IE 400
Principles of Engineering Management
2019-2020 Spring

PROJECT REPORT

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1. IP MODEL

$$min \sum_{i=0}^{N} \sum_{j=0}^{N} D_{ij} x_{ij} + \sum_{i=1}^{N} y_i$$

$$s.t \ \ \forall\ 0 \leq i \leq N \ \ \sum_{j=0}^{N} x_{ij} = \sum_{j=0}^{N} x_{ji} = 1,\ x_i \ \epsilon \{0, 1\},$$

$$u_0 = 1,\ u_i - u_j \leq (N+1)(1 - x_{ij}),\ u_i, u_j \ \epsilon\ \mathbb{N}\ \ \forall\ 1 \leq i, j \leq N$$

$Decision\ variables\ are\ x_{ij}\ 's\ and\ u_{ij}\ 's\ (0 \leq i, j \leq N)$

$Parameters\ are\ D_{ij}\ 's\ (Distance\ between\ node\ i\ and\ node\ j),$
$y_i\ 's\ (waiting\ time\ for\ student\ i\ for\ 1 \leq i \leq N)$

2. DP MODEL

$Let\ the\ minimum\ cost\ starting\ from\ node\ 0\ and\ ending\ from\ node\ i\ by\ travelling\ all\ the\ nodes\ exactly\ once$ $in\ set\ S\ is\ C(S, i)\ and\ the\ recursive\ relation\ is\ like\ in\ the\ below:$

$$\begin{cases} dist(0, i), |S| = 2 \qquad else \\ min\{C(S - \{i\}, j)\ + dist(i, j)\ for\ all\ values\ of\ j \\ \qquad s.t\ j \neq 0,\ j \neq i\} \end{cases}$$

$After\ C(S, i)\ is\ found,\ the\ optimal\ path\ length\ can\ be\ found\ by\ finding\ min\{C(S, i) for\ the\ i\ values\ 1 \leq i \leq N\}.$

$Then\ the\ answer\ will\ be\ min\{C(S, i)\} + \sum_{i=1}^{N} x_i\ where\ x_i\ 's\ are\ the\ waiting\ times\ of\ students.$

$Parameters\ are\ dist(i, j)\ values\ and\ x_i\ 's.$
$Decision\ variables\ are\ i\ values\ for\ every\ step,\ which\ is\ the\ next\ node\ to\ be\ arrived.$

3. RUNNING TIME ANALYSIS

CPLEX Optimizer is used for solving IP.

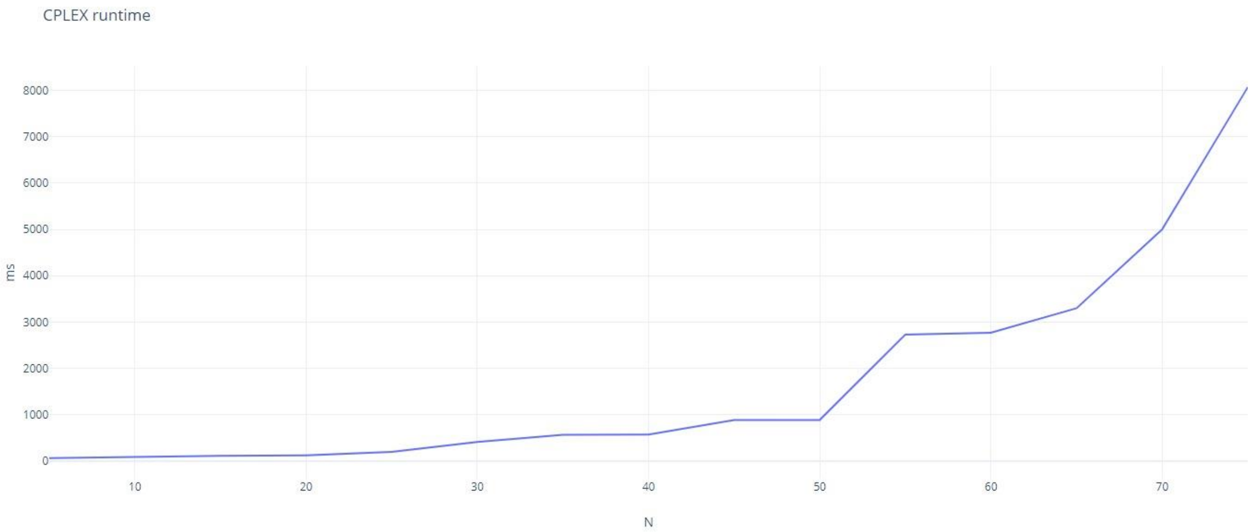
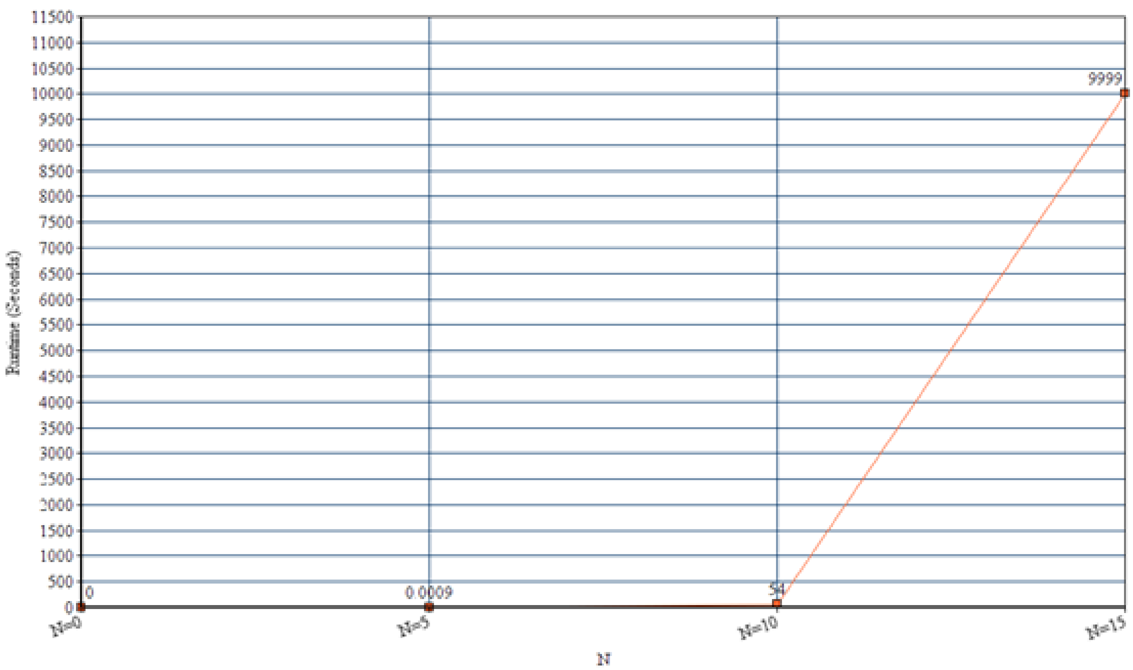


Figure 1: Run time results of CPLEX

Until the value of N=50 there is a linear trend in terms of running time but after N=50 graph trend turns in to exponential.

The code written for solving DP is in Python language.



Running time for DP code is O(n!) which is the worst case. So after the passing the N=10, problems become unsolvable. 9999 value is given to N=15 just for showing this situation. Our code couldn't solve an N=15 problem in an hour.

Results of CPLEX and Python codes are very different. Already CPLEX is an optimizer and it can work more efficient in average case. However Python code depends on the developer. If developer can have an algorithm with O(2^n) better, it would provide better results. Because of the higher growing rate of our algorithm, this kind of a difference between running time occurred.

*Codes of CPLEX & Python and dataset are in the project folder.