HOMEWORK 5

Production Planning Algorithms

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(Individual Submission)

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CS 218

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Performance comparison of ILP vs DP for the production planning algorithm

Note1: DP.cpp was compiled using these settings: `g++ -pipe -O2 -std=c++14 DP.cpp -lm`

Note 2: Test cases were generated manually using given test cases as a baseline

The time taken by the Integer Linear Programming algorithm (ILP) depends on the number of variables and constraints to the algorithm. The time taken by the Dynamic Programming algorithm (DP) depends on the size of the cost table constructed. This table dimensions are `(M+1)*(e_max+1)*(inventory_max+1)`.

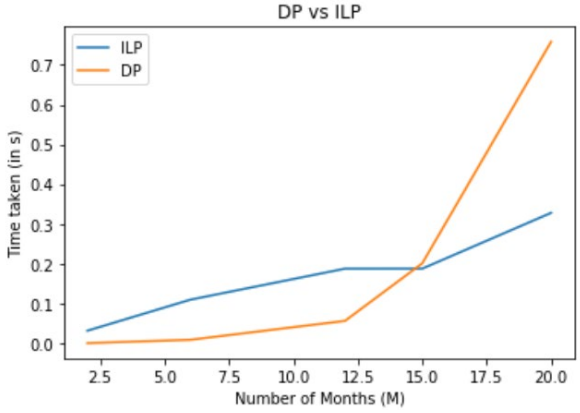
1. **Preliminary analysis on given test cases:**

Test Case 1: 2 5 4 1 32 40 200 2 1 180 6 Cost: 1052 Time (LP): 0.0313 Time (DP): 3.6e-05	Test Case 2: 3 50 40 70 5 32 40 200 8 3 35 6 Cost: 4272 Time (LP): 0.0312 Time (DP): 0.048668

Observations: LP seems more robust to different kinds of test cases.

2. **Varying M (number of months)**

Test Case 1: 2 5 4 1 32 40 200 2 1 180 6 Cost: 1052 TLP: 0.0313 TDP: 3.6e-05	Test Case 2: 6 5 4 5 5 4 4 1 32 40 200 2 1 180 6 Cost: 2930 TLP: 0.1094 TDP: 0.00845	Test Case 3: 12 5 4 5 4 5 4 5 4 5 4 5 4 1 32 40 200 2 1 180 6 Cost: 5688 TLP: 0.1874 TDP: 0.05606	Test Case 4: 15 5 4 5 4 5 4 5 4 5 4 5 4 5 4 5 1 32 40 200 2 1 180 6 Cost: 7136 TLP: 0.1875 TDP: 0.20086	Test Case 5: 20 5 4 5 4 5 4 5 4 5 4 5 4 5 4 5 4 5 4 5 4 1 32 40 200 2 1 180 6 Cost: 9420 TLP: 0.3278 TDP: 0.75835

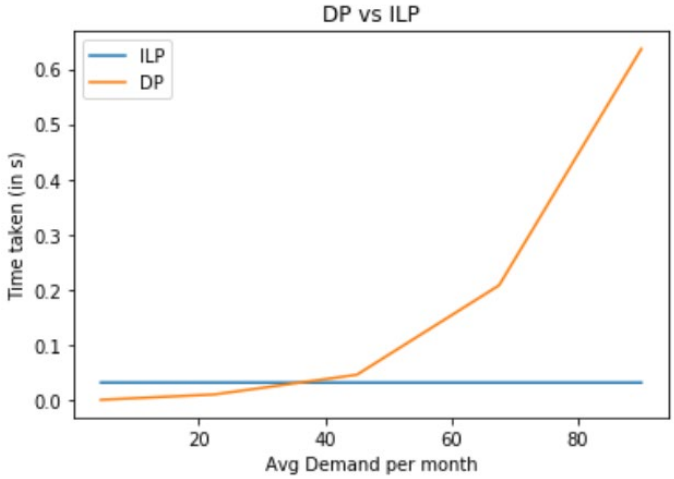


Observations:

- DP is faster than ILP when number of months is lower
- ILP is faster than DP when the number of months is large

3. Varying Demand

Test Case 1: 2 5 4 1 32 40 200 2 1 180 6 Cost: 1052 TLP: 0.0313 TDP: 3.6e-05	Test Case 2: 2 25 20 1 32 40 200 2 1 180 6 Cost: 5372 TLP: 0.0313 TDP: 0.00983	Test Case 3: 2 50 40 1 32 40 200 2 1 180 6 Cost: 10728 TLP: 0.0312 TDP: 0.04548	Test Case 4: 2 75 60 1 32 40 200 2 1 180 6 Cost: 16172 TLP: 0.0312 TDP: 0.20769	Test Case 5: 2 100 80 1 32 40 200 2 1 180 6 Cost: 21528 TLP: 0.0312 TDP: 0.63653

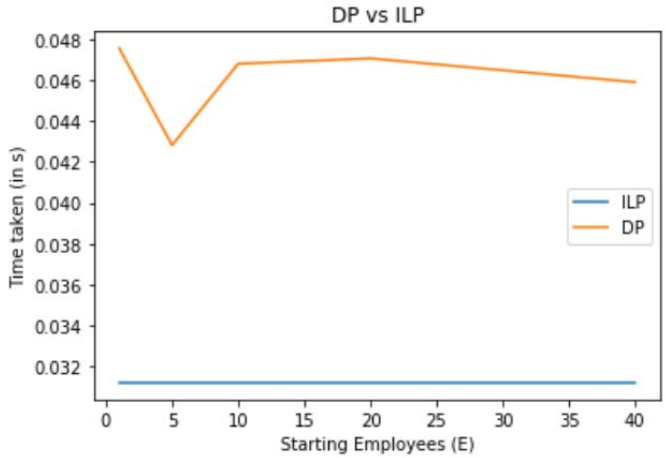


Observations:

- DP performs better when demand is lower whereas ILP is way better at higher demand
- ILP performance is consistent and doesn't change with demand. This is expected as the number of constraints remain the same. DP performance becomes slower as the size of the memorization table increases along 2 dimensions (2^{nd} and 3^{rd})

4. Varying only starting number of employees

Test Case 1: 2 50 40 1 32 40 200 2 1 180 6 Cost: 10728 TLP: 0.0312 TDP: 0.04756	Test Case 2: 2 50 40 5 32 40 200 2 1 180 6 Cost: 10440 TLP: 0.0312 TDP: 0.04282	Test Case 3: 2 50 40 10 32 40 200 2 1 180 6 Cost: 10080 TLP: 0.0312 TDP: 0.0468	Test Case 4: 2 50 40 20 32 40 200 2 1 180 6 Cost: 9360 TLP: 0.0312 TDP: 0.04706	Test Case 5: 2 50 40 40 32 40 200 2 1 180 6 Cost: 10440 TLP: 0.0312 TDP: 0.04590

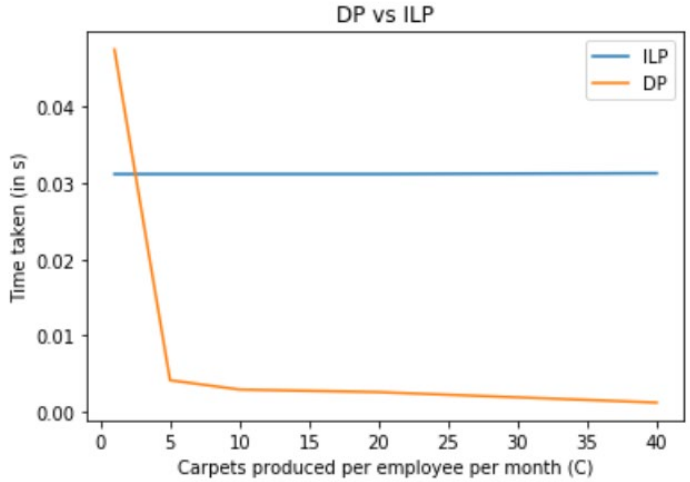


Observations:

- No major variation for either ILP or DP. This is expected because for ILP, the number of constraints remains the same. For DP, the size of the table doesn't change so the time is expected to remain the same

5. **Varying number of carpets produced by an employee per month (C)**

Test Case 1:	Test Case 2:	Test Case 3:	Test Case 4:	Test Case 5:
2 50 40 1 32 40 200 2 1 180 6 Cost: 10728 TLP: 0.0312 TDP: 0.04756	2 50 40 1 32 40 200 6 1 180 6 Cost: 3600 TLP: 0.0312 TDP: 0.00411	2 50 40 1 32 40 200 12 1 180 6 Cost: 1948 TLP: 0.0312 TDP: 0.00289	2 50 40 1 32 40 200 15 1 180 6 Cost: 1476 TLP: 0.0312 TDP: 0.00255	2 50 40 1 32 40 200 20 1 180 6 Cost: 1204 TLP: 0.0313 TDP: 0.00118

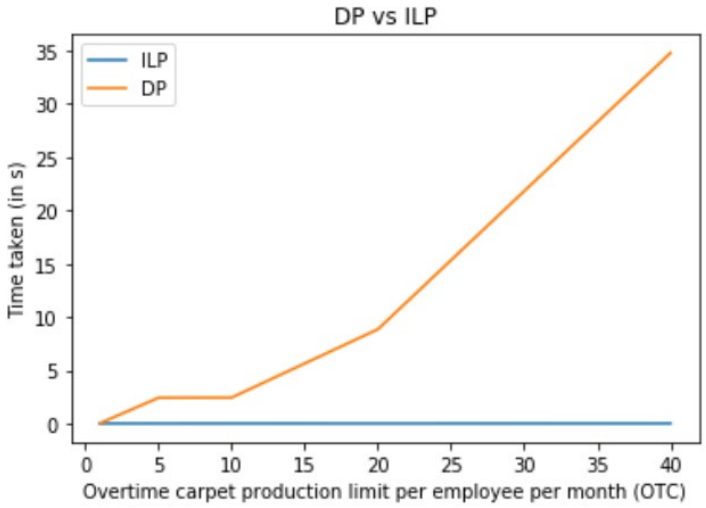


Observations:

- ILP shows no time variation. This is expected due to no change in number of constraints
- DP running time decreases as C increases. This is expected as size of the memorization table decreases in the 2nd and 3rd dimension

6. **Varying overtime carpet production limit (OTC)**

Test Case 1:	Test Case 2:	Test Case 3:	Test Case 4:	Test Case 5:
2 50 40 1 32 40 200 2 1 180 6 Cost: 10728 TLP: 0.0312 TDP: 0.04756	2 50 40 1 32 40 200 2 10 180 6 Cost: 10728 TLP: 0.0312 TDP: 2.43847	2 50 40 1 32 40 200 2 20 180 6 Cost: 10728 TLP: 0.0330 TDP: 2.45483	2 50 40 1 32 40 200 2 40 180 6 Cost: 10728 TLP: 0.0312 TDP: 8.86327	2 50 40 1 32 40 200 2 80 180 6 Cost: 10728 TLP: 0.0340 TDP: 34.7744



Observations:

- ILP shows negligible running time variation as number of constraints remains same
- DP shows an increase in running time as the OTC increases. This is because the size of the table along the 2nd dimension is directly proportional to this parameter

7. **Varying Salary/Hcost/Fcost/OTPrice/W**
   This will not lead to any significant variation in either algorithm as no. of constraints remain same for ILP and also the table size doesn't change in DP. Hence these parameters do not have any significant effect on runtimes as compared to variation over other parameters (just how no of start employees didn't affect running times much)

Final Inferences:

- ILP is a much more stable and robust algorithm and is not affected much by variation in task parameters. DP is highly sensitive to parameters that cause a change in its memorization table size and hence shows a lot of variation over these parameters.
  Hence for most real-world applications and for flexibility, ILP would be a better choice. However, if we need very short-term projections, DP can give us faster results without taking too much space

Final Note: Better time estimates can be obtained by explicitly taking average over multiple runs but for the purposes of our comparison, this suffices