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Program Structures and Algorithms
Spring 2021(SEC 05)

Task:

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

Conclusion:

If we have a tree of height 1, it must have at least 2 nodes i.e., 2^h nodes, where h = height of the tree.

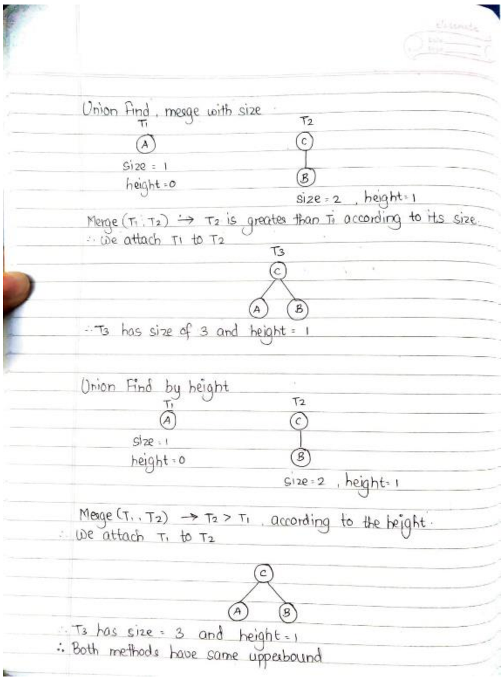
Union Find by size

So, for height = 0, minimum number of nodes will be 1 ∴ size of tree is 1
Similarly, for height = 1, minimum number of nodes will be 2 ∴ size of tree is 2
If we increase the height of the tree, it will always increment by 1
So, we get h = log(n)

Union Find by height

For height = 0, minimum number of nodes will be 1
Similarly, for height = 1, minimum number of nodes will be 2
Here, we get h = log(n)

Evidence to support that conclusion:



Union Find, merge with size

T1
A
T2
C
B

size = 1
height = 0

size = 2, height = 1

Merge (T_1, T_2) → T_2 is greater than T_1 according to its size.
∴ We attach T_1 to T_2

T3
C
A
B

∴ T_3 has size of 3 and height = 1

Union Find by height

T1
A
T2
C
B

size = 1
height = 0

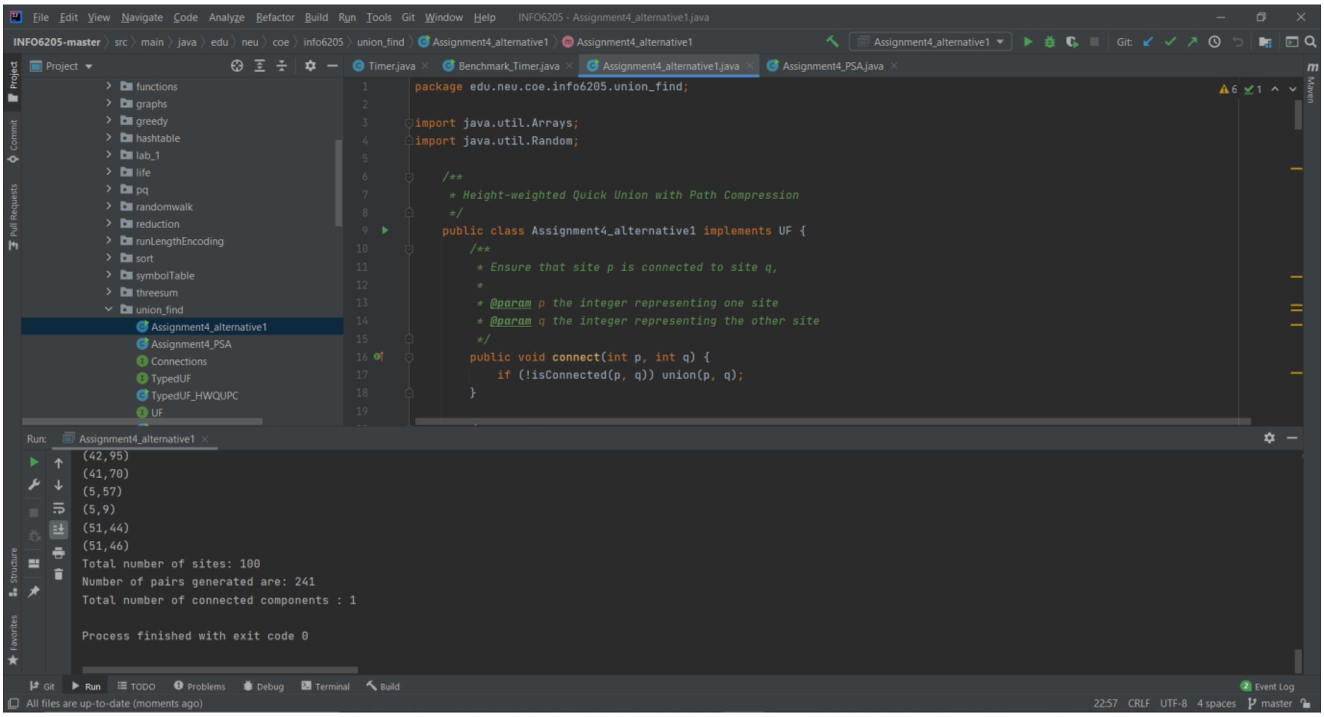
size = 2, height = 1

Merge (T_1, T_2) → $T_2 > T_1$, according to the height.
∴ We attach T_1 to T_2

C
A
B

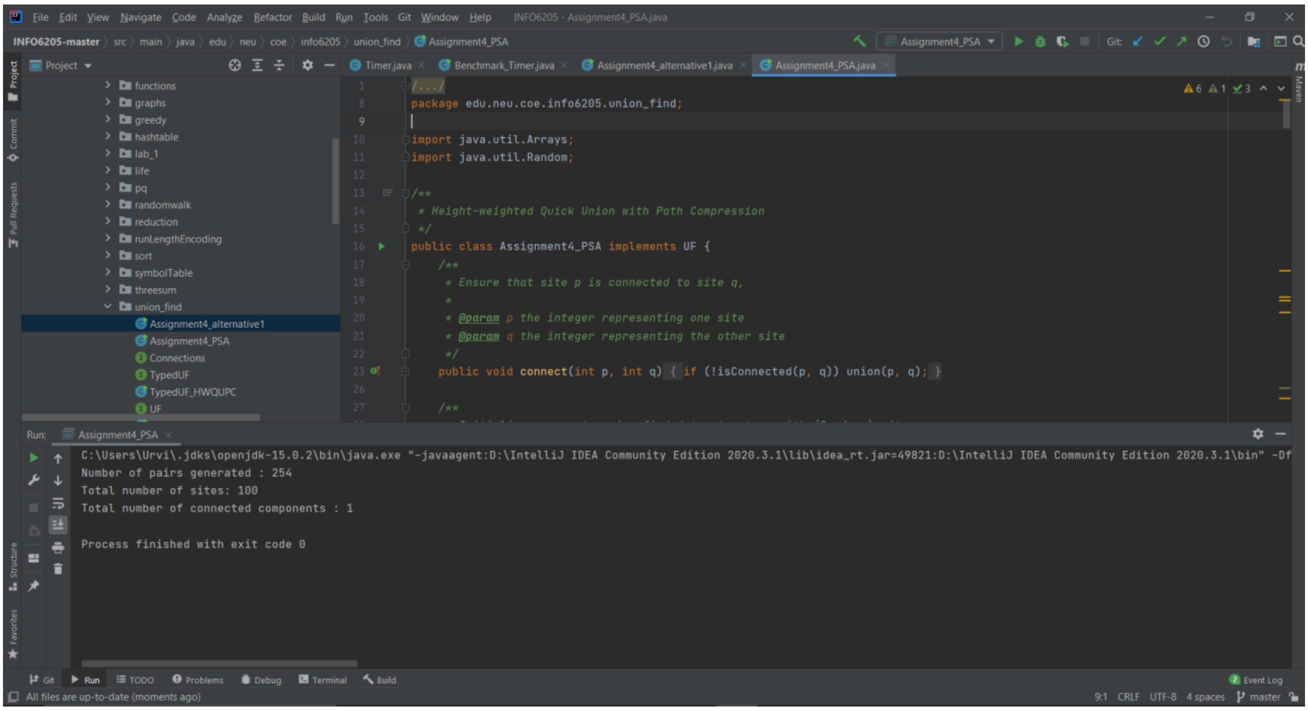
∴ T_3 has size = 3 and height = 1
∴ Both methods have same upperbound

Output Screenshots


File Edit View Navigate Code Analyze Refactor Build Run Tools Git Window Help
INFO6205 - Assignment4_alternative1.java
INFO6205-master src main java edu neu coe info6205 union_find Assignment4_alternative1 Assignment4_alternative1
Timer.java
Benchmark_Timer.java
Assignment4_alternative1.java
Assignment4_PSA.java
Project
functions
graphs
greedy
hashtable
lab_1
life
pq
randomwalk
reduction
runLengthEncoding
sort
symbolTable
threesum
union_find
Assignment4_alternative1
Assignment4_PSA
Connections
TypedUF
TypedUF_HWQUPC
UF
Run:
Git
TODO
Problems
Debug
Terminal
Build
Event Log
All files are up-to-date (moments ago)
22:57 CRLF UTF-8 4 spaces master

```java
package edu.neu.coe.info6205.union_find;

import java.util.Arrays;
import java.util.Random;

    /**
     * Height-weighted Quick Union with Path Compression
     */
    public class Assignment4_alternative1 implements UF {
        /**
         * Ensure that site p is connected to site q,
         *
         * @param p the integer representing one site
         * @param q the integer representing the other site
         */
        public void connect(int p, int q) {
            if (!isConnected(p, q)) union(p, q);
        }
```

