TD/TP n°3

Exercise 1 (warehouse location)

A company considers opening warehouses at some candidate locations in order to supply its existing stores. Each possible warehouse has the same maintenance cost, and a capacity designating the maximum number of stores that it can supply. Each store must be supplied by exactly one open warehouse.

The supply cost to a store depends on the warehouse. The objective is to determine which warehouses to open, and which of these warehouses should supply the various stores, such that the sum of the maintenance and supply costs is minimized.

The following data are considered.

- The building cost of a warehouse is equal to 30.
- There are 10 stores.
- The potential warehouses are located in Bonn, Bordeaux, London, Paris and Rome. Their capacities (in the same order) are equal to 1, 4, 2, 1, 3.
- The supply costs are given as a matrix (one store per row).

Bonn	Bordeaux	London	Paris	Rome
20	24	11	25	30
28	27	82	83	74
74	97	71	96	70
2	55	73	69	61
46	96	59	83	4
42	22	29	67	59
1	5	73	59	56
10	73	13	43	96
93	35	63	85	46
47	65	55	71	95

Question: Propose a constraint model.

Exercise 2 (rehearsal scheduling)

A concert is to consist of nine pieces of music of different durations each involving a different combination of the five members of the orchestra. Players can arrive at rehearsals immediately before the first piece in which they are involved and depart immediately after the last piece in which they are involved.

The problem is to devise an order in which the pieces can be rehearsed so as to minimize the total time that players are waiting to play, i.e. the total time when players are present but not currently playing.

In the following table, 1 means that the player is required for the corresponding piece, 0 otherwise. The duration (i.e. rehearsal time) is in some unspecified time units.

Piece	1	2	3	4	5	6	7	8	9
Player 1	1	1	0	1	0	1	1	0	1
Player 2	1	1	0	1	1	1	0	1	0
Player 3	1	1	0	0	0	0	1	1	0
Player 4	1	0	0	0	1	1	0	0	1
Player 5	0	0	1	0	1	1	1	1	0
Duration	2	4	1	3	3	2	5	7	6

For example, if the nine pieces were rehearsed in numerical order as given above, then the total waiting time would be: Player 1 ($1+3+7=11$), Player 2 ($1+5=6$), Player 3 ($1+3+3+2=9$), Player 4 ($4+1+3+5+7=20$), Player 5 (3) giving a total of 49 units.

Question: Propose a model in order to find the optimal sequence of pieces.

Exercise 3 (bioinformatics)

The problem of word design for DNA computing on surfaces is to find as large a set S of strings (words) of length 8 over the alphabet $W = \{A, C, G, T\}$ with the following properties:

- Each word in S has 4 symbols from $\{C, G\}$.
- Each pair of distinct words in S differ in at least 4 positions.
- Each pair of words x and y in S (where x and y may be identical) are such that x_R and y_C differ in at least 4 positions, where $x_R = (x_8, \ldots, x_1)$ is the reverse of $x = (x_1, \ldots, x_8)$ and y_R is the Watson-Crick complement of $y = (y_1, \ldots, y_8)$ obtained from y by replacing each A by T, each T by A, each C by G and each G by C.
- The allowed words must belong to a given set of words (corpus).

This problem has its roots in bioinformatics and coding theory. A solution with 15 words follows.

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GACCCTAA CGGTCTAA GCAGTGAA ACTCGGAA AAGGCGAA
CGAAGGAA TACGGCAA GTGAGCAA TGTCCCAA CTAGCCAA
CAGCTCAA GGCTTCAA ACCACCAA CGCGAAAA GCGCAAAA
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Questions:

1. Propose a constraint model given a fixed number of words N.
2. Define constraints breaking symetries in order to remove the different permutations of the same words.
3. Translate this model in Minizinc.