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# Program Structures & Algorithms

## FALL 2021

### Assignment 3

- **Task**

Step 1:

(a) Implement height-weighted Quick Union with Path Compression. For this, you will flesh out the class UF\_HWQUPC. All you have to do is to fill in the sections marked with // TO BE IMPLEMENTED ... // ...END IMPLEMENTATION.

(b) Check that the unit tests for this class all work. You must show "green" test results in your submission (screenshot is OK).

Step 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. If you prefer, you can create a main program that doesn't require any input and runs the experiment for a fixed set of  $n$  values. Show evidence of your run(s).

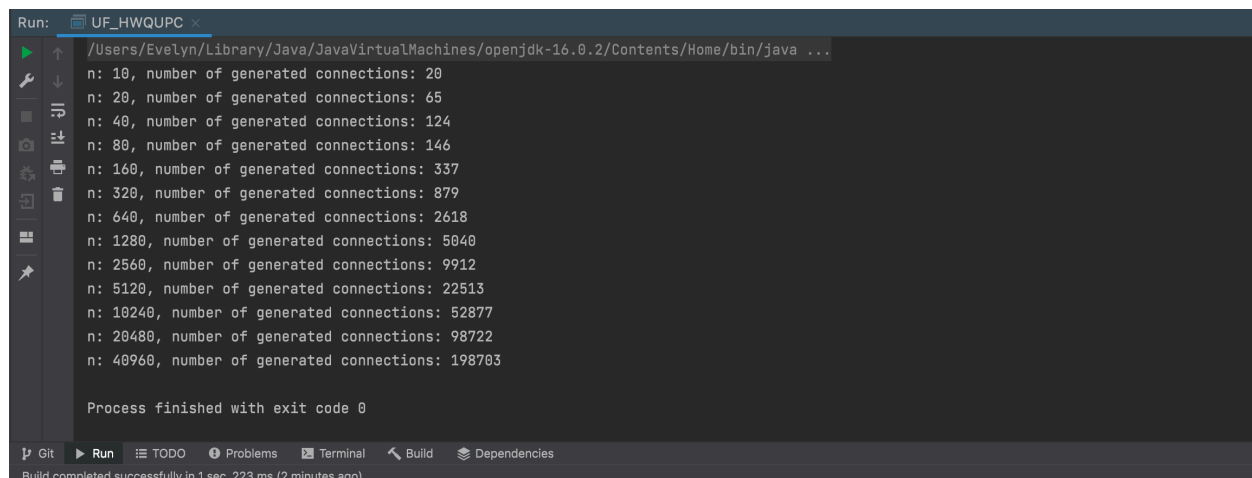
Step 3:

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). Justify your conclusion in terms of your observations and what you think might be going on.

- **Relationship Conclusion:**

The relationship between the number of objects ( $n$ ) and the number of pairs ( $m$ ) generated to accomplish is  $N/2 * \ln(N)$ .

- Output:



```
Run: UF_HWQUPC x
/Users/Evelyn/Library/Java/JavaVirtualMachines/openjdk-16.0.2/Contents/Home/bin/java ...
n: 10, number of generated connections: 20
n: 20, number of generated connections: 65
n: 40, number of generated connections: 124
n: 80, number of generated connections: 146
n: 160, number of generated connections: 337
n: 320, number of generated connections: 879
n: 640, number of generated connections: 2618
n: 1280, number of generated connections: 5040
n: 2560, number of generated connections: 9912
n: 5120, number of generated connections: 22513
n: 10240, number of generated connections: 52877
n: 20480, number of generated connections: 98722
n: 40960, number of generated connections: 198703

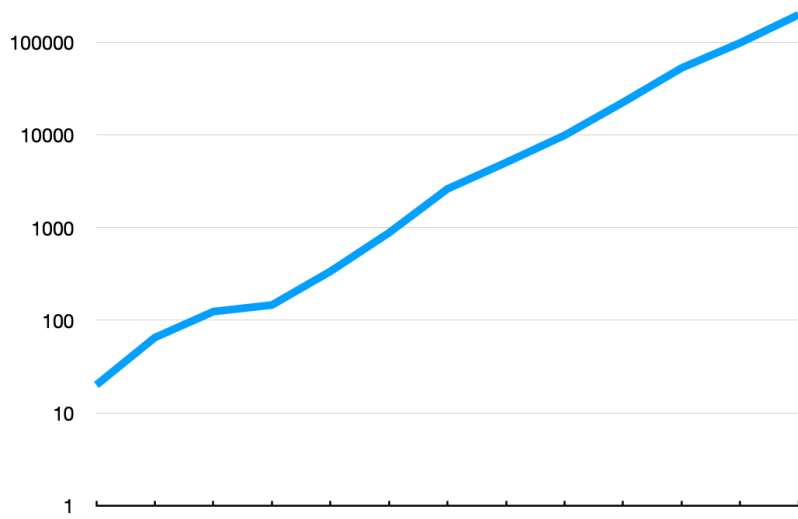
Process finished with exit code 0
```

Build completed successfully in 1 sec, 223 ms (2 minutes ago)

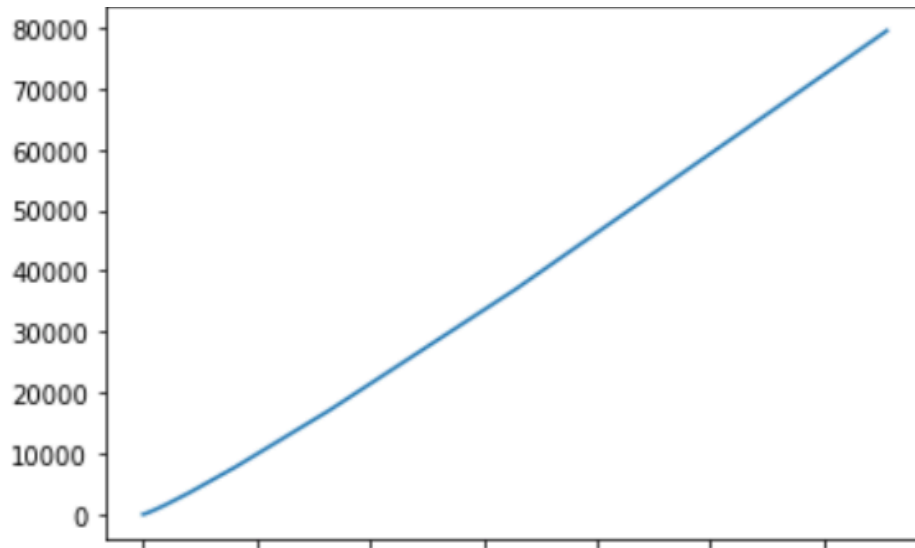
- Graphical Representation:

number of objects (n)	number of pairs (m)
10	20
20	65
40	124
80	146
160	337
320	879
640	2618
1280	5040
2560	9912
5120	22513
10240	52877
20480	98722
40960	198703

**n vs. m:**



**n vs.  $N/2 \cdot \ln(N)$**



- **Unit Test:**

