2 - PBL LOOP

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TOPIC

Instructions

QUIZ:PROSIT: NO COMPLEX

Your collaboration with Agathe has been very rewarding. But now that your colleague is going to continue her project together with the Grand Est region, it's time for you to fully engage in answering ADEME's call.

The main advantage is that you will be able to directly use this work in the management of delivery routes. All you have to do is replace the bridges with cities. But when it's time to wish you all the best, Agathe, who has overheard you, can't help but intervene:

Agathe: 'It's not that simple, the problem is not the same...'

Your enthusiasm fades instantly. Agathe then proposes to stay with you a little longer to think things through.

Agathe: 'Do you think that passing through each city only once is the same as passing through each path only once?' Moreover, it's not a question of knowing whether it is possible to pass through once, but to do the route no matter what, while minimising the time it takes. It's an optimization problem.'

You: 'We could try to sort the cities by travel time required going from the starting point, and choose... Or we calculate the shortest paths between each pair of cities...'

Agathe: 'Not so fast! You're already trying to find an algorithm, while you have not yet modelled the decision problem corresponding to this optimization problem!'

You: 'What's the purpose of the decision problem? All we want is to find the best solution!'

Agathe: 'Depending on the complexity class of the decision problem associated with the optimization problem, the methods you're envisioning will most likely be heuristic, or of exponential complexity. This complexity must be established in order to know if we can look for an optimal algorithm that might stand a chance of being within a reasonable asymptotic complexity class. This is crucial, otherwise you risk spending the next few weeks coding for nothing.'

You: 'When we launched the project, I heard others say that it was an application of the travelling salesman problem. Is its complexity known? We'll have the answer straight away.'

After a short pause to think...

Agathe: 'It makes sense, but it seems to me that the travelling salesman problem has different constraints on the graphs compared to your case. Besides, you absolutely need a route as output. I know there's a metric version of the problem. Perhaps this version fits better here... You should be able to find that in the literature, as there must be dozens of scientific articles that address the subject.

In any case, if you find that you can start by using this problem and it's already proven to be NP-Complete, the formal proof by polynomial-time reduction should be easy to get.'

You: 'And if we actually find an article proving that it is NP-Complete, what do we do? Do we start with a heuristic algorithm?'

Agathe: 'Start by determining the time complexity of your problem. Or better yet, first check if the associated decision problem is in NP. Imagine if a Turing Machine is not even capable of deciding on the correctness of a solution, not even algorithms of exponential complexity would work! You're good at programming, so you should easily be able to propose a simple certificate algorithm proving membership in NP. I doubt that we're dealing with a problem that is so complex as to be outside of NP.'

You: 'And the space complexity too, right?'

Agathe: ‘In essence, you’re right to mention that, but given the capabilities of modern computing systems, it shouldn’t be a problem.’

What is clear in all this is that the code is not needed straight away.

Resources for students

- P NP and NP Completeness :The Basics of Computational Complexity (chapters 2, 3 and 4) - EN
- P, NP, NP-Hard & NP-complete problems - EN
- NP-Hard and NP-Complete Problems video - EN
- Computers and Intractability - A Guide to the Theory of NP Completeness - EN
- P NP NP-Hard NP-Complete||Design and Analysis of Algorithm video - EN
- What is the Traveling Salesman Problem? - video EN
- Complexité algorithmique partie 2 - NP-Complétude, Benjamin COHEN BOULAKIA (2020) - FR continuation of the video from Prosit 1