Program Structures and Algorithms
Spring 2023(SEC –01)

NAME: Harshini Venkata Chalam
NUID: 002934047
Assignment 4 (WQUPC)

Task:
Step 1: Implementation of height-weighted Quick Union with Path Compression and testing all the test case scenarios

Step 2: Using the implementation of UF_HWQUPC, developed a UF ("union-find") client, uses a main program for a fixed set of n values to print the number of connections generated

Step 3: To determine the relationship between the number of objects (n) and the number of pairs (m) generated

Relationship Conclusion:

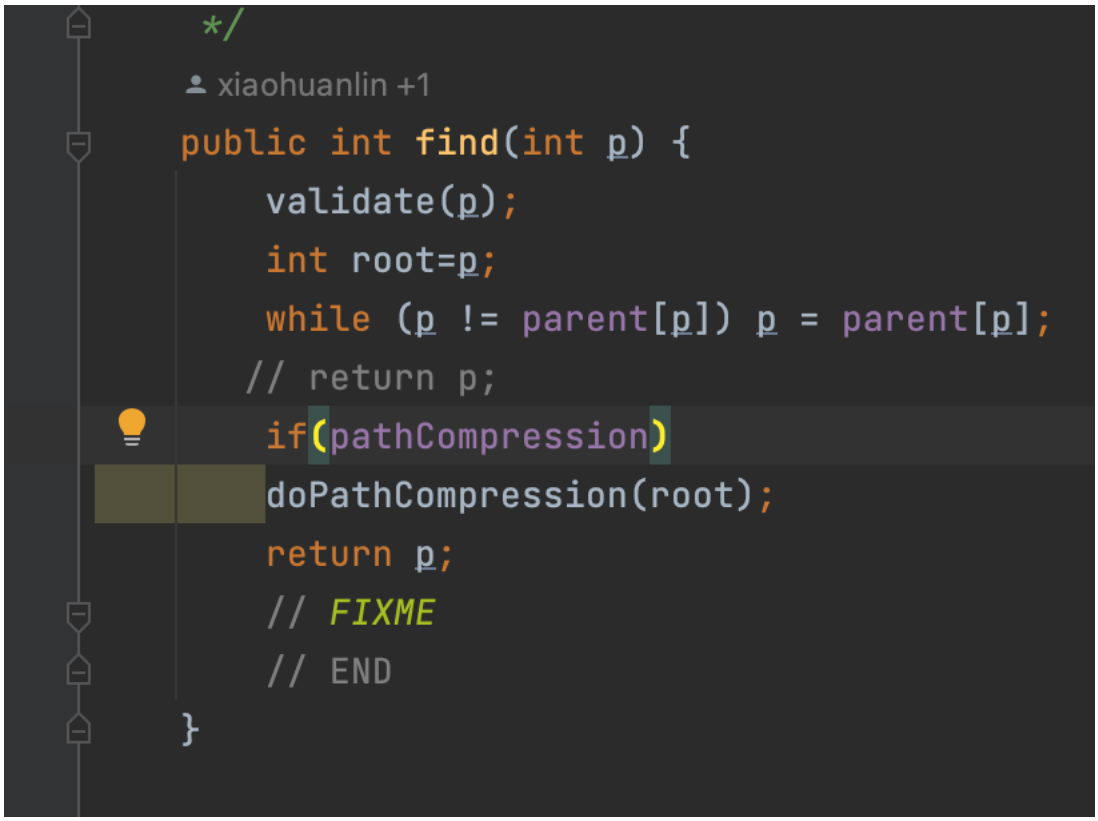
After running the UF_HWQUPC for various values of n ranging from 50 to 6400 we can observe that the relationship between the number of objects (n) and the number of pairs (m)

