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Program Structures & Algorithms

Fall 2021

Assignment No. 3

⊙ Task

Step1:
(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).
Step2:
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).
Step3:
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.

NOTE: although I'm not going to tell you in advance what the relationship is, I can assure you that it is a *simple* relationship.

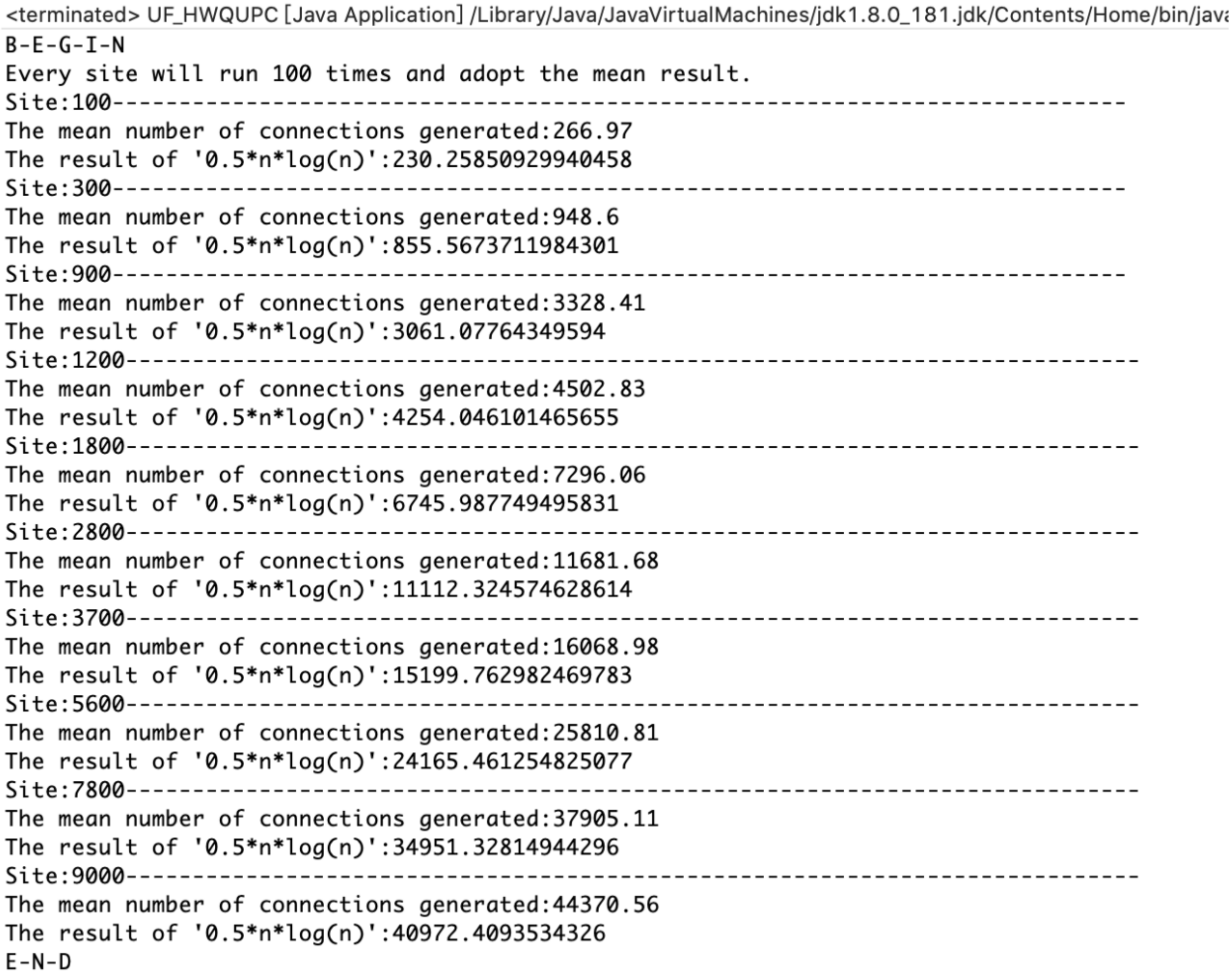
- **Relationship Conclusion:**

  The relationship between the number of objects (*n*) and the number of pairs (*m*) is close to:

  *m = 0.5 * n * lg(n)*

- **Evidence to support the conclusion:**

1. **Output**



```
<terminated> UF_HWQUPC [Java Application] /Library/Java/JavaVirtualMachines/jdk1.8.0_181.jdk/Contents/Home/bin/jav
B-E-G-I-N
Every site will run 100 times and adopt the mean result.
Site:100----------------------------------------------------------------------------
The mean number of connections generated:266.97
The result of '0.5*n*log(n)':230.25850929940458
Site:300----------------------------------------------------------------------------
The mean number of connections generated:948.6
The result of '0.5*n*log(n)':855.5673711984301
Site:900----------------------------------------------------------------------------
The mean number of connections generated:3328.41
The result of '0.5*n*log(n)':3061.07764349594
Site:1200----------------------------------------------------------------------------
The mean number of connections generated:4502.83
The result of '0.5*n*log(n)':4254.046101465655
Site:1800----------------------------------------------------------------------------
The mean number of connections generated:7296.06
The result of '0.5*n*log(n)':6745.987749495831
Site:2800----------------------------------------------------------------------------
The mean number of connections generated:11681.68
The result of '0.5*n*log(n)':11112.324574628614
Site:3700----------------------------------------------------------------------------
The mean number of connections generated:16068.98
The result of '0.5*n*log(n)':15199.762982469783
Site:5600----------------------------------------------------------------------------
The mean number of connections generated:25810.81
The result of '0.5*n*log(n)':24165.461254825077
Site:7800----------------------------------------------------------------------------
The mean number of connections generated:37905.11
The result of '0.5*n*log(n)':34951.32814944296
Site:9000----------------------------------------------------------------------------
The mean number of connections generated:44370.56
The result of '0.5*n*log(n)':40972.4093534326
E-N-D
```

Github:https://github.com/ZixuanZhu-faye/INFO-6205/blob/8fedc32517ce8a127f5696c96582e003d4802605/INFO6205-Fall2021/src/main/java/edu/neu/coe/info6205/union_find/UF_HWQUPC.java

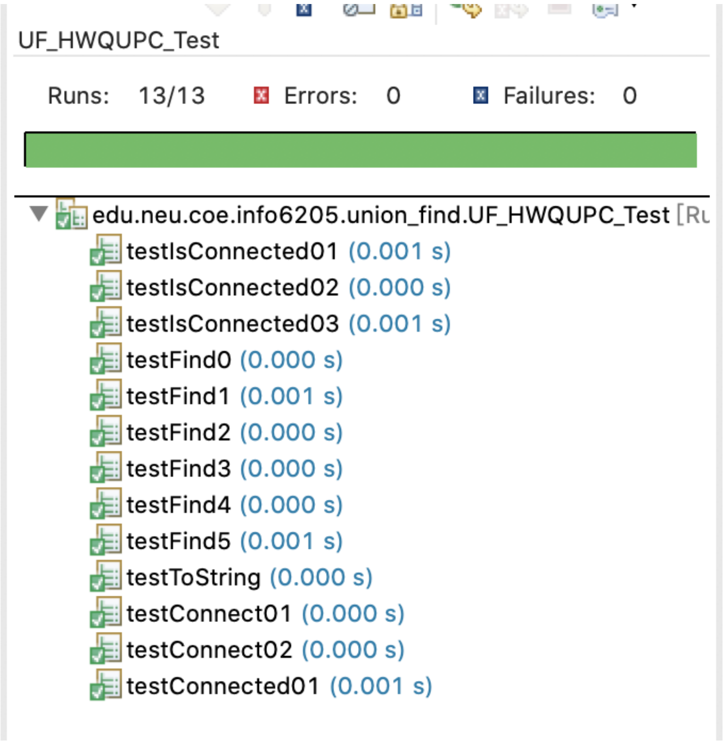
For each number of sites n, “Connections” means the mean number of connections generated after 100 times running, “Expected” means we expect the connections should be 0.5 * n * lg(n).

Times	Sites	Connections	Expected	Ratio
100	100	266.97	230.2585	1.16
100	300	984.6	855.5674	1.15
100	900	3328.41	3061.0776	1.07
100	1200	4502.83	4254.0461	1.06
100	1800	7296.06	6745.9877	1.08
100	2800	11681.68	11112.3246	1.05
100	3700	16068.98	15199.7630	1.06
100	5600	25810.81	24165.4613	1.07
100	7800	37905.11	34951.3281	1.08
100	9000	44370.56	40972.4094	1.08

According to the output from the program, the conclusion on the relationship between the number of objects (*n*) and the number of pairs (*m*) has been proved.

2. Graphical Representation

⊙ Unit tests result:



```
UF_HWQUPC_Test

  Runs:   13/13     Errors:   0      Failures:   0

edu.neu.coe.info6205.union_find.UF_HWQUPC_Test [Ru
    testIsConnected01 (0.001 s)
    testIsConnected02 (0.000 s)
    testIsConnected03 (0.001 s)
    testFind0 (0.000 s)
    testFind1 (0.001 s)
    testFind2 (0.000 s)
    testFind3 (0.000 s)
    testFind4 (0.000 s)
    testFind5 (0.001 s)
    testToString (0.000 s)
    testConnect01 (0.000 s)
    testConnect02 (0.000 s)
    testConnected01 (0.001 s)
```