Program Structures and Algorithms
Spring 2023(SEC –03)

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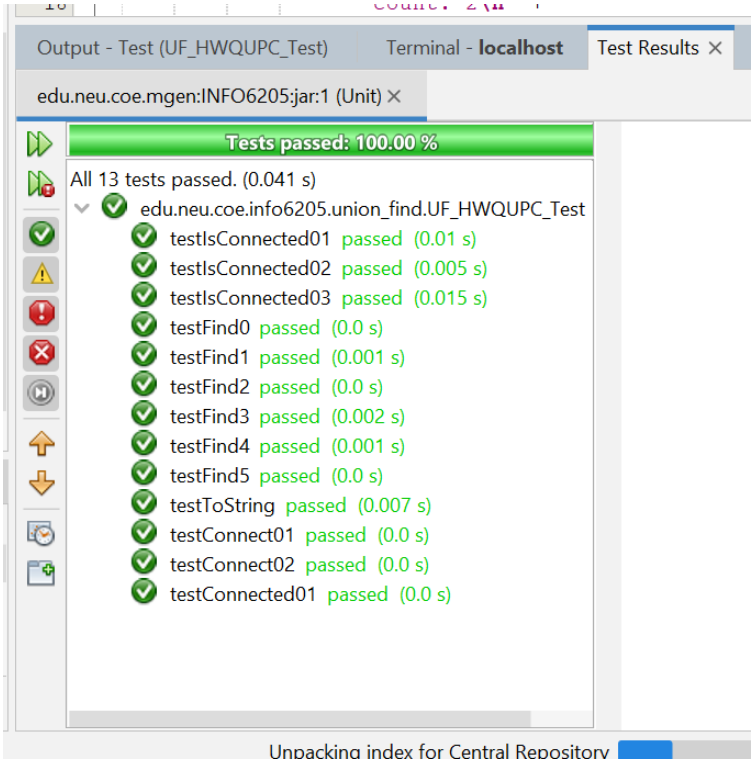
Task:

- Implement height-weighted Quick Union with Path Compression
- Develop a UF ("union-find") client that takes an integer value n from the command line to determine the number of "sites."
- Determine the relationship between the number of objects (*n*) and the number of pairs (*m*) generated

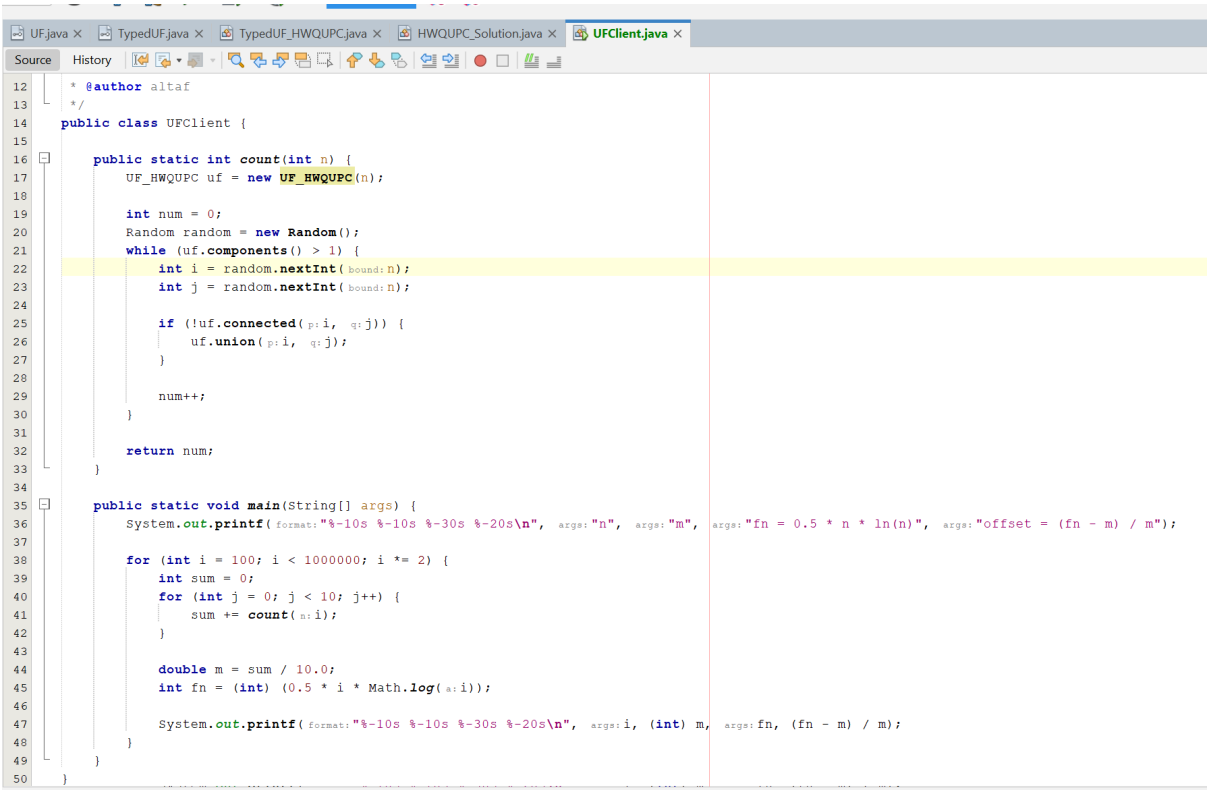
Step 1: UF_HWQUPC implementation snippets

