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**Program Structures & Algorithms**

**Fall 2021**

**Assignment No. 3**

**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 and , calling to determine if they are connected and if not. Loop until all sites are connected then print the number of connections generated. Package your program as a static method that takes n as the argument and returns the number of connections; and a that takes n from the command line, calls and prints the returned value.
* (Part 3) Determine the relationship between the number of objects () and the number of pairs ()

**Relationship Conclusion:**

The relationship between the number of objects and the number of pairs generated to reduce the number of components from to is:

Where,

**Evidence to support the conclusion:**

Let be the number of pairs generated to reduce the number of components from  to .

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

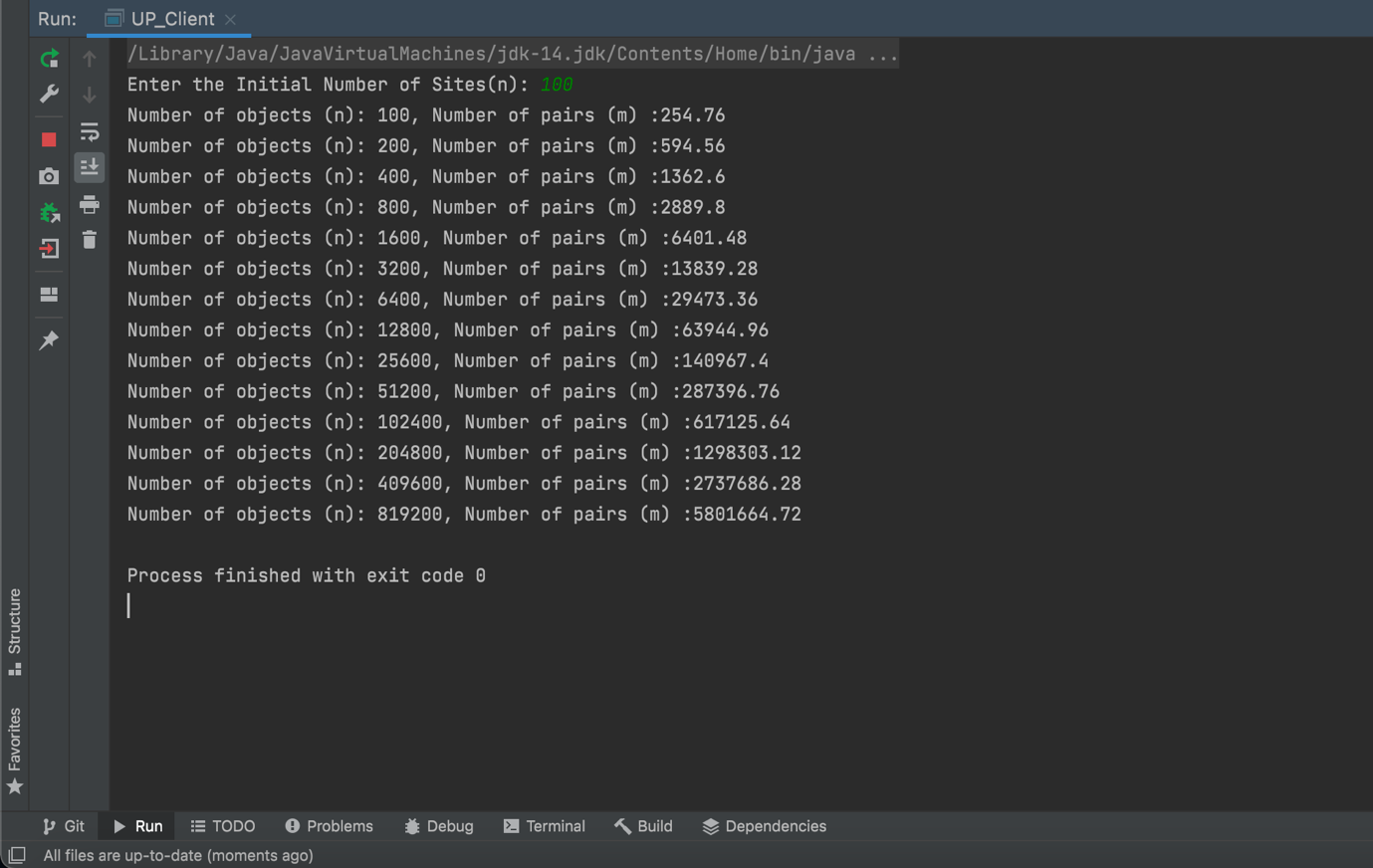
For larger values of , although not equal, the average number of pairs needed to reduce the component 1 is pretty close to .

We can consider a union-find operation similar to the sorting of a list. Instead, we check if the pairs are connected or disconnected There are only two possibilities for each pair. Hence, the relationship between m and n is almost identical to .

|  |  |  |
| --- | --- | --- |
| **Number of Objects (n)** | **Number of pairs (m)** | **0.5\*n\*ln(n)** |
| 100 | 254.76 | 230.2585093 |
| 200 | 594.56 | 529.8317367 |
| 400 | 1362.6 | 1198.292909 |
| 800 | 2889.8 | 2673.844691 |
| 1600 | 6401.48 | 5902.207127 |
| 3200 | 13839.28 | 12913.44974 |
| 6400 | 29473.36 | 28044.97046 |
| 12800 | 63944.96 | 60526.08288 |
| 25600 | 140967.4 | 129924.4497 |
| 51200 | 287396.76 | 277593.4672 |
| 102400 | 617125.64 | 590676.07 |
| 204800 | 1298303.12 | 1252330.411 |
| 409600 | 2737686.28 | 2646617.365 |
| 819200 | 5801664.72 | 5577147.815 |

The below diagrams show the result of plotting the above table data, on a standard scale, with the number of objects on the and number of pairs generated to reduce the number of components from to on the s.

**Console Output:**



Enter the Initial Number of Sites(n): 100

Number of objects (n): 100, Number of pairs (m) :254.76

Number of objects (n): 200, Number of pairs (m) :594.56

Number of objects (n): 400, Number of pairs (m) :1362.6

Number of objects (n): 800, Number of pairs (m) :2889.8

Number of objects (n): 1600, Number of pairs (m) :6401.48

Number of objects (n): 3200, Number of pairs (m) :13839.28

Number of objects (n): 6400, Number of pairs (m) :29473.36

Number of objects (n): 12800, Number of pairs (m) :63944.96

Number of objects (n): 25600, Number of pairs (m) :140967.4

Number of objects (n): 51200, Number of pairs (m) :287396.76

Number of objects (n): 102400, Number of pairs (m) :617125.64

Number of objects (n): 204800, Number of pairs (m) :1298303.12

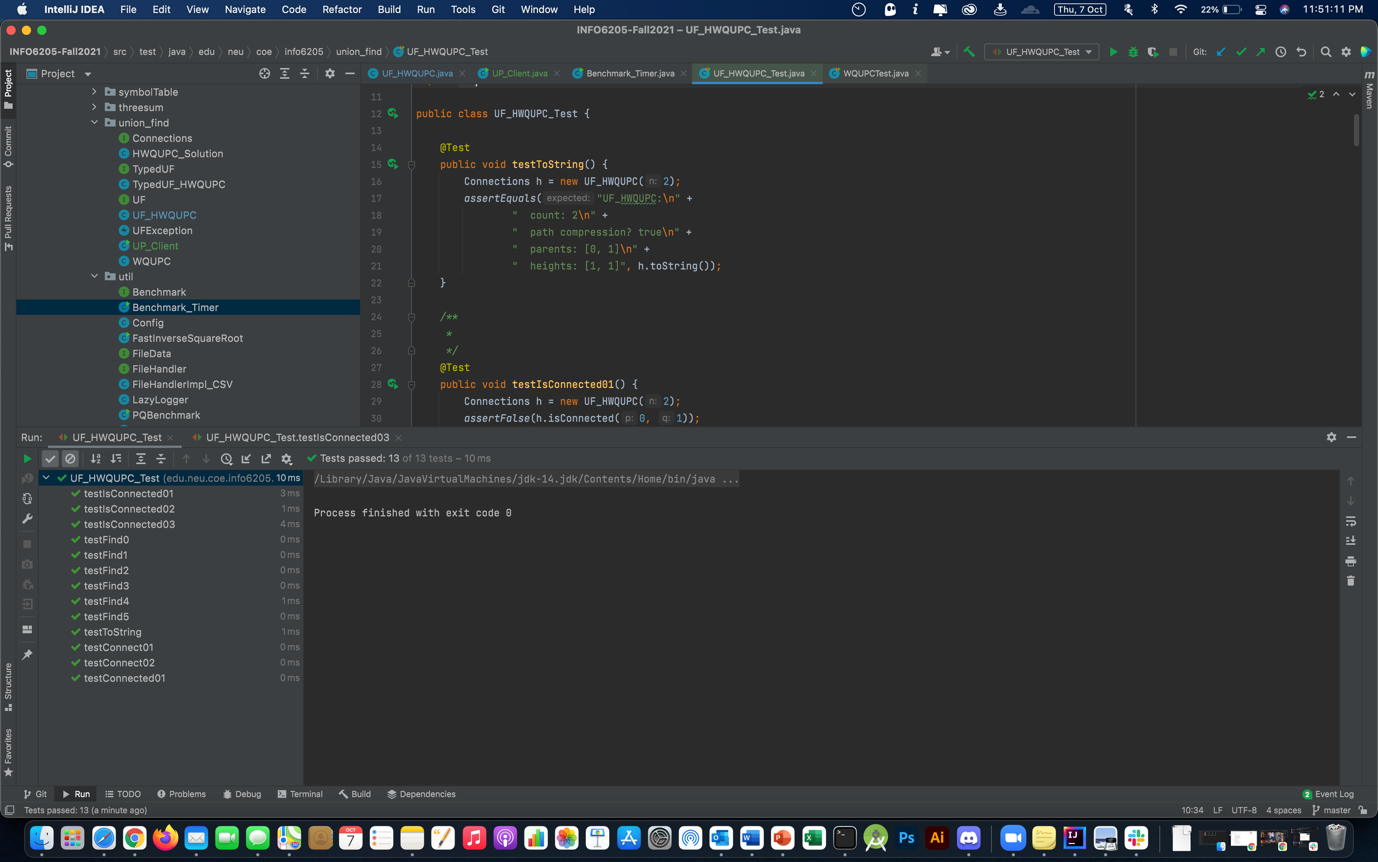
Number of objects (n): 409600, Number of pairs (m) :2737686.28

