

**Jackson State University**  
**Department of Computer Science**  
**CSC 323 Algorithm Design and Analysis**  
**Spring 2015**  
**Instructor: Dr. Natarajan Meghanathan**  
**Programming Project 1**

**Determining the Average Number of Comparisons in the Element Uniqueness Problem**

**Due: February 12, 2015, 1 PM**

**Maximum Points: 100**

Maximum Possible value ( $m$ ) of the elements in your arrays:

Student Name	$m$ values
Anderson, Leon	200, 2000
Andrew	400, 4000
Jeffery D. Taylor	600, 6000
Dallas, Jonathan T.	800, 8000
Triplett, Raymond L.	1000, 10000
Student 6	1200, 12000

Email your video link (uploaded through Google Drive) and project report to [natarajan.meghanathan@jsums.edu](mailto:natarajan.meghanathan@jsums.edu), See the submission section for more instructions

**Important:** Along with the assignment, each student should submit a cover sheet that has the following details: Student name, Semester, Assignment number, Date and time of submission of the assignment, Number of pages of the assignment excluding the cover sheet and Student signature. Assignments submitted without the cover sheet having all the above required information will not be graded.

**Also, indicate the two values of  $m$  assigned to you for this project in the front page.**

Project Description

Consider the “Element Uniqueness” problem discussed in class. The problem is: Given an array, determine whether the elements in the array are distinctly unique or not. For example, the array [3, 5, 9, 2, 1] has unique elements. The array [4, 9, 4, 2, 3] does not have unique elements as element 4 is present more than once. Following is the algorithm to determine whether a given array  $A[0..n-1]$  of size  $n$  has unique elements or not.

```
ALGORITHM UniqueElements( $A[0..n - 1]$ )
    //Determines whether all the elements in a given array are distinct
    //Input: An array  $A[0..n - 1]$ 
    //Output: Returns “true” if all the elements in  $A$  are distinct
    //         and “false” otherwise
    for  $i \leftarrow 0$  to  $n - 2$  do
        for  $j \leftarrow i + 1$  to  $n - 1$  do
            if  $A[i] = A[j]$  return false
    return true
```

The run-time of the algorithm is dependent on the number on the number of comparisons, which is the basic operation.

For a given array size  $n$ , the number of comparisons depends on the contents of the array, i.e., the values of the elements of the array.

- For arrays of any size  $> 1$ , the best-case number of comparisons is 1. This will happen when the first and second elements of the array are the same.
- For array of size  $n$ , the worst case number of comparisons is  $\frac{n(n-1)}{2}$

The objective of this project is to determine the average-case number of comparisons required for array of size  $n$ .

It has been observed that given an array size  $n$ , the contents of which are randomly generated, the average number of comparisons depends on the maximum possible value of the elements in the array.

Let  $m$  be the maximum value of the elements in an array. Each student would do the project with two given values of  $m$ . The two values are written by the instructor in the first-page of the project description.

### Implementation

Generate arrays of size  $n = 0.1m, 0.2m, 0.3m, 0.4m, 0.5m, 0.6m, 0.7m, 0.8m, 0.9m, m, 2m, 3m$ . You need to use a random number generator to generate the elements of the array.

For each value of  $n$  and  $m$ , you would generate 100 sets of arrays. Make sure, you use the seed of the random number generator to be “System time”, which is continuously changing.

Implement the “Element Uniqueness” algorithm, say with filename `uniqueElements.java`. For a given value of  $n$  and  $m$ , you need to run the code 100 times. For a given value of  $m$ , the array of size  $n$  (from the above list of different values) should be generated randomly in your `uniqueElements.java` code. You will determine the number of comparisons it takes for each run of the code and then average it over the 100 runs. The average represents the average number of comparisons for an  $n$ -element array, whose contents are generated randomly, and the maximum possible value for any element in the array is  $m$ .

To run the code 100 times for a given value of  $n$  and  $m$ , it is better to automate the code such that it runs a loop 100 times, during each run, it randomly generates an array of size  $n$  such that the maximum possible value for any element in the array is  $m$ .

Make sure to repeat your experiments with the values of  $n = 0.1m, 0.2m, 0.3m, 0.4m, 0.5m, 0.6m, 0.7m, 0.8m, 0.9m, m, 2m, 3m$ .

### Results

Plot the following graph for each value of  $m$ :

Use the different values of  $n$  as the X-axis. In the Y-axis, you will plot the worst-case number of comparisons  $\frac{n(n-1)}{2}$  and the average-case number of comparisons determined from your experiments.

$$\frac{n(n-1)}{2}$$

So, you will have two curves in your graph.

Are the two curves close enough to each other or far away from each other? What is the trend as  $n$  increases?

## Testing for Software Safety:

Program Specification: The values for the maximum value of an element ( $m$ ) and the number of elements ( $n$ ) in the array input by the user are both positive (i.e.,  $> 0$ ).

Add appropriate code to make sure that the program specification is satisfied. Your program should terminate after displaying appropriate error messages if either of these two inputs is  $\leq 0$  and do not proceed further.

## **What to submit:**

(1) **A Desktop recorded video** (displaying your code, in full or in parts) with your explanation on the different sections of the code (starting from the execution in the main function) and walk through the code explaining how it will be executed starting from the input phase to the output phase.

You should show the execution of the program for a sample input (in this project, the input that you should use to show/record the demo will be sample value for  $m$  and  $n$ , based on the values of  $m$  and  $n$  assigned to you).

You should also display your results graph and explain your interpretation of the results (including how you relate the average number of comparisons observed for each of the values for  $m$  and the corresponding  $n$  values used). Explain what is your conclusion for the average-case time complexity.

**Note that even though I am not specifying a minimum time for your video, your video explanation is expected to last at least for 8-10 minutes and should cover all of the above required explanations.**

Note that the contents of the desktop/programs captured through your video should be clearly readable.

**Upload the video to your JSU email account using Google Drive and email me the link to download it.**

You could try using one of the **desktop recording software** (or anything of your choice):

CamStudio: <http://sourceforge.net/projects/camstudio/files/legacy/>

Debut: <http://www.nchsoftware.com/capture/index.html>

(2) **A project report** that has the following:

- **Your Java code**
- **The result graphs** for the two values of  $m$  given to you
- **Your interpretation of the results.** Relate the average number of comparisons observed for each of the values for  $m$  and the corresponding  $n$  values used. *What can you conclude about the average case number of comparisons for a given  $n$  and  $m$ ?*

Upload the video through Google Drive and send me the link to download it as well as email the project report to [natarajan.meghanathan@jsu.edu](mailto:natarajan.meghanathan@jsu.edu), with the subject of the e-mail clearly stating "CSC 323, Spring 2015: Project 1".

See next page for Startup code

The following code segment generates 100 different sets of arrays of size 10, such that the maximum possible value for any element in the array is 100. You could use this code segment and expand it by implementing the “Element Uniqueness” algorithm, determine the number of comparisons in each run and the average number of runs.

```
import java.util.*;

class uniqueElements{

    public static void main(String[] args){

        Scanner sc = new Scanner(System.in);

        // Get the input for the maximum value of an element and store it in variable name maxValue
        System.out.print("Enter the maximum value for an element: ");

        // Get the input for the number of elements in the array and store it in variable name numElements
        System.out.print("Enter the number of elements in the array: ");

        /* Test the two inputs maxValue and numElements for software safety. Display appropriate error messages and
           then terminate the program if one or both of the inputs are not appropriate as specified. */

        int totalRuns = 100;

        int A[] = new int[numElements];

        // initialize a variable, totalComp, to 0 and it keeps track of the total number of comparisons

        for (int runs = 1; runs <= totalRuns; runs++){ // begin each run

            Random rand = new Random(System.nanoTime( ));

            // initialize a variable, numComp, to 0
            // and it keeps track of the number of comparisons in a particular run

            for (int index = 0; index < numElements; index++){ // generate array for a particular run

                A[index] = rand.nextInt(maxValue);

            }

            /*
               Implement your "Element Uniqueness" algorithm here. Increment numComp appropriately.
               Note: Instead of using return statements as given in the pseudo code description,
                   You should use break statement to come out of your loops, when the array is
                   found to have two identical elements.
            */

            // add numComp to totalComp

        } // end each run

        // print the average number of comparisons (divide totalComp by 100)

    }
}
```