Aufgabe 23 (Warmup – Single-Source Shortest Path)**.**
Find the shortest path from a given source vertex $s \in V$ to all other vertices $v \in V$ in a weighted directed graph $G = (V, E)$. The weight-function $w : E \to \mathbf{R}$ is lifted for a path $p = \langle v_0, v_1, ..., v_k \rangle$ to $w(p) = \sum_{i=1}^{k} w(v_{i-1}, v_i)$. The shortest path between vertices u and v is the minimum weight of all paths $u \rightsquigarrow v$, or if there is no such path it is ∞.
To avoid negative weight cycles we allow non-negative weights only.

a) Write a CHR program to solve the SSSP problem using the standard relaxation method.
b) Enhance your program, s.t. for all vertices $v \in V$ the path from s to v yielding minimal weight is stored.

Test and comment your program.

Aufgabe 24 (Major assignment – Country Puzzle[1])**.**
Consider a quadratic map consisting of $n \times n$ squares. Find positive integers for the remaining empty squares of the map s.t. any maximal contiguous set of squares containing the same integer (that makes a country) has the size equal to this integer (two squares are contiguous if they share a side). If this is not possible output `no`. An example puzzle and its unique solution is given below.

Use CHR **and** the `clpfd` library.

2	1		4	3
			2	
	5		3	
3				2

2	4	4	3	3
2	1	4	4	3
3	5	5	2	2
3	5	3	3	3
3	5	5	2	2

The unique solution to the given 5×5 country puzzle is given on the right.

a) Model the problem.
b) State what "properties" are to be handled by
   – CHR-constraints,
   – solved by the `clpfd` library, or require
   – auxiliary Prolog-predicates.
c) Implement the auxiliary predicates.
d) Implement the constraints.
e) Comment your source code.
f) Test your implementation with a test suite containing
   – 1×1 and 2×2 maps (one `yes`, one `no` each),
   – the given example above, and
   – the 6×6 example given by
```
[[1,_,_,_,_,_],[_,_,1,_,_,4],[3,_,_,_,_,3],
 [2,_,_,_,2,4],[_,_,3,_,_,_],[2,_,_,_,3,_]].
```

Hint: This major assignment is probably not solvable in one evening's time! You are encouraged to send proposals per mail to the participants and Marc (no matter there's Christmas vacation).

[1]Example taken from P. Szeredi, Teaching Constraints through Logic Puzzles, LNAI 3010.