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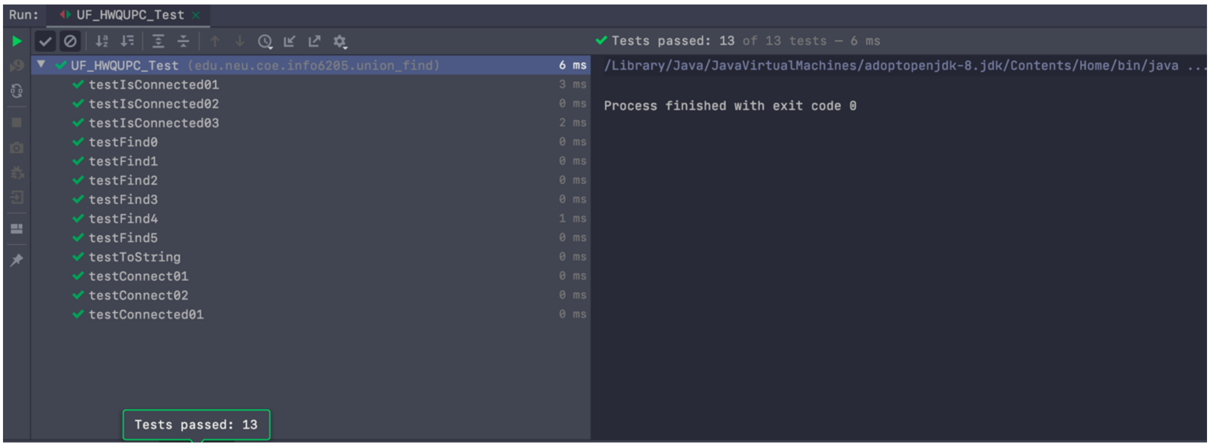
INFO 6205 Program Structures and Algorithms
Assignment 3

Task 1:

Implement height-weighted Quick Union with Path Compression

Unit Test Results:



Task 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.

Source Code:

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

import java.util.Random;
import java.util.Scanner;

public class UnionFind_Client {


    public static void main(String[] args) {

        Scanner sc=new Scanner(System.in);

        System.out.print("Enter No of test Cases : ");
        int testCases=sc.nextInt(),i=1;
        while (testCases>0)
        {
            System.out.println("Enter No of nodes for testCase "+ i);
            int input=sc.nextInt();
            int generatedPairs=count(input);
            System.out.println("No of nodes = "+input+"  Avg Generated-Pairs = "+generatedPairs);
            testCases--;
            i++;
```

```java
            System.out.println();
        }

    }

    private static int[] generateRandomPairs(int n, Random r)
    {
        return new int[]{r.nextInt(n), r.nextInt(n)};
    }

    private static int count(int i) {
        // considering average of 200
        int connections=0;

        Random random=new Random();
        for(int t=1;t<200;t++) {
            UF_HWQUPC client = new UF_HWQUPC(i, true);
            {
                int uf=0;
                int c = 0;
                while (client.components() > 1) {
                    int[] pairs = generateRandomPairs(i, random);
                    if (!(client.connected(pairs[0], pairs[1]))) {
                        client.union(pairs[0], pairs[1]);
                    }
                    c++;
                }
                connections += c;
            }
        }

        return connections/200;
    }
}
```

Output :

```
Run:  UnionFind_Client
/Library/Java/JavaVirtualMachines/adoptopenjdk-8.jdk/Contents/Home/bin/java ...
Enter No of test Cases : 10
Enter No of nodes for testCase 1
100
No of nodes = 100  Avg Generated-Pairs = 266

Enter No of nodes for testCase 2
200
No of nodes = 200  Avg Generated-Pairs = 604

Enter No of nodes for testCase 3
500
No of nodes = 500  Avg Generated-Pairs = 1693

Enter No of nodes for testCase 4
700
No of nodes = 700  Avg Generated-Pairs = 2465

Enter No of nodes for testCase 5
1000
No of nodes = 1000  Avg Generated-Pairs = 3673

Enter No of nodes for testCase 6
5000
No of nodes = 5000  Avg Generated-Pairs = 22967

Enter No of nodes for testCase 7
10000
No of nodes = 10000  Avg Generated-Pairs = 49503

Enter No of nodes for testCase 8
15000
No of nodes = 15000  Avg Generated-Pairs = 75399

Enter No of nodes for testCase 9
25000
No of nodes = 25000  Avg Generated-Pairs = 133654

Enter No of nodes for testCase 10
30000
No of nodes = 30000  Avg Generated-Pairs = 164291
```

Task 3:

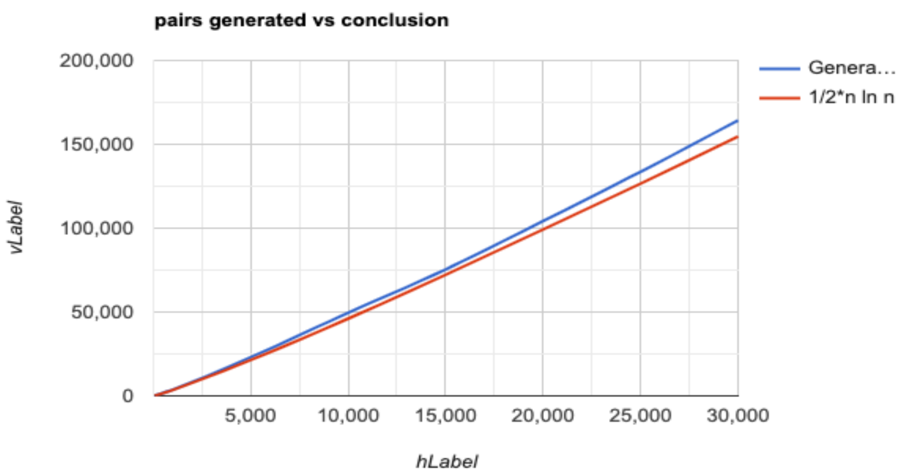
Determine the relationship between the number of objects (*n*) and the number of pairs (*m*) generated to accomplish this (i.e. to reduce the number of components from *n* to 1).

Conclusion:

The result was taken by generating random pairs to union all the nodes and computing the average by repeatedly running the count method 200 times. In most cases, the number of pairs generated has a similar trend to that of C * N ln N (where ln is the natural logarithm of N),Where C $\equiv$ 0.5 . Based on this, it can be demonstrated that in order to reduce the number of components from N to 1**, A = C * N ln N + Z** (where ln is the natural logarithm of N) of connections are necessary. Where C, Z is some constant , N is the number of nodes and A is the result.

Evidence:

Initial Nodes	Generated Pairs	1/2 n ln n where n is natural logarithm of n	
100	266	230.25850929940500	
200	604	529.8317366548040	
500	1693	1553.652024605550	
700	2465	2292.8781172651900	
1000	3673	3453.8776394910700	
5000	22967	21292.982978540600	
10000	49503	46051.701859880900	
15000	75399	72118.5411006326	
25000	133654	126582.88879812900	
30000	164291	154634.2899096640	



Source Code (Link)