$m \sim 1/2 n \ln n$

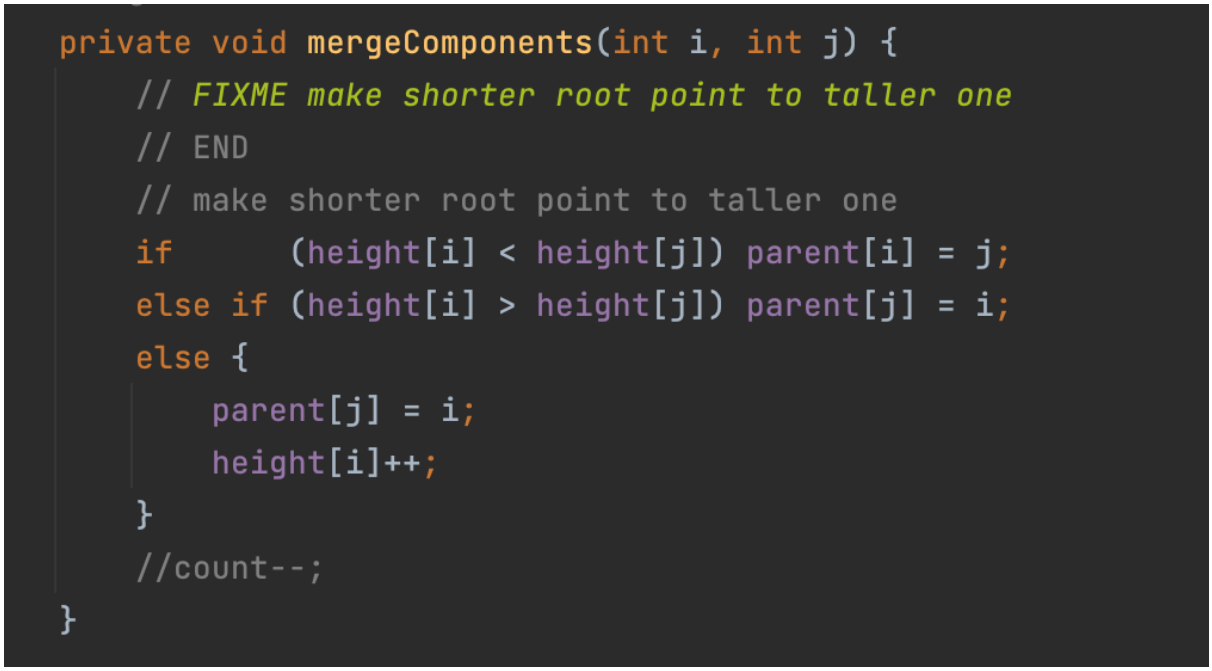
It can be **concluded from the** graphical representation shown below for the values of n, m increases linearithmically.

The reason for this relationship is due to the nature of the union-find algorithm and the path compression. As the number of objects increases, it becomes increasingly likely that two randomly chosen objects will already be connected, reducing the number of required connections. At the same time, the number of components being combined also increases, leading to a slower reduction in the number of components. These two factors result in the observed relationship between n and m.

Evidence to support that conclusion:



```
     */
    xiaohuanlin +1
    public int find(int p) {
        validate(p);
        int root=p;
        while (p != parent[p]) p = parent[p];
       // return p;
        if(pathCompression)
        doPathCompression(root);
        return p;
        // FIXME
        // END
    }
```

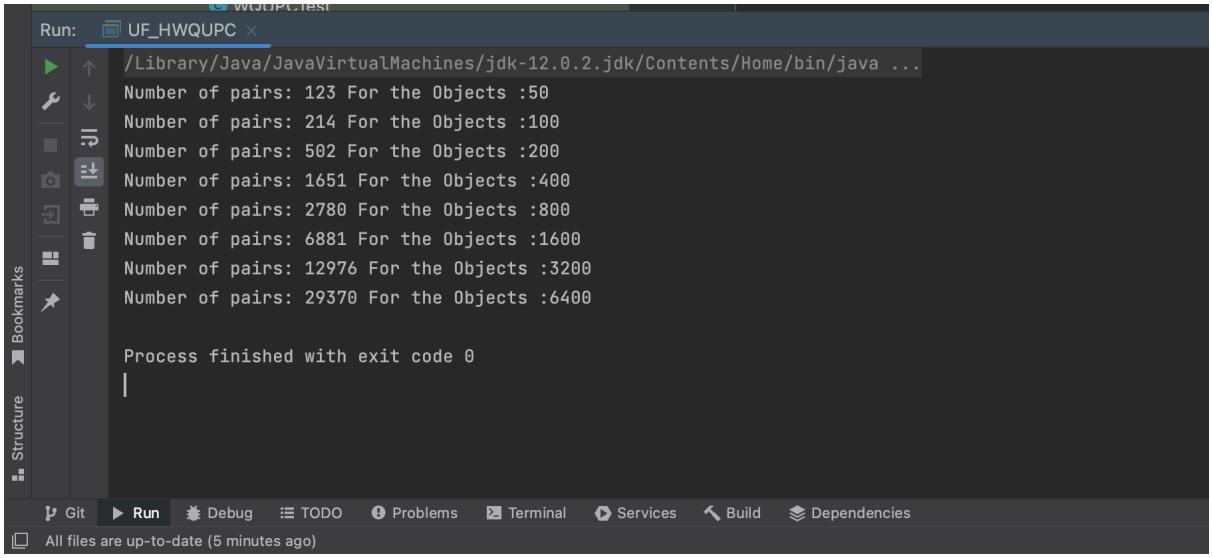


```
private void mergeComponents(int i, int j) {
    // FIXME make shorter root point to taller one
    // END
    // make shorter root point to taller one
    if      (height[i] < height[j]) parent[i] = j;
    else if (height[i] > height[j]) parent[j] = i;
    else {
        parent[j] = i;
        height[i]++;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

