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Program Structures & Algorithms INFO 6205
Fall 2021
Assignment 3

Task:

Part 1:

1. Implement height-weighted Quick Union with Path Compression
2. Implement doPathCompression(), mergeComponents(),find()
3. Pass all the test cases

Part 2:

4.Create a main program to generate site pairs and union them if they are not connected
5.Return the number of pairs generated to bring n components to 1 component

Part 3:

6. Form a relationship between n(sites) and the number of pairs generated(m)

Part 1:

Code for To do implementation:

doPathCompression() method

```
private void doPathCompression(int i) {
    // TO BE IMPLEMENTED update parent to value of grandparent
    parent[i]=parent[parent[i]];
}
```

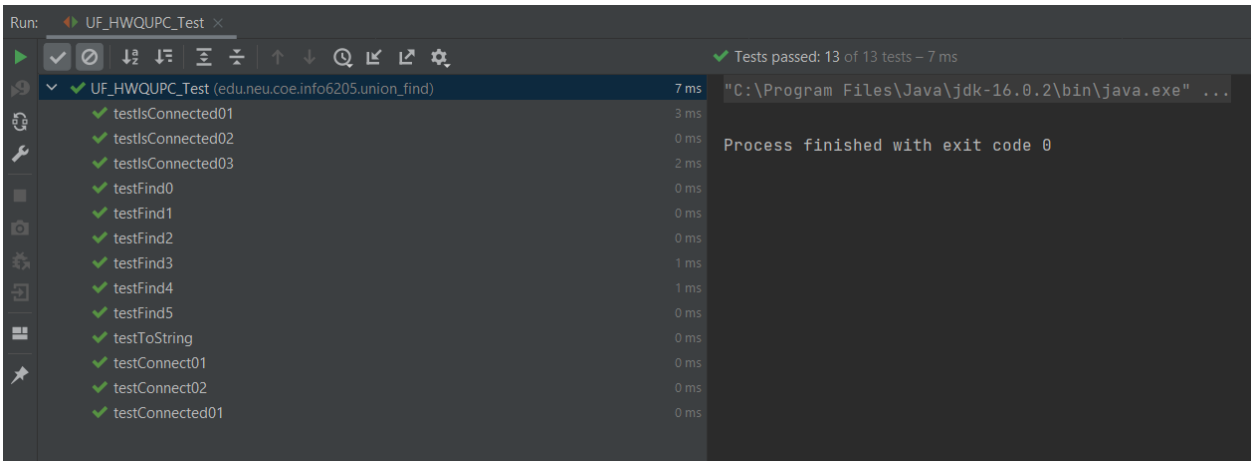
mergeComponents() method:

```
private void mergeComponents(int i, int j) {
    // TO BE IMPLEMENTED make shorter root point to taller one
    int findi=find(i);
    int findj=find(j);
    if(findi!=findj)
    {

        if(height[findi]>=height[findj])
        {
            parent[findj]=findi;
            height[i]+=height[j];
        }
        else{
            parent[findi]=findj;
            height[j]+=height[i];
        }
    }

}
```

Find() method:

```java
public int find(int p) {
    validate(p);
    int root = p;
    // TO BE IMPLEMENTED
    while(parent[root]!=root)
    {
        if(pathCompression==true)
        {
            doPathCompression(root);
            //System.out.println();
        }
        root=parent[root];
    }
    return root;
}
```

Test Cases passed for Union find:



Part 2: Main program implementation:

```java
package edu.neu.coe.info6205.union_find;
import java.util.Random;
public class UFmain {
    public static void main(String[] args)
    {
        /*arraysites has n values*/
        int arraysites[]={5000,10000,20000,40000,80000,160000,320000};
for(int i=0;i<arraysites.length;i++) {
    int run=0;
    int n1=0,n2=0;
    UF_HWQUPC compobj = new UF_HWQUPC(arraysites[i],  pathCompression: false);
    Random random = new Random();
    while (true) {
        run++;
        n1 = random.nextInt(arraysites[i]);
        //System.out.println(n1);
        n2 = random.nextInt(arraysites[i]);
        //System.out.println(n2);
        if (compobj.connected(n1, n2) == false) {
            compobj.union(n1, n2);
        }
        if (compobj.components() == 1) {
            System.out.println(run+" for " +arraysites[i]);
            break;
        }
    }
}
    }
}
```

