Program Structures & Algorithms
Spring 2022
Assignment No. 3

Name: Jayanth Vakkalagadda
(NUID): 002950342

Task

- (Part 1) Implement height-weighted Quick Union with Path Compression
- (Part 2) Develop a UF 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
- (Part 3) Determine the relationship between the number of objects *"n"* and the number of pairs *"m"*

Relationship Conclusion

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:

$$m = f(n) = 0.5 \times n * \ln(n)$$

where,

m = number of pairs generated to reduce the number of components to 1
n = number of objects

Evidence to the Conclusion

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

Taking initial value of n as 100 and using the doubling method, we can calculate the number of pairs (m) generated to reduce the number of components from n to 1, and compute the average number of pairs generated to accomplish this for each value of n.

For larger values of n, although not equal, the average number of pairs needed to reduce the components to 1 is close to *0.5 x n * ln(n).*

In this 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 to *0.5 x n * ln(n).*

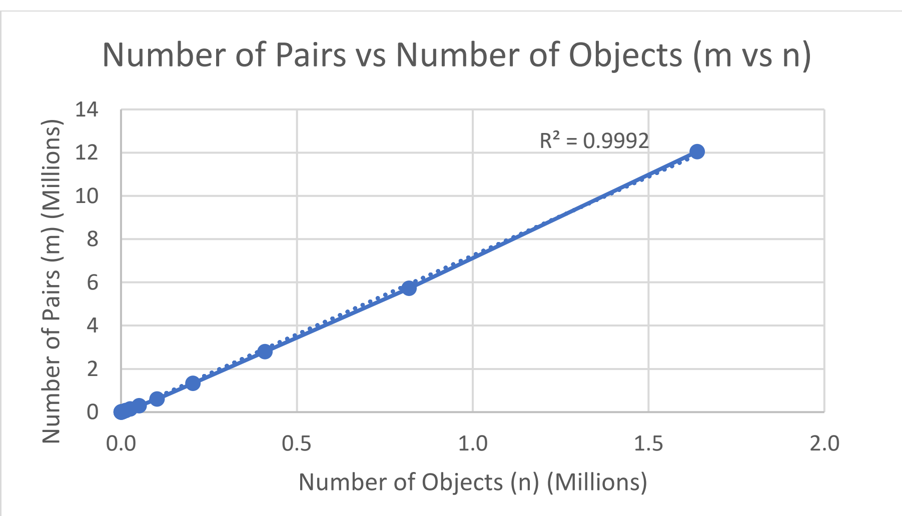
Below are the results for the performed simulations:

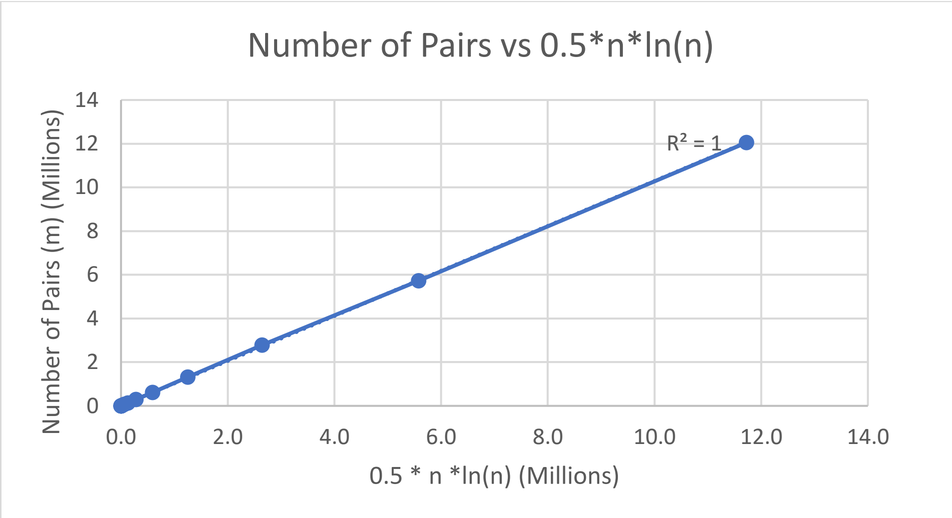
Number of Objects (n)	0.5 * n * ln(n)	Number of pairs (m)
100	230	258
200	530	616
400	1198	1276
800	2674	2847
1600	5902	6615
3200	12913	14077
6400	28045	29922
12800	60526	65302
25600	129924	136056
51200	277593	286517
102400	590676	607969
204800	1252330	1322209
409600	2646617	2787815
819200	5577148	5729626
1638400	11722122	12048479

I have checked two plots to test the relationship between “n” and “m”. They are as follows

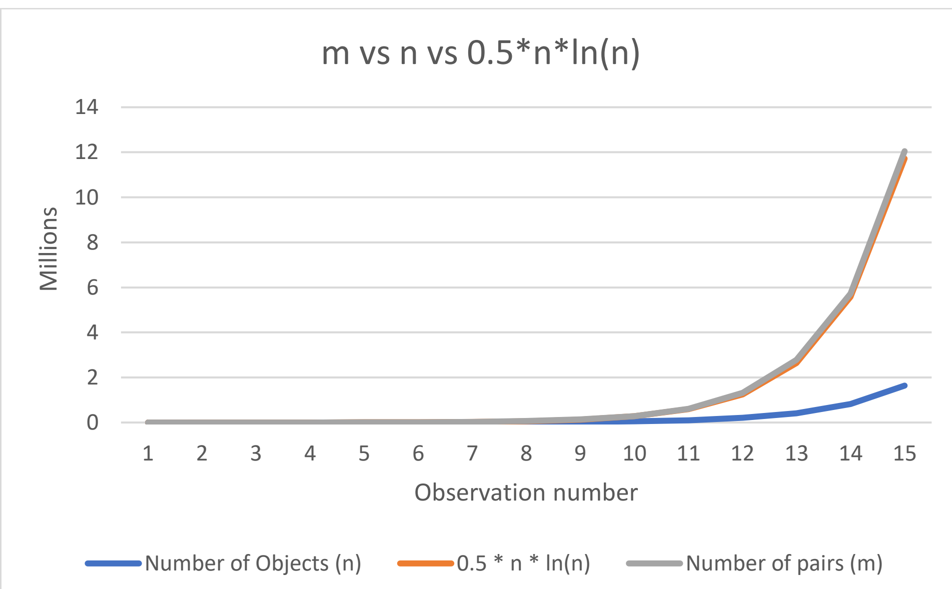
1) m vs n
2) m vs 0.5*n*ln(n)

Coefficient of determination (R^2) has been leveraged to identify the best fit among the below plots. But turns out that both the plots have similar R^2 value.

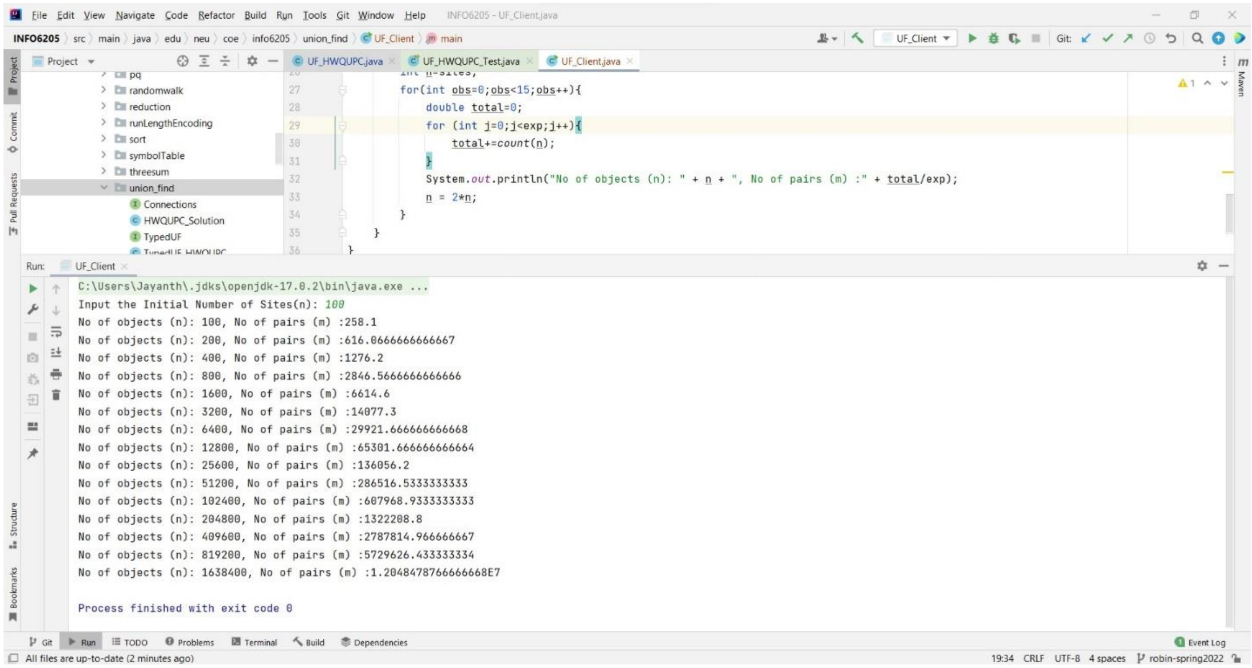


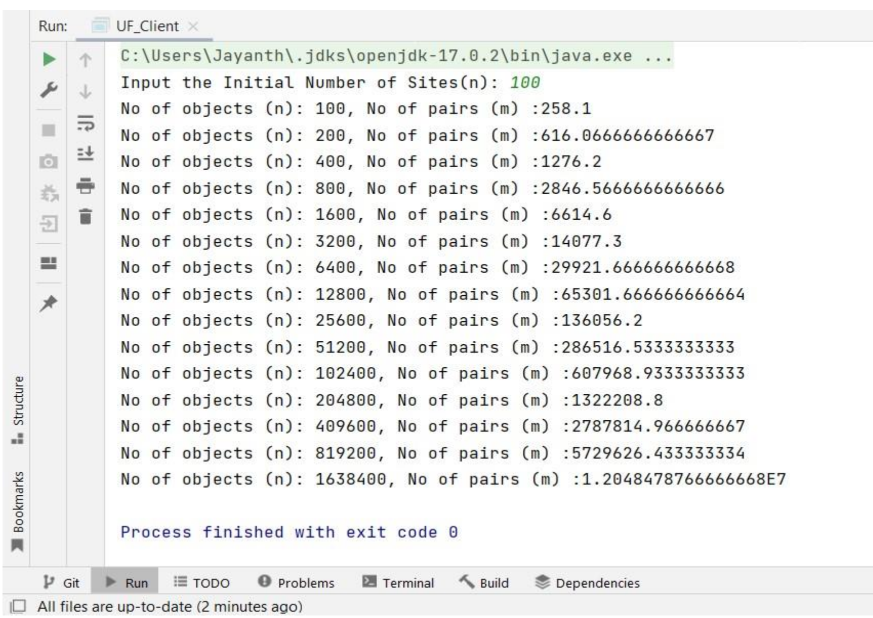


As R^2 value is not helping much here, I have plotted all the three parameters (m, n, 0.5*n*ln(n)) in a single plot for various observation points. From the plot below, it is clearly evident that "m" and "0.5*n*ln(n)* are strongly correlated and would be the best fit for our data points.



Output Screenshot



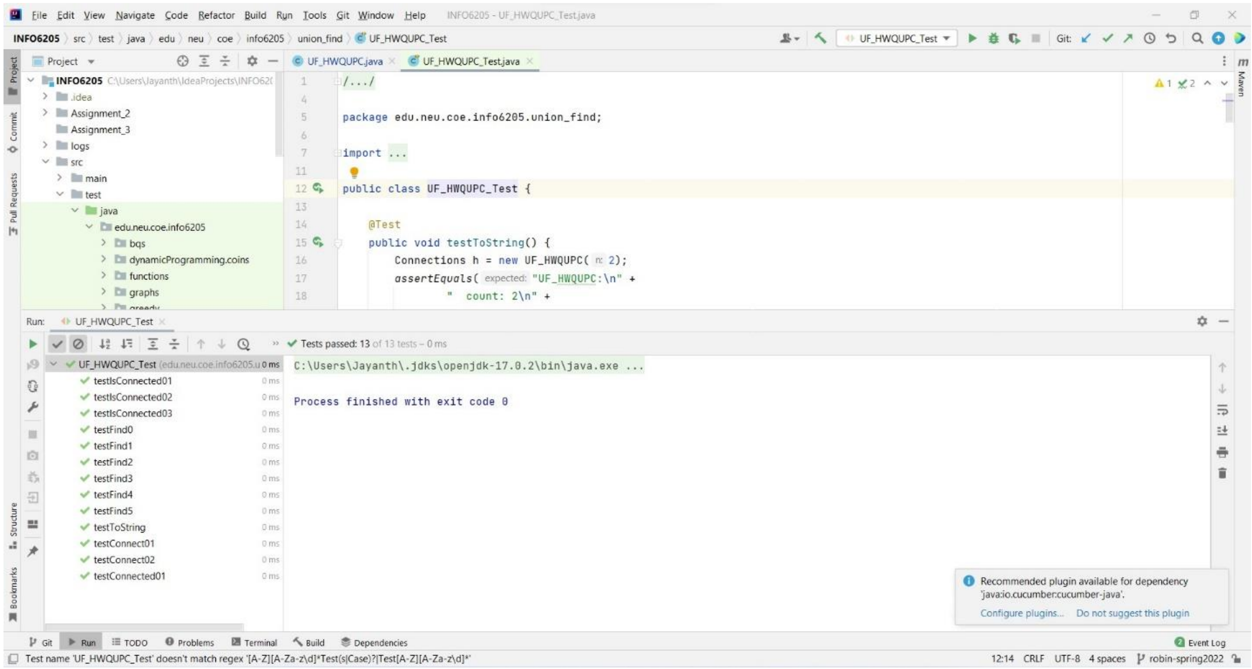


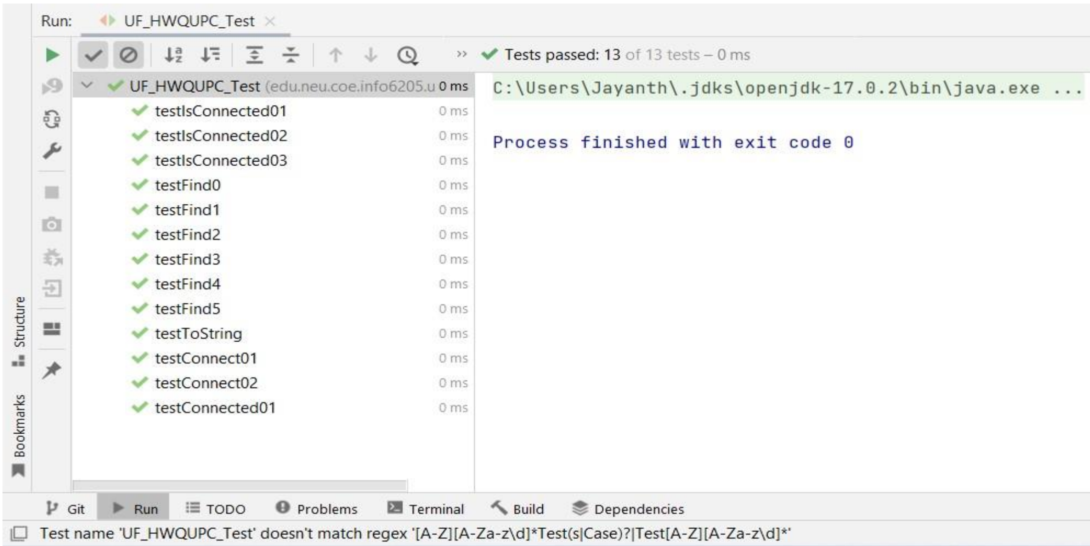
Output

Input the Initial Number of Sites(n): 100
No of objects (n): 100, No of pairs (m) :258.1
No of objects (n): 200, No of pairs (m) :616.0666666666667
No of objects (n): 400, No of pairs (m) :1276.2
No of objects (n): 800, No of pairs (m) :2846.5666666666666
No of objects (n): 1600, No of pairs (m) :6614.6
No of objects (n): 3200, No of pairs (m) :14077.3
No of objects (n): 6400, No of pairs (m) :29921.666666666668
No of objects (n): 12800, No of pairs (m) :65301.666666666664
No of objects (n): 25600, No of pairs (m) :136056.2
No of objects (n): 51200, No of pairs (m) :286516.5333333333
No of objects (n): 102400, No of pairs (m) :607968.9333333333
No of objects (n): 204800, No of pairs (m) :1322208.8
No of objects (n): 409600, No of pairs (m) :2787814.966666667
No of objects (n): 819200, No of pairs (m) :5729626.433333334
No of objects (n): 1638400, No of pairs (m) :1.2048478766666668E7

Process finished with exit code 0

Unit Tests




Run:
UF_HWQUPC_Test
Tests passed: 13 of 13 tests – 0 ms
UF_HWQUPC_Test (edu.neu.coe.info6205.u 0 ms
testIsConnected01 0 ms
testIsConnected02 0 ms
testIsConnected03 0 ms
testFind0 0 ms
testFind1 0 ms
testFind2 0 ms
testFind3 0 ms
testFind4 0 ms
testFind5 0 ms
testToString 0 ms
testConnect01 0 ms
testConnect02 0 ms
testConnected01 0 ms
C:\Users\Jayanth\.jdks\openjdk-17.0.2\bin\java.exe ...
Process finished with exit code 0
Structure
Bookmarks
Git
Run
TODO
Problems
Terminal
Build
Dependencies
Test name 'UF_HWQUPC_Test' doesn't match regex '[A-Z][A-Za-z\d]*Test(s|Case)?|Test[A-Z][A-Za-z\d]*'