

Program Structures & Algorithms
Spring 2022
Assignment No. 3 (WQUPC)

Name: Prathamesh Nemade

NUID: 002139730

Tasks:

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

Conclusion:

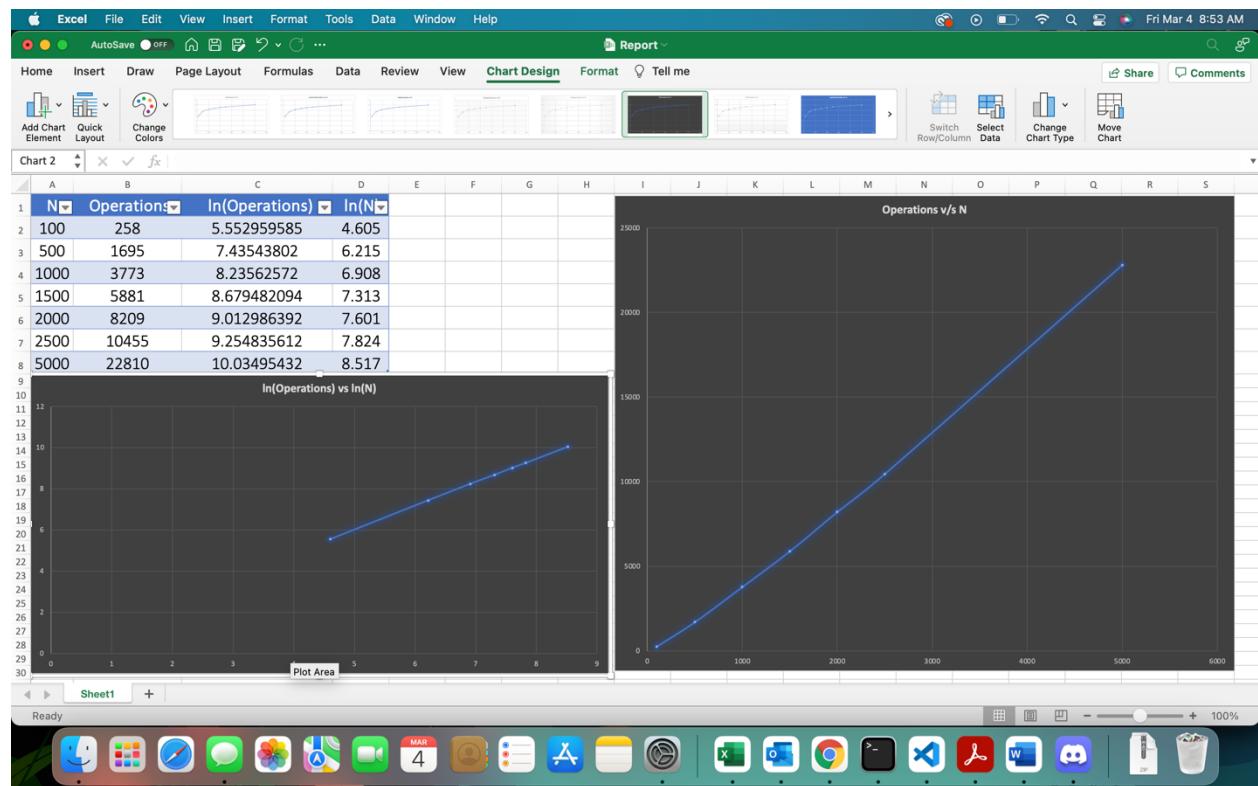
Based on the data, viz. total no. of operations needed to connect all the points/nodes can be verified by the following relation:

$$M = (N \cdot \ln(N))/2$$

Example: from the screenshots, let's consider $N = 1000$. Therefore the no. of operations needed are
= $(1000 \cdot (\ln(1000)))/2$
= $(1000 \cdot 6.90)/2$
= 3450 operations.

which is almost equivalent to the computed value i.e., 3773.
Correction(error) factor: $(3773 - 3450) \cdot 100 / 3773 = 8\%$

