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# Lab07: Program Inspection, Debugging and Static Analysis

IT314 – Software Engineering

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# Code Link :

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

1. How many errors are there in the program? Mention the errors you have identified.

The code does not contain outright compilation errors, but it has several potential issues and shortcomings:

Logical Errors

- Month and Day Calculation Logic:
    - In the AddMonths function, when adding months, if the resulting day exceeds the number of days in the new month, the code sets the day to the last valid day of that month. For example, if you add one month to January 31st, it may return February 28th or 29th, which could lead to ambiguity or unintended behavior if the user expects to stay on the last day of the month regardless of its length.

Assumption of Valid Input Dates

- Date Range Limitations:
    - The code's internal logic for date calculations, particularly with Julian Day Numbers (JDN), assumes that inputs will always be within a reasonable range. If a user inputs a date far in the past or future, it could lead to incorrect results. For example, the algorithm does not handle dates before 4714 BC or the potential overflow for dates beyond the maximum representable value in the underlying system.

Undefined Behavior with DoIsHoliday

- Missing Implementation:
    - The function DoIsHoliday(dt) is called within loops but is not defined in the provided code snippets. If this function does not exist or is incorrectly implemented, the entire process of identifying holidays will fail.

Error Handling

- Lack of Robust Error Checking:
  - The code does not provide adequate error handling for invalid dates, such as when dtStart is after dtEnd. If the user provides incorrect input, the code will silently return empty results without notifying the user. Implementing checks and returning meaningful error messages would improve usability significantly.

## 2. Which category of program inspection would you find more effective?

Formal Code Review and Static Analysis would be the most effective inspection categories for this code. Here's why:

- Formal Code Review:
  - This involves a detailed examination of the code by peers to catch logical errors and ensure the implementation meets the required standards. Given the complexity of date and time manipulations, having multiple sets of eyes on the logic can help uncover nuanced bugs and assumptions that one developer might miss. For instance, reviewers could focus specifically on how leap years are handled, how holidays are calculated, and whether the assumptions made in the code are valid in all scenarios.
- Static Analysis Tools:
  - Using tools that automatically analyze the code for potential errors (like SonarQube, ESLint, or Clang Static Analyzer) would also be beneficial. These tools can identify issues such as unreachable code, potential memory leaks, and adherence to coding standards. For example, if there's code that checks if a date is a holiday but lacks proper checks for the validity of the date, static analysis can flag this.

## 3. Which type of error can you not identify using the program inspection?

Dynamic Errors are a significant category that might go unnoticed during program inspection:

- Runtime Errors:
  - These errors occur when the code is executed rather than when it is compiled. Examples include:
    - Incorrect handling of user input (e.g., invalid dates that lead to out-of-range calculations).

        - Logical errors that only become apparent with specific data inputs, such as unexpected behavior when calculating holidays for non-standard years (like those with adjusted leap year rules).
- Performance Issues:
    - While static analysis can identify some inefficiencies, it cannot truly gauge how the code performs under load. For example, if a user queries a date range spanning many years, the linear iteration over each day may lead to performance bottlenecks that are only identifiable during runtime.

### 4. Is the program inspection technique worth applying?

Yes, program inspection techniques are absolutely worth applying, and here's why:

- Early Detection of Bugs:
    - Regular inspections can catch bugs before they are deployed, which is much cheaper than fixing them post-deployment. Catching logical errors in date calculations early on can save significant troubleshooting time later.
- Improved Code Quality:
    - Inspections encourage adherence to best practices and coding standards, which enhance the overall quality and maintainability of the code. For example, using consistent naming conventions for functions and variables can make the codebase easier to navigate.
- Knowledge Sharing and Team Learning:
    - Code reviews foster a culture of collaboration and learning among team members. They allow developers to share insights about date-time calculations, potential pitfalls, and alternate approaches.
- Comprehensive Documentation:
    - Inspections often lead to better documentation practices, which is especially important for complex functionalities like date-time handling. This documentation helps future developers understand the reasoning behind certain implementation decisions and improves the maintainability of the codebase.

# 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%1
```

```
    0
}
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(ke
            y)) 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(ke
        y)) 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;


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:

```
/ 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

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]
```