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. 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 (the 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 randomly generated pairs (m) needed to reduce the number of components/objects from n to 1 can be described as follows:

m is proportional to n times the logarithm of n, with the logarithm taken to the base of 2. This relationship was determined by taking the average of m over 100 runs of a program, with the value of c, which is approximately equal to 1.22,

being determined from the results of runs with n ranging from 1000 to 512000 (doubling in each iteration).

**m = c * n * log(n)**
where c = m/n * log(n) which is approximately equal to 1.22 as observed over n ranging from 1000 to 512000(doubling)

Therefore we can summarize the relationship as
**m ∝ n * log(n)**

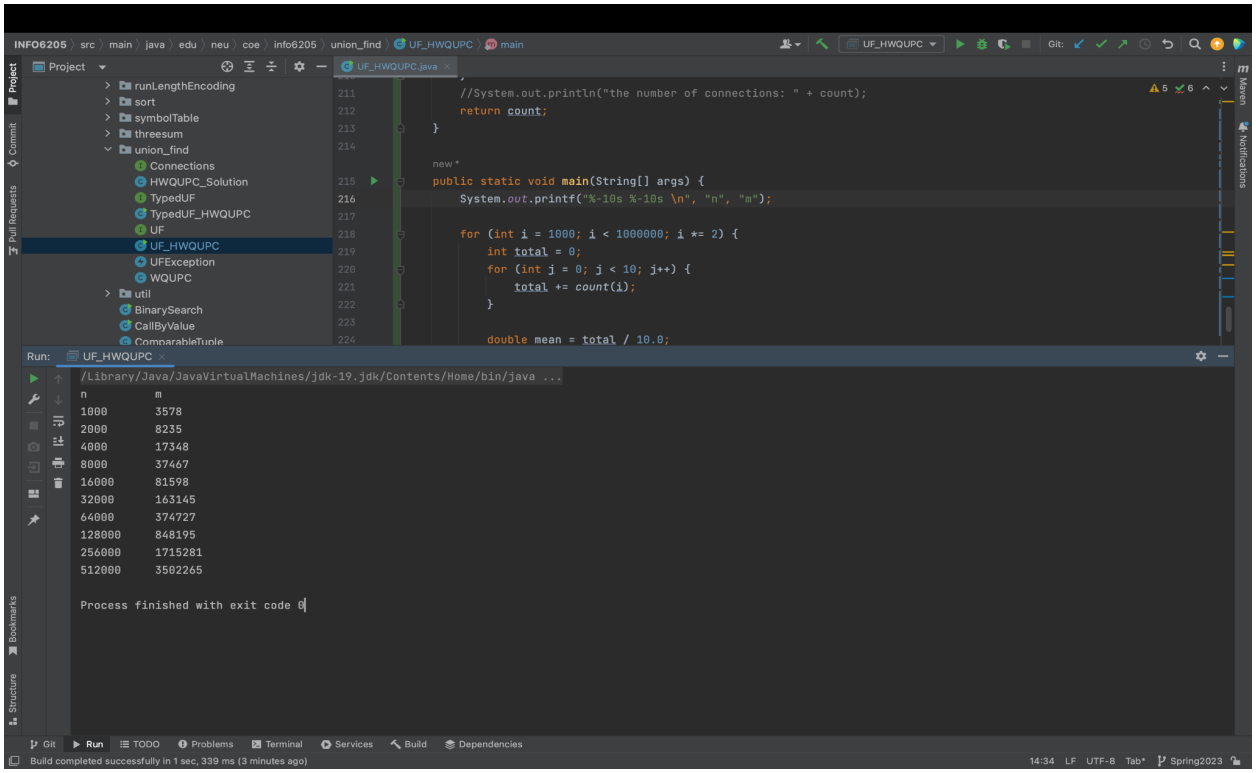
**Evidence to support that conclusion:**

