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INFO 6205
Program Structures & Algorithms
Fall 2020
Assignment No. 3

The report format follows this document

Task

Your task is

Step 1

(a) Implement height-weighted Quick Union with Path Compression. For this, you will flesh out the class UF_HWQUPC. All you have to do is to fill in the sections marked with // TO BE IMPLEMENTED ... // ...END IMPLEMENTATION.

(b) Check that the unit tests for this class all work. You must show "green" test results in your submission (screenshot is OK).

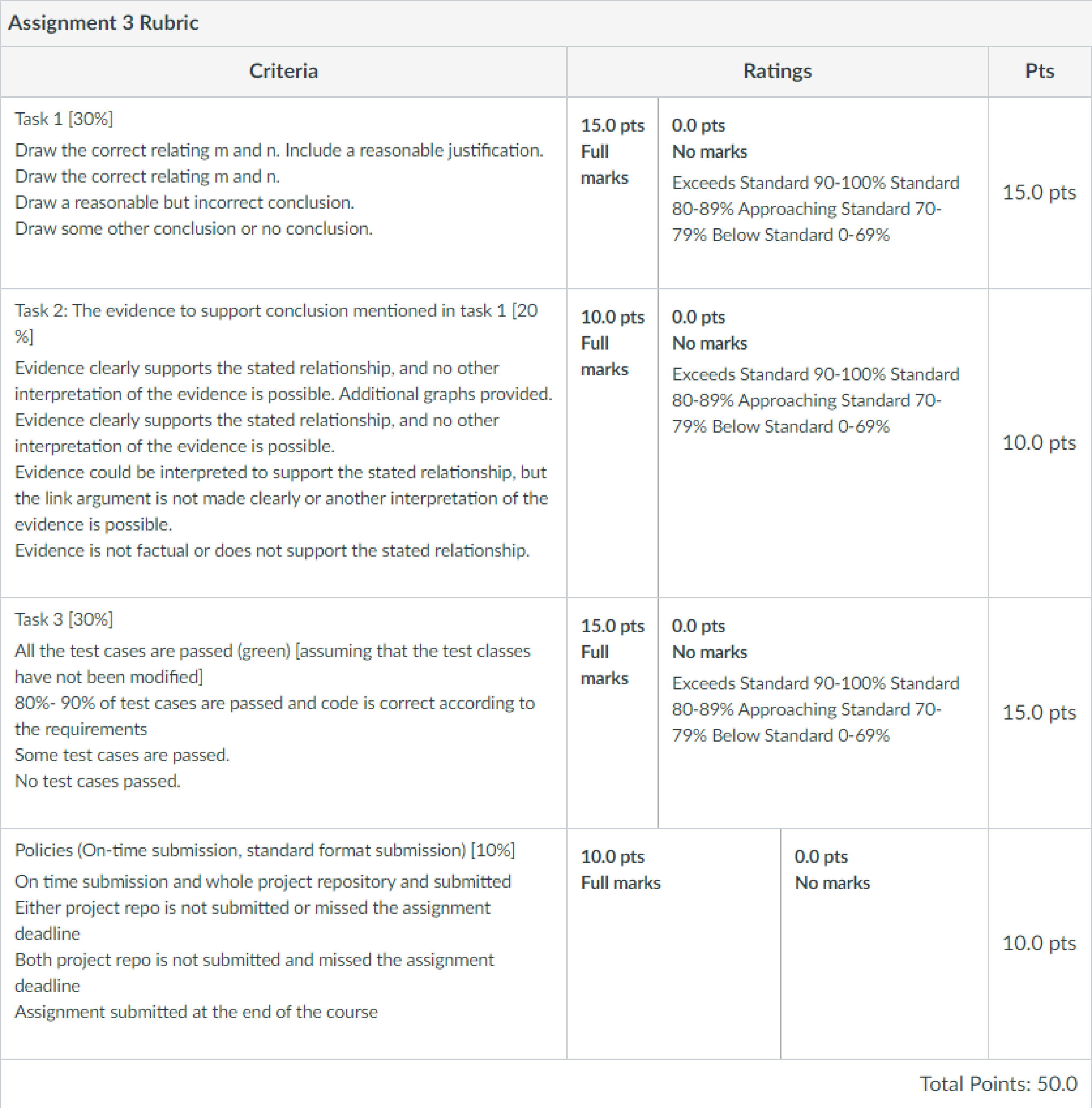
Step 2

Using your 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 your 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. If you prefer, you can create a main program that doesn't require any input and runs the experiment for a fixed set of n values. Show evidence of your run(s).

Step 3

Determine the relationship between the number of objects (n) and the number of pairs (m) generated to accomplish this (i.e. to reduce the number of components from n to 1). Justify your conclusion.

Don't forget to follow the submission guidelines. And to use sufficient (and sufficiently large) different values of n.



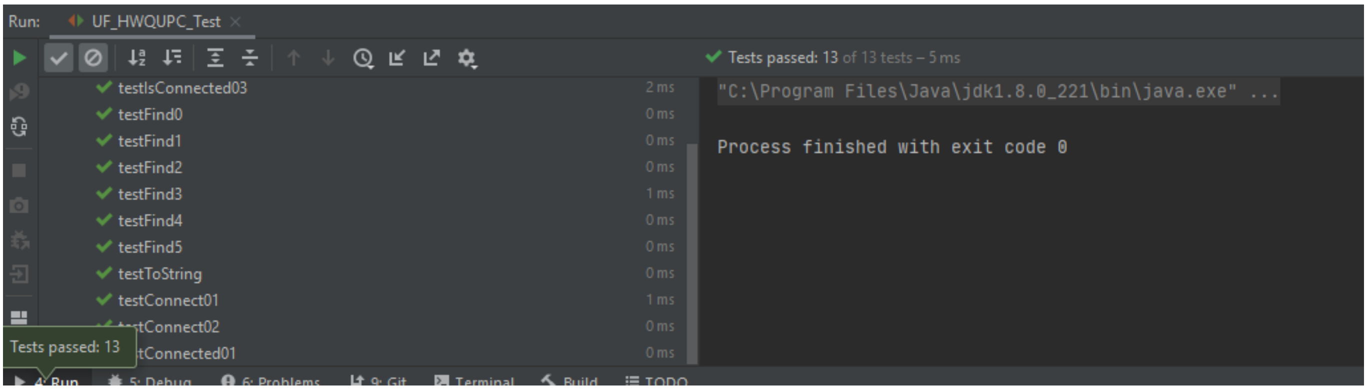
Assignment 3 Rubric

Criteria	Ratings		Pts
Task 1 [30%] Draw the correct relating m and n. Include a reasonable justification. Draw the correct relating m and n. Draw a reasonable but incorrect conclusion. Draw some other conclusion or no conclusion.	**15.0 pts** **Full marks**	**0.0 pts** **No marks** Exceeds Standard 90-100% Standard 80-89% Approaching Standard 70-79% Below Standard 0-69%	15.0 pts
Task 2: The evidence to support conclusion mentioned in task 1 [20 %] Evidence clearly supports the stated relationship, and no other interpretation of the evidence is possible. Additional graphs provided. Evidence clearly supports the stated relationship, and no other interpretation of the evidence is possible. Evidence could be interpreted to support the stated relationship, but the link argument is not made clearly or another interpretation of the evidence is possible. Evidence is not factual or does not support the stated relationship.	**10.0 pts** **Full marks**	**0.0 pts** **No marks** Exceeds Standard 90-100% Standard 80-89% Approaching Standard 70-79% Below Standard 0-69%	10.0 pts
Task 3 [30%] All the test cases are passed (green) [assuming that the test classes have not been modified] 80%- 90% of test cases are passed and code is correct according to the requirements Some test cases are passed. No test cases passed.	**15.0 pts** **Full marks**	**0.0 pts** **No marks** Exceeds Standard 90-100% Standard 80-89% Approaching Standard 70-79% Below Standard 0-69%	15.0 pts
Policies (On-time submission, standard format submission) [10%] On time submission and whole project repository and submitted Either project repo is not submitted or missed the assignment deadline Both project repo is not submitted and missed the assignment deadline Assignment submitted at the end of the course	**10.0 pts** **Full marks**	**0.0 pts** **No marks**	10.0 pts
			Total Points: 50.0

