CS325: Homework 9

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1. **NP - completeness: the TSP problem**

   The steps to prove a problem to be NP-complete

   1. Show that it belongs to the NP-class, in other words can be verified in polynomial time
   2. Show that the problem is in NP-hard

   Then, to show that the problem, TSP, is NP-Hard I will use reduction to transform the problem

   1. Picking a known NP-Hard problem
   2. Show that we can reduce that problem to our problem in polynomial time

   For proving a problem to be NP-complete and verifying in polynomial time you can check if each node was visited once which would be done in polynomial time.

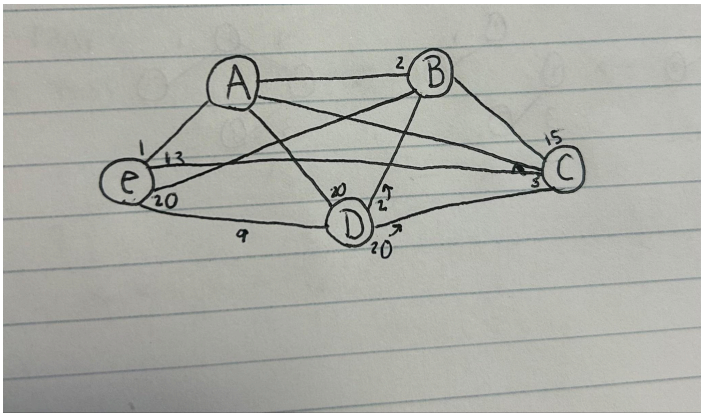
   Showing that a problem is NP-Hard, I will use the HAM-cycle which is a proven NP-completeness problem.

   For reduction → from the HAM-cycle to TSP
   You would transform the HAM-cycle problem into a TSP problem by creating a complete graph where each edge has the same weight (1 for edges that are in the original graph and a higher number for edges that do not exist), then ask for the shortest tour. If the shortest tour equals the number of vertices, a hamilton cycle exists in the original graph.

   For example, my mapping each vertex “V” to a city and each edge “E” to a path with a weight of 1, higher if the path is not part of the original HAM-cycle problem, ie inf. In which, G=(V,E) and G’=(V’, E’). We find a route not greater than cost k (k = Vtotal) which is a mirror of the Ham-cycle. This is the reduction and its steps are in polynomial time.

   From the reduction, it shows that if we could solve TSP in polynomial time, we could also solve HAM-cycle in polynomial time because HAM-cycle has been reduces to TSP, showing TSP is NP-Hard by being at least as hard as an NP-complete problem.

2. **Implement Heuristic algorithm**
    a. **Matrix to graph**



    b. **Apply nearest-neighbor heuristic to this matrix and find the approximate solution for this matrix if this were for TSP problem**
    A - E - D - B - C - A → total cost is 30

    c. **What is the approximation ratio of your approximate solution**
    The optimal would be 29 so the accuracy ratio is 29/30 which about 1
    d. **Implement TSP using the nearest-neighbor heuristic**
        i. In gradescope