

# Program Structures & Algorithms

Spring 2022

## Assignment No. 3

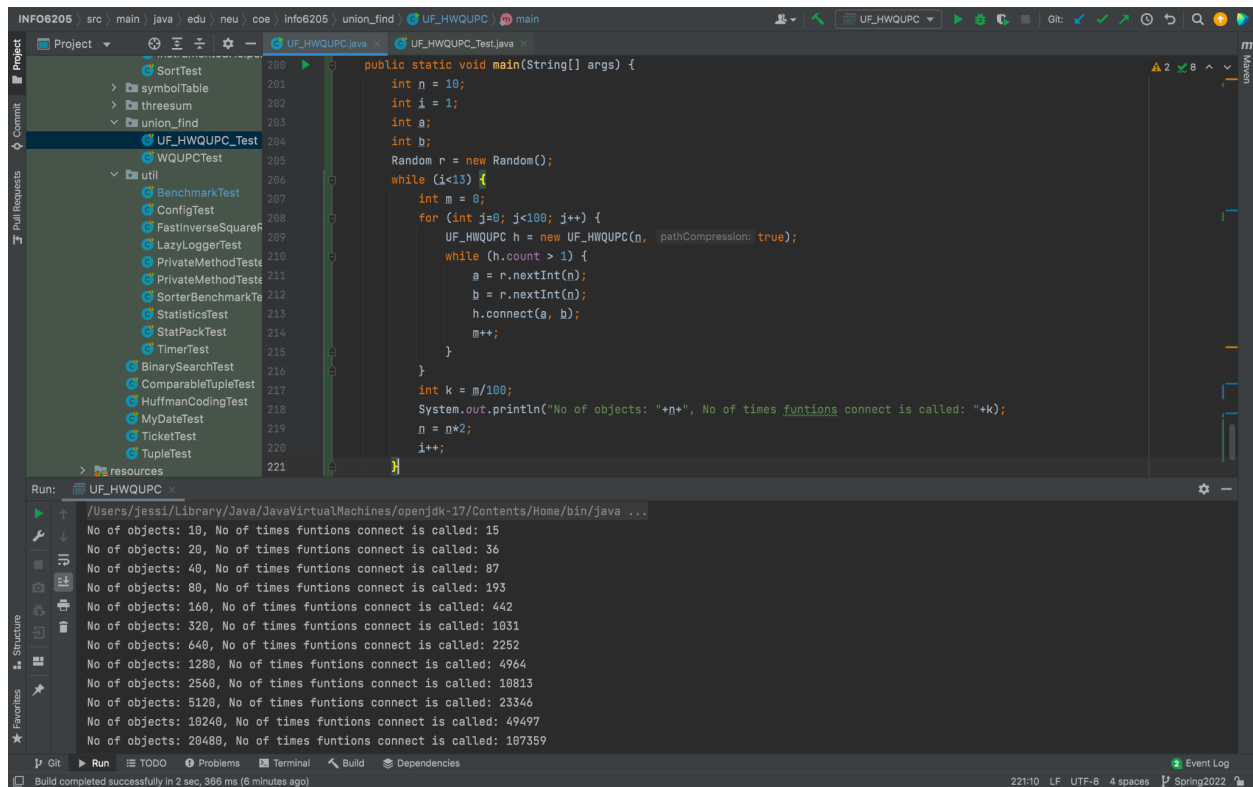
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### Task:

- 1) (a) Implement height-weighted Quick Union with Path Compression.  
(b) Check that the unit tests for this class all work.
- 2) Create a main program 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 ( $m$ )

Output screenshot:



The screenshot shows an IDE with a project named 'UF\_HWQUPC'. The left sidebar displays a package tree with 'UF\_HWQUPC\_Test' selected. The main editor shows the 'main' method of 'UF\_HWQUPC.java'. The code initializes 'n' to 10 and enters a loop where it repeatedly calls 'UF\_HWQUPC.h' with 'n' and 'pathCompression: true'. The output window at the bottom shows the results of these calls, indicating a linear relationship between 'n' and the number of times 'funtions connect' is called.

```
public static void main(String[] args) {
    int n = 10;
    int i = 1;
    int a;
    int b;
    Random r = new Random();
    while (i < 13) {
        int m = 0;
        for (int j = 0; j < 100; j++) {
            UF_HWQUPC h = new UF_HWQUPC(n, pathCompression: true);
            while (h.count > 1) {
                a = r.nextInt(n);
                b = r.nextInt(n);
                h.connect(a, b);
                m++;
            }
        }
        int k = m / 100;
        System.out.println("No of objects: " + n + ", No of times funtions connect is called: " + k);
        n = n * 2;
        i++;
    }
}
```

Run: UF\_HWQUPC

```
/Users/jessi/Library/Java/JavaVirtualMachines/openjdk-17/Contents/Home/bin/java ...
No of objects: 10, No of times funtions connect is called: 15
No of objects: 20, No of times funtions connect is called: 36
No of objects: 40, No of times funtions connect is called: 87
No of objects: 80, No of times funtions connect is called: 193
No of objects: 160, No of times funtions connect is called: 442
No of objects: 320, No of times funtions connect is called: 1031
No of objects: 640, No of times funtions connect is called: 2252
No of objects: 1280, No of times funtions connect is called: 4964
No of objects: 2560, No of times funtions connect is called: 10813
No of objects: 5120, No of times funtions connect is called: 23346
No of objects: 10240, No of times funtions connect is called: 49497
No of objects: 20480, No of times funtions connect is called: 107359
```

Conclusion:

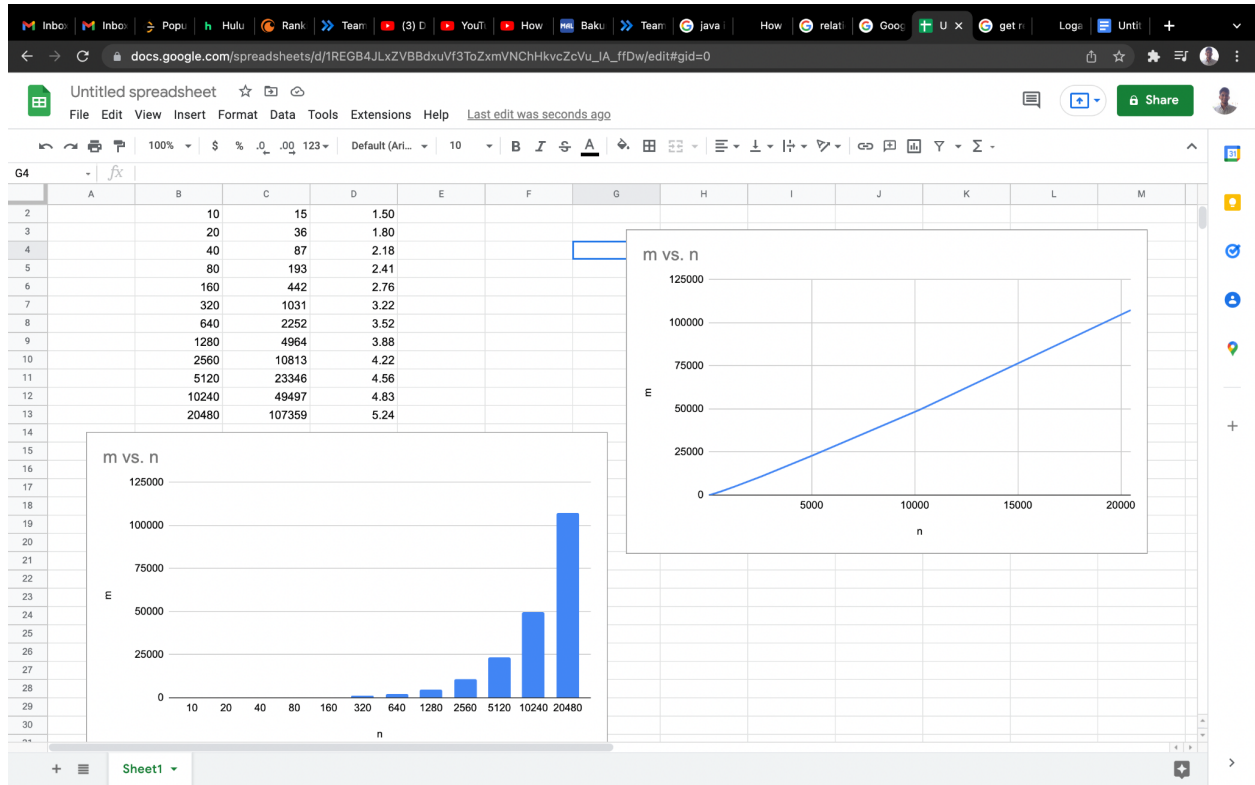
As the number of objects( $n$ ) are increasing the number of pairs( $m$ ) changes linearithmic with  $n$ . To be more precise  $m$  is increasing  $n$  times the log of  $n$  to the base 5 which can be approximated to below expression.

$$m = n * \log (n)$$

For larger values of  $n$  which is around 5000 to 20000,  $m$  value is nearly 5 times of  $n$  which can be seen in the evidence graph.

$$m = 5n$$

Evidence / Graph:



n	m	m/n
10	15	1.50
20	36	1.80
40	87	2.18
80	193	2.41
160	442	2.76
320	1031	3.22
640	2252	3.52
1280	4964	3.88
2560	10813	4.22
5120	23346	4.56
10240	49497	4.83

20480

107359

5.24

## Unit tests result

### Part 1:

The screenshot displays an IDE interface with the following components:

- Project Explorer:** Shows a project structure with folders like 'sort', 'symbolTable', 'threesum', and 'union\_find'. The 'union\_find' folder contains files such as 'Connections', 'HWQUPC\_Solution', 'TypedUF', 'TypedUF\_HWQUPC', 'UF', 'UF\_HWQUPC', 'UFException', 'WQUPC', and 'util'.
- Code Editor:** Displays the 'doPathCompression' method in 'UF\_HWQUPC.java'. The code includes a comment: `/** This implements the single-pass path-halving mechanism of path compression */` and a private method `doPathCompression(int i)` that calls `updateParent(i, getParent(getParent(i)))`. A yellow lightbulb icon indicates a suggestion or warning.
- Run Console:** Shows the execution of 'UF\_HWQUPC\_Test' with the following results:
  - Tests passed: 13 of 13 tests - 12 ms
  - Test results table:

Test Name	Duration
testIsConnected01	5 ms
testIsConnected02	0 ms
testIsConnected03	4 ms
testFind0	1 ms
testFind1	0 ms
testFind2	1 ms
testFind3	0 ms
testFind4	1 ms
testFind5	0 ms
testToString	0 ms
testConnect01	0 ms
testConnect02	0 ms
testConnected01	0 ms
  - Process finished with exit code 0
- Bottom Bar:** Includes tabs for 'Git', 'Run', 'TODO', 'Problems', 'Terminal', 'Build', and 'Dependencies'. The status bar at the bottom shows '195/50 LF UTF-8 4 spaces Spring2022'.