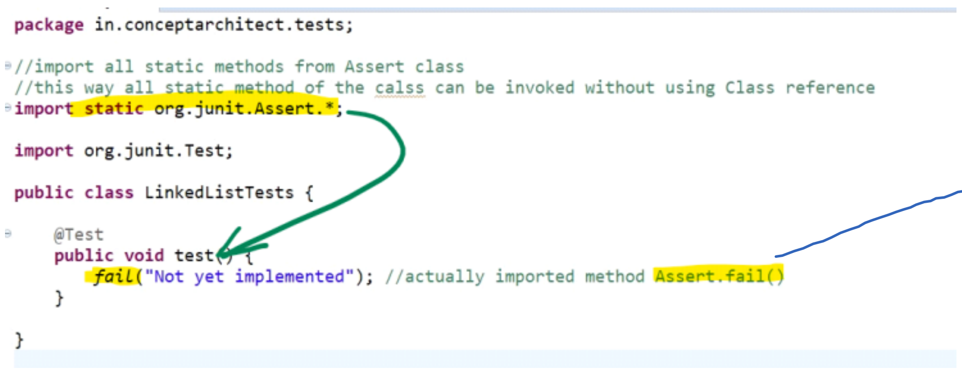
static import

Monday, June 1, 2020 5:20 PM



```java
package in.conceptarchitect.tests;

//import all static methods from Assert class
//this way all static method of the calss can be invoked without using Class reference
import static org.junit.Assert.*;

import org.junit.Test;

public class LinkedListTests {

    @Test
    public void test() {
        fail("Not yet implemented"); //actually imported method Assert.fail()
    }

}
```

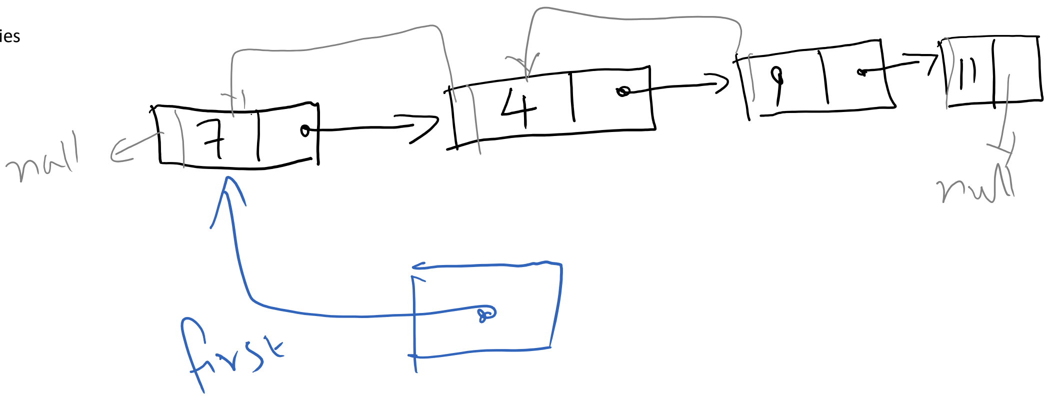
Allows all static method of a
class to be imported as a global method

These methods don't require class name
to call them

Assignment01 LinkedList

Thursday, May 21, 2020 2:58 PM

- Create a class to represent a Linked List
- A Linked List should support following operations
    - **add(int value)** //Adds to end of the List
    - **get(int pos)** //get a value from a given position
    - **set(int pos)** //set a valjue to a given position
    - **size()** //returns the size of the list
    - **remove(int pos)** //remove the value from a given position
- Create the necessary classes
- Write a **main function** to test its functionalities



List Access

- A list should allow random access (logically)
    - LinkedList is however physically sequential
    - To access it random we need to internally travel sequential.

- A List supports two common access requirements

1. Direct Access a.k.a Random Access

- User may need to access value at index 27, 49,112,4,18,37
    - This requirement is likely
    - we have **get(int pos)** to handle this requirement

2. Access all items one by one

- in a sequence
- for-each item
- This appears to be a very popular use case

We can't do much to improve performance of direct access ✗

Optimization

- may be improving performance for specific use case
- May not be for all use case

✓

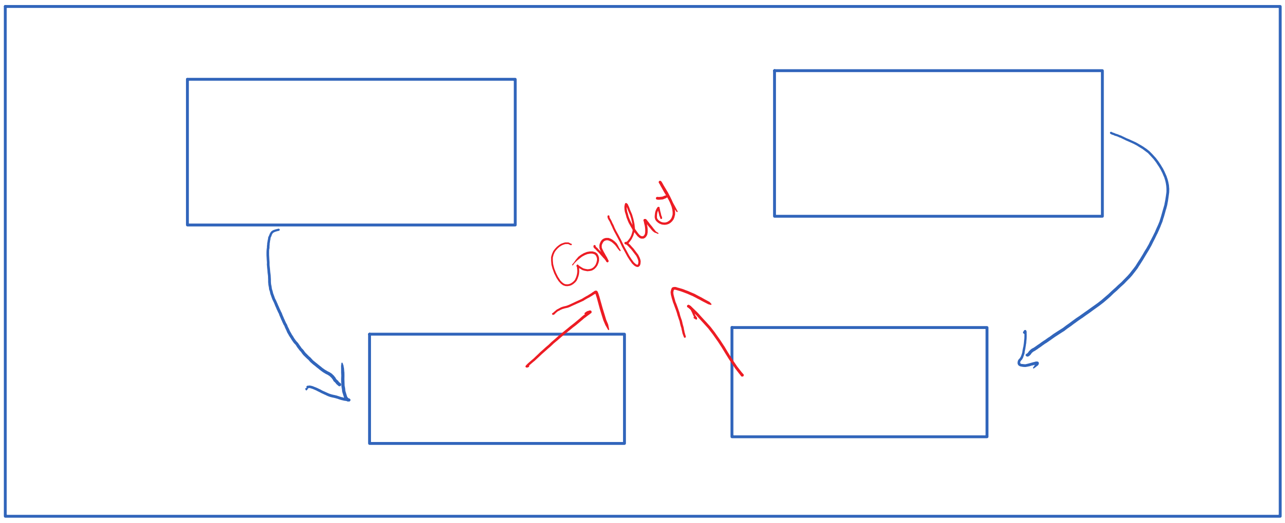
But we can improve the performance of sequential access (Popular Use case)

- ***I we have accessed an item at position 'n' the next request is going to be more likely for position 'n+1'***

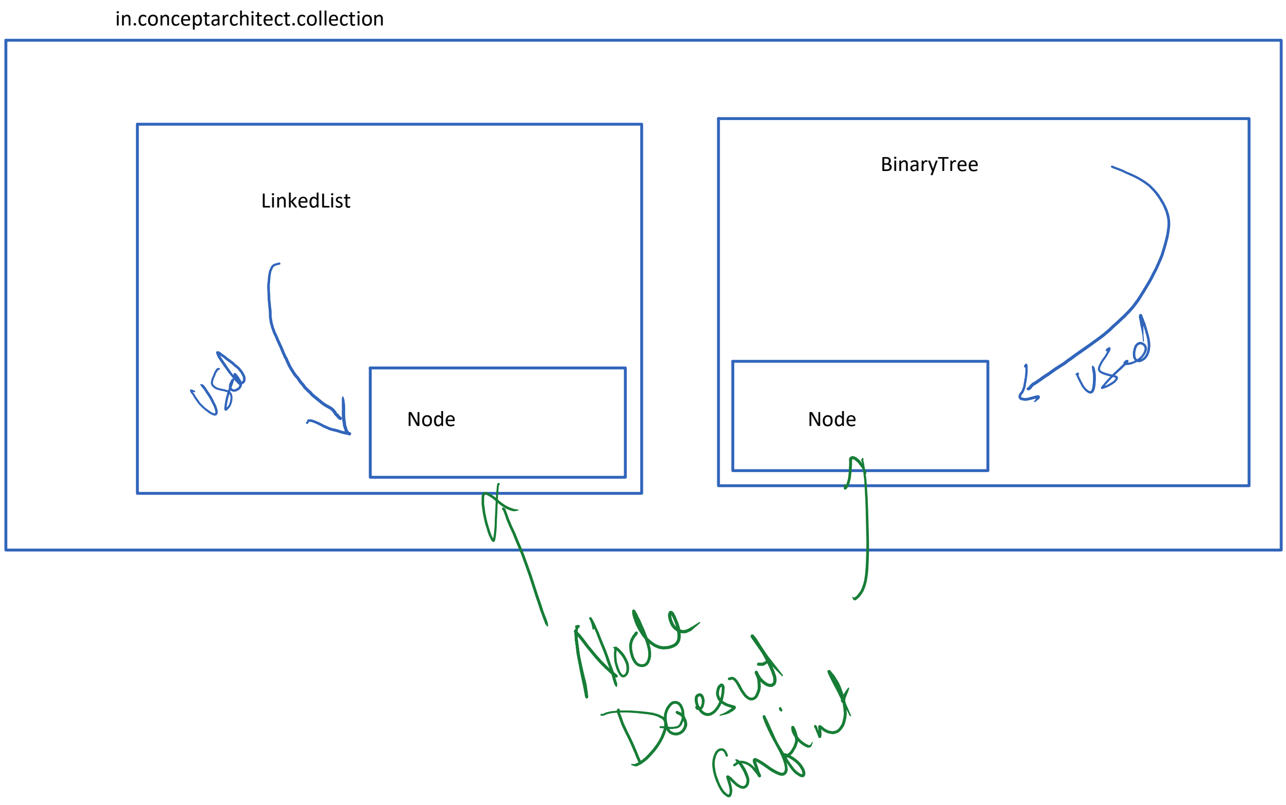
Can we maintain a pointer on the last accessed position.

Package vs Class Boundry

Friday, May 22, 2020 3:57 PM



A class to can act as a Package to separate class name visibility



When should I user inner class

- The outer class uses the objects of inner class **exclusively**
- The inner class object is not directly utilized by anyone else
- The only purpose of inner class is to support the outer class

Not every child component should be inner class

- A car contains tyres
- But a Tyre has independent existence and manufacturer
- We will not define Tyre class as inner class to Car

Packaging best practice guidelines

Monday, June 1, 2020 10:50 AM

Do's

- Make sure, your reusable components that can be productive to more than one applications, should be int its own
    - Package
    - Jar
- A Package is **Not designed to hold a single class**, but it is designed to hold a similar or related set of classes
    - Good Examples
        - collection —> to hold collection classes related to data structure
        - sql —> classes related to database access
        - net —> Network related classes
        - swt —> database related classes
    - Bad Examples
        - util —> to hold unrelated utilities such as Date, StringBuilder, Scanner, LinkedList
            - **java.util is an example of bad example**

- A Sub package may contain more specific elements from the super package
    - GoodExample
        - net.http —> classes related to http protocol which is a type of network protocol
        - jface.text —> text related elements in jface
- Top level package should be an identity space
        - **java.**sql
        - **java.**awt
        - **org.eclipse.**swt
        - **org.eclipse.**jface
        - **org.eclipse.**jface.text
        - **in.conceptarchitect.**collection
        - **in.conceptarchitect.**utils
        - **in.conceptarchitect.**taskmanager <—objects related to task manager application
        - **in.conceptarchitect.**taskmanager.ui <— ui layer of task manager application
        - **in.conceptarchitect.**taskmanager.repository <-- data access layer of taskmanager application

- Same rule applies to Jar also
    - However a jar can have multiple Packages
    - **org.eclipse.jface.jar** may contain all **jface** packages and subpackages
    - **Remember:** jar is the smallest unit of deployment
- **internal and inner classes**
    - You should limit the visibility of those classes that are for **internal usage only** and which the client shouldn't access.
    - To limit the visibility we have three choices
        1. use package level class (don't make it public)
            - This is an elementry security
            - Client can create package with same name and can still access it
        2. Make private inner classes
            - No one within the package can access it
            - Client's can't access
            - Not always possible
        3. Use Java9 Module system <— discussed later

