Optimization Challenge 2025

Efficient Deployment and Operation of Healthcare Units

Delivering essential healthcare services efficiently is a critical challenge in ensuring access for underserved communities across the country. The public health authority has launched a project to address this issue by deploying healthcare units that will provide services such as medical consultations, vaccinations, and diagnostic tests. However, ensuring effective deployment of these units while balancing accessibility and operational efficiency is a complex task.

The public health authority has decided to deploy M healthcare units to strategically serve N underserved communities across the country. Each community has a specific population size representing the number of individuals in need. The effort required for individuals to access a unit depends on geographical distances, calculated as Euclidean distances based on the coordinates of the communities, which are provided in the dataset. The healthcare units will be deployed in some of these communities, that is, the positions of the units will be drawn from among the communities, and each unit has a limited capacity, which means it cannot serve more than C individuals.

As a member of the operations team, your task is to propose a solution that decides the deployment of the M healthcare units and assigns communities to receive service from the deployed units in a way that minimizes the maximum population-weighted distance traveled by any community. Your solution must ensure that no unit exceeds its capacity and that the deployment plan efficiently serves all communities.

Beyond providing direct healthcare services, the healthcare units must also be supplied with the necessary equipment to ensure uninterrupted operations. A designated depot, with its position provided in the dataset as node 0, will facilitate the distribution of equipment to healthcare units. For each healthcare unit, the amount of equipment to be delivered is based on the total population size it serves. A sufficiently large fleet of ambulances, each with capacity $Q = 10000$, will transport the necessary equipment from the depot to the deployed health units, ensuring that the number of vehicles does not constrain the distribution plan. The objective is to design distribution routes and schedules that minimize the overall distribution effort (e.g., the total distance traveled by the ambulances) while ensuring that every healthcare unit is visited exactly once.

This is a two-stage problem: first, the deployment of the healthcare units is optimized, and then, in the second stage, the distribution of equipment from the depot to the units is planned.

Challenge Instructions

Develop a comprehensive solution that:

- Determines the optimal placement of the M healthcare units and assigns communities to receive service so that the maximum population-weighted distance for patient access is minimized.
- Proposes an efficient method that minimizes the total travel distance required to distribute medical equipment, ensuring that all healthcare units receive their necessary resources without disruption.

Expected Deliverables

You need to submit the following via email (opt-challenge@sabanciuniv.edu) by **April 20, 2025**:

1. A short report presenting:
    - Your solution approach.
    - Relevant implementation details, including the choice of programming language, solver, or any additional software (if applicable), algorithm-specific parameter choices, and where you ran the experiments.
2. Your code file(s).
3. Your solution files in a zip folder:
    - See the instance folder for a sample solution file. You must have a solution file in the given format for every instance you solve. Submissions that do not conform to the sample solution file structure will not be considered.
    - Make sure to submit a separate solution file for each individual instance and name it using the convention `Sol_Instance_ID` where `ID` is the ID number of the instance (ranging from 1 to 24). For example, your solution file for `Instance_1` should be named `Sol_Instance_1`.
4. Proof of student certificate for each group member (recall that only undergraduate students are eligible).

Evaluation Criteria

Evaluations will be based on the quality of the solutions submitted. The quality of a solution in the first stage is measured by the maximum population-weighted distance; solutions with smaller maximum values are considered to be of higher quality. In the second stage, among solutions with the same first-stage objective value, those that minimize the total distance traveled by the ambulances for equipment distribution will be preferred. In case of ties, solutions that require the fewest number of routes will be favored.

Submitted solutions will be ranked based on these three criteria in this respective order:

1. First stage objective value
2. Second stage objective value
3. The number of routes used

Note that you need to register in order to access the problem instances.