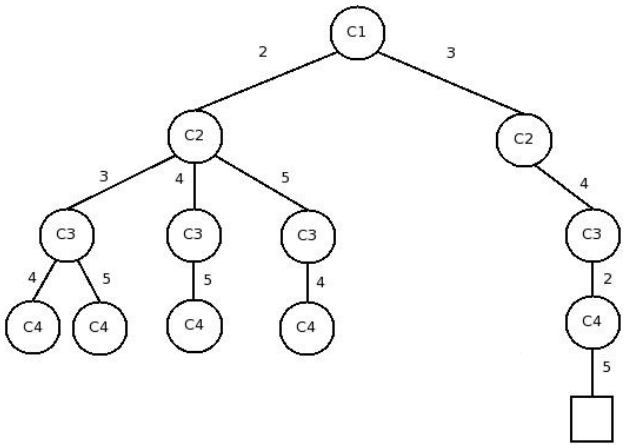
Solutions to Exercises Week 8
Intelligent Systems Programming (ISP)

Exercise 1

a) Backtracking:

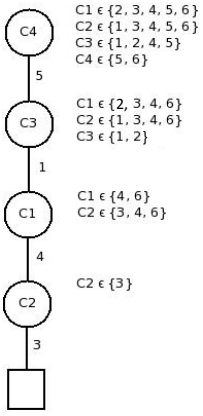


Each **leaf** on the tree with a circular shape represents a failed node. The variable inside the circle is the variable that doesn't have a possible value in its domain to fulfill the constraints. The square represents a solution.

The solution found is: $C_1 = 3$, $C_2 = 4$, $C_3 = 2$, $C_4 = 5$.

All failed leaves are failed for the same reason, it is not possible to assign a value to C_4 that satisfies the constraint $C_4 - C_3 > 2$.

b) Now the FC + MRV tree:



Here the combination of forward checking and the MRV heuristic finds a solution without any failed leaves. However, another solution, $C_1 = 4$, $C_2 = 3$, $C_3 = 1$, $C_4 = 5$ was found by the MRV.

Exercise 2

CSP Model:

Variables: {*B*, *C*, *D*, *F*, *G*, *M*, *P*}

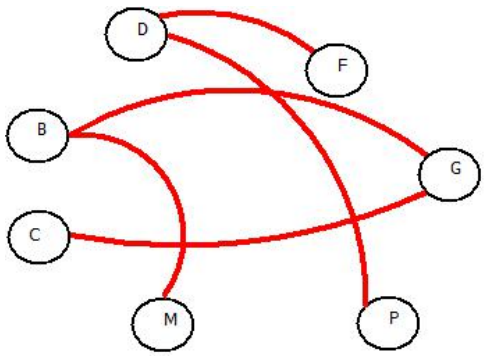
Domains: {[*1…7*], [*1…7*], [*1…7*], [*1…7*], [*1…7*], [*1…7*], [*1…7*]}

Constraints: {*B≠ C*, *B≠D*, *B≠F*, *B≠G*, *B≠M*, *B≠P*, *C ≠D*, *C ≠F*, *C ≠G*, *C≠M* ,*C ≠P*, *D ≠F*, *D ≠G*, *D≠M* ,*D ≠P*, *F ≠G*, *F≠M*, *F ≠P*, *M≠ G*, *M≠ P* ,*G≠ P*}

a) *adj*(*X*,*Y*) : *X=Y+1* || *X=Y-1*.

The main idea of the adj constraint is to represent the fact that for a pair of variables the values assigned to them have to be next to each other, no matter which of those values come first. In the case of the constraint above you can observe that for any possible value assigned to *X*, the value assigned to *Y* has to be either the next or the one before to the X value.

b)



This is the graph representation of the cps model considering just the adjacency constraints.

c) The new CSP is defined as:

Variables: {*B*, *C*, *D*, *F*, *G*, *M*, *P*}

Domains: {[*1…7*], [*1…7*], [*1…7*], [*1…7*], [*1…7*], [*1…7*], [*1…7*]}

Constraints: {*B≠ C*, *B≠D*, *B≠F*, *B≠G*, *B≠M*, *B≠P*, *C ≠D*, *C ≠F*, *C ≠G*, *C≠M* ,*C ≠P*, *D ≠F*, *D ≠G*, *D≠M* ,*D ≠P*, *F ≠G*, *F≠M*, *F ≠P*, *M≠ G*, *M≠ P* ,*G≠ P*, *B=1*, *adj*(*B,G*), *adj*(*B,M*), *adj*(*C,G*), *adj*(*F,D*), *adj*(*P,D*)}

The first constraint to be considered is *B=1*, since it is the only unary constraint. After *B* has been assigned to *1*, *G* gets assigned to *2* due to *adj*(*B,G*), and so does M due to *adj*(*B,M*), (neither of the two variables have in their domains the value *0*, therefore the only adjacent position to *B* is 2). The assignments *M=2* and *G=2* break the constraint *M≠ G,* making the CSP inconsistent.

Exercise 3

According to the problem we have:

Colors: red, yellow, blue, green, ivory.

Nationalities: English, Spaniard, Norwegian, Ukrainian, Japanese.

Pets: dog, fox, snails, horse, zebra.

Cigarettes Brands: Kool, Chesterfields, Winston, Lucky Strike, Parliaments.

Drinks: orange juice, tea, coffee, milk, water.

5 houses.

One possible CSP model for this problem is to define as variables all possible features of the houses (color, nationality of the person who lives there, etc) and as domain for each variable the possible houses that feature belongs to. That means the model is going to have 25 variables and the domain of each of those variables is going to be the set of numbers from 1 to 5, e.g. red Є {1, 2, 3, 4, 5}

Variables: {red, yellow, blue, green, ivory, English, Spaniard, Norwegian, Ukrainian, Japanese, dog, fox, snails, horse, zebra, Kool, Chesterfields, Winston, Lucky Strike, Parliaments, orange juice, tea, coffee, milk, water}

Domains: for each variable the domain is {1, 2, 3, 4, 5}

Constraints:

English = red (English man lives in the red house, meaning that variable English and variable red will have the same value)

Spaniard=dog

Norwegian=1 (The Norwegian lives in the first house on the left)

Kool=yellow

adj(Chesterfields, fox)

adj(Norwegian, blue)

Winston=snails

Lucky Strike=orange juice

Ukrainian=tea

Japanese=Parliaments

adj(Kool, horse)

coffee = green

green=ivory+1

milk=3

alldiff (red, yellow, blue, green, ivory)

alldif (English, Spaniard, Norwegian, Ukrainian, Japanese)

alldiff (dog, fox, snails, horse, zebra)

alldiff (Kool, Chesterfields, Winston, Lucky Strike, Parliaments)

alldiff (orange juice, tea, coffee, milk, water)