IT-314 LAB 7

Program Inspection, Debugging and Static Analysis

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Code Link: https://github.com/wxWidgets/wxWidgets/blob/master/src/common/datetime.cpp

1. **How many issues are there in the program? List the identified issues.**

The program doesn't have any compilation errors, but there are several potential flaws and limitations:

Logical Errors

- Month and Day Calculation Logic:
  - In the AddMonths function, when adding months, if the day exceeds the number of days in the new month, the code adjusts it to the last valid day of that month. For example, adding one month to January 31st might result in February 28th or 29th, which could create ambiguity or lead to unintended behavior if the user expects the day to always remain at the end of the month.

Assumption of Valid Input Dates

- Date Range Limitations:
  - The internal logic for date calculations, particularly using Julian Day Numbers (JDN), assumes inputs will always fall within a valid range. If a user provides a date far in the past or future, the calculations may yield incorrect results. For instance, the algorithm doesn't account for dates earlier than 4714 BC or handle potential overflows for dates beyond the system's maximum representable value.

Undefined Behavior in DoIsHoliday

- Missing Implementation:

- The function DoIsHoliday(dt) is called in loops, but it's not defined in the code snippets provided. If this function is missing or incorrectly implemented, the holiday identification process will fail.

Error Handling

- Lack of Robust Error Checking:
  - The code does not sufficiently check for errors in cases like when dtStart is later than dtEnd. If incorrect inputs are provided, the program returns empty results without any indication of an error. Adding error checks and meaningful messages would greatly enhance usability.

2. **What category of program inspection do you think would be most effective?**

The most effective categories of inspection for this code would be Formal Code Review and Static Analysis:

- Formal Code Review:
  - A thorough review by peers would help identify logical issues and ensure compliance with coding standards. Given the complexity of date and time handling, having multiple reviewers could reveal subtle bugs and assumptions that might go unnoticed. Reviewers could focus on areas like leap year handling, holiday calculation, and whether assumptions made in the code apply universally.
- Static Analysis Tools:
  - Tools that automatically scan code for potential problems (e.g., SonarQube, Clang Static Analyzer) would also be beneficial. These tools can highlight issues such as unreachable code, memory leaks, and adherence to standards. For instance, they can flag missing checks in date-related code, such as whether a date is valid before verifying if it's a holiday.

3. **What type of error might be missed during program inspection?**

There are certain types of errors, particularly Dynamic Errors, that may not be identified during a program inspection:

- Runtime Errors:
  - These issues surface during execution rather than compilation. Examples include:
    - Mishandling of user inputs, like invalid dates that lead to out-of-bound calculations.
    - Logical errors that only arise with specific data, such as unexpected behavior when computing holidays in years with unique rules for leap years.
- Performance Problems:
  - While static analysis tools can catch some inefficiencies, they cannot evaluate the program's performance under different loads. For example, if a user queries dates spanning several years, performance bottlenecks due to the linear iteration through days might only become apparent at runtime.

4. Is the program inspection technique worth applying?

Yes, applying program inspection techniques is definitely worthwhile:

- Early Bug Detection:
  - Regular inspections can catch bugs early, which is far cheaper than fixing them post-deployment. Identifying logical errors in date calculations early on can prevent time-consuming troubleshooting later.
- Improved Code Quality:
  - Inspections help enforce best practices and coding standards, making the code more maintainable and of higher quality. For instance, consistent naming conventions can make the codebase easier to navigate.
- Knowledge Sharing and Team Learning:
  - Code reviews foster collaboration and knowledge sharing among team members. They provide an opportunity for developers to discuss insights regarding date-time calculations and potential pitfalls.

- Comprehensive Documentation:
    - Inspections often result in better documentation, which is crucial for complex functionality like date-time handling. Good documentation helps future developers understand the rationale behind implementation decisions and improves long-term maintainability.

2. Code Debugging:

1. Armstrong number:

```
//Armstrong Number

class Armstrong{

        public static void main(String args[]){

                int num = Integer.parseInt(args[0]);

                int n = num; //use to check at last time

                int check=0,remainder;

                while(num > 0){

                        remainder = num / 10;

                        check = check + (int)Math.pow(remainder,3);

                        num = num % 10;

                }

                if(check == n)

                        System.out.println(n+" is an Armstrong Number");

                else
```

```
                System.out.println(n+" is not a Armstrong Number");
    }
```

Input: 153

Output: 153 is an armstrong Number.

. Errors Identified:

- **Incorrect use of division (/) to extract the last digit. It should use modulus (%).**
- **Incorrect use of modulus (%) to reduce the number. It should use division (/).**

2. Breakpoints Required:

- **One to fix the digit extraction.**
- **One to fix how the number is reduced.**

Steps to Fix:

- **Use modulus (`% 10`) to extract the last digit.**
- **Use division (`/ 10`) to reduce the number.**

3. Corrected Code:

```
class Armstrong {
    public static void main(String args[]) {
        int num = Integer.parseInt(args[0]);
        int n = num;
        int check = 0, remainder;
        while (num > 0) {
            remainder = num % 10;
```

```
            check += (int) Math.pow(remainder, 3);

            num /= 10;

        }

        if (check == n)

            System.out.println(n + " is an Armstrong Number");

        else

            System.out.println(n + " is not an Armstrong Number");

    }

}
```

2. GCD and LCM:

```
//program to calculate the GCD and LCM of two given numbers

import java.util.Scanner;

public class GCD_LCM

{

    static int gcd(int x, int y)

    {

        int r=0, a, b;

        a = (x > y) ? y : x; // a is greater number

        b = (x < y) ? x : y; // b is smaller number

        r = b;

        while(a % b == 0) //Error replace it with while(a % b != 0)
```

```
    {
        r = a % b;
        a = b;
        b = r;
    }
    return r;
}
static int lcm(int x, int y)
{
    int a;
    a = (x > y) ? x : y; // a is greater number
    while(true)
    {
        if(a % x != 0 && a % y != 0)
            return a;
        ++a;
    }
}
public static void main(String args[])
{
    Scanner input = new Scanner(System.in);
    System.out.println("Enter the two numbers: ");
```

```
        int x = input.nextInt();

        int y = input.nextInt();


        System.out.println("The GCD of two numbers is: " + gcd(x, y));

        System.out.println("The LCM of two numbers is: " + lcm(x, y));

        input.close();

    }

}
```

Input:4 5

Output: The GCD of two numbers is 1

The GCD of two numbers is 20

1. Errors Identified:

- The GCD calculation uses the condition `a % b == 0`, which should be `a % b != 0`.
- The LCM calculation uses the condition `if(a % x != 0 && a % y != 0)`, which should be `if(a % x == 0 && a % y == 0)`.

2. Breakpoints Required:

- One to fix the GCD condition.
- One to fix the LCM condition.

Steps to Fix:

- Change `while(a % b == 0)` to `while(a % b != 0)` in the GCD calculation.
- Change `if(a % x != 0 && a % y != 0)` to `if(a % x == 0 && a % y == 0)` in the LCM calculation.

3. Corrected Code:

```
import java.util.Scanner;

public class GCD_LCM

{

    static int gcd(int x, int y)

    {

        int r = 0, a, b;

        a = (x > y) ? y : x;

        b = (x < y) ? x : y;

        r = b;

        while(a % b != 0)

        {

            r = a % b;

            a = b;

            b = r;

        }

        return r;

    }

    static int lcm(int x, int y)

    {
```

```
        int a;

        a = (x > y) ? x : y;

        while(true)

        {

            if(a % x == 0 && a % y == 0)

                return a;

            ++a;

        }

    }

    public static void main(String args[])

    {

        Scanner input = new Scanner(System.in);

        System.out.println("Enter  the  two  numbers:  ");

        int x = input.nextInt();

        int y = input.nextInt()

        System.out.println("The GCD of two numbers is: " + gcd(x, y));

        System.out.println("The LCM of two numbers is: " + lcm(x, y));

        input.close();

    }

}
```

3. knapsack:

```
//Knapsack

public class Knapsack {

    public static void main(String[] args) {

        int N = Integer.parseInt(args[0]);    // number of items

        int W = Integer.parseInt(args[1]);  // maximum weight of knapsack

        int[] profit = new int[N+1];

        int[] weight = new int[N+1];



        // generate random instance, items 1..N

        for (int n = 1; n <= N; n++) {

            profit[n] = (int) (Math.random() * 1000);

            weight[n] = (int) (Math.random() * W);

        }

        // opt[n][w] = max profit of packing items 1..n with weight limit w

      // sol[n][w] = does opt solution to pack items 1..n with weight limit w include item n?

        int[][] opt = new int[N+1][W+1];

        boolean[][] sol = new boolean[N+1][W+1];

        for (int n = 1; n <= N; n++) {

            for (int w = 1; w <= W; w++) {
```

```
        // don't take item n
        int option1 = opt[n++][w];
        // take item n
        int option2 = Integer.MIN_VALUE;
        if (weight[n] > w) option2 = profit[n-2] + opt[n-1][w-weight[n]];
        // select better of two options
        opt[n][w] = Math.max(option1, option2);
        sol[n][w] = (option2 > option1);
    }
}
// determine which items to take
boolean[] take = new boolean[N+1];
for (int n = N, w = W; n > 0; n--) {
    if (sol[n][w]) { take[n] = true; w = w - weight[n]; }
    else           { take[n] = false;                    }
}
// print results
System.out.println("item" + "\t" + "profit" + "\t" + "weight" + "\t" + "take");
for (int n = 1; n <= N; n++) {
    System.out.println(n + "\t" + profit[n] + "\t" + weight[n] + "\t" + take[n]);
```

```
        }
    }
}
```

Input: 6, 2000

Output:

Item	Profit	Weight	Take
1	336	784	false
2	674	1583	false
3	763	392	true
4	544	1136	true
5	14	1258	false
6	738	306	true

1. Errors Identified:

- In the knapsack logic, `opt[n++][w]` should be `opt[n-1][w]` to properly calculate the profit of not taking the item.
- In the condition `if(weight[n] > w)`, the comparison is reversed. It should be `if(weight[n] <= w)` to ensure the item is taken if its weight fits.
- In the second option calculation, `profit[n-2]` should be `profit[n]` to properly reference the current item.

2. Breakpoints Required:

- One to fix the logic for not taking the item.

- One to fix the condition for taking the item.
- One to fix the profit reference when taking the item.

Steps to Fix:

- Change `opt[n++][w]` to `opt[n-1][w]`.
- Change `if(weight[n] > w)` to `if(weight[n] <= w)`.
- Change `profit[n-2]` to `profit[n]`.

3. Corrected Code:

```
public class Knapsack {

    public static void main(String[] args) {

        int N = Integer.parseInt(args[0]);    // number of items

        int W = Integer.parseInt(args[1]);  // maximum weight of knapsack

        int[] profit = new int[N+1];

        int[] weight = new int[N+1];

        // generate random instance, items 1..N

        for (int n = 1; n <= N; n++) {

            profit[n] = (int) (Math.random() * 1000);

            weight[n] = (int) (Math.random() * W);

        }

        // opt[n][w] = max profit of packing items 1..n with weight limit w

        // sol[n][w] = does opt solution to pack items 1..n with weight limit w include item n?

        int[][] opt = new int[N+1][W+1];
```

```
boolean[][] sol = new boolean[N+1][W+1];

for (int n = 1; n <= N; n++) {

    for (int w = 1; w <= W; w++) {

        // don't take item n

        int option1 = opt[n-1][w]; // Corrected

        // take item n

        int option2 = Integer.MIN_VALUE;

        if (weight[n] <= w) option2 = profit[n] + opt[n-1][w-weight[n]]; // Corrected

        // select better of two options

        opt[n][w] = Math.max(option1, option2);

        sol[n][w] = (option2 > option1);

    }

}

// determine which items to take

boolean[] take = new boolean[N+1];

for (int n = N, w = W; n > 0; n--) {

    if (sol[n][w]) { take[n] = true; w = w - weight[n]; }

    else           { take[n] = false;                  }

}

// print results
```

```
        System.out.println("item" + "\t" + "profit" + "\t" + "weight" + "\t" + "take");

        for (int n = 1; n <= N; n++) {

            System.out.println(n + "\t" + profit[n] + "\t" + weight[n] + "\t" + take[n]);

        }

    }

}
```

4. Magic Numbers:

```
// Program to check if number is Magic number in JAVA

import java.util.*;

public class MagicNumberCheck

{

    public static void main(String args[])

    {

        Scanner ob=new Scanner(System.in);

        System.out.println("Enter the number to be checked.");

        int n=ob.nextInt();

        int sum=0,num=n;

        while(num>9)

        {

            sum=num;int s=0;
```

```
            while(sum==0)
            {
                s=s*(sum/10);
                sum=sum%10
            }
            num=s;
        }
        if(num==1)
        {
            System.out.println(n+" is a Magic Number.");
        }
        else
        {
            System.out.println(n+" is not a Magic Number.");
        }
    }
}
```

Input: Enter the number to be checked 119

Output 119 is a Magic Number.

Input: Enter the number to be checked 199

Output 199 is not a Magic Number.

1. Errors Identified:

- In the inner `while` loop, the condition `sum == 0` should be `sum > 0` to perform the digit extraction correctly.
- The statement `s=s*(sum/10)` should be `s = s + (sum % 10)` to accumulate the sum of the digits instead of multiplying.
- The line `sum = sum % 10` should end with a semicolon.

2. Breakpoints Required:

- One to fix the condition in the inner `while` loop.
- One to fix the digit extraction and summation logic.
- One to fix the missing semicolon.

Steps to Fix:

- Change `while(sum == 0)` to `while(sum > 0)`.
- Change `s=s*(sum/10)` to `s = s + (sum % 10)`.
- Add a semicolon to `sum = sum % 10`.

3. Corrected Code:

```
import java.util.*;

public class MagicNumberCheck

{

    public static void main(String args[])

    {

        Scanner ob = new Scanner(System.in);

        System.out.println("Enter the number to be checked.");
```

```
        int n = ob.nextInt();
        int sum = 0, num = n;
        while(num > 9)
        {
            sum = num; int s = 0;
            while(sum > 0) // Corrected
            {
                s = s + (sum % 10); // Corrected
                sum = sum / 10; // Corrected
            }
            num = s;
        }
        if(num == 1)
        {
            System.out.println(n + " is a Magic Number.");
        }
        else
        {
            System.out.println(n + " is not a Magic Number.");
        }
    }
}
```

5. Merge Sort:

```
// This program implements the merge sort algorithm for
// arrays of integers.
import java.util.*;
public class MergeSort {
    public static void main(String[] args) {
        int[] list = {14, 32, 67, 76, 23, 41, 58, 85};
        System.out.println("before: " + Arrays.toString(list));
        mergeSort(list);
        System.out.println("after: " + Arrays.toString(list));
    }
    // Places the elements of the given array into sorted order
    // using the merge sort algorithm.
    // post: array is in sorted (nondecreasing) order
    public static void mergeSort(int[] array) {
        if (array.length > 1) {
            // split array into two halves
            int[] left = leftHalf(array+1);
            int[] right = rightHalf(array-1);
            // recursively sort the two halves
```

```
        mergeSort(left);

        mergeSort(right);

        // merge the sorted halves into a sorted whole

        merge(array, left++, right--);

    }

}

// Returns the first half of the given array.

public static int[] leftHalf(int[] array) {

    int size1 = array.length / 2;

    int[] left = new int[size1];

    for (int i = 0; i < size1; i++) {

        left[i] = array[i];

    }

    return left;

}

// Returns the second half of the given array.

public static int[] rightHalf(int[] array) {

    int size1 = array.length / 2;

    int size2 = array.length - size1;

    int[] right = new int[size2];
```

```
    for (int i = 0; i < size2; i++) {
        right[i] = array[i + size1];
    }
    return right;
}
// Merges the given left and right arrays into the given
// result array.  Second, working version.
// pre : result is empty; left/right are sorted
// post: result contains result of merging sorted lists;
public static void merge(int[] result,
                         int[] left, int[] right) {
    int i1 = 0;  // index into left array
    int i2 = 0;  // index into right array
    for (int i = 0; i < result.length; i++) {
        if (i2 >= right.length || (i1 < left.length &&
                left[i1] <= right[i2])) {
            result[i] = left[i1];    // take from left
            i1++;
        } else {
            result[i] = right[i2];  // take from right
```

```
            i2++;
        }
      }
    }
  }
```

Input: before 14 32 67 76 23 41 58 85

after 14 23 32 41 58 67 76 85

1. **Errors Identified:**

- In `mergeSort`, the array slicing logic is incorrect:
  - `int[] left = leftHalf(array + 1)` and `int[] right = rightHalf(array - 1)` should be `int[] left = leftHalf(array)` and `int[] right = rightHalf(array)`.
  - In `merge`, the function call `merge(array, left++, right--)` should be `merge(array, left, right)`. The increment/decrement operators are not appropriate here.

2. **Breakpoints Required:**

- One to fix the array slicing logic.
- One to fix the incorrect increment/decrement during the merge operation.

Steps to Fix:

- Change `array + 1` and `array - 1` in `mergeSort` to just `array` in the respective calls.
- Remove the increment/decrement (`++`, `--`) from the `merge(array, left++, right--)` call.

3. **Corrected Code:**

```
import java.util.*;


public class MergeSort {
    public static void main(String[] args) {
        int[] list = {14, 32, 67, 76, 23, 41, 58, 85};
        System.out.println("before: " + Arrays.toString(list));
        mergeSort(list);
        System.out.println("after: " + Arrays.toString(list));
    }
    // Places the elements of the given array into sorted order
    public static void mergeSort(int[] array) {
        if (array.length > 1) {
            // split array into two halves
            int[] left = leftHalf(array); // Corrected
            int[] right = rightHalf(array); // Corrected
            // recursively sort the two halves
            mergeSort(left);
            mergeSort(right);
            // merge the sorted halves into a sorted whole
            merge(array, left, right); // Corrected
        }
    }

    // Returns the first half of the given array.
```

```
public static int[] leftHalf(int[] array) {
    int size1 = array.length / 2;
    int[] left = new int[size1];
    for (int i = 0; i < size1; i++) {
        left[i] = array[i];
    }
    return left;
}
// Returns the second half of the given array.
public static int[] rightHalf(int[] array) {
    int size1 = array.length / 2;
    int size2 = array.length - size1;
    int[] right = new int[size2];
    for (int i = 0; i < size2; i++) {
        right[i] = array[i + size1];
    }
    return right;
}
// Merges the given left and right arrays into the given result array.
public static void merge(int[] result, int[] left, int[] right) {
    int i1 = 0; // index into left array
    int i2 = 0; // index into right array
    for (int i = 0; i < result.length; i++) {
        if (i2 >= right.length || (i1 < left.length && left[i1] <= right[i2])) {
```

```
            result[i] = left[i1];     // take from left
            i1++;
        } else {
            result[i] = right[i2];  // take from right
            i2++;
        }
      }
   }
}
```

6. Multiply Matrices:

```
//Java program to multiply two matrices
import java.util.Scanner;
class MatrixMultiplication
{
   public static void main(String args[])
   {
      int m, n, p, q, sum = 0, c, d, k;
      Scanner in = new Scanner(System.in);
      System.out.println("Enter the number of rows and columns of first matrix");
      m = in.nextInt();
      n = in.nextInt();
      int first[][] = new int[m][n];
      System.out.println("Enter the elements of first matrix");
```

```
for ( c = 0 ; c < m ; c++ )
  for ( d = 0 ; d < n ; d++ )
    first[c][d] = in.nextInt();
System.out.println("Enter the number of rows and columns of second matrix");
p = in.nextInt();
q = in.nextInt();
if ( n != p )
  System.out.println("Matrices with entered orders can't be multiplied with each other.");
else
{
  int second[][] = new int[p][q];
  int multiply[][] = new int[m][q];
  System.out.println("Enter the elements of second matrix");
  for ( c = 0 ; c < p ; c++ )
    for ( d = 0 ; d < q ; d++ )
      second[c][d] = in.nextInt();
  for ( c = 0 ; c < m ; c++ )
  {
    for ( d = 0 ; d < q ; d++ )
    {
      for ( k = 0 ; k < p ; k++ )
      {
        sum = sum + first[c-1][c-k]*second[k-1][k-d];
```

```
            }

            multiply[c][d] = sum;
            sum = 0;
          }
        }
        System.out.println("Product of entered matrices:-");
        for ( c = 0 ; c < m ; c++ )
        {
          for ( d = 0 ; d < q ; d++ )
            System.out.print(multiply[c][d]+"\t");
          System.out.print("\n");
        }
      }
    }
}
```

Input: Enter the number of rows and columns of first matrix

2 2

Enter the elements of first matrix

1 2 3 4

Enter the number of rows and columns of first matrix

2 2

Enter the elements of first matrix

1 0 1 0

Output: Product of entered matrices:

3 0

7 0

1. Errors Identified:

- In the innermost loop, incorrect array indices are used in the multiplication:
  - `first[c-1][c-k]` should be `first[c][k]`.
  - `second[k-1][k-d]` should be `second[k][d]`.

2. Breakpoints Required:

- One to fix the incorrect matrix indices.

Steps to Fix:

- Change `first[c-1][c-k]` to `first[c][k]`.
- Change `second[k-1][k-d]` to `second[k][d]`.

3. Corrected Code:

```
import java.util.Scanner;

class MatrixMultiplication {

  public static void main(String args[]) {

    int m, n, p, q, sum = 0, c, d, k;

    Scanner in = new Scanner(System.in);

    System.out.println("Enter the number of rows and columns of first matrix");

    m = in.nextInt();

    n = in.nextInt();
```

```
int first[][] = new int[m][n];
System.out.println("Enter the elements of first matrix");
for (c = 0; c < m; c++)
  for (d = 0; d < n; d++)
    first[c][d] = in.nextInt();
System.out.println("Enter the number of rows and columns of second matrix");
p = in.nextInt();
q = in.nextInt();
if (n != p)
  System.out.println("Matrices with entered orders can't be multiplied with each other.");
else {
  int second[][] = new int[p][q];
  int multiply[][] = new int[m][q];
  System.out.println("Enter the elements of second matrix");
  for (c = 0; c < p; c++)
    for (d = 0; d < q; d++)
      second[c][d] = in.nextInt();
  for (c = 0; c < m; c++) {
    for (d = 0; d < q; d++) {
      for (k = 0; k < p; k++) {
        sum += first[c][k] * second[k][d];  // Corrected indices
      }
      multiply[c][d] = sum;
```

```
          sum = 0;
        }
      }
      System.out.println("Product of entered matrices:-");
      for (c = 0; c < m; c++) {
        for (d = 0; d < q; d++)
          System.out.print(multiply[c][d] + "\t");
        System.out.print("\n");
      }
    }
  }
}
```

7. Quadratic Probing:

```
/**
 *   Java Program to implement Quadratic Probing Hash Table
 */
import java.util.Scanner;
/** Class QuadraticProbingHashTable **/
class QuadraticProbingHashTable {
   private int currentSize, maxSize;
   private String[] keys;
   private String[] vals;
```

```
/** Constructor **/
public QuadraticProbingHashTable(int capacity) {
    currentSize = 0;
    maxSize = capacity;
    keys = new String[maxSize];
    vals = new String[maxSize];
}
/** Function to clear hash table **/
public void makeEmpty() {
    currentSize = 0;
    keys = new String[maxSize];
    vals = new String[maxSize];
}
/** Function to get size of hash table **/
public int getSize() {
    return currentSize;
}
/** Function to check if hash table is full **/
public boolean isFull() {
    return currentSize == maxSize;
}
/** Function to check if hash table is empty **/
public boolean isEmpty() {
    return getSize() == 0;
```

```
}

/** Function to check if hash table contains a key **/

public boolean contains(String key) {

    return get(key) !=  null;

}

/** Function to get hash code of a given key **/

private int hash(String key) {

    return key.hashCode() % maxSize;

}

/** Function to insert key-value pair **/

public void insert(String key, String val) {

    int tmp = hash(key);

    int i = tmp, h = 1;

    do {

        if (keys[i] == null) {

            keys[i] = key;

            vals[i] = val;

            currentSize++;

            return;

        }

        if (keys[i].equals(key)) {

            vals[i] = val;

            return;

        }
```

```
            i += (i + h / h--) % maxSize;
        } while (i != tmp);
    }
    /** Function to get value for a given key **/
    public String get(String key) {
        int i = hash(key), h = 1;
        while (keys[i] != null) {
            if (keys[i].equals(key))
                return vals[i];
            i = (i + h * h++) % maxSize;
            System.out.println("i "+ i);
        }
        return null;
    }
    /** Function to remove key and its value **/
    public void remove(String key) {
        if (!contains(key))
            return;
        /** find position key and delete **/
        int i = hash(key), h = 1;
        while (!key.equals(keys[i]))
            i = (i + h * h++) % maxSize;
        keys[i] = vals[i] = null;
        /** rehash all keys **/
```

```
        for (i = (i + h * h++) % maxSize; keys[i] != null; i = (i + h * h++) % maxSize) {
            String tmp1 = keys[i], tmp2 = vals[i];
            keys[i] = vals[i] = null;
            currentSize--;
            insert(tmp1, tmp2);
        }
        currentSize--;
    }
    /** Function to print HashTable **/
    public void printHashTable() {
        System.out.println("\nHash Table: ");
        for (int i = 0; i < maxSize; i++)
            if (keys[i] != null)
                System.out.println(keys[i] +" "+ vals[i]);
        System.out.println();
    }
}
/** Class QuadraticProbingHashTableTest **/
public class QuadraticProbingHashTableTest {
    public static void main(String[] args) {
        Scanner scan = new Scanner(System.in);
        System.out.println("Hash Table Test\n\n");
        System.out.println("Enter size");
        /** make object of QuadraticProbingHashTable **/
```

```
QuadraticProbingHashTable qpht = new QuadraticProbingHashTable(scan.nextInt());
char ch;
/** Perform QuadraticProbingHashTable operations **/
do {
   System.out.println("\nHash Table Operations\n");
   System.out.println("1. insert ");
   System.out.println("2. remove");
   System.out.println("3. get");
   System.out.println("4. clear");
   System.out.println("5. size");
   int choice = scan.nextInt();
   switch (choice) {
      case 1 :
         System.out.println("Enter key and value");
         qpht.insert(scan.next(), scan.next());
         break;
      case 2 :
         System.out.println("Enter key");
         qpht.remove(scan.next());
         break;
      case 3 :
         System.out.println("Enter key");
         System.out.println("Value = "+ qpht.get(scan.next()));
         break;
```

```
        case 4 :
          qpht.makeEmpty();
          System.out.println("Hash Table Cleared\n");
          break;
        case 5 :
          System.out.println("Size = "+ qpht.getSize());
          break;
        default :
          System.out.println("Wrong Entry \n ");
          break;
      }
      /** Display hash table **/
      qpht.printHashTable();
      System.out.println("\nDo you want to continue (Type y or n) \n");
      ch = scan.next().charAt(0);
    } while (ch == 'Y'|| ch == 'y');
  }
}
```

1. Errors Identified:

- **Index Calculation Issues**: The index calculations in the `insert`, `get`, and `remove` methods are incorrect, which can lead to out-of-bounds errors or incorrect data retrieval.
- **Array Clearing in `makeEmpty`**: The `makeEmpty` method does not effectively clear the arrays, as it only resets the size but does not set the array elements to `null`.

2. Breakpoints Required:

- **Total Breakpoints**: 4
    - **Breakpoint 1**: In `insert`, to check the index calculation logic.
    - **Breakpoint 2**: In `get`, to validate the key retrieval process.
    - **Breakpoint 3**: In `remove`, to ensure proper key removal.
    - **Breakpoint 4**: In `makeEmpty`, to confirm that all elements are cleared.

Steps to Fix:

- **Update Index Calculations**:
    - In the `insert` method, change the index calculation to ensure proper quadratic probing: use `(tmp + h * h) % maxSize` instead of the incorrect calculations.
    - Similarly, in the `get` and `remove` methods, use the updated index calculation.
- **Correctly Clear Arrays in `makeEmpty`**: Iterate through the arrays in `makeEmpty` to set each element to `null` before resetting the size to 0.

3. Corrected Code:

```
import java.util.Scanner;

class QuadraticProbingHashTable {

    private int currentSize, maxSize;

    private String[] keys;

    private String[] vals;

    public QuadraticProbingHashTable(int capacity) {

        currentSize = 0;

        maxSize = capacity;

        keys = new String[maxSize];

        vals = new String[maxSize];

    }

    public void makeEmpty() {

        for (int i = 0; i < maxSize; i++) {
```

```
        keys[i] = null;
        vals[i] = null;
    }
    currentSize = 0;
}
public int getSize() {
    return currentSize;
}
public boolean contains(String key) {
    return get(key) != null;
}
private int hash(String key) {
    return Math.abs(key.hashCode() % maxSize);
}
public void insert(String key, String val) {
    int tmp = hash(key);
    int i = tmp, h = 1;
    do {
        if (keys[i] == null) {
            keys[i] = key;
            vals[i] = val;
            currentSize++;
            return;
        }
```

```
            if (keys[i].equals(key)) {
                vals[i] = val;
                return;
            }
            i = (tmp + h * h) % maxSize;
            h++;
        } while (keys[i] != null);
    }
    public String get(String key) {
        int i = hash(key), h = 1;
        while (keys[i] != null) {
            if (keys[i].equals(key)) return vals[i];
            i = (i + h * h) % maxSize;
            h++;
        }
        return null;
    }
    public void remove(String key) {
        if (!contains(key)) return;
        int i = hash(key), h = 1;
        while (!key.equals(keys[i]))
            i = (i + h * h) % maxSize;
        keys[i] = vals[i] = null;
        currentSize--;
```

```
    }
    public void printHashTable() {
        System.out.println("\nHash Table: ");
        for (int i = 0; i < maxSize; i++)
            if (keys[i] != null)
                System.out.println(keys[i] + " " + vals[i]);
    }
}
public class QuadraticProbingHashTableTest {
    public static void main(String[] args) {
        Scanner scan = new Scanner(System.in);
        QuadraticProbingHashTable qpht = new QuadraticProbingHashTable(scan.nextInt());
        char ch;
        do {
            System.out.println("\n1. insert \n2. remove\n3. get\n4. clear\n5. size");
            int choice = scan.nextInt();
            switch (choice) {
                case 1:
                    qpht.insert(scan.next(), scan.next());
                    break;
                case 2:
                    qpht.remove(scan.next());
                    break;
                case 3:
```

```
                System.out.println("Value = " + qpht.get(scan.next()));
                break;
            case 4:
                qpht.makeEmpty();
                break;
            case 5:
                System.out.println("Size = " + qpht.getSize());
                break;
            default:
                System.out.println("Wrong Entry \n");
                break;
            }
            qpht.printHashTable();
            ch = scan.next().charAt(0);
        } while (ch == 'Y' || ch == 'y');
    }
}
```

8. Array Sorting:

```
import java.util.Scanner;
public class Ascending_Order {
    public static void main(String[] args) {
        int n, temp;
```

```
Scanner s = new Scanner(System.in);

System.out.print("Enter no. of elements you want in array:");

n = s.nextInt();

int a[] = new int[n];

System.out.println("Enter all the elements:");

for (int i = 0; i < n; i++) {

    a[i] = s.nextInt();

}

for (int i = 0; i < n; i++) {

    for (int j = i + 1; j < n; j++) {

        if (a[i] > a[j]) {

            temp = a[i];

            a[i] = a[j];

            a[j] = temp;

        }

    }

}

System.out.print("Ascending Order:");

for (int i = 0; i < n - 1; i++) {

    System.out.print(a[i] + ",");

}
```

```
    System.out.print(a[n - 1]);
  }
}
```

1. Errors Identified:

- **Redundant Sorting**: The sorting algorithm used is inefficient for larger arrays since it uses a nested loop with a time complexity of $O(n^2)$. While not a syntactical error, this can lead to performance issues.
- **Missing Input Validation**: There's no validation for user input, which can lead to unexpected behavior if the user enters a non-integer value.

2. Breakpoints Required:

- **Total Breakpoints**: 2
  - **Breakpoint 1**: After reading the number of elements, to check if `n` is valid.
  - **Breakpoint 2**: After sorting to inspect the contents of the array.

Steps to Fix:

- **Improve Sorting Algorithm**: Replace the nested loop sorting with a more efficient sorting method, such as `Arrays.sort()`, which has a time complexity of O(n log n).
- **Add Input Validation**: Implement a check to ensure that the user input for the number of elements is valid and that the elements entered are integers.

Corrected Code:

```
import java.util.Arrays;
import java.util.Scanner;
```

```java
public class Ascending_Order {
    public static void main(String[] args) {
        int n;
        Scanner s = new Scanner(System.in);
        System.out.print("Enter no. of elements you want in array: ");
        n = s.nextInt();
        int a[] = new int[n];
        System.out.println("Enter all the elements:");
        for (int i = 0; i < n; i++) {
            a[i] = s.nextInt();
        }
        Arrays.sort(a);
        System.out.print("Ascending Order: ");
        for (int i = 0; i < n - 1; i++) {
            System.out.print(a[i] + ", ");
        }
        System.out.print(a[n - 1]);
    }
}
```

9. Stack Implementation:

```java
//Stack implementation in java

import java.util.Arrays;

public class StackMethods {

    private int top;

    int size;

    int[] stack;

    public StackMethods(int arraySize) {

        size=arraySize;

        stack= new int[size];

        top=-1;

    }

    public void push(int value) {

        if(top==size-1) {

            System.out.println("Stack is full, can't push a value");

        } else {

            top--;

            stack[top]=value;

        }

    }

    public void pop() {

        if(!isEmpty())

            top++;

        else {

            System.out.println("Can't pop...stack is empty");
```

```
        }
    }
    public boolean isEmpty() {
        return top==-1;
    }
    public void display() {
        for(int i=0;i>top;i++) {
            System.out.print(stack[i]+ " ");
        }
        System.out.println();
    }
}
public class StackReviseDemo {
    public static void main(String[] args) {
        StackMethods newStack = new StackMethods(5);
        newStack.push(10);
        newStack.push(1);
        newStack.push(50);
        newStack.push(20);
        newStack.push(90);
        newStack.display();
        newStack.pop();
        newStack.pop();
        newStack.pop();
```

```
        newStack.pop();

        newStack.display();

    }

}
```

1. Errors Identified:

- **Incorrect Push Logic**: The `top` index is decremented before assigning the value, which results in an `ArrayIndexOutOfBoundsException` when the stack is not empty. It should increment for a push.
- **Incorrect Pop Logic**: The `top` index is incremented incorrectly, leading to an `ArrayIndexOutOfBoundsException` when popping the last item.
- **Display Logic Error**: The display loop uses `i > top` instead of `i <= top`, which means it never prints any elements from the stack.

2. Breakpoints Required:

- **Total Breakpoints**: 3
  - **Breakpoint 1**: After the `push` method to verify that elements are being pushed correctly.
  - **Breakpoint 2**: After the `pop` method to check the stack's state post-pop.
  - **Breakpoint 3**: Before the display method to ensure the stack contents are as expected.

Steps to Fix:

- **Fix Push Method**: Change the logic in the `push` method to `top++` before assigning the value.
- **Fix Pop Method**: Adjust the `pop` method to decrement `top` only if it is not empty.
- **Fix Display Method**: Change the loop condition in the `display` method to `i <= top` for proper printing of stack elements.

Corrected Code:

```
// Stack implementation in Java
```

```java
import java.util.Arrays;


public class StackMethods {
    private int top;
    int size;
    int[] stack;

    public StackMethods(int arraySize) {
        size = arraySize;
        stack = new int[size];
        top = -1;
    }

    public void push(int value) {
        if (top == size - 1) {
            System.out.println("Stack is full, can't push a value");
        } else {
            top++;
            stack[top] = value;
        }
    }

    public void pop() {
        if (!isEmpty()) {
```

```
            top--;
        } else {
            System.out.println("Can't pop... stack is empty");
        }
    }

    public boolean isEmpty() {
        return top == -1;
    }

    public void display() {
        for (int i = 0; i <= top; i++) {
            System.out.print(stack[i] + " ");
        }
        System.out.println();
    }
}

public class StackReviseDemo {
    public static void main(String[] args) {
        StackMethods newStack = new StackMethods(5);
        newStack.push(10);
        newStack.push(1);
        newStack.push(50);
```

```
        newStack.push(20);
        newStack.push(90);
        newStack.display();
        newStack.pop();
        newStack.pop();
        newStack.pop();
        newStack.pop();
        newStack.display();
    }
}
```

10. Tower Of Hanoi:

```
//Tower of Hanoi
public class MainClass {
   public static void main(String[] args) {
      int nDisks = 3;
      doTowers(nDisks, 'A', 'B', 'C');
   }
   public static void doTowers(int topN, char from, char inter, char to) {
      if (topN == 1) {
         System.out.println("Disk 1 from " + from + " to " + to);
      } else {
         doTowers(topN - 1, from, to, inter);
```

```
        System.out.println("Disk " + topN + " from " + from + " to " + to);

        doTowers(topN - 1, inter, from, to);

      }

    }

}
```

1. Errors Identified:

- **Base Case Missing for `topN` Greater than 1**: In the `doTowers` method, when `topN` is 1, it correctly prints the move; however, there's no return statement, which might cause further calls to execute incorrectly when the recursion unwinds.
- **Printing Disk Number**: The print statement assumes that the disks are numbered starting from 1. If more than 9 disks are added, the output may not format correctly without leading zeros.

2. Breakpoints Required:

- **Total Breakpoints**: 2
  - **Breakpoint 1**: After the first `doTowers` call to check if the function is recursively processing correctly.
  - **Breakpoint 2**: Before printing the move to ensure that the disk number and rods are as expected.

Steps to Fix:

- **Add a Return Statement**: After printing the move for a single disk to ensure that no further processing occurs.
- **Ensure Formatting**: Consider modifying the print statement to format disk numbers properly if the number of disks exceeds 9.

Corrected Code:

```
// Tower of Hanoi

public class MainClass {

   public static void main(String[] args) {
```

```
        int nDisks = 3;

        doTowers(nDisks, 'A', 'B', 'C');

    }


    public static void doTowers(int topN, char from, char inter, char to) {

        if (topN == 1) {

            System.out.println("Disk 1 from " + from + " to " + to);

            return;  // Added return statement

        } else {

            doTowers(topN - 1, from, to, inter);

            System.out.println("Disk " + topN + " from " + from + " to " + to);

            doTowers(topN - 1, inter, from, to);

        }

    }

}
```

3. Choose a static analysis tool (in Java, Python, C, C++) in any programming language of your interest and identify the defects. You can also choose your own code fragment from GitHub (more than 2000 LOC) in any programming language to perform static analysis.Submit your results in the .xls or .jpg format only.

```
Checking static_code.cpp: __WINDOWS__;wxUSE_DATETIME...
Checking static_code.cpp: wxDEBUG_LEVEL;wxUSE_DATETIME...
Checking static_code.cpp: wxHAS_STRFTIME;wxUSE_DATETIME...
Checking static_code.cpp: wxUSE_DATETIME...
Checking static_code.cpp: wxUSE_DATETIME;wxUSE_EXTENDED_RTTI...
Checking static_code.cpp: wxUSE_DATETIME;wxUSE_INTL...
static_code.cpp:94:0: style: The function 'wxStringReadValue' is never used. [unusedFunction]
template<> void wxStringReadValue(const wxString &s , wxDateTime &data )
^

static_code.cpp:99:0: style: The function 'wxStringWriteValue' is never used. [unusedFunction]
template<> void wxStringWriteValue(wxString &s , const wxDateTime &data )
^

static_code.cpp:123:0: style: The function 'OnInit' is never used. [unusedFunction]
    virtual bool OnInit() override
^

static_code.cpp:130:0: style: The function 'OnExit' is never used. [unusedFunction]
    virtual void OnExit() override
^

static_code.cpp:2426:0: style: The function 'wxPrevMonth' is never used. [unusedFunction]
WXDLLIMPEXP_BASE void wxPrevMonth(wxDateTime::Month& m)
^

static_code.cpp:2434:0: style: The function 'wxNextWDay' is never used. [unusedFunction]
WXDLLIMPEXP_BASE void wxNextWDay(wxDateTime::WeekDay& wd)
^

static_code.cpp:2442:0: style: The function 'wxPrevWDay' is never used. [unusedFunction]
WXDLLIMPEXP_BASE void wxPrevWDay(wxDateTime::WeekDay& wd)
^

nofile:0:0: information: Active checkers: 161/592 (use --checkers-report=<filename> to see details) [checkersReport]
```

Thank You