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**Program Structures & Algorithms**

**Fall 2021 - Assignment (WQUPC)**

# Task:

1. a. Implement height-weighted Quick Union with Path Compression.
2. Check that the unit tests for this class all work.
3. Using the 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 the 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. Show evidence of the run(s).
4. Determine the relationship between the number of objects (n) and the number of pairs (m) generated to accomplish this. Justify your conclusion in terms of your observations and what you think might be going on.

**Task 1a:** Implement height-weighted Quick Union with Path Compression.

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**Task 1b:** All the unit tests for this class work without any modification.

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**Task 2: UF\_Client Implementation and output**

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**Task 3: Relationship between the number of objects (N) and the number of pairs (M)**

Based on my observations as noted below, I can conclude that the relationship between the m & n is linear.

It can be defined as m = k(NlogN)

With my observations k can be approximates to 1.2

Hence final relationship between the number of objects (N) and the number of pairs (M) is -

M = 1.2(NlogN)

**Supporting Evidence:**

With intervals of 2500, N value has been taken between 5000 and 100000, as displayed below.

|  |  |  |  |
| --- | --- | --- | --- |
| **Number of count sites(n)** | **nlogn** | **1.2(nlogn)** | **Number of Runs(m)** |
| 2500 | 8494.850022 | 10193.82 | 10548 |
| 5000 | 18494.85002 | 22193.82 | 22947 |
| 7500 | 29062.95948 | 34875.5514 | 35456 |
| 10000 | 40000 | 48000 | 49191 |
| 12500 | 51211.37516 | 61453.6502 | 63471 |
| 15000 | 62641.36889 | 75169.6427 | 75850 |
| 17500 | 74253.16585 | 89103.799 | 90356 |
| 20000 | 86020.59991 | 103224.72 | 106719 |
| 22500 | 97924.10666 | 117508.928 | 116668 |
| 25000 | 109948.5002 | 131938.2 | 132897 |
| 27500 | 122081.6491 | 146497.979 | 147879 |
| 30000 | 134313.6376 | 161176.365 | 160432 |
| 32500 | 146636.2092 | 175963.451 | 176917 |
| 35000 | 159042.3816 | 190850.858 | 191796 |
| 37500 | 171526.1725 | 205831.407 | 208417 |
| 40000 | 184082.3997 | 220898.88 | 222435 |
| 42500 | 196706.5295 | 236047.835 | 236822 |
| 45000 | 209394.5631 | 251273.476 | 253945 |
| 47500 | 222142.9465 | 266571.536 | 270679 |
| 50000 | 234948.5002 | 281938.2 | 278715 |
| 52500 | 247808.3634 | 297370.036 | 298992 |
| 55000 | 260719.9479 | 312863.938 | 319786 |
| 57500 | 273680.9011 | 328417.081 | 334189 |
| 60000 | 286689.075 | 344026.89 | 343085 |
| 62500 | 299742.5011 | 359691.001 | 359144 |
| 65000 | 312839.3682 | 375407.242 | 378919 |
| 67500 | 325978.0047 | 391173.606 | 396240 |
| 70000 | 339156.8628 | 406988.235 | 409775 |
| 72500 | 352374.5055 | 422849.407 | 423535 |
| 75000 | 365629.5948 | 438755.514 | 442923 |
| 77500 | 378920.8819 | 454705.058 | 455391 |
| 80000 | 392247.199 | 470696.639 | 486406 |
| 82500 | 405607.4508 | 486728.941 | 495528 |
| 85000 | 419000.6087 | 502800.73 | 514702 |
| 87500 | 432425.7046 | 518910.846 | 525863 |
| 90000 | 445881.8258 | 535058.191 | 534836 |
| 92500 | 459368.1103 | 551241.732 | 549379 |
| 95000 | 472883.7425 | 567460.491 | 571390 |
| 97500 | 486427.95 | 583713.54 | 592778 |
| 100000 | 500000 | 600000 | 601641 |