Rapport Travaux Pratiques : Programmation par Contraintes - TP 4 : **Contraintes Logiques**

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Dans ce T.P., nous allons utiliser la programmation par contraintes pour faire un planning pour organiser une régate, planning qui respecte certaines contraintes.

Question 4.1 Nous définissons ici un prédicat *getData(?TailleEquipes, ?NbEquipes, ?CapaBateaux, ?NbBateaux, ?* qui unifie les variables passées en paramètres avec les données du problème.

Listing 1 – "getData"

```
1  getData(TailleEquipes,NbEquipes,CapaBateaux,NbBateaux,NbConf):-
2          TailleEquipes = [](5,5,2,1),
3          NbEquipes = 4,
4          CapaBateaux = [](7,6,5),
5          NbBateaux = 3,
6          NbConf = 3.
7
8  /* Tests
9  [eclipse 7]: getData(TailleEq,NbEq,CapaBat,NbBat,NbConf).
10
11 TailleEq = [](5, 5, 2, 1)
12 NbEq = 4
13 CapaBat = [](7, 6, 5)
14 NbBat = 3
15 NbConf = 3
16 Yes (0.00s cpu)
17 */
```

Question 4.2 Nous définissons ici un prédicat *defineVars(?T,+NbEquipes,+NbConf,+NbBateaux)* qui unifie T au tableau des variables et contraint le domaine des variables.

Listing 2 – "defineVars"

```
1  defineVars(T,NbEquipes,NbConf,NbBateaux):-
```

```
2           dim(T,[NbEquipes,NbConf]),
3           (for(Ind1,1,NbEquipes),param(T,NbBateaux,NbConf)
4           do
5                   (for(Ind2,1,NbConf),param(T,Ind1,NbBateaux)
6                   do
7                           T[Ind1,Ind2] #:: 1..NbBateaux
8                   )
9           ).
10
11  /* Tests
12  [eclipse 8]: getData(TailleEq,NbEq,CapaBat,NbBat,NbConf),defineVars(T,NbEq,
        NbConf,NbBat).
13
14  TailleEq = [](5, 5, 2, 1)
15  NbEq = 4
16  CapaBat = [](7, 6, 5)
17  NbBat = 3
18  NbConf = 3
19  T = []([](_419{1 .. 3}, _488{1 .. 3}, _557{1 .. 3}), [](_628{1 .. 3}, _697{1
        .. 3}, _766{1 .. 3}), [](_837{1 .. 3}, _906{1 .. 3}, _975{1 .. 3}), [](
        _1046{1 .. 3}, _1115{1 .. 3}, _1184{1 .. 3}))
20  Yes (0.00s cpu)
21  */
```

Question 4.3 Nous définissons ici un prédicat *getVarList(+T, ?L)* qui construit la liste L des variables contenues dans le tableau T. La liste des variables contient les variables de la première colonne suivies de celles de la seconde colonne, etc.

Listing 3 – "getVarList"

```
1   getVarList(T,L):-
2           dim(T,[NbEquipes,NbConf]),
3           (for(Indice1,1,NbConf),fromto([],In,Out,L),param(T,NbEquipes)
4           do
5                   (for(Indice2,1,NbEquipes),fromto([],In2,Out2,L2),param(T,
                        Indice1)
6                   do
7                           Var is T[Indice2,Indice1],
8                           append(In2,[Var],Out2)
9                   ),
10                  append(In,L2,Out)
11          ).
12
13  /* Tests
14  [eclipse 9]:  getData(TailleEq,NbEq,CapaBat,NbBat,NbConf),defineVars(T,NbEq,
        NbConf,NbBat),getVarList(T,L).
15
16  TailleEq = [](5, 5, 2, 1)
17  NbEq = 4
18  CapaBat = [](7, 6, 5)
19  NbBat = 3
20  NbConf = 3
```

```
21 T = [](_484{1 .. 3}, _553{1 .. 3}, _622{1 .. 3}), [](_693{1 .. 3}, _762{1
       .. 3}, _831{1 .. 3}), [](_902{1 .. 3}, _971{1 .. 3}, _1040{1 .. 3}), [](
       _1111{1 .. 3}, _1180{1 .. 3}, _1249{1 .. 3}))
22 L = [_484{1 .. 3}, _693{1 .. 3}, _902{1 .. 3}, _1111{1 .. 3}, _553{1 .. 3},
       _762{1 .. 3}, _971{1 .. 3}, _1180{1 .. 3}, _622{1 .. 3}, _831{1 .. 3},
       _1040{1 .. 3}, _1249{1 .. 3}]
23 Yes (0.00s cpu)
24 */
```

Question 4.4 Nous définissons ici un prédicat *solve(?T)* qui résoud le problème des régates où seules les contraintes de domaines sont posées.