Output

Step 1

`UF_HWQUPC_Test` Unit test



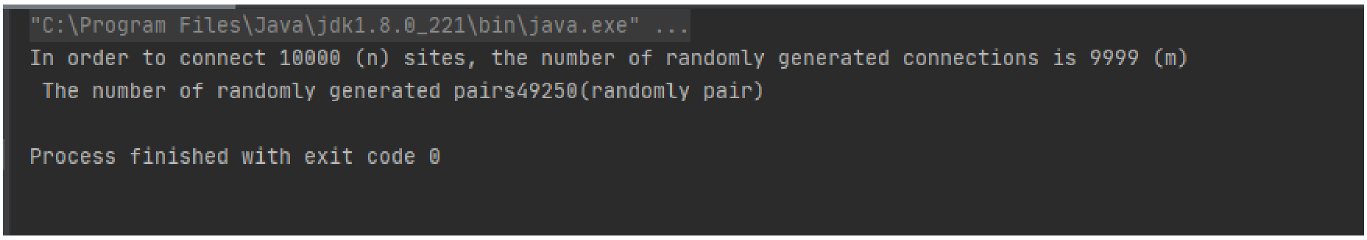
```
Tests passed: 13 of 13 tests – 5 ms

testIsConnected03   2 ms
testFind0           0 ms
testFind1           0 ms
testFind2           0 ms
testFind3           1 ms
testFind4           0 ms
testFind5           0 ms
testToString        0 ms
testConnect01       1 ms
tConnect02          0 ms
tConnected01        0 ms

Tests passed: 13
```

```
"C:\Program Files\Java\jdk1.8.0_221\bin\java.exe" ...

Process finished with exit code 0
```

