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Program Structures & Algorithms

Fall 2021

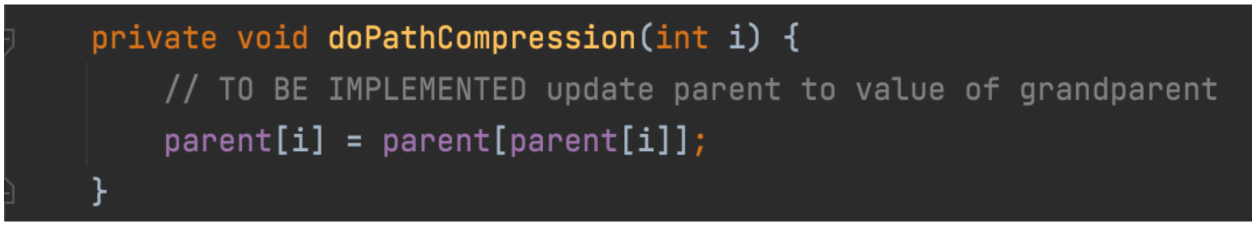
Assignment No. 3

Task:

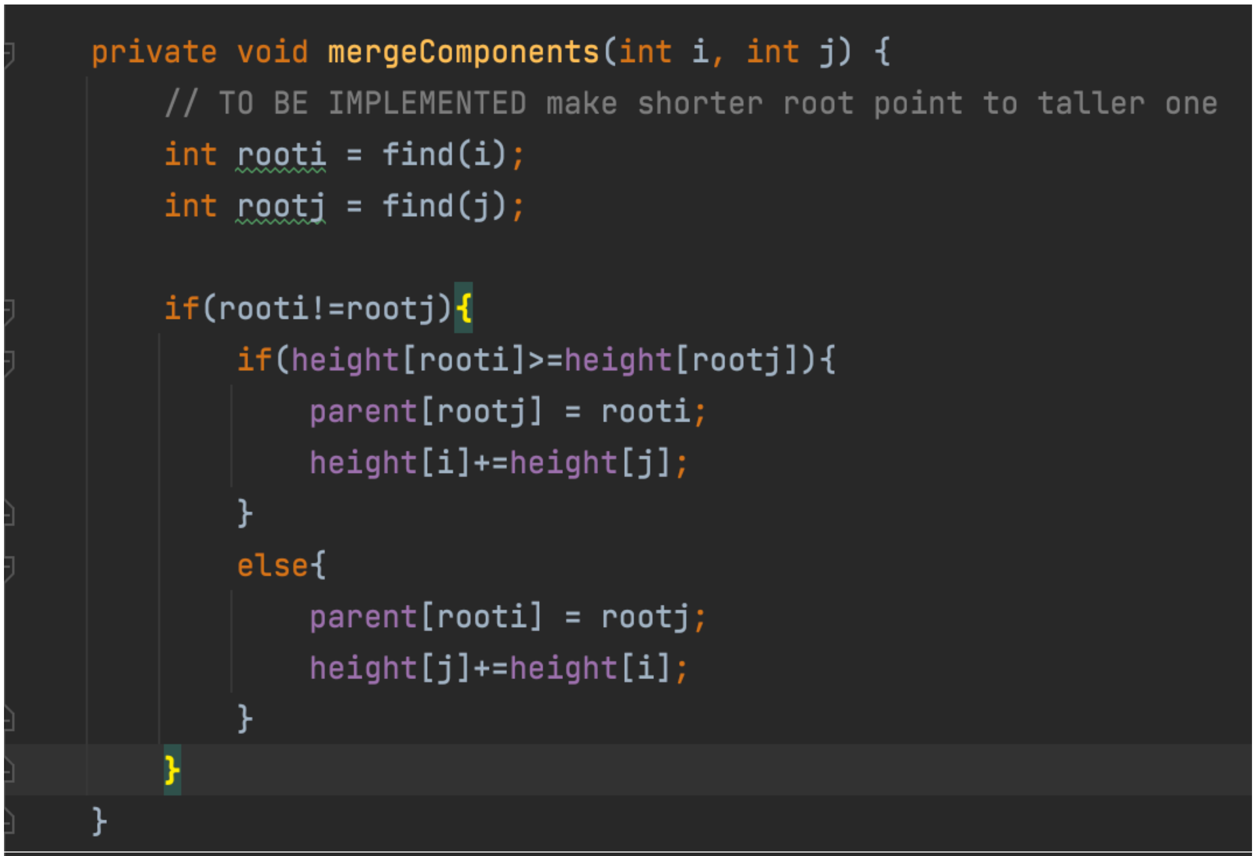
1. **Implement Quick Union**
2. **Pass All Test cases for UF_HWQUPC.java**
3. **Then generates random pairs of integers between 0 and n-1,**
4. **Show Evidence of run**
5. **Determine the relationship between the number of objects (*n*) and the number of pairs (*m*) generated**

Part 1.

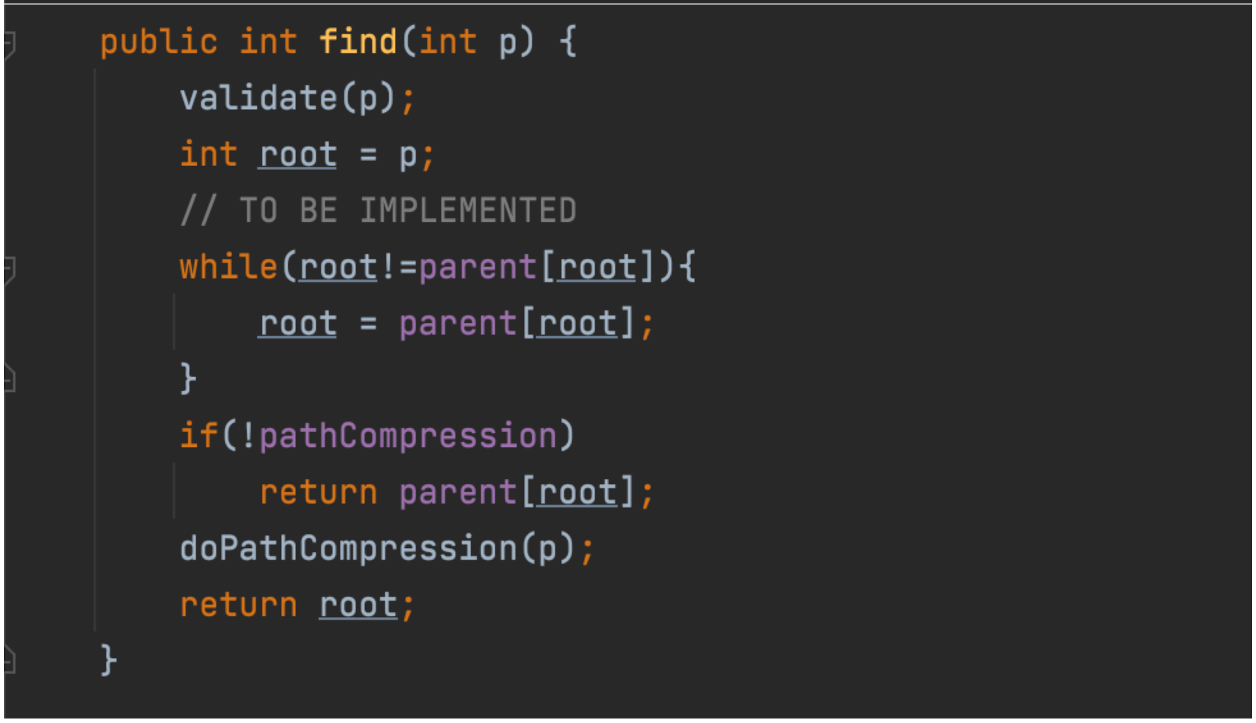
Added code below to implement quick union



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



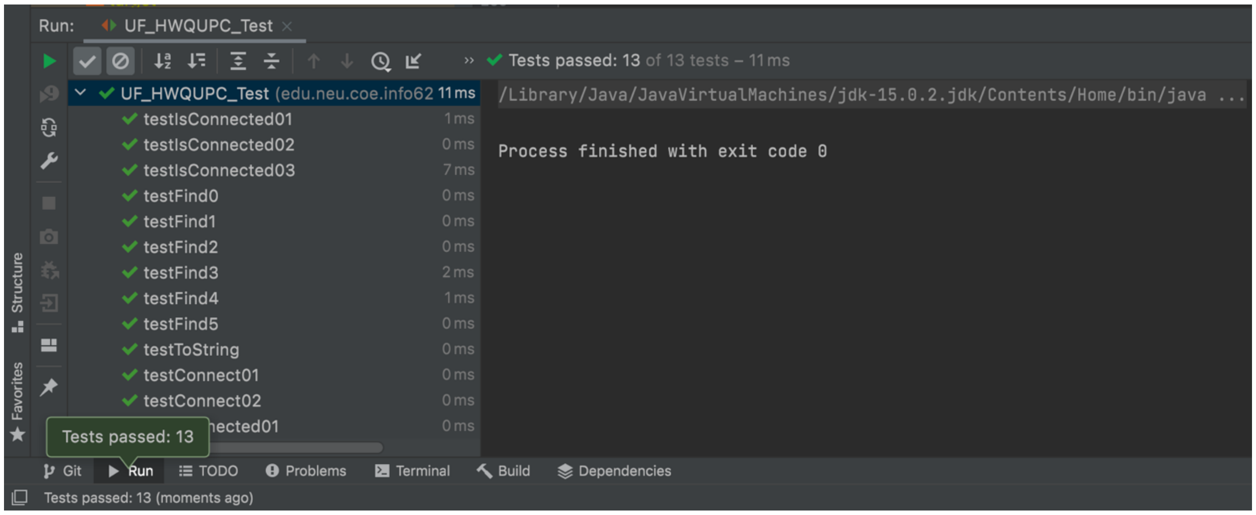
```java
private void mergeComponents(int i, int j) {
    // TO BE IMPLEMENTED make shorter root point to taller one
    int rooti = find(i);
    int rootj = find(j);

    if(rooti!=rootj){
        if(height[rooti]>=height[rootj]){
            parent[rootj] = rooti;
            height[i]+=height[j];
        }
        else{
            parent[rooti] = rootj;
            height[j]+=height[i];
        }
    }
}
```



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

Part 2:

Pass All Test cases for UF_HWQUPC.java



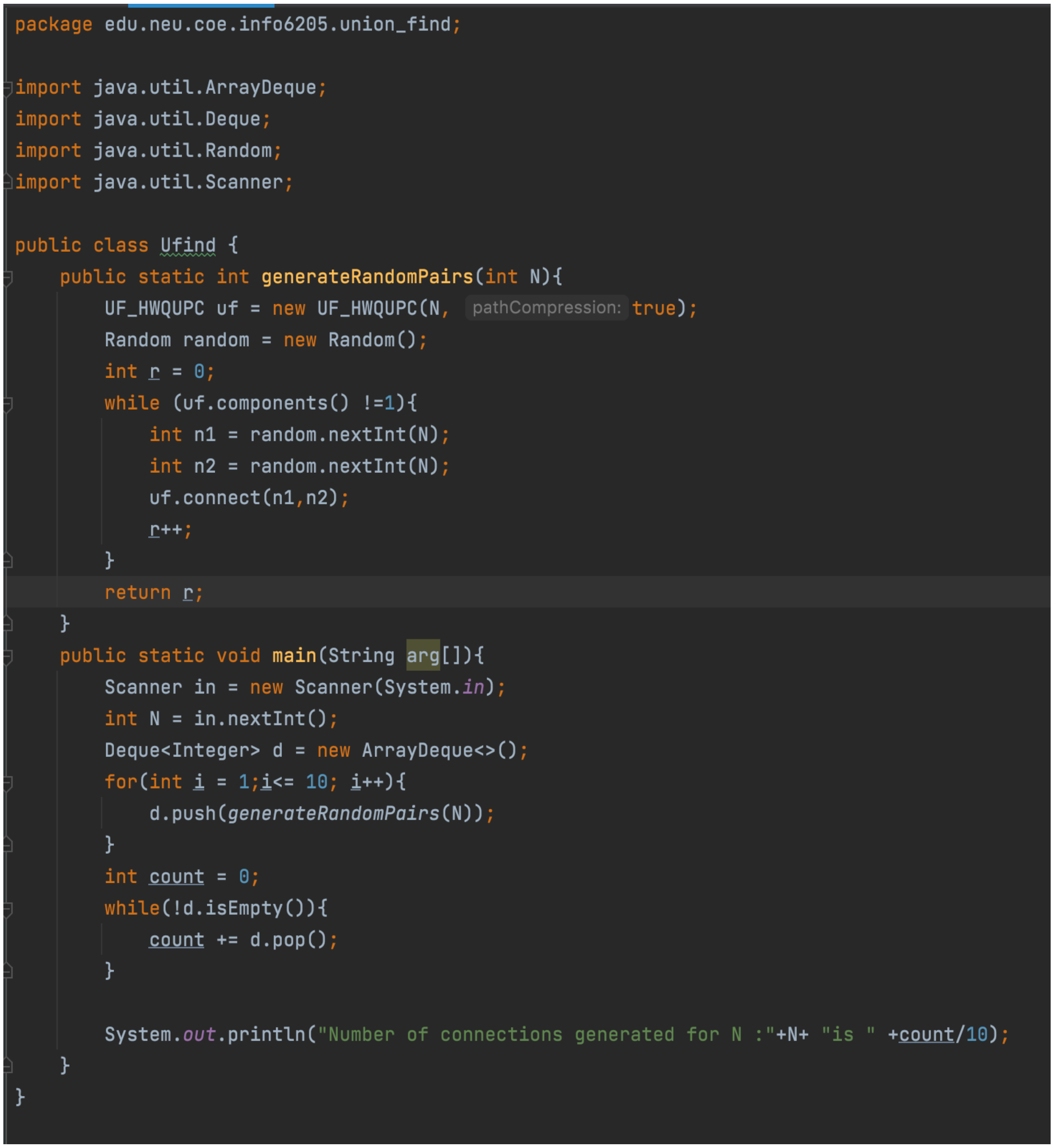
Run: UF_HWQUPC_Test

```
Tests passed: 13 of 13 tests – 11 ms

UF_HWQUPC_Test (edu.neu.coe.info62 11 ms
    testIsConnected01    1 ms
    testIsConnected02    0 ms
    testIsConnected03    7 ms
    testFind0            0 ms
    testFind1            0 ms
    testFind2            0 ms
    testFind3            2 ms
    testFind4            1 ms
    testFind5            0 ms
    testToString         0 ms
    testConnect01        0 ms
    testConnect02        0 ms
    ...nected01          0 ms

/Library/Java/JavaVirtualMachines/jdk-15.0.2.jdk/Contents/Home/bin/java ...

Process finished with exit code 0
```