Evidence:



Output Screenshot:

Step 1:

The screenshot shows the Eclipse IDE interface. In the center, the code editor displays `UF_HWQUPC.java` with a green status bar indicating "Finished after 0.038 seconds" and "Runs: 13/13 Errors: 0 Failures: 0". Below the code editor is the "Failure Trace" view, which is currently empty. At the bottom of the screen, the Mac OS X dock shows the "System Preferences" icon.

```
    70     return count;
71   }
72   /**
73    * Returns the component identifier for the component containing site {code p}.
74    *
75    * @param p the integer representing one site
76    * @return the component identifier for the component containing site {code p}
77    * @throws IllegalArgumentException unless {@code 0 <= p < n}
78    */
79   public int find(int p) {
80     validate(p);
81     int root = p;
82     // FIXME
83     // END
84     while (root != parent[root]) {
85       if (pathCompression) {
86         doPathCompression(root);
87       }
88       root = getParent(root);
89     }
90     System.out.println(root);
91     return root;
92   }
93
94   /**
95    * Returns true if the two sites are in the same component.
96    *
97    * @param p the integer representing one site
98    * @param q the integer representing the other site
99    */
100  public boolean connected(int p, int q) {
101    return find(p) == find(q);
102  }
```

The terminal window at the bottom shows the command `<terminated> UF_HWQUPC_Test [JUnit] /Library/Internet Plug-Ins/JavaAppletPlugin.plugin/Contents/Home/bin/java` was run at 9:19:36 AM on Mar 3, 2022.

On the right side of the screen, the "System Preferences" window is open, showing the user's profile picture and name: prathamesh nemade. It also displays links for Apple ID, iCloud, Media & App Store, and Family Sharing.

Step 2:

The screenshot shows the Eclipse IDE interface. The code editor now displays `UF_HWQUPCTest.java`. The terminal window at the bottom shows the command `<terminated> UF_HWQUPCTest [Java Application] /Library/Internet Plug-Ins/JavaAppletPlugin.plugin/Contents/Home/bin/java` was run at 8:56:54 AM on Mar 4, 2022.

```
10     Random rand = new Random();
11     Integer n = rand.nextInt(max);
12     return n;
13   }
14
15   public static int[] getAPair(int max) {
16     int[] pair = new int[2];
17     pair[0] = getRandomNumber(max);
18     pair[1] = getRandomNumber(max);
```

The terminal window also displays a list of generated pairs of integers, ranging from [1, 1] to [99, 83], followed by the message "No. of pairs generated:259".

On the right side of the screen, the "System Preferences" window is open, showing the user's profile picture and name: prathamesh nemade. It displays various system settings icons: General, Desktop & Screen Saver, Dock & Menu Bar, Mission Control, Siri, Spotlight, Language & Region, Internet Accounts, Passwords, Wallet & Apple Pay, Users & Groups, Accessibility, Screen Time, Extensions, Notifications & Focus, Security & Privacy.

Step 3: For different sizes of inputs

```

    package com.prathmesh.dp;
    import java.util.Scanner;
    public class Uf_HWQPCTest {
        public static void main(String[] args) {
            Scanner reader = new Scanner(System.in);
            int totalElements = reader.nextInt();
            int netPairs = 0;
            for (int i = 0; i <= correctionFactor(); i++) {
                while (i < totalElements) {
                    netPairs += generatePairs(i, totalElements);
                    i++;
                }
            }
            System.out.println("No. of pairs generated: " + netPairs/correctionFactor());
        }
        private final static int correctionFactor = 1000;
    }

```

```

    package com.prathmesh.dp;
    import java.util.Scanner;
    public class Uf_HWQPCTest {
        public static void main(String[] args) {
            Scanner reader = new Scanner(System.in);
            int totalElements = reader.nextInt();
            int netPairs = 0;
            for (int i = 0; i <= correctionFactor(); i++) {
                while (i < totalElements) {
                    netPairs += generatePairs(i, totalElements);
                    i++;
                }
            }
            System.out.println("No. of pairs generated: " + netPairs/correctionFactor());
        }
        private final static int correctionFactor = 1000;
    }

```

```

    package com.prathmesh.dp;
    import java.util.Scanner;
    public class Uf_HWQPCTest {
        public static void main(String[] args) {
            Scanner reader = new Scanner(System.in);
            int totalElements = reader.nextInt();
            int netPairs = 0;
            for (int i = 0; i <= correctionFactor(); i++) {
                while (i < totalElements) {
                    netPairs += generatePairs(i, totalElements);
                    i++;
                }
            }
            System.out.println("No. of pairs generated: " + netPairs/correctionFactor());
        }
        private final static int correctionFactor = 1000;
    }

```

System Preferences Edit View Window Help

eclipse-workspace - INFO6205-Spring2022/src/main/java/edu/neu/coe/info6205/union_find/UF_HWQUPCTest.java - Eclipse IDE

Package Explorer JUnit UF_HWQUPC.java UF_HWQUPCTest.java

```

15
16     public static int[] getPair(int max) {
17         int[] pair = new int[2];
18         pair[0] = getRandomNumber(max);
19         pair[1] = getRandomNumber(max);
20         while (pair[0] == pair[1]) {
21             pair[1] = getRandomNumber(max);
22         }
23     }
24
25     public static void main(String[] args) {
26         Scanner reader = new Scanner(System.in);
27         System.out.println("Enter no. of elements: ");
28         int totalElements = reader.nextInt();
29         int netPairs = 0;
30         System.out.println("No. of elements tested:" + totalElements);
31         for (int i = 1; i <= correctionFactor; i++) {
32             UF_HWQUPC uf = new UF_HWQUPC(totalElements);
33             while (uf.components() != 1) {
34                 int[] pair = getPair(totalElements);
35                 uf.connect(pair[0], pair[1]);
36                 netPairs++;
37             }
38         }
39         System.out.println("No. of pairs generated:" + netPairs/correctionFactor);
40         reader.close();
41     }
42     private final static int correctionFactor = 1000;
43
44 }
```

Problems Javadoc Declaration Console Terminal

<terminated> UF_HWQUPCTest [Java Application] /Library/Internet Plug-Ins/JavaAppletPlugin.plugin/Contents/Home/bin/java (Mar 3, 2022, 10:45:19 AM – 10:46:29 AM)

Enter no. of elements:
2000
No. of elements tested:2000
No. of pairs generated:8207

System Preferences

prathamesh nemade
Apple ID, iCloud, Media & App Store

Apple ID Family Sharing

Test Cases:

Step 1:

The screenshot shows the Eclipse IDE interface with the following details:

- Top Bar:** System Preferences, Edit, View, Window, Help, Thu Mar 3 9:21 AM
- Packaging Explorer:** Shows a package named "edu.neu.coe.info6206.union_find" containing classes "UF_HWQUPC.java" and "UF_HWQUPC_Test.java".
- UF_HWQUPC.java:** A Java code snippet for a Union-Find data structure. It includes methods like `find(int p)` which performs path compression and `union(int p, int q)` which finds common roots.
- UF_HWQUPC_Test.java:** A JUnit test class with various test methods such as `testConnected01`, `testConnected02`, etc.
- Console:** Displays the output of the test run, showing 13 successful tests and 0 failures.
- Failure Trace:** An empty section.
- Bottom Status Bar:** <terminated> UF_HWQUPC_test [JUnit] /Library/Internet Plug-ins/JavaAppletPlugin.plugin/Contents/Home/bin/java (Mar 3, 2022, 9:19:36 AM - 9:19:36 AM)
- System Preferences Overlay:** A modal window titled "System Preferences" is open, showing the user's profile picture and links to Apple ID, iCloud, Media & App Store, and Family Sharing.

Code:

Step2:

