Pei-Ling Chiang (NUID:001533847) - Sec02

INFO 6205

Program Structures & Algorithms

Fall 2020

Assignment 4 -Union Find Alternatives

Output:

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2020-10-12 04:35:40 INFO  Benchmark_Timer - Begin run: running with 10 runs
Number of sites n: 100, Number of pairs m: 196, Depth: 3
Number of sites n: 100, Number of pairs m: 288, Depth: 4
Number of sites n: 100, Number of pairs m: 284, Depth: 4
Number of sites n: 100, Number of pairs m: 249, Depth: 4
Number of sites n: 100, Number of pairs m: 199, Depth: 4
Number of sites n: 100, Number of pairs m: 211, Depth: 4
Number of sites n: 100, Number of pairs m: 272, Depth: 3
Number of sites n: 100, Number of pairs m: 295, Depth: 3
Number of sites n: 100, Number of pairs m: 271, Depth: 4
Number of sites n: 100, Number of pairs m: 244, Depth: 3
Number of sites n: 100, Number of pairs m: 361, Depth: 3
Number of sites n: 100, Number of pairs m: 229, Depth: 4
2020-10-12 04:35:40 INFO  Benchmark_Timer - Begin run: running with 10 runs
Number of sites n: 100, Number of pairs m: 372, Depth: 1
Number of sites n: 100, Number of pairs m: 262, Depth: 1
Number of sites n: 100, Number of pairs m: 290, Depth: 1
Number of sites n: 100, Number of pairs m: 263, Depth: 1
Number of sites n: 100, Number of pairs m: 281, Depth: 1
Number of sites n: 100, Number of pairs m: 216, Depth: 1
Number of sites n: 100, Number of pairs m: 284, Depth: 1
Number of sites n: 100, Number of pairs m: 207, Depth: 1
Number of sites n: 100, Number of pairs m: 221, Depth: 1
Number of sites n: 100, Number of pairs m: 393, Depth: 1
Number of sites n: 100, Number of pairs m: 282, Depth: 1
Number of sites n: 100, Number of pairs m: 187, Depth: 1
[WQU_Depth] Number of sites n: 100, running times: 0.2
[WQUPC]     Number of sites n: 100, running times: 0.1
2020-10-12 04:35:40 INFO  Benchmark_Timer - Begin run: running with 10 runs
Number of sites n: 1000, Number of pairs m: 3352, Depth: 5
Number of sites n: 1000, Number of pairs m: 3655, Depth: 5
Number of sites n: 1000, Number of pairs m: 4294, Depth: 4
Number of sites n: 1000, Number of pairs m: 2998, Depth: 5
Number of sites n: 1000, Number of pairs m: 3869, Depth: 5
Number of sites n: 1000, Number of pairs m: 3572, Depth: 5
Number of sites n: 1000, Number of pairs m: 3472, Depth: 5
Number of sites n: 1000, Number of pairs m: 3417, Depth: 5
Number of sites n: 1000, Number of pairs m: 3716, Depth: 4
Number of sites n: 1000, Number of pairs m: 4070, Depth: 5
Number of sites n: 1000, Number of pairs m: 2817, Depth: 4
Number of sites n: 1000, Number of pairs m: 4201, Depth: 4

2020-10-12 04:35:40 INFO  Benchmark_Timer - Begin run: running with 10 runs
Number of sites n: 1000, Number of pairs m: 3523, Depth: 1
Number of sites n: 1000, Number of pairs m: 3940, Depth: 1
Number of sites n: 1000, Number of pairs m: 3101, Depth: 1
Number of sites n: 1000, Number of pairs m: 2676, Depth: 1
Number of sites n: 1000, Number of pairs m: 3147, Depth: 1
Number of sites n: 1000, Number of pairs m: 3335, Depth: 1
Number of sites n: 1000, Number of pairs m: 5781, Depth: 1
Number of sites n: 1000, Number of pairs m: 3133, Depth: 1
Number of sites n: 1000, Number of pairs m: 2927, Depth: 1
Number of sites n: 1000, Number of pairs m: 3881, Depth: 1
Number of sites n: 1000, Number of pairs m: 2983, Depth: 1
Number of sites n: 1000, Number of pairs m: 3890, Depth: 1
[WQU_Depth] Number of sites n: 1000, running times: 1.1
[WQUPC]     Number of sites n: 1000, running times: 0.9
2020-10-12 04:35:40 INFO  Benchmark_Timer - Begin run: running with 10 runs
Number of sites n: 10000, Number of pairs m: 56625, Depth: 6
Number of sites n: 10000, Number of pairs m: 40762, Depth: 5
Number of sites n: 10000, Number of pairs m: 46443, Depth: 5
Number of sites n: 10000, Number of pairs m: 50175, Depth: 5
Number of sites n: 10000, Number of pairs m: 42765, Depth: 5
Number of sites n: 10000, Number of pairs m: 44610, Depth: 6
Number of sites n: 10000, Number of pairs m: 45413, Depth: 6
Number of sites n: 10000, Number of pairs m: 54849, Depth: 6
Number of sites n: 10000, Number of pairs m: 52824, Depth: 5
Number of sites n: 10000, Number of pairs m: 55394, Depth: 5
Number of sites n: 10000, Number of pairs m: 46170, Depth: 5
Number of sites n: 10000, Number of pairs m: 53076, Depth: 6
2020-10-12 04:35:40 INFO  Benchmark_Timer - Begin run: running with 10 runs
Number of sites n: 10000, Number of pairs m: 46938, Depth: 1
Number of sites n: 10000, Number of pairs m: 47695, Depth: 1
Number of sites n: 10000, Number of pairs m: 46319, Depth: 1
Number of sites n: 10000, Number of pairs m: 49643, Depth: 1
Number of sites n: 10000, Number of pairs m: 48246, Depth: 1
Number of sites n: 10000, Number of pairs m: 58623, Depth: 1
Number of sites n: 10000, Number of pairs m: 47396, Depth: 1
Number of sites n: 10000, Number of pairs m: 51625, Depth: 1
Number of sites n: 10000, Number of pairs m: 46051, Depth: 1
Number of sites n: 10000, Number of pairs m: 56841, Depth: 1
Number of sites n: 10000, Number of pairs m: 53636, Depth: 1
Number of sites n: 10000, Number of pairs m: 47177, Depth: 1
[WQU_Depth] Number of sites n: 10000, running times: 11.9
[WQUPC]     Number of sites n: 10000, running times: 7.6
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2020-10-12 04:35:40 INFO  Benchmark_Timer — Begin run: running with 10 runs
Number of sites n: 100000, Number of pairs m: 542502, Depth: 7
Number of sites n: 100000, Number of pairs m: 573188, Depth: 6
Number of sites n: 100000, Number of pairs m: 582663, Depth: 6
Number of sites n: 100000, Number of pairs m: 649608, Depth: 7
Number of sites n: 100000, Number of pairs m: 581922, Depth: 7
Number of sites n: 100000, Number of pairs m: 549382, Depth: 7
Number of sites n: 100000, Number of pairs m: 635844, Depth: 7
Number of sites n: 100000, Number of pairs m: 844048, Depth: 7
Number of sites n: 100000, Number of pairs m: 590958, Depth: 7
Number of sites n: 100000, Number of pairs m: 551145, Depth: 7
Number of sites n: 100000, Number of pairs m: 650008, Depth: 7
Number of sites n: 100000, Number of pairs m: 655182, Depth: 7
2020-10-12 04:35:41 INFO  Benchmark_Timer — Begin run: running with 10 runs
Number of sites n: 100000, Number of pairs m: 741460, Depth: 1
Number of sites n: 100000, Number of pairs m: 632396, Depth: 1
Number of sites n: 100000, Number of pairs m: 609054, Depth: 1
Number of sites n: 100000, Number of pairs m: 625414, Depth: 1
Number of sites n: 100000, Number of pairs m: 575540, Depth: 1
Number of sites n: 100000, Number of pairs m: 579390, Depth: 1
Number of sites n: 100000, Number of pairs m: 513335, Depth: 1
Number of sites n: 100000, Number of pairs m: 667116, Depth: 1
Number of sites n: 100000, Number of pairs m: 615958, Depth: 1
Number of sites n: 100000, Number of pairs m: 541377, Depth: 1
Number of sites n: 100000, Number of pairs m: 563412, Depth: 1
Number of sites n: 100000, Number of pairs m: 529646, Depth: 1
[WQU_Depth] Number of sites n: 100000, running times: 95.6
[WQUPC]     Number of sites n: 100000, running times: 62.1
2020-10-12 04:35:42 INFO  Benchmark_Timer — Begin run: running with 10 runs
Number of sites n: 1000000, Number of pairs m: 6942939, Depth: 9
Number of sites n: 1000000, Number of pairs m: 7712357, Depth: 8
Number of sites n: 1000000, Number of pairs m: 7210891, Depth: 8
Number of sites n: 1000000, Number of pairs m: 6812826, Depth: 8
Number of sites n: 1000000, Number of pairs m: 6999931, Depth: 8
Number of sites n: 1000000, Number of pairs m: 7293384, Depth: 8
Number of sites n: 1000000, Number of pairs m: 7701982, Depth: 8
Number of sites n: 1000000, Number of pairs m: 6565608, Depth: 8
Number of sites n: 1000000, Number of pairs m: 7034304, Depth: 8
Number of sites n: 1000000, Number of pairs m: 6694217, Depth: 8
Number of sites n: 1000000, Number of pairs m: 7017608, Depth: 8
Number of sites n: 1000000, Number of pairs m: 6860353, Depth: 8

2020-10-12 04:36:03 INFO  Benchmark_Timer — Begin run: running with 10 runs
Number of sites n: 1000000, Number of pairs m: 6755238, Depth: 1
Number of sites n: 1000000, Number of pairs m: 7713406, Depth: 1
Number of sites n: 1000000, Number of pairs m: 8195347, Depth: 1
Number of sites n: 1000000, Number of pairs m: 7736469, Depth: 1
Number of sites n: 1000000, Number of pairs m: 6738798, Depth: 1
Number of sites n: 1000000, Number of pairs m: 6680631, Depth: 1
Number of sites n: 1000000, Number of pairs m: 7341268, Depth: 1
Number of sites n: 1000000, Number of pairs m: 6855399, Depth: 1
Number of sites n: 1000000, Number of pairs m: 8163229, Depth: 1
Number of sites n: 1000000, Number of pairs m: 7164125, Depth: 1
Number of sites n: 1000000, Number of pairs m: 7574100, Depth: 1
Number of sites n: 1000000, Number of pairs m: 9220076, Depth: 1
[WQU_Depth] Number of sites n: 1000000, running times: 1692.1
[WQUPC]     Number of sites n: 1000000, running times: 1437.7
```

Conclusion:

For the find operation, WQU_Depth finds the root of p each time without making any nodes point to their parents. However, WQUPC makes every other node in path point to its grandparent when implementing the find operation, which will optimize the subsequent performance.

For the performance, although there is no significant difference when number of sites are rather small (i.e. 100 or 1000), we can see WQUPC is way better than WQU_Depth as number of sites are getting larger (i.e. 10000, 100000, 1000000).

For the average depth of the tree, since WQUPC uses path halving method, the final tree of WQUPC is flat with an average of depth 1. As for WQU_Depth, since the algorithm cares about size not height, its final tree has an average of depth much deeper than WQUPC.

Evidence:

Number of sites	WQU_Depth running times	WQUPC running times
100	0.2	0.1
1000	1.1	0.9
10000	11.9	7.6
100000	95.6	62.1
1000000	1692.1	1437.7

Number of sites	Avg Depth of WQU_Depth	Avg Depth of WQUPC
100	3.58	1
1000	4.67	1
10000	5.42	1
100000	6.83	1
1000000	8.08	1