American University of Sharjah
School of Engineering
Computer Science & Engineering Dpt.
P. O. Box 26666
Sharjah, UAE

Instructor: Dr. Michel Pasquier
Office: ESB-2057
Phone: 971-6-515-2883
E-mail: mpasquier@aus.edu
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CMP 333 ARTIFICAL INTELLIGENCE

PROJECT #2

Due date/time: Saturday 17 April 2022, 11 pm

Instructions: Submit to *iLearn,* before or on the due date, a single *Zip/Rar* archive that contains all your *code* files and output *results,* as described hereafter. Make sure to include the *name and ID* of all team members inside all your files and in the name of the archive itself, as per the following format: "CMP333-PR2-MPasquier75321-IZualkernan70594.zip". Follow any further instructions as may be posted on *iLearn.* Late submissions will be penalized as per the course policy.

Note that you are to complete this assignment *as a team of three students* exactly. Furthermore, each team must *work independently* and hand in their own original answers. You are *not* allowed to discuss or *share* any solution or to *copy* from others or from any sourced material. Plagiarism and cheating will be severely penalized, starting with a zero grade for the assignment. Recall you are bound by the AUS Academic Integrity Code which you signed when joining AUS.

Assignment: In this second AI course project, you are to program and solve several *Constraint Satisfaction Problems,* using the CLP(FD) Prolog module. Some of the selected problems were formulated earlier in class or in previous assignments, and some are new problems.

You should first get familiar with SWI-prolog or its online SWISH version, learn how to load files, edit and run code / answer queries. Next, you should examine the given examples and later browse the CLP(FD) online documentation to learn the syntax, how to define *variables,* model *constraints,* and compute the *solution(s).*

A complete CLP(FD) *example* is included, that shows exactly what your answers should look like. That is, for each problem hereafter, you must provide your CSP "program" i.e., a *model* that defines problem *variables, domain,* and *constraints.* Make sure to name all variables appropriately and to include comments as deemed necessary. Finally, you must include your *queries* and the *solution/s* obtained by "running" that program, giving either one or all solutions as specified hereafter.

(Note that we could do the same, albeit writing more code, in C++ using *Gecode,* in Java with *JaCoP,* in Python using *Numberjack* or the *python-constraint* module, or in your language of choice using Google *OR tools,* etc. So many tools…)

Example:

Cryptarithmetic puzzle

We want to solve the classic cryptarithmetic puzzle shown on the right, where different letters denote distinct integers between 0 and 9.

```
    S E N D
+   M O R E
-----------
= M O N E Y
```

Give your *CSP model* of this problem using CLP(FD) and show *all the solutions.*

→ program:

```
puzzle(Digits) :-
    Digits = [S,E,N,D,M,O,R,Y] ,                    % variables
    Digits ins 0..9,  S #\= 0, M #\= 0 ,            % domains
    all_different(Digits) ,                         % constraints:
                    S*1000 + E*100 + N*10 + D       % all diff + sum
    +               M*1000 + O*100 + R*10 + E
    #= M*10000 + O*1000 + N*100 + E*10 + Y ,
    label(Digits) .                                 % -> solution
```

solution/s:

```
?- puzzle(Solution) .
Solution = [9, 5, 6, 7, 1, 0, 8, 2] ;               % other solution?
false.                                              % no
```

Problems:

Sculptures puzzle

You are helping to decorate the office building. Your job is to place three sculptures in a room, each on a different table: an ice carving of a swan, a gold lion, and a marble pyramid. There are three tables arranged in a row; the first table is closest to the door while the third table is farthest into the room. Because it is a hot day, the ice carving cannot be nearest the door. In addition, your boss said it is much better if animal sculptures are not placed on adjacent tables.

Give your *CSP model* of this problem using CLP(FD) and show *all the solutions.*

Map coloring

Given the map on the right (center of Europe), you must assign a color to each country so that two neighboring countries have different colors. You should use as few colors as possible.

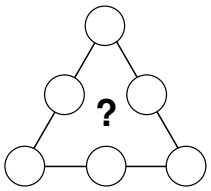
Give your *CSP model* of this problem using CLP(FD) and show *one possible solution.*

Cryptarithmetic puzzle with carries

One issue with the given model of the cryptarithmetic puzzle given earlier is that it has one big constraint equation involving all the variables. CSP is much more efficient if we have many smaller equations instead. Amend the given code to model *carries* explicitly. Modify it to show *all the solutions* that involve at least one (non-zero) carry.

Magic triangle

You need to place each of the numbers from 1 to 6 in one of the circles along the sides of the triangle so that the sum of the three numbers on any side is the same magic sum S.



Give your *CSP model* of this problem using CLP(FD) and show *all possible solutions* (if any) for S=9, S=10, S=11, and S=12.

Interview scheduling

A manager needs to schedule five individual job interviews, each 1-hour long, from 1 PM to 6 PM. He was told that Ali is busy before 2 and after 4, Ben does not like odd hours, Cam has similar appointments at 2 and 4, Don is free before 3 and Eva only after 3.

Give your *CSP model* of this problem using CLP(FD) and show *all solutions.* What if Don would prefer to follow right after Cam? Add the constraint and show the only solution.

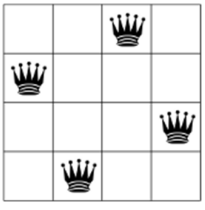
Zebra story

Five men live in five different colored houses in a street. They all have different nationalities, professions, drink preferences, and pets. You must find out who has a zebra and who drinks water, given the following information: The Englishman lives in the red house. The Spaniard has a dog. The Japanese is a painter. The Italian drinks tea. The Norwegian lives in the first house on the left. The owner of the green house drinks coffee. The green house is on the right of the white house. The sculptor breeds snails. The diplomat lives in the yellow house. They drink milk in the middle house. The Norwegian lives next door to the blue house. The violinist drinks fruit juice. The fox is in the house next to the doctor's. The horse is in the house next to the diplomat's.

Give your *CSP model* of this problem using CLP(FD) and show *all the solutions*.

4-queens problem

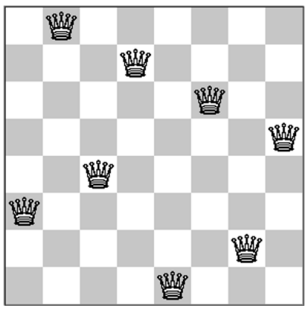
You are tasked to solve the classic 4-queens problem (the simplest), a solution of which is shown on the right. Recall the 4 queens must be placed so that there is only one on each row, column, and diagonal.



Give your *CSP model* of this problem using CLP(FD) and show *all the solutions.*

N-queens problem

Expand your *CSP model* with 4 queens to handle the general problem with *N queens.* A solution with *N*=8 queens is shown on the right.



Give your *CSP model* of this problem using CLP(FD) and show *one solution* for *N*=20. What is the largest value of *N* you can solve under 10 minutes on your computer?