IE 400 Principles of Engineering Management
Term Project

Fall 2023

Due Date: 15 December 23:59

Urban railway systems are fundamental in addressing transportation challenges in densely populated areas, but they face increasing pressure to reduce energy consumption and environmental impact. To achieve sustainable urban mobility, Railway Development Project seeks to optimize an urban railway network through a meticulous selection and deployment of different types of trains, taking into consideration energy efficiency, environmental considerations, and passenger demand.

To kick-start the project, government wants to see some expected results and you're responsible for designing a model to reach optimality in the outcome of the project. Your project group decides on using data on small area to present some representative results.

So, imagine a small urban area with a railway network that connects multiple stations. There are 10 stations in the network (2 of them are depot stations) with different distances and preexisting railways.

The problem includes 15 trains to be used in 15 different fixed paths, each train assigned to one fixed path which starts in the assigned depot station of the train at the start of the day and ends in the same station. Each train should be left in depot stations for at least 4 hours daily to get maintenance. Trains can be scheduled multiple times a day for the same path. Each train should complete maximum amount for their daily travel paths. e.g. 4 hour path with extra 1 hour for depot - start node and end node - depot should be completed 4 times (Total $4 \times 4 + 2 = 18$ hours + 4 hour maintenance). All trains should start their schedule at the start of the day and there cannot be any waiting time between sequences. The path information can be seen in "paths.txt" file.

1 Depot-Train Assignment Problem (20 points)

Your first problem is to assign the trains to the 2 fixed depots (X and Y) by minimizing the distance traveled by trains (only include distances from start

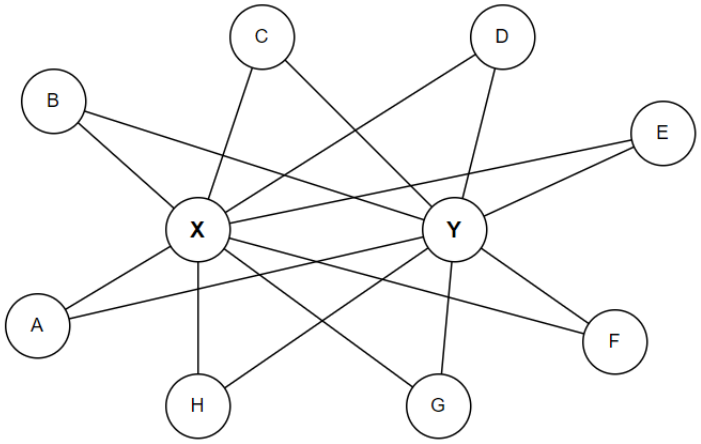

Figure 1: Depots to Nodes Representation

and end nodes of the paths to depots). The distances between each node (A-H) can be seen from "distances.txt" file in unit of hours. The distances between the depot nodes and other nodes can be seen from "depot_node_distances.txt" file (unit hour). Each depot should have at least 5 trains assigned to it. At the start of each day a route from depot to a station cannot be used by more than 3 trains (For each depot, starting node cannot be same for more than 3 trains).

Provide a clear explanation of your decision variables, parameters and model in your report. Give the assignments of nodes to depots and comment on the results you've found.

2 Railway Development Project (80 points)

After the train-depot assignment, the goal is to optimize the efficiency and energy consumption while taking into account the limitations and capabilities of each train type.

Two train types that are considered;

- Electric Trains: These trains run on electricity and are energy-efficient but require charging stations at specific intervals. They have capacity of maximum 8 hour travels without recharging.
- Diesel Trains: Diesel trains are less energy-efficient but do not require charging infrastructure. The diesel trains can go up-to 20 hour travels without refueling.

The maintenance in-depot nodes includes charging or refueling. So, in-depot charging and refueling stations should be built to accommodate all assigned trains to the depot. Similarly, some on-route charging stations can be built in other nodes with a lesser capacity. The charging or refueling times can be neglected. However, a train can be charged at a station only at the hour it comes to that station/node, e.g. train is at node A at time t and it takes 3 hours to go to the next node, it cannot be charged at time t+1 or t+2. In-depot stations have capacity of 3 electric trains for charging and 2 diesel trains for refueling. On-route charging stations have 1 train capacity.

Other required parameters can be found in "parameters.txt" file. Build a model that minimizes the total cost and energy usage (energy levels can be taken as costs directly without scaling). Provide a clear explanation of your decision variables, parameters and model in your report. Also mention other work you've done (e.g. processing of parameters to obtain the utilized format). The results should include the train types and charging or fueling stations and amounts. Please comment on the results you've obtained.

You can use Gurobi-Python API or Cplex-Python API. You should submit your commented codes as a python file and a report as a pdf file that explains your work in a detailed manner (there will be no codes in your report). Please submit them in a zip with a name in format "IE400_GroupX_Name1_Name2.zip".