Integer programming example

Selection of nests to be cut from a set of existing nests

$$\text{Min} \quad Z(x) = \sum_{i=1}^{M} G_i \left(\sum_{j=1}^{N} A_{ij} x_j + L_i - R_i \right)$$

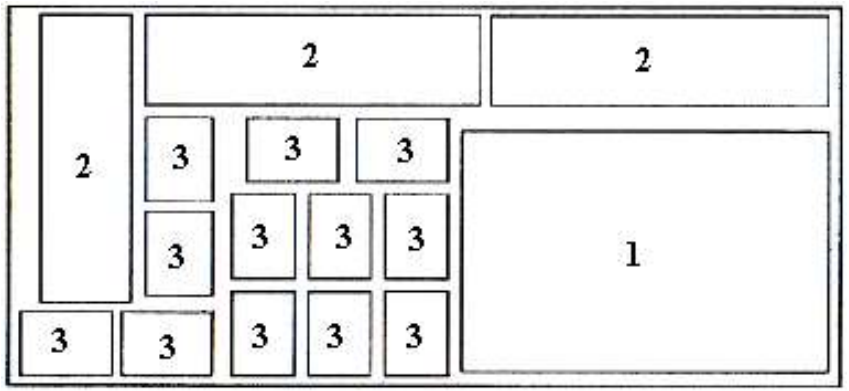
so that

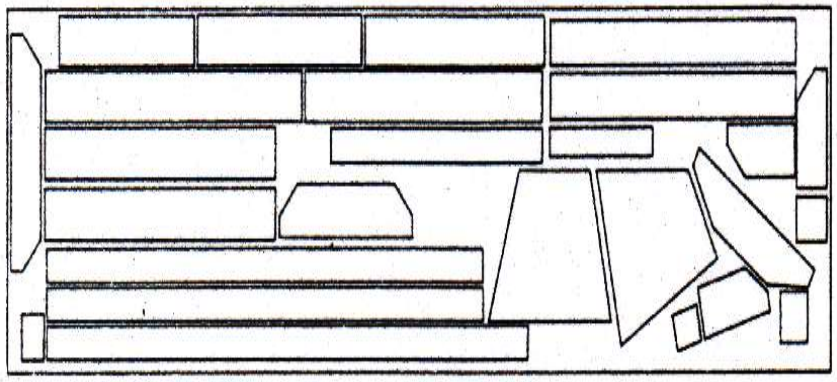
$$\sum_{j=1}^{N} A_{ij} x_j + L_i \geq R_i, \qquad i = 1,..M,$$

$$x_j \geq 0, \text{ integer},$$

where

M **= number of part types**
N **= number of nests**
G_i **= Weight of part *i* (value)**
A_{ij} **= parts *i* in nest *j***
x_j **= number of nests *j* cut**
L_i **= parts *i* in stock already**
R_i **= demand of parts *i***





Integer programming – nonlinear example

Tool magazine optimization

Problem is the classical Quadratic Assignment Problem (QAP). Objective is to find such an order for tools in a magazine of N slots for *M* tools that magazine travel is minimized. The magazine travel with tool *i* in slot *k* and tool *j* in slot *l* is c_{ijkl}, which is the product of distance between slots *k* and *l* and number of tool changes between tools *i* and *j*:

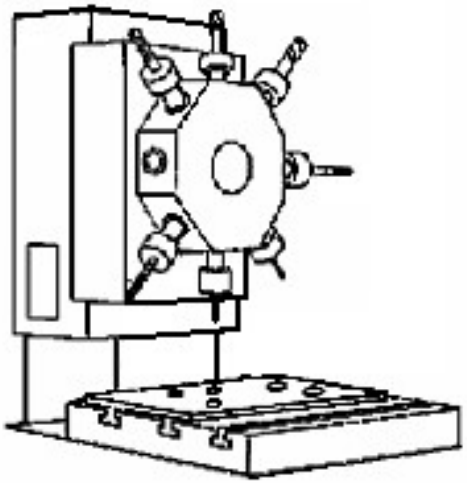
$$\text{Min} \sum_{i=1}^{M}\sum_{k=1}^{N}\sum_{j=1}^{M}\sum_{l=1}^{N} c_{ijkl}\, x_{ik}\, x_{jl}$$

st

$$\sum_{i=1}^{M} x_{ik} \le 1 \qquad k = 1,\ldots,N$$ **Every slot is occupied at most by 1 tool**

$$\sum_{k=1}^{N} x_{ik} = 1 \qquad i = 1,\ldots,M$$ **Every tool is in a slot**

x_{ik} = 1 if tool *i* is in slot *k*, otherwise 0.



Number of possible relevant permutations is (N - 1)!/2

A machine with a buffering tool changer and magazine is a different story!

Tool magazine heuristic optimization

Optimization can be done for example using following heuristic:

1. **Locate tools in random slots and calculate total travel for the set of given NC programs**
2. **Try all possible pairwise interchanges of tools and calculate travel every time. Tools are returned to the previous order after each interchange**
3. **If result improved at any interchanges, freeze the best order and return to step 1**
4. **Otherwise stop**