidAmount);
    withdrawTests("Withdraw should fail for wrong password", a1, 1, "wrong password",BankingStatus.invalidCredentials);
    withdrawTests("Withdrw shoudl fail for insufficent balance",a1, amount+1, password, BankingStatus.insufficientBalance);
    withdrawTests("Withdraw should pass for happy case",a1,1,password,BankingStatus.success);
```

- The internal logic of withdraw is correct but it is reported as flawed because of an unrelated test condition

```
FAILED: Withdrw shoudl fail for insufficent balance
        expected: insufficientBalance found: success
```

# Unit Testing Architecture

Tuesday, February 7, 2023 1:47 PM




- You need if and System.out.println
- Same program will run multiple tests
  - you may need to comment un comment tests
  - tests may interfere with each other causing
    - false negative
    - false positive

- No main function
  - we may have multiple independent test method
  - each test method may test a particular aspect
- No prints or if

- replacement of traditional print and if
- Asserts against the values
- Automatically generates test results

Bottom Line

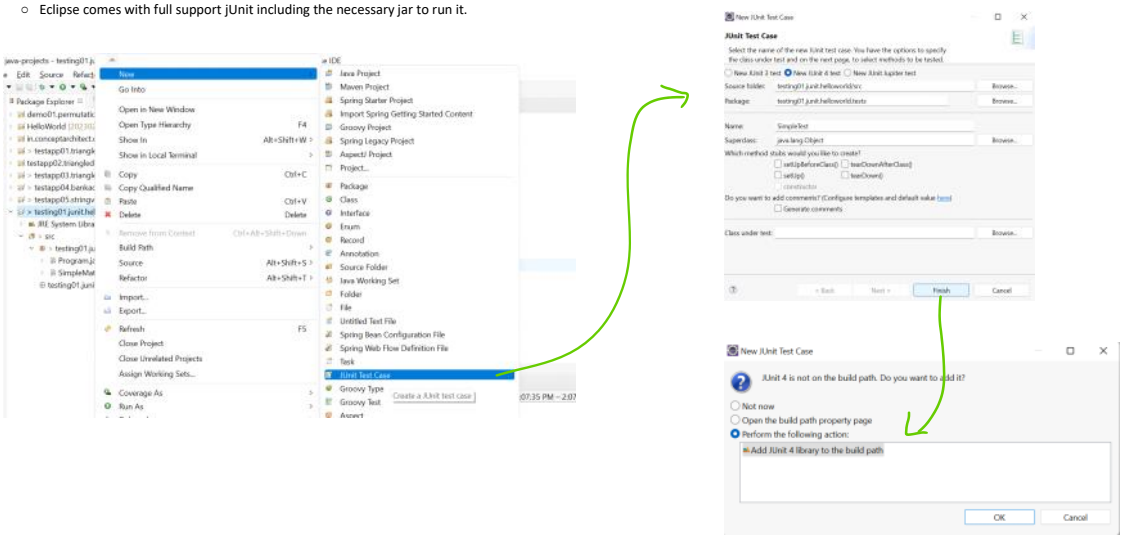
- A test is still a Java method
- You can write anything here what you can write anywhere
- We generally avoid direct print or if
  - we replace with assert
  - we may still use print (not recommeneded)

- Forms a typical Test Enviornment
- There can additional helper library to make tests better and more efficient
- Any of these components canbe replaced by third party library
- TestReporter
  - can be as simple as a console output
  - or can be presented in a special window inside your IDE.

# jUnit

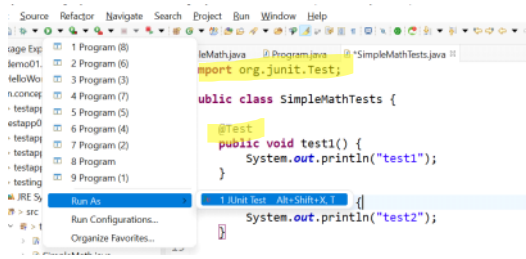
Tuesday, February 7, 2023 2:01 PM

- jUnit is a third party library created by jUnit for java Unit testing
- This is the first testing library
- It is one of the most popular library under java
  - It is a defacto standard
- We need a separate jar download to make jUnit testing work
- Good News
  - Eclipse comes with full support jUnit including the necessary jar to run it.



## Identifying a Test

- A test method is any method that is marked with a @Test annotation
- Eclipse recognizes a class with one or more test method and runs it as a test

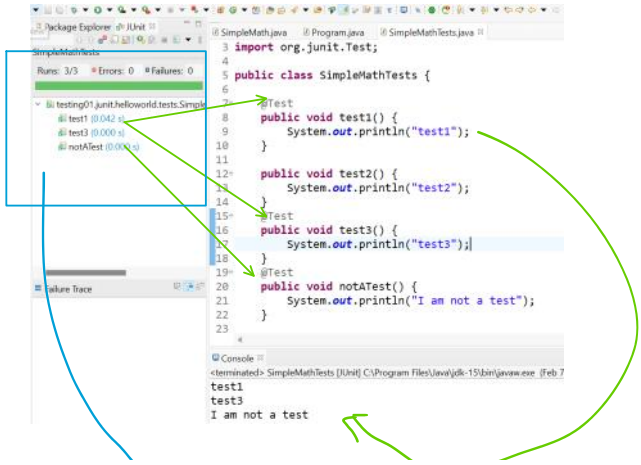



- Any method marked with @Test is a a test

## What is an annotation?

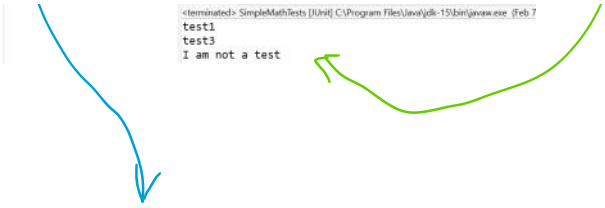
- Annotation is a Java language feature
- It is a speical syntax to introduce meta information in a class
- more on annotation later...

## Running first set of Tests




Note

1. every method marked as @Test is executed
   a. name doesn't matter
2. each of these methods run independendly and in no particular order
   a. we may see their output in console




## Why did all three test pass?

- They passed because they had no reason to fail.

## Assert

- jUnit provides a set of Assert methods present in Assert class
- These method help us "assert" our expectation
  - If our expectations prove correct, test passes
  - else fails

```
public class SimpleMathTests {

    int x=50;
    int y=15;

    @Test
    public void test1() {
        var result= SimpleMath.plus(x, y);
        assertEquals(x+y, result);
    }
    @Test
    public void test2() {
        var result= SimpleMath.minus(x, y);
        assertEquals(x-y, result);
    }
    @Test
    public void test3() {
        var result= SimpleMath.multiply(x, y);
        assertEquals(x*y, result);
    }
```

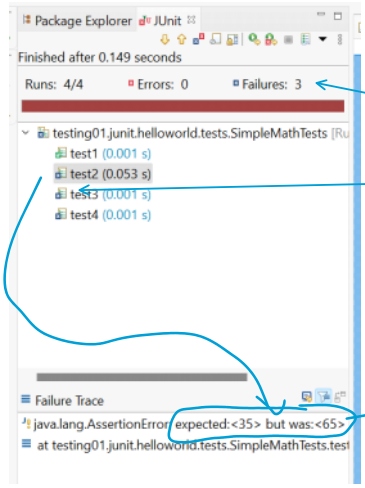
## Aside Static Import

- allows us to import a static method from a class

```
//importing a static method from class
//now we can use this static method without using class reference
import static org.junit.Assert.assertEquals;
```

- Once imported the static method can be used like a global method without needing class reference

```
@Test
public void test1() {
    var result= SimpleMath.plus(x, y);
    assertEquals(x+y, result);
}
```

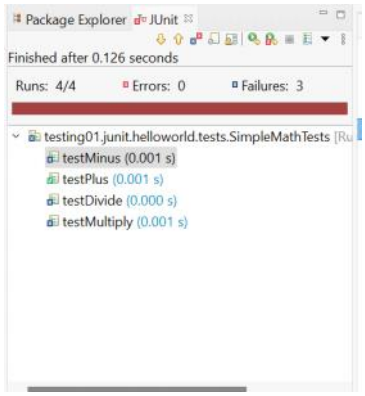



Note

- Here we have three failing tests marked with blue cross
- even if 1 of 100 tests fails you get a brown bar instead of green
- You also get a more detailed report for failure

- report includes the method names for each test
  - what does test2 fail mean?

## Use Meaningful Test names




## More of Naming

```
public class BankAccountTests {

    String password="p@ss";
    double amount=20000;
    double interestRate=12;


    public void testDeposit() {

    public void testDeposit2() {

}
```

- Generally there will be multiple tests verifying different conditional paths of the same method
- Example
  - deposit
    - for invalid amount
    - for valid amount
  - withdraw
    - for invalid amount
    - excess amount
    - wrong password
    - happy path

- nameing methods with sufix 1,2  may not be clear enough
  - testDeposit1
  - testDeposit2

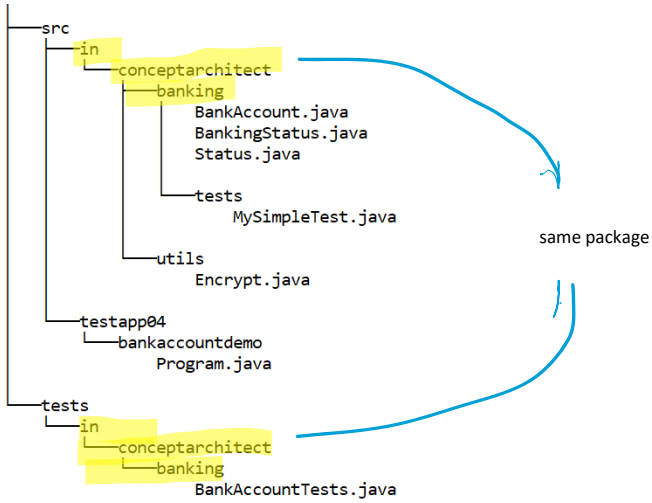
## DAMP principle (Descriptive and Meaningful Phrases)

- Method name shouldn't just be a descripted word, it should be like a phrase
  - It appears in the test report

# Unit Testing for package scope

Wednesday, February 8, 2023 9:31 AM

- A package scope members are part of same API
- They can be accessed by other member of the same package but not outsiders
- To test the packages members we can put the test files in the same package
  - The problem is same folder will have
    - application code
    - test code
- To better organize
  - create two sub folders
    - src
      - package in.conceptarchitect.banking
        - Banking related application classes
    - tests
      - package in.conceptarchtiect.banking
        - Banking related test classes
  - Now add both src and tests in the classpath
  - This way we have to physical folders but one package
    - tests can still access package members of src



# BankAccount memory model

Tuesday, February 7, 2023 3:13 PM

```
BankAccount b1=new BankAccount(1,"Vivek", 20000,"p@ss",12);

BankAccount b2=new BankAccount(1,"Sanjay", 20000,"p@ss",13);
```

b1

| 1 | Vivek | 20000 | p@ss | 12 |
|---|---|---|---|---|

b2

| 1 | Sanjay | 20000 | p@ss | 13 |
|---|---|---|---|---|

## Problem

- account number should be unique
- name, password, balance may or many not be similar
- **what about interest rate?**

## In General all accounts of same type gets same interest

- If we get same interest rate for all object why maintain redundant data?
- How can we have a single shared source of interest rate?
  - global?

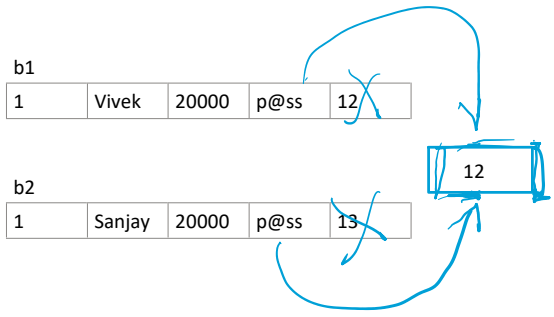
- Java doesn't have global variable
- closest candidate is "static" class fields

## Static Fields

- Static fields belong to class and not object
- There is a single copy maintained in the memory
- Every object can access this memory
  - no one owns it.
- change fo value will impact everyone

```
class BankAccount{
    int accountNumber;
    String name;
    String password;
    double amount

    static double interestRate;
}
```

```
BankAccount b1=new BankAccount(1,"Vivek", 20000,"p@ss",12);

BankAccount b2=new BankAccount(1,"Sanjay", 20000,"p@ss",13);
```



# Assignment 4.1

Tuesday, February 7, 2023 3:31 PM

## 1. How do I make sure account number is unique?

- write the code to make the account number unqiue
- write unit test to validate that the account numbers are unique

# Composite Output

Wednesday, February 8, 2023 8:18 AM

```
public Outcome getBalance(String pass) {
    var o = new Outcome();

    if (!checkPassword(pass)) {
        o.setDescription(BankingStatus.invalidCredentials.toString());
        o.setResult(false);
    } else {
        o.setResult(true);
        o.setDoubleValue(this.balance);
    }
    return o;

}
```

```
1  package com.an2.midan2.util;
2
3  public class Outcome {
4
5      boolean result;
6      int     intValue;
7      double  doubleValue;
8      String  description;
9
10     public boolean isResult() {
11         return result;
12     }
13     public void setResult(boolean result) {
14         this.result = result;
15     }
16     public int getIntValue() {
17         return intValue;
18     }
19     public void setIntValue(int intValue) {
20         this.intValue = intValue;
21     }
22     public double getDoubleValue() {
```

# Static

Wednesday, February 8, 2023 9:35 AM

## Static Fields

- A single shared copy is maintained in the memory
- No object owns it
- Everyone can use it.
- Example

```
public class BankAccount {

    int accountNumber;
    String name;
    String password;
    double balance;

    static double interestRate;

    static int lastId=0;
```

- one copy per object
- belongs to object of the class

- belongs to class and not object
- single copy created for the class
- shared/accessed by every one.

## Static Methos

- What is the role of a static method?
- both static and non static methods have single copy in memory
- Difference between static and non-static method

| Feature | Non Static Method | Static Method |
|---|---|---|
| How to call | • using an object reference | • using class reference<br>• using object reference |
| this | • contains special this reference that refers to invoking object | • doesn't have this reference as there may not be an object |
| accessing static members | • YES | • YES |
| accessing non-static members | • YES | • NO |

## Why do we need static method?

- We don't need an object to call it
  - Are we sure we are talking about Object Oriented Programming?

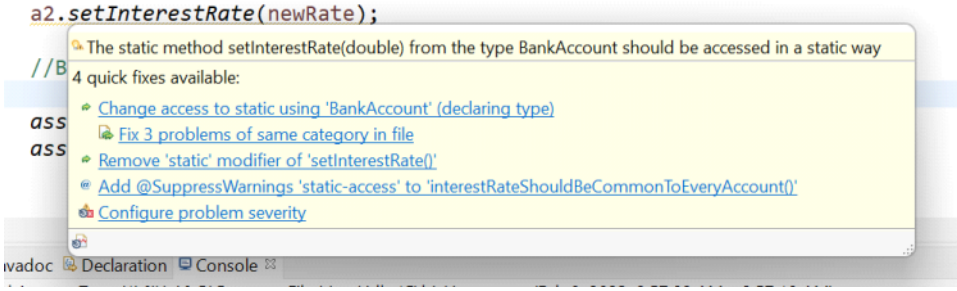
```
@Test
public void interestRateShouldBeCommonToEveryAccount() {

    var a2=new BankAccount(1, "Vivek", password, amount, interestRate);

    //when we change it for a1
    var newRate= interestRate* 1.05;

    a2.setInterestRate(newRate);

    assertEquals(newRate,account.getInterestRate(),0.001);
    assertEquals(newRate,a2.getInterestRate(),0.001);

}
```

- this code appears to be chaning the interest rate for a particular object "a2"
- Actually it is changing for everyone which is not clear by looking at the code
- static will allow you to call this method using class reference

```
//a2.setInterestRate(newRate);

BankAccount.setInterestRate(newRate);
```

## Should a class level method be allowed to access by Object reference?

- Java (and c++) allows  us to access static methods even using object reference
- But it defeats the purpose of static method
    - Ideally static methods should be used only with class
    - c# doesn't allow accessing static from object reference
- Java best practice guidelines strongly recommedns that static methods should be accessed only using class referenc eand NOT using object reference.



# Do I really need static?

Wednesday, February 8, 2023 10:03 AM

- static means class level and not part of object
  - what is class?
    - description for object (blueprint of an object)
      - if something doesn't belong to object how can it belong to class?
- static means no need of object.
  - Is it Object Oreinted.

- interestRate and lastId isn't owned by account object
  - who owns them?

```
public class BankAccount {

    int accountNumber;
    String name;
    String password;
    double balance;

    static double interestRate;

    static int lastId=0;
```

```
class Bank{

    double interestRate;
    int lastId;

    int openAccount( String name, String password, double amount){
        var a = new BankAccount(++lastId, name, password, amount);

        return a.getAccountNumber();

    }

    boolean deposit( int accountNumber, double amount){
        return getAccount(accountNumber).deposit(amount);
    }

}
```

```
var icici = new Bank("ICICI",12);

var a1= icici.openAccount("Vivek","p@ss", 20000);

var a2= icici.openAccount("Sanjay","p2", 40000);

icici.transferFunds(a1, "p@ss", 1000, a2);
```

# Test Elements

Wednesday, February 8, 2023 11:02 AM

## AAA —> Arrange Act Assert

### Arrange (Setup)

- setup the intial test condition
- example
    - create the object that we need to test
- It can be done
    - in the beginning of test case
    - @Before
    - @BeforeClass

### Act

- execute the function that you want to test
- this is the main activity that we are testing

### Assert

- verify code worked as required.

# TDD/TFD

Wednesday, February 8, 2023 10:45 AM

- Test First Development or Test Driven development is a paradigm that uses Tests as design specification
  - to underline this idea tdd classes should have a Specs suffix rather than Tests suffix
    - ~~BankTests.java~~ BankSpecs.java
- The idea is we first create a spec file that defines my system's requirement as Test cases
  - At this stage the actual classes is not created
  - Remember it is test first
- Then we create the classes and ensure that it works as per the requirement

## TDD Lifecycle —> Red-Green-Refactor

### Red Phase

- We start with failing test (Red)
- Remember a Test will essentially fail initally as we don't have the classes that can make it pass.
- If we don't have a failing test then it is NOT TDD

- This is the phases where we define design specification that we need to follow.
- Since it is not implemented yet it will fail
- The goal is to provider developer with the system requirement in form of specs files (.java)

### Green Phase

- Write the minimal code to make the test pass
- The goal is make the test pass and not write the perfect code
  - You can cheat!!!
- This minimal code may not even be correct or working

- This is not solving the problem but acknolwdging the problem
- Here you will get the correct signature of the method that we need to create
- Logic may evolve over a period of time.

### Refactor

- Modify the code ensuring that our specs don't break
- With each refactor it may push us to red phase
- We again need to write minimal code to make all tests pass.

# Account Types

Wednesday, February 8, 2023 2:59 PM

- A Bank may have different types of Account

| Account Type | Min Balance | Max Transactions | Interest Rate | |
|---|---|---|---|---|
| SavingsAccount | 5000 | 50 | standard | |
| CurrentAccount | 0 | no limit | 0 | |
| Overdraft Account | balance+ OdLimit | 50 | rate slab<br><br>1% extra interest if balance >100000 | |