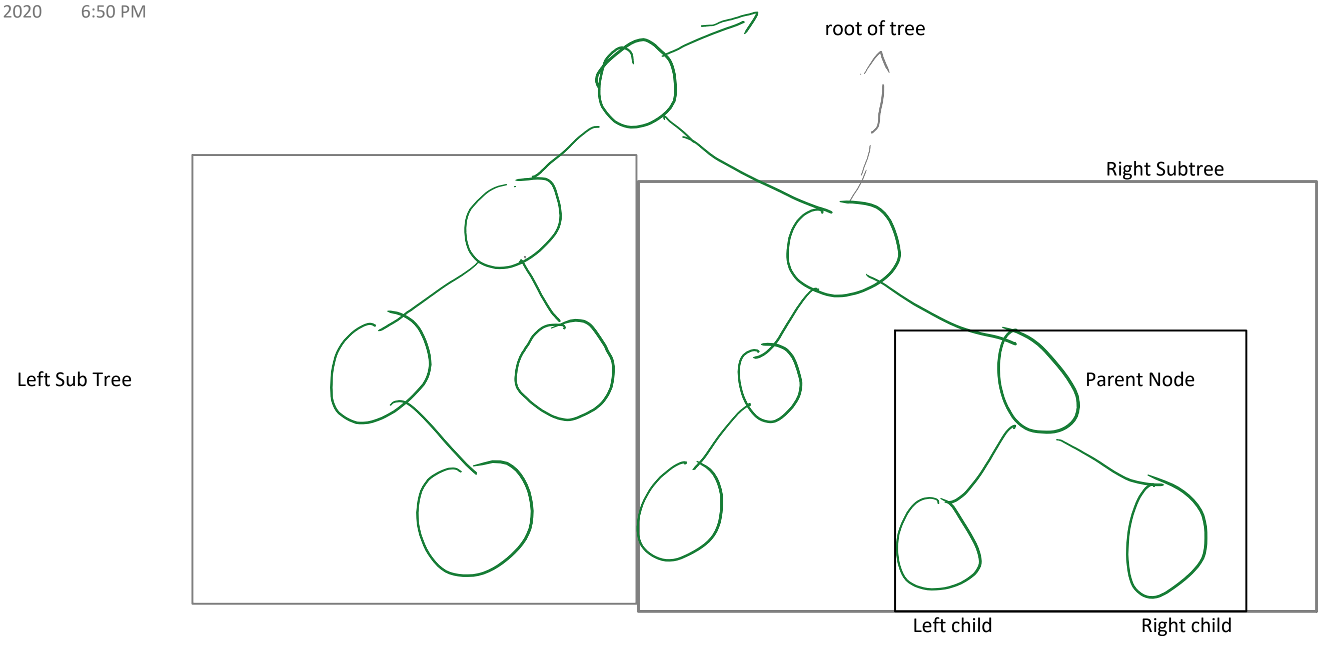
Don'ts

- Don't keep **main()** in your component class
- **Always remember main() should be in its own class in the client jar**
- Don't create single level package
    - It must have a brand identity
        - You may use a fictious brand such as **com.yourname**
- Don't create meaningless package
- A good structure for simple practice exercise could be
    - **jar: com.myname.collection**
        - **package: com.myname.collection**
            - **class LinkedList**
                - **class Node**

    - **client:**
        - **option1**
            - **com.myname.testapp.linkedlist**
                - **package: com.myname.testapp.linkedlist**
                    - **class: Program (or Test or App or Client)**
                        - **method: main()**
        - **option2 (relaxation)**
            - **jar: testapp01.linkedlist <— this makes seeing the package explorer easy**
                - **This is just a test application which is a throaway later**

BinaryTree of int

Friday, May 22, 2020 6:50 PM

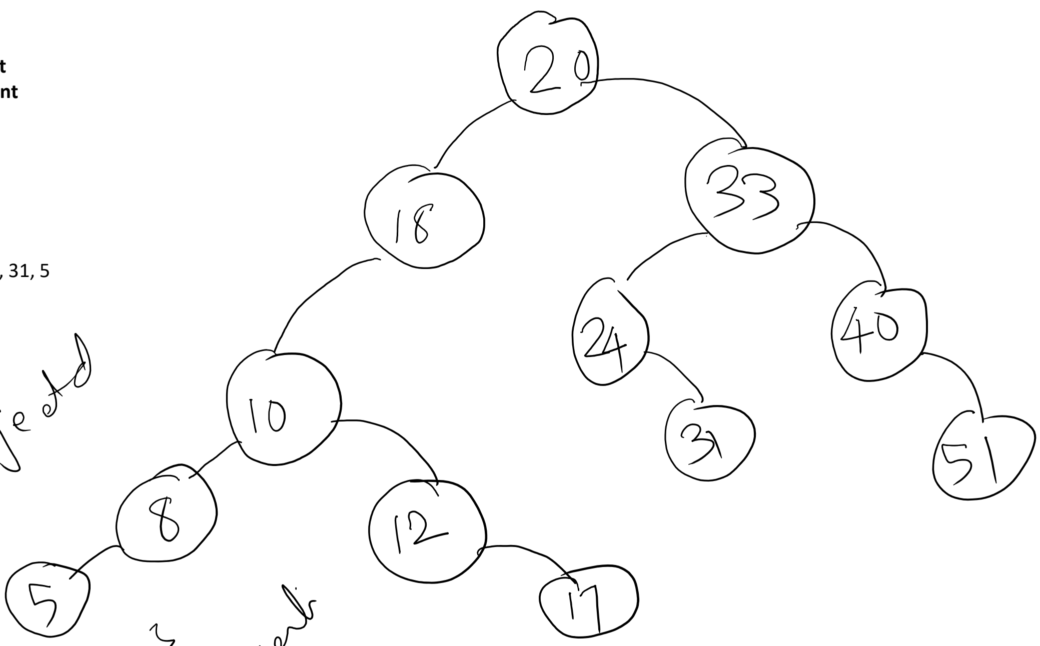


BinaryTree Create Rule

Friday, May 22, 2020

Tree Rule: L<P<R

- **Parent should be greater than Left**
- **Right should be greater than Parent**



To Add following Numbers

20 , 18, 10, 12, 17, 33, 24, 40, 51, ,20, 8, 31, 5

↓

Rejected

- If you want to retain duplicate you can change the tree forumula to one of the two given below
  - L<=P < R
  - or L<P<=R
- But Not
  - L<=P<=R X

→ Allows Duplicates

Never Use //

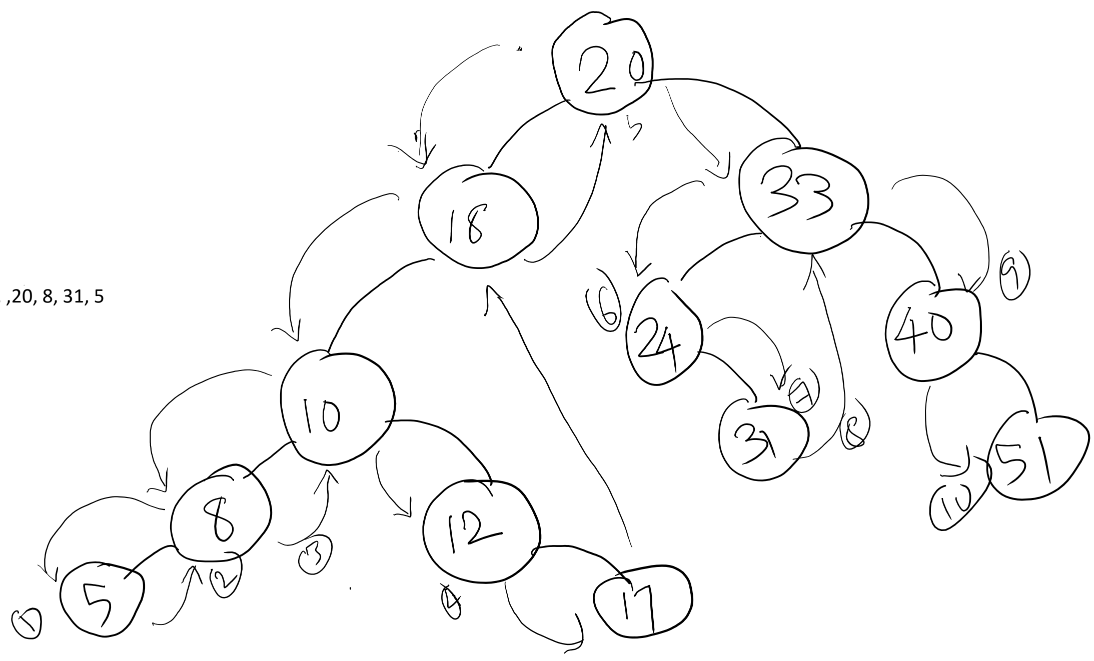
```
Node  insert ( Node root, int value){

        if(root==null){
                root=new Node(value);

        } else if(value< root.value)
                root.left=insert(root.left,value);
        else if(vlaue> root.value)
                root.right=insert(root.right,value);
        return root;
}



}
```

BinaryTreeAccess Rule -- Inorder

Friday, May 22, 2020

Inorder: L-->P-->R

- **Visit Left (subtree)**
- **Visit Parent**
- **Visit Right(subtree)**



To Add following Numbers

20 , 18, 10, 12, 17, 33, 24, 40, 51, ,20, 8, 31, 5

Inorder

5
8
10
12
17
18
20
24
31
33
40
51

```
Node inorder ( Node root){

        if(root==null){
                return;

        }
        inorder(root.left); //L
        print(root.value);  //P
        inorder(root.right); //R



}
```

Preorder

P --> L --> R

Preorder

L --> R --> P

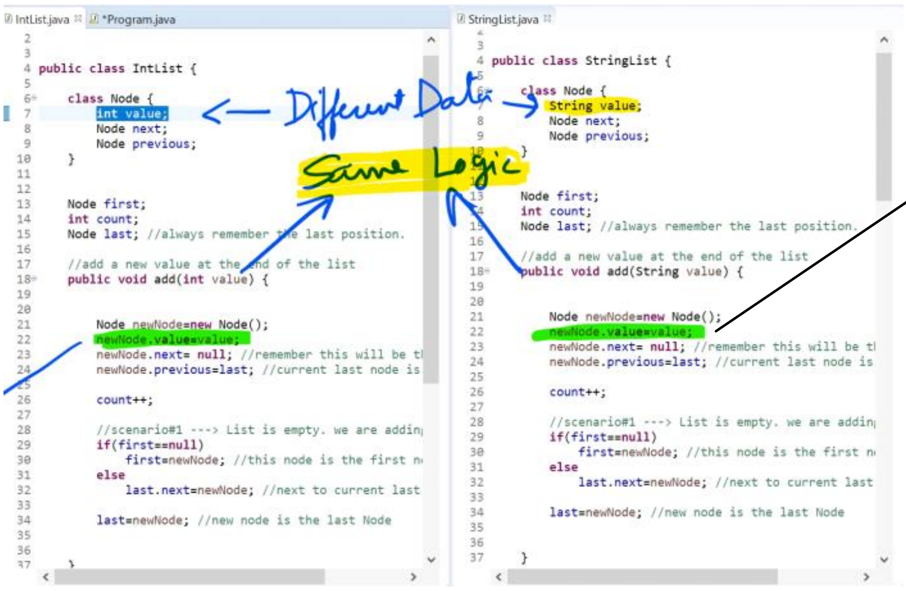
Assignment 02

Friday, May 22, 2020 7:10 PM

- create class BinaryTree to store integers
- Implement operations
    - Insert
    - Inorder
    - Preorder
    - Postorder

Same Logic Different Data

Monday, June 1, 2020 11:15 AM



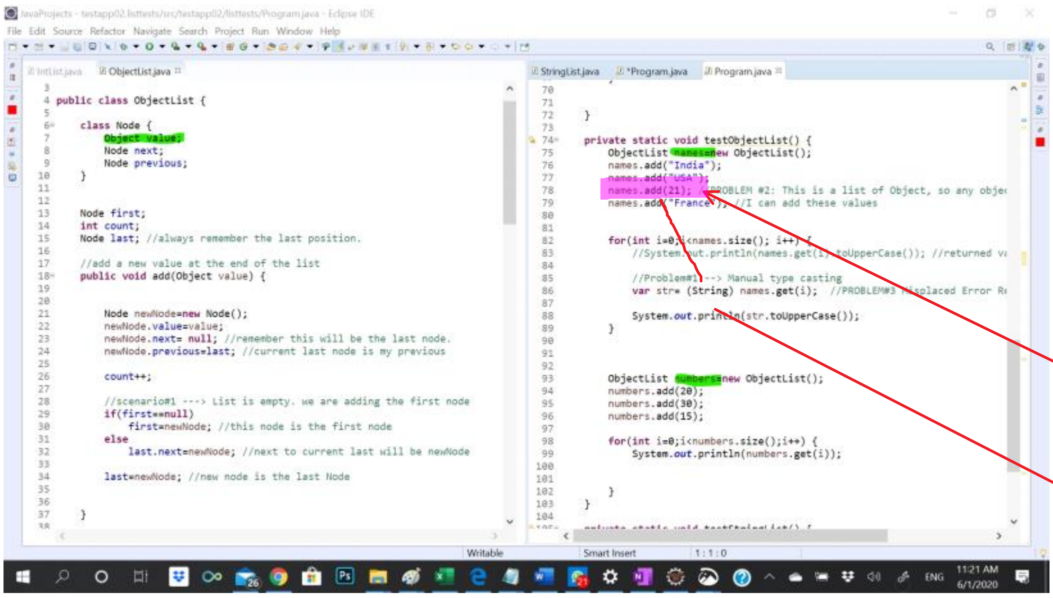
```java
public class IntList {

    class Node {
        int value;
        Node next;
        Node previous;
    }


    Node first;
    int count;
    Node last; //always remember the last position.

    //add a new value at the end of the list
    public void add(int value) {


        Node newNode=new Node();
        newNode.value=value;
        newNode.next= null; //remember this will be t
        newNode.previous=last; //current last node is

        count++;

        //scenario#1 ---> List is empty. we are addin
        if(first==null)
            first=newNode; //this node is the first n
        else
            last.next=newNode; //next to current last

        last=newNode; //new node is the last Node


    }
```

```java
public class StringList {

    class Node {
        String value;
        Node next;
        Node previous;
    }


    Node first;
    int count;
    Node last; //always remember the last position.

    //add a new value at the end of the list
    public void add(String value) {


        Node newNode=new Node();
        newNode.value=value;
        newNode.next= null; //remember this will be t
        newNode.previous=last; //current last node is

        count++;

        //scenario#1 ---> List is empty. we are addin
        if(first==null)
            first=newNode; //this node is the first n
        else
            last.next=newNode; //next to current last

        last=newNode; //new node is the last Node


    }
```

- Because the LinkedList algorithm doesn't know or care to know what is the data type
- it doesn't try to use any internal functionality or property of the data
- It is simply storing the data at the end without caring the exact value or meaning of data.
- If your algorithm needs to call special methods from the data, it can't be used as a generic alorithm easily.

Object List

Monday, June 1, 2020 11:22 AM



```java
public class ObjectList {

    class Node {
        Object value;
        Node next;
        Node previous;
    }


    Node first;
    int count;
    Node last; //always remember the last position.

    //add a new value at the end of the list
    public void add(Object value) {


        Node newNode=new Node();
        newNode.value=value;
        newNode.next= null; //remember this will be the last node.
        newNode.previous=last; //current last node is my previous

        count++;

        //scenario#1 ---> List is empty. we are adding the first node
        if(first==null)
            first=newNode; //this node is the first node
        else
            last.next=newNode; //next to current last will be newNode

        last=newNode; //new node is the last Node


    }
```

```java
    }

    private static void testObjectList() {
        ObjectList names=new ObjectList();
        names.add("India");
        names.add("USA");
        names.add(21); //PROBLEM #2: This is a list of Object, so any objec
        names.add("France"); //I can add these values


        for(int i=0;i<names.size(); i++) {
            //System.out.println(names.get(i).toUpperCase()); //returned va

            //Problem#1 --> Manual type casting
            var str= (String) names.get(i);  //PROBLEM#3 Misplaced Error Re

            System.out.println(str.toUpperCase());
        }



        ObjectList numbers=new ObjectList();
        numbers.add(20);
        numbers.add(30);
        numbers.add(15);

        for(int i=0;i<numbers.size();i++) {
            System.out.println(numbers.get(i));


        }
    }
```

Good

- Same LinkedList class can allow you to create linkedlist to hold different type of data
    - String
    - Date
    - Task
- You don't have to create different classes, just different objects

Bad

- class doesn't know what kind of object you want to store in linked list. so it allows you to store even number in a list of Strings
- returns from object method will be an object and should be typecasted before used. You don't get intellisense unless you typecase

- if you stored wrong value, the typecasting will faile
-

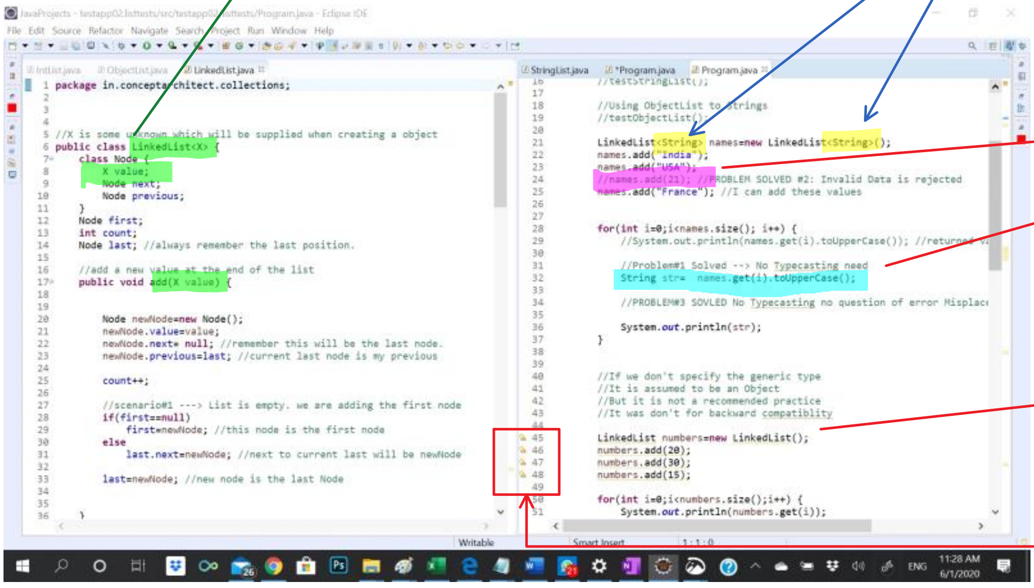
Generics

Monday, June 1, 2020 11:29 AM

1. Class is Created in terms of unknown like an Alzebric unit
   a. It can be any valid identifier that you may create
   b. Generally java uses **E** for element

2. The data type must be specified while creating the object

After java 6, it is ok to mention type only on the left side and not on right side.



JavaProjects - testapp02.listtests/src/testapp02.listtests/Program.java - Eclipse IDE

LinkedList.java

```java
package in.conceptarchitect.collections;



//X is some unknown which will be supplied when creating a object
public class LinkedList<X> {
    class Node {
        X value;
        Node next;
        Node previous;
    }
    Node first;
    int count;
    Node last; //always remember the last position.

    //add a new value at the end of the list
    public void add(X value) {


        Node newNode=new Node();
        newNode.value=value;
        newNode.next= null; //remember this will be the last node.
        newNode.previous=last; //current last node is my previous

        count++;

        //scenario#1 ---> List is empty. we are adding the first node
        if(first==null)
            first=newNode; //this node is the first node
        else
            last.next=newNode; //next to current last will be newNode

        last=newNode; //new node is the last Node


    }
```

Program.java

```java
        //testStringList();

        //Using ObjectList to Strings
        //testObjectList();

        LinkedList<String> names=new LinkedList<String>();
        names.add("India");
        names.add("USA");
        //names.add(21); //PROBLEM SOLVED #2: Invalid Data is rejected
        names.add("France"); //I can add these values


        for(int i=0;i<names.size(); i++) {
            //System.out.println(names.get(i).toUpperCase()); //returned va

            //Problem#1 Solved --> No Typecasting need
            String str=  names.get(i).toUpperCase();

            //PROBLEM#3 SOVLED No Typecasting no question of error Misplace

            System.out.println(str);
        }


        //If we don't specify the generic type
        //It is assumed to be an Object
        //But it is not a recommended practice
        //It was don't for backward compatiblity

        LinkedList numbers=new LinkedList();
        numbers.add(20);
        numbers.add(30);
        numbers.add(15);

        for(int i=0;i<numbers.size();i++) {
            System.out.println(numbers.get(i));
```

The benefits

1. **Detects and complains for error early**
2. **Use object without typecasting**

Java Implementation

- **Java allows to create object without specifiying type.** This is for backward compatibility and is Not Recommended
- When you don't specify the type it falls back to Object type
- **This is not Recommended and java complains by giving warning**

Generic is internally Object

Monday, June 1, 2020 12:01 PM

- When Java created Generics, it was a language level feture and **Not byte code feature.**
    - ***JVM was not expected to understand generic***
- Java internally converted a Generic type **X** to an **Object** type
    - It internally checked if you are breaking any rule by inserting wrong value type
    - Intellisence is a combined feature of compiler and the IDE.
- Once a java generic is compiled, it becomes Object.

    LinkedList<String> list=new LinkedList<String>(); // This code is essentially same as

    LinkedList<Object> list=new LinkedList<Object>(); // This code is essentially same as

    - with compiler checking if you are trying to insert anything other than String.

- That is why when you don't specify Generic during object creation it becomes Object

LinkedList list=new LinkedList(); // This code is essentially same as

LinkedList<Object> list=new LinkedList<Object>(); // This code is essentially same as

- With compiler making no checks.

Problem — You can't create LInkedList of int

LinkedList<int> list=new LinkedList<int>();

- Why?
    - because in java **int is not a primitive type and not an Object type**
    - Java Generic convert to Object and int can't be object.

Solution — This is not a big problem in the first place.

- We can use following syntax

LinkedList<Integer> list=new LinkedList<Integer>();

- Integer is a wrapper **class** around int
- **Integer** is a **class type** that extends **Object**
- Java provides autoboxing and auto unboxing between Integer and int

//auto boxing

Integer i= 49; //—> it is same as **Integer i=new Integer(49) —> This is autoboxing**

int j= I ; //—> It is same as **int j= i.intValue(); —> Auto boxing**

How to use LinkedList<int>

1. create a **LinkedList<Integer>** not ~~**LinkedList<int>**~~
2. Add int value normally --> autoboxing will convert int to integer
3. Access int value normally —> autounboxing will convert Integer to int

Accessing All Items of a List

Tuesday, June 2, 2020 3:28 PM

Manual way

- Remember the last access index and node
- if the request is for next item, it will be fast,
- else go sequential.

Implementing Iterator Pattern

- Sequential access is such an important use case that it is a **Design Pattern called Iterator.**
- Iterator defines an infrastructure so that each Item can be accessed in a given sequence one after another
- Java defines an Iterator interface that you should be implementing

Java Iterator Interface

- next()
  - return a value and moves to next item
- hasNext()
  - reurns a if there is a next item

- Java Iterators are generally implemented using an inner class

- A class that has an iterator is Iterable.

```
pubilc interface Iterable<T>{
        Iterator<T> iterator()
}
public interface Iterator<T>{

        T next();   //returns the next item

        boolean hasNext();  //tells if there
        is a next item avaialble

}
```

```
class LinkedList<T> implements Iterable<T> {

        public Iterator<T> iterator(){
                return new MyIterator();
        }

        class MyIterator implements Iterator<T>{
                public T next(){

                }

                public boolean hasNext(){

                }

        }
}
```

How do I Use Iterator

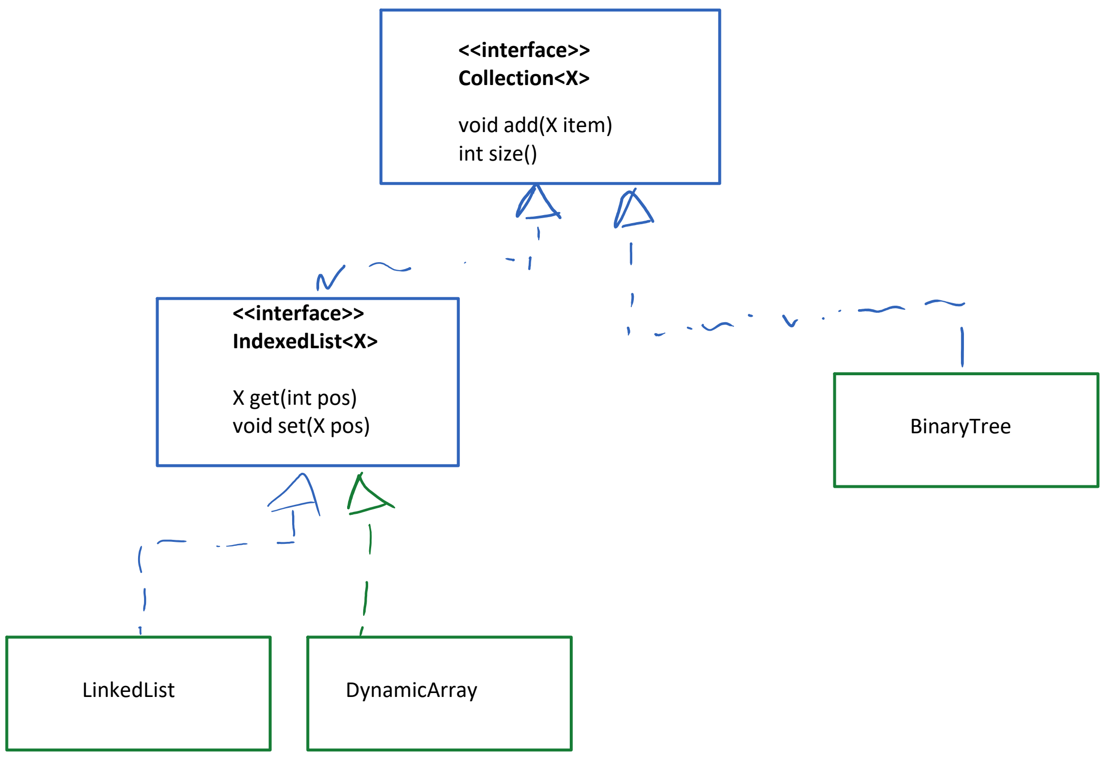
- There are two way to use Iterator
  1. Traditional Object Oriented Way
  2. using for loop

1. Using Object Oriented Approach

```
@Test
public void accessIterableValues(){

        Iterator<Integer> it= list.iterator();
        while(it.hasNext()){
                int value= it.next(); //instead of list.get()
        }
}
```