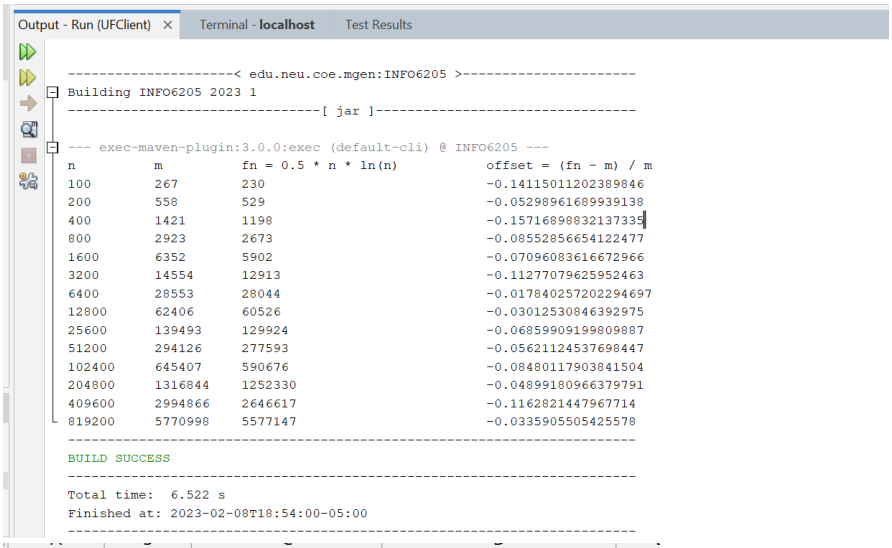
```
/** Returns the component identifier for the component containing site ...9 lines */
public int find(int p) {
    validate(p);
    int root = p;
    ////////////////////////////////////////////////////////////////////////////////////////
    // FIXME

    while (parent[root] != root) {
        doPathCompression( i:root);
        root = parent[root];
    }
    // END
    return root;
}
```

```
179
180     private void mergeComponents(int i, int j) {
181         ////////////////////////////////////////////////////////////////////////////////////
182         // FIXME make shorter root point to taller one
183         if (height[j] > height[i]) {
184             parent[i] = j; height[j] += height[i]; height[i] = 0;
185         } else {
186             parent[j] = i; height[i] += height[j]; height[j] = 0;
187         }
188         // END
189     }
190     /**
191      * This implements the single-pass path-halving mechanism of path
192      * compression
193      */
194     private void doPathCompression(int i) {
195         // FIXME update parent to value of grandparent
196
197         ////////////////////////////////////////////////////////////////////////////////////
198         if (this.pathCompression) {
199             parent[i] = parent[parent[i]];
200         }
201         // END
202     }
203 }
204
```

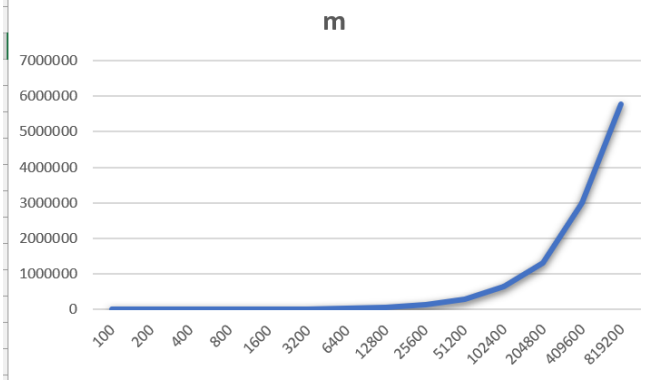


Step 2: UF Client implementation





n	m	fn = 0.5 * n * ln(n	offset = (fn - m) / m
100	267	230	-0.141150112
200	558	529	-0.052989617
400	1421	1198	-0.157168988
800	2923	2673	-0.085528567
1600	6352	5902	-0.070960836
3200	14554	12913	-0.112770796
6400	28553	28044	-0.017840257
12800	62406	60526	-0.030125308
25600	139493	129924	-0.068599092
51200	294126	277593	-0.056211245
102400	645407	590676	-0.084801179
204800	1316844	1252330	-0.04899181
409600	2994866	2646617	-0.116282145
819200	5770998	5577147	-0.033590551



Relationship Conclusion:

The correlation between "n" and "m" can be estimated using the equation "fn = 0.5 * n * ln(n)". "m" represents the number of connections needed to connect all the elements in a union find data structure, while "n" represents the number of elements in the data structure.

The relationship between "n" and "m" can be viewed as **logarithmic**, meaning that as the number of elements "n" increases, the number of connections "m" required also increases, but at a slower pace. The offset value shows how close the value of "m" is to the calculated value "fn", with a positive offset indicating that "m" is greater than "fn" and a negative offset indicating that "m" is less than "fn".