Program Structures & Algorithms

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Assignment – 3

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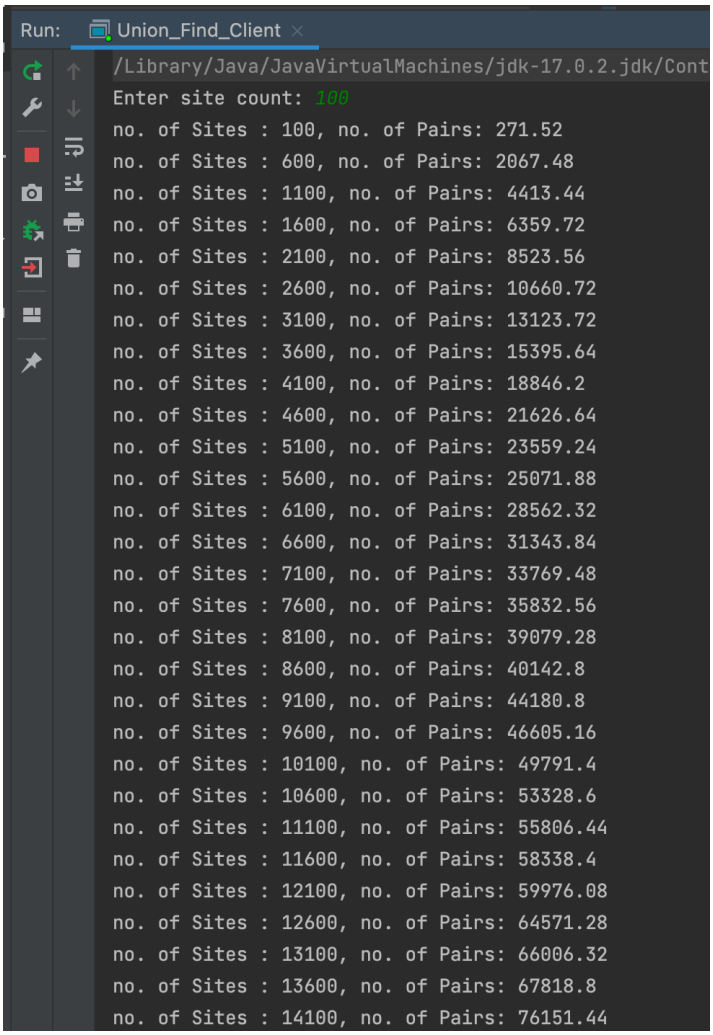
Task –

- 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.

Output –

Output of the above code is shown in the below picture. We have n for site count and m for no. of connections generated against each n value. We have shown value of m against different values of n below.



Relationship Conclusion –

From the above, we can see that the relationship between the number of objects (n) and the number of pairs (m) generated to reduce the number of components from n to 1 is:

$$m = ½ \times n \times \ln(n)\ 2$$

$m = number\ of\ pairs\ generated\ to\ reduce$ the $number\ of$ connections
$n = number\ of\ sites$

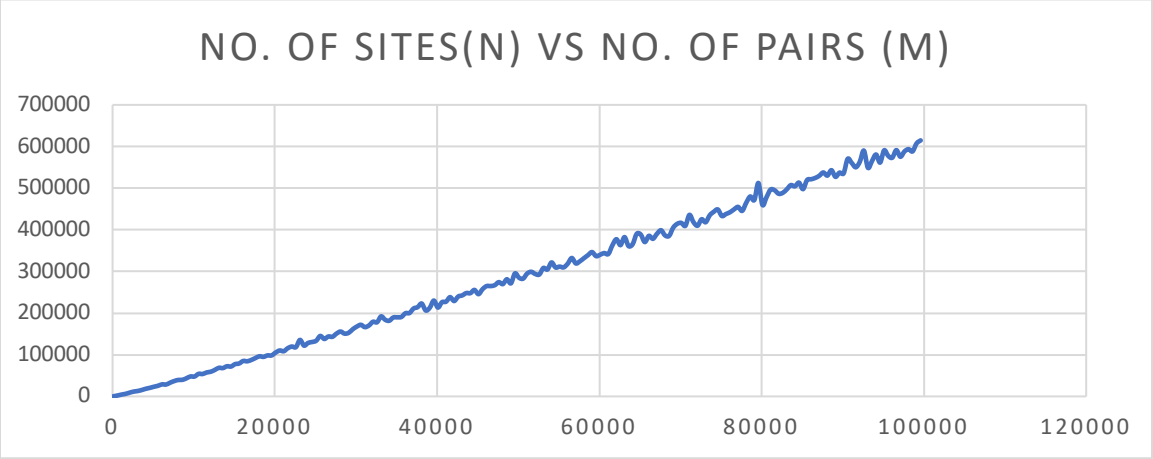
Evidence –

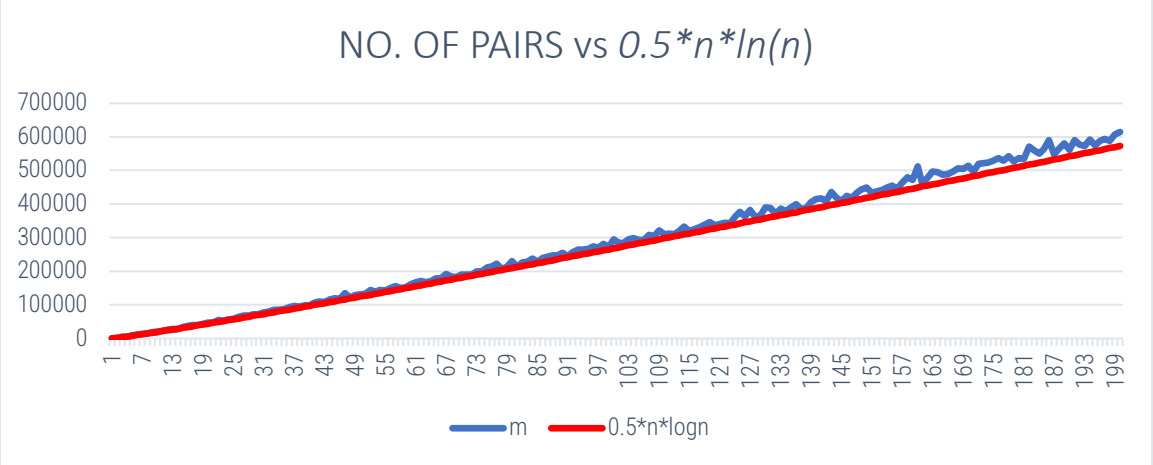
Let $f(N)$ be the number of pairs (m) generated to reduce the number of components from n to 1.

We took initial value of n as 100 and using the doubling method, we ran and calculated the number of pairs (m) generated to reduce the number of connections from n to 1 and computed the average number of pairs generated to accomplish this for each value of n.

In a union-find operation, we check if the pairs are connected or disconnected ($n\ ln(n)$). There are only two possibilities for each pair. Hence, the relationship between m and n is almost identical ½ × n × ln(n) 2.

The below graphs plotted between no. of sites and no. of pairs & pair and ½ × n × ln(n) 2 confirms the conclusion.

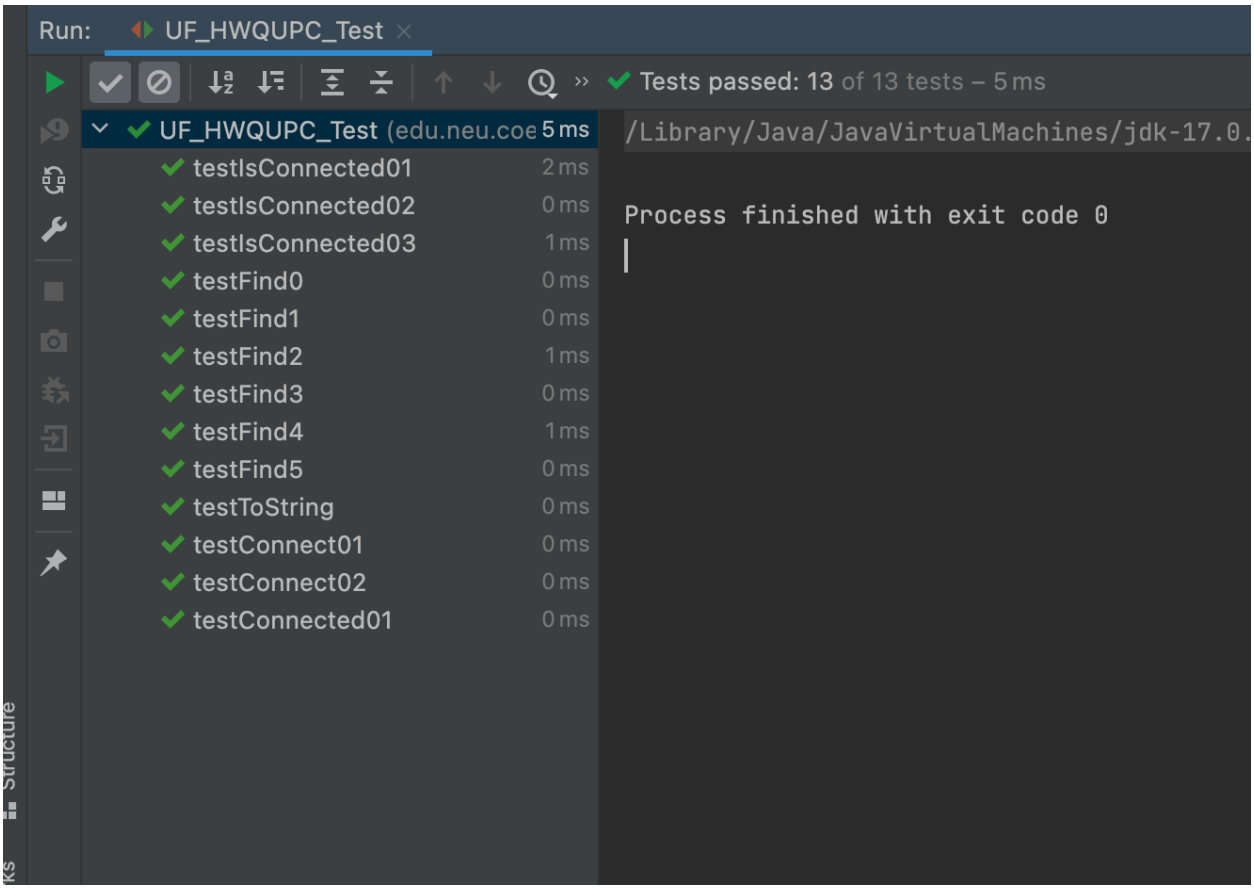




Unit Test Result –

Here is a screenshot of unit test results. The two classes are -

UF_HWQUPC_Test



WQUPC_Test