Collection Hierarcy

Tuesday, June 2, 2020 4:34 PM

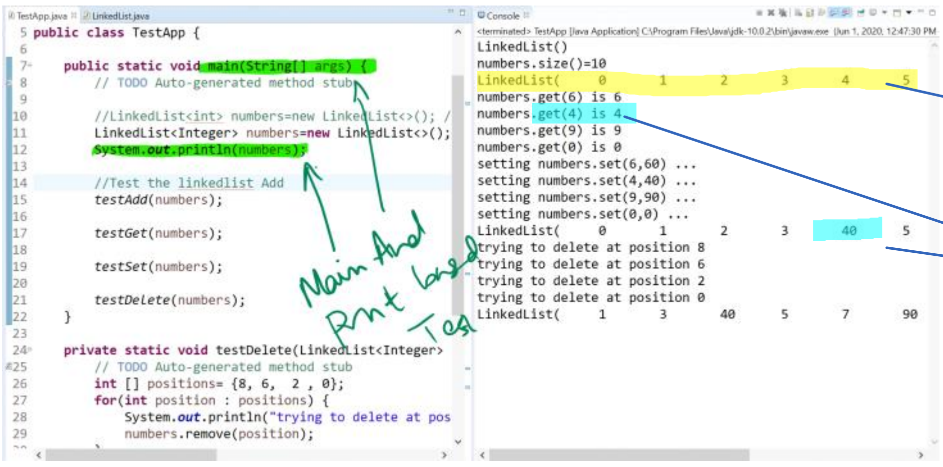


Print and Main Based Test

Monday, June 1, 2020   12:56 PM

main() function wasn't designed to test your code. It was to run a tested code

- print() is for output and the output is for **Humans**
- with a print() outptu you must look and verify if the result is expected or not
    - system can't decide for your
    - This is a manual testing process not automated testing process.
- main() is not for testing, its to run one core activity
    - Test should test different part of a system



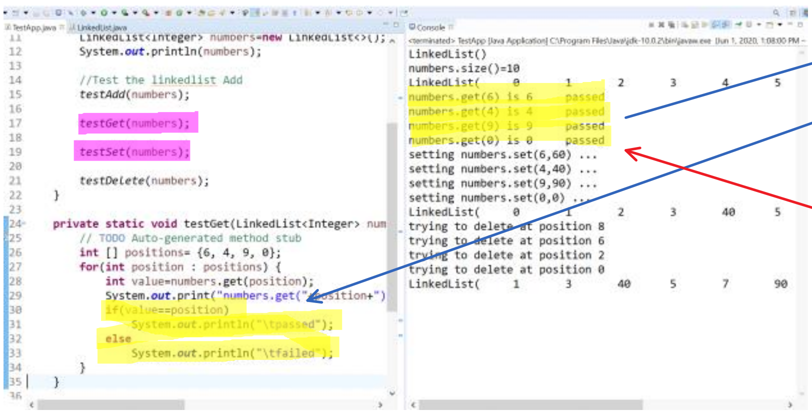
```java
public class TestApp {

    public static void main(String[] args) {
        // TODO Auto-generated method stub

        //LinkedList<int> numbers=new LinkedList<>(); /
        LinkedList<Integer> numbers=new LinkedList<>();
        System.out.println(numbers);

        //Test the linkedlist Add
        testAdd(numbers);

        testGet(numbers);

        testSet(numbers);

        testDelete(numbers);
    }

    private static void testDelete(LinkedList<Integer>
        // TODO Auto-generated method stub
        int [] positions= {8, 6,  2 , 0};
        for(int position : positions) {
            System.out.println("trying to delete at pos
            numbers.remove(position);
```

```
<terminated> TestApp [Java Application] C:\Program Files\Java\jdk-10.0.2\bin\javaw.exe (Jun 1, 2020, 12:47:30 PM
LinkedList()
numbers.size()=10
LinkedList(     0       1       2       3       4       5
numbers.get(6) is 6
numbers.get(4) is 4
numbers.get(9) is 9
numbers.get(0) is 0
setting numbers.set(6,60) ...
setting numbers.set(4,40) ...
setting numbers.set(9,90) ...
setting numbers.set(0,0) ...
LinkedList(     0       1       2       3       40      5
trying to delete at position 8
trying to delete at position 6
trying to delete at position 2
trying to delete at position 0
LinkedList(     1       3       40      5       7       90
```

Problems

1. How do we know where first test ends and second begins?
    a. Which test prints this line — testAdd or testGet?
2. How do I know if the printed value is the expected value?
    a. Even wrong value printed will still be an output.
    b. Are we sure we expected this output?

One Result Can Influence Other Result



```java
        LinkedList<Integer> numbers=new LinkedList<>();
        System.out.println(numbers);

        //Test the linkedlist Add
        testAdd(numbers);

        testGet(numbers);

        testSet(numbers);

        testDelete(numbers);
    }

    private static void testGet(LinkedList<Integer> num
        // TODO Auto-generated method stub
        int [] positions= {6, 4, 9, 0};
        for(int position : positions) {
            int value=numbers.get(position);
            System.out.print("numbers.get("+position+")
            if(value==position)
                System.out.println("\tpassed");
            else
                System.out.println("\tfailed");
        }
    }
```

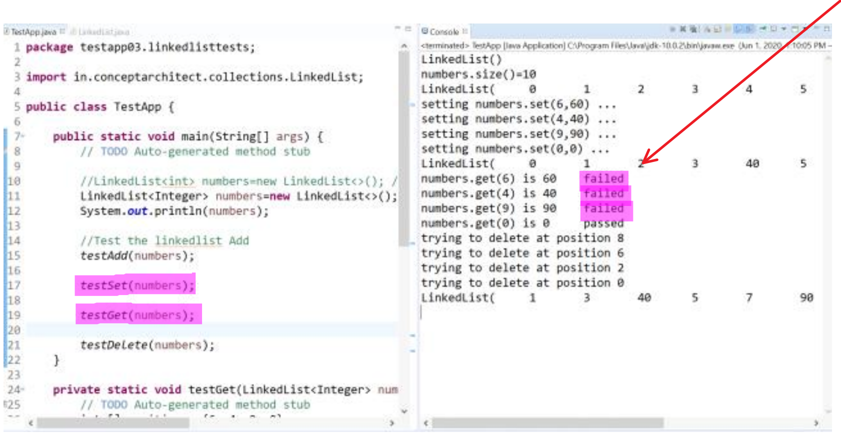
```
<terminated> TestApp [Java Application] C:\Program Files\Java\jdk-10.0.2\bin\javaw.exe (Jun 1, 2020, 1:08:00 PM -
LinkedList()
numbers.size()=10
LinkedList(     0       1       2       3       4       5
numbers.get(6) is 6     passed
numbers.get(4) is 4     passed
numbers.get(9) is 9     passed
numbers.get(0) is 0     passed
setting numbers.set(6,60) ...
setting numbers.set(4,40) ...
setting numbers.set(9,90) ...
setting numbers.set(0,0) ...
LinkedList(     0       1       2       3       40      5
trying to delete at position 8
trying to delete at position 6
trying to delete at position 2
trying to delete at position 0
LinkedList(     1       3       40      5       7       90
```

Test Results can be interpreted better

if there is a good logic written

Problem

3. Test Result Changes when we change the order of the test.
    a. Are we sure getFunction is working currectly?
    b. which of the two gives test result more accurate?
    c. How to we decide the correct sequence?
    d. Will user of my code use the code in same sequence?
        i. Do they need to call get becore calling set?
    e. Result is changing based on call sequence



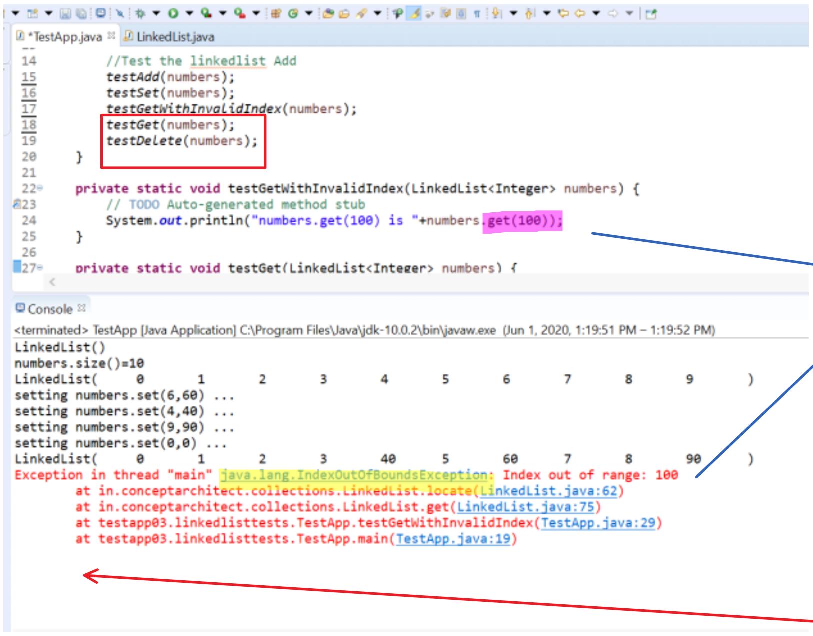
```java
package testapp03.linkedlisttests;

import in.conceptarchitect.collections.LinkedList;

public class TestApp {

    public static void main(String[] args) {
        // TODO Auto-generated method stub

        //LinkedList<int> numbers=new LinkedList<>(); /
        LinkedList<Integer> numbers=new LinkedList<>();
        System.out.println(numbers);

        //Test the linkedlist Add
        testAdd(numbers);

        testSet(numbers);

        testGet(numbers);

        testDelete(numbers);
    }

    private static void testGet(LinkedList<Integer> num
        // TODO Auto-generated method stub
```

```
<terminated> TestApp [Java Application] C:\Program Files\Java\jdk-10.0.2\bin\javaw.exe (Jun 1, 2020, 1:10:05 PM -
LinkedList()
numbers.size()=10
LinkedList(     0       1       2       3       4       5
setting numbers.set(6,60) ...
setting numbers.set(4,40) ...
setting numbers.set(9,90) ...
setting numbers.set(0,0) ...
LinkedList(     0       1       2       3       40      5
numbers.get(6) is 60    failed
numbers.get(4) is 40    failed
numbers.get(9) is 90    failed
numbers.get(0) is 0     passed
trying to delete at position 8
trying to delete at position 6
trying to delete at position 2
trying to delete at position 0
LinkedList(     1       3       40      5       7       90
```

Problem 5

- Are we sure we have tested all scenario?
- Is my application Working correctly with invalid index?

- Is my application working correctly with invalid index?



```
*TestApp.java   LinkedList.java
14          //Test the linkedlist Add
15          testAdd(numbers);
16          testSet(numbers);
17          testGetWithInvalidIndex(numbers);
18          testGet(numbers);
19          testDelete(numbers);
20      }
21
22      private static void testGetWithInvalidIndex(LinkedList<Integer> numbers) {
23          // TODO Auto-generated method stub
24          System.out.println("numbers.get(100) is "+numbers.get(100));
25      }
26
27      private static void testGet(LinkedList<Integer> numbers) {
```

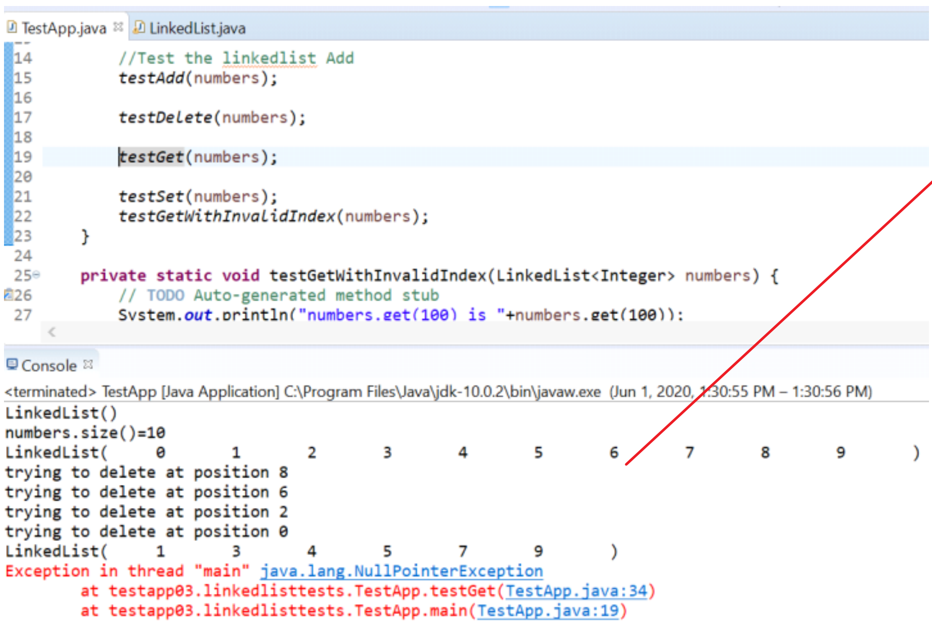
```
Console
<terminated> TestApp [Java Application] C:\Program Files\Java\jdk-10.0.2\bin\javaw.exe  (Jun 1, 2020, 1:19:51 PM – 1:19:52 PM)
LinkedList()
numbers.size()=10
LinkedList(     0       1       2       3       4       5       6       7       8       9       )
setting numbers.set(6,60) ...
setting numbers.set(4,40) ...
setting numbers.set(9,90) ...
setting numbers.set(0,0) ...
LinkedList(     0       1       2       3       40      5       60      7       8       90      )
Exception in thread "main" java.lang.IndexOutOfBoundsException: Index out of range: 100
        at in.conceptarchitect.collections.LinkedList.locate(LinkedList.java:62)
        at in.conceptarchitect.collections.LinkedList.get(LinkedList.java:75)
        at testapp03.linkedlisttests.TestApp.testGetWithInvalidIndex(TestApp.java:29)
        at testapp03.linkedlisttests.TestApp.main(TestApp.java:19)
```

Problem 5.1

- Is the result a proof of success or a proof failure?
  - Does this exception mean success or fail?
- For a invalid index (100) my code is expected to throw **IndexOutOfBoundsException**
  - Since we are getting what we are expecting the LinkedList Code is working correctly (as per expectation)
  - But Human eyes see
    - Red as Trouble
  - Developers eyes see
    - Exception as Red as Trouble

Problem 6

- What about the remaining tests — testGet() and testDelete()?
- You see they haven't executed.
  - Exception breaks the program



```
TestApp.java   LinkedList.java
14          //Test the linkedlist Add
15          testAdd(numbers);
16
17          testDelete(numbers);
18
19          testGet(numbers);
20
21          testSet(numbers);
22          testGetWithInvalidIndex(numbers);
23      }
24
25      private static void testGetWithInvalidIndex(LinkedList<Integer> numbers) {
26          // TODO Auto-generated method stub
27          System.out.println("numbers.get(100) is "+numbers.get(100));
```

```
Console
<terminated> TestApp [Java Application] C:\Program Files\Java\jdk-10.0.2\bin\javaw.exe  (Jun 1, 2020, 1:30:55 PM – 1:30:56 PM)
LinkedList()
numbers.size()=10
LinkedList(     0       1       2       3       4       5       6       7       8       9       )
trying to delete at position 8
trying to delete at position 6
trying to delete at position 2
trying to delete at position 0
LinkedList(     1       3       4       5       7       9       )
Exception in thread "main" java.lang.NullPointerException
        at testapp03.linkedlisttests.TestApp.testGet(TestApp.java:34)
        at testapp03.linkedlisttests.TestApp.main(TestApp.java:19)
```

Most Important Problem

- Is this just a sequencing problem or a real error?
- Error exists in testAdd(), testDelete() or testGet()
- Is there a bug in LinkedList add(), get(), delete()

Summary

1. print is for human eyes.
   a. A causal glance may not tell you if result is expected or not
   b. Wrong result is also printed the same way as right result
   c. Makes testing manual, system can't tell it worked or failed
   d. test boundries are not clear
2. test results influence each other
   a. reording the sequence may cause wrong answers even if there is no bug in the code
3. Sad path testing (Exceptions) may look like a failure even when they are success
4. Exception breaks the exuection of application so remaining test may not execute
5. When a bug comes it may be due to
   a. calling all functions together
   b. due to a function which had bug but was not discovered earlier
6. Since we are calling several functions we are not sure who the real culprit is.

Unit Testing Framework

Monday, June 1, 2020 1:39 PM

- Modern age testing tools
- Special framework to make testing easy

Qualities of a Good Testing Framework

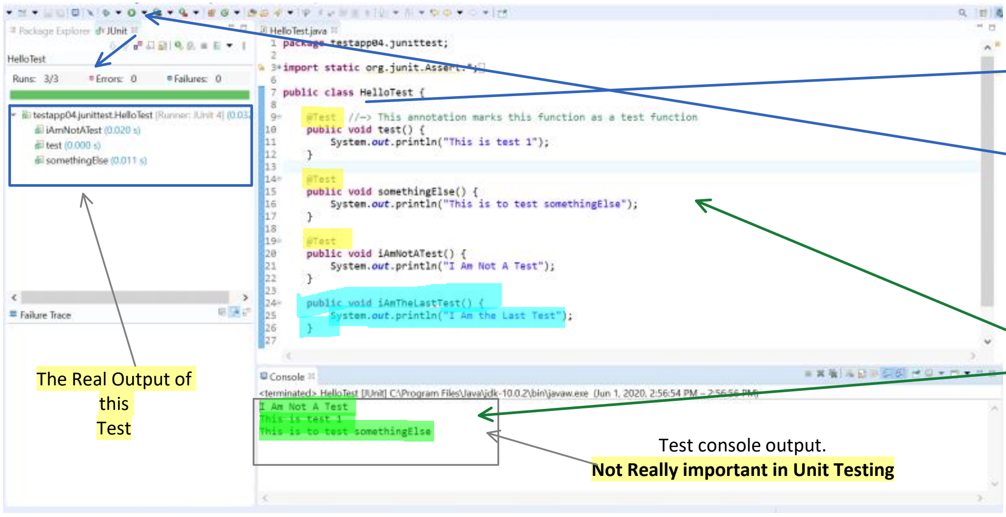
1. Automatic
    a. Can detect if the test is giving correct result or not
        i. Not based on main() and print()
2. Atomic
    a. Each test is expected to test a very small atomic unit of the code and ensuring this piece works
3. Isolated
    a. Tests should not influence each other. They all should work independently
        i. easy to find out the real problem
4. Sad Path
    a. Should also successfully test the SAD path

Junit

- Junit is a unit testing framework for Java language
- It the first unit testing framework in any programming language.
- It influeced the design of testing frameworks across all programming languages.

Junit Test Design

Monday, June 1, 2020 2:57 PM



```
HelloTest
Runs: 3/3    Errors: 0    Failures: 0

testapp04.junittest.HelloTest [Runner: JUnit 4] (0.03
    iAmNotATest (0.020 s)
    test (0.000 s)
    somethingElse (0.011 s)
```

```java
package testapp04.junittest;

import static org.junit.Assert.*;

public class HelloTest {

    @Test  //--> This annotation marks this function as a test function
    public void test() {
        System.out.println("This is test 1");
    }

    @Test
    public void somethingElse() {
        System.out.println("This is to test somethingElse");
    }

    @Test
    public void iAmNotATest() {
        System.out.println("I Am Not A Test");
    }

    public void iAmTheLastTest() {
        System.out.println("I Am the Last Test");
    }

```

```
<terminated> HelloTest [JUnit] C:\Program Files\Java\jdk-10.0.2\bin\javaw.exe (Jun 1, 2020, 2:56:54 PM – 2:56:56 PM)
I Am Not A Test
This is test 1
This is to test somethingElse
```

The Real Output of this Test

Test console output.
Not Really important in Unit Testing

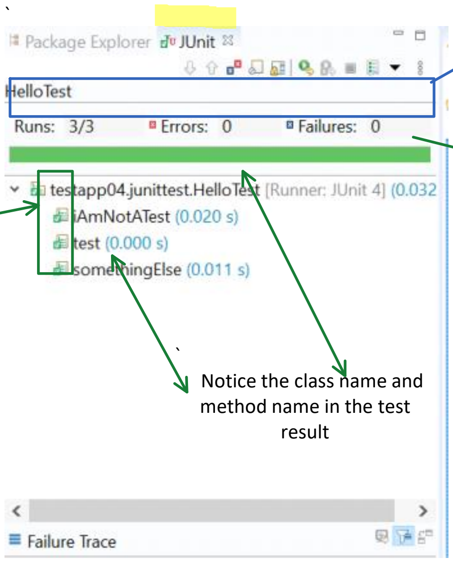
1. Marks our class and this method as A Test Method.
2. A Test Method is executed by a Test Framework
3. Methods that are marked as **@Test** are executed, others ignored

IMPORTANT!

- **Test doesn't have order.**
- **Order Is not important**
- **Remember: Each Test is Isolated**

Test Explorer

Monday, June 1, 2020 3:09 PM



HelloTest

Runs: 3/3 Errors: 0 Failures: 0

testapp04.junittest.HelloTest [Runner: JUnit 4] (0.032

iAmNotATest (0.020 s)

test (0.000 s)

somethingElse (0.011 s)

Failure Trace

Test Summary

- 3 our of 3 Test Executed
- Total Errors 0
- Total Failures 0

Tick against individual tests

- gree indicates success

Green Bar

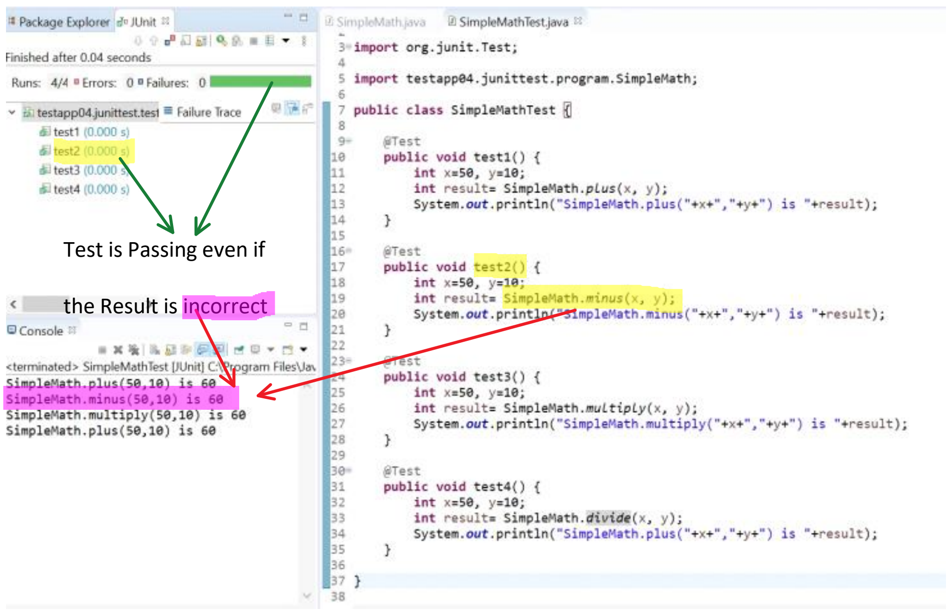
- Junit uses green color to mark success
- You get this green bar only if All your tests are success.
- If any test fails, the bar will be dark red (brown)

Notice the class name and method name in the test result

Why has all test passed?

What is a Test Pass or fail?

Monday, June 1, 2020 3:29 PM



Finished after 0.04 seconds

Runs: 4/4 Errors: 0 Failures: 0

testapp04.junittest.test
- test1 (0.000 s)
- test2 (0.000 s)
- test3 (0.000 s)
- test4 (0.000 s)

Test is Passing even if

the Result is incorrect

```
<terminated> SimpleMathTest [JUnit] C:\Program Files\Jav
SimpleMath.plus(50,10) is 60
SimpleMath.minus(50,10) is 60
SimpleMath.multiply(50,10) is 60
SimpleMath.plus(50,10) is 60
```

```java
import org.junit.Test;

import testapp04.junittest.program.SimpleMath;

public class SimpleMathTest {

    @Test
    public void test1() {
        int x=50, y=10;
        int result= SimpleMath.plus(x, y);
        System.out.println("SimpleMath.plus("+x+","+y+") is "+result);
    }

    @Test
    public void test2() {
        int x=50, y=10;
        int result= SimpleMath.minus(x, y);
        System.out.println("SimpleMath.minus("+x+","+y+") is "+result);
    }

    @Test
    public void test3() {
        int x=50, y=10;
        int result= SimpleMath.multiply(x, y);
        System.out.println("SimpleMath.multiply("+x+","+y+") is "+result);
    }

    @Test
    public void test4() {
        int x=50, y=10;
        int result= SimpleMath.divide(x, y);
        System.out.println("SimpleMath.plus("+x+","+y+") is "+result);
    }

}
```

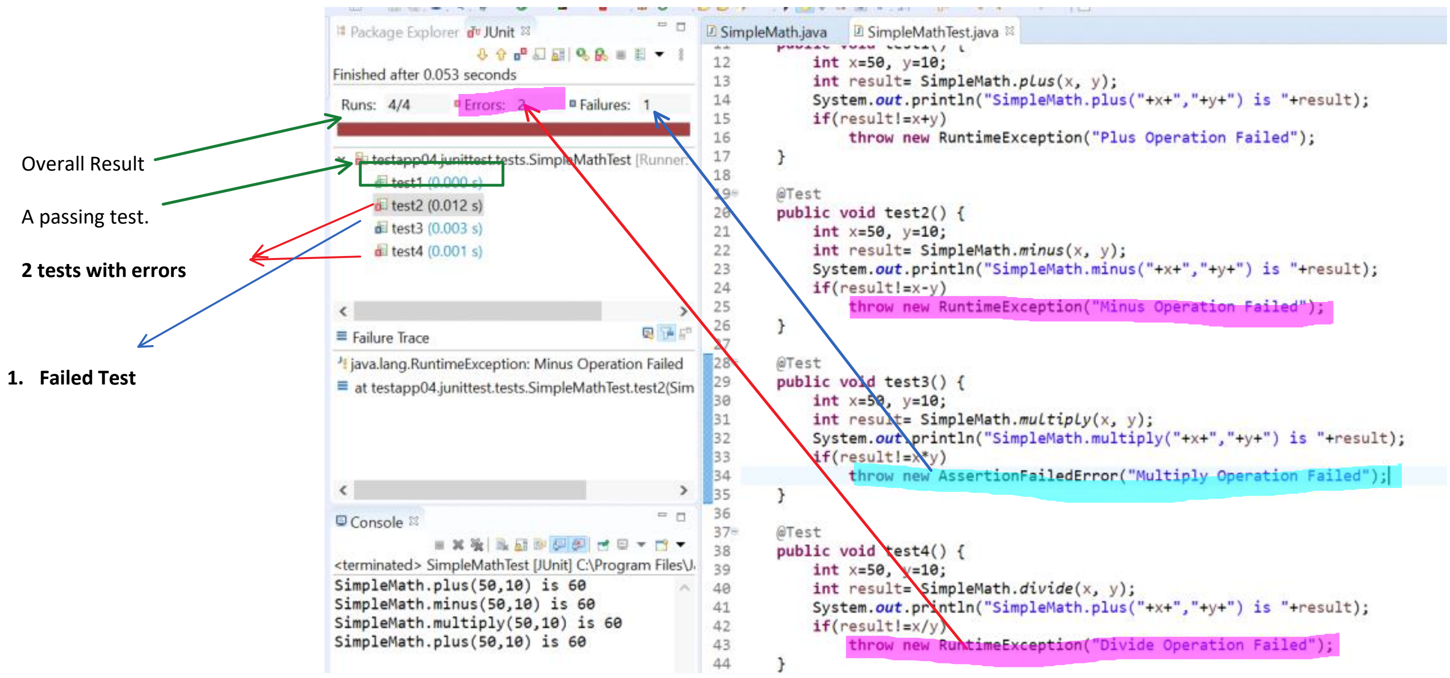
Why does the test pass?

- Junit doesn't know what is the expected output
- If wrong result printed is an output
- We follow a simple rule

No news is a good news. So unless there is something Exception wrong, it is a success.

Test with Errors

Monday, June 1, 2020 3:36 PM



Finished after 0.053 seconds

Runs: 4/4 Errors: 2 Failures: 1

testapp04.junittest.tests.SimpleMathTest [Runner:
- test1 (0.000 s)
- test2 (0.012 s)
- test3 (0.003 s)
- test4 (0.001 s)

```
java.lang.RuntimeException: Minus Operation Failed
at testapp04.junittest.tests.SimpleMathTest.test2(Sim
```

```
<terminated> SimpleMathTest [JUnit] C:\Program Files\J
SimpleMath.plus(50,10) is 60
SimpleMath.minus(50,10) is 60
SimpleMath.multiply(50,10) is 60
SimpleMath.plus(50,10) is 60
```

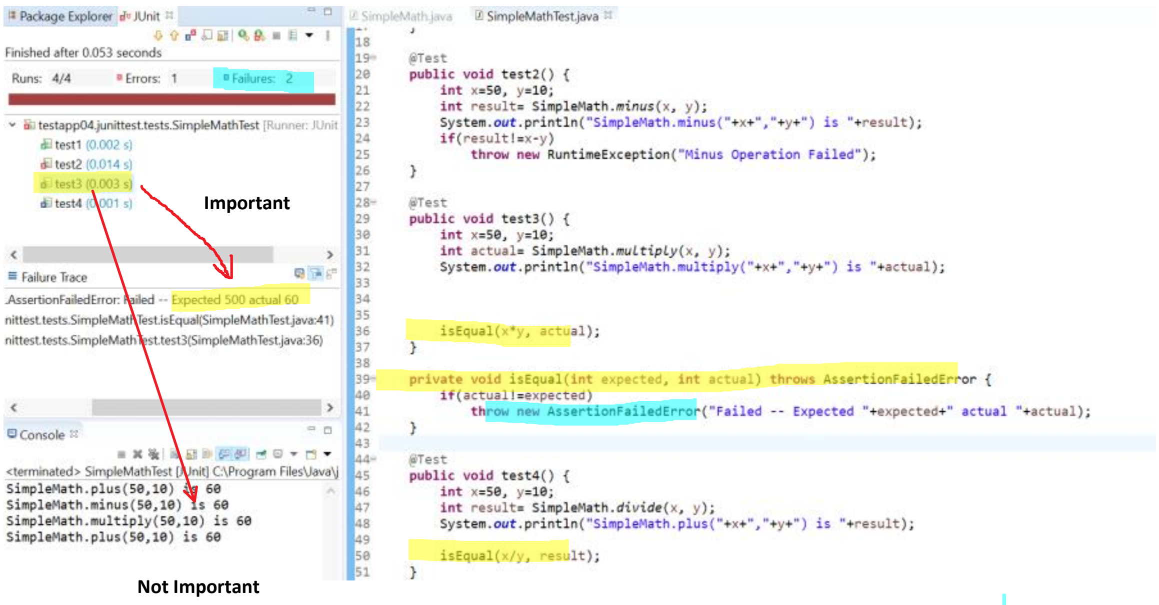
```java
        int x=50, y=10;
        int result= SimpleMath.plus(x, y);
        System.out.println("SimpleMath.plus("+x+","+y+") is "+result);
        if(result!=x+y)
            throw new RuntimeException("Plus Operation Failed");
    }

    @Test
    public void test2() {
        int x=50, y=10;
        int result= SimpleMath.minus(x, y);
        System.out.println("SimpleMath.minus("+x+","+y+") is "+result);
        if(result!=x-y)
            throw new RuntimeException("Minus Operation Failed");
    }

    @Test
    public void test3() {
        int x=50, y=10;
        int result= SimpleMath.multiply(x, y);
        System.out.println("SimpleMath.multiply("+x+","+y+") is "+result);
        if(result!=x*y)
            throw new AssertionFailedError("Multiply Operation Failed");
    }

    @Test
    public void test4() {
        int x=50, y=10;
        int result= SimpleMath.divide(x, y);
        System.out.println("SimpleMath.plus("+x+","+y+") is "+result);
        if(result!=x/y)
            throw new RuntimeException("Divide Operation Failed");
    }
```

What is the difference between an Error and A failure

- The purpose of a unit test is to indentify if the code is working as expected
  - expected working => function gives the expected result
- A function that gives unexpected result is a **failure**.
  - Function completes execution
  - It returns a result
  - The result is not what we expected.
  - Internally jUnit throws AssertionFailedException to indicate failure
- If a function fails to complete it is an error
  - If a function throws an exception while execution
  - Its execution is not complete
  - It has not produced a result to be considered success or failure
  - It is considered as an error.
  - Any exception other than AssertionFailedError make it an Error

Error And Failure

Monday, June 1, 2020 3:55 PM



```
Finished after 0.053 seconds

Runs: 4/4     Errors: 1     Failures: 2

testapp04.junittest.tests.SimpleMathTest [Runner: JUnit
    test1 (0.002 s)
    test2 (0.014 s)
    test3 (0.003 s)
    test4 (0.001 s)

Failure Trace
.AssertionFailedError: Failed -- Expected 500 actual 60
nittest.tests.SimpleMathTest.isEqual(SimpleMathTest.java:41)
nittest.tests.SimpleMathTest.test3(SimpleMathTest.java:36)
```

```
Console
<terminated> SimpleMathTest [JUnit] C:\Program Files\Java\j
SimpleMath.plus(50,10) is 60
SimpleMath.minus(50,10) is 60
SimpleMath.multiply(50,10) is 60
SimpleMath.plus(50,10) is 60
```

```java
18
19      @Test
20      public void test2() {
21          int x=50, y=10;
22          int result= SimpleMath.minus(x, y);
23          System.out.println("SimpleMath.minus("+x+","+y+") is "+result);
24          if(result!=x-y)
25              throw new RuntimeException("Minus Operation Failed");
26      }
27
28      @Test
29      public void test3() {
30          int x=50, y=10;
31          int actual= SimpleMath.multiply(x, y);
32          System.out.println("SimpleMath.multiply("+x+","+y+") is "+actual);
33
34
35
36          isEqual(x*y, actual);
37      }
38
39      private void isEqual(int expected, int actual) throws AssertionFailedError {
40          if(actual!=expected)
41              throw new AssertionFailedError("Failed -- Expected "+expected+" actual "+actual);
42      }
43
44      @Test
45      public void test4() {
46          int x=50, y=10;
47          int result= SimpleMath.divide(x, y);
48          System.out.println("SimpleMath.plus("+x+","+y+") is "+result);
49
50          isEqual(x/y, result);
51      }
```

We can have Test Helper

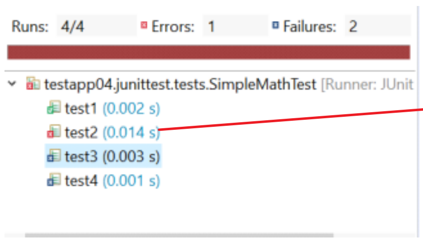
that throws

AssertionFailedEerror

in case the expected condition is not me

Test Design Practices

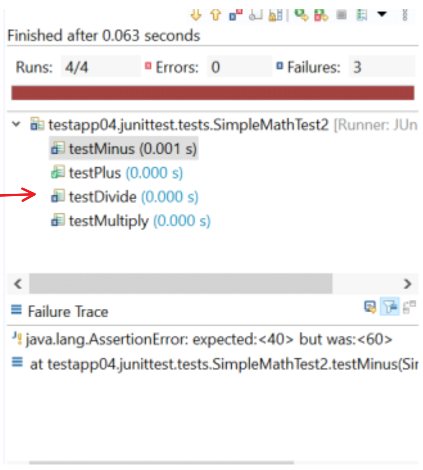
Monday, June 1, 2020 4:01 PM



```
Runs: 4/4    Errors: 1    Failures: 2

testapp04.junittest.tests.SimpleMathTest [Runner: JUnit
    test1 (0.002 s)
    test2 (0.014 s)
    test3 (0.003 s)
    test4 (0.001 s)
```

What does test2 do?

- Which programming logic has error?
- How do I know looking at this test result alone?
- What does test2 represent here?



```
Finished after 0.063 seconds

Runs: 4/4    Errors: 0    Failures: 3

testapp04.junittest.tests.SimpleMathTest2 [Runner: JUn
    testMinus (0.001 s)
    testPlus (0.000 s)
    testDivide (0.000 s)
    testMultiply (0.000 s)

Failure Trace
java.lang.AssertionError: expected:<40> but was:<60>
at testapp04.junittest.tests.SimpleMathTest2.testMinus(Si
```

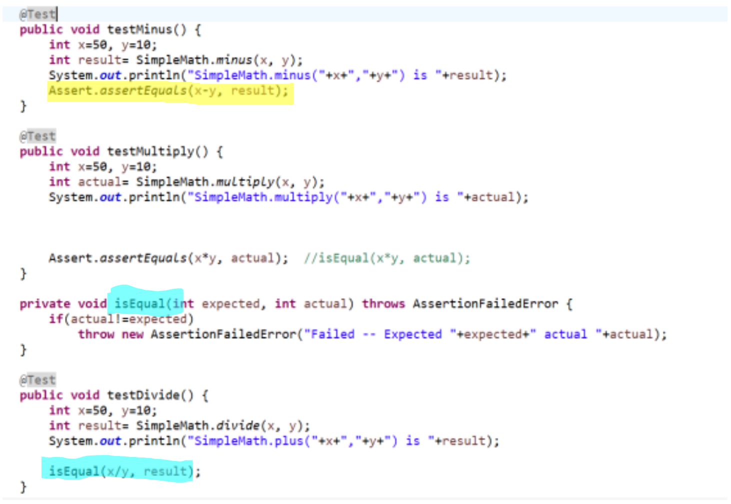
What does this method do?

- Which one has failed?

Your Test Names should be meaningful

Assertion Library

Monday, June 1, 2020 4:09 PM



```java
@Test
public void testMinus() {
    int x=50, y=10;
    int result= SimpleMath.minus(x, y);
    System.out.println("SimpleMath.minus("+x+","+y+") is "+result);
    Assert.assertEquals(x-y, result);
}

@Test
public void testMultiply() {
    int x=50, y=10;
    int actual= SimpleMath.multiply(x, y);
    System.out.println("SimpleMath.multiply("+x+","+y+") is "+actual);



    Assert.assertEquals(x*y, actual);  //isEqual(x*y, actual);
}

private void isEqual(int expected, int actual) throws AssertionFailedError {
    if(actual!=expected)
        throw new AssertionFailedError("Failed -- Expected "+expected+" actual "+actual);
}

@Test
public void testDivide() {
    int x=50, y=10;
    int result= SimpleMath.divide(x, y);
    System.out.println("SimpleMath.plus("+x+","+y+") is "+result);

    isEqual(x/y, result);
}
```

Both are conceptually same. **isEquals** is our own logic
Assert.assertEquals is a junit library that does the exact same job

jUnit has provided several such functions to Assert on your result
You get a failure when your result is not as per expectation. Common Assert includes

- assertEquals
- assertNotEquals
- assertTrue
- assertNotNull
- assertNull
- fail() <— absolute failure

You may need to write multiple test for a single method

Monday, June 1, 2020 4:14 PM

Example:

- **Is divide working correctly if denominator is non-zero**
- **Is divide working correctly if denominator is zero**

How do I name different tests related to same divide method?

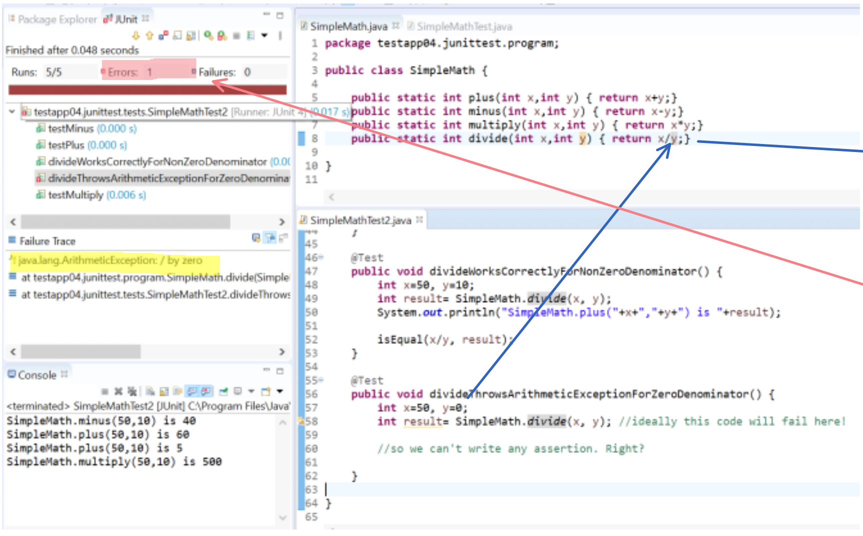
- divideReturnsCorrectResultForNonZeroDenominator()
- divideThrowsExceptionForZeroDenominator()

A test name should follow **DAMP** principle

DAMP --> Descriptive and menaingful phrases
- **Normally you method names should menaingful words.**
- **Your test metods should be longer and descripive phrases or sentenses not just words**

Asserting For Exception

Monday, June 1, 2020 4:22 PM



```
Finished after 0.048 seconds
Runs: 5/5    Errors: 1    Failures: 0

testapp04.junittest.tests.SimpleMathTest2 [Runner: JUnit 4] (0.017 s)
    testMinus (0.000 s)
    testPlus (0.000 s)
    divideWorksCorrectlyForNonZeroDenominator (0.0
    divideThrowsArithmeticExceptionForZeroDenomina
    testMultiply (0.006 s)
```

```
java.lang.ArithmeticException: / by zero
at testapp04.junittest.program.SimpleMath.divide(Simple
at testapp04.junittest.tests.SimpleMathTest2.divideThrows
```

```
<terminated> SimpleMathTest2 [JUnit] C:\Program Files\Java\
SimpleMath.minus(50,10) is 40
SimpleMath.plus(50,10) is 60
SimpleMath.plus(50,10) is 5
SimpleMath.multiply(50,10) is 500
```

SimpleMath.java

```java
package testapp04.junittest.program;

public class SimpleMath {

    public static int plus(int x,int y) { return x+y;}
    public static int minus(int x,int y) { return x-y;}
    public static int multiply(int x,int y) { return x*y;}
    public static int divide(int x,int y) { return x/y;}

}
```

SimpleMathTest2.java

```java
    /

    @Test
    public void divideWorksCorrectlyForNonZeroDenominator() {
        int x=50, y=10;
        int result= SimpleMath.divide(x, y);
        System.out.println("SimpleMath.plus("+x+","+y+") is "+result);

        isEqual(x/y, result);
    }

    @Test
    public void divideThrowsArithmeticExceptionForZeroDenominator() {
        int x=50, y=0;
        int result= SimpleMath.divide(x, y); //ideally this code will fail here!

        //so we can't write any assertion. Right?

    }

}
```

If y == 0 it throws
ArithmeticException

It is an expected behavior
So the test should pass

But since it is a error it is categorized as
Error

Important!

- Even if except is thrown, The tests continued to execute without any interruption.
- Failure of one test case doesn't effect the other.

How to handle expected exception

1. User define approach

```
@Test
public  void divideByZeroShouldThrowArithmeticException(){

        try{
                SimpleMath.divide(7,0); //should throw ArithemeticException

                //If I reach here. It means exception is not throw  and
                //the test has failed
                fail("excpected exception ArithmeticException wasn't thrown");
        }catch(ArithmeticException ex){
                //test passed as the exception was expected
                //do nothing and test will pass.
        }


}
```

2. Junit approach

```
//indicate which exception you exception
@Test(expected = ArithmeticException.class)
public void divideThrowsArithmeticExceptionIfDenominatorIsZero() {
            SimpleMath.divide(7, 0);
    }
```

You may still need to user approach 1 if you need to assert on the values of Exception such as message or nested exception

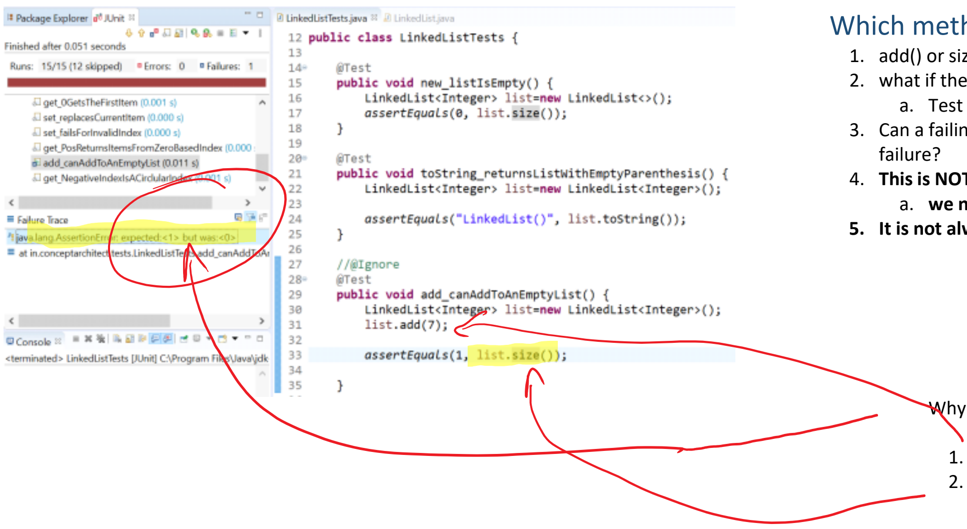
Assignment

Monday, June 1, 2020 4:35 PM

- Create a jUnit test for LinkedLIst
    - Write test cases for
        - get/set
            - should return value from beginning of list
            - from end of list
            - should throw IndexOutOfBoundException for invalid index
        - add
            - adds to the empty list
            - adds item to the end of non-empty list
        - remove
            - can remove first item
            - can remove last item
            - can remove middle item
        - toString
            - what test can you do with toString?

Is it a unit test

Tuesday, June 2, 2020 10:31 AM



```
Finished after 0.051 seconds
Runs: 15/15 (12 skipped)   Errors: 0   Failures: 1

get_0GetsTheFirstItem (0.001 s)
set_replacesCurrentItem (0.000 s)
set_failsForInvalidIndex (0.000 s)
get_PosReturnsItemsFromZeroBasedIndex (0.000
add_canAddToAnEmptyList (0.011 s)
get_NegativeIndexIsACircularIndex (0.001 s)

Failure Trace
java.lang.AssertionError: expected:<1> but was:<0>
at in.conceptarchitect.tests.LinkedListTests.add_canAddToAn

<terminated> LinkedListTests [JUnit] C:\Program Files\Java\jdk
```

```java
public class LinkedListTests {

    @Test
    public void new_listIsEmpty() {
        LinkedList<Integer> list=new LinkedList<>();
        assertEquals(0, list.size());
    }

    @Test
    public void toString_returnsListWithEmptyParenthesis() {
        LinkedList<Integer> list=new LinkedList<Integer>();

        assertEquals("LinkedList()", list.toString());
    }

    //@Ignore
    @Test
    public void add_canAddToAnEmptyList() {
        LinkedList<Integer> list=new LinkedList<Integer>();
        list.add(7);

        assertEquals(1, list.size());

    }
```

Which method are we really testing here?

1. add() or size()?
2. what if there is a logical error in the size()?
    a. Test will still fail.
3. Can a failing test conclusively prove that it's a add() failure and not size() failure?
4. **This is NOT a pure unit test**
    a. **we need to apply two different functions**
5. **It is not always possible to avoid this scenario.**

Why is size 0?

1. add failed to add the item. so size is 0
2. add was successful, but size has a unimplemented logic?

How do we isolate the problem

1. **(preferred)** the method under test can return a value that can be asserted upon
2. You methods should throw appropriate exceptions on failures and we can assert against failure.
    a. even if function is void and does't throw exception can indicate success
3. make sure we have comrehensive unit test for the helper method ensuring that the other method is working correctly.

Multiple Asserts

Tuesday, June 2, 2020 10:46 AM

```
@Test
public void add_canAddToAnEmptyList() {
        LinkedList<Integer> list=new LinkedList<Integer>();
        list.add(7);


        assertEquals(1, list.size());
        assertEquals("LinkedList(\t7\t)",list.toString());

}
```

Q1. How many assert can be present in single test?

Answer: There is not limit.

Q2. How many assert should be present in a single test

Answer: There are two school of thoughts

Answer 2.a Strict Rule

- There should be a single assert per test method
- Multiple asserts generally mean you are trying to do test multiple paths in a single test — this vioalates the basic idea of Unit testing
- You should have multiple tests testing all possible outcomes from a single method
  - Example
    - get with valid index
    - get with invalid index
    - get with circular index
- If multiple asserts are allowed test designers may just write one test to test all paths
- When first assertion fails, test fails. It doesn't move forward. So we don't know if others would work or not

Answer 2.b Contextual Descision

- Sometimes multiple asserts are mechanism to be double sure of a single fact
  - As it is in the above case
  - We are still doubly verifyng the outcome of adding to an empty list
- This may be a more holestic understanding.
  - logic of size() or toString() may be wrong
  - chances of both being wroing is slim

Recommendation

- Avoid multiple asserts as much as you.
- They often suggest you don't have a great strategy
- Don't be too strict that you can never have multiple asserts.
- When using multiple asserts, ask yourself if they test one code path only.
- Are they checking the same thing?

```
@Test
public void goodUseCaseOfMultiAssert(){

        list.add(10);           //when I add to an empty list

        assertEquals(1,size());   //list size increased
        assertEquals(10, list.get(0);  //and item becomes the first item

}
```

This is a good use case, but can we not test thiese two ideas as two separate tests?

```
@Test
public void badUseCaseOfMultiAssert(){

        list.add(2);
        list.add(9);
        list.add(15);

        assertEquals(2, list.get(0)); //can access 0th item
        assertEquals(15, list.get(2)); //can access last item
        assertEquals(15,list.get(-1)); //circular index is working
        try{
        list.get(100);
        fail("indexoutofbound not thrown");
        }
        catch(IndexOutOfBoundsException ex){

        }
}


}
```

Test AAA

Tuesday, June 2, 2020 11:04 AM

Every test conceptually follows the idea of AAA

- **Arrange**
  - Prepare for your test
  - Creatign the required objects
  - Add sample data which may be pre-requisite for a test
- **Act**
  - Peform the action which you are about to test
  - Gather the result if required
- **Assert**
  - specify what do you think the ideal response should be

It's a good idea to mark three comments in your test as //Arrange //Act //Assert

Arrange

- we often need same arrange in multiple tests.
- we can do such initialization at the class level rather than at the method level
- Where should I arrange
  1. In the constructor

Why I shouldn't arrange in constructor.

- Unit Testing framework follows a life cycle (check **Unit Test Lifecycle page**)

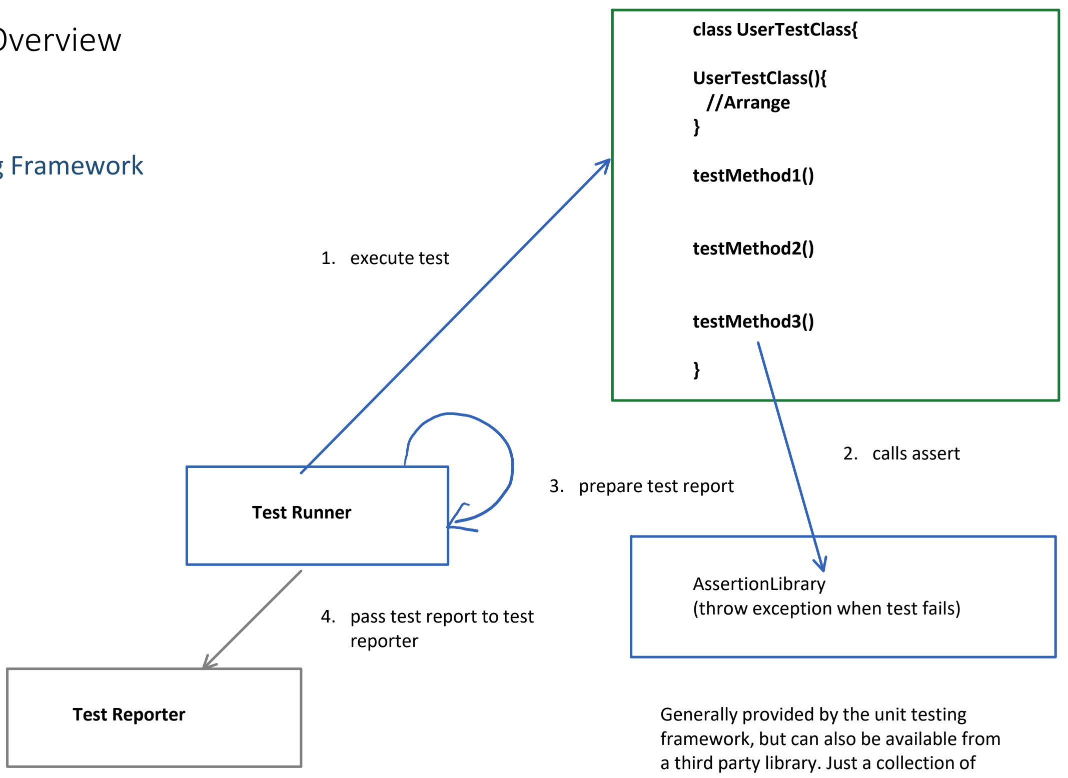
```
@Test
public void add_addedItemsAreShownInToString() {
    //ARRANGE

    //ACT
    list.add(1);
    list.add(2);
    list.add(3);

    //ASSERT
    assertEquals("LinkedList(\t1\t2\t3\t)",
    list.toString());
}


@Test
public void get_0GetsTheFirstItem() {
    //ARRANGE
    list.add(10);
    list.add(15);
    list.add(12);

    //ACT

    //ASSERT
}
```

Unit Test Architectural Overview

Tuesday, June 2, 2020 11:18 AM

Key Elements in a Unit Testing Framework

1. **Test Runner**
2. User Defined Test Class
3. Assertion Library
4. Test Reporter



```
class UserTestClass{

UserTestClass(){
  //Arrange
}

testMethod1()


testMethod2()


testMethod3()

}
```

Generally provided by the unit testing framework, but can also be available from a third party library. Just a collection of asserts to make your life easy

The Job of test Reporter is to present the test report to user
It can be thirdparty element also. Popular choices include

1. Console. Test framework can put result on console
2. Log file
3. **IDE GUI based test reporter (we use eclipse test reproter)**

How TestRunner Runs your Unit Test (psudocode to understand the flow)

```
public class TestRunner{

    public List<TestResult>  runTest( ){

        //Step 1. Create object of testClass
        Object testObject= new new LinkedListTest() ;

        ArrayList<TestResult> results=new ArrayList<TestResult>()
        for(TestMethod method :  testObject.getTestMethods())
        {
            //Object testObject=new LinkedListTest(); //Official junit 4 test runner only
            initMethod.execute()
            TestResult result= method.execute();
            results.add(result);
        }
        return result;

    }


}
```

1. constructor is called only once
a. same list is used by all three methods

2. each test is called (order not gurateed)

```
class LinkedListTest{
    LinkedList list;
    public void LinkedListTest(){
        list=new LinkedList();
        list.add(1);
        list.add(2);
    }

    @Test
    public void addTest(){   list.add(3); }

    @Test
    public void removeTest( list.remove(0); }

    @Test
    public void sizeTest( list.size(); }

}
```

all tests are using same linkedlist

what is the size of list in sizeTest()

- Result may vary on order of running
  - result 3 if sequence is
    - addTest-->sizeTest-->removeTest
  - result 2 if sequence is
    - sizeTest-->addTest-->removeTest
    - addTest-->removeTest-->sizeTest
  - result 1 if sequece is
    - removeTest-->sizeTest-->addTest
- Tests are influencing each other and not properly isolated.

How to Isolate The Test

- To Isolate the test, jUnit provides the concept init method
- **A init method is any method decorated with @Before annotation**

- **Note in the code above the @Before method is called before every running test**
- **Any initialization here ensure that each test gets the same set of data.**

Constructor Vs Init Method

- A constructor may execute only once before running all test methods
  - Constructor initialization may be shared among different testmethods
  - This may make the design non isolated
- @Before ensures that the method executes before each test
  - It can reset the arrangement
  - One test work doesn't effect others

you should avoid constructor initalization and follow @Before initlization

Junit 4 changes

- Junit 4 onwards, constructor is also called withing the loop
- Now constructor initialzation is also isolated just like @Before
- You can use either of them
- For backward compatiblity and easy readability you should always use @Before
- Many frameworks may replace the default test runner making it possible that constructor approach may fail
-

code coverage

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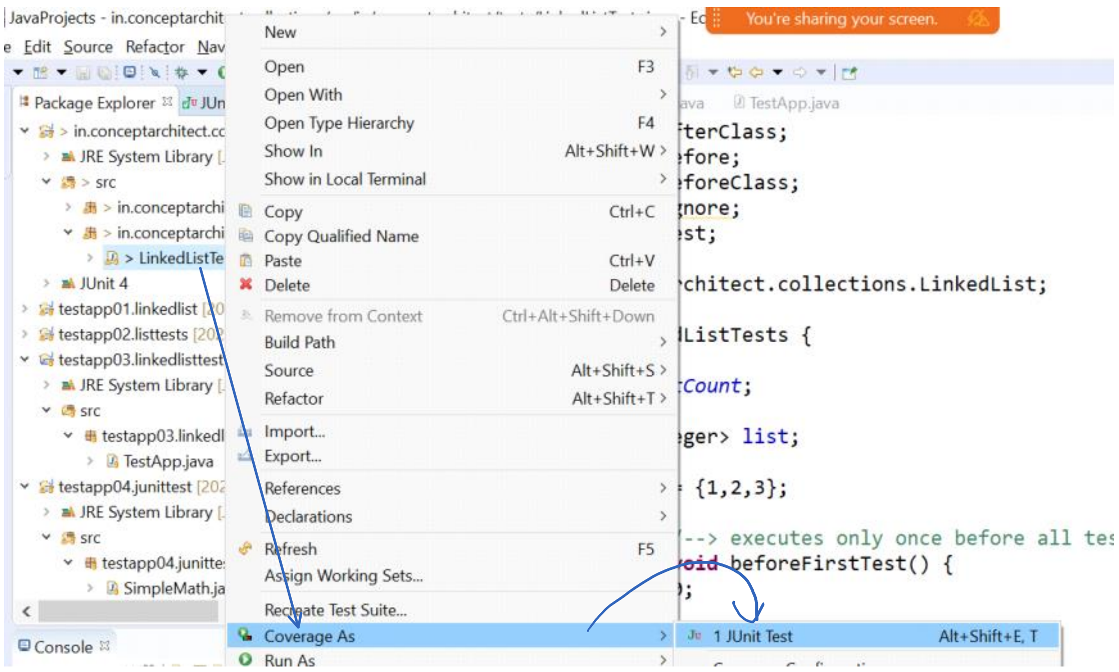
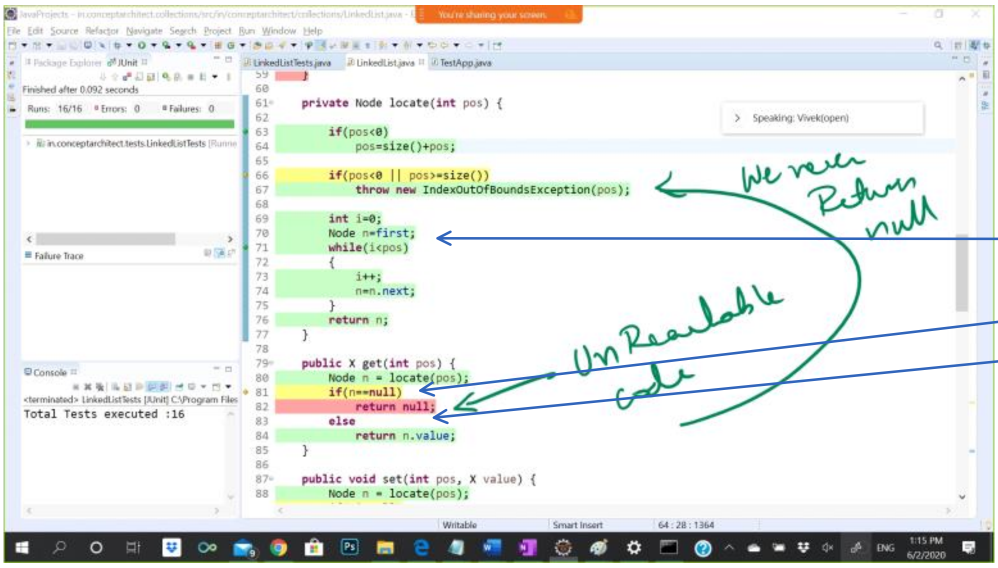




```
Total Tests executed :16
```

```java
    private Node locate(int pos) {

        if(pos<0)
            pos=size()+pos;

        if(pos<0 || pos>=size())
            throw new IndexOutOfBoundsException(pos);

        int i=0;
        Node n=first;
        while(i<pos)
        {
            i++;
            n=n.next;
        }
        return n;
    }

    public X get(int pos) {
        Node n = locate(pos);
        if(n==null)
            return null;
        else
            return n.value;
    }

    public void set(int pos, X value) {
        Node n = locate(pos);
```

Color Code

1. Green: This is tested by at least one of the tests
2. Yellow: Partially tested (as never entered the loop)
3. Red. No test reached this spot

What to do to handle Red code here

- Red code indicate that no test case ever reached here. There are two possible reasons

1. You have not written an important test case to reach there
   a. Think and plan the test to make sure you reach
   b. This should be your first preference

2. That code is actually a unreachable code
   a. Such codes are generally not required
   b. Remove them if you don't need them

Part Coverage

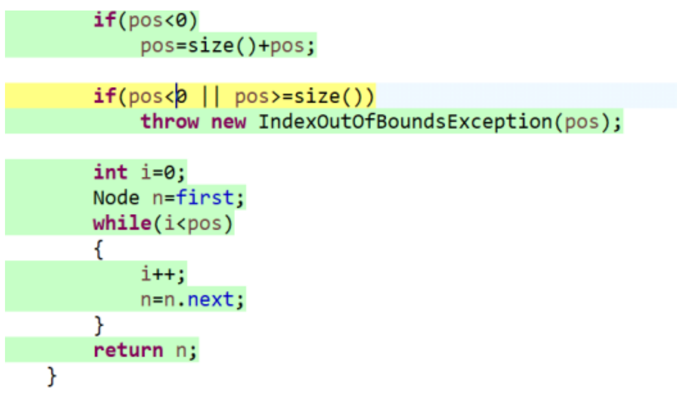
- Yellow indicate part of the coverage.
- In the given code if is a part coverage
- If has two conditions, probably we never hit one of them
- Solution

```java
private Node locate(int pos) {

        if(pos<0)
            pos=size()+pos;

        if(pos<0 || pos>=size())
```

- Yellow indicate part of the coverage.
- In the given code if is a part coverage
- If has two conditions, probably we never hit one of them
- Solution
    1. Write test case to hit the one which is not hit
    2. Delete un-needed condition
- How do



```
        if(pos<0)
            pos=size()+pos;

        if(pos<0 || pos>=size())
            throw new IndexOutOfBoundsException(pos);

        int i=0;
        Node n=first;
        while(i<pos)
        {
            i++;
            n=n.next;
        }
        return n;
    }
```

How do I know which condition is hit?

- you may try using two separate if to verify.

Timeout Test

Tuesday, June 2, 2020 2:52 PM

- Sometimes we need to make sure that method completes in a given time frame
- If method takes longer than expected, it should be considered a failure

time specified in ms

```
@Test(timeout = 50)
public void timeTakenToAccessMaxItems() {
        System.out.println("time taken to access "+max+" items");
        long sum=0;
        for(int i=0;i<list.size();i++) {
                sum+=list.get(i); //it is important we access the item
        }

        System.out.println("Sum of all values is "+sum);

}
```

TDD a.k.a TFD

Tuesday, June 2, 2020 4:39 PM

Test Driven Development (or Test First Development)

- In standard approach of SDLC we follow
    - design --> code --> test
- TFD says **Test first**
- **You start to write a test even before you have the test code**
- **This helps you evolve the design**

TDD paradigm --> Red Green Refactor

RED

- Start with a failing test
- Test will obviously fail as there is no code
- You write test cases that is more like a use case
    - since there is not code it would fail

Green

- Write the minimum code that will make the test pass.
- Focus is passing the test and not writing the correct logic
    - Write minimum logic even if not correct that should pass the test

Refactor

- Refactor your logic as an when needed
- Run test everytime to ensure your refactoring has not broken up tests

Why Start with a failing test?

- Here we are just defining the use case
- If it passes that means we already have a code
    - break TFD paradigm
- In this stage designer informs developer what code they are supposed to develop
    - what is the requirement
- This is more like a design documentation at this stage
    - A replacement for
        - UML
        - word document explaining the requirement

Why write code to make test pass and not to make it work?

- The minimum code is an agile way of acknowledging requirment
- developer says, I got the requirement
- The actual design shall be done in Refactor stage.