Listing 4 – "solve1"

```
1  solve1(T) :-
2          getData(_TailleEquipes,NbEquipes,_CapaBateaux,NbBateaux,NbConf),
3          defineVars(T,NbEquipes,NbConf,NbBateaux),
4          getVarList(T,L),
5          labeling(L).
6
7  /* Tests
8  [eclipse 10]: solve1(T).
9
10 T = []([](1, 1, 1), [](1, 1, 1), [](1, 1, 1), [](1, 1, 1))
11 Yes (0.00s cpu, solution 1, maybe more) ? ;
12
13 T = []([](1, 1, 1), [](1, 1, 1), [](1, 1, 1), [](1, 1, 2))
14 Yes (0.00s cpu, solution 2, maybe more) ? ;
15
16 T = []([](1, 1, 1), [](1, 1, 1), [](1, 1, 1), [](1, 1, 3))
17 Yes (0.00s cpu, solution 3, maybe more) ?
18 */
```

Question 4.5 Nous définissons ici un prédicat *pasMemeBateaux(+T,+NbEquipes,+NbConf)* qui impose qu'une même équipe ne retourne pas deux fois sur le même bateau. On modifie ensuite le prédicat *solve* pour qu'il prenne en compte cette nouvelle contrainte.

Listing 5 – "pasMemeBateaux"

```
1  pasMemeBateaux(T,NbEquipes,NbConf):-
2          dim(T,[NbEquipes,NbConf]),
3          ( for(Indice1,1,NbEquipes),param(T,NbConf)
4          do
5                  ( for(Indice2,1,NbConf), fromto([],In,Out,L), param(T,Indice1
                       )
6                  do
7                          Bat is T[Indice1,Indice2],
8                          append(In,[Bat],Out)
9                  ),
10                 alldifferent(L)
11         ).
12
```

```
13 solve2(T) :-
14         getData(_TailleEquipes,NbEquipes,_CapaBateaux,NbBateaux,NbConf),
15         defineVars(T,NbEquipes,NbConf,NbBateaux),
16         pasMemeBateaux(T,NbEquipes,NbConf),
17         getVarList(T,L),
18         labeling(L).
19
20 /* Tests
21 [eclipse 11]: solve2(T).
22
23 T = []([](1, 2, 3), [](1, 2, 3), [](1, 2, 3), [](1, 2, 3))
24 Yes (0.00s cpu, solution 1, maybe more) ? ;
25
26 T = []([](1, 2, 3), [](1, 2, 3), [](1, 2, 3), [](1, 3, 2))
27 Yes (0.00s cpu, solution 2, maybe more) ? ;
28
29 T = []([](1, 2, 3), [](1, 2, 3), [](1, 3, 2), [](1, 2, 3))
30 Yes (0.00s cpu, solution 3, maybe more) ?
31 */
```

Question 4.6 Nous définissons ici un prédicat *pasMemePartenaires(+T,+NbEquipes,+NbConf)* qui impose qu'une même équipe ne se retrouve pas deux fois avec la même équipe. On modifie une nouvelle fois le prédicat *solve* pour qu'il prenne en compte cette nouvelle contrainte.

Listing 6 – "pasMemePartenaires"

```
1  pasMemePartenaires(T,NbEquipes,NbConf):-
2          dim(T,[NbEquipes,NbConf]),
3          ( for(Equipe1,1,NbEquipes),param(T,NbConf,NbEquipes)
4          do
5                  Indice is Equipe1+1,
6                  ( for(Equipe2,Indice,NbEquipes), param(T,Equipe1,NbConf)
7                  do
8
9                          ( for(Conf,1,NbConf),param(T,Equipe1,Equipe2),fromto
                               (0,In,Out,Tot)
10                         do
11                                 Bateau1 is T[Equipe1,Conf],
12                                 Bateau2 is T[Equipe2,Conf],
13                                 #=(Bateau1,Bateau2,Ans),
14                                 Out #= In + Ans
15                         ),
16                         Tot #=< 1
17                 )
18         ).
19
20 solve3(T) :-
21         getData(_TailleEquipes,NbEquipes,_CapaBateaux,NbBateaux,NbConf),
22         defineVars(T,NbEquipes,NbConf,NbBateaux),
23         pasMemeBateaux(T,NbEquipes,NbConf),
24         pasMemePartenaires(T,NbEquipes,NbConf),
25         getVarList(T,L),
26         labeling(L).
```

```
27
28 /* Tests
29 [eclipse 12]: solve3(T).
30
31 T = [](](1, 2, 3), [](1, 3, 2), [](2, 1, 3), [](2, 3, 1))
32 Yes (0.00s cpu, solution 1, maybe more) ? ;
33
34 T = [](](1, 2, 3), [](1, 3, 2), [](2, 3, 1), [](2, 1, 3))
35 Yes (0.00s cpu, solution 2, maybe more) ? ;
36
37 T = [](](1, 3, 2), [](1, 2, 3), [](2, 1, 3), [](2, 3, 1))
38 Yes (0.00s cpu, solution 3, maybe more) ?
39 */
```

