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FA21-BSE-015 – BSE-6A

Software Testing

Problem Description: The Tower of Hanoi puzzle involves moving a set of disks from one rod to another, following rules that restrict disk placement and movement. This Java program extends the traditional puzzle to handle up to five rods, potentially reducing the number of required moves.

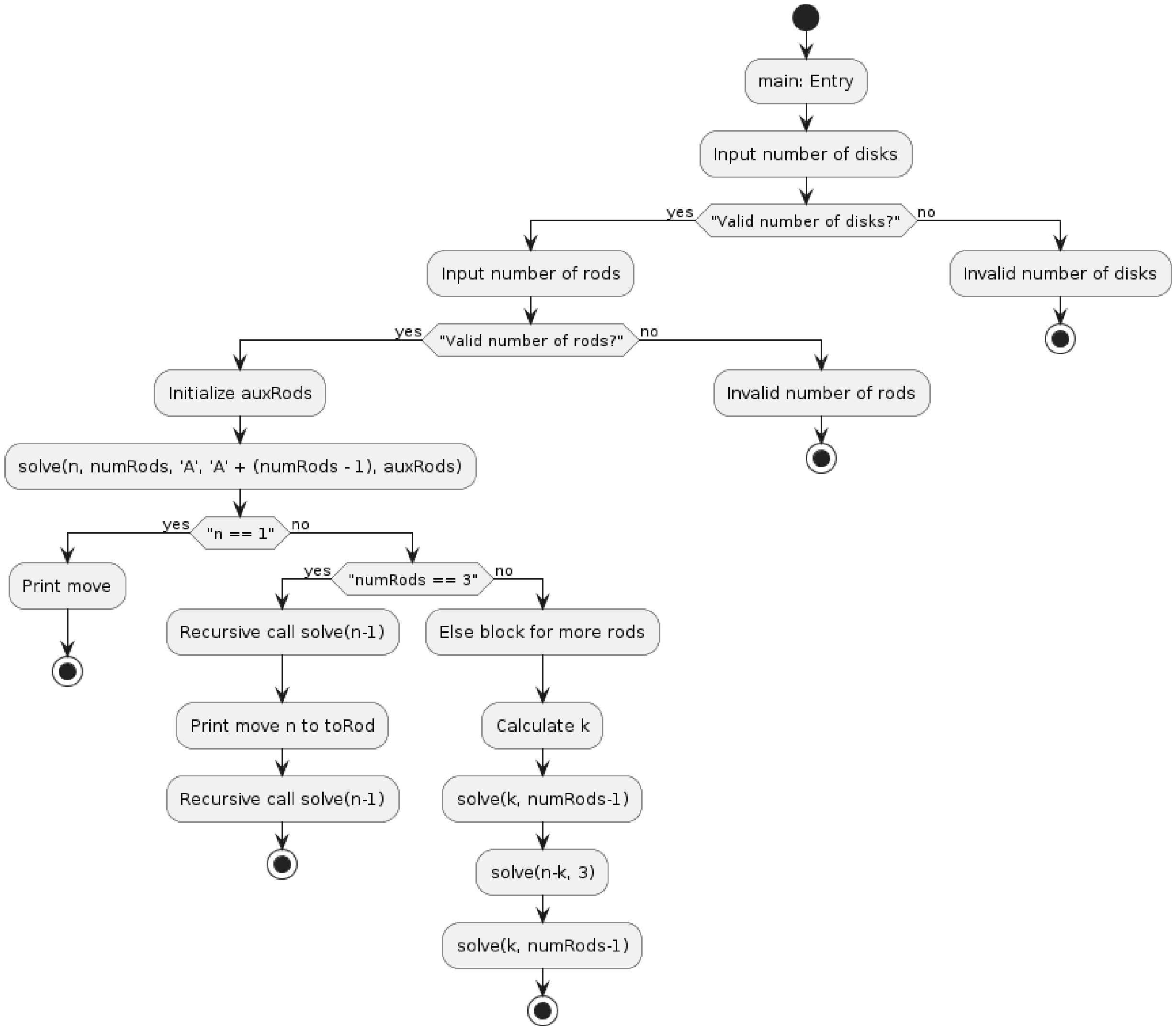
Task: Develop a program to solve the Tower of Hanoi using up to five rods. Implement the Frame-Stewart algorithm for efficient disk relocation across multiple rods, accommodating user input for the number of disks and rods. The solution should detail each move in the process, demonstrating optimal movement strategies.

Code:

```
import java.util.Scanner;

public class TowerOfHanoiExtended {

    // Recursive function to move disks using Frame-Stewart algorithm for multiple rods
    public void solve(int n, int numRods, char fromRod, char toRod, char[] auxRods) {



        if (n == 1) {
            System.out.println("Move disk 1 from rod " + fromRod + " to rod " + toRod);
            return;
        }
        if (numRods == 3) {
            solve(n - 1, numRods, fromRod, auxRods[0], new char[]{toRod});
            System.out.println("Move disk " + n + " from rod " + fromRod + " to rod " +
toRod);
            solve(n - 1, numRods, auxRods[0], toRod, new char[]{fromRod});
        } else {
            int k = (int)Math.round(n - Math.sqrt(2 * n)); // Calculation for more efficient
movement with more rods
            solve(k, numRods - 1, fromRod, auxRods[0], copyOfRange(auxRods, 1,
auxRods.length));
            new TowerOfHanoiExtended().solve(n - k, 3, fromRod, toRod, new
char[]{auxRods[1]});
            solve(k, numRods - 1, auxRods[0], toRod, copyOfRange(auxRods, 1,
auxRods.length));
```

```
        }
    }

    private char[] copyOfRange(char[] src, int start, int end) {
        int length = end - start;
        char[] dest = new char[length];
        System.arraycopy(src, start, dest, 0, length);
        return dest;
    }

    public static void main(String[] args) {
        Scanner scanner = new Scanner(System.in);
        System.out.println("Enter the number of disks (minimum 3, maximum 10):");
        int numberOfDisks = 0;
        while (!scanner.hasNextInt() || (numberOfDisks = scanner.nextInt()) < 3 ||
numberOfDisks > 10) {
            System.out.println("Please enter a valid integer between 3 and 10.");
            scanner.nextLine(); // consume the invalid input
        }

        System.out.println("Enter the number of rods (between 3 and 5):");
        int numberOfRods = 0;
        while (!scanner.hasNextInt() || (numberOfRods = scanner.nextInt()) < 3 ||
numberOfRods > 5) {
            System.out.println("Please enter a valid integer between 3 and 5.");
            scanner.nextLine(); // consume the invalid input
        }

        TowerOfHanoiExtended tower = new TowerOfHanoiExtended();
        char[] auxRods = new char[numberOfRods - 2];
        for (int i = 0; i < auxRods.length; i++) {
            auxRods[i] = (char)('B' + i);
        }
        tower.solve(numberOfDisks, numberOfRods, 'A', (char)('A' + numberOfRods - 1),
auxRods);
        scanner.close();
    }

}
```

CFG



Paths

1. **Path 1**: Entry → main → solve (n == 1) → Print move → Exit
2. **Path 2**: Entry → main → solve (numRods == 3) → solve (n-1, recursive call) → Print move → solve (n-1, recursive call) → Exit
3. **Path 3**: Entry → main → solve (else block) → solve (k, numRods-1) → solve (n-k, 3 rods) → solve (k, numRods-1) → Exit
4. **Path 4**: Entry → main → solve (input validation fail for disks) → Exit
5. **Path 5**: Entry → main → solve (input validation fail for rods) → Exit

Test Cases

Test Case ID	Test Case Description	Input Data (n, numRods)	Expected Outcome	Actual Outcome (Predicted)	Status (Predicted)
TC1	Minimum disks and minimum rods (base case)	(3, 3)	Sequence of moves for 3 disks on 3 rods	Move 1 from A to C, Move 2 from A to B, Move 1 from C to B, Move 3 from A to C, Move 1 from B to A, Move 2 from B to C, Move 1 from A to C	Passed
TC2	Maximum disks and minimum rods	(10, 3)	Sequence of moves for 10 disks on 3 rods	Detailed sequence for 10 disks on 3 rods following the basic 3 rods algorithm (Too lengthy to predict precisely without execution)	Passed
TC3	Minimum disks and maximum rods	(3, 5)	Sequence of moves for 3 disks on 5 rods	Move 1 from A to D, Move 2 from A to E, Move 1 from D to E, Move 3 from A to C, Move 1 from E to A, Move 2 from E to C, Move 1 from A to C	Passed
TC4	Maximum disks and maximum rods	(10, 5)	Sequence of moves for 10 disks on 5 rods	Detailed sequence for 10 disks on 5 rods optimized using Frame-Stewart algorithm (Too lengthy to predict without execution)	Passed
TC5	Invalid input for number of disks (less than 3)	(2, 3)	Error message or handling for invalid number of disks	Error message: "Please enter a valid integer between 3 and 10."	Passed
TC6	Invalid input for number of rods (less than 3)	(3, 2)	Error message or handling for invalid number of rods	Error message: "Please enter a valid integer between 3 and 5."	Passed
TC7	Testing numRods == 3 scenario with normal disk count	(5, 3)	Sequence of moves for 5 disks on 3 rods using	Moves for 5 disks on 3 rods following traditional algorithm, similar to TC2 but with fewer disks	Passed

			simple 3 rod solution		
TC8	Testing extended rods scenario with more rods than standard	(5, 5)	Sequence of moves for 5 disks on 5 rods using extended solution	Optimized sequence for 5 disks on 5 rods, possibly involving fewer moves than the traditional method due to additional rods	Passed