```java
private void doPathCompression(int i) {
    // FIXME update parent to value of grandparent
    // END
    int root=i;
    while(parent[root]!=root) {
    root = parent[root];
    }
    parent[i]=root;
}
```

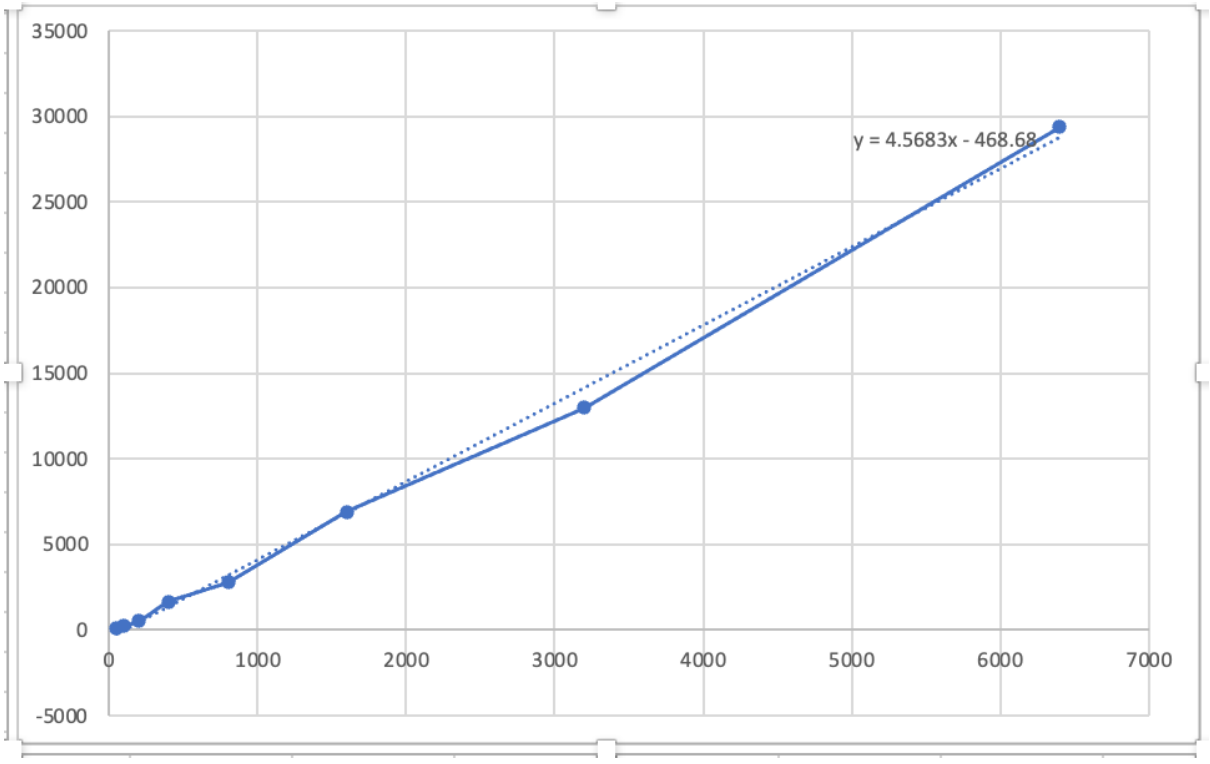
```java
new *
public static int count(int n) {
    Random random = new Random();
    UF_HWQUPC uf = new UF_HWQUPC(n);
    int m =0;
    int p=0,q = 0;
    while (uf.count > 1) {
        p = random.nextInt(n);
        q = random.nextInt(n);
        m++;
        if (!uf.connected(p, q)) {
            uf.union(p, q);
        }
    }
    return m;
}

