

Program Structures and Algorithms

Assignment-4

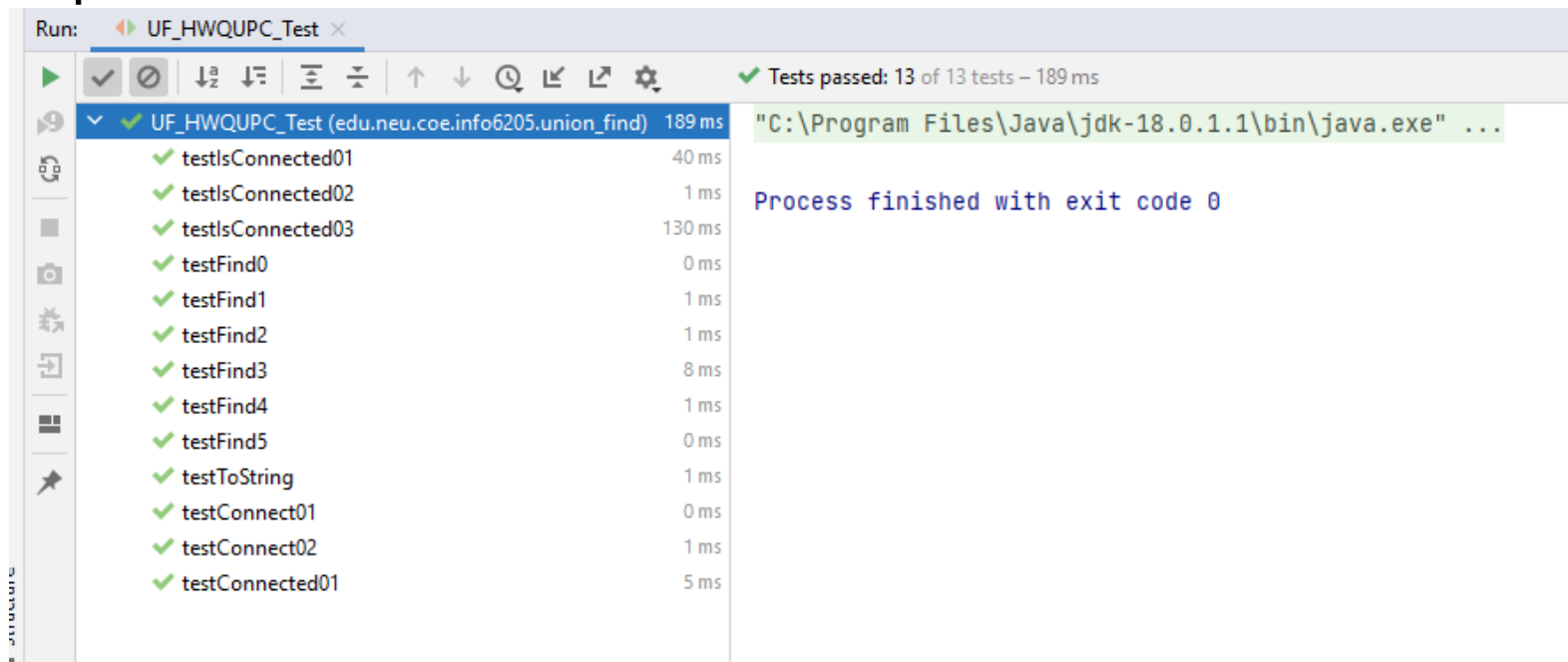
Summer-2022

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Task-1:

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

Output:



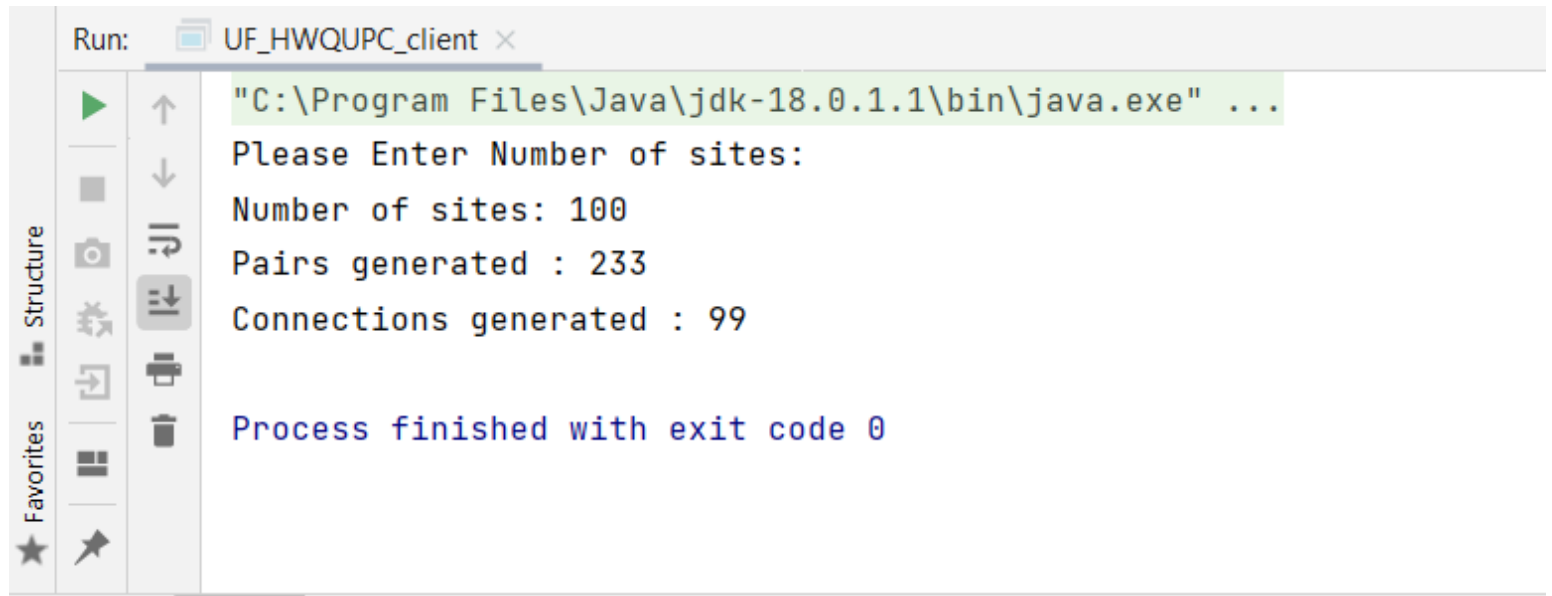
```
Run: UF_HWQUPC_Test x
[Icons] Tests passed: 13 of 13 tests – 189 ms
  ✓ UF_HWQUPC_Test (edu.neu.coe.info6205.union_find) 189 ms
    ✓ testIsConnected01 40 ms
    ✓ testIsConnected02 1 ms
    ✓ testIsConnected03 130 ms
    ✓ testFind0 0 ms
    ✓ testFind1 1 ms
    ✓ testFind2 1 ms
    ✓ testFind3 8 ms
    ✓ testFind4 1 ms
    ✓ testFind5 0 ms
    ✓ testToString 1 ms
    ✓ testConnect01 0 ms
    ✓ testConnect02 1 ms
    ✓ testConnected01 5 ms
  "C:\Program Files\Java\jdk-18.0.1.1\bin\java.exe" ...
  Process finished with exit code 0
```

Task-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).

Output:

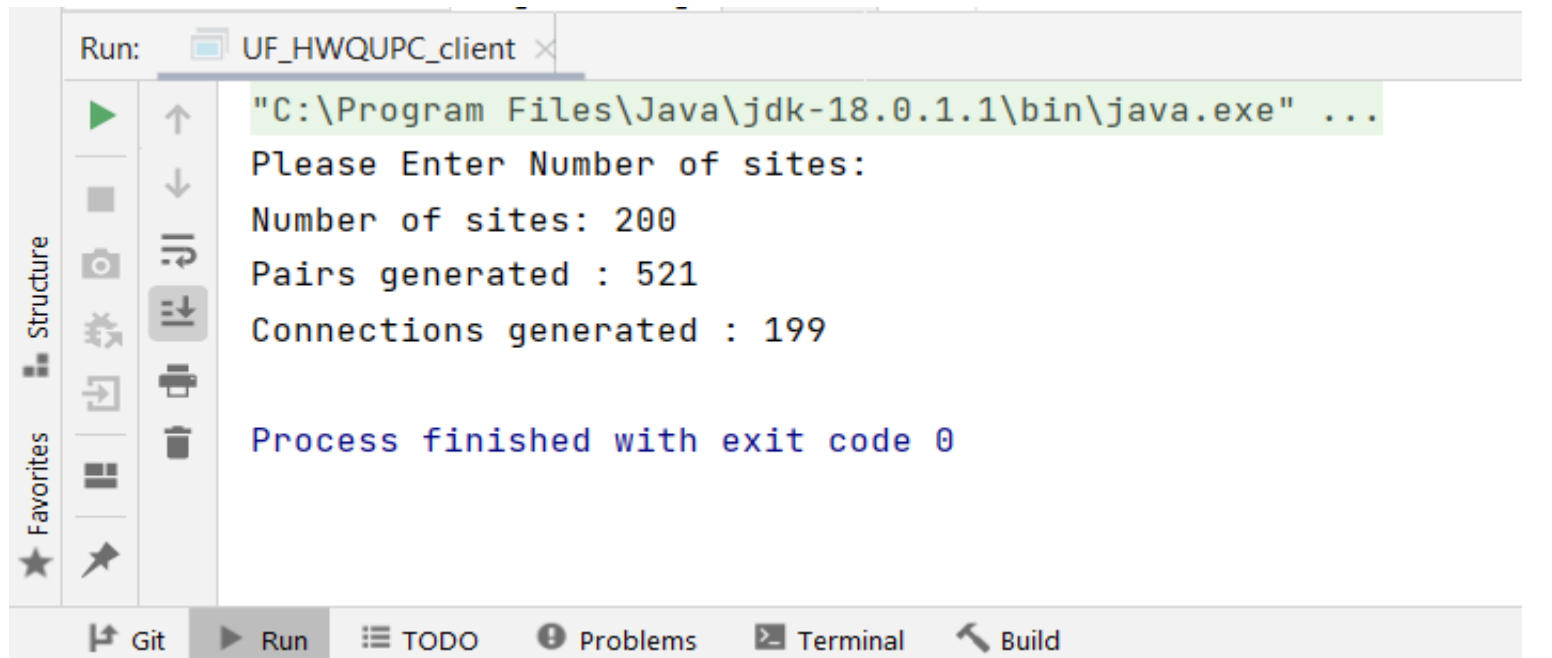
For 100 sites:



The screenshot shows the Run console of an IDE with the tab 'UF_HWQUPC_client'. The output text is as follows:

```
"C:\Program Files\Java\jdk-18.0.1.1\bin\java.exe" ...  
Please Enter Number of sites:  
Number of sites: 100  
Pairs generated : 233  
Connections generated : 99  
  
Process finished with exit code 0
```

For 200 sites :

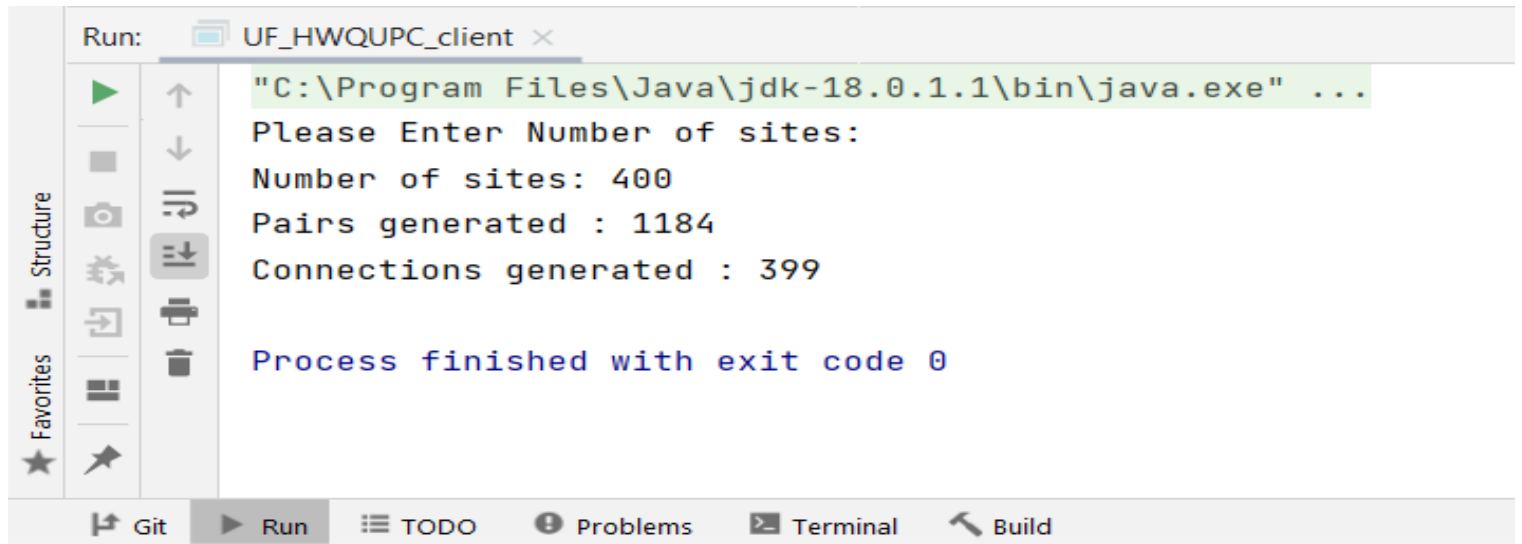


The screenshot shows the Run console of an IDE with the tab 'UF_HWQUPC_client'. The output text is as follows:

```
"C:\Program Files\Java\jdk-18.0.1.1\bin\java.exe" ...  
Please Enter Number of sites:  
Number of sites: 200  
Pairs generated : 521  
Connections generated : 199  
  
Process finished with exit code 0
```

At the bottom of the IDE window, the status bar shows icons for Git, Run, TODO, Problems, Terminal, and Build.

For 400 sites:

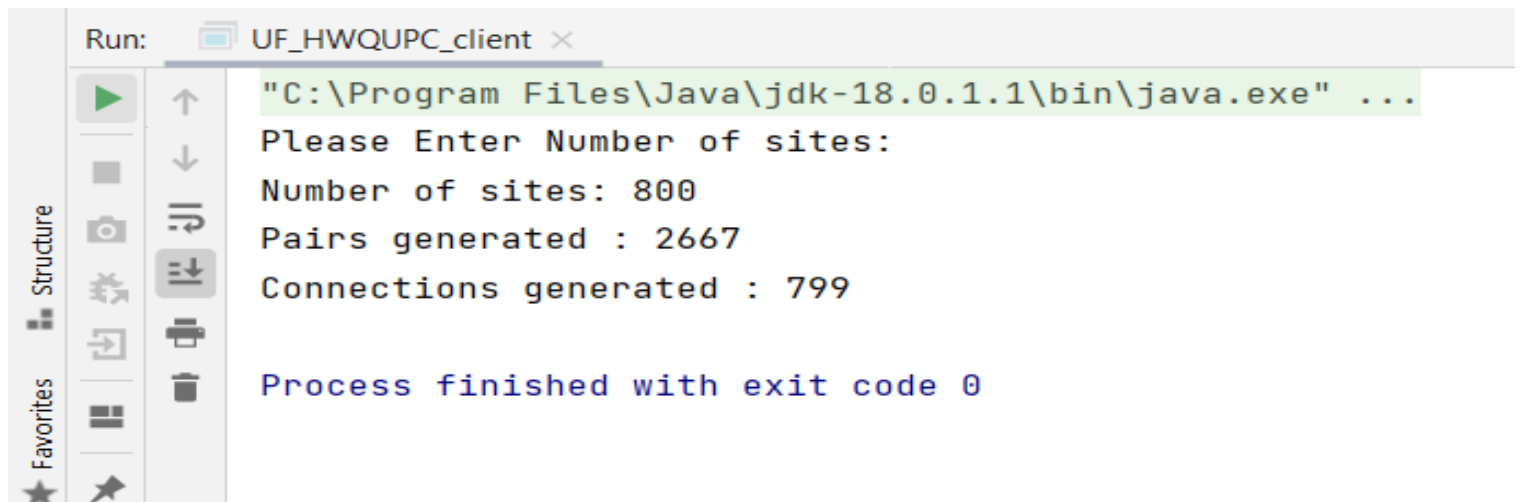


The screenshot shows an IDE interface with a terminal window titled "Run: UF_HWQUPC_client". The terminal output is as follows:

```
"C:\Program Files\Java\jdk-18.0.1.1\bin\java.exe" ...  
Please Enter Number of sites:  
Number of sites: 400  
Pairs generated : 1184  
Connections generated : 399  
  
Process finished with exit code 0
```

The IDE's left sidebar shows "Structure" and "Favorites" tabs. The bottom status bar includes "Git", "Run", "TODO", "Problems", "Terminal", and "Build" buttons.

For 800 sites:

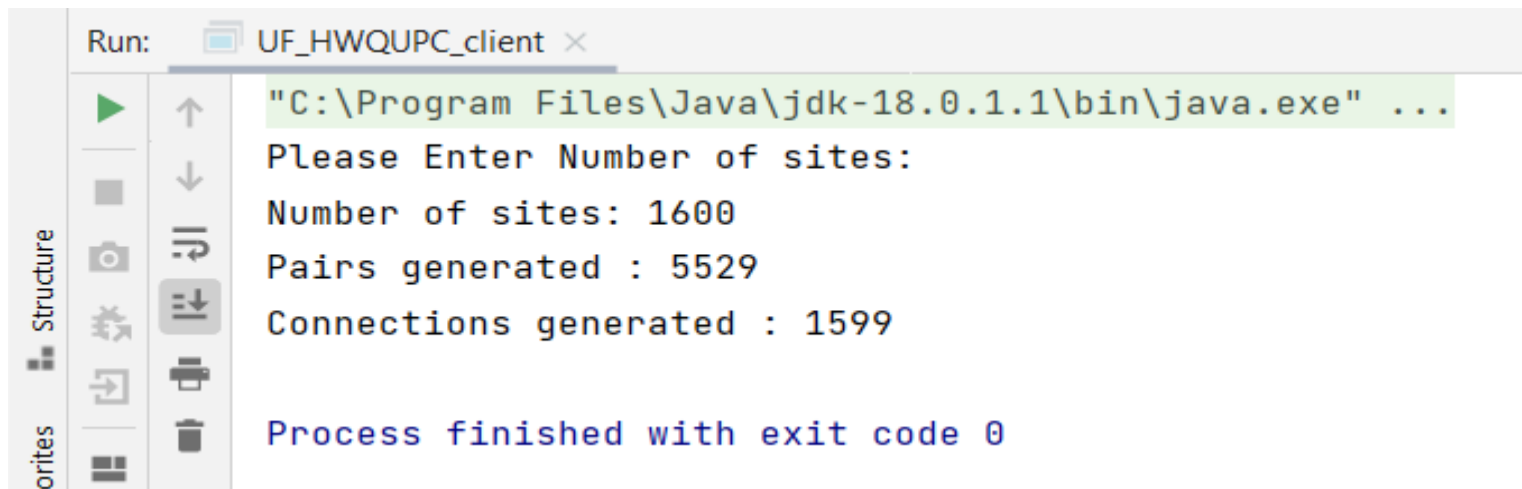


The screenshot shows an IDE interface with a terminal window titled "Run: UF_HWQUPC_client". The terminal output is as follows:

```
"C:\Program Files\Java\jdk-18.0.1.1\bin\java.exe" ...  
Please Enter Number of sites:  
Number of sites: 800  
Pairs generated : 2667  
Connections generated : 799  
  
Process finished with exit code 0
```

The IDE's left sidebar shows "Structure" and "Favorites" tabs. The bottom status bar includes "Git", "Run", "TODO", "Problems", "Terminal", and "Build" buttons.

For 1600 sites:

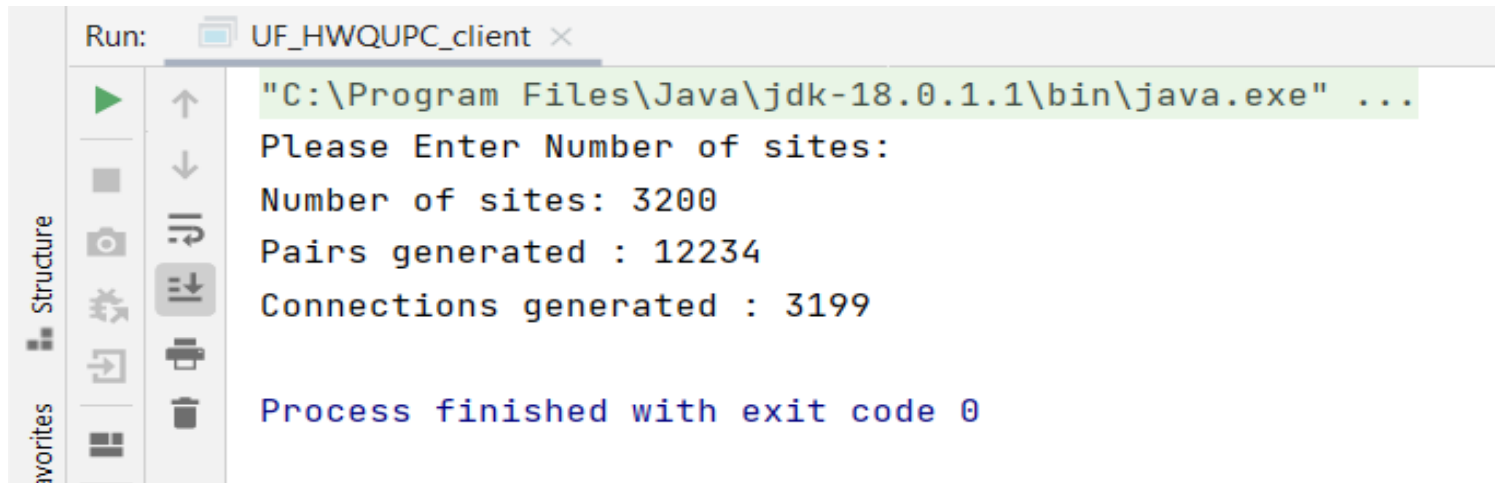


The screenshot shows an IDE interface with a terminal window titled "Run: UF_HWQUPC_client". The terminal output is as follows:

```
"C:\Program Files\Java\jdk-18.0.1.1\bin\java.exe" ...  
Please Enter Number of sites:  
Number of sites: 1600  
Pairs generated : 5529  
Connections generated : 1599  
  
Process finished with exit code 0
```

The IDE's left sidebar shows "Structure" and "Favorites" tabs. The bottom status bar includes "Git", "Run", "TODO", "Problems", "Terminal", and "Build" buttons.

For 3200 sites:

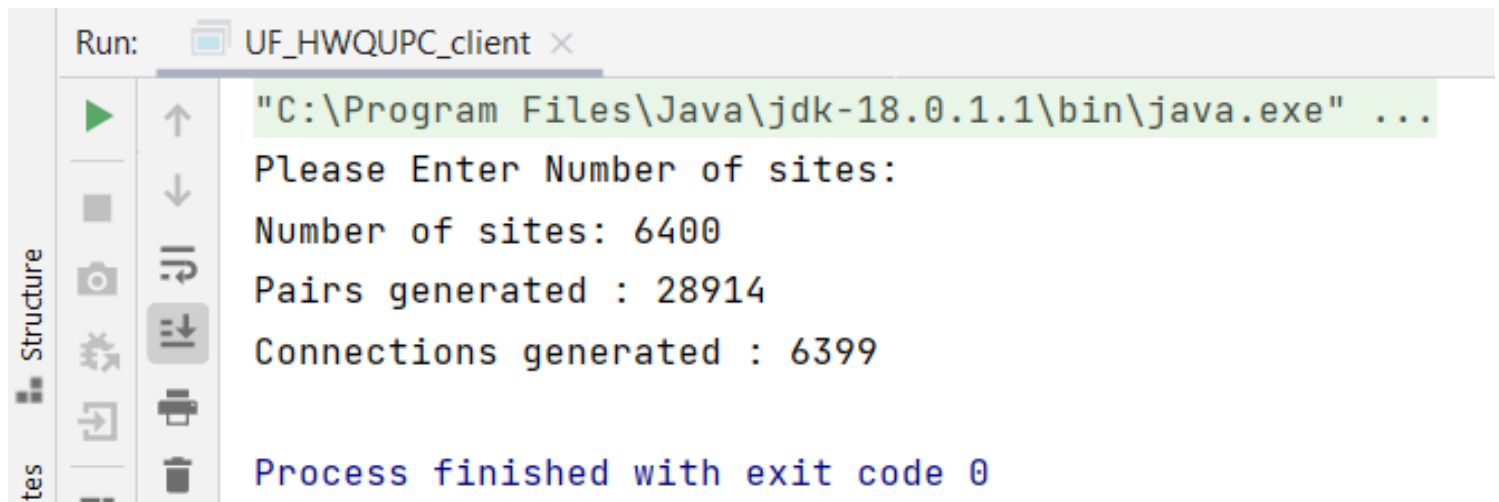


The screenshot shows an IDE interface with a console window titled "Run: UF_HWQUPC_client". The console output is as follows:

```
"C:\Program Files\Java\jdk-18.0.1.1\bin\java.exe" ...  
Please Enter Number of sites:  
Number of sites: 3200  
Pairs generated : 12234  
Connections generated : 3199  
  
Process finished with exit code 0
```

The IDE interface includes a sidebar with icons for "Structure", "Favorites", and "Run and Debug".

For 6400 sites:

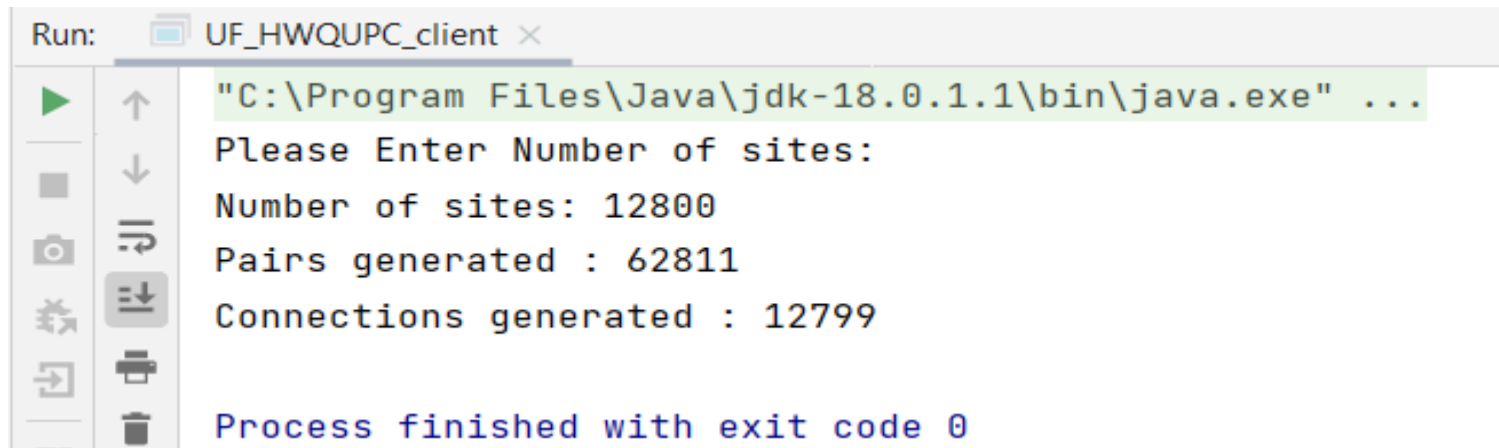


The screenshot shows an IDE interface with a console window titled "Run: UF_HWQUPC_client". The console output is as follows:

```
"C:\Program Files\Java\jdk-18.0.1.1\bin\java.exe" ...  
Please Enter Number of sites:  
Number of sites: 6400  
Pairs generated : 28914  
Connections generated : 6399  
  
Process finished with exit code 0
```

The IDE interface includes a sidebar with icons for "Structure", "Favorites", and "Run and Debug".

For 12800 Sites:



The screenshot shows an IDE interface with a console window titled "Run: UF_HWQUPC_client". The console output is as follows:

```
"C:\Program Files\Java\jdk-18.0.1.1\bin\java.exe" ...  
Please Enter Number of sites:  
Number of sites: 12800  
Pairs generated : 62811  
Connections generated : 12799  
  
Process finished with exit code 0
```

The IDE interface includes a sidebar with icons for "Structure", "Favorites", and "Run and Debug".

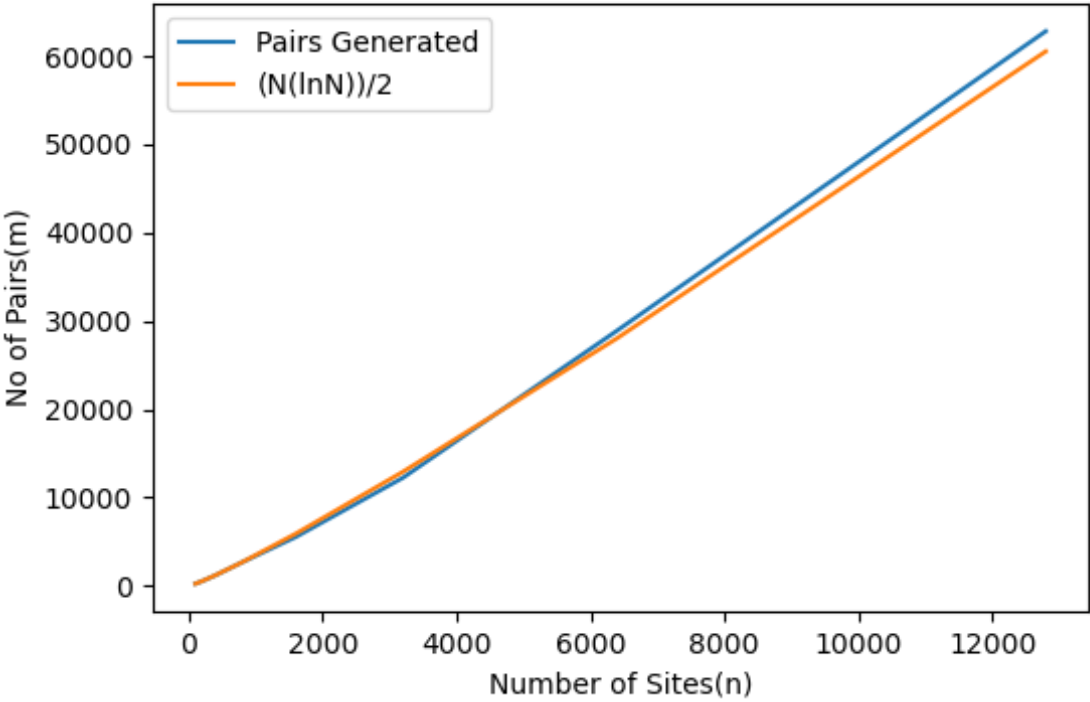
Task-3:

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 in terms of your observations and what you think might be going on.

Comparison Table:

N(Sties)	Pairs(m) Generated	$\frac{1}{2}N(\ln N)$
100	233	230.25
200	521	529.38
400	1184	1198.29
800	2667	2673.84
1600	5529	5902.20
3200	12234	12913.45
6400	28914	28044.97
12800	62811	60526.08

Comparison Graph:



Conclusion :

From the above simulations, it is observed that the relationship between the number of sites/objects(N) and the number of pairs (m) is,

$$m = \frac{N \ln(N)}{2}$$