Notes: The Dynamics of Plant Layout[1]

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Abstract

This note develops a fathoming procedure for the Dynamic Plant Layout Problem (DPLP) discussed by Rosenblatt (1986) in this journal, This procedure can be used to reduce the number of candidate static layouts to be examined. An important feature of our procedure is that a feasible dynamic solution is not required in order to apply it. The effectiveness of this procedure depends on the relative magnitude of the shifting costs.

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In this paper, a fathoming procedure is developed for R0senblatt's (1986) Dynamic Plant Layout Problem (DPLP). We use the notation in Rosenblatt.

THEOREM. *In period t, no static layout configuration A_r, with cost Z_{tr} may become part of the optimal multi-period solution if $Z_{tr} — Z_{t1} > 2 \times Max \{C_{km}\}$, where C_{km} denotes the rearrangement cost of shifting from configuration A_k to A_m.*

PROOF. Let L^*_{Ar} indicate any feasible *T*-period solution in which A_r is the layout used in period *t*. Then, L^*_{Ar} is given by

$$L^*_{Ar} = Z_{1k} + C_{kl} + Z_{2l} + \cdot\cdot + Z_{(t-1)j} + C_{jr} + Z_{tr} + C_{rs} + Z_{(t+1)s} + \cdot\cdot\cdot Z_{Ti} \qquad (1)$$

where *k, l, j, r, s*, and *i* represent static layouts. Also, the shifting costs associated with A_r in period *t* are C_{jr} and C_{rs}. Now, consider another configuration, A_b the layout corresponding to the least cost static solution, Z_{t1}. Here, L^*_{Ab}. is given by

$$L^*_{Ab} = Z_{1k} + C_{kl} + Z_{2l} + \cdot\cdot + Z_{(t-1)j} + C_{jb} + Z_{t1} + C_{bs} + Z_{(t+1)s} + \cdot\cdot\cdot Z_{Ti} \qquad (2)$$

Subtracting L^*_{Ab} from L^*_{Ar} we get

$$L^*_{Ar} - L^*_{Ab} = C_{jr} + Z_{tr} + C_{rs} + Z_{t1} – (C_{jb} + Z_{t1} + C_{bs}) \qquad (3)$$

If A_j, A_b and A_s are such that C_{jb}, and C_{bs} each represents the maximum rearrangement cost that could occur, then this represents the highest cost (worst case) way in which A_b, can enter the solution. Let this maximum rearrangement cost be denoted by Max { C_{km}}, Further, if C_{jr}, and C_{rs} are both zero, which represents the lowest cost (best case) way in which A_r can enter the solution, (3) reduces to

$$L^*_{Ar} - L^*_{Ab} = Z_{tr} - (Z_{t1} + 2 \times Max \{C_{km}\}) \qquad (4)$$

If $Z_{tr} - Z_{t1} > 2 \times Max \{C_{km}\}$, then L^*_{Ar} will always be greater than L^*_{Ab} and A_r will never replace A_b in period *t*.

In the first and last periods, only one rearrangement can occur. Thus, the above condition reduces to $Z_{tr} - Z_{t1} > Max \{C_{km}\}$. Note that a feasible solution is not required in order to apply our theorem. A rank ordering of the static layouts in a period is sufficient.

Rosenblatt reports that in his experiments, he was not able to fathom any layouts using the fathoming procedure of Sweeney and Tatham (1976). Our approach was able to fathom 91 of the 720 static layouts in the last period of his six—department, five-period example, about 2% of the total number of static layouts in the problem. The effectiveness of our procedure depends on the cost of shifting relative to the cost of material handling flow. For example, in Rosenblatt's problem, $Max \{C_{km}\}$ is given by $\sum_{i=1}^{6} s_i$ = \$3,197, the cost of shifting all six departments. If this value is reduced by 50% to \$1,599, then 368, 203, 172, 156, and 550 static layouts can be eliminated from the possible 720 static layouts in each of the periods 1 through 5, respectively. Thus, more than 40% of the static layouts can be eliminated. This will result in a significant reduction in the computation time required to solve the DPLP[2].

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[2]The author wishes to thank an anonymous referee for valuable suggestions.

References

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