## TD5: CSP (Modeling)

## Exercise 1

Consider the following addition problem:

	SEND
+	MORE
=	MONEY

Each letter represents a distinct digit between 0 and 9. We must determine the value of each letter, keeping in mind that the first letter of each word cannot be zero.

**Question 1** • Model the problem as a constraint network  $N = \langle X, D, C \rangle$ .

**Question 2** • What is the size of the search space for this problem?

## Exercise 2

A Golomb ruler is a ruler with m marks placed at integer positions, such that each pair of marks has a different length. Additionally, the total length of the ruler does not exceed  $m^2$ .



**Question 1** • Model the problem as a constraint network  $N = \langle X, D, C \rangle$  (model  $M_0$ ).

**Question 2** • Give the optimized version of the problem, with the goal of returning the smallest Golomb ruler (model  $M_1$ ).

**Question 3** • Propose a model that uses the global constraint allDifferent (model  $M_2$ ).

**Question 4** • Propose a model that breaks symmetries (model  $M_3$ ).

**Question 5** • Propose redundant constraints to add to the model (model  $M_4$ ).

## Practical Session to be completed in pairs

In the GitHub repository, you will find an example program written in Choco, intended as an introduction to the solver.

The task to be completed in pairs consists of implementing and testing the different models of the Golomb ruler problem that you defined in the tutorial.

**Question 6** • Compare the different versions of the model, from the basic version  $M_0$  to the most refined and optimized version  $M_4$ . Write a short report detailing the improvements made at each iteration and the gains obtained in terms of performance or accuracy.