VE477
Introduction to Algorithms

Challenge

Manuel — UM-JI (Fall 2021)

- Abstract a real life problem
- Find an algorithm to solve a problem
- Prove its correctness and complexity
- Rewarded by a bonus on the final grade

Although the Fall semester is pretty busy you decide to take an internship in order to improve the quality of your graduate school applications. After a bit of search and a few unsuccessful interviews you eventually get a position in a logistics company which has just opened a new branch in Shanghai.

On your first day, you enter a messy office space where plenty of people seem to randomly walk with big boxes. Bob, the boss that you have met online for the interview comes to you and apologizes for the disorganisation: "Sorry, I know it doesn't look good for a logistics company... but this is our first day in this new office, we are just moving in. Actually at the moment this is only me, Bill the tall guy over there, and you the new intern." While saying that he waves and a skinning young man approaches and greets you: "Welcome! And sorry for the mess, when they are all gone and everything is in place it will be good, you'll see." On those words Bob leads your small group to a more quiet and less crowded room where you can go over the goal of your internship.

From what you understand they are the new contractor of a famous freight company. If things work out well during the trial period they will be able to sign a big contract. Bob and Bill being over busy at the moment they entrust you with finding the best, most optimal solution for their customer. They will of course support and help you by providing hints related to the problem you have to solve.

At the moment this freight company asks you to figure out the cheapest way to send packages from Shanghai to Suzhou. Packages can leave from Shanghai or a predefined list of cities (stops) on the way, and all the transportation is done by trucks leaving from Shanghai. The whole question is to know the minimum number of trucks necessary to carry the parcels to Suzhou over a day of t hours long, without any warehouse exceeding its capacity. To refine and clarify the problem Bill adds the following rules:

- The variation in traffic is neglected, and the itinerary never changes;
- Each truck can be loaded with a maximum of s packages;
- In each city a truck loads as many packages as possible without exceeding its capacity s;
- If a truck is full at stop i, then no more package can be loaded on the way to Suzhou;
- City i features a warehouse with capacity w_i, i.e. no more than w_i packages can be stored until the next truck arrives;
- Packages can be left overnight in a warehouse, i.e. packages left behind at the end of the day can be picked up on the following morning;
- Every hour new packages arrive and are stored in the city warehouse until a truck comes;
- The freight company provides extra information:
  - The initial number of packages p_i to be picked up at stop i;
  - The number of packages a_i that are added every hour at stop i;
  - The capacity of the warehouse w_i at stop i, i.e. how many packages can be stored until the next truck arrives in city i;

After ensuring you fully grasp the problem both Bob and Bill leave the room, leaving you alone to work on it. As you have no idea where to start or what to do next, you try to recall everything you learnt in ve477 on how to tackle new problems...

Rules

Follow the rules below:

- Prepare a proof of correctness and determine the complexity of the proposed algorithm;
- Implement the proposed algorithm in Python or OCaml;
- Test the correctness of the solution on JOJ;

Reward

The reward will de determined as follows.

- Single: up to 3 extra marks on the final course grade;
- Team: up to 6 extra marks on the final course grade to be equally shared among the team members;
- Two hints will be provided on a weekly basis;
- The first hint is free while the second one will cost 0.5 mark;
- To get a full reward, all JOJ test cases must be passed;
- Participants partially passing JOJ test will receive a partial bonus;
- A similarity check will be run on all submissions and cheating participants will not receive any bonus;