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# INFO 6205

# Program Structures & Algorithms

# Fall 2020

# Assignment No.4

- **Task**

We mentioned two alternatives for implementing Union-Find:

1. For weighted quick union, store the depth rather than the size;

2. For weighted quick union with path compression, do two loops, so that all intermediate nodes point to the root, not just the alternates.

For both of these, code the alternative and benchmark it against the implementation in the repository. You have all of that available from a previous assignment.

If you can explain why alternative #1 is unnecessary to be benchmarked, you may skip benchmarking that one.

- **Output** (few outputs to prove relationship)

```
<terminated> WQUPC [Java Application] /Library/Java/JavaVirtualM
(WQUPC_Simpler:20000):3.1678148
(WQUPC:20000):3.37362908
(WQU_SIZE:20000):4.42756689
(WQU_DEPTH:20000):5.16603422

(WQUPC_Simpler:40000):6.88529325
(WQUPC:40000):7.159335680000001
(WQU_SIZE:40000):9.56462217
(WQU_DEPTH:40000):10.04929838

(WQUPC_Simpler:80000):15.891704460000001
(WQUPC:80000):16.45149367
(WQU_SIZE:80000):22.91139275
(WQU_DEPTH:80000):24.70012419

(WQUPC_Simpler:160000):37.13039862
(WQUPC:160000):37.749463139999996
(WQU_SIZE:160000):56.65309271
(WQU_DEPTH:160000):59.620989030000004

(WQUPC_Simpler:320000):84.6383249
(WQUPC:320000):85.81148189
(WQU_SIZE:320000):130.82446331
(WQU_DEPTH:320000):136.86854213

(WQUPC_Simpler:640000):219.36851959
(WQUPC:640000):224.15948909
(WQU_SIZE:640000):327.67834418
(WQU_DEPTH:640000):350.28712767999997

(WQUPC_Simpler:1280000):632.96354711
(WQUPC:1280000):634.11949851
(WQU_SIZE:1280000):973.48090254
(WQU_DEPTH:1280000):986.81565245

(WQUPC_Simpler:2560000):1818.99150803
(WQUPC:2560000):1803.2719407900001
(WQU_SIZE:2560000):3008.53117654
(WQU_DEPTH:2560000):3054.02199536
```

```
<terminated> WQUPC [Java Application] /Library/Java/JavaVirtualMachine
WQUPC_Simpler Depth(n = 20000): 1.66
WQUPC_Simpler Depth(n = 40000): 1.73
WQUPC_Simpler Depth(n = 80000): 1.87
WQUPC_Simpler Depth(n = 160000): 1.67
WQUPC_Simpler Depth(n = 320000): 1.76
WQUPC_Simpler Depth(n = 640000): 1.77
WQUPC_Simpler Depth(n = 1280000): 1.78
WQUPC_Simpler Depth(n = 2560000): 1.73
WQUPC Depth(n = 20000): 1.73
WQUPC Depth(n = 40000): 1.76
WQUPC Depth(n = 80000): 1.8
WQUPC Depth(n = 160000): 1.75
WQUPC Depth(n = 320000): 1.74
WQUPC Depth(n = 640000): 1.72
WQUPC Depth(n = 1280000): 1.65
WQUPC Depth(n = 2560000): 1.76
WQU_SIZE Depth(n = 20000): 6.42
WQU_SIZE Depth(n = 40000): 6.89
WQU_SIZE Depth(n = 80000): 7.25
WQU_SIZE Depth(n = 160000): 7.68
WQU_SIZE Depth(n = 320000): 7.94
WQU_SIZE Depth(n = 640000): 8.39
WQU_SIZE Depth(n = 1280000): 8.78
WQU_SIZE Depth(n = 2560000): 9.16
WQU_DEPTH Depth(n = 20000): 6.06
WQU_DEPTH Depth(n = 40000): 6.37
WQU_DEPTH Depth(n = 80000): 6.83
WQU_DEPTH Depth(n = 160000): 7.15
WQU_DEPTH Depth(n = 320000): 7.45
WQU_DEPTH Depth(n = 640000): 7.81
WQU_DEPTH Depth(n = 1280000): 8.15
WQU_DEPTH Depth(n = 2560000): 8.4
```

- **Relationship conclusion**

According to output and graph, I found that:

For weighted quick union, no matter we store the depth or the size, there is no obvious difference in running time(graph 1 in evidence).

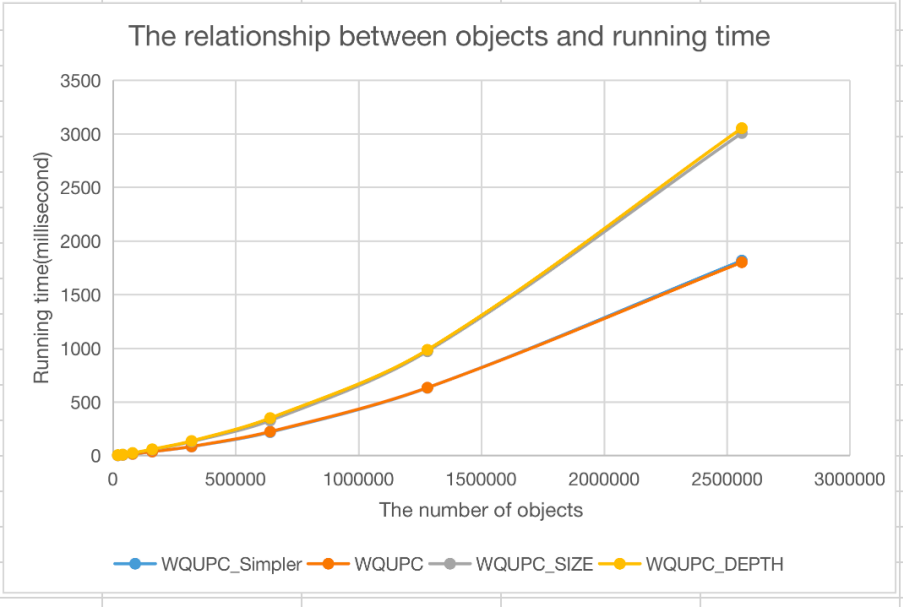
For weighted quick union with path compression, no matter we do two loops or implement the grandparent fix, there is no obvious difference in running time(graph 1 in evidence).

For weighted quick union, if we store the depth, the average depth of tree is smaller than the average depth of tree when we store the size.(graph 2 in evidence).

For weighted quick union with path compression, no matter we do two loops or implement the grandparent fix, there is no obvious difference in the average depth of tree(graph 2 in evidence).

- **Evidence to support relationship** (screen shot and/or graph and/or spreadsheet)

| n | WQUPC_Simpler | WQUPC | WQUPC_SIZE | WQUPC_DEPTH |
|---|---|---|---|---|
| 20000 | 3.1678148 | 3.37362908 | 4.42756689 | 5.16603422 |
| 40000 | 6.88529325 | 7.15933568 | 9.56462217 | 10.04929838 |
| 80000 | 15.89170446 | 16.45149367 | 22.91139275 | 24.70012419 |
| 160000 | 37.13039862 | 37.74946314 | 56.65309271 | 59.62098903 |
| 320000 | 84.6383249 | 85.81148189 | 130.8244633 | 136.8685421 |
| 640000 | 219.3685196 | 224.1594891 | 327.6783442 | 350.2871277 |
| 1280000 | 632.9635471 | 634.1194985 | 973.4809025 | 986.8156525 |
| 2560000 | 1818.991508 | 1803.271941 | 3008.531177 | 3054.021995 |



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| n | WQUPC_Simpler | WQUPC | WQUPC_SIZE | WQUPC_DEPTH |
|---|---|---|---|---|
| 20000 | 1.66 | 1.73 | 6.42 | 6.06 |
| 40000 | 1.73 | 1.76 | 6.89 | 6.37 |
| 80000 | 1.83 | 1.8 | 7.25 | 6.83 |
| 160000 | 1.67 | 1.75 | 7.68 | 7.15 |
| 320000 | 1.76 | 1.74 | 7.94 | 7.45 |
| 640000 | 1.77 | 1.72 | 8.39 | 7.81 |
| 1280000 | 1.78 | 1.65 | 8.78 | 8.15 |
| 2560000 | 1.73 | 1.76 | 9.16 | 8.4 |