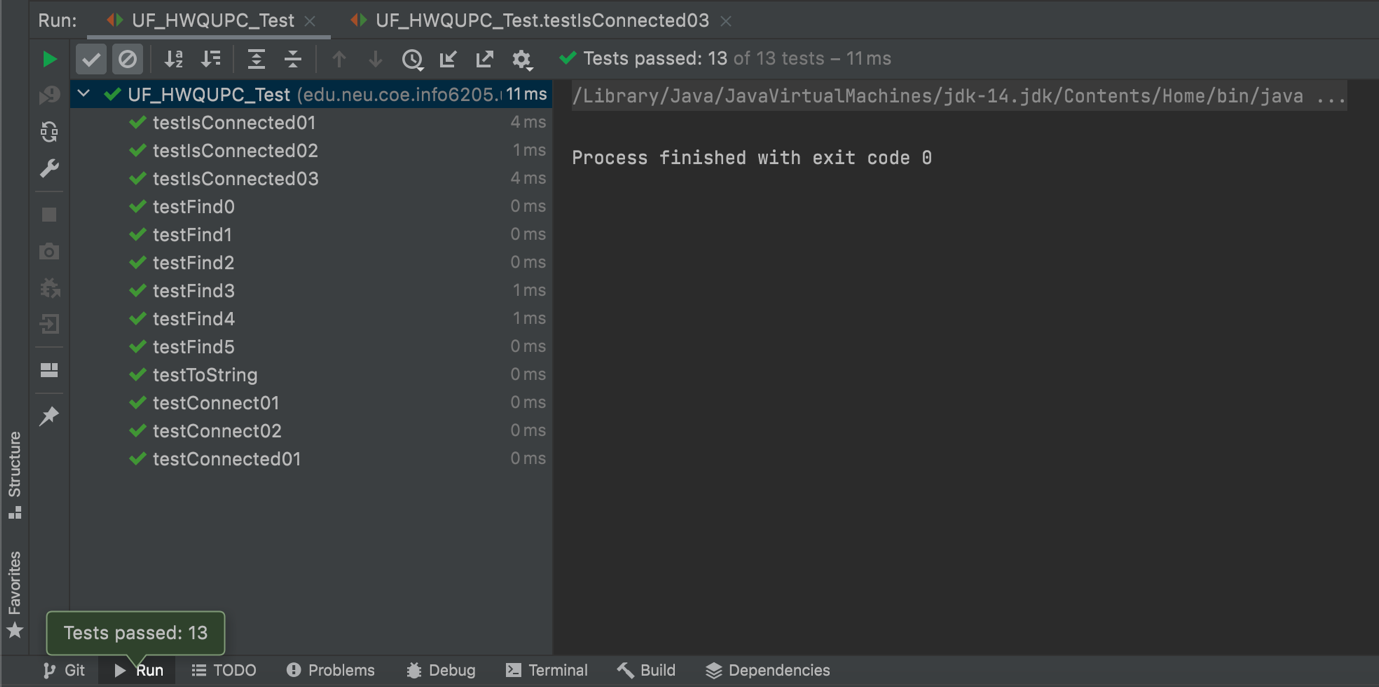
Number of objects (n): 819200, Number of pairs (m) :5801664.72

Process finished with exit code 0

**Unit Test Results:**

UF\_HWQUPC\_Test.java

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WQUPC\_Test.java

