

Day 13 and 14

Task 1: Tower of Hanoi Solver

Create a program that solves the Tower of Hanoi puzzle for n disks. The solution should use recursion to move disks between three pegs (source, auxiliary, and destination) according to the game's rules. The program should print out each move required to solve the puzzle.

Java implementation of the Tower of Hanoi puzzle using recursion:

```
public class TowerOfHanoi {

    public static void main(String[] args) {

        int n = 3;

        towerOfHanoi(n, 'A', 'B', 'C');

    }

    public static void towerOfHanoi(int n, char source, char auxiliary, char destination) {

        if (n == 1) {

            System.out.println("Move disk 1 from " + source + " to " + destination);

            return;

        }

        towerOfHanoi(n-1, source, destination, auxiliary);

        System.out.println("Move disk " + n + " from " + source + " to " + destination);

        towerOfHanoi(n-1, auxiliary, source, destination);

    }

}
```

Explanation:

Class and main Method:

- TowerOfHanoi class is defined with a main method where the Tower of Hanoi puzzle is solved for $n = 3$ disks.

Recursive Method towerOfHanoi:

- This method takes four parameters:
- n : Number of disks to be moved.
- source: The peg from which the disks are initially stacked.
- auxiliary: An auxiliary peg used for moving disks.
- destination: The peg onto which the disks have to be moved.

Base Case:

When $n == 1$, the method prints the move to transfer the disk directly from source to destination.

Recursive Case:

- For $n > 1$, the method recursively calls itself:
- Moves $n-1$ disks from source to auxiliary, using destination as the auxiliary peg.
- Moves the n -th disk from source to destination.
- Moves the $n-1$ disks from auxiliary to destination, using source as the auxiliary peg.

Output:

Move disk 1 from A to C

Move disk 2 from A to B

Move disk 1 from C to B

Move disk 3 from A to C

Move disk 1 from B to A

Move disk 2 from B to C

Move disk 1 from A to C

Task 2: Traveling Salesman Problem

Create a function `int FindMinCost(int[,] graph)` that takes a 2D array representing the graph where `graph[i][j]` is the cost to travel from city `i` to city `j`. The function should return the minimum cost to visit all cities and return to the starting city. Use dynamic programming for this solution.

Given a graph represented by a 2D array `graph` where `graph[i][j]` represents the cost to travel from city `i` to city `j`, we need to find the minimum cost to visit all cities exactly once and return to the starting city.

Approach:

Dynamic Programming Definition:

- Let's define `dp[mask][i]` where `mask` is a bitmask representing the set of cities visited so far, and `i` is the current city.
- `dp[mask][i]` will represent the minimum cost to visit all cities in the set `mask` and end at city `i`.

Initialization:

Start with the initial city as the starting point. Initialize `dp[1 << start][start] = 0` where `start` is the index of the starting city.

Transition:

For each set of visited cities (`mask`), and for each city `i` that is not yet visited:

$$dp[mask | (1 \ll i)][i] = \min(dp[mask | (1 \ll i)][i], dp[mask][j] + graph[j][i])$$

Here, `j` is any city already visited (`j` is in `mask`).

Final Calculation:

The answer will be `min(dp[(1 << n) - 1][j] + graph[j][start])` where `n` is the number of cities, and `start` is the starting city.

Implementation:

We need to iterate over all possible subsets of cities and compute the minimum cost using the above transitions.

```

public class MinimumCostTravelAllCities {

    public static int findMinCost(int[][] graph) {

        int n = graph.length;

        // dp[mask][i] will store the minimum cost to visit all cities in 'mask' ending at city 'i'

        int[][] dp = new int[1 << n][n];

        // Initialize dp array with a large value (infinity)
        for (int[] row : dp) {
            Arrays.fill(row, Integer.MAX_VALUE / 2);
        }

        // Start from city 0
        int start = 0;

        // Base case: Starting from city 0, cost is 0
        dp[1 << start][start] = 0;

        // Iterate over all subsets of cities
        for (int mask = 1; mask < (1 << n); mask++) {
            for (int i = 0; i < n; i++) {
                if ((mask & (1 << i)) != 0) { // i is in the current subset mask
                    for (int j = 0; j < n; j++) {
                        if (j != i && (mask & (1 << j)) != 0) { // j is in the current subset mask
                            dp[mask][i] = Math.min(dp[mask][i], dp[mask ^ (1 << i)][j] + graph[j][i]);
                        }
                    }
                }
            }
        }
    }
}

```

```

        }
    }
}

// Find the minimum cost to visit all cities and return to starting city
int minCost = Integer.MAX_VALUE;
int fullMask = (1 << n) - 1;
for (int j = 0; j < n; j++) {
    if (j != start) {
        minCost = Math.min(minCost, dp[fullMask][j] + graph[j][start]);
    }
}

return minCost;
}

public static void main(String[] args) {
    int[][] graph = {
        {0, 10, 15, 20},
        {5, 0, 9, 10},
        {6, 13, 0, 12},
        {8, 8, 9, 0}
    };

    int minCost = findMinCost(graph);

    System.out.println("Minimum cost to visit all cities and return to starting city: " +
minCost); // Output: 35
}
}

```

Output Explanation:

{0, 10, 15, 20},

{5, 0, 9, 10},

{6, 13, 0, 12},

{8, 8, 9, 0}

Minimum cost to visit all cities and return to starting city: 42

Task 3: Job Sequencing Problem

Define a class Job with properties int Id, int Deadline, and int Profit. Then implement a function List<Job> JobSequencing(List<Job> jobs) that takes a list of jobs and returns the maximum profit sequence of jobs that can be done before the deadlines. Use the greedy method to solve this problem.

```
import java.util.ArrayList;
import java.util.Collections;
import java.util.Comparator;
import java.util.List;
```

```
// Job class to store job details
```

```
class Job {
    int id;
    int deadline;
    int profit;

    Job(int id, int deadline, int profit) {
        this.id = id;
        this.deadline = deadline;
        this.profit = profit;
    }
}
```

```
}
```

```
public class JobSequencing {
```

```
// Function to find the maximum profit job sequence
```

```
public List<Job> jobSequencing(List<Job> jobs) {
```

```
    // Sort jobs by profit in descending order
```

```
    Collections.sort(jobs, new Comparator<Job>() {
```

```
        @Override
```

```
        public int compare(Job job1, Job job2) {
```

```
            return job2.profit - job1.profit;
```

```
        }
```

```
    });
```

```
// Find the maximum deadline to determine the size of the job sequence array
```

```
int maxDeadline = jobs.stream().mapToInt(job -> job.deadline).max().orElse(0);
```

```
int[] sequence = new int[maxDeadline]; // This will store the sequence of jobs
```

```
// Initialize the sequence array
```

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

```
    sequence[i] = -1; // -1 means slot is empty
```

```
}
```

```
// Fill the sequence array
```

```
int totalProfit = 0;
```

```
for (Job job : jobs) {
```

```
    // Find a slot for this job, from its deadline to 0
```

```
    for (int j = job.deadline - 1; j >= 0; j--) {
```

```
        if (sequence[j] == -1) {
```

```

        sequence[j] = job.id;

        totalProfit += job.profit;

        break;
    }
}

}

// Create the list of jobs in the sequence

List<Job> result = new ArrayList<>();

for (int i = 0; i < maxDeadline; i++) {
    if (sequence[i] != -1) {
        Job job = jobs.stream().filter(j -> j.id == sequence[i]).findFirst().orElse(null);
        if (job != null) {
            result.add(job);
        }
    }
}

return result;
}

```

```

public static void main(String[] args) {
    // Example usage:

    List<Job> jobs = new ArrayList<>();

    jobs.add(new Job(1, 4, 20));
    jobs.add(new Job(2, 1, 10));
    jobs.add(new Job(3, 1, 40));
    jobs.add(new Job(4, 1, 30));
}

```



```

JobSequencing solution = new JobSequencing();

List<Job> result = solution.jobSequencing(jobs);

// Output the jobs in the sequence

System.out.println("Job Sequence:");

for (Job job : result) {

    System.out.println("Job Id: " + job.id + ", Deadline: " + job.deadline + ", Profit: " +
job.profit);

}

}

}

```

Explanation:

- **Job Class:** Represents a job with properties **id**, **deadline**, and **profit**.
- **JobSequencing Class:**
- **jobSequencing Method:**
- Sorts the jobs by profit in descending order using `Collections.sort`.
- Initializes an array sequence to keep track of the jobs scheduled.
- Iterates through the sorted jobs and finds a slot in the sequence array for each job, from its deadline to 0.
- Calculates the total profit and creates a list result of jobs in the sequence.

Main Method:

- Example usage of the `jobSequencing` method with a list of jobs.
- Prints out the jobs in the sequence.
- Example:

For the input jobs:

Job 1: Id=1, Deadline=4, Profit=20

Job 2: Id=2, Deadline=1, Profit=10

Job 3: Id=3, Deadline=1, Profit=40

Job 4: Id=4, Deadline=1, Profit=30

The output will be:

Job Sequence:

Job Id: 3, Deadline: 1, Profit: 40

Job Id: 1, Deadline: 4, Profit: 20