Program Structures & Algorithms

Spring 2022

Assignment No. 3

WQUPC

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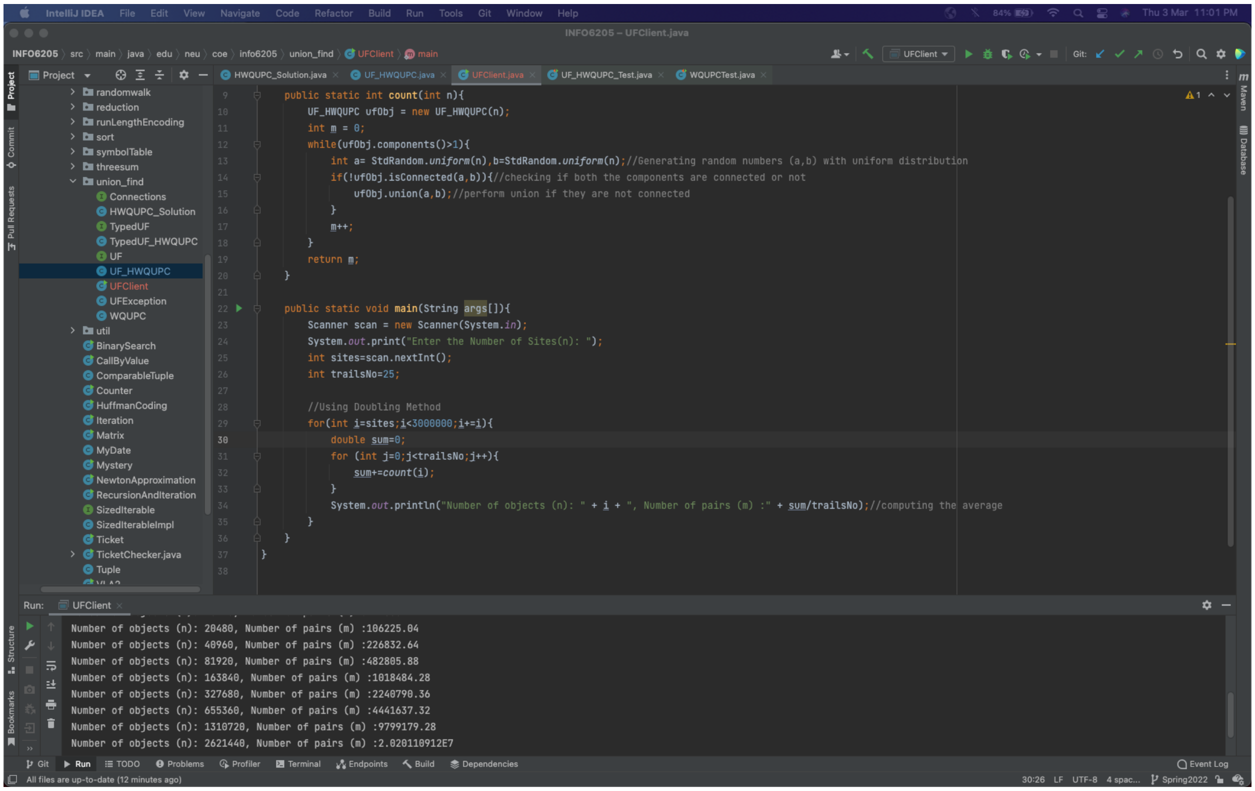
Section - 8

Task

1. (a) Implement height-weighted Quick Union with Path Compression.
   (b) Check that the unit tests for this class all work.
2. Using your implementation of UF_HWQUPC, develop a UF ("union-find") client that takes an integer value n from the command line to determine the number of "sites." Then generates random pairs of integers between 0 and n-1, calling connected() to determine if they are connected and union() if not. Loop until all sites are connected then print the number of connections generated. Package your program as a static method count() that takes n as the argument and returns the number of connections; and a main() that takes n from the command line, calls count() and prints the returned value.
3. Determine the relationship between the number of objects (*n*) and the number of pairs (*m*) generated to accomplish this (i.e. to reduce the number of components from *n* to 1).