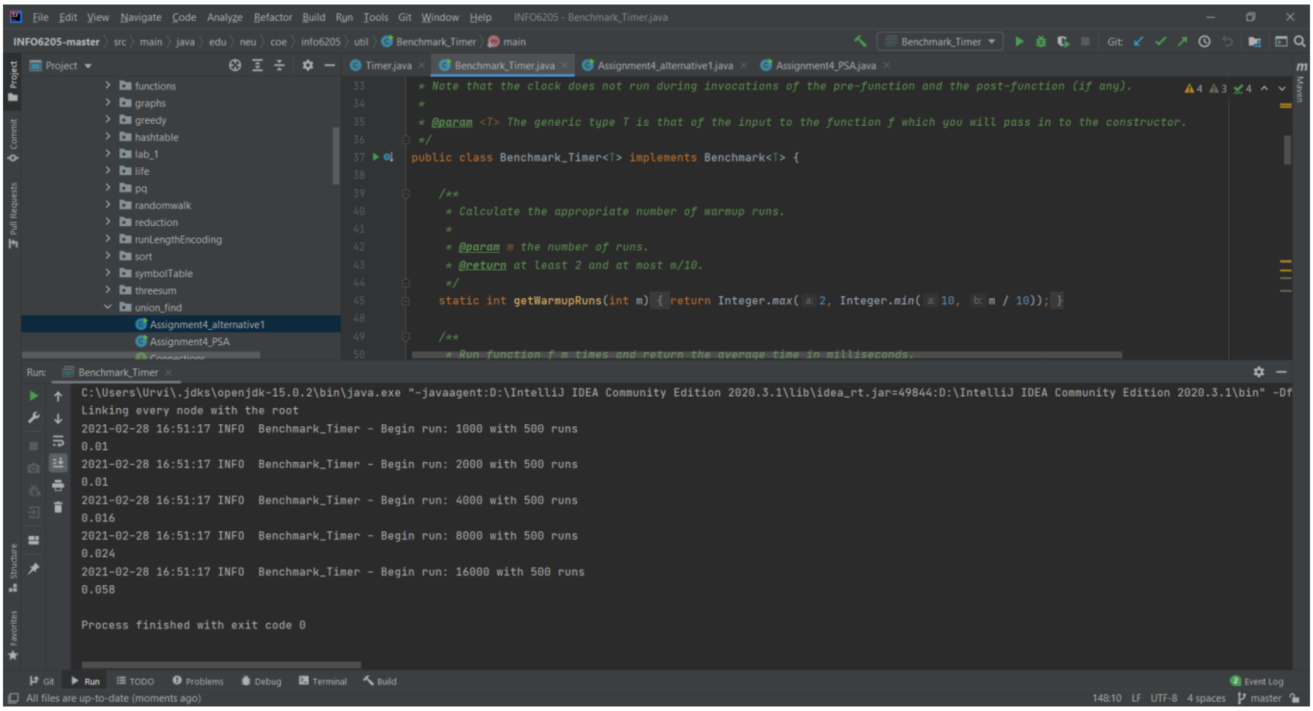
```
(42,95)
(41,70)
(5,57)
(5,9)
(51,44)
(51,46)
Total number of sites: 100
Number of pairs generated are: 241
Total number of connected components : 1

Process finished with exit code 0
```



```java
/.../
package edu.neu.coe.info6205.union_find;

import java.util.Arrays;
import java.util.Random;

/**
 * Height-weighted Quick Union with Path Compression
 */
public class Assignment4_PSA implements UF {
    /**
     * Ensure that site p is connected to site q,
     *
     * @param p the integer representing one site
     * @param q the integer representing the other site
     */
    public void connect(int p, int q) { if (!isConnected(p, q)) union(p, q); }

    /**
```

```
C:\Users\Urvi\.jdks\openjdk-15.0.2\bin\java.exe "-javaagent:D:\IntelliJ IDEA Community Edition 2020.3.1\lib\idea_rt.jar=49821:D:\IntelliJ IDEA Community Edition 2020.3.1\bin" -Df
Number of pairs generated : 254
Total number of sites: 100
Total number of connected components : 1

Process finished with exit code 0
```

Benchmarking implementation



```
 * Note that the clock does not run during invocations of the pre-function and the post-function (if any).
 *
 * @param <T> The generic type T is that of the input to the function f which you will pass in to the constructor.
 */
public class Benchmark_Timer<T> implements Benchmark<T> {

    /**
     * Calculate the appropriate number of warmup runs.
     *
     * @param m the number of runs.
     * @return at least 2 and at most m/10.
     */
    static int getWarmupRuns(int m) { return Integer.max( a: 2, Integer.min( a: 10,  b: m / 10)); }

    /**
     * Run function f m times and return the average time in milliseconds.
```

```
C:\Users\Urvi\.jdks\openjdk-15.0.2\bin\java.exe "-javaagent:D:\IntelliJ IDEA Community Edition 2020.3.1\lib\idea_rt.jar=49844:D:\IntelliJ IDEA Community Edition 2020.3.1\bin" -Df
Linking every node with the root
2021-02-28 16:51:17 INFO  Benchmark_Timer - Begin run: 1000 with 500 runs
0.01
2021-02-28 16:51:17 INFO  Benchmark_Timer - Begin run: 2000 with 500 runs
0.01
2021-02-28 16:51:17 INFO  Benchmark_Timer - Begin run: 4000 with 500 runs
0.016
2021-02-28 16:51:17 INFO  Benchmark_Timer - Begin run: 8000 with 500 runs
0.024
2021-02-28 16:51:17 INFO  Benchmark_Timer - Begin run: 16000 with 500 runs
0.058

Process finished with exit code 0
```