```
class BankAccount{
    ~~AccountType type;~~

}
```

- you will have to add all logic and information for all account types in a single class
- if we need a new type tomorrow this class will change again.

- OdLimit is 10% of max historical balance
  - If your historical max balance was 100000 your odLimit is 10% of 100000 = 10000
- If your current balance is 20000 you can withdraw upto
  - 20000+10000 = 30000
- If you withdraw 25000 you balance becomes
  - 20000-25000=-5000
- There will be a 1% charge on Od
  - 1% of 5000 = 50
- Final balance
  - -5000-50 = -5050

# Inheritance

Wednesday, February 8, 2023 3:07 PM

- Inhertiance allows you to extend a class definition by creating a sub class
- The sub class that extends the super class should have a relationship which can be expressed in terms of
  - sub class **is a type of** super class
  - Example
    - Crow is a type of Bird
    - Car is a type of Veichle
- We shouldn't extend a class for any other reason/relations like
  - Has A
    - Computer Has a Harddisk
    - Bank has BankAccount(s)
    - Department has Employee
  - Is Like A
    - Crow is Like a Parrot
  - Associated/Works together
    - Computer and Printer works together

### Assume we have a class

```
class X {

    int a;

    public void doTaskA(){
        …
    }
}
```

### Now we can extend this class by sub class Y

```
class Y  extends X {


}
```

- Now y has all the properties and behaviors of X which it can use

```
Y y = new Y();

y.a=20;  //works

y.doTaskA(); //works
```

### A sub class object can be refered by a super class reference

```
X v = new Y(); //remember new Y() is a type of X
```

## But we don't want a class that is just as good as super class

- Unless you want some additional or changes in the way X object works you don't need to create a sub class

### A sub class can add additional property or behavior

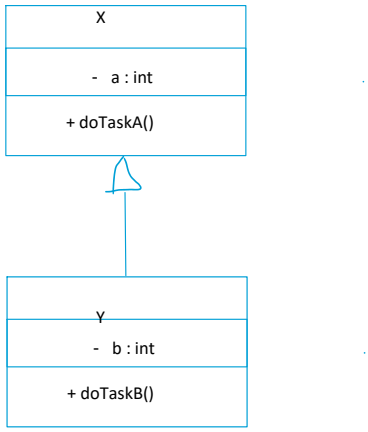
```
class X {

    int a;

    public void doTaskA(){
        …
    }
}


class Y extends X{

    int b;

    public void doTaskB(){

    }
}
```

```
//super class
class Animal{

    void eat();
}


//sub class
class Tiger extend Animal{

    void hunt();

}


Animal myFavAnimal = new Tiger()
```

```
    public void doTaskB(){

    }
}
```

```
}

Animal myFavAnimal = new Tiger()
```

- Now




## Inheritance is about creating a relationship:  Is A Type Of

- a class Y can extend any class X
- X and Y can be anything
    - Airplane extends Cow
    - Cycle extends Circle
    - RubberDuck extends RealDuck
    - Computer extends HardDisk
- Inheritance is not about everything
- Don't inherit
    - If there is no relationship
    - don't inherit for relationships like
        - Has A /Owner / Owned
        - Is Like A / Is Similar To
        - Contains
        - Know
        - Associated with
        -

## Modifying existing behavior

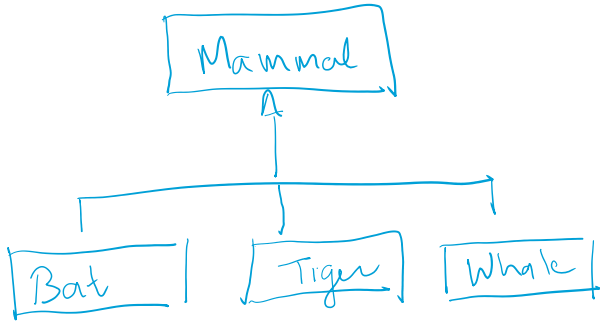
- Sometimes a behavior defined by the generic super class is not same as what we need in a sub class
    - Example:
        - Mammals generally walk on land
            - Exceptions
                - Bat is a flying mammal
                - Whale swims

## How do we modify the behavior specific to the sub classes?

- We can modify the behavior we rewriting the same method (with same signature) in the derived class.
- This is known as overriding.

```
class Mammal{

    public String breed(){
        return "Child Bearing";
    }

    public String move(){

        return "Walk on legs";
    }

}

class Bat extends Mammal{
```

```
    //overrides the super class move method
    public String move(){
        return "Fly";
    }

}


class Whale extends Mammal {

    @Override
    public String move(){
        return "Swim in ocean";
    }

}

class Tiger extends Mammal{

    public Strin hunt(){
        return "Hunt's it's pray";
    }
}
```




## Working with a class Hierarchy

- Since Tiger, Bat and Whale are types of Mammal
  - A Mammal reference can refer to them
  - We can store objects of these types in an array of Mammal

```
Mammal [] mammals = {

    new Tiger(),
    new Bat(),
    new Whale()

}
```

- Now we can use all these objects in a single for loop

```
for (  var mammal : mammals){

    System.out.println( mammal.breed());

    System.out.println(mammal.move());
}
```

- It will always display "child bearing"
  - It is invoking the breed method defined by the Mammal class and not modified by any subclass

## Which method would be invoked here?

- We have two possible candicates
  1. Mammal class method as the reference used is of Mammal
     - we don't know which exact type of object will be used
     - In our case everytime it would be different
  2. The method from the class whose object is being used
     - This can't be determined during compile time
     - It must be decided at runtime only

- In olden compiler driven langauges like c++ the default idea was to use method belonging to reference type unless we activate a special mechanism.

- Java inspects the actual objects at runtime and then decides which method should be called.
- Java calls this process as **Dynamic Method Dispatch**

- **The more common object oriented term for this behaing is**
  - Polymorhphism

## Polymorphism

## IMPORTANT!!!

- Starting Java 6, we have an annotation to mark a method that overrides another method from the super class.
- This annotation is optional (as it was introduced late) but recommended.
- Advantage
  - If you write an annotation of a method that doesn't have a correspondence in the super class it will give you a compile time error

```
class Bat extends Mammal{

    //No error. It will be considered as an additional method
    public String move(int speed){
        return "Fly";
    }

}


class Whale extends Mammal {

    //considered as an error as no correspoding method present in super class
    //if you want this method to be an additional one, remove the annotation
    @Override
    public String move(int speed){
        return "Swim in ocean";
    }

}
```

```
Mammal mammal = getARandomMammal();


//Here we (compiler) doesn't know which exact mammal will be returned

var x= mammal.breed() ; //no confusion here. No class Overrides it

var y = mammal.move();  //must select the right move() based on object
```

- In dynamic method dispatch,
  - runtime checks for the object, if it defines/overrides the move method
    - if yes, that method is called
    - if no,
      - it checks for the same in the super class and their super class

- We call the beahvior as polymorphism because same move() call may be mapped to different objects depending on the dynamic context ( object being used)

### Inhertiance special operator : instanceof

- this is a boolean operator that checks if a given object is an instanceof a given type
- LHS is the object
- RHS is the class

```
tiger instanceof Tiger   // true
tiger instanceof Mammal   // true
tiger instanceof Animal   // true
tiger instanceof Bat   // false
bat   instanceof Tiger //false
```

### Summary so far…

- Any class can extend any other class
- We must extends to achieve an "is a type of" relationship
- Everything (almost) defined in the super class becomes part of the sub-class
- we can add additional attributes (data memebers) and behaviors (method) in sub class
- we can override an existing behavior of the super class
  - prefer using @Override
- A super class reference (generic reference) can refer to objects of sub class (specific instances)
- When a super class reference refers to a sub class object
  - It can access only those elements that are defined in the super class
    - It can't access any new name or behavior
  - Override is considered as modification of existing behavior and not a new behavior
    - super class reference can polymorphically (dynamic method dispatch) access the overridden method from the sub class

#### Important

- super class reference can refer to overriden sub class method
- super class reference can't refer to additional behaviors defined by the sub class and not know to super class.

## How can Tiger among Mammals Hunt?

```
class Mammal{

    public String eat(){  return "eats food"; }
    public String breed() { return "child bearing";}

    public Sring move(){ return "walks"; }
}

class Horse extends Mammal{

    public String move(int speed){ return "walks with speed "+speed; }  //new behavior
}


class Tiger extends Mammal{

    public String hunt(){ return "Hunts"; }

    @Override
    public String eat() {  return hunt()+" and eats" ;}
}
```

```
Tiger tiger =new Tiger(); //this reference can access all Tiger methods both owned and inherited.

@Test
public void tigerCanHunt(){

    assertEquals("Hunts", tiger.hunt());
}


@Test
public void tigerHuntsAndEats(){

    assertEquals("Hunts and eats", tiger.eat());
}

@Test
public void horseCanMoveWithSpeed(){
    int speed=40;

    assertEquals("walks with speed "+speed, horse.move(speed));
}
```

### But using Mammal Reference would be different

```
Mammal mammal = new Tiger();

assertEquals ("Hunts and eats", mammal.eat());  //note indirectly mammal invoked hunt also

if(System.currentTimeMillis()%5==0)
    mammal=new Horse();


//which mammal do we have here? A tiger or a Horse? Can we allow it to hunt!!!
var x = mammal.hunt(); //mammal doesn't know how to hunt. It is a method specific to Tiger not available in mammals
```

### How do we access the hunt method here

```
Mammal mammal = new Tiger();

//here we are 100% sure my mammal is a Tiger. But Java doesn't know so it refuses to execute

mammal.hunt(); // error
```

### We can typecast reference to Tiger to use it

```
((Tiger)mammal).hunt();  //works if it is really a Tiger. Runtime error otherwise.



Mammal [] mammals = { new Tiger(), new Horse(), new Bat() };

for( var mammal : mammals){

    Tiger t  = (Tiger) mammal;
    System.out.println(t.hunt());

}
```

- Works fine for the first loop iternation
- crashes while tyring to typecast a Horse into a Tiger
    - This is a runtime error

### Always typecast when you are sure it wouldn't crash

```
Mammal [] mammals = { new Tiger(), new Horse(), new Bat() };

for( var mammal : mammals){

    if(mammal instanceof Tiger){
        Tiger t  = (Tiger) mammal;
        System.out.println(t.hunt());
    }

}
```

## Partial Overriding or Partial Modification

```
class Point{
    int x,y;

    public String toString(){

        return String.format("Point %d,%d ",x,y);
    }
}

class Point3d extends Point{
    int z;

    public String toString(){
        //can I reuse the logic from Point toStrin

        return toString()+","+z;  //recursive call to subclass toString
    }

}
```

- sometimes we need a slight adjustment in the core logic that we inherited from the super class
- We can't really have a partial overrride or modification
  - we either override or we don't
- Once we override, the subclass method will hide the superclass implementation

### we can access the super class version of method using super reference

```
class Point{
    int x,y;

    public String toString(){

        return String.format("Point %d,%d ",x,y);
    }
}

class Point3d extends Point{
    int z;

    public String toString(){
        //can I reuse the logic from Point toStrin

        return super.toString()+","+z;  }

}
```

## What is not inherited?

- In java when we inherit we inherit all the properties and behavior associated with the super class object.
- We, however, don't inherit the constructor of the class
  - constructor is the creator of the object
  - constructor is not part of the object
- constructor is not inherited because
  - we may need different approach to create object of a sub class
    - we may need to have additional initalization
  - both constructor have different names

## A word of "private" members

- private members of a super class is inherited into sub class
- However due to "private" scope, they can't be accessed by any member of the sub class
  - Not even overridden methods
- They can only be accessed using the super class methods that were already accessing it

- This leads to widely accepted WRONG notion that private members are not inherited.
  - There is difference between owning the something and accessing something.

- If a method is private, it can't be overriden
  - It is not accessible

## Protected

- protected is a scope for inheritance model
- a protected member is like a private member for the rest of the world
- It is however accessible by the sub classes

# Constructor Chaining

Monday, February 13, 2023 9:51 AM

- Although a super class constructor is not inherited, a super class constructor is called alongwith (And before) calling the sub class constructor to create the super class portion

```
class Animal {
    public Animal(){
        System.out.println("Animal Constructor called");

    }
}

class Mammal extends Animal {
    public Mammal(){
        System.out.println("Mammal Constructor called");

    }
}

class Horse extens Mammal {
    public Horse(){
        System.out.println("Horse Constructor called");

    }
}


var horse = new Horse(); //calls constructor of super classes
```

```
Animal Constructor called
Mammal Constructor called
Horse Constructor called
```

## Note

- Whenever we create the object of the sub class super class constructor is always called
- A super class constructor will execute before executing the sub class constructor
- This process can't be modified.
- By default the sub class constructor always attempts to call the zero argument constructor of the super class
- A code will fail to compile
    - If zero argument constructor is not available
    - It the constructor is not accessible (eg. if it is private)
- A sub class however can specify it it wants a different super class constructor to be called.

```
class Point {
    private int x,y;

    public Point(int x,int y){
        this.x=x;
        this.y=y;
    }
}

class Point3d{

    int z;

    public Point3d( int x, int y, int z) {

        //fails as constructor will try to call 0 argument constructor from super class
        this.x=x; //fails because x is private
    }

}
```

### Note

- A sub class constructor must take all parameters required to initalize values, both inherited and new
- User will not be explicitly calling super class constructor
    - They may not even know you inherited something
    - We need to take all parameter

- We can specify which super class constructor it should call

```
class Point3d{

    int z;

    public Point3d( int x, int y, int z) {
        super(x,y);

        this.z=z;

    }

}
```

## Note

- when we don't write "super" it is assumed as super()
- if super() is used it MUST be the first statement in the constructor
- You can't write

```
public Point3d( int x, int y, int z) {

    this.z=z;
    super(x,y); //MUST BE FIRST STATEMENT


}
```

# Polymorphism

Monday, February 13, 2023 3:22 PM

Different Objects, behaving differently, in the same context is xxxx

# Class Oriented vs Object Oriented

Tuesday, February 14, 2023 8:24 AM

```
//Approach A


Animal tiger = new Animal (AnimalType.Tiger);

Animal eagle =new Animal (AnimalType.Eagle);

Animal snake = new Animal(AnimalType.Snake);
Animal crocodile =new Animal(AnimalType.Crocodile);


Animal animals[]={tiger,eagle,snake};

for(var animal :animals){
    animal.move();
    animal.eat();
}


package in.conceptarchitect.animals;

enum AnimalType{ Tiger,Eagle,Snake };

class Animal{

    AnimalType type;
    int poisonIntensity;
    Wings wings;

    public Animal(AnimalType type){
        this.type=type;
    }

    public void move(){

        switch(type){
            case AnimalType.Tiger:
                System.out.println("moves on land");

            case AnimalType.Crocodile:
                System.out.println("crawls");
            case AnimalType.Eagle:
                System.out.println("flies");
                break;
            case AnimalType.Snake:
                System.out.println("crawls");
                break;


        }
    }
}



Tiger tiger =new Tiger();

tiger.setType(AnimalType.eagle);
```

```
//Approach B


Tiger tiger =new Tiger();

Eagle eagle = new Eagle();

Snake snake =new Snake();


…
Animal animals [] = {tiger,eale,snake};




   package in.conceptarchitect.animals;

    class Animal{
        public void move(){
            System.out.println("Moves somehow");
        }
   }



   class Reptile extends Animal{

   }

   class Mammal extends Animal{

   }

   class Bird extends Animal{

   }

   class Tiger extends Mammal{


        public void move(){
            System.out.println("moves on land");
        }
   }

   class Eagle extends Bird{

        Wings wings;
        public void move(){
            System.out.println("flies");
        }
   }


   class Snake extends Reptile{

        int poisonIntensity;
        public void move(){
            System.out.println("crawls");
        }
   }


   //
   package com.anz.animals;
   import in.conceptarchitect.animals.Animal;

   class Dinasaur extends Reptile{
```

```
public void printMammals(Animal[] animals){

}
```

```
}


// client code

import in.conceptarchitect.Animals.*;
import com.anz.animals.Dinasaur;


…

Animal [] animals={new Tiger(), new Dinasaur() };


public void printMammals(Animal[] animals){

    for(var animal:animals){
        if(animal instanceof Mammal)
            System.out.println(animal);

    }


}
```

# Animal Hierarchy

Tuesday, February 14, 2023 9:37 AM

```
3  public class Animal {
4
5
6      public String eat() {
7          return this+" eats something";
8      }
9
10     public String move() {
11         return this+" moves somehow";
12     }
13
14     public String breed() {
15
16         return this+" breads somehoe";
17     }
18
19     public String toString() {
20         return getClass().getSimpleName();
21     }
22
23 }
```

- We don't know the exact implementation details here
- But by returning this information we are actually creating an implementation.

## Abstract Methods and Abstract Class

- If we do not have sufficient details to implement a behavior (method), we should mark the method as abstract
  - abstract method tells system that we can't provide implementation details for this method yet
    - It is too generic
  - The implementation shall be provided by some sub class.

- A class that contains one or more abstract methods should also be marked abstract.
  - If class contains non-abstract methods also, it doesn't matter.
  - An abstract class means we don't have sufficient specific information available to create instances of this class
    - Actual instances will be created for the sub class
    - This class is meant only to be a super class

```
2
3  public class Animal {
4
5
6      public abstract String eat();
7
8      public String move() {
9          return this+" moves
0      }
1
2      public String breed() {
```

Remove 'abstract' modifier
Make type 'Animal' abstract

- If even one method is abstract, the class must be abstract
- When class becomes abstract you can't instantiate it

```
25 new Animal(),
26 new
27 new
28 new Dog(),
```

Cannot instantiate the type Animal

## Why we create an abstract method when we don't know the implementation?

```
ublic abstract class Animal {

    public abstract String eat();

    public abstract String move();

    public abstract String breed();
```

- In this case we don't know what Animal will **exactly** eat.
  - But we know animal will eat.
- If we don't have "eat" method in Animal class we can't call "eat" polymorphically for the sub class.

Animal animal = new Tiger();

animal.eat(); //possible only if Animal class has a eat

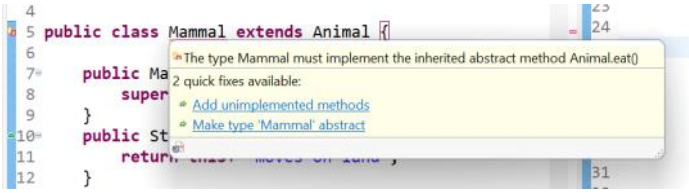
## Why do we need abstract class (Animal) if we can't create an object of this class?

- While we can't create Animal Object (~~new Animal()~~), we can create

- A reference of Animal that can refer to a sub class Object
- An Array of Animal that can hold objects of sub classes

## How does Abstract change class or method behavior

- An abstract method must be overriden by the sub class to provide the necessary implementation
- Any class that extends an abstract class must either
  1. override and implement all the abstract method
  2. or declare itself abstract.

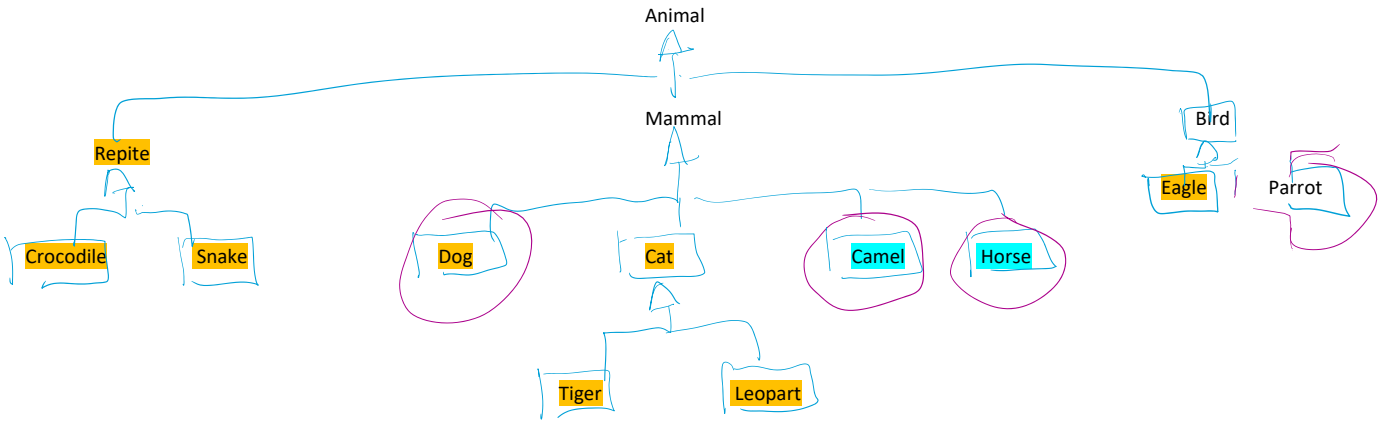



## Abstract by design

- sometimes a class should be abstract as per design but we don't have any specific abstract behavior
- In such cases we can mark a class abstract even if there is no abstract method in the class

```
public abstract class Cat extends Mammal {

    public Cat() {
        super();
    }

    @Override
    public String eat() {
        // TODO Auto-generated method stub
        return this+" is a flesh eater";
    }

```

- Now the sub classes will naturally be "concrete or instantiable classe




## What is the relationship between animals marked Orange?

- They all have hunt() method
  - They can be called Hunter
  - We may consider that they belong to a super class called Hunter
- A Tiger is an Animal or is it a Hunter?

## What is the relationship between objects highlighted blue

- They are Rideable

## What does purple circle indicate?

- They all have hunt() method
  - They can be called Hunter
  - We may consider that they belong to a super class called Hunter
- A Tiger is an Animal or is it a Hunter?
  - Which super class does it belong?
  - Can't it belong to (extend) two super class?

## Inheritance Restriction

- Java doesn't allow you to extend more than one super class
  - It doesn't support multiple inheritance.
  - You must choose exactly one super class.

## Interfaces

- An interface is another mechanism to define an object hierarchy
- It is like an abstract class with important changes
  - All methods inside an interface is by default public,abstract
    - You can't use either modifier
      - In latest java releases you are allowed to use public abstract explictly
      - but you cant use other modifiers like protected
    - There is no concrete or non-public member
  - You implement and interface (and not extend it)
    - just a keyword difference
  - There would be no field or data member in interface
    - If you define it would be final
- While you can extend a single class you may implement any number of interfaces

```
interface Hunter{

    public abstract String hunt();

}
```

- Any class that implements the interface MUST either
  - implement all the interface method
  - declare itself abstract

## How can Tiger among Animals Hunt?