Data Output



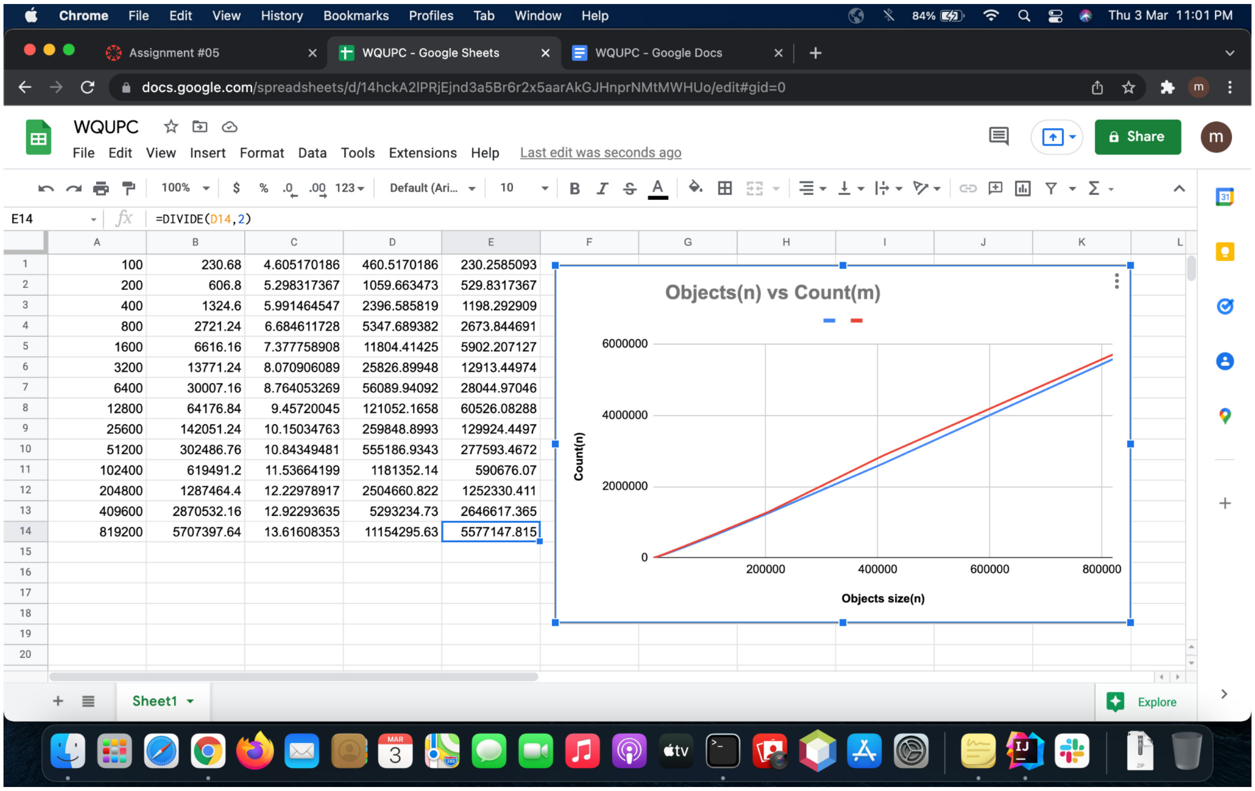
```java
    public static int count(int n){
        UF_HWQUPC ufObj = new UF_HWQUPC(n);
        int m = 0;
        while(ufObj.components()>1){
            int a= StdRandom.uniform(n),b=StdRandom.uniform(n);//Generating random numbers (a,b) with uniform distribution
            if(!ufObj.isConnected(a,b)){//checking if both the components are connected or not
                ufObj.union(a,b);//perform union if they are not connected
            }
            m++;
        }
        return m;
    }

    public static void main(String args[]){
        Scanner scan = new Scanner(System.in);
        System.out.print("Enter the Number of Sites(n): ");
        int sites=scan.nextInt();
        int trailsNo=25;

        //Using Doubling Method
        for(int i=sites;i<3000000;i+=i){
            double sum=0;
            for (int j=0;j<trailsNo;j++){
                sum+=count(i);
            }
            System.out.println("Number of objects (n): " + i + ", Number of pairs (m) :" + sum/trailsNo);//computing the average
        }
    }
}
```

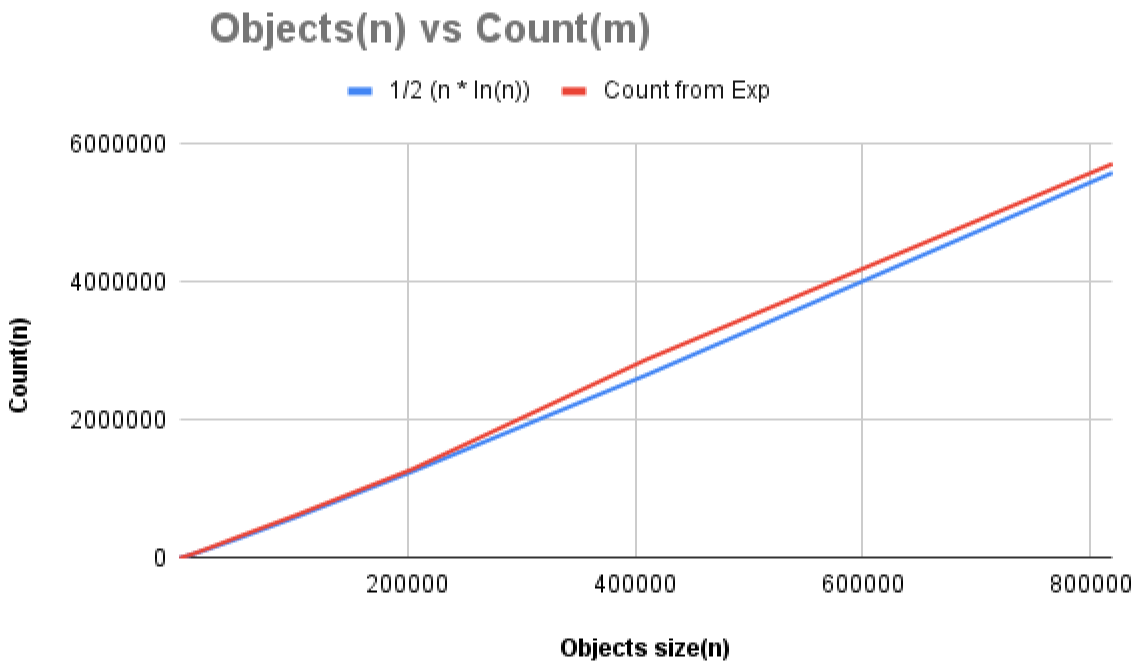
```
Number of objects (n): 20480, Number of pairs (m) :106225.04
Number of objects (n): 40960, Number of pairs (m) :226832.64
Number of objects (n): 81920, Number of pairs (m) :482805.88
Number of objects (n): 163840, Number of pairs (m) :1018484.28
Number of objects (n): 327680, Number of pairs (m) :2240790.36
Number of objects (n): 655360, Number of pairs (m) :4441637.32
Number of objects (n): 1310720, Number of pairs (m) :9799179.28
Number of objects (n): 2621440, Number of pairs (m) :2.020110912E7
```

All files are up-to-date (12 minutes ago)



