Project Title:

Designing a Cost-Effective Utility Network for Smart City Development

Project Overview

In this project, students will take on the role of engineers tasked with connecting various critical locations in a new smart city with a cost-effective utility network. The goal is to ensure that every location (such as community centers, schools, hospitals, and administrative offices) is connected while minimizing the total construction cost. This is achieved by applying the Minimum Spanning Tree (MST) algorithm.

Real-Time Story

Imagine you are part of the city planning team for a rapidly growing smart city. The mayor has just announced a massive infrastructure project: to build a new utility network that will connect all key locations across the city. However, budget constraints mean that the network must be constructed as economically as possible.

The city map consists of several nodes representing critical locations. There are multiple potential paths (edges) between these locations, each with an associated construction cost. Your task is to determine which roads (or cables, pipelines, etc.) to build so that every location is connected directly or indirectly, while keeping the overall cost to a minimum. The MST algorithm is the perfect tool to solve this problem because it finds a subset of the edges that connects all nodes with the least total weight, without any cycles.

Problem Statement

You are given a list of locations (nodes) and a list of possible connections between them (edges) along with the cost to build each connection. Your task is to compute a Minimum Spanning Tree (MST) for this graph, which will represent the most cost-effective way to connect all the locations in the city.

Input Format

- **First Line:** Two integers, `N` and `M`, where `N` is the number of locations (nodes) and `M` is the number of possible connections (edges).
- **Next M Lines:** Each line contains three integers:
  - `u` – the starting location (node)
  - `v` – the ending location (node)
  - `w` – the cost (weight) to build the connection between `u` and `v`

Example:

```
5 7
1 2 4
1 3 2
2 3 1
2 4 5
3 4 8
3 5 10
4 5 2
```

Output Format

- **First Line:** The total minimum cost required to build the network.
- **Following Lines:** A list of the connections (edges) that form the MST. Each edge should be represented as a pair of connected nodes along with the cost for that connection.

Example:

```
9
1 3 2
2 3 1
4 5 2
1 2 4
```

(Note: The order of edges may vary as long as they represent a valid MST and the total cost is correct.)