Question 4.7 Nous définissons ici un prédicat *capaBateaux(+T,+TailleEquipes,+NbEquipes,+CapaBateaux,+NbB* qui vérifie que les capacités des bateaux sont respectées lors de chaque confrontation. On modifie une nouvelle fois le prédicat *solve* pour qu'il prenne en compte cette nouvelle contrainte.

Listing 7 – "capaBateaux"

```
1  capaBateaux(T, TailleEquipes, NbEquipes, CapaBateaux, NbBateaux, NbConf):-
2          dim(T,[NbEquipes,NbConf]),
3          ( for(Bateau,1,NbBateaux), param(T,NbEquipes,NbConf,CapaBateaux,
               TailleEquipes)
4          do
5                  ( for(Conf,1,NbConf), param(T,NbEquipes,Bateau,CapaBateaux,
                       TailleEquipes)
6                  do
7                          ( for(Equipe,1,NbEquipes),param(T,Bateau,Conf,
                               TailleEquipes),fromto(0,In,Out,Total)
8                          do
9                                  BateauI is T[Equipe,Conf],
10                                 #=(Bateau,BateauI,Cond),
11                                 Inc #= TailleEquipes[Equipe] * Cond,
12                                 Out #= In + Inc
13                         ),
14                         Capacite is CapaBateaux[Bateau],
15                         Total #=< Capacite
16                 )
17         ).
18
19 solve4(T) :-
20         getData(TailleEquipes,NbEquipes,CapaBateaux,NbBateaux,NbConf),
21         defineVars(T,NbEquipes,NbConf,NbBateaux),
22         pasMemeBateaux(T,NbEquipes,NbConf),
23         pasMemePartenaires(T,NbEquipes,NbConf),
24         capaBateaux(T,TailleEquipes,NbEquipes,CapaBateaux,NbBateaux,NbConf),
25         getVarList(T,L),
26         labeling(L).
27
28 /* Tests
29 [eclipse 13]: solve4(T).
30
```

```
31 T = [](](1, 2, 3), [](2, 3, 1), [](3, 1, 2), [](3, 2, 1))
32 Yes (0.01s cpu, solution 1, maybe more) ? ;
33
34 T = [](](1, 3, 2), [](2, 1, 3), [](3, 2, 1), [](3, 1, 2))
35 Yes (0.01s cpu, solution 2, maybe more) ? ;
36
37 T = [](](1, 2, 3), [](3, 1, 2), [](2, 3, 1), [](1, 3, 2))
38 Yes (0.01s cpu, solution 3, maybe more) ?
39 */
```

Question 4.8 On passe ici à un problème de taille réelle. On dispose dorénavant de 13 voiliers et de 29 équipes qui doivent effectuer la régate comportant 7 confrontations.
Le temps d'exécution étant relativement long, il nous a été proposé d'améliorer le labeling. Pour cela, nous avons mélanger la liste des varaibles obtenu après *getVarList*, en alternant simplement les grosses et les petites équipes. Le gain sur le temps d'exécution est relativement important, puisqu'il est quasiment de 10 !

Listing 8 – "Problème de taille réelle et labeling"

```
1  getData2(TailleEquipes,NbEquipes,CapaBateaux,NbBateaux,NbConf):-
2          TailleEquipes =
               [](7,6,5,5,5,4,4,4,4,4,4,4,4,3,3,2,2,2,2,2,2,2,2,2,2,2,2,2,2),
3          NbEquipes = 29,
4          CapaBateaux = [](10,10,9,8,8,8,8,8,8,7,6,4,4),
5          NbBateaux = 13,
6          NbConf = 7.
7
8  solve5(T):-
9          getData2(TailleEq,NbEq,CapaBat,NbBat,NbConf),
10         defineVars(T,NbEq,NbConf,NbBat),
11         pasMemeBateaux(T,NbEq,NbConf),
12         pasMemePartenaires(T,NbEq,NbConf),
13         capaBateaux(T,TailleEq,NbEq,CapaBat,NbBat,NbConf),
14         getVarList(T,L),
15         labeling(L).
16
17 /* Tests
18 [eclipse 14]: solve5(T).
19
20 T = [](](1, 2, 3, 4, 5, 6, 7), [](2, 1, 4, 3, 6, 5, 8), [](3, 4, 1, 2, 7, 8,
       5), [](4, 3, 1, 5, 2, 7, 6), [](5, 6, 2, 1, 3, 4, 9), [](2, 3, 5, 1, 4,
     9, 10), [](3, 1, 2, 6, 4, 10, 11), [](6, 5, 7, 2, 1, 3, 4), [](6, 7, 5,
     8, 2, 1, 3), [](7, 5, 6, 8, 3, 2, 1), [](7, 8, 9, 6, 1, 11, 2), [](8, 7,
     6, 9, 10, 12, 2), [](8, 9, 7, 10, 11, 1, 12), [](1, 4, 8, 3, 9, 7, 10),
     [](4, 2, 8, 10, 7, 3, 9), [](5, 8, 3, 11, 6, 9, 1), [](9, 6, 4, 5, 8, 11,
      13), [](9, 8, 10, 12, 13, 2, 11), [](9, 10, 8, 11, 12, 13, 2), [](9, 11,
      12, 13, 1, 10, 3), [](10, 9, 11, 7, 12, 3, 13), [](10, 11, 9, 12, 8, 1,
     4), [](10, 12, 13, 11, 9, 2, 3), [](11, 9, 10, 13, 8, 4, 5), [](11, 10,
     12, 9, 13, 5, 1), [](11, 12, 9, 7, 10, 13, 8), [](12, 10, 13, 7, 11, 9,
     4), [](12, 13, 11, 9, 8, 2, 6), [](13, 11, 10, 7, 9, 8, 1))
21 Yes (55.23s cpu, solution 1, maybe more) ?
22 */
```

```
23
24 % Amelioration du labeling pour gagner du temps
25
26 getLast([A],A,[]).
27 getLast([A|R],B,[A|L]):- getLast(R,B,L).
28
29 debutfin([A|R],A,L,B) :- getLast(R,B,L).
30 debutfin([A,B,C],A,[A,C,B],C).
31
32 melangListe([],[]).
33 melangListe([A,B,C],[A,C,B]):-!.
34 melangListe(L,[A,B|L2]) :- debutfin(L,A,L1,B),melangListe(L1,L2).
35
36 getVarList2(T,L):-
37         dim(T,[NbEquipes,NbConf]),
38         ( for(Indice1,1,NbConf),fromto([],In,Out,L),param(T,NbEquipes)
39         do
40                 ( for(Indice2,1,NbEquipes),fromto([],In2,Out2,L2),param(T,
                        Indice1)
41                 do
42                         Var is T[Indice2,Indice1],
43                         append(In2,[Var],Out2)
44                 ),
45                 melangListe(L2,L3),
46                 append(In,L3,Out)
47         ).
48
49 solve6(T):-
50         getData2(TailleEq,NbEq,CapaBat,NbBat,NbConf),
51         defineVars(T,NbEq,NbConf,NbBat),
52         pasMemeBateaux(T,NbEq,NbConf),
53         pasMemePartenaires(T,NbEq,NbConf),
54         capaBateaux(T,TailleEq,NbEq,CapaBat,NbBat,NbConf),
55         getVarList2(T,L),
56         labeling(L).
57
58 /* Tests
59 [eclipse 15]: solve6(T).
60
61 T = []([](1, 2, 3, 4, 5, 6, 7), [](2, 1, 4, 3, 6, 5, 8), [](3, 4, 1, 2, 8, 7,
        9), [](4, 3, 5, 1, 2, 9, 10), [](5, 6, 2, 7, 1, 3, 4), [](6, 5, 7, 2, 1,
        4, 3), [](6, 7, 8, 5, 2, 1, 11), [](7, 5, 6, 8, 9, 1, 2), [](8, 9, 7,
       10, 4, 11, 5), [](8, 10, 9, 6, 11, 3, 2), [](9, 8, 12, 13, 7, 2, 6),
       [](10, 9, 8, 