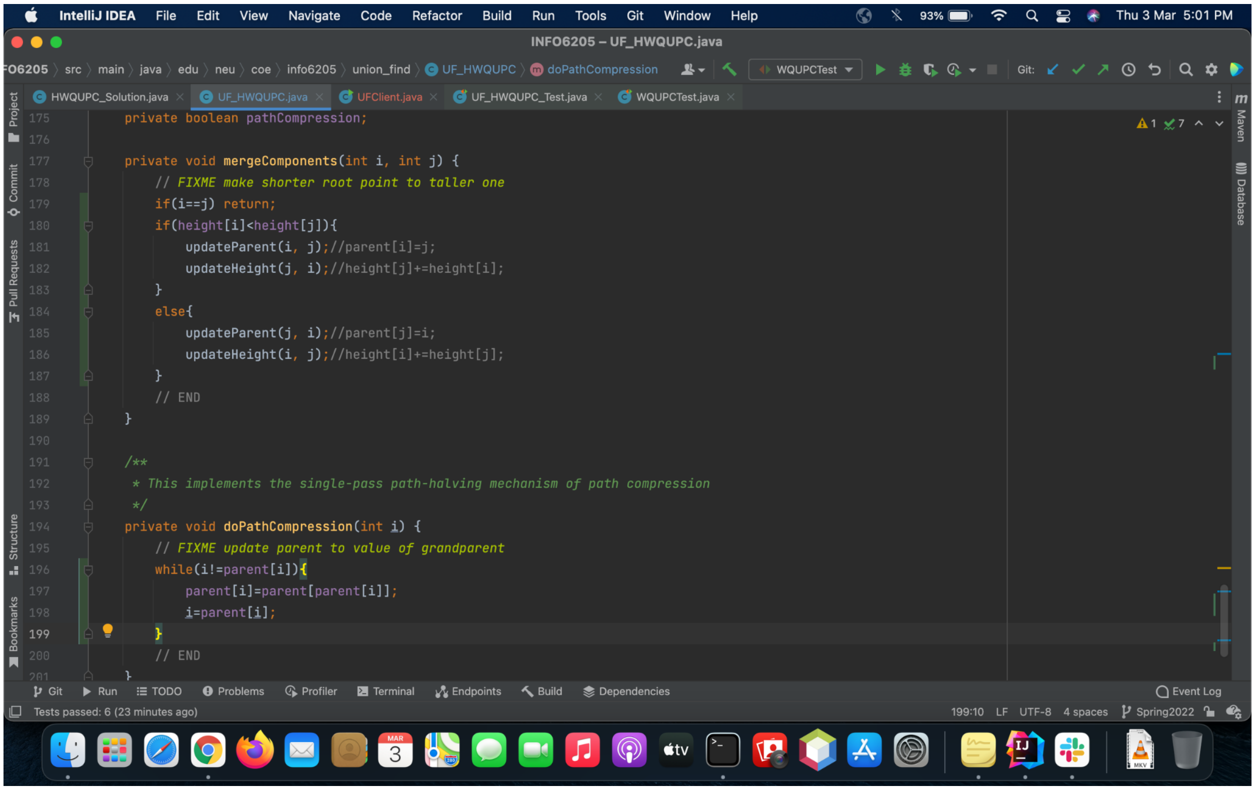
E14 =DIVIDE(D14,2)

	A	B	C	D	E
1	100	230.68	4.605170186	460.5170186	230.2585093
2	200	606.8	5.298317367	1059.663473	529.8317367
3	400	1324.6	5.991464547	2396.585819	1198.292909
4	800	2721.24	6.684611728	5347.689382	2673.844691
5	1600	6616.16	7.377758908	11804.41425	5902.207127
6	3200	13771.24	8.070906089	25826.89948	12913.44974
7	6400	30007.16	8.764053269	56089.94092	28044.97046
8	12800	64176.84	9.45720045	121052.1658	60526.08288
9	25600	142051.24	10.15034763	259848.8993	129924.4497
10	51200	302486.76	10.84349481	555186.9343	277593.4672
11	102400	619491.2	11.53664199	1181352.14	590676.07
12	204800	1287464.4	12.22978917	2504660.822	1252330.411
13	409600	2870532.16	12.92293635	5293234.73	2646617.365
14	819200	5707397.64	13.61608353	11154295.63	5577147.815



Code changes

Made code changes to the file UF_HWQUPC.java and Added a new file UFClient.java

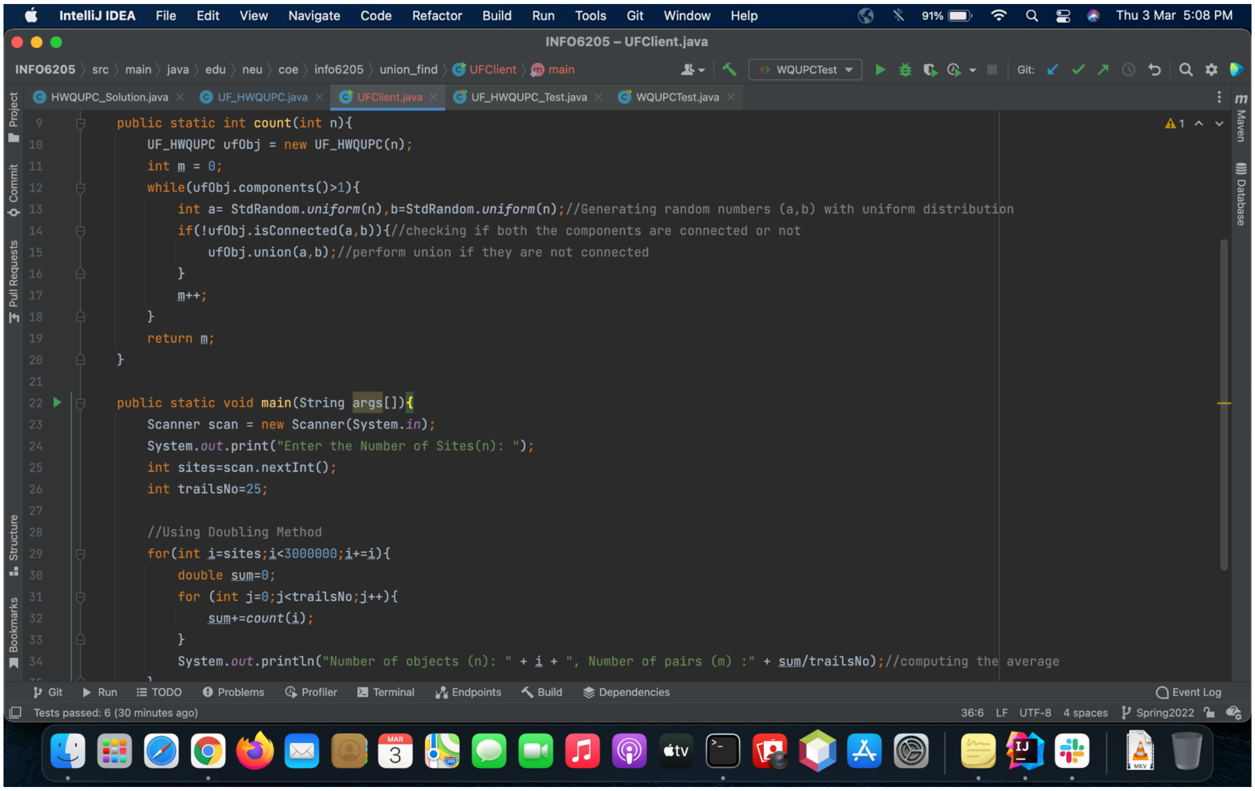

IntelliJ IDEA File Edit View Navigate Code Refactor Build Run Tools Git Window Help
93% Thu 3 Mar 5:01 PM
INFO6205 – UF_HWQUPC.java
O6205 〉 src 〉 main 〉 java 〉 edu 〉 neu 〉 coe 〉 info6205 〉 union_find 〉 UF_HWQUPC 〉 doPathCompression
WQUPCTest
Git:
HWQUPC_Solution.java
UF_HWQUPC.java
UFClient.java
UF_HWQUPC_Test.java
WQUPCTest.java
Project
Commit
Pull Requests
Structure
Bookmarks
Maven
Database
Git
Run
TODO
Problems
Profiler
Terminal
Endpoints
Build
Dependencies
Event Log
199:10 LF UTF-8 4 spaces Spring2022

```java
    private boolean pathCompression;

    private void mergeComponents(int i, int j) {
        // FIXME make shorter root point to taller one
        if(i==j) return;
        if(height[i]<height[j]){
            updateParent(i, j);//parent[i]=j;
            updateHeight(j, i);//height[j]+=height[i];
        }
        else{
            updateParent(j, i);//parent[j]=i;
            updateHeight(i, j);//height[i]+=height[j];
        }
        // END
    }

    /**
     * This implements the single-pass path-halving mechanism of path compression
     */
    private void doPathCompression(int i) {
        // FIXME update parent to value of grandparent
        while(i!=parent[i]){
            parent[i]=parent[parent[i]];
            i=parent[i];
        }
        // END
    }
```

Tests passed: 6 (23 minutes ago)



```java
    public static int count(int n){
        UF_HWQUPC ufObj = new UF_HWQUPC(n);
        int m = 0;
        while(ufObj.components()>1){
            int a= StdRandom.uniform(n),b=StdRandom.uniform(n);//Generating random numbers (a,b) with uniform distribution
            if(!ufObj.isConnected(a,b)){//checking if both the components are connected or not
                ufObj.union(a,b);//perform union if they are not connected
            }
            m++;
        }
        return m;
    }

    public static void main(String args[]){
        Scanner scan = new Scanner(System.in);
        System.out.print("Enter the Number of Sites(n): ");
        int sites=scan.nextInt();
        int trailsNo=25;

        //Using Doubling Method
        for(int i=sites;i<3000000;i+=i){
            double sum=0;
            for (int j=0;j<trailsNo;j++){
                sum+=count(i);
            }
            System.out.println("Number of objects (n): " + i + ", Number of pairs (m) :" + sum/trailsNo);//computing the average
```

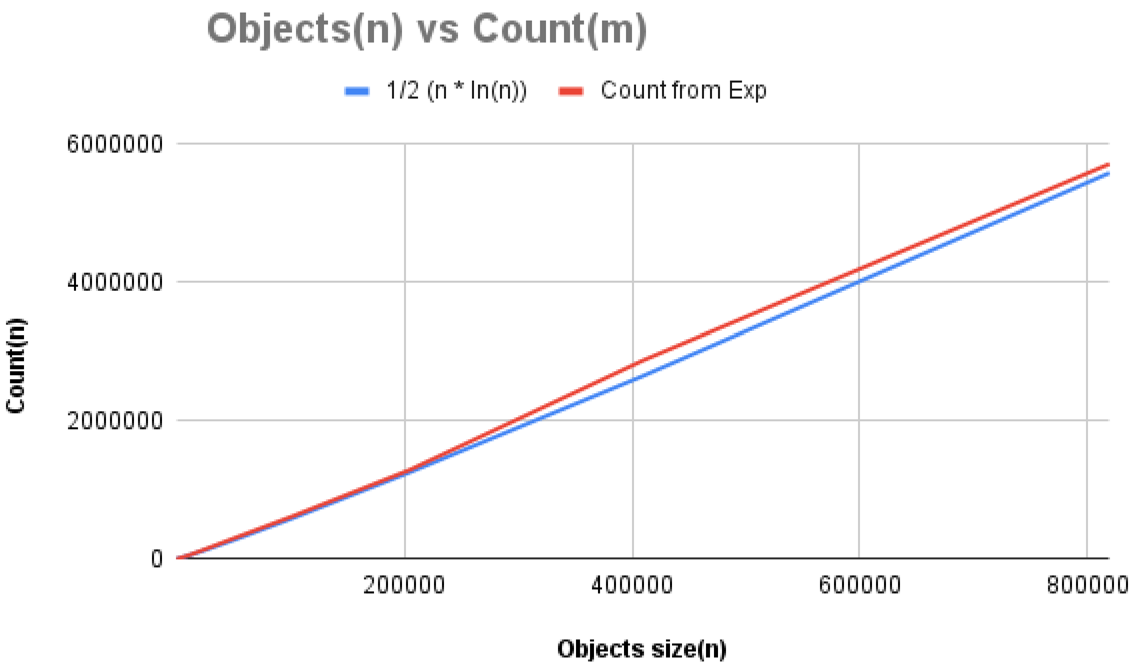
Tests passed: 6 (30 minutes ago)

Observations

After collecting the data and adding data to the excel. I have plotted them in a 2d graph to better visualize them. The results are added below.

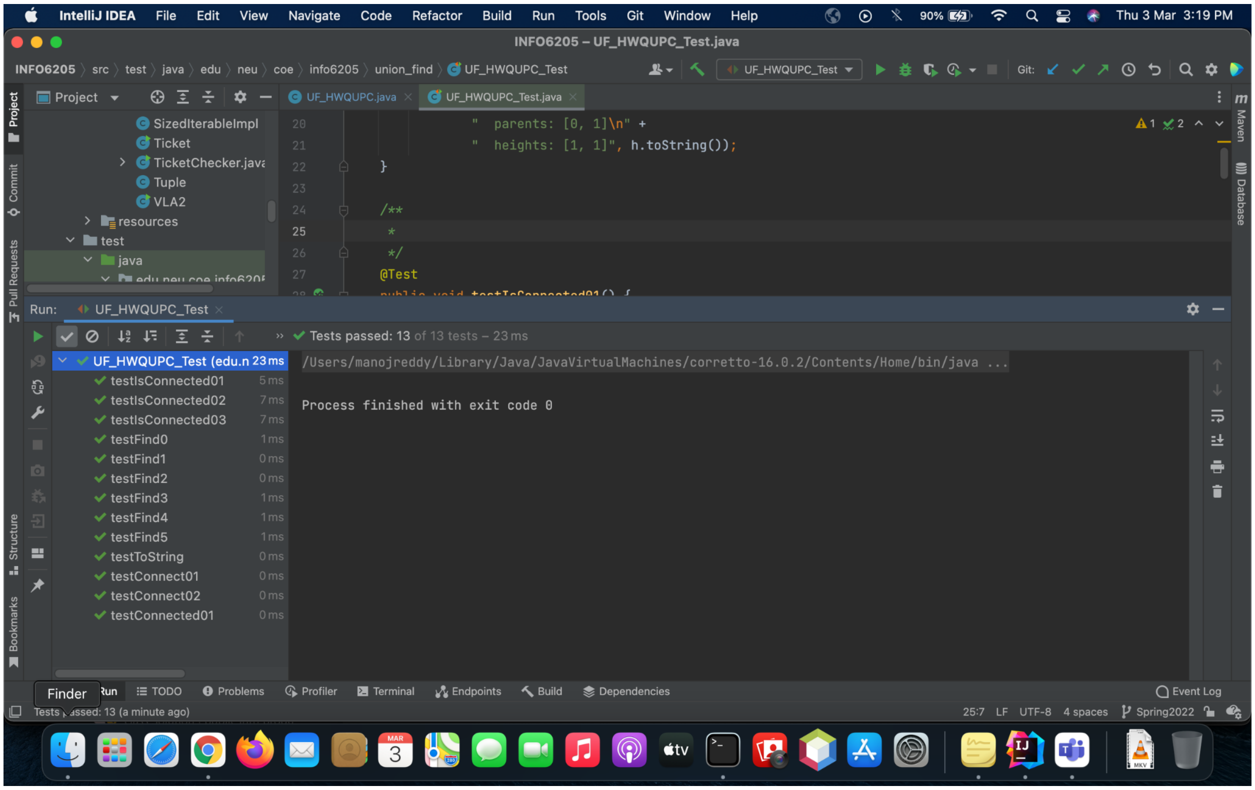
Relationship

By looking at the graph of the count from experiments with ½(n * ln(n)). They are almost similar. So hence we can say that their relationship is the same.



Unit Test Results

Ran the unit tests on the files UF_HWQUPC_Test.java and WQUPCTest.java



INFO6205 – UF_HWQUPC_Test.java

```
                "  parents: [0, 1]\n" +
                "  heights: [1, 1]", h.toString());
    }

    /**
     *
     */
    @Test
    public void testIsConnected01() {
```

Run: UF_HWQUPC_Test

Tests passed: 13 of 13 tests – 23 ms

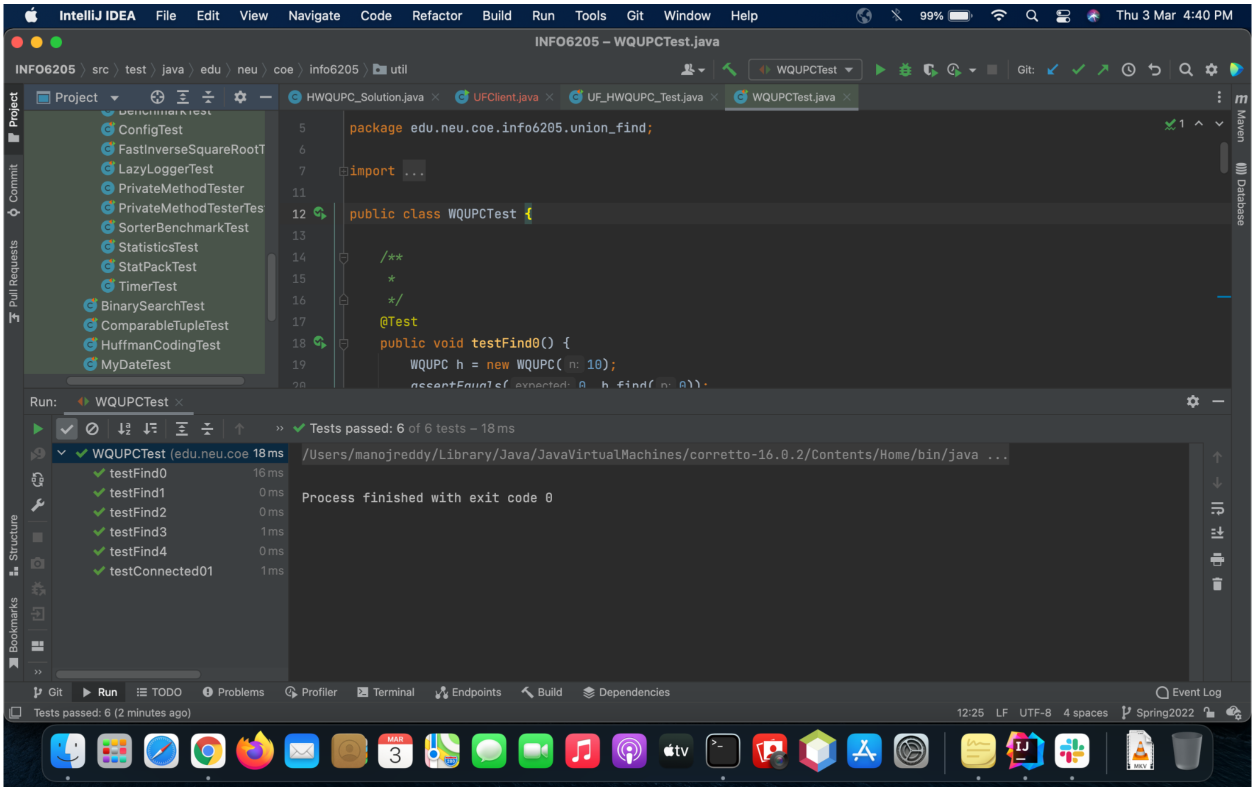
```
UF_HWQUPC_Test (edu.n 23 ms
  testIsConnected01    5 ms
  testIsConnected02    7 ms
  testIsConnected03    7 ms
  testFind0            1 ms
  testFind1            0 ms
  testFind2            0 ms
  testFind3            1 ms
  testFind4            1 ms
  testFind5            1 ms
  testToString         0 ms
  testConnect01        0 ms
  testConnect02        0 ms
  testConnected01      0 ms
```

```
/Users/manojreddy/Library/Java/JavaVirtualMachines/corretto-16.0.2/Contents/Home/bin/java ...

Process finished with exit code 0
```

Tests passed: 13 (a minute ago)

IntelliJ IDEA File Edit View Navigate Code Refactor Build Run Tools Git Window Help
90%
Thu 3 Mar 3:19 PM
INFO6205 〉 src 〉 test 〉 java 〉 edu 〉 neu 〉 coe 〉 info6205 〉 union_find 〉 UF_HWQUPC_Test
Project
UF_HWQUPC.java
UF_HWQUPC_Test.java
SizedIterableImpl
Ticket
TicketChecker.java
Tuple
VLA2
resources
test
java
Finder
Run
TODO
Problems
Profiler
Terminal
Endpoints
Build
Dependencies
Event Log
25:7 LF UTF-8 4 spaces Spring2022



INFO6205 – WQUPCTest.java

```
package edu.neu.coe.info6205.union_find;

import ...

public class WQUPCTest {

    /**
     *
     */
    @Test
    public void testFind0() {
        WQUPC h = new WQUPC( n: 10);
        assertEquals( expected: 0, h.find( p: 0));
```

Run: WQUPCTest

Tests passed: 6 of 6 tests – 18 ms

```
WQUPCTest (edu.neu.coe 18 ms
  testFind0           16 ms
  testFind1            0 ms
  testFind2            0 ms
  testFind3            1 ms
  testFind4            0 ms
  testConnected01      1 ms
```

```
/Users/manojreddy/Library/Java/JavaVirtualMachines/corretto-16.0.2/Contents/Home/bin/java ...

Process finished with exit code 0
```

Tests passed: 6 (2 minutes ago)