new *
public static void main(String[] args) {
    int n;
    for (n=50;n<6500;n=n*2)
    {
    int m = count(n);
    System.out.println("Number of pairs: " + m+" For the Objects :"+n);
}
}
```

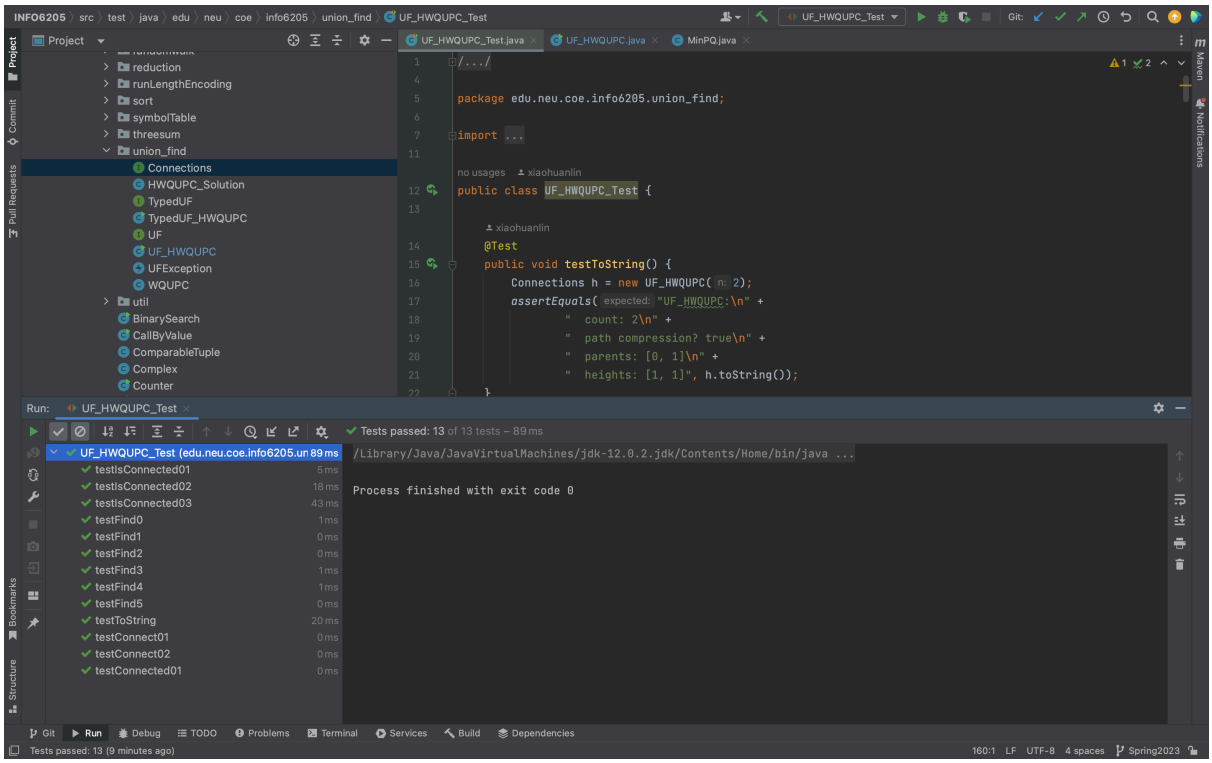

Run:
UF_HWQUPC
/Library/Java/JavaVirtualMachines/jdk-12.0.2.jdk/Contents/Home/bin/java ...
Number of pairs: 123 For the Objects :50
Number of pairs: 214 For the Objects :100
Number of pairs: 502 For the Objects :200
Number of pairs: 1651 For the Objects :400
Number of pairs: 2780 For the Objects :800
Number of pairs: 6881 For the Objects :1600
Number of pairs: 12976 For the Objects :3200
Number of pairs: 29370 For the Objects :6400
Process finished with exit code 0
Bookmarks
Structure
Git
Run
Debug
TODO
Problems
Terminal
Services
Build
Dependencies