> All test case passed

Step 2

`UF_HWQUPC_Client.java` Output

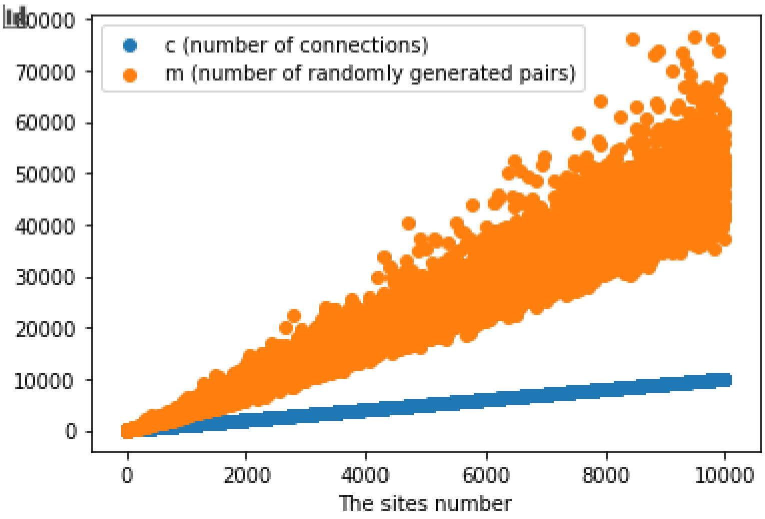


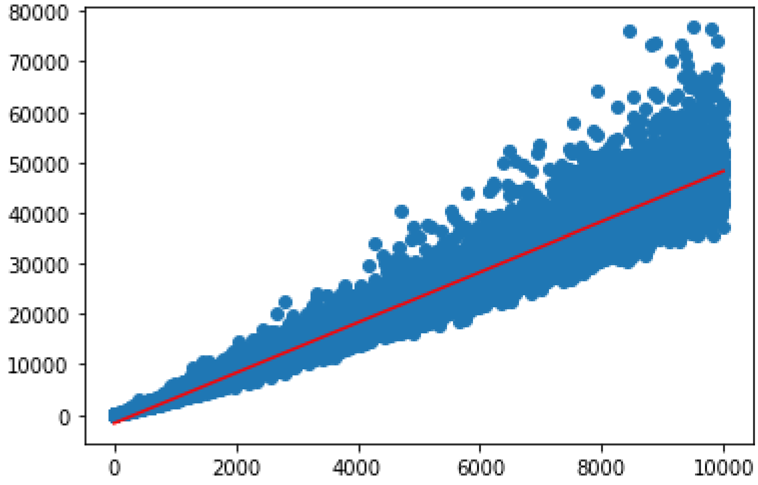
```
"C:\Program Files\Java\jdk1.8.0_221\bin\java.exe" ...
In order to connect 10000 (n) sites, the number of randomly generated connections is 9999 (m)
 The number of randomly generated pairs49250(randomly pair)

Process finished with exit code 0
```

> In order to connect 10000 (n) sites, the number of randomly generated connections is 9999 (m) The number of randomly generated pairs 43385 (randomly pair)

Step 3

Model output





> Red line is the linear regression to model the (n,m)

Relationship

The relationship between the number of objects (n) and the number of pairs (m) generated(i.e. to reduce the number of components from n to 1) is:

$$m = 4.995 \times n - 1724.3$$

`CSVExport.java` Output

```
"n (number of sites)","m (number of
connections)","rp (number of randomly
generated pairs)",
"10000","9999","46056",
"9999","9998","48611",
"9998","9997","47635",
"9997","9996","50053",
"9996","9995","42640",
"9995","9994","52187",
"9994","9993","41644",
"9993","9992","57459",
"9992","9991","45416",
"9991","9990","43986",
"9990","9989","43256",
"9989","9988","55932",
"9988","9987","48440",
"9987","9986","61362",
"9986","9985","60189",
"9985","9984","61984",
"9984","9983","51294",
"9983","9982","37344",
"9982","9981","42158",
```

