Exercises Lecture 9
Intelligent Systems Programming (ISP)

Exercise 1

Johnny Seafood works at the aquarium in his town. He is attending some courses at the local university and now he has a problem at work where he might be able to apply what he has learned in school. The aquarium where Johnny works has recently got 5 new fish species that need to be allocated in the three available tanks. There are some constraints concerning what species can be together in a tank and also some specific requirements.

- Sharks and dolphins can't be together in the same tank.
- Sharks and remoras must be in the same tank.
- Dolphins can't be in tank 3. It is not possible for them to perform their show in this tank.
- There are too many dolphins so they cannot share the tank with the whale.
- The tank closest to the food deposit is tank 2. Johnny wants to allocate the whale there so he doesn't have to carry its food too far.
- Remoras are so small that the whale could eat them. Thus, they can't be in the same tank as the whale.
- Lobsters can be anywhere.

a) Define the problem as a CSP. That is, define the variables, domains, and constraints of the problem. All your constraints should be binary.
b) Draw the constraint graph of the CSP.
c) Use the Forward Checking algorithm to solve the problem, make the CSP node consistent before starting the algorithm. Draw the search tree and the domain of the variables at each node. Assume the fixed variable order: sharks, lobsters, remoras, dolphins, and whale.
d) Use the MAC algorithm to solve the problem. Draw the search tree and the domain of the variables at each node. Assume the same order for selecting the variables as in c).

Exercise 2

The map coloring problem consists on coloring the different regions of a map in such a way that no two adjacent regions are colored the same. A map is **c** colorable iff it is possible to color it by using at most ***c*** colors.

a) Define a CSP for the map coloring problem over Australia's map (Figure 1) where ***c*** = *3*. Add the extra constraint that Queensland has to be colored different to Victoria. Consider as possible colors *red*, *green*, and *blue*.

b) Use the MAC algorithm to find a solution for the CSP. Use the order Western Australia, Queensland, South Australia, Northern Territory, New South Wales, Victoria, Tasmania.

c) Consider each color to have a weight assigned to it such that *red* < *green* <*blue*. Add to your CSP the symmetry-breaking constraint: *Western Australia* > *Northern Territory* > *South Australia*, i.e., the color assigned to Western Australia must have a higher weight than that of Northern Territory and so on. Solve this new CSP using the MAC algorithm and the variable order selection defined in b). Are there any reductions in the search tree?

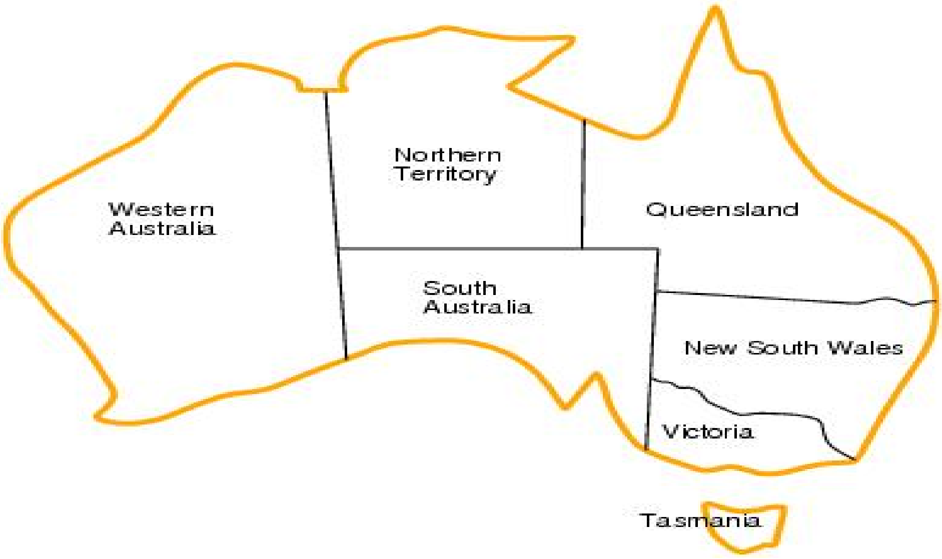


Figure 1

Exercise 3 (adapted from Mozart-OZ online tutorial)

A kid goes into a grocery store and buys four items. The cashier charges \$7.11, the kid pays and is about to leave when the cashier calls the kid back, and says ``Hold on, I multiplied the four items instead of adding them; I'll try again; Hah, with adding them the price still comes to \$7.11''. What were the prices of the four items?

a) Define the problem as a CSP. That is, define the variables, domains, and constraints of the problem. You will need to use constraints involving more than two variables. **DO NOT SOLVE THE PROBLEM**, this is a modeling exercise.

b) Are there any symmetries in the CSP you defined for this problem? If so, suggest symmetry-breaking constraints to break them.

Mandatory assignment

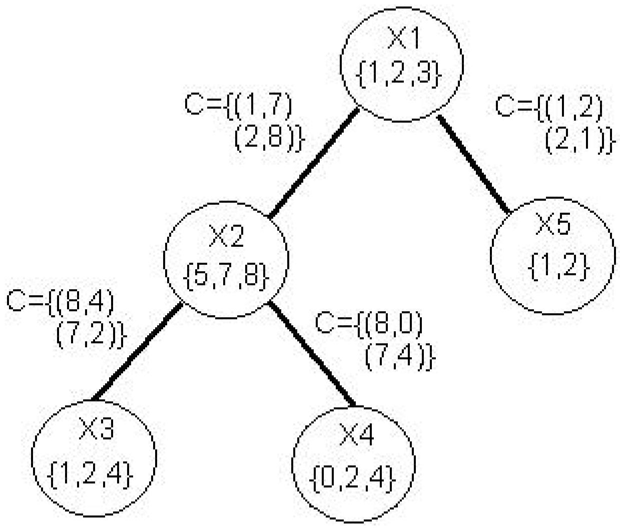
In this assignment we consider binary CSPs where the constraint graph forms a tree. Recall that the nodes and edges of the constraint graph represent variables and constraints, respectively. As an example consider the binary CSP $W = (X,D,C)$ where:

$X=\{X_1, X_2, X_3, X_4, X_5\}$

$D=\{\{1,2,3\},\{5,7,8\},\{1,2,4\},\{0,2,4\},\{1,2\}\}$

$C=\{\ Cx_1x_2=\{(1,7),(2,8)\},$
$\quad Cx_1x_5=\{(1,2),(2,1)\},$
$\quad Cx_2x_3=\{(8,4),(7,2)\},$
$\quad Cx_2x_4=\{(8,0),(7,4)\}\}$

The constraint graph of *W* is:



1) Reduce the domains of the variables of *W* such that *W* becomes arc consistent.
2) Write a solution to *W*.
3) Describe in words a polynomial time algorithm that can find a solution to an arbitrary binary CSP where the constraint graph forms a tree.