All files are up-to-date (5 minutes ago)

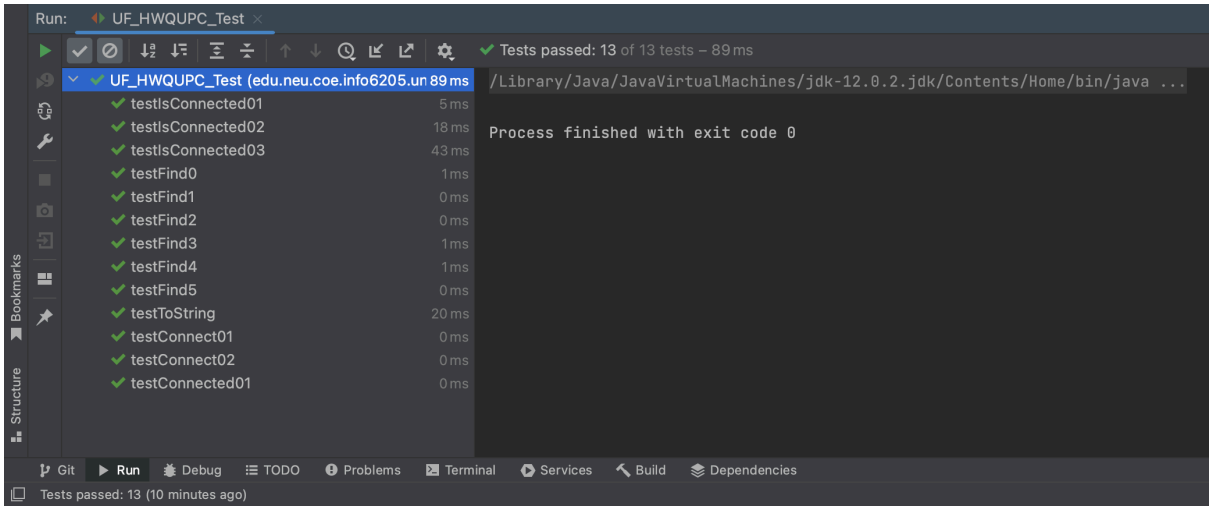
Graphical Representation:

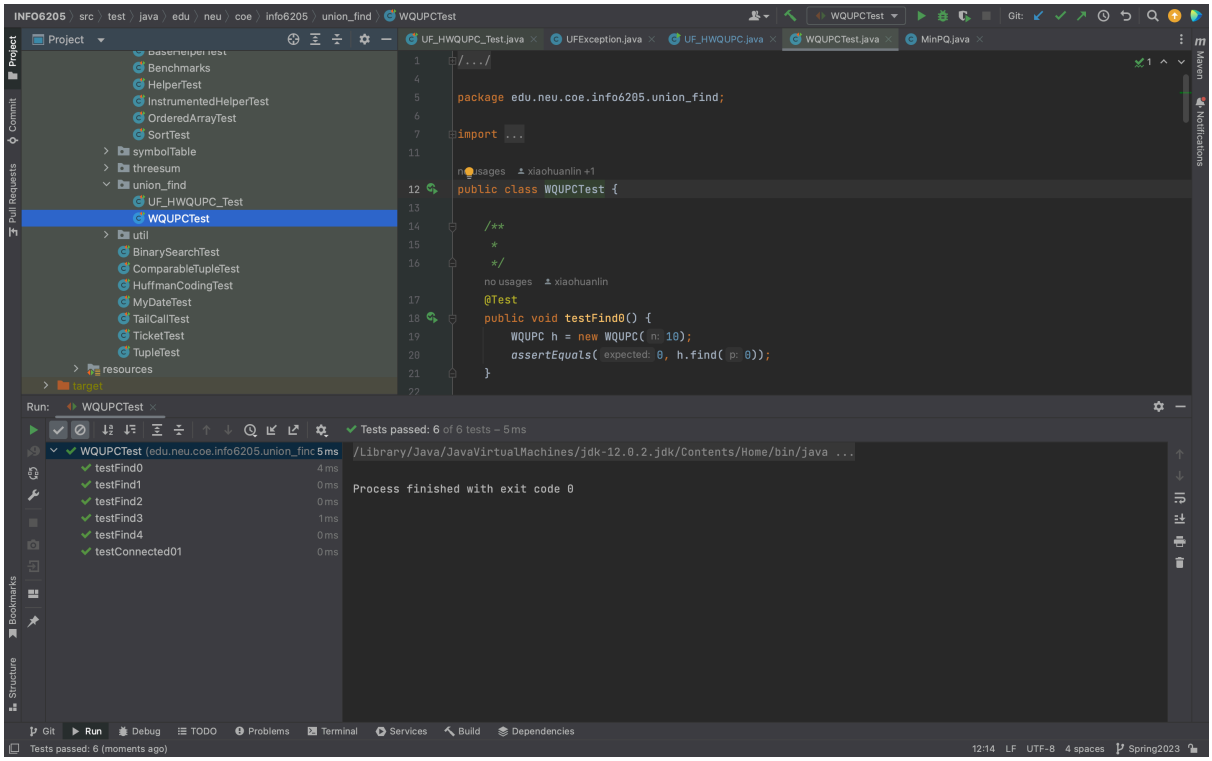
Objects (n)	No of Pairs(m)
50	123
100	214
200	502
400	1651
800	2780
1600	6881
3200	12976
6400	29370

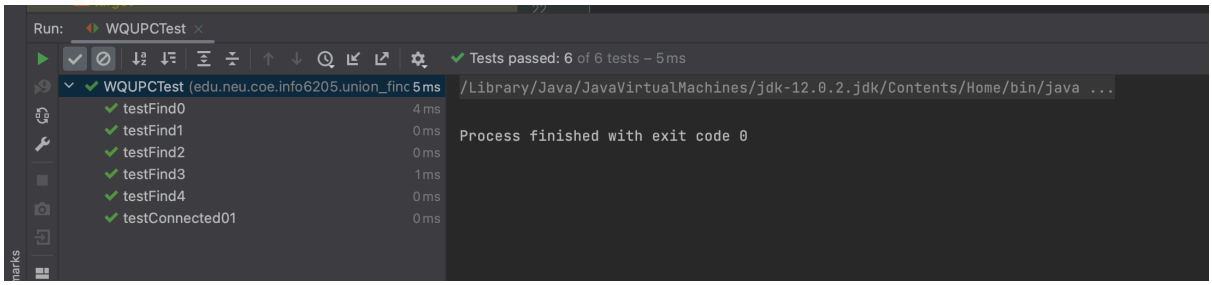


Unit Test Screenshots:






INFO6205 src test java edu neu coe info6205 union_find WQUPCTest
Project
Benchmarks
HelperTest
InstrumentedHelperTest
OrderedArrayTest
SortTest
symbolTable
threesum
union_find
UF_HWQUPC_Test
WQUPCTest
util
BinarySearchTest
ComparableTupleTest
HuffmanCodingTest
MyDateTest
TailCallTest
TicketTest
TupleTest
resources
target
UF_HWQUPC_Test.java
UFException.java
UF_HWQUPC.java
WQUPCTest.java
MinPQ.java
/.../
package edu.neu.coe.info6205.union_find;
import ...
no usages xiaohuanlin +1
public class WQUPCTest {
/**
*
*/
no usages xiaohuanlin
@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 – 5 ms
WQUPCTest (edu.neu.coe.info6205.union_find 5 ms
testFind0 4 ms
testFind1 0 ms
testFind2 0 ms
testFind3 1 ms
testFind4 0 ms
testConnected01 0 ms
/Library/Java/JavaVirtualMachines/jdk-12.0.2.jdk/Contents/Home/bin/java ...
Process finished with exit code 0
Git Run Debug TODO Problems Terminal Services Build Dependencies
Tests passed: 6 (moments ago)
12:14 LF UTF-8 4 spaces Spring2023


Run: WQUPCTest
Tests passed: 6 of 6 tests – 5 ms
WQUPCTest (edu.neu.coe.info6205.union_find 5 ms
testFind0 4 ms
testFind1 0 ms
testFind2 0 ms
testFind3 1 ms
testFind4 0 ms
testConnected01 0 ms
/Library/Java/JavaVirtualMachines/jdk-12.0.2.jdk/Contents/Home/bin/java ...
Process finished with exit code 0