University of M'sila
Faculty of Maths and Computer Science
Computer Science Department

May 11, 2025
M1 IDO
Duration : 1h30

Final Exam
Constraint Logic Programming

Exercice 1 (6 pts):

A **Latin square** is an $n \times n$ array filled with n different symbols, each occurring exactly once in each row and exactly once in each column. An example of a 4×4 Latin square is :

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

Give the CSP of an $n \times n$ Latin square.

Exercice 2 (6 pts):

Consider the following crypto-arithmetic problem.

$$\begin{array}{cccccc} & C & R & O & S & S \\ + & R & O & A & D & S \\ \hline D & A & N & G & E & R \end{array}$$

Write a GNU Prolog program to solve this problem.

Exercice 3 (8 pts):

Consider the following CSP:

X = {X1, X2, X3}
D(X1) = D(X2) = D(X3) = {0,1, 2, 3,4,5}
C ={X1 + X2 = 3, X2 + X3 <= 3, X1 <= X3 }

Apply the AC3 Algorithm to reduce the domains of the variables X1, X2, and X3 based on the constraints.

Dr. T. Mehenni

University of M'sila
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January 19th, 2025
M2 AI
Duration : 1h30

Final Examen
Constraint Logic Programming
Solution

<u>Exercice 1 (6 pts):</u>

Variables : x_{ij} — digit in cell (i , j). $1 \le i \le n$ and $1 \le j \le n$. There are n^2 variables. **(1.5 pts)**
Domains : $Dx_{ij} = \{1, \dots ,n\}$, $\forall (i , j)$. $1 \le i \le n$ and $1 \le j \le n$. **(1.5 pts)**
Constraints :
The digits in each line are different : all-different(x_{i1} , x_{i2} , … , x_{in}), $1 \le i \le n$. **(1.5 pts)**
The digits in each column are different : all-different(x_{1j} , x_{2j} , … , x_{nj}), $1 \le j \le n$. **(1.5 pts)**

Alternative solution
Particular CSP for the 4 x 4 matrix
Variables : x_{ij} — digit in cell (i , j). $1 \le i \le 4$ and $1 \le j \le 4$. There are 16 variables. **(1.5 pts)**
Domains : $Dx_{ij} = \{1, \dots ,4\}$, $\forall (i , j)$. $1 \le i \le 4$ and $1 \le j \le 4$. **(1.5 pts)**
Constraints :
The digits in each line are different : all-different(x_{i1} , x_{i2} , … , x_{i4}), $1 \le i \le 4$, **(1.5 pts)**
The digits in each column are different : all-different(x_{1j} , x_{2j} , … , x_{4j}), $1 \le j \le 4$, **(1.5 pts)**

<u>Exercice 2 (6 pts):</u>

$$
\begin{array}{cccccc}
 & C & R & O & S & S \\
+ & R & O & A & D & S \\
\hline
D & A & N & G & E & R
\end{array}
$$

solution([C,R,O,S,A,D,N,G,E]):-fd_domain([C,R,O,S,A,D,N,G,E],0,9), **(1pt)**
C*10000+R*1000+O*100+S*10+S+R*10000+O*1000+A*100+D*10+S#=
D*100000+A*10000+N*1000+G*100+E*10+R, **(2pts)**
C#>0, R#>0,D#>0, **(1pt)**
fd_all_different([C,R,O,S,A,D,N,G,E]), **(1pt)**
fd_labeling([C,R,O,S,A,D,N,G,E]). **(1pt)**

Alternative solution
problem([C,R,O,S,A,D,N,G,E,R1,R2,R3,R4]):-fd_domain([C,R,O,S,A,D,N,G,E],0,9), **(1pt)**
fd_domain([R1,R2,R3,R4],0,1), **(0.5pt)**
S+S#=R+10*R1, R1+S+D#=E+10*R2, R2+O+A#=G+10*R3, R3+R+O#=N+10*R4,
R4+C+R#=A+10*D, **(2pts)**
D#>0, C#>0,R#>0, **(0.5pt)**
fd_all_different([C,R,O,S,A,D,N,G,E]), **(1pt)**
fd_labeling([C,R,O,S,A,D,N,G,E]). **(1pt)**

Solution of the problem: A = 5, C = 9, D = 1, E = 4, G = 7, N = 8, O = 2, R = 6, S = 3

$$
\begin{array}{cccccc}
 & 9 & 6 & 2 & 3 & 3 \\
+ & 6 & 2 & 5 & 1 & 3 \\
\hline
1 & 5 & 8 & 7 & 4 & 6
\end{array}
$$

<u>Exercice 3 (8 pts): </u> (1pt/step (i.e. line of the following table) where are mentioned:

State of the variables, handled constraint, result of REVISE function and state of the Queue.

AC3	Variables			C1:X1 + X2 = 3, c2: X2 + X3 <= 3, c3: X1 <= X3		
Step	X1	X2	X3	Constraint	REVISE	Queue
01	D(X1)= {0,1,2,3,**4**,**5**}	D(X2)= {0,1,2,3,4,5}	D(X3)= {0,1,2,3,4,5}	c1	True	Q={ ~~(X1, X2)~~, (X2, X1), (X2, X3), (X3, X2), (X1, X3), (X3, X1)}
02	D(X1)= {0,1,2,3}	D(X2)= {0,1,2,3,**4**,**5**}	D(X3)= {0,1,2,3,4,5}	c1	True	Q={ ~~(X2, X1)~~, (X2, X3), (X3, X2), (X1, X3), (X3, X1)}
03	D(X1)= {0,1,2,3}	D(X2)= {0,1,2,3}	D(X3)= {0,1,2,3,4,5}	c2	False	Q={ ~~(X2, X3)~~, (X3, X2), (X1, X3), (X3, X1)}
04	D(X1)= {0,1,2,3}	D(X2)= {0,1,2,3}	D(X3)= {0,1,2,3,**4**,**5**}	c2	True	Q={ ~~(X3, X2)~~, (X1, X3), (X3, X1), **(X2, X3)**}
05	D(X1)= {0,1,2,3}	D(X2)= {0,1,2,3}	D(X3)= {0,1,2,3}	c3	False	Q={ ~~(X1, X3)~~, (X3, X1), **(X2, X3)**}
06	D(X1)= {0,1,2,3}	D(X2)= {0,1,2,3}	D(X3)= {0,1,2,3}	c3	False	Q={ ~~(X3, X1)~~, **(X2, X3)**}
07	D(X1)= {0,1,2,3}	D(X2)= {0,1,2,3}	D(X3)= {0,1,2,3}	c3	False	Q={ ~~**(X2, X3)**~~}
08	D(X1)= {0,1,2,3}	D(X2)= {0,1,2,3}	D(X3)= {0,1,2,3}			Q={ }

Dr. T. Mehenni