Output:

Part 3:

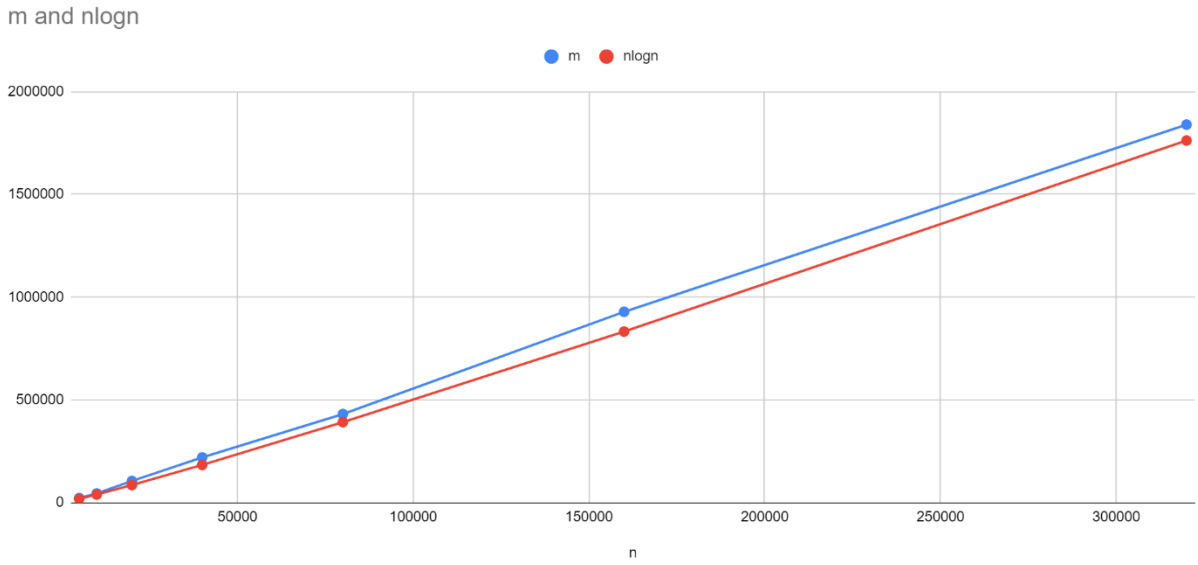
Forming the relationship between n (number of sites) and m (number of pairs generated):

I used the doubling method and took n as 5000, 10000, 20000, 40000, 80000, 160000, 320000
Ran the program 4 times for all the values of sites and calculated the average.

From the above calculations we can see that the m value is more closer to nlog(n) than n square or n or log(n)

A	B	C	D	E	F	G	H
n	m	nlogn					
5000	22842	18495					
10000	45169	40000					
20000	105870	86021					
40000	220420	184082					
80000	431430	392247					
160000	928729	832659					
320000	1839052	1761648					
n=5000			n=10000				
1	22842		1	54997			
2	20689		2	46370			
3	23897		3	42286			
4	27587		4	45004			
avg	23753.75		avg	47164.25			
n=20000			n=40000			n=80000	
1	105870		1	220420		1	431430
2	88320		2	220528		2	439790
3	110156		3	210588		3	417530
4	101597		4	210345		4	448237
avg	101485.8		avg	215470.3		avg	434246.8
n=160000			n=320000				
1	928729		1	1839052			
2	1051771		2	2420919			
3	1014254		3	1989307			
4	882999		4	1890712			
avg	969438.3		avg	2034998			

Evidence:



From the above plotted graph we can see that m is directly proportional to a constant times nlogn

Conclusion:

Hence, we arrive at a conclusion that the total number of pairs (m) generated is directly proportional to nlog(n) times a constant(k), where n are the number of sites or objects.

$$m \propto n \log(n)$$

or

$$m = k\, n \log(n)$$