> Data output for model the relation about N and randomly generated pairs

Tasks

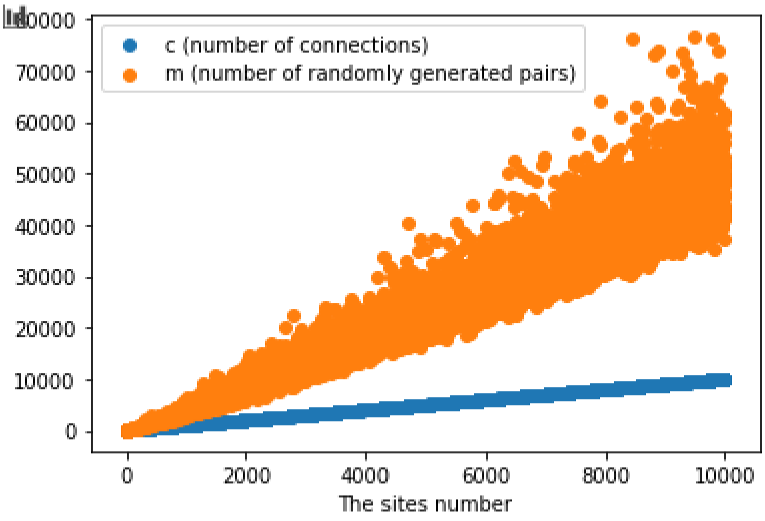
Task 1

The relationship between m and n is

$$m = 4.995 \times n - 1724.3$$

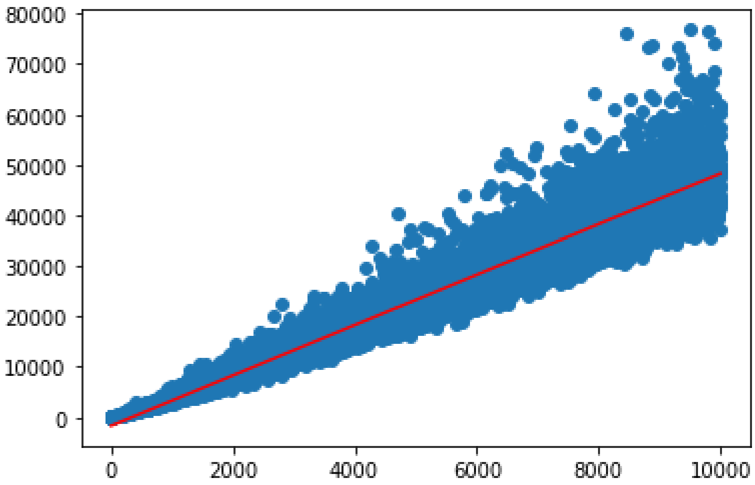
Task 2

I implement the `UF_HWQUPC_Client.java` and then save the m by to reduce the number of components from n to 1.



> You can see the raw relationship between m(orange) and n

Then use the linear regression to model the data. Then I got the result.

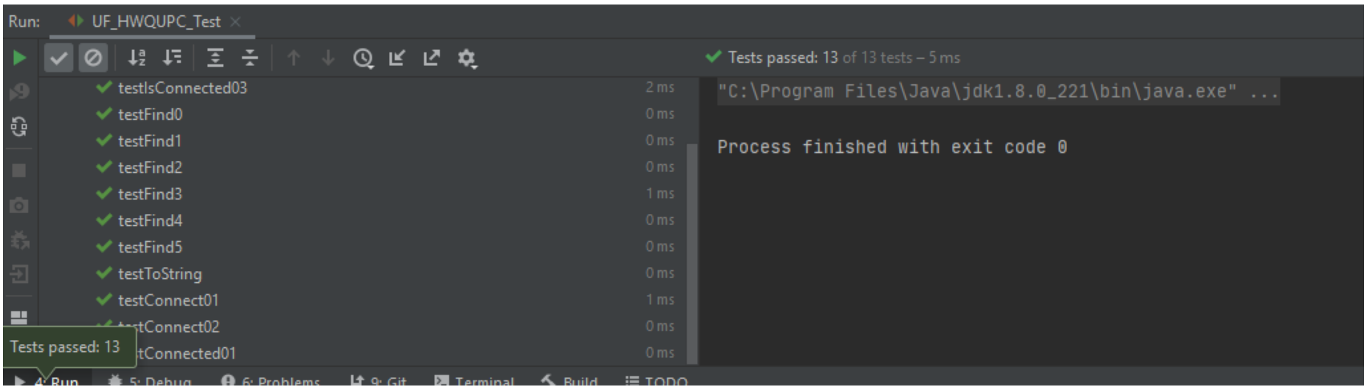


> Red line is the linear regression to model the (n,m)

And the coefficient is as this function:

$$m = 4.995 \times n - 1724.3$$

Task 3



```
✓ testIsConnected03   2 ms
✓ testFind0           0 ms
✓ testFind1           0 ms
✓ testFind2           0 ms
✓ testFind3           1 ms
✓ testFind4           0 ms
✓ testFind5           0 ms
✓ testToString        0 ms
✓ testConnect01       1 ms
✓ testConnect02       0 ms
  tConnected01        0 ms
```

```
"C:\Program Files\Java\jdk1.8.0_221\bin\java.exe" ...

Process finished with exit code 0
```

> All test cases passed

Implementation - Code

`UF_HWQUPC.java`

`UF_HWQUPC_Client.java`

`CSVExport.java`

Python Code

For this part of code, you should run it in jupyter notebook! Or you need to modify some part of it