Tests passed: 13 (moments ago)

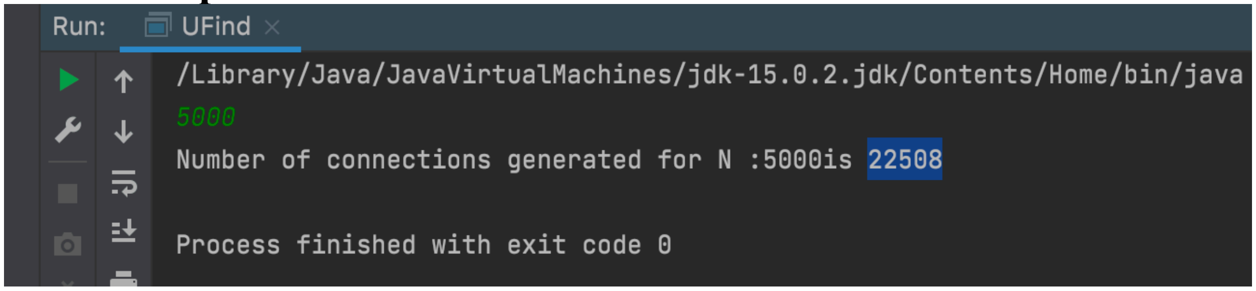
Part 3:

Built Ufind.java class to generate random pair and count number of connection

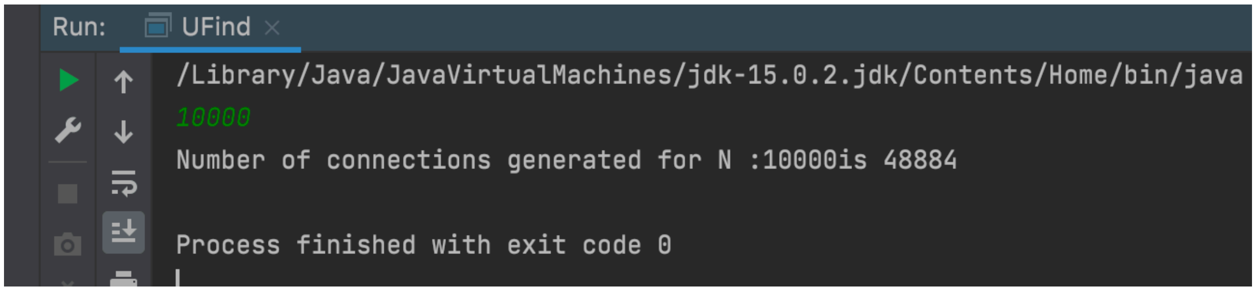


```
package edu.neu.coe.info6205.union_find;

import java.util.ArrayDeque;
import java.util.Deque;
import java.util.Random;
import java.util.Scanner;

public class Ufind {
    public static int generateRandomPairs(int N){
        UF_HWQUPC uf = new UF_HWQUPC(N,  pathCompression: true);
        Random random = new Random();
        int r = 0;
        while (uf.components() !=1){
            int n1 = random.nextInt(N);
            int n2 = random.nextInt(N);
            uf.connect(n1,n2);
            r++;
        }
        return r;
    }
    public static void main(String arg[]){
        Scanner in = new Scanner(System.in);
        int N = in.nextInt();
        Deque<Integer> d = new ArrayDeque<>();
        for(int i = 1;i<= 10; i++){
            d.push(generateRandomPairs(N));
        }
        int count = 0;
        while(!d.isEmpty()){
            count += d.pop();
        }

        System.out.println("Number of connections generated for N :"+N+ "is " +count/10);
    }
}
```

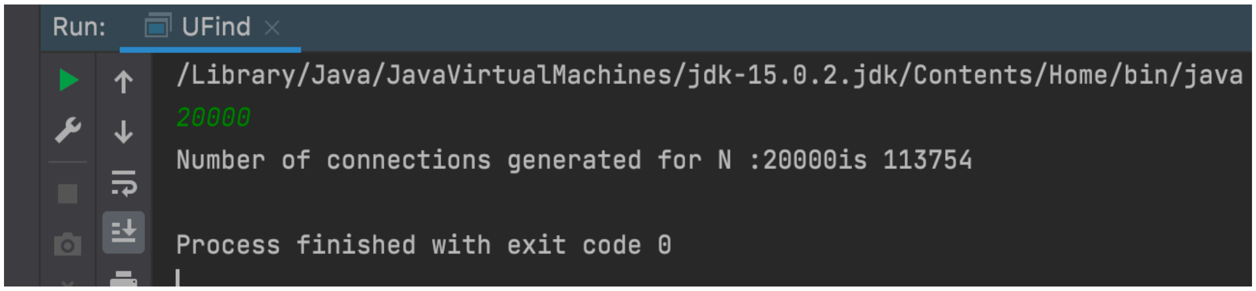
Part 4 Output :


Run: UFind

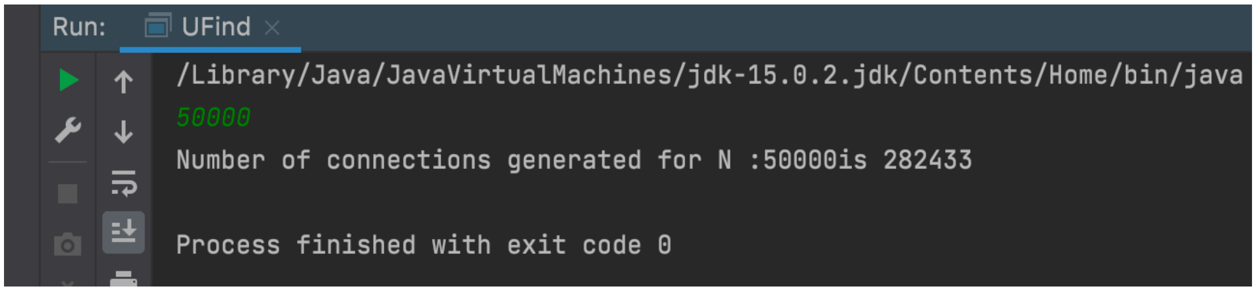
```
/Library/Java/JavaVirtualMachines/jdk-15.0.2.jdk/Contents/Home/bin/java
5000
Number of connections generated for N :5000is 22508

Process finished with exit code 0
```


Run: UFind

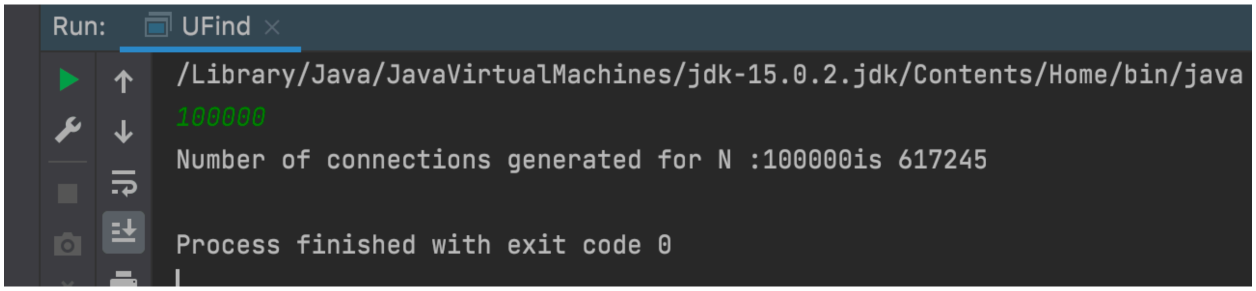
```
/Library/Java/JavaVirtualMachines/jdk-15.0.2.jdk/Contents/Home/bin/java
10000
Number of connections generated for N :10000is 48884

Process finished with exit code 0
```


Run: UFind

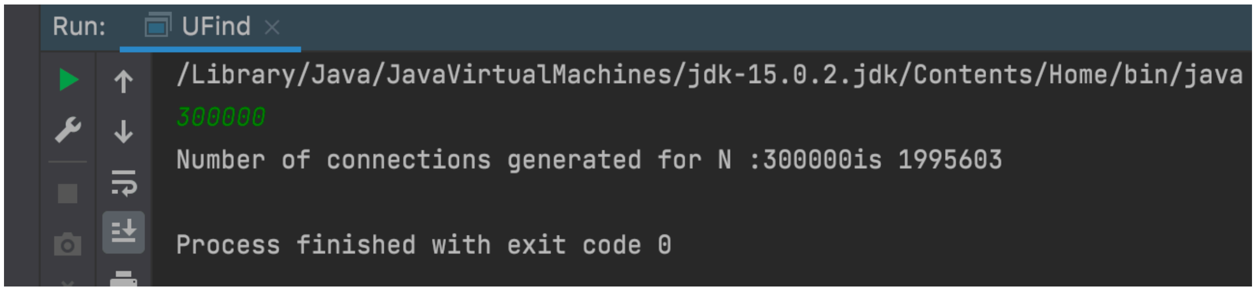
```
/Library/Java/JavaVirtualMachines/jdk-15.0.2.jdk/Contents/Home/bin/java
20000
Number of connections generated for N :20000is 113754

Process finished with exit code 0
```


Run: UFind

```
/Library/Java/JavaVirtualMachines/jdk-15.0.2.jdk/Contents/Home/bin/java
50000
Number of connections generated for N :50000is 282433

Process finished with exit code 0
```

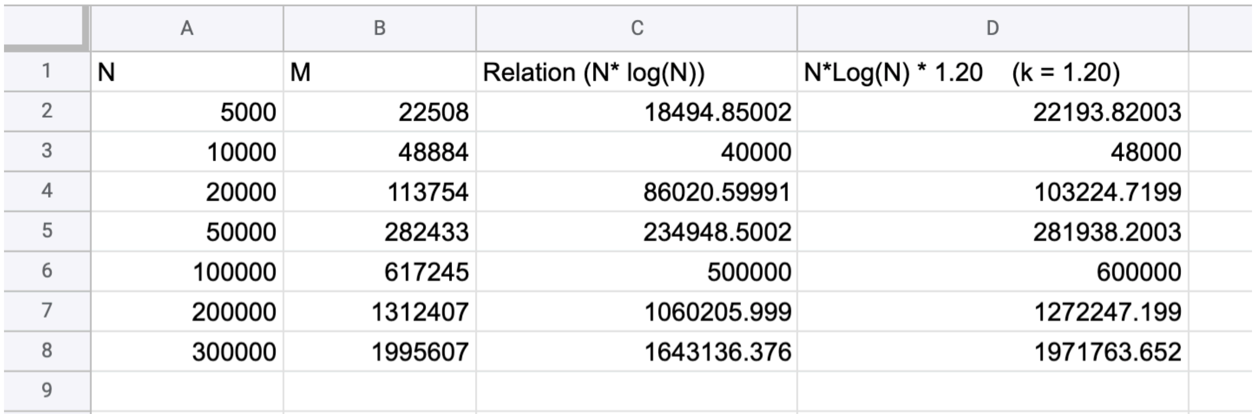

Run: UFind

```
/Library/Java/JavaVirtualMachines/jdk-15.0.2.jdk/Contents/Home/bin/java
100000
Number of connections generated for N :100000is 617245

Process finished with exit code 0
```

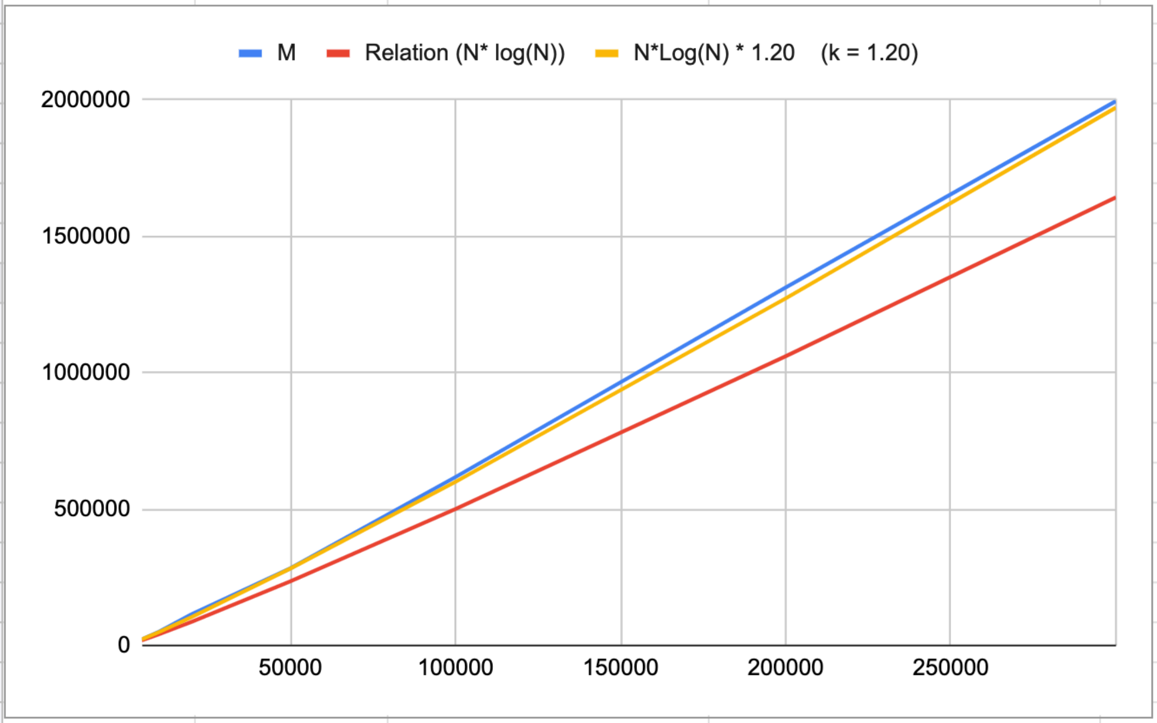


```
Run:    UFind ×
/Library/Java/JavaVirtualMachines/jdk-15.0.2.jdk/Contents/Home/bin/java
300000
Number of connections generated for N :300000is 1995603

Process finished with exit code 0
```

Part 5:



	A	B	C	D
1	N	M	Relation (N* log(N))	N*Log(N) * 1.20 (k = 1.20)
2	5000	22508	18494.85002	22193.82003
3	10000	48884	40000	48000
4	20000	113754	86020.59991	103224.7199
5	50000	282433	234948.5002	281938.2003
6	100000	617245	500000	600000
7	200000	1312407	1060205.999	1272247.199
8	300000	1995607	1643136.376	1971763.652
9				



N - >

After tying multiple values of N and as shown above. I got following relationship.

$$M = k * N * Log(N)$$

Where k is constant = $\sim$ 1.20