1. Values of n are ranging from 1000 to 2048000(doubling each time).

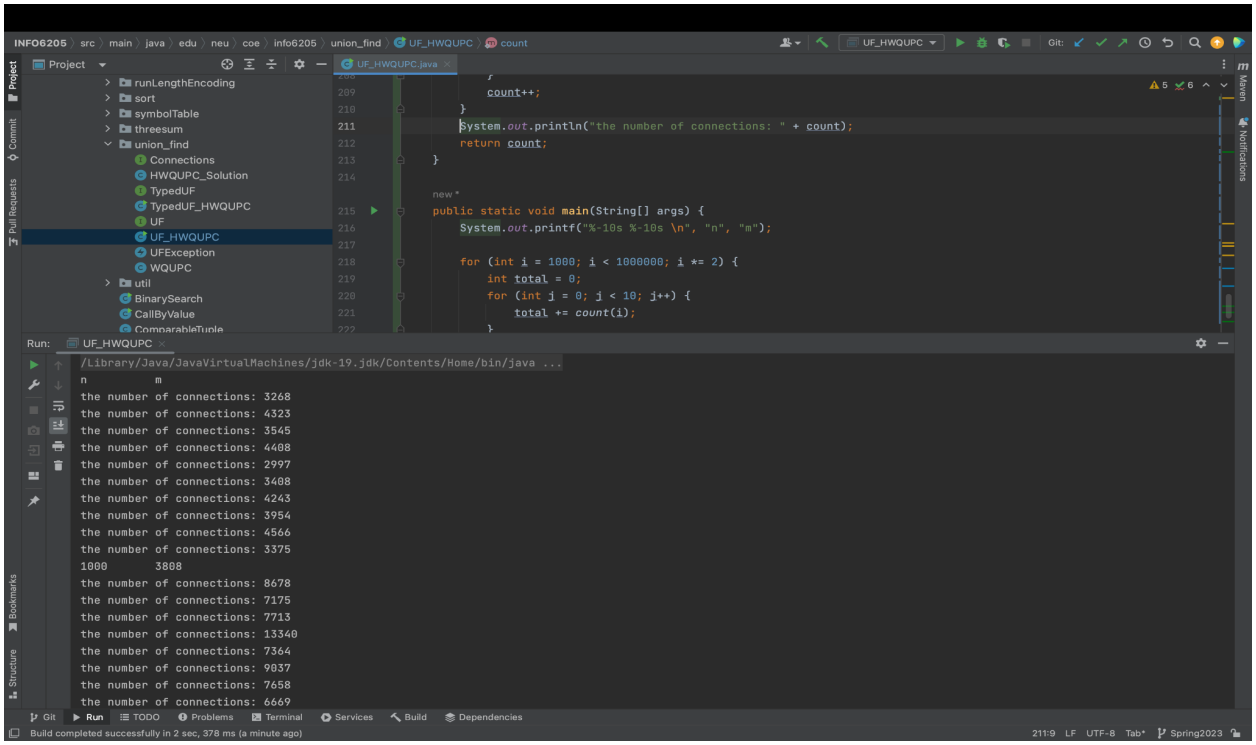
2. For each value of n, the program is running 100 times, and the average value of m is shown below.

3. The constant c = m/n * log(n) can be approximated to 1.22 And therefore the relationship can be established as

m = c* n* log(n)  or  m ∝ n* log(n)



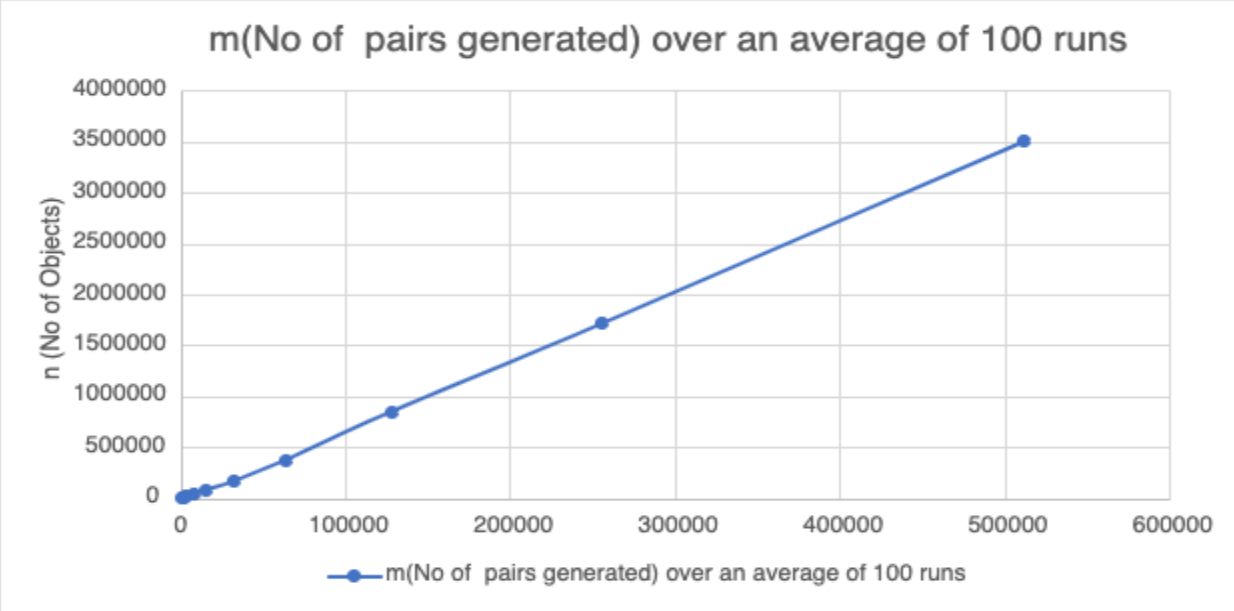
No. of Connections screenshots:




## Graphical Representation:

| n(No of Objects) | m(No of pairs generated) over an average of 100 runs |
|---|---|
| 1000 | 3578 |
| 2000 | 8235 |
| 4000 | 17348 |
| 8000 | 37467 |
| 16000 | 81598 |

| | |
|---|---|
| **32000** | **163145** |
| **64000** | **374727** |
| **128000** | **848195** |
| **256000** | **1715281** |
| **512000** | **3502265** |



# Unit Test Screenshots: