Program Structures and Algorithms
Spring 2023(SEC –1)

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

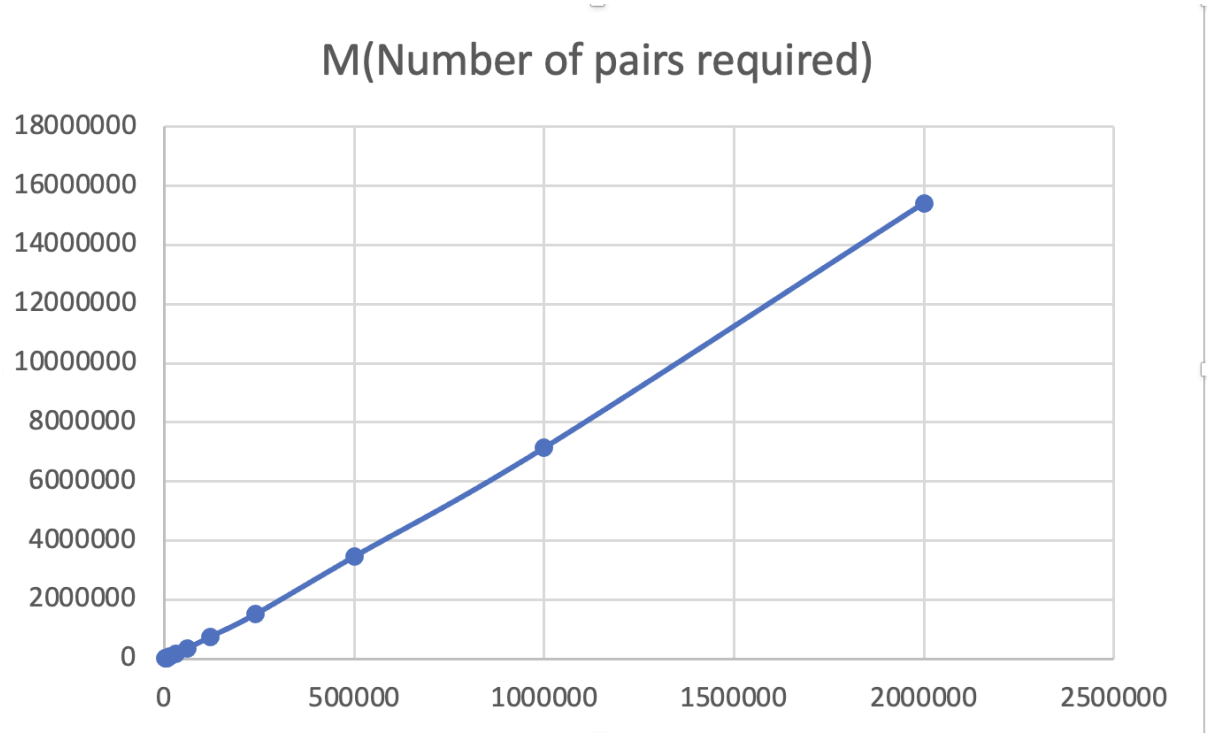
- The number of pairs required increases as the number of nodes increases. This relationship is likely since as the number of nodes in a network increases, the number of connections required to connect all nodes also increases.
- It appears to be a roughly linear relationship. We could estimate the equation using linear regression to find the line of best fit for the data points. The equation would then have the form:
- M = a * N + b
- where M is the number of pairs required, N is the number of nodes, a is the slope of the line, and b is the y-intercept. The specific values of a and b would need to be determined using the data points.

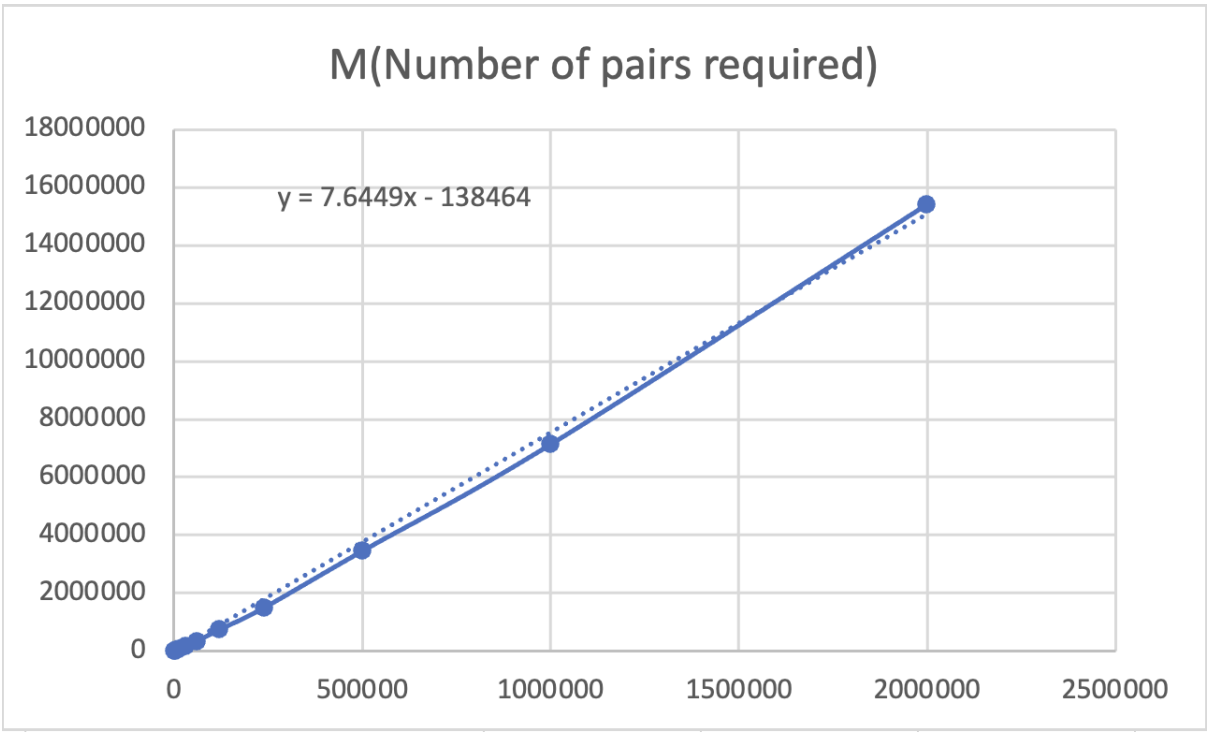
Evidence to support that conclusion:

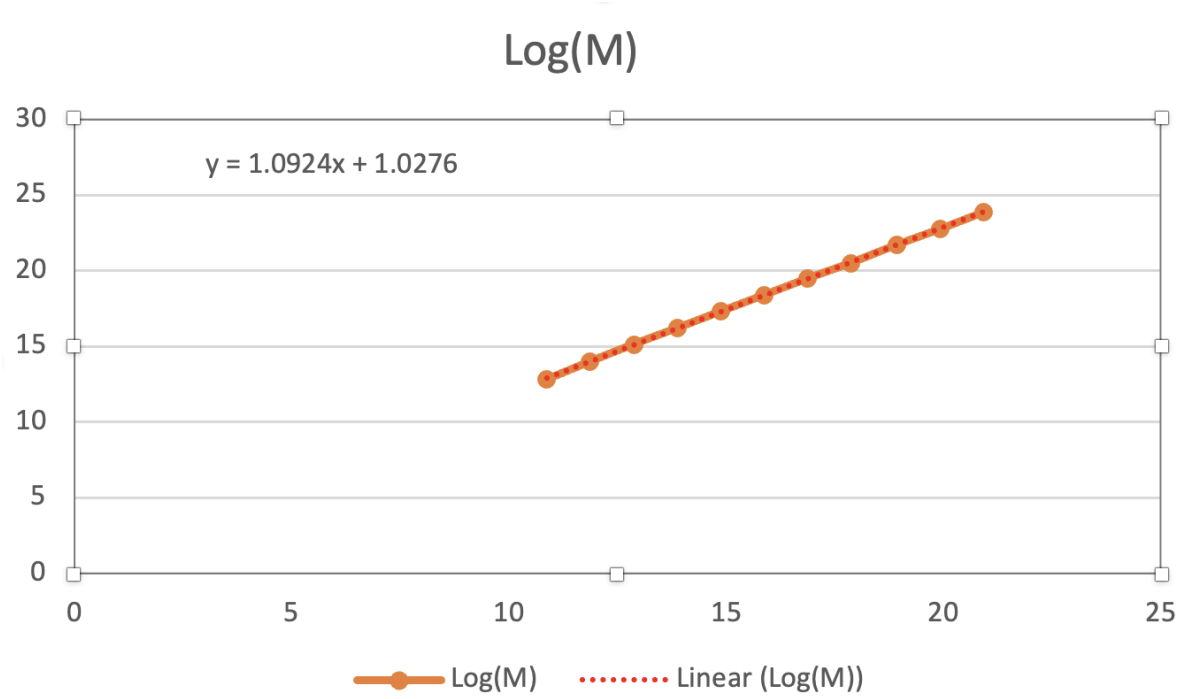
N(Number of Nodes)	M(Number of pairs required)	Log(N)	Log(M)
1875	7203	10.8726749	12.8143822
3750	16357	11.8726749	13.9976206
7500	36124	12.8726749	15.14067
15000	75619	13.8726749	16.2064612
30000	162456	14.8726749	17.3096895
60000	343634	15.8726749	18.3905133
120000	736003	16.8726749	19.4893521
240000	1506407	17.8726749	20.5226802
500000	3454399	18.9315686	21.7200033
1000000	7134112	19.9315686	22.7663024
2000000	15416906	20.9315686	23.8780099

- From the below graphs we can infer that Relationship is linear to prove it I have plotted log log graph which give a linear line with an equation of
- Y = 1.0924 * X + 1.0276
- Where Slope of the line is 1.0924 which is nearly 1 which indicate the exponent is 1 which means its linear relationship.

Graphical Representation:







Unit Test Screenshots: