Supply delivery optimization

You are given a road network of the state of Tamilnadu, where there are 3 kinds of roads: primary, secondary, and tertiary.

The data format is as follows:

- Line 1: Number of `points` or nodes (N)
- Line 2 to N+1: `Longitude` and `Latitude` values of points (type `float`). Points have IDs from 0 to N-1
- Line N+2: Number of road edges (R)
- Line N+3 to end of file (N+3+R-1): one road segment per line

The format of a road segment is as follows:

- `src`: ID of the source node (0 to N-1)
- `dst`: ID of destination node
- `type`: `p` for primary, `s` for secondary, `t` for tertiary
- `distance`: distance along segment in km

Supplies can be transported from one point to another using supply trucks. Primary roads can carry up to 100 trucks per hour, but have a maximum speed constraint of 60kph. Secondary roads can carry up to 50 trucks per hour at a maximum of 40kph, while tertiary roads can carry 20 trucks per hour at 30kph. The number of trucks per hour on a road must be an integer.

Problem 1

Given two points A and B (node indices), you need to find a scheme to transport the maximum number of units per hour from A to B in the steady state where a large number of supply vehicles are continuously running. (Note: this means you can ignore the speed constraints for this problem).

Problem 2

You need to get X units of supplies from A to B in the minimum total time. Here assume that if you want to send 10 trucks on a primary road of length 12 km, the time taken is 10/100 = 0.1 hours + the latency (time taken to cover the road) = 12/60 = 0.2 hours, for a total time to deliver supplies of 0.3 hours.

For example, in the figure, road A-B has a capacity of 100 trucks per hour, but is carrying only 70 units because roads further down don't have enough capacity. Similarly C-E has only 50 units of input, so is carrying less than capacity.

If we want to transport a total of 500 trucks, one possible choice is to send 250 units along A-B-C-E and 250 units along A-B-D-E. In this case, the time taken along A-B-C-E will be a total of 250/50 + 30/60+20/40+30/60 = 5 + 1.5 = 6.5

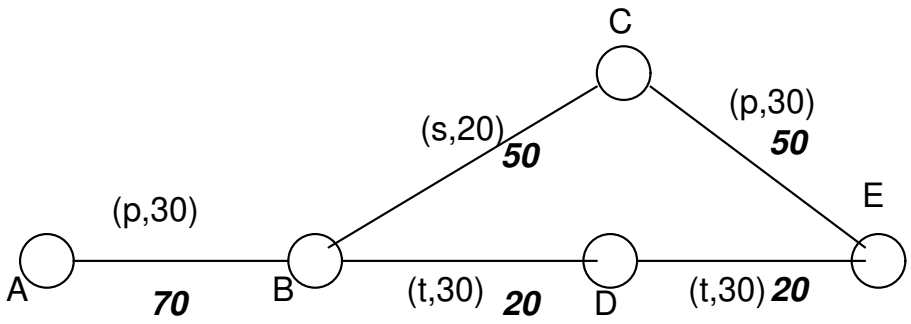

Figure 1: Road capacity

hours (Note that 50 is the bottleneck here because of the secondary road on the path). The time along A-B-D-E will be 250/20+30/60+30/30+30/30=12.5+2.5 = 15 hours. So the overall time to deliver all supplies will be 15 hours (maximum of the different possible paths).

You will be given one source node and one destination node. Your goal is to minimize the final time of delivery of supplies to the destination.

Remarks

- While it would be great if you can come up with the solutions on your own, you are also encouraged to review existing literature on algorithms to find the right solutions. You need to clearly state where you found the solutions from as part of your final submission. Each person is expected to work on this independently, but if you do discuss it with others, it is better to state this clearly, as otherwise any excessive similarities in the approaches used by multiple people will be flagged as copying.
- If you are directly using an algorithm from an online source, you need to provide an explanation for why the algorithm gives the correct solution.
- You can use any of the data-types in the C++ STL (including map, list, vector etc.), although this is not a requirement. If you are more comfortable using your own data structures, that is perfectly fine.
- Some people had asked about whether they can implement this in Python or some other language: this is acceptable, but you are NOT permitted to use graph libraries such as `networkx` or equivalents from other languages. Also, it is your responsibility to ensure that your program reads in data in the same format as the C/C++ models we have used so far, so that the automated checking scripts can work directly on the executables.