```
if(animal instanceof Tiger) {
    var tiger=(Tiger) animal;
    System.out.println(tiger.hunt());
}
```

### How can we check for Hunt for other Animals?

- We essentially don't want to write similar if block for all animals that hunt

- They are Rideable

### What does purple circle indicate?

- They can be pet animal

## Real World Models

- An object can belong to multiple hierarchies
  - Tiger
    - Mammal
    - Hunter
    - Wild
  - Dog
    - Mammal
    - Hunter
    - Pet
  - Crocodile
    - Reptile
    - Hunter
    - Wild
  - Eagle
    - Bird
    - Hunter
  - Horse
    - Mammal
    - Rideable
    - Pet

### Remember

- class extends class
- class implements interface(s)
- interface extends interface

## Inteface Implementation


```
public class Dog extends Mammal implements Hunter{

    public String eat() {
    public String move() {

    @Override
    public String hunt() {
        return this+" hunts in jungle";
    }

}
```

## How do I model a Pet?

- A Hunter is one who Hunts

```
public interface Hunter {
    String hunt();
}
```

- A Rideable is one you Ride on

```
public interface Rideable {

    public abstract String ride();
}
```

- A pet is one which ...?
    - There isn't any specific behavior that defines a Pet
    - Each pet has a different purpose or behavior

```
public interface Pet {

}
```

## Marker Interface

- A marker interface is an empty interface with no defined behavior
- implementing classes donot require to override anything
- There is no behavior that can be referred using Pet interface references

### What can be the use case of such an interface?

- It is just to define a class hierarchy
- It gives me an ability to test for "instanceof"

## Final Method/Class

- A method or a class can be marked final
- If a method is marked final, it can't be overriden by the sub classes

```
public abstract class Animal {

    public Animal() {

    public abstract String eat();

    public abstract String move();

    public abstract String breed();

    public final boolean isPet() {
        return this instanceof Pet;
    }
```

```
public class Tiger extends Cat {

    public boolean isPet() {
        return t
    }
}
```

Cannot override the final method from Animal

1 quick fix available:

## Final Class

- if a class is marked final it can't be sub classed

```
4
5 public abstract class Bird extends Animal {
6
7     @Override
8     public final String breed() {
9         // TODO Auto-generated method stub
10        return this+" lays eggs";
11    }
12
13
```

```
interface BankingStatus{

    String succcess="success";
    String insufficientBalance="insufficient balance";

}


class BankingStatus{

    public final String succcess="success";
    public final String
    insufficientBalance="insufficient balance";

}
```

# Object class

Tuesday, February 14, 2023 11:36 AM

- Java has a special class called **Object** class
- This class is the super class or all Java classes
  - predfined
  - userdefined
- Every class directly or indirectly extends Object class
  - A class that extends nothing extends Object
- Example

```
class Triangle extends Object{


}
```

- Class Tiger extends Cat
  - Cat extends Mammal
    - Mammal extends Animal
      - Animal extends Object

- Tiger instanceof Object —> true
- any object x instance of Object —> true

## What is the advantage of Object class?

1. An Object reference can refer to any object

```
Object o= new Tiger();
o=new SavingsAccount(…);
```

2. You can put any object into an Object array

```
Object [] universe= { new Triangle(), new SavingsAccount(), new Tiger() };
```

## Any method present in Object class is by default available to every Object

- Object class contains a few interesting methods

```
class Object{

    public final Class getClass(){…}
```

```
    public int hashCode(){…}

    public  String toString() {  return String.format("%s@%x",
    getClass().getName(), hashCode()); }

    public boolean equals( Object object) {  return hashCode() ==
    object.hashCode(); }


    public final void wait();
    public final void notify();
    public final void notifyAll();


}
```

## Not everything is an Object

- In java primitive types are not classes
- They don't extend Object class
- They don't fall in the hierarchy

```
Object [] values = {
                  new Tiger(),    //works
                  "Hello World", //works
                  29, //not allowed

              };
```

int x=29;

x instanceof Object

### Wrapper classes

- to treat "int" as a reference type Object  java provides a wrapper class around each primitive type

| primitive type | Wrapper Class |
|---|---|
| int | Integer |
| boolean | Boolean |
| char | Character |
| float | Single |
| double | Double |

- We can use objects of these types to work with Object Hierarcy

```
int x=20;

Integer y= new Integer(x);


Object o1= x; //not allowed

Object o2 = y; //allowed
```

## Auto boxing and unboxing

- java supports implicit conversion between int and Integer

```
int x=20;

Integer y = x;  //new Integer(x);

int z = y;  // y.intValue()
```

# Some standard Java Packages

Tuesday, February 14, 2023 11:52 AM

- java.lang
  - The most important of all Java Packages
  - It contains most important classes related to any Java Proramming including
    - Object
    - String
    - Math
    - System
    - Primitive Wrappers
    - …
  - This is so important that all these classes are implicitly imported in all source file
    - It is like we have a pre-written statement

```
import java.lang.*;
```

  - All other standard java packages when used must be imported

- java.util
  - A set of assorted utilitiy functions not as important as java.lang
  - we need to explcitly import
  - Important class here is
    - Random
    - Date
    - Collection classes
      - LinedList
      - ArrayList
      - HashSet
      - …
- java.io
  - Classes related to input-output operations that may be
    - file i/o
    - network i/o
    - memory i/o
    - File and Directory management
- java.net
  - Related to network programming
  - TcpSocket
  - UdpSocket
- java.awt
  - For devloping java desktop application

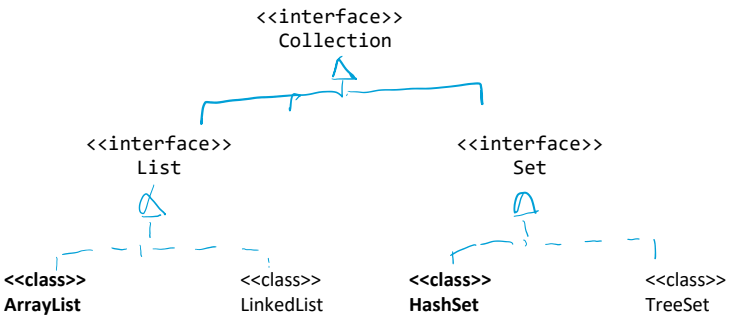
# Java Collection Classes

Tuesday, February 14, 2023 12:02 PM

- Java provides a set of dynamic collection classes
- Think of a them as advanced version of Array that can expand infinitely
- They have additional features
- Java Collection classes came with original version of Java and got major imporoves after Java 6

## Pre Java 6

- Java collections classes were collection of Objects
- This way they can hold any object inside




```
interface Collection{

    void add(Object o);
    boolean contains(Object o);
    void remove(Object o);
    void clear();
    int size();
    Object [] toArray();
    Iterator iterator();

}

//linear indexed collection
interface List extends Collection{
    void insert(int index, Object value);
    void set(int index, Object value);
    Object get(int index, Object value);
    void removeAt(int index);

}

interface Set extends Collection{
    //no additional method
    //defines collection of unqiue values
}
```

- ArrayList
  - It is a dynamic array
  - It is expanded in an optimized way
  - One of the most popular collection
  - Memory is internally continous
  - good to access random values programmetically

- LinkedList
  - Uses double linked list algorithm
  - data is stored in non-contgous nodes
  - good choice if you need to insert values in between collection

- TreeSet
  - stores unqiue set of values
  - Values are stored in sorted order using Binary Search Tree algorithm
  - It is a better choice if you need sorted set of values

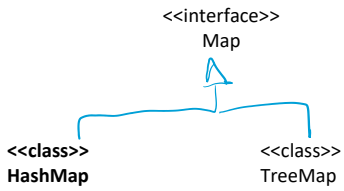
- HashSet
  - stores unqiue set of values using hashing algorithm
  - values are not sorted
  - It is optimized for fast search of data inside the collection

## A simple example

```
var accounts= new ArrayList();

accounts.add (new SavingsAccount(…));
accounts.add(new CurrentAccount(…));
accounts.add(new OverdraftAccount(…));

…

//accessing using standard for loop
vor( int i=0; i<accounts.size(); i++){
```

```
    Object a= accounts.get(i); //we get Object

    a.creditInterest(); //not allowed as Object doesn't know creditInterest

    if(a instanceof BankAccount){ //skipped as we stored only BankAccount sub type
        BankAccount account= (BankAccount) a;

        account.creditInterest(); //works
    }

}


//also supports for-each type loop
for(var a : accounts){

    var account= (BankAccount) a;
    account.creditInterest(12);
}
```

## A collection that is not a Collection




```
//Map interface represents a collection of key value pairs
//where both key and values are Objects


interface Map{

    void put(Object key, Object value);
    Object get(Object key);
    void remove(Object key);
    boolean contains(Object key);
    void empty();

    Set keys();
    Collection values();
}
```

- this of Map as a array that doesn't have integer index but can have any other type index
- Keys are unique

- putting multiple values against the same key overwrites the previous value without warning

```
//Example: Storing Country Information


HashMap db=new HashMap();


db.put("IN", new CountryInfo("India", "New Delhi", "INR",…));

db.put("FR", new CountryInfo("France","Paris",…));

…

db.contains("IN"); //–>true
db.contains("XYZ"); //–>false

for(var key :  db.keys()){

    System.out.printf("%s : %s\n", key, db.get(key));

}

db.put("IN", new CountryInfo("Bharat", …)); //replaces "India"
```

## IMPORTANT!!!

- Since Collection and Map stores Object they can work with any Object but NOT with premitive types
- To use premitive type you need to use Object wrappers

```
var numbers =new ArrayList();
```

```
numbers.add( 29);  //numbers.add (new Integer(29)) --> autoboxed to Integer

numbers.add( 40);


int x= (Integer) numbers.get(0);
```

# Generics

Tuesday, February 14, 2023 1:37 PM

- Generics is a programming paradigm to create algorithms that are independent or agnostic of the data type they operate on
  - Example: Collection like ArrayList
    - It is expected to store some value
    - But storae and retrieval doesn't care about "what exactly" you store
    - All we need to know is it is an "Object"

## Problems with traditional Object based Generics

- When we create an object, we intend to store specific type of value in this collection
  -

```
ArrayList  accounts = new ArrayList();
```

- Here we expect to store BankAccount objects

```
accounts.add(new SavingsAccount(…));

account.add(new CurrentAccount(…));
```

- Problem #1 compiler not detecting the problem is a problem.

- But we want to store BankAccount is known to us, not to Java compiler or runtime
  - we can store anything we want

```
account.add(new Tiger());  //illogical but symatically perpfectly
```

- Problem #2 when fetching the value it is retrieved as Object and not as Bank Account

```
for(  var   a :  accounts){

    a.creditInterest(12); //fails. Object reference doesn't have creditInterest

}
```

- Solution to Problem#2 : explicit typecast

```
for(  var   a :  accounts){

    var account = (BankAccount) a;
    account.creditInterest(12);//fails. Object reference doesn't have creditInterest

}
```

- Problem #3 (caused by Problem #1 and Problem #2)

- We can't restrain a collection object to store a paritcular type only
  - we can store anything
  - when typecasting it will throw exception

```
ArrayList  accounts = new ArrayList();



accounts.add(new SavingsAccount(…));
```

```
account.add(new CurrentAccount(…));

account.add(new Tiger()); //false positive


for(  var   a :  accounts){

     var account = (BankAccount) a; //false negative
     account.creditInterest(12);//fails. Object reference doesn't have creditInterest

}
```

- code will crash on this line
- because of an error in this line
- Not only code is failing it is reporting a failure at a wrong place
  - You get a false negative here

### Problem #3 solution —> guarded typecasting

```
for(  var   a :  accounts){
     if( a instanceof BankAccount){

          var account = (BankAccount) a; //false negative
          account.creditInterest(12);//fails. Object reference doesn't have
          creditInterest

     }
}
```

- This is not a clean solution
  1. we shouldn't be needing this check
     - afterall aren't we suppose to store only accounts
- We may need to write similar if block through out application
  - withdraw
  - deposit
  - transfer
- What should I do for bad/incompatible object here?

## Java 6 Generics

- Now we have special syntax called generic syntax in Java
- We define our class or object in terms of abstract data type and not specific one

### Step #1  We need an Array of BankAccount

```
ArrayList<BankAccount> accounts = new ArrayList<BankAccount>();
```

- Now accounts is an ArrayList of BankAccount type only
- Java compiler is now aware that only BankAccounts can be stored

Note

- this is a Java 6 generic syntax
- ArrayList class is created to store a generic value and NOT specific type
  - Not even Object
- We should (must) inform Java about what Kind of value I want to store in my ArrayList
- This is not an ArrayList or Collection Specific feature
  - we can also create our own Generic designs

### Step #2 adding values to collection

```
accounts.add( new SavingsAccount(…)); //works because SavingsAccount is a BankAccount

accounts.add(new CurrentAccount(…));


accounts.add( new Tiger()); //compile time error!!!
```

### Step#3  accessing the value back

- since array List knows that we are storing BankAccount it returns BankAccount reference and Not Object reference

```
for( var a in accounts){

     //here var –> BankAccount

     a.creditInterest(); //works fine. Not typecast. No Error
```

```
}
```

## Generic parameter can be any class/interface but not premitive

```
ArrayList<Hunter>  searchAllHunters(ArrayList<Animal> animals){

    ArrayList<Hunter> hunters=new ArrayList<Hunter>();

    for(Animal animal : animals){

        if(animal instanceof Hunter){

            hunters.add((Hunter)animal);
        }
    }

    return hunters;

}
```

- we can't have primitive type as parameter

```
ArrayList<int> numbers; //not allowed
```

- But we can use wrapper type

```
ArrayList<Integer> numbers;
```

## Generic Maps

- Simple HashMap —> storing CountryInfo against Country code

```
HashMap<String,CountryInfo>  db=new HashMap<String,CountryInfo>();
```

## Handling complex Generic Parameters

- Consider a map where
  - key is Deparment
  - value is an ArrayList of employees

```
HashMap<Department, ArrayList<Employee>> db = new  HashMap<Department, ArrayList<Employee>>();
```

- We can handle it in two different ways
- Java 7 syntax

```
HashMap<Department, ArrayList<Employee>> db = new  HashMap<>();
```

- Auto detect from the LHS
- Java 9 syntax

```
var db = new  HashMap<Department, ArrayList<Employee>>();
```

  - auto detect from RHS

- Don't use both
- Will not work

```
var db=new HashMap<>();
```

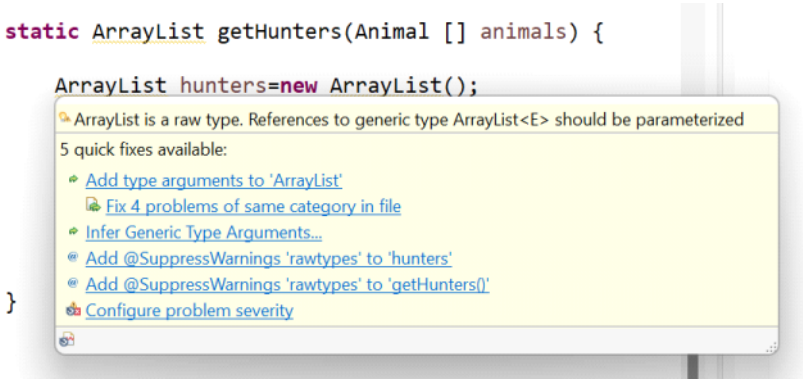
## Generic Parameter if not supplied defaults to Object

```
ArrayList  list =new ArrayList();  //this code will give warning messae.
```

- is same as

```
ArrayList<Object> list= new ArrayList<>();
```

- This first syntax is not recommended in modern code
- It is just for backward compatibility from pre-generic releases
- If we really want an array List of Objects we should use the second explcit syntax



# Generic Part 2

Wednesday, February 15, 2023 12:14 PM

## A Tiger is an Object. But a List<Tiger> is not a List<Object>

```
List<Tiger>  tigers  =  new ArrayList<Tiger>();

List<Object> objects = tigers; //not allowed.
```

### Why is it not allowed?

- If it is allowed, then we can write

objects.add(new Triangle()); //now a triangle is added to a List<Tiger>

- This will invalidate a List<Tiger>

## Where can I use generic

- A generic can represent an object or a method where the algorithm doesn't need to know actual data type
- It can think of the data type to be just like Object
    - It knows methods present in Object class
- It can't directly access behaviors defined for a given type

# Assignment 7.1

Tuesday, February 14, 2023 2:52 PM

- Write a method to search a List and return a List of all numbers that are divisible by 3

```
class Search{
    List<Integer> searchDivisibleBy3(List<Integer> values){

        var result= new ArrayList<Integer>();

        for(int value : values){
            if(value%3==0){
                result.add(value);
            }
        }

        return result;
    }
}


class Test{

    var list = Arrays.asList( 2, 9, 8, 4, 11, 3, 2, 17,6);

    @Test
    public void searchCanSearchAndReturnNumbersDivisibleBy3(){

        Search s=new Search();

        var result = s.search(list);

        //assert

        for( var value : result)
            assertTrue(value%3==0);

    }

}
```

```
class Search{
    List<Integer> searchDivisibleBy3(List<Integer> values){

        var result= new ArrayList<Integer>();

        for(int value : values){
            if(value%3==0){
                result.add(value);
            }
        }

        return result;
    }


    List<BankAccount> searchCurrentAccountsWithBalanceAbove5000(List<BankAccount> values){

        var result= new ArrayList<BankAccount>();

        for(var value:values){
            if(value instanceof CurrentAccount && value.getBalance()>5000)
                result.add(value);
        }

        return result;

    }

    List<Animal> searchPetMammals(List<Animal> animals){

        var result=new ArrayList<Animal>();
        for(var value :values){
            if(value instanceof Mammal && value.isPet())
                result.add(value);
        }

        return result;
    }
}
```

## Important Steps In Search

1. Make a Result list
2. Loop through the original list
   a. check if the current value is a match
   b. Add the current value in the result
3. Return the result

## Note the methods are performing two Job

1. How to Search a.k.a Core Search Algorithm
   - A Generic Logic
2. What to Search
   - This is specific to situation
   - Keeps changing very frequently
   - Because of this part the search method can't be generic to serve all needs.

## Solution —> Apply DRY

1. Encapsulate whatever repeats
2. Abstract Whatever changes

3. Inject abstraction in encapsulation

```
List<Integer> searchDivisibleBy3(List<Integer> values){

    var result= new ArrayList<Integer>();

    for(int value : values){
        if(value%3==0){
            result.add(value);
        }
    }

    return result;
}
```

```
List<BankAccount> searchCurrentAccountsWithBalanceAbove5000(List<BankAccount> values){

    var result= new ArrayList<BankAccount>();

    for(var value:values){
        if(value instanceof CurrentAccount && value.getBalance()>5000)
            result.add(value);
    }

    return result;

}
```

## 1. Encapsulate whatever repeats

```
List<Object>    search_____( List<Object> values){


}
```

- doesn't work because List<Object> reference can't accept List of other types

## Java Generic Syntax

- we can write our own generic function which can take a List of any generic type X and return a List of the same generic type X
- X is indicated as a prefix to the generic method

```
<X>  List<X>   search____(List<X> values){

    var result= new ArrayList<X>();

    for(X value : values){
        if(value%3==0){
            result.add(value);
        }
    }

    return result;

}
```

## Rule#2 Abstract whatever changes

- what is the abstraction for
  - value%3==0
  - value.getBalance()>5000
  - value.getCost()>2000
  - value.getAuthor().equals("Vivek Dutta Mishra")
- what are we doing here?
  - MatchCriteria

```
<X>  List<X>   search(List<X> values,Matcher<X> matcher){

    var result= new ArrayList<X>();

    for(X value : values){
        if(matcher.match(value)){
            result.add(value);
        }
    }

    return result;

}
```

- Who will do the match (which object)
  - search object?
  - It should be other class
    - It should be abstract

## Where will I get this matcher object?

## Rule #3

- we can pass the matcher as a parameter

## What is a Matcher?

```
interface Matcher<T>{

    boolean match( T value)
}
```

# Object Oriented Programming Recap

Wednesday, February 15, 2023 8:13 AM

## There are two Key terms

### 1. Object

- Represents a domain (problem space) entity
- It may be something like a real world object having
  - property/attribute/state
  - behaviors
    - Responsibility
- Idea is to treat the program as a set of interacting objects

### 2. Class

- Generally class is called blueprint/template of an object
- Class —> Classification and Sub Classification
  - The basis of these classficiation is object's properties and behavior
  - Forms a hierarchy
- Class is conceptually optional
  - It is not optional in Java
  - There are Object Oriented Langauge with no notion of class
    - Java Script

## Object Oriented Modeling Elements

### Encapsulation

- binding state and behavior together to model a **responsibility**
- we achieve this by
  - ensuring states can't change in an invalid way
    - generally guard them from external access using scope rule or conventional approach
    - Define proper getter/setter/property to access them adhering to the business/domain requirement
- An object **has/owns** states that helps it perform the expected job
- Defines an element of **Reuse**
- **More Responsible => More Usable**

### Inheritance

- Defining a hierarchy of class and sub-class
- It defines "Is A Type of Relationship"
- Inheritance Helps Us in
  - ~~Helps Us Reuse~~
  - ~~Models Parent-Child Relationship~~

- Try to avoid using inerhitance for "reusability"
    - We should mostly inherit from abstract class / interface
        - where there is little to re-use
- What is the role of inheritance or class hierarchy?
    - define  a group of similar entities that can be substituted for each other
    - Allows us to create a design where a component can be replaced with another
        - because requirment changes.
- Inhertiance is a mechanism to implement "polymorphism"

## Polymorphism

- Allows us to create components that implement a common standard (abstract class/inheritance)
- We use the concrete component as an implementation of same common standard
    - We don't code against concrete class but against the abstract idea
        - We have a holder (socket) where we can add a Bulb
            - Bulb is something that can give light
            - Exact implementation technology doesn't matter
                - It can change is future as long as the interface (method signature) doesn't change.
- Super class or interface defines abstract (we know what to do but not how) standard
- Sub class defines the exact implementation details (how)
- While we use the sub class object, we focus on the super class core concept where we plug in different implementation.

# Parent Child Inheritance (Real World)

Wednesday, February 15, 2023 8:41 AM

## Model A

```
class Father{
    …
}

class Son extends Father{
    …
}


Father  aman = new Father(…);


Son ajit =new Son(…);
```

## Model B

```
class Person{
    String name;
    Person father;
}

Person aman = new Person(…);

Person ajit =new Person("Ajit",aman);



//how ajit gets property from aman?

bank.transfer(
      aman.getAccount(),
            amount, password,
      ajit.getAccount()
);

ajit.setDNAFrom(aman);
```

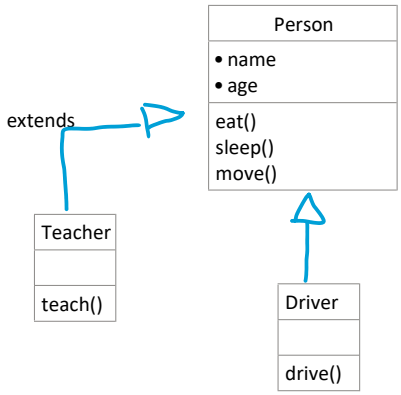
## Quiz: A father has 3 childs and 3 lac Rs in property. How much each child will get (Assume No biase)

## Takeaway

| Real World Inheritance | OOP Inhiertiance |
|---|---|
| Object to Object relationship | Class to Class Relation Ship |
| Both parent child are objects generally of same type<br>• parent or a Dog is a Dog not Mammal | Doesn't represent Parent-Child Relationship<br>Represents Type and Sub Type relationship<br>• Dog extends Mammal to represent Dog is a sub type of Mammal |
| Represented by transferring property from one object to antoher | Information is shared by generic super class to specific sub class to define their behavior |

# Representing Person

Wednesday, February 15, 2023 8:57 AM



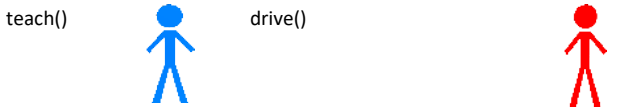

var vivek = new Teacher(); //new ~~Person();~~

var prabhat=new Person();

Is Vivek a teacher or driver?

```
class Vivek extends Person implements
Teacher,Driver{

}
```

```
var vivek=new Vivek();
```

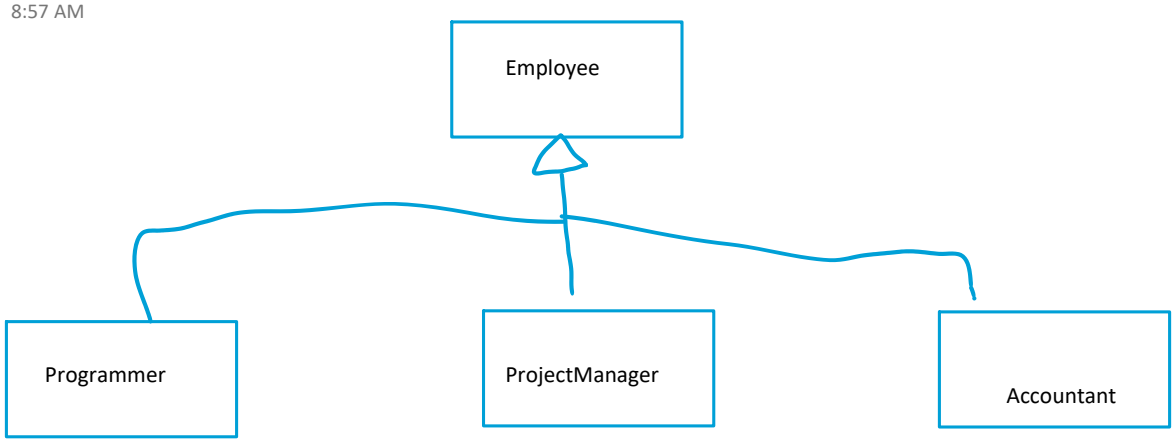



Vivek

Prabhat

# Employee Management System

Wednesday, February 15, 2023 8:57 AM




```
Programmer p=new Programmer("Rajiv Bagga");

//how do I promote the programmer to a project manager

ProjectManager pm=p; //incompatible reference

ProjectManager pm=(ProjectManager)p; //fails
```

# Is A  vs Has A

Wednesday, February 15, 2023  9:15 AM

## Prefer Has A over Is A

- Whenever possible try to model a relationship as "Has A" instead of "Is A"
- Why?
  - Has a is more dynamic, runtime, re-usable and scalable relationship
- Can we really convert "is a type of " to "has a"

```
var rajiv = new ???();

rajiv.setEmployement( …);
```

### Use Case #1:  Rajiv is an Employee

- Can I Convert
  - Rajiv is an Employee to
    - ~~Rajiv Has an Employee~~
      - It becomes a different idea
    - **Rajiv Has an Employement**
      - Often when changing from is a to has you may have rething the naming.
- What is the advantage?
  - if "rajiv" is an employee
    - rajiv is always an employee
      - no retirement
      - no self employement
  - if rajiv has an employeement
    - rajiv.setEmployement(null); //just left the job
    - rajiv.setEmployment(new SelfEmployment());

## Inheritance is a no-scalable relationship

- If Rajiv is an employee he is just "one" instance of employee
  - Not object can be multiple instance of  a class
- If Kent Clark has an employment
  - Can be journalist
  - Can be Superman

```
class _____{

    //Employment employment;
    List<Employement> employments;

}
```

## IMPORTANT

- Many "Is  A" relationship is badly understood has a relationship.
- Anand is a Doctor or
  - Anand has the role of a Doctor
- Anita is a Mother
  - Anita has a relationship of being mother to …
- Vivek is a teacher or a driver?
  - Vivek has the role of a teacher or driver

```
vivek.setRole( teacher);
vivek.work(); //works as teacher

vivek.setRole(driver);
vivek.work(); //works as driver

vivek.setRole(new Author());
```

## Who is Vivek?

- ~~Vivek is a Human?~~
- Vivek has human qualities

- Vivek is a Person

# Object Oriented Design Principles

Wednesday, February 15, 2023 10:49 AM

## 1. Open Close Principle (OCP)

- This can also be considered as the key goal of any software design
- It suggests that design should be
  - **Open for extension**
    - There will be future changes
    - We should create a future proof design that can accommodate
      - new additions
      - modifications
      - removal of old features
    - **Every program is by nature "open" as long as you have the source code**
      - You may convert a Cow to an Airplane if you wish!!!
  - **Close for modification (source level)**
    - When a change comes, it shouldn't be by changing existing source code
    - Every future change should be adding new class rather than modifying the old one.
      - change should additive.
- **Why is important to Close the code for source level changes?**
  - Every change tiggers a cycle of compile-test-deploy-distribute
    - changes are expensive.
  - A change may introduce bugs
  - A change may not be acceptable to every stakeholder
    - changes are not always from version 1 to version 2
    - it may be version A and version B.

OCP

- Open for modification
  - If there is a bug in your code feel free to modify it and correct
- Close for extension
  - Do not add additional features to the code.

## Single Responsibility Principle

- A single responsibility
- One reason to exist
- One reason to change
- Guidelines for Achiving SRP
  1. Use Meaningful name
     - without meaningful name responsibility can't be ascertained
       - Fish Swim —> valid responsibility
       - Fish fly —> invalid responsibility
       - Foo bar —> unclear
     - Avoid names joined with and/or
       - Example
         - class IncomeAndServiceTaxCalculator
         - void createAndSave(){}
         - void insertOrUpdate(){}
     - Avoid using abstract names for concrete class
       - Use Abstract name for abstract class / interfaces
       - More concrete names for concrete classes
         - class TaxCalculator
           - Is it violating SRP?
           - I am still doing IncomeTax calculation and Service Tax calculation
       - TaxCalculator is a generic for an concrete class
  2. You should have fewer behaviors
     - Single Responsibility doesn't mean single behavior
     - But it means a set of co-hesive behavior
     - Example#1 Printer
       - should have
         - print()
         - cancel()
         - ejectPaper()
       - shouldn't have
         - scan()
     - Example#2 Car
       - should have
         - start()
         - move()
         - turn()

        - stop()
    - shouldn't have
        - drive()
            - car's don't drive themselves

3. Cohesive Design
    - Most of your methods should access most of the fields most of the time
    - PrintingDevice
        - fields
            - ink
            - roller
            - scanning surface
        - methods
            - **print()**
            - scan()
            - eject()
            - cancel()

    - avoid mutually exclusive codes in the same class/method
    - avoid parameters that are always null in a given context

## 3. DRY Principle (Don't Repeat Yourself)

- avoid redundant code in your design
- redundat codes are generally violation of SRP
- when the code core functionality changes we need to change at multiple places
- Solution
    1. Encapsulate whatever repeats
    2. Abstract whatever changes (as abstract class/interface)
    3. Inject abstractions in the encapsulated unit

## 4. Interface Segregation Principle

- Avoid FAT interface (interface with too many methods)
- Fat interface => Fat Class => Violation of SRP
- An interface should have only as many methods that every implentor would like to implent
    - avoid optional methods
    - avoid mutually exclusive methods
- Solution
    - Let interfaces with optional method extend interface with core method
    - A class may implement many interfaces

## 5. Liskov's substitution Principle (Definition of Polymorphism)

- A client that can use a super class component can use the sub class component without any problem
- A subclass shouldn't introduce breaking changes
    - If it works for super class, it works for sub class
    - breaking changes may mean a bad class hierarchy
- Advantage
    - When a new changes comes, it can be brought as a sub class
        - open for extension
            - a new class (subclass) introduces the required changes
            - it can override existing methods
        - closed for modification
            - client doesn't not need to change
            - current component (super class) doesn't need to change
    - IMPORTANT!
        - In newer languages including java it is difficult to break LSP
            - In Java a method can be overridden in a more relaxed scope but not restricitive one
                - a protected superclass method can be overriden as public in subclass
                - but a public super class method can't be overriden as protected or private in sub class
                    - If a method exists in super class it exists in sub class. It can't be removed.
            - BUT LSP can still be broken
                - to be discussed later.

## Dependency Inversion Principle

- What is dependency?

    - Knowledge is ownership
        - If you know something you own it.
    - Knowledge is dependency
        - When something that you know (depend) changes, it may change you also.
        - Dependency causes a cascading change
- Dependency Inversion Principle says
    - A concerete class X instead of depending (knowing) another class A should depend on a common abstraction
        - client uses abstraction
        - component impleents abstraction
    - What you depend on should be abstract
- Advantage
    - we can plug in any concrete implmentation
    - we can switch the implementation whenever we wish

| | | |
|---|---|---|
| S | R | P |
| | | |
| O | C | P |
| L | S | P |
| I | S | P |
| D | I | P |

# Car vs SelfDriven Car

Wednesday, February 15, 2023 11:36 AM

## How do I define Car and Self Driven Car?

- Normal cars don't have drive()

```
class Car{

    public void start(){…}

    public void stop(){…}

    public void move(){…}

    public void turn(){…}

}

class SelfDrivenCar extends Car{

    public void drive();
}
```

```
class Car{
    Driver driver;

    public void start(){…}

    public void stop(){…}

    public void move(){…}

    public void turn(){…}

}
```

```
interface Driver{
    void drive();
}

class HumanDriver implements Driver{

}

class RoboDriver implements Driver{

}
```

# Nested Inner and Anonymous Classes

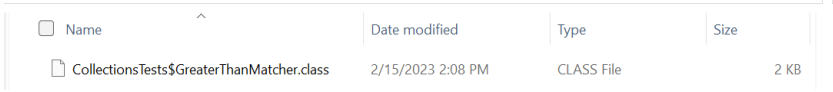
Wednesday, February 15, 2023 2:08 PM

- Sometimes we need a class that will be used by only one class
- It may be for the internal implemention logic
- This class may not be required by others.
- In such cases we can write a class inside another class

```
16 public class CollectionsTests {
17
18     class GreaterThanMatcher implements Matcher<Integer>{
19
20         int threshhold;
21         public GreaterThanMatcher(int threshhold) {
22             this.threshhold=threshhold;
23         }
24         @Override
25         public boolean match(Integer value) {
26
27             return value> threshhold;
28         }
29
30     }
31
32     @Test
33     public void searchCanReturnAllValuesGreaterThan20() {
34         var result = cu.search(numbers,new GreaterThanMatcher(20));
35
36         assertEquals(2, result.size());
37     }
```

## Nested/Inner class still creates a separate class file

- the class file will have a name like
  - OuterClass$InnerClass.class




## Nested vs Inner class

- If a inner class is static it is called Nested class

- If a nested class is static it can be referenced using class reference
- if it is is non-static it can be referred only using Objects

```
class  Outer{

        public class Nested{

        }

        public static class Inner{

        }

}


@Test
public void canCreateInnerObjectFromOutside(){

        var obj= new Outer.Inner();
}

@Test
public void canCreateNestedObjectFromOutside(){

        ~~var obj=new Outer.Nested();~~ //Not  static and not allowed

        var outer=new Outer();

        var nested = new outer.Nested();

}
```

## Anonymous class

- sometimes a class is needed only by a single method
- In such cases we can create a class directly inside the method
- These classes are created as anonymous class
  - They will have no name
  - There will be a single object of this object
  - This object must extend some class or implement some interface

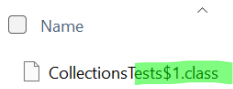
```
public void searchCanReturnAllSavingsAccount() {
    var accounts=createAccounts();

    var matcher=  new Matcher<BankAccount>() {

        public boolean match(BankAccount value) {

            return value instanceof SavingsAccount;
        }
    };

    var result= cu.search(accounts, matcher);
```

## One "new" creates two new Things!

1. create a new class that implements Matcher<BankAccount>
   - This class is never called again
   - It doesn't need a name
2. create a new Object of this matcher class

## Even Anonymous classes are created as separate .class file

```
var result= cd.search(accounts, matcher);
```




## Java 8 Lambda Functions

- Lambda functions are like anonymous class Object
- They works for only interfaces that have a single interface method
- They don't work for
  - abstract class
  - interface with more than one method

## To Find All OdAccount with negative balance

```
//using regular/nested/inner class

class OdAccountNegativeBalanceMatcher implements Matcher<BankAccount>{

    public boolean match(BankAccount account){

        return account instanceof OdAccount && account.getBalance()<0;
    }
}
```

- we have a lot of redundant information
- What is the really important piece of information in this class

```
//using anonymous class
Matcher<BankAccount> matcher = new implements Matcher<BankAccount>{

    public boolean match(BankAccount account){

        return account instanceof OdAccount && account.getBalance()<0;
    }
}
```

## Java 8 lambda intends to simply the anonymous model

- The idea of lambda is to remove those piece that can be inferred based on LHS
- Since we are creating a Matcher<BankAccount> we can understand
  - we want to implement the interface Matcher<BankAccount>
  - we will need "new" object
  - the interface will have a public boolean match method
  - matcher will take a Object of type BankAccount

```
Matcher<BankAccount> matcher = new implements Matcher<BankAccount>{

    public boolean match(BankAccount account) -> {

        return account instanceof OdAccount && account.getBalance()<0;
    }
}
```

simplified form

```
Matcher<BankAccount> matcher =  ( account ) ->{
    return account instanceof OdAccount && account.getBalance()<0;
};
```

## If your lambda expression has a single return statement

- You can remove
  - function block markers
  - return keyword
  - semicolon of return statement
- It becomes a lambda expression

```
Matcher<BankAccount> matcher =  account -> account instanceof OdAccount &&
account.getBalance()<0
```

# Exception Handling

Wednesday, February 15, 2023 2:48 PM

## What is an Exception?

- ~~unexpected situation~~
- ~~not supposed to happen~~
- Undesirable
  - But expected
    - So that we can be ready to handle it
- In programming it is an error situation that should be tackled

## Two parts of exception Handling

1. The Source of Exception
   - The point/object where the error occurs
2. The Handler
   - One who is supposed to handle the problem

- In expcetion handling the two parties are expected to be different and NOT same.

## Three Steps of exception Handling

1. source recongnizes the error condition
   - generally with some if check
   - example
     - if authentication fails
     - if amount<0
     - if amount>balance
2. sending a signal to the handler (informing the handler)
   - What can be a signal
     - generally a invalid value can be returned as signal
       - example returning
         - false
         - null
         - Double.NaN
         - BankingStatus.invalidCredentials
       - settinng a invalid flag
         - isValid()
3. Handling the exeption by the handler
   a. done using a if check again

## An ATM model

ATM
- start()
  - displayMainMenu() **<— we want to handle errors here**
    - displayWithdrawMenu()
      - bank.withdraw()
        - bank.getAccount()
        - BankAccount.withdraw()
          - BankAccount.authenticate() **<— suppose authentication fails here**

## Problem

### 1. We return invalid value for error

- same return statement returns a value and also error
- how do I know if the return is error or valid value?
- what If I don't have any value that can act as signal
  - suppose a function is expected to return int
    - How will it indicate a failure?
- since we can return anything there is no standar value for error
- What if a function doesn't have a return type
  - constructor?
  - how do we indicate error?
- When returning error we often loose the detailed error information
  - example if withdraw fails for insufficient balance we can say insufficientbalance but not how much insufficient
  - in balance transfer we may get the answer invalidaccountnumber but how do we which of the two account was invalid

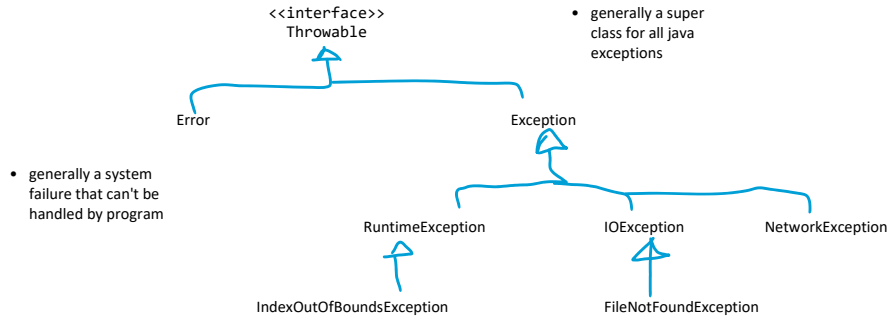
### 2. return can return to immediate caller function

- actual error source and handler may be quite apart in function call chain.
- the source return value to it's caller which returns to its caller and so on
  - autenticate returns to BankAccount.withdraw
  - BankAccount.withdrw returns to Bank.withdraw
  - Bank.withdraw return to atm.withdrawMenu
  - atm.withdrawMenu return to atm.mainManue
- You may have to write same return every where
- bank.withdraw() is neither the source nor target of error
  - it still needs to check if authentication fails I have forward the error

## Object Oreinted Exception Handling

### 1. What is an Exception

- Exception is an Object that inherits Throwable or one of it's sub class
- We can create custom exception by inheriting from any of the given points
- Generally it is recommended to extend RuntimeException or its subclass




- generally a super class for all java exceptions
- generally a system failure that can't be handled by program

## 2. Raising the singal

- source raises the signal by "throwing" and exception object
- Note we don't return, we throw
- Unlike return we don't have to always specify what we throw
- we can return a different type and throw a different type
- When we throw it propagates till somebody handles it
  - intermediates may not have any role to play.

## 3. Handle the exception using try-catch

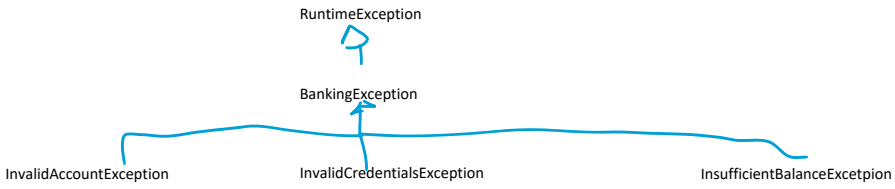
```
try{

    someFunctionThatMayThrow();

    //if you reach here,  no error occured
}catch( ExceptionType1 ex){

    //your each here is try block throws ExceptionType1

}
catch(ExceptionType2 ex2){

    //you reach ehre if try block throws Exception Type 2
    //once you reach here we believe you handled the exception even if you
    did nothing
}
```

### Note

- we don't need try-catch to throw
  - if there is no try-catch exception will reach JVM and it will crash
- try indicates a block that contains a code that may throw exception
  - It indicates our readyness to handle exception
  - A try may be followed by one or more catch blocks
    - each catch block handles an exception of its own type

## We can have User Defined Exception

- We can create our own class that sub classes any existing class in the hierarchy like
  - Exception
  - **RuntimeException**
    - **Recommended**
  - IOException
  - ...
- Because Exception is a class we can include any information in this class
  - Exception in Java can't be generic!!!
  - Example
    - account number
    - deficit balance
- We can create our own exception hierarchy




## Assignment

- Create Exception Hierarchy
- Implement Exception in the banking classes
- Update Unit tests

# Object Oriented Design

Friday, February 17, 2023 8:06 AM

## Object

- Models a domain entity
  - OrganizationManagement
    - Employee
    - Project
    - Department
    - SalarySlip
    - Resource
  - HostpitalManagement
    - Doctor
    - Patient
    - Deparment
    - Treatment
- **A unit of responsibility**
  - We define what responsibility this object has
  - What are the properties Object needs to fulfil its responsibility
  - Helps us create reusable domain objects
- **It should be replacable**
  - when the requirement changes, an object can be replaced with another of same or similar (compatible) type.
  - When a tungsten bulb fuses
    - we can replace it with another
      - tungsten bulb
      - cfl
      - led
      - smart light
      - … (who knows the future)
    - The only criteria
      - It should fit in a similar socket.

## Encapsulation

- process of creating a unit of responsibility
- It defines an object model by
  - binding it's state and behavior together to create a working and reliable model
  - we may use scope rules or convention to prevent access to private components
  - **The idea is to define how state and behaviors are interconnected.**

## Polymorphism

- different objects
- behave differently (internal implementation)
  - how is encapsulated
- in the same context (external usage)
  - is external functionality or interface

- Polymorphism is achieved using Inheritance/interface

## Inheritance/Interface

- They allow us to create class hierarchy
- Is a type of relationship
- Objects of same hierarchy should be polymorphically compatible to each other
  - similar to each other
- Is a tool to achieve polymorphic design.

## Class

- class —> classification
  - A description for the object
  - and its hierarchy

## How how static polymorphism or compile time polymorphism.

- this kind of polymorphism is achieved using method overloading.
  - creating different methods with same name and different parameters
    - parameters may differ in
      - number
      - type

### Is it really polymorphism?

- conceptually two overloaded methods are as different as two methods with different names
- It is just a convinience in some basic cases.
- compiler invokes the right version by looking at the exact arguments
- It it fails to detect the argument, it will result in compile time error.

```
class ParkerPen{

    public void use(Hand hand){
        return "writing";
    }

    public void use(Pocket pocket){
        return "status";
    }
```

### Aside — How c++ translated overloading to C?

```
//C++ code
int divide(int a, int b){

}

double divide(double a, double b){

}


//translated to C by name decoration/mangling

int divide_int_int(int a, int b){

}

double divide_double_double(double a, double b){
```

```
    public void use(Pocket pocket){
        return "status";
    }

}

Object getHandOrPocket(int type){
    //returned at runtime
    if(type==0)
        return new Hand();
    else
        return new Pocket();
}
```

```
@Test
public void testInPocket(){

    Object obj = getHandOrPocket(1);

    var pen=new ParkerPen();

    var result = pen.use(obj);

    assertEquals("status", result);

}
```

will this pass or fail?

- neither.
- compiler fails

Error: no overload of use accepts Object type

- overloading works on reference and NOT on actual object
- It is compile time and NOT runtime.

```
@Test
public void testInPocketCorrectWork(){

    Object obj = getHandOrPocket(1);

    var pen=new ParkerPen();
    String result="";

    if(obj instanceof Pocket)
        result = pen.use((Pocket) obj);
    else
        result = pen.use((Hand) obj);

    assertEquals("status", result);


}
```

- These are two different sockets
  - one for pocket
  - one for hand
- hand and pocket can't be polymorphic substitute for each other.

## Problem with Overloading

- An overloaded set of methods belongs to same object
  - The object can't replace itself.
- violates Open Close Principle
  - If you have three overloads today, you may have a fourth one tomorrow
  - Adding next overload will force to break OCP.
- violates Single Responsibility Principle
  - each overload represents a different responsibility
  - More responsible you are more likely to change in future

## Assignment —> create the parker pen model with hand and pocket using true polymorphism (override)

- HINT: ParkerPen should have a single use method

```
interface PenConnect{

    String penUse();
}


class ParkerPen {

    public void use(PenConnect connect){
        String connect.penUse();
    }
```

```
PenConnect getHandOrPocket(int type){

    if(type==0)
        return new Hand();
    else
        return new Pocket();

}
```

```
                `
    public void use(PenConnect connect){
        String connect.penUse();
    }
}


class Hand implements PenConnect{

    public String penUse(){ return "write"; }
}

class Pocket implements PenConnect{

    public String penUse(){ return "status"; }
}
```

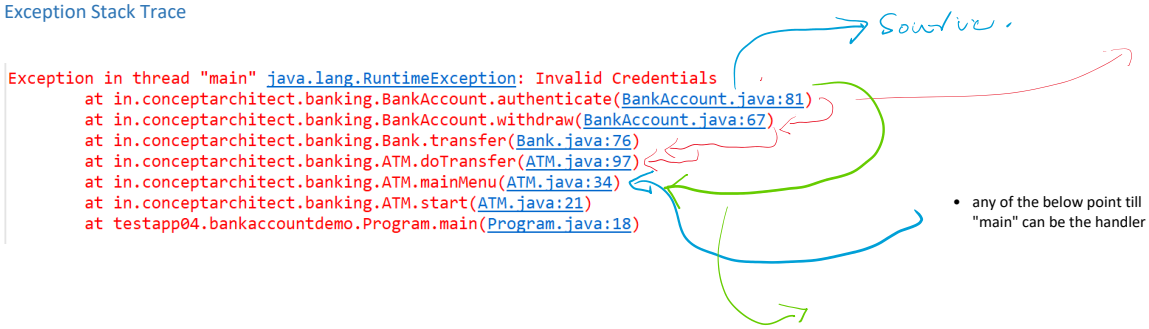
```
    else
        return new Pocket();

}

@Test
public void testInPocket(){

    PenConnect c = getHandOrPocket(1);
    ParkerPen pen=new ParkerPen();

    var result= pen.use(c);

    assertEquals("status", result);

}
```

# Exception Part 2

Friday, February 17, 2023 10:52 AM

## Exception Stack Trace

```
Exception in thread "main" java.lang.RuntimeException: Invalid Credentials
        at in.conceptarchitect.banking.BankAccount.authenticate(BankAccount.java:81)
        at in.conceptarchitect.banking.BankAccount.withdraw(BankAccount.java:67)
        at in.conceptarchitect.banking.Bank.transfer(Bank.java:76)
        at in.conceptarchitect.banking.ATM.doTransfer(ATM.java:97)
        at in.conceptarchitect.banking.ATM.mainMenu(ATM.java:34)
        at in.conceptarchitect.banking.ATM.start(ATM.java:21)
        at testapp04.bankaccountdemo.Program.main(Program.java:18)
```



- any of the below point till "main" can be the handler

- How return works
  - at each intermediate function we need to check for error and return
  - sometimes we need to convert error from one type to another based on return type of intermediate function

Exception automatically proapagates

- from point of origin (source) till someone catches it
- if no one catches it
  - It reaches JVM
  - JVM displays the stack trace message (above)
  - JVM terminates the current thread

## To Handle This exception

- we can write a try-catch around any desired point in the stack trace.
- We have chosen the main menu.

## User defined Exceptions for Specific Business Cases

```
2
3 public class InvalidCredentialsException extends RuntimeException {
4
5     public InvalidCredentialsException() {
6         super("Invalid Credentials");
7     }
8 }
9
```

## Handling specific and generic Exceptions

- for a single try block you can have multiple catch
- catch block can be written in any order if they are not class and sub class
- In case you want to catch both super class and sub class exceptions you must first handle specific (sub class exception) and then superclass.

*

```
}catch(RuntimeException ex) {
    System.out.println("Error:"+ex.getMessage());
}catch(InvalidCredentialsException ex) {
    Sys
    pas
}

System.
while(choi
```

Unreachable catch block for InvalidCredentialsException. It is already handled by the catch block for RuntimeException

2 quick fixes available:

Remove catch clause

Replace catch clause with throws

- The correct approach is

## Exception Hierarchy

- We can have our own exception hierarcy

- RuntimeException
  - BankingException (should include account number as details)
    - InvalidCredentialsException (should include consequitive wrong attempts <— assignment)
    - InvalidAmountException
    - InvalidAccountException
    - InsufficientBalanceException (should include deficit)

```
public class BankingException extends RuntimeException{

    int accountNumber;


    public int getAccountNumber() {
        return accountNumber;
    }

    public BankingException(int accountNumber) {
        this(accountNumber,"Banking Exception");
        // TODO Auto-generated constructor stub
    }
```

## Unit Testing Exception

- there can be different approaches

### Option #1. Write a try-catch (Manual Process)

```
@Test
public void withdrawShouldFailForNegativeAmount() {
    try{
        account.withdraw(-1, password);
        fail("Excepted InvalidDenominationException wasn't thrown");

    }catch(InvalidDenominationException ex) {

    }

}
```

Note

- We expect exception should be thrown
- You fail when exception is not thrown
  - we indicate this by writing fail in try block
- we may also assert against exception message in catch block

### Option#2 Add exepected property to @Test annotation

```
@Test(expected = InvalidCredentialsException.class)
public void withdrawShouldFailForInvalidPassword() {

    account.withdraw(1, "invalid password");

}
```

- Here test passes if expected exception is thrown
- Test fails if
  - no exception is thrown
  - some other exception is thrown

### Option #3  Use assertThrows function

- Assert Throws function takes and Runnable interface

```
interface Runnable{

    void run();

}
```

- Now we can write the actual code we want to run inside execute function and pass to assertThrows
- If expected exception was thrown from execute the test will pass else fail

- This syntax works best with Lambda function
- we can write our logic as

```
assertThrows ( () ->{

    //my logic here

});
```

```
@Test
public void withdrawShouldFailForInsufficientBalance() {

    assertThrows(InsufficientBalanceException.class, ()->{

        //your code here
        account.withdraw(amount+1, password);
    });

}
```

#### Advantage

- assertThrows **returns** the exception object if expected exception was thrown
  - Note the method catches and returns the object. It doesn't throw
- Now we can write asserts against exception properties

```java
@Test
public void withdrawShouldFailForInsufficientBalance() {

    var ex= assertThrows(InsufficientBalanceException.class, ()->{
        //your code here
        account.withdraw(amount+1, password);
    });

    //you can also validate agains exception properties
    assertEquals(5001, ex.getDefict(),0.0);

}
```

## finally block

- each try block can be followed by 0 or more catch block and 0 or 1 finally block
- A try must have atleast one catch or one finally following it
- finally if present must be the last block after all catch

```
try{

}catch(Ex1 ex1){

}catch(Ex2 ex2){

}finally{

}
```

or

```
try{
}catch(Ex1 ex){

}
```

or

```
try{

}finally{


}
```

### Not Allowed is

```
try{


}
```

## Why finally

- in a method with a try and catch block we can't be sure if
  1. whole try block will execute
     - we may get exception
  2. catch block will execute
     - we may not get exception
     - we may get some other not matching exception
  3. code after try-catch
     - you may get an exception for which catch block is not present

- if we need to ensure that some code (Generally cleanup code) must execute in all situations we put them in finally block

- A finally block executes
  1. In case of no exception —> soon after try block
     - try —> finally —> rest of the code —> exit from method with return
  2. In case of an exception that is caught
     - it jumpts out of try,
     - executes catch
     - executes finally after catch
     - executes rest of the code
     - try —> catch —> finally —> rest of the code —> exit from method with return
  3. In case an exception is thrown but not caught
     - runs finally and then exits method with throw
     - try —> finally —> exit from method with throw

- finally is generally used for cleanup
  - close and open
    - file
    - connection

## Checked vs Unchecked Exception

- Java supports two model of Exception Handling

## Checked Exceptions

- All exceptions that are inherited from Exception super class except those inherited from RuntimeException
- For all checked exception Java compiler verifies if you have written a try-catch for it or not
  - This is to ensure that you have handled the exception
- Any method that may throw an exception must do one of these two things
  1. write and try-catch
  2. declares 'throws' on the method signature
- Now any method that calls a method that 'throws' must again do the same thing.

```
public void authenticate(String password) {
    Encrypt en=new Encrypt();
    if(!this.password.equals(en.encrypt(password)))
        //throw new RuntimeException("Invalid Credentials");
        throw new InvalidCredentialsException(accountNumber);
}

public void change                                    ewPassword) {
    authenticate(o
```

Unhandled exception type InvalidCredentialsException
1 quick fix available:
Add throws declaration

```
public void withdraw(double amount,String password) {

    authenticate(password);
    balance-=amount;

}
```

Unhandled exception type InvalidCredentialsException
2 quick fixes available:
Add throws declaration
Surround with try/catch

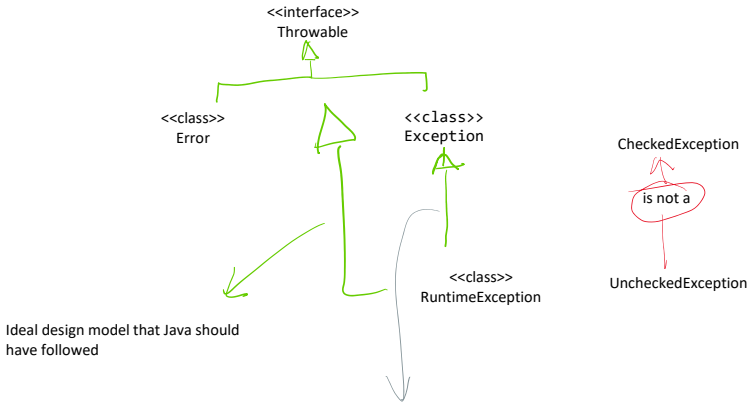
```
ption(accountNumber, amount-max);
```

```
public void authenticate(String password) throws InvalidCredentialsException {
    Encrypt en=new Encrypt();
    if(!this.password.equals(en.encrypt(password)))
        //throw new RuntimeException("Invalid Credentials");
        throw new InvalidCredentialsException(accountNumber);

}
```

- indicates that this method may throw an exception that it doesn't catch
- This is like a "return" spec
- Any method that calls this again can either
  - provide try-catch
  - declare throws itself

## Unchecked Exception

- those exceptions that are inherited from RuntimeException
- No throws clause is needed.
- Modern best practices guidelines strongly recommend to use Unchecked exceptions only
- Avoid using checked exceptions.




Ideal design model that Java should have followed

- Actual relationship implemented in Java
- Flawed as it is not a "is a type of " relationship

## Converting Checked Exception to Unchecked Exception

- Checked exceptions are now considered as an anti-pattern.
- We should avoid creating new checked exceptions.
- But what to do with existing checked exceptions like InterruptedException or IOException or SQLException
  - Java initially created many checked exception

### Solution

1. Create a unchecked exception to replace the checked exception. You may include original exception as cause

```
class ThreadInterruptedException extends RuntimeException{
    Thread thread;
    public ThreadInterruptedException( Exception cause){
        thread=Thread.currentThread();
        super(cause);
    }

}
```

- We can replace Thread.sleep function with our own version of Sleep
  - Thread.sleep throws InterruptedException which is checked.
  - Our sleep will catch InterruptedException and throw the new Exception

```
class ThreadUtils{

    public static void sleep( int millisecond){
        try{
            Thread.sleep(millisecond);
        } catch(InterruptedException ex){

            throw new ThreadInterruptedException(ex);
        }
    }

}
```

Now if client is sure this exception will not occur, they may ignore it without a try or throws

```
void clientThatKnowsNoExceptionWillBeThrown(){

    try{
        Thread.sleep(2000);
    }catch(InterruptedException ex){
        //will never reach here
    }

    ThreadUtils.sleep(2000);

}
```

If client actually has a need of catching the exception it is still easy

```
void clientThatNeedsToCatchException(){

    try{
        ThreadUtils.sleep(2000);

    }catch(ThreadInterruptedException ex){
        //if you need the original expception
        var original = ex.getCause();

    }


}
```

## Should I always handle exception or may return a sensible default

- If we except an error and we have a sensible default for those scenario, we can write code accrodingly

```
    public String readString(String prompt) {
        try {
            System.out.print(prompt);
            return reader.readLine();
        }catch(IOException ex) {
            return "";
        }
    }
```

- Many standard Libraries provide two variants of a function
  - One that throws error on invalid value
  - One that may return a sensible default on invalid value
    - generally these methods have "try" prefix
    - example
      - tryConvert
        - if conversion fails return a null

```
class DateUtils{

    public static Date tryParse(String value){

        try{

            return Date.parse(value);
        } catch(Exception ex){
            return new Date(); //today's date
        }

    }
}
```

# Multi-threading

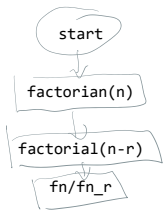
Friday, February 17, 2023 1:50 PM

```
int permutation(int n, int r){

    int fn = factorian(n);
    int fn_r=factorian(n-r);

    return fn/fn_r;

}
```

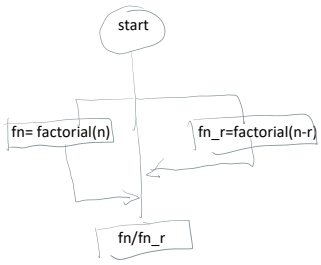
Why have we calculated factorial(n) before calculating factorian(n-r)?

- we have to do something first
- why?
  - because we can do only one thing at a time.

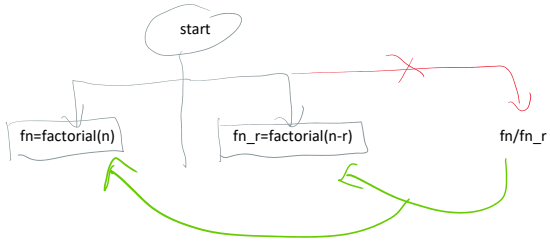
## Current Model




## Expected Model




## Not everything can be independent




calculation depends on completion of the other two calculations.

- Each limb can be independent of each other
- If they can be independent few can be parallel/concurrent also

- Although the threads are independent, they are part of the same puppet
  - we need to synchronize their working failing which puppet may break.

## How to work with multithreading (puppets) in Java

### Puppet Show

### Thread (Gray)

- controller for a portion of puppet (limb)
- makes a limb move or stop.

### Limb That is being controlled (Green)

- A portion of the puppet that should work independently
- It could be anything based on current puppet show
  - hand of aperson
  - wing of a bird
  - sword of a warrior
  - ...

### Java or any other proramming language

### class java.lang.Thread

- controls portion of a program (sub task)
- starts or stops the working of a sub task

### interface java.lang.Runnable

```
interface Runnable{
    void run();
}
```

### Why interface?

- It represents a **user defined logic** that should run independendly.
- Remember, as athread controller we don't know what we are controlling. It could be different logic like
  - wings of brid

- sword of warrior

## 1. Every application is either multi-threaded or single-threaded.

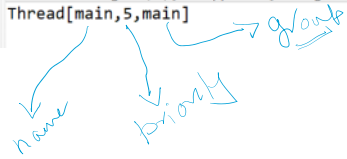
- there is no un-threaded application
- every application we wrote so far had a thread which was running main function
- We can check out this thread's details.

BankingException.java | BankAccount.java | Program.java

```
1  package testmt01.mainthread.app;
2
3  public class Program {
4
5      public static void main(String[] args) {
6
7          Thread currentThread = Thread.currentThread();
8
9          System.out.println(currentThread);
10
11     }
12
13 }
14
```

Console

```
<terminated> Program (11) [Java Application] C:\Program Files\Java\jdk-15\bin\javaw.exe  (Feb 17,
Thread[main,5,main]
```




### Thread elements

- Name
  - just for identification
- Group
  - to group several threads together
  - not much used
- prioritiy
  - How important it is
  - varies in range 1-10 (highest)
  - default is 5
  - we can change these values

# Creating New user defined thread

Friday, February 17, 2023 2:24 PM

- A thread is a controller for a Runnable
- There are couple of different ways we can create a thread

## Approach #1 Create Runnable class

Step #1 : Create a class that implements Runnable

- The run() method will include the thread logic

Step #2 : Create the thread object and pass runnable object as argument

- Now the thread knows what to run when asked.
- Thread will not automatically start

Step #3:

- Start the thread by calling thread.start()

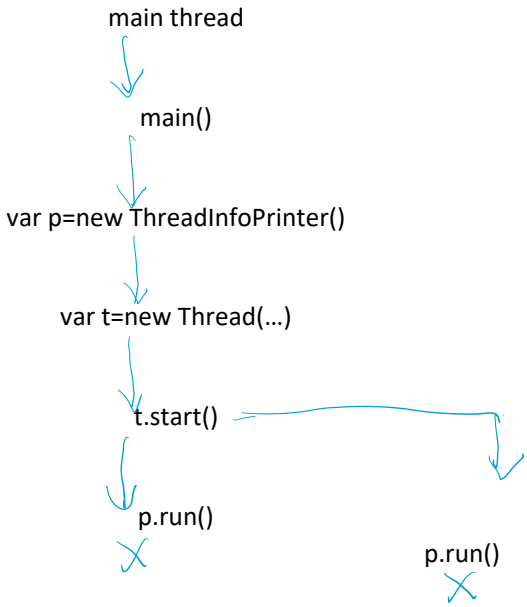
```
//Step #1
var printer=new ThreadInfoPrinter(); //this may run on a new thread

//Step #2
var userThread= new Thread(printer); //connect logic to a new thread

//Step#3
userThread.start(); //start the new thread and calls printer.run()

//printer is an ordinary object. It can be used even without new thread
printer.run(); //runs on the current thread printer.run()
```

```
Thread[main,5,main] has id 1
Thread[Thread-0,5,main] has id 14
```

```
Thread[Thread-0,5,main] has id 14
Thread[main,5,main] has id 1
```

## The Flow

main thread




## Why second thread has id 14 and not 2?

- JVM runs several threads internally to manage the runtime
- Example
  - It runs garbage collector behind the scene
- It doesn't mean there are 13 threads in use.
  - Few threads are just reserved.

# Creating Thread Alternative Models

Friday, February 17, 2023 2:40 PM

## Approach #2 Extend Thread

- java.lang.Thread itself implements Runnable
- You may create a new class that extends Thread
- @Override the run()

### Implements Runnable

Program.java | CountDownTask.java

```
public class CountDownTask implements Runnable {

    @Override
    public void run() {
        int max=100;
        System.out.printf("Thread %d  starts\n",Thread.currentTh

        while(max>=0) {
            System.out.printf("Thread %d  counts %d\n",Thread.cu
            max--;
        }

        System.out.printf("Thread %d  stops\n",Thread.currentThr

    }
```

### Extends Thread

*CountDownThread.java

```
package testmt01.mainthread.app;

public class CountDownThread extends Thread {

    @Override
    public void run() {
        int max=100;
        System.out.printf("Thread %d  starts\n",Thread.currentTh

        while(max>=0) {
            System.out.printf("Thread %d  counts %d\n",Thread.cu
            max--;
        }

        System.out.printf("Thread %d  stops\n",Thread.currentThr
```

Program.java | CountDownTask.java

```
    public static void main(String[] args) {

        //Step #1
        var c1=new CountDownTask(); //this may run on a new thre
        var c2=new CountDownTask();
        var c3=new CountDownTask();

        //Step #2
        var t1= new Thread(c1); //connect logic to a new thread
        var t2=new Thread(c2);
        var t3=new Thread(c3);

        //step#3
        t1.start();
        t2.start();
        t3.start();
```

*CountDownThread.java | *Program.java

```
    public static void main(String[] args) {

        //Step #1
        var t1=new CountDownThread(); //this may run on a new t
        var t2=new CountDownThread();
        var t3=new CountDownThread();


        //step#3
        t1.start();
        t2.start();
        t3.start();


    }
```

```
class Thread  implements Runnable{
        Runnable runnable;
        public Thread(Runnable r){
                this.runnable=r;
        }
        public Thread(){
                runnable=this;
        }
        public void run(){}
        public void start(){
                //starts new os thread
                runnable.run()
        }

}
```

```
interface Runnable{

        void run();
}
```

## Approach #3  Use Lambda function to implement runnable

```
public static void main(String[] args) {


    var t1= new Thread(()->countDown()); //connect logic to a new thread
    var t2=new Thread(()->countDown());
    var t3=new Thread(()->countDown());

    //step#3
    t1.start();
    t2.start();
    t3.start();

    System.out.println("end of program");

}

static void countDown() {
    int max=100;
    System.out.printf("Thread %d  starts\n",Thread.currentThread().getId());

    while(max>=0) {
        System.out.printf("Thread %d  counts %d\n",Thread.currentThread().getI
        max--;
    }

    System.out.printf("Thread %d  stops\n",Thread.currentThread().getId());
}
```

```
class _______ implements Runnable{

        public void run(){
                countDown();
        }
}
```

# How to pass parameter to a thread?

Friday, February 17, 2023 3:04 PM

- I may not always want to countdown from 10 or 100
- How do I pass parameter to CountDown Task
- Remember, run function can't take a parameter

## When Implementing interface or extending class

```
class CountDownTask implements Runnable{
     int max;
     public CountDownTask(int max){
          this.max=max;
     }

     public void run(){
          int max=10;
          while(max>=0){
               …
          }

     }

}


public static void main(String []args){

     var t1=new Thread( new CountDownTask(20));
     var t2 =new Thread( new CountDownTask(30));

     t1.start();
     t2.start();
}
```

## When Using Lambda Function

```
static void countDown(int max){
     int max=10;
     while(max>=0){
          …
     }
}


public static void main(String[]args){

     var t1= new Thread( () -> countDown(20));
     var t2= new Thread( () -> countDown(30));

     t1.start();
     t2.start();

}
```

# Java Thread Model

Friday, February 17, 2023 3:12 PM

- In java application doesn't end when main() method ends
- main() method ends only main thread
- by default java application keeps running till at least one thread is running
- Ideally main thread should end after the child threads
    - if it ends before garbage collector may end up collecting theother thread memory
    - there is no one to control the child threads if we need.

## How do I make main wait….

### Approach #1 Let main do something even longer…

# Reflection

Monday, February 20, 2023 8:31 AM

- Reflection is a library that helps you understand and utilize program structure dynamically.

```
class Employee{

    String employeeId;
    String name;
    Department department;
    Designation designation;
    Salary salary;

    public void work(){

    }
}
```

```
class Circle{

    double radius;

    public double getPerimeter(){…}

    public double getArea(){…}

}
```

## If everything is an object, is "class" too an object?

- Assume I have an object that represents a class like Circle

```
var cls ; //assume it to be a class object
```

- what are the properties of this object

```
class Class{

    String name;

    Method[] methods;
    Cosntructor[] constructors;
    Field [] fields;

    Class superClass;
    Class []interfaces;
    int scopes; //public,privates,abstract,final

}
```

## But you can create an object of a class by calling new Class()

- We can't create an object of a class by creating

```
var c= new Class();
```

- This syntax can't create  a class. The right way to create a class is creating the source file

```
class Employee{

    String employeeId;
    String name;
    Department department;
    Designation designation;
    Salary salary;

    public void work(){

    }
    …
}
```

## Everytime we create a class or an interface (or enum) java internally creates a 'Class' object for this class

- This object is pre-created
- There will be a single object created per Class

## How to access this "Class" object

### Option#1. If you can refer to the actual class

```
Class c1 =  Employee.class;  //gives access to the class object associated with Class
```

### Option #2. If you have an access to any object of that class

```
Employee emp1 =new Employee(…);

Employee emp2 = new Employee(…);


Class c2 = emp1.getClass();

Class c3= emp2.getClass();
```

### Option #3  If you know the class name (package qualified class name)

```
Class c4 = Class.forName( "in.conceptarchitect.ems.Employee");
```

### important note

- all the references c1,c2,c3,c4 are referin to exact same instance of Class.
    - They are not creating new instance
- They will have the same hashCode

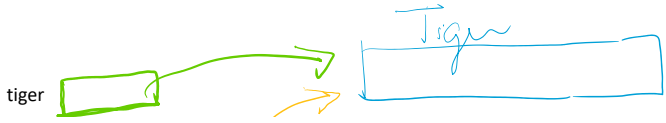
## What is the purpose of 'Class' class?

- Using 'Class' class helps us
    - get meta information about all the methods, fileds and constructors present in a Class
    - This may help is creating dynamic documentation about the class.

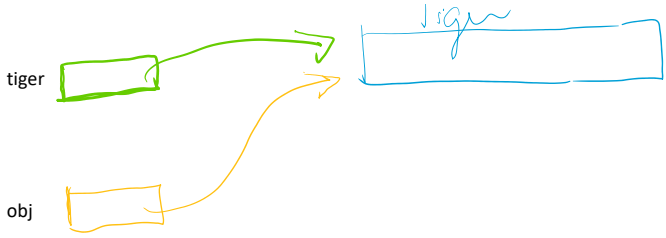
- The Class also has a method called newInstance(), which can create an object of the current class using the default constructor.

- Class contains a list of constructors.
    - each constructor is an object of type Constructor
    - we can use parameterized cosntructor and call it's newInstance() method to create object using non-default constructor

- Class contains a list of methods
    - each method is an object of the Method
    - The object includes
        - name of the method
        - return type
        - parameters
        - scope
    - invoke
        - You can also invoke the method at runtime calling the method
- Class contains a list of fields
    - each field is of type Field
    - The object includes
        - name of field
        - type of field
        - scope
    - can be used to
        - get current value of the field
        - set new value in the field.



```
Tiger tiger =new Tiger();


Object obj= tiger;


obj = "Hello";
…

tiger.hunt() ; //works

obj.hunt(); //fails
```




## IMPORTANT CONCERN!!!

- obj refers to actual Tiger object
- Tiger object has "hunt" method
- Why can't obj access hunt() method that actually exists on the object?
  - compiler is not sure if obj reference actaully a Tiger
    - It plays safe and rejects those codes that may fail in future.

### Why Can't we decide it at runtime?

- we can check if a method exist in the current object or not using Reflection
- Then we can invoke the method at runtime using Reflection.

```
@Test
public void aTigerCanHuntEvenWithObjectReferece() throws NoSuchMethodException, SecurityException,
                                                         IllegalAccessException, IllegalArgumentException,
                                                         InvocationTargetException, ClassNotFoundException,
                                                         InstantiationException {

    //Get class reference
    Class cls = Class.forName("in.conceptarchitect.animals.mammals.Tiger");


    //Object obj=cls.newInstance();

    Object obj = cls.getConstructor().newInstance();


    //var result= obj.hunt();

    //get the hunt method of the object
    //if not found will throw NoSuchMethodException
    Method hunt = obj.getClass().getMethod("hunt");

    //invoke the method to get the result

    var result = hunt.invoke(obj);

    assertEquals("Tiger hunts in jungle", result);

}
```

- we can get the class information from a string that may come from user input
  - compiler may not be aware of this class
- If we have a class, we can create the object of that class using constructor
  - getConstructor()
    - takes parameter types
  - getConstructors()
    - get an array of all constructors
- we can get a access to the method of the class using
  - getMethod()
    - takes method name and required parameter types
  - or getMethods()
    - get an array of all the methods
- We can invoke the method by passing
  - obj that should invoke it
    - obj.hunt()
    - hunt.invoke(obj)
  - if hunt takes parameters they should come after obj

## Annotation

- annotations are some meta information that can be associated with a
  - class
  - method
  - field
  - parameter
  - …
- annotation generally work as a flag to mark some element for a special purpose
  - you can think of them as Marker interface

    - Here we have conceptual translation from marker interface to an annotation
        - **NOTE: It will not work this way**
    - **dd**
- An  annotation can also include some additional information like
    - `@Test(expected=RuntimeException.class)`

## How to create an annotation

- Annotation is introduced late in Java (6+)
- They reused the keyword "interface" with "@" prefix to define an annotation
    - It's more a patch than an interface.

```
@interface Pet{

}
```

- Now we can write

```
@Pet
class Dog {

}
```

## How does annotation work?

- annotation doesn't WORK on it's own
- It's like a book sitting aroud.
    - it doesn't work on it's own
- someone need to open the book and read it
    - annotations are read and used using "reflection"

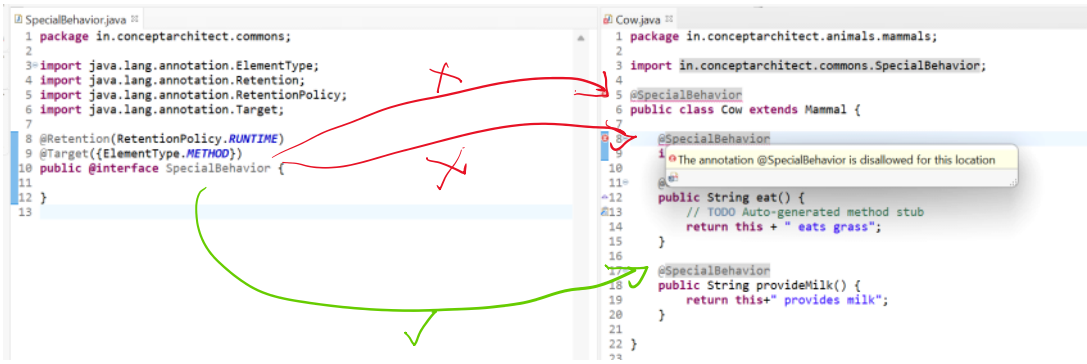
## Use Case

- Every animal may have some special behaviors that can make it unique
    - Tiger —> hunt()
    - Horse —> ride()
    - Parrot —> humanSpeak()
    - Dog —> humanCompanion()
    - Cow —> provideMilk

- How do I represent these sepcial behaviors in programming?
    - No single interface can cover it all.
    - an animal may have more than one speciality.

## Solution#1

- Let us create an annotation called @SpecialBehavior
- Let us tell java compiler that this annotation should be
    - avaiailable at runtime
    - applicable only on methods



- Now we have applied the annotation to selected methods
- **But By default it does nothing.**
    - **It must be checked and acted upon by some method**

- **If we don't have a method that uses annotation it is as good as some comment lying around**

```
public static List<Method> findSpecialBehavior(Object obj) {
    // TODO Auto-generated method stub
    List<Method> methods= new ArrayList<>();

    var cls= obj.getClass();

    for(var method : cls.getMethods()) {

        if(method.isAnnotationPresent(SpecialBehavior.class))
            methods.add(method);

    }


    return methods;
}
```

## What if An animal can have a single @Speciality

- we can't prevent user from adding same annotation to multiple methods within the same class
- But we may create a design where
    1. we can apply annotation to class rather than method
    2. Pass the method name as a prameter to the annotation

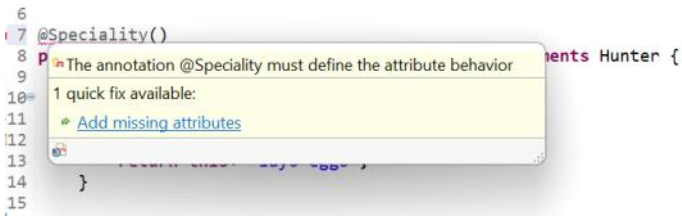
### How to add information to annotations?

- annotations are @interfaces
- interfaces can't have non-final field
- so we attach a property to annotation as a method
    - it looks like a method
    - but it acts like a field
- annotation is patchy design!!!

SpecialBehavior.java | ReflectionTests.java | Animal.java | Speciality.java

```
1  package in.conceptarchitect.commons;
2
3  import static java.lang.annotation.ElementType.TYPE;
8
9  @Retention(RUNTIME)
10 @Target(TYPE)
11 public @interface Speciality {
12
13     //this is treated as a field
14     //it is passed as a named parameter to Speciality annotation
15     public String behavior();
16
17 }
18
```

- Now we must pass the behavior property in annotation or give a default




```
@Speciality(behavior = "humanSpeak")
public class Parrot extends Bird implements Pet{

```

- Note we can also have defaults for a property

```
public static Object invokeSpeciality(Object object, Object...params) {
    // TODO Auto-generated method stub
    var cls=object.getClass();
    var speciality= cls.getAnnotation(Speciality.class);

    if(speciality==null)
        throw new MethodInvocationException(cls.getSimpleName()+" has no speciality");

    var behaviorName=speciality.behavior(); //note invoked like method

    Method method=null;
    for(var m : cls.getMethods()) {
        if(m.getName().equals(behaviorName)) {
            method=m;
            break;
        }

    }

    if(method!=null) {
        try {
            return method.invoke(object, params);
        } catch (IllegalAccessException | IllegalArgumentException | InvocationTargetException e) {
            // TODO Auto-generated catch block
            throw new MethodInvocationException( e.getMessage(),e);
        }
    } else {
        throw new MethodInvocationException(cls.getSimpleName()+" has no speciality "+behaviorName,
                new NoSuchMethodException(behaviorName));
    }
```

# Assignment

Monday, February 20, 2023 11:13 AM

## Create your own Unit Testing Framework

- The framework will run on Console

- Your test case file should resemble the standard test files
  - @Test
  - @Ignore
  - @Before

- you should run the test in the given way

```
public static void main(String []args){

    TestRunner runner= new TestRunner();


    var result = runner.run( MyTest.class);

    result.print();

}
```

//The Test results should be displayed on console using System.out.println AND not in eclipse Test explorer.

```
class MyTest{

    @Before()
    public void setup(){

    }

    @Test
    public void test1(){
        assertEquals(2,3);
    }

    @Ignore @Test
    public void test2(){
        fail("This should be ingored");
    }

    @Test
    public void test3(){

        throw new RuntimeException("This should result in error");
    }

    @Test
    public void test4(){

        assertThrows( RuntimeException.class, ()-> throw new
        RuntimeException("This should pass"));
    }

}
```

# Interfaces and Lambdas

Wednesday, February 22, 2023 8:04 AM

```
interface  IAction{

    void start(Configuratin config, bool throwException);
    void end();
}
```

```
//implementation option #1 --> named class

class MyAction1 implements IAction{

    @Override public void start(Configuratin config, bool throwException){…}

    @Override public void end(){…}
}


//implementation option #2 --> anonymous class (can be done only inside a
method)


var  action2 = new IAction(){

    @Override public void start(Configuratin config, bool throwException){…}

    @Override public void end(){…}

}
```

## Lambdas work only with Functional interface

- A Functional interface is an interface that has single abstract method
- It may be optionally decorated with @FunctionalInterface annotation
  - introduced in java 8
  - if applied and you add more than one method you get compile time error

```
@FunctionalInterface
interface  ICommand{

    void execute(Configuratin config, bool throwException);

}
```

## Implementing the Interface

```
class MyCommand1 implements ICommand{

    @Override public void execute(Configuratin config, bool
    throwException){…}

}
var command1=new MyCommand1();


//implementation option #2 --> anonymous class (can be done only inside a
method)
```

- The following code does two things
  1. Create a class (no name) that implements Iaction
  2. create an object of that class

```
var  command2 = new ICommand(){

    @Override public void start(Configuratin config, bool throwException)
    {…}

}


//Implementation Option #3 —> Lambda Function

ICommand command3 = (c,t) -> { …}
```

- looks like we are just implementing a function that takes config and throwException and does something
- Actually this function has a name "execute" and is part of a class that implements Icommand
- How does it know it implements ICommand?
  - because we assign the lambda to Icommand
  - We can't assign it to "var" as it will fail to detect the method name of signature

```
var result = command3.execute( new Configuration(), false);
```

## A lambda knows the signature best on where it is assigned

- assigned to a reference
- passed as method parameter
- Same lambda may actually mean different interfaces based on context

```
interface Command{

    void execute();
}
```

```
interface Runnable{

    void run();
}
```

- For the implementation of the two interfaces using regular or anonymous classes it will be different
  - You need to implement different classes
  - You need to implement different method

- But for lambda it is going to be same

```
Command print = () -> System.out.println("Hello World");
```

- () -> System.out.println("Hello World") represents execute method

```
Runnable print = () -> System.out.println("Hello World");
```

- () -> System.out.println("Hello World"); represents run method

## Function Reference Syntax.

- sometimes we may already have a function that has same signature as

# Simple Calculator

Wednesday, February 22, 2023 8:32 AM

```
class SimpleCalculator{


    public int printAndReturn(int x, String opr, int y){

        int result;
        switch(opr){
            case "+": result=x+y; break;
            case "-": result=x+y; break;
            case "*": result=x+y; break;
            case "/": result=x+y; break;
            default: throw new InvalidArumentException("Unsupported operator :"+opr);
        }

        System.out.println(result);
        return result;

    }

}
```

```
var calc=new SimpleCalculator();

calc.printAndReturn(5,"+", 10);

calc.printAndReturns(20,"/",3);

calc.printAndReturn(50, "%",4);
```

# Simple Lambda Example

Wednesday, February 22, 2023 8:22 AM

```
interface BinaryOperator{

    double calculate(double x,double y);

}

class Calculator{

    public double printAndReturn(double value1, BinaryOperator opr, double value2){

        var result= opr.calculate(value1,value2);

        System.out.println(result);

        return result;

    }

}


class CalculatorTests{

int x=50;
int y=15;
Calculator calc=new Calculator();

@Test
public void canWorkWithPlusOperator(){

    var plus= new Plus();
    var result = calc.printAndReturn( x, plus, y);
    assertEquals(65, result);

}
```

```
class Plus implements BinaryOperator{

    public double calculate(double x, double y){
        return x+y;
    }
}
```

```
class Minus implements BinaryOperator{

    public int calculate(double x, doubke y){
        return x-y;
    }
}
```

```
@Test
public void canWorkWithMinusOperator(){

    var result = calc.printAndReturn(x, new Minus(), y);
    assertEquals(35, result);

}
```

```
@Test
public void canWorkWithMultipyOperator(){

    // m is the object of a (new class that implements ) BinaryOperator
    var m = new BinaryOperator() {  public double calculate(double x, double y){return x*y;}};

    assertEquals(750,  calc.printAndReturn(x, m, y) );


}


@Test
public void canCalculateModOperator(){

    assertEquals(5,  calc.printAndReturn(x, new BinaryOperator(){public double calculate(double x, double y){return x%y; }), y);
}
```

```
@Test
public void canDivideUsingLambdaOperator(){

    //var d = new BinaryOperator() {  public double calculate(double x, double y){return x/y;}};

    //BinaryOperator d = new BinaryOperator (){double calculate (double x, double y)->{return x/y;} };
    BinaryOperator d = ( x,  y)->{return x/y;} ;
```

```
    assertEquals( 50.0/15, calc.printAndReturn(x, d, y);

}


@Test
public void canFindModUsingLambdaOperator(){

    //var d = new BinaryOperator() {  public double calculate(double x, double y){return x/y;}};

    //BinaryOperator d = new BinaryOperator (){double calculate (double x, double y)->{return x/y;} };
    //BinaryOperator d = ( x,  y)->{return x/y;} ;

    //if lambda contains a single statement you can drop {}, ;  and return keyword

    //BinaryOpeator mod = (x,y) -> x%y ;


    assertEquals( 50.0/15, calc.printAndReturn(x, (a,b)->a%b , y);

}
```

## Function Reference Model

- sometimes we may have an existing method that has similar signature as what we need
  - signature includes
    - parameters
    - return
  - It doesn't include
    - method name
    - scope
- In standard practice we can wrap the method in lambda

```
class Math{


    public static double pow(double x, double y){…}
}
```

```
@Test
public void canUseExistingMathPowUsingLambda(){

    var result = calc.printAndReturn( 5,  (a,b) -> Math.pow(a,b),  2);

    assert(25,result,0.01);
}
```

- Here we created a new class with a method that takes (a,b) ->
- The method called another method with exact same parameter Math.pow(a,b)

### Java provides simpler syntax for lambda using Function Reference

```
@Test
public void useExistingMathPowUsingFunctionReference(){

    var result= calc.printAndReturn( 5, Math::pow , 2);
}
```

## IMPORTANT

- Math.pow
  - although doesn't match BinaryOperator calculate method
    - it is a static function
    - Math doesn't implent interface
    - It is not called calculate
  - It matches the signature of lambda
    - lamdba doesn't have explict  method name
    - it doesn't have explicit scopes like public or static
- My Lambda is just a wrapper to collect the value and pass to another method
  - In such cases we can use Method reference syntax

## Method reference for non static method

```
class Permutation{

    public double get(double n, double r){

        …
```

```
    }
}


@Test
public void canCalculatePermutationUsingLambda(){

    var p =new Permutation();

    //var r = calc.printAndReturn(5,  p, 3); //p doesn't implement interface

    var r = calc.printAndReturn(5,  (x,y) -> p.get(x,y)  ,  3);

    …

}



@Test
public void canCalculatePermutationUsingFunctionReferece(){

    var p =new Permutation();

    //var r = calc.printAndReturn(5,  p, 3); //p doesn't implement interface

    var r = calc.printAndReturn(5,   p::get  ,  3);

    …

}
```

- here we are calling p.get(x,y) insider the calculate method of an anonymous class that implements BinaryOperator

# Create A Calculator with following Design

Wednesday, February 22, 2023 9:35 AM

```
var calc= new Calculator();


calc.addOperator("+" , (x,y) -> x+y);

calc.addOperator("-", (x,y) -> x-y);


calc.calculate(5, "+", 2);  //should print 5+2=7

calc.calculate(5,"-",2);  //should print 5-2=3

calc.caclulate(5,"*",2); //should throw InvalidArumentException
```

- Note

- calculate is a void method and by default prints the result on console
- But there should be a provision to
    - print the result somewhere else also like
        - gui
        - web page
        - save to a file
- I may also want to see result either
    - full format
        - 2+3=5
    - or raw format
        - 5

- How do we unit test calculate?

# A traditional distributed application

Monday, February 20, 2023 1:50 PM

## N-Tier Architecture

Presentation Tier

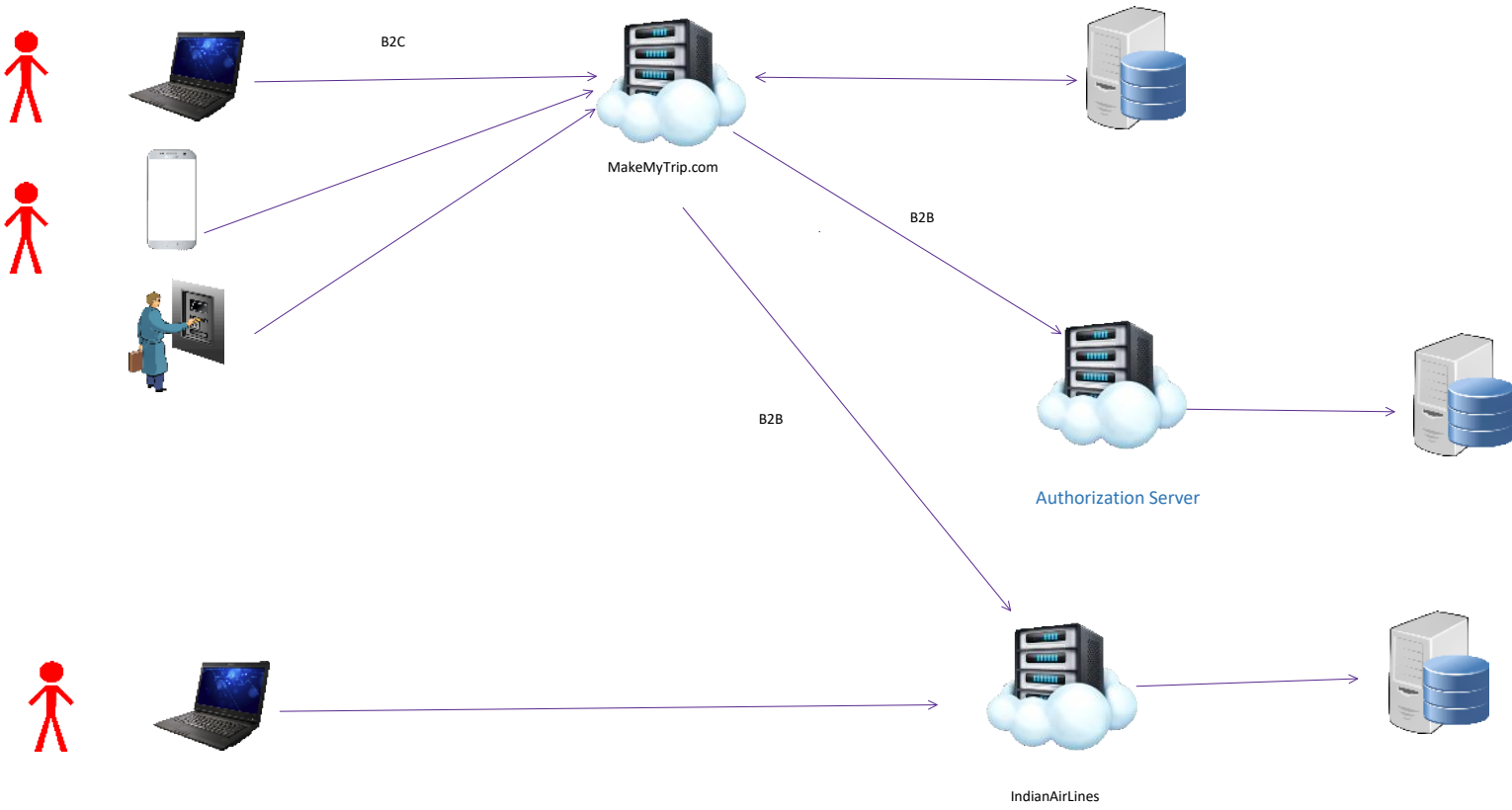
Business Tier

**Application Server**
**a.k.a**
**Web Server**

**( Handles the Business Logic)**

Data Tier

**Data Server**



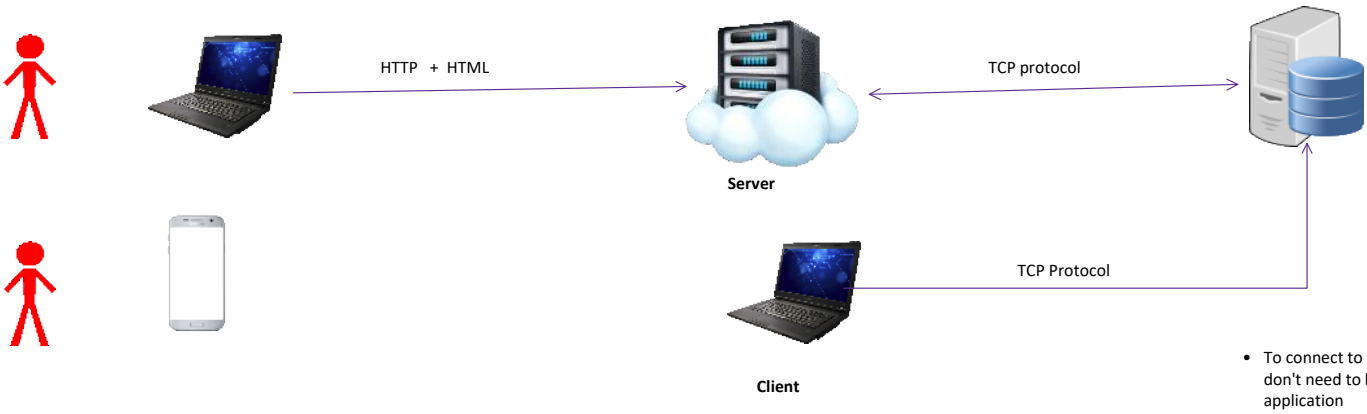
# Simple 3 Tier Architecture

Monday, February 20, 2023 2:07 PM

## Presentation Tier

**a.k.a**
**Web Server**

**( Handles the Business Logic)**




- To connect to a database you don't need to be a server application
- A simple java console application can still connect to the database server with right credentials.

## Distributed Application

- includes Server (and client)
-
- Two different programs interact with each other over some network protocol
- A server is essentially a Application (Program) that knows
  - The core business
    - still consists of
      - class
      - object
      - method
  - How to interact over network request and response
    - You can't
      - call methods directly from a different program
      - get the return of method
      - See the output on the screen
    - You need to
      - connect over network
      - send data in bytes
      - receive data in bytes

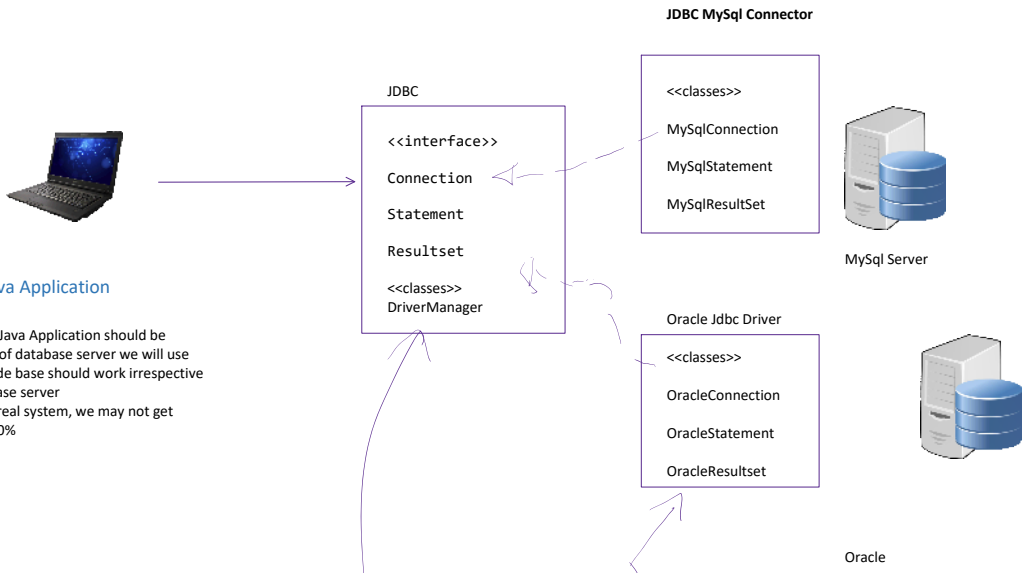
## How Java connects to a database Server?

- Internally the communication is a network communication (TCP)
- But Java provides a set of classes that encapsulates the internal implementations and allows us to interact with data base with the help of few objects.
- This API is known as JDBC (Java Database Connectivity)

# JDBC

Monday, February 20, 2023 2:16 PM

- A Java standard for a Java application to connect to any RDBMS system like
  - Oracle
  - MySql
  - SqlServer
  - Postgres
  - ...




- Ideally a Java Application should be agnostic of database server we will use
- Same code base should work irrespective of database server
  - In real system, we may not get 100%

## Jdbc Has two important Parts

### 1. An standard api that comes as part of core Java

- includes
  - interfaces
    - connection
      - how we connect to database
    - statement
      - query we need to send to database
    - ResultSet
      - Result returned by database
  - class
    - DriverManager
      - allows us to connect specific Driver to our application

### 2. Driver/Connector for specific database

- generally not part of core java library
- **provided by database vendors**
  - mysql connector should be obtained from mysql website
  - oracle connector should be obtained from oracle website
- The connector will be packaged as a jar file
- The jar contains implementations of JDBC interfaces specific to the underlying database
  - there may be implementation difference between how oracle and mysql connections are made

## Getting Started with JDBC - MySql

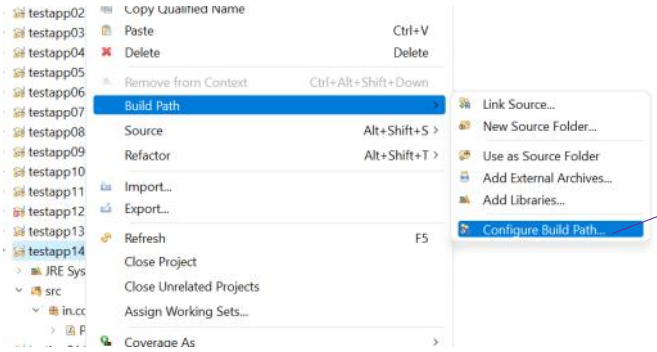
### 1. Install/procure the database Server

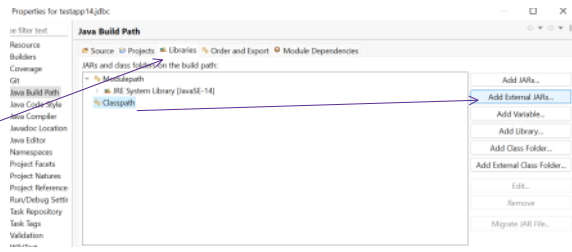
- we can install the server application
- we may subscribe to some cloud server that allows us to store data with them.
  - Example: elephantsql.com

### 2. Working with Java Program to Access the server.

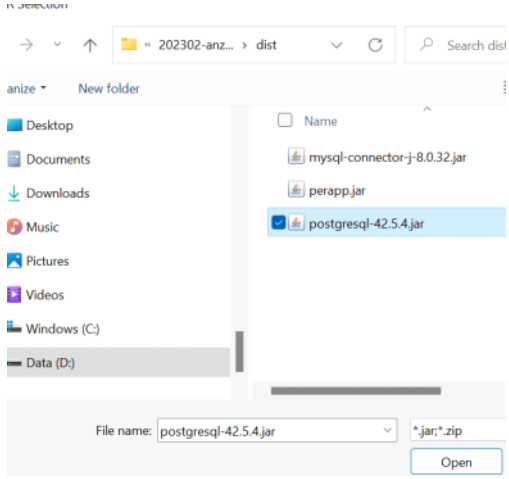
- We need the connection string or credentials to connect to the database
- Generally it includes An URL containing
  - server address and port
  - database name
  - user name
  - password

### 3. Add the database sepecific connector jar to your build path




4. A basic code to connect to database and fetch the details.



# Assignment

Monday, February 20, 2023 3:34 PM

- Create a BookDbManager class that supports basic CRUD functions
  - Get a list of all books
  - Add a new book
  - get a book by Id
  - update a book
  - delete a book

# OO Patterns

Tuesday, February 21, 2023 10:20 AM

## Constructor Problem

1. constructor has a completely meaningless name.
2. constructor is used with "new" and there is no "existing" keyword
   a. It fails to differentiate between needing an object and needign a new object
3. constructor is non-polymorphic

## Is Constructor class level (static) or object level (non static)

- is neither class level
  - no static keyword
  - has 'this'
  - can't be accessed using class reference
- nor object level
  - can't be accessed using object reference

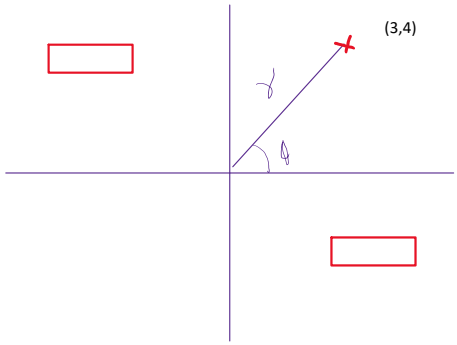
```
Circle c=new Circle();
Circle c2= c.Circle();
```

## Think!!!

- if it doesn't belong to class and doesn't belong to object what is it doing in the class?

## Has a completely Meaningless Name

- Class represents (describes) Object
- Constructor represents the creator of the Object
- A name that is meaningful for an object (or a product) doesn't become automatically meaningful for it's creator also
  - The fact is, we h ave no control on the constructor name




Gemoetrically each point is unique on a given plaine

### Constructor means new

- It doesn't promote Object re-use

```
var p1= new Point(3,4); //it's a new point

var p2= new Point(1,1); //it's also a new point

var p3= new Point(3,4); //Is it a new Point?
```

overload with same signature is not allowed

```
Point p1 = new Cartisian(3,4);   //can't control the constructor name

Point p2=new Polar(5,45);  //can't control the constructor name
```

```
class Point{

    double x, y;

    public Point(double x, double y){
        this.x=x;
        this.y=y;
    }

    public Point(double r, double theta){
        var rad= theta*Math.pi/180;
        x= r* Math.cos(rad);
        y=r*Math.sin(rad);
    }

    public double getR(){
        return Math.sqrt(x*x+y*y);
    }

    public double getTheta(){
        var rad= Math.atan(y/x);
        return rad*180/Math.pi;
    }

}
```

## Constructors are non-polymorphic

- polymorphism works when a super class/interface reference refers to an object of the sub class
  - but when constructor is called, object doesn't exist yet to be referenced.
- In polymorphism when we call shape.area(), we may not be knowing which shape and how area will be calculated. It varies if shape is triangle or circle
  - In constructor you always know which constructor you are calling
    - var x= new Circle();
    - var y= new Triangle();
- constructor can't be overridden.
- constructor can't be part of the interface
  - can't implement DIP
- Dependency Inversion Principle
  - says know the abstract class / interface but not the concerete implementation
  - constructor forces you to know the concrete class
    - a constructor has same name as that of the concrete class.
- you can't replace a constructor with another to implement LSP
- Since It doesn't support DIS and LSP, it also tends to violate OCP
  - When we need to change the logic, we need

## Constructors are NOT optional

- It's a language feature.
- It can't be removed.

- Object creation always involves constructor call.

## Solution —> We can't remove the constructor. But we can hide it.

- We can replace the constructor by hiding it behind some user defined method.
- Advantage
  - User defined method is user defined.
    - we can chose whatever name we like
    - we may choose if we want to create a new object or return an exisiting one
    - we may choose to create object of different types depending on the context.

```
class Point{

    double x, y;

    public Point(double x, double y){
        this.x=x;
        this.y=y;
    }

    public Point(double r, double theta){
        var rad= theta*Math.pi/180;
        x= r* Math.cos(rad);
        y=r*Math.sin(rad);
    }

    public double getR(){
        return Math.sqrt(x*x+y*y);
    }

    public double getTheta(){
        var rad= Math.atan(y/x);
        return rad*180/Math.pi;
    }

}
```

*var p1= new Point(3,4); //x=3, y=4*

*var p2= new Point(5,45); //r=5, theta=45*

```
class Point{

    double x, y;

    private Point(double x, double y){
        this.x=x;
        this.y=y;
    }

    public static Point getPolar(double r, double theta){
        var rad= theta*Math.pi/180;
        x= r* Math.cos(rad);
        y=r*Math.sin(rad);
        return getPoint(x,y);
    }

    public static Point getCartisian(double x, double y){
        return getPoint(x,y);
    }

    public static Point getPoint(double x, double y){
        return new Point(x,y);
    }

    public double getR(){
        return Math.sqrt(x*x+y*y);
    }

    public double getTheta(){
        var rad= Math.atan(y/x);
        return rad*180/Math.pi;
    }

}

var p1=Point.getCartisian(3,4);

var p2=Point.getPolar(5,45);

var p3=Point.getCartisian(3,4);

//is p1 == p3 //-->no
```

## Re-using existing Objects

```
class Point{

    double x, y;

    private Point(double x, double y){
        this.x=x;
        this.y=y;
    }

    public static Point getPolar(double r, double theta){
        var rad= theta*Math.pi/180;
        x= r* Math.cos(rad);
        y=r*Math.sin(rad);
        return getPoint(x,y);
    }

    public static Point getCartisian(double x, double y){
        return getPoint(x,y);
    }

    static List<Point> cache= new ArrayList<Point();

    public static Point getPoint(double x, double y){

        for(var p : cache){
            if(p.x==x && p.y==y)
```

```
var p1= Point.getCartisian(3,4); // new point

var p2= Point.getCartisian(1,1); //new point


var p3=Point.getCartisian(3,4); //same as p1
```

- p3 is re-using the same object as p1

```
                return p;
            }

            var p= new Point(x,y);
            cache.add(p);
            return p;
        }

        public double getR(){
            return Math.sqrt(x*x+y*y);
        }

        public double getTheta(){
            var rad= Math.atan(y/x);
            return rad*180/Math.pi;
        }

}


var p1=Point.getCartisian(3,4);

var p2=Point.getPolar(5,45);

var p3=Point.getCartisian(3,4);

//is p1 == p3 //-->no
```

## Factory Method

- Ordinary user defined methods that can replace a direct construtor call
  - factory can hide constructor not really replace it.
- Advatange
  - More meaningful name
  - can create or reuse object
  - can create objects of different types
  - can be mentioneda s part of interface
    - can be overriden or replaced.

```
Connection con = DriverManager.getConnection(url, user,password);  //which object is created?


Statement statement = con.createStatement();
```

### Factory in a separate Class

```
class Point{

    double x, y;

    /*package*/ Point(double x, double y){
        this.x=x;
        this.y=y;
    }

    public double getR(){
        return Math.sqrt(x*x+y*y);
    }

    public double getTheta(){
        var rad= Math.atan(y/x);
        return rad*180/Math.pi;
    }
```

```
class PointFactory{

public Point getPolar(double r, double theta){
    var rad= theta*Math.pi/180;
    x= r* Math.cos(rad);
    y=r*Math.sin(rad);
    return getPoint(x,y);
}

public  Point getCartisian(double x, double y){
    return getPoint(x,y);
}

List<Point> cache= new ArrayList<Point();

static Point getPoint(double x, double y){

    for(var p : cache){
```

```
    public double getTheta(){
        var rad= Math.atan(y/x);
        return rad*180/Math.pi;
    }

}



var pf= new PointFactory();
var p1=pf.getCartisian(3,4);

var p2=pf.getPolar(5,45);

var p3=pf.getCartisian(3,4);

//is p1 == p3 //-->no
```

```
List<Point> cache= new ArrayList<Point();

static Point getPoint(double x, double y){

    for(var p : cache){
        if(p.x==x && p.y==y)
            return p;
    }

    var p= new Point(x,y);
    cache.add(p);
    return p;
}



}
```

# Unit Testing Jdbc Objects

Tuesday, February 21, 2023 11:37 AM

- Databases persists your records
- Each add test will add a new record in the database
    - that will impact total number of records in the database
    - assert will fail
- We MUST NOT run tests agains production database
    - we must have separate test data base to run the code
- We must clear the rows or tables in @Before or @After

# Refactoring Code

Tuesday, February 21, 2023 2:04 PM

```
public List<Book> getAllBooks(){
    var books=new ArrayList<Book>();

    Connection connection=null;
    try {
        connection=DriverManager.getConnection(url,userName,password);
        var statement=connection.createStatement();
        var rs= statement.executeQuery("select * from books");
        while(rs.next()) {

            var book=new Book();
            book.setTitle(rs.getString("title"));
            book.setAuthor(rs.getString("author"));
            book.setPrice(rs.getInt("price"));
            book.setRating(rs.getDouble("rating"));
            book.setDescription(rs.getString("description"));
            book.setTags(rs.getString("tags"));
            book.setCover(rs.getString("cover"));
            book.setId(rs.getString("isbn"));


            books.add(book);
        }

        return books;

    }catch(SQLException ex) {
        throw new JdbcException(ex.getMessage(),ex);

    }finally {
        try {
            if(connection!=null)
                connection.close();
        }catch(Exception ex) {
            throw new JdbcException(ex.getMessage(),ex);
        }
    }

}
```

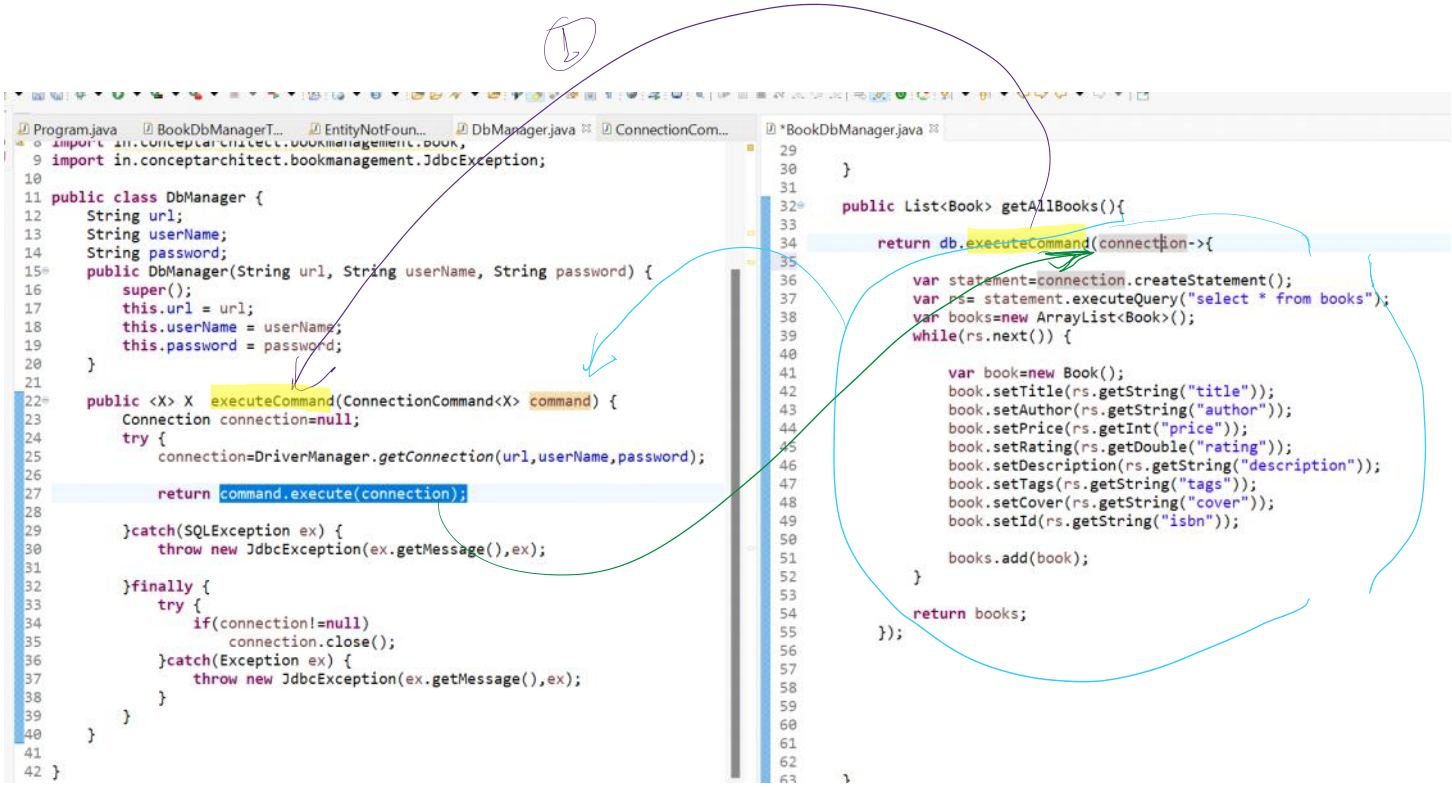
```
public void addBook(Book book) {
    Connection connection=null;
    try {
        connection=DriverManager.getConnection(url,userName,password);

        var statement= connection.prepareStatement("insert into books "
                + "       (isbn,title,author,price,rating,cover,description,tags)"
                + " values(?,?,?,?,?,?,?,?)");

        statement.setString(1, book.getId());
        statement.setString(2, book.getTitle());
        statement.setString(3, book.getAuthor());
        statement.setInt(4, book.getPrice());
        statement.setDouble(5, book.getRating());
        statement.setString(6, book.getCover());
        statement.setString(7, book.getDescription());
        statement.setString(8, book.getTags());

        statement.executeUpdate();


    }catch(SQLException ex) {
        throw new JdbcException(ex.getMessage(),ex);

    }finally {
        try {
            if(connection!=null)
                connection.close();
        }catch(Exception ex) {
            throw new JdbcException(ex.getMessage(),ex);
        }
    }

}
```

```
class DbManager{
public <X>  X   executeCommand(ConnectionCommand<X> x){

        Connection connection=null;

        try{
                connection=DriverManager.getConnection(url,username,password);

                //TODO: what?
                x.execute(connection );

        }catch(SQLException e){
                throw new JdbcException(e.getMessage(),e);
        } finally{
                try{
                        if(connection!=null)
                                connection.close();
                }catch(SQLException e){
                        throw new JdbcException(e.getMessage(),e);
                }
        }

                }
                }
```

```
interface ConnectionCommand<T>{

        T execute(Connection con);
}
```

```
var statement=connection.createStatement();
var rs= statement.executeQuery("select * from books");
var books=new ArrayList<Book>();
while(rs.next()) {

    var book=new Book();
    book.setTitle(rs.getString("title"));
    book.setAuthor(rs.getString("author"));
    book.setPrice(rs.getInt("price"));
    book.setRating(rs.getDouble("rating"));
    book.setDescription(rs.getString("description"));
    book.setTags(rs.getString("tags"));
    book.setCover(rs.getString("cover"));
    book.setId(rs.getString("isbn"));


    books.add(book);
}

return books;
```

```
var statement= connection.prepareStatement("insert into books "
        + "       (isbn,title,author,price,rating,cover,description,tags)"
        + " values(?,?,?,?,?,?,?,?)");

statement.setString(1, book.getId());
statement.setString(2, book.getTitle());
statement.setString(3, book.getAuthor());
statement.setInt(4, book.getPrice());
statement.setDouble(5, book.getRating());
statement.setString(6, book.getCover());
statement.setString(7, book.getDescription());
statement.setString(8, book.getTags());

statement.executeUpdate();
```


Program.java
BookDbManagerT...
EntityNotFoun...
DbManager.java
ConnectionCom...
*BookDbManager.java
import in.conceptarchitect.bookmanagement.JdbcException;
public class DbManager {
String url;
String userName;
String password;
public DbManager(String url, String userName, String password) {
super();
this.url = url;
this.userName = userName;
this.password = password;
}
public <X> X executeCommand(ConnectionCommand<X> command) {
Connection connection=null;
try {
connection=DriverManager.getConnection(url,userName,password);
return command.execute(connection);
}catch(SQLException ex) {
throw new JdbcException(ex.getMessage(),ex);
}finally {
try {
if(connection!=null)
connection.close();
}catch(Exception ex) {
throw new JdbcException(ex.getMessage(),ex);
}
}
}
}
}
public List<Book> getAllBooks(){
return db.executeCommand(connection->{
var statement=connection.createStatement();
var rs= statement.executeQuery("select * from books");
var books=new ArrayList<Book>();
while(rs.next()) {
var book=new Book();
book.setTitle(rs.getString("title"));
book.setAuthor(rs.getString("author"));
book.setPrice(rs.getInt("price"));
book.setRating(rs.getDouble("rating"));
book.setDescription(rs.getString("description"));
book.setTags(rs.getString("tags"));
book.setCover(rs.getString("cover"));
book.setId(rs.getString("isbn"));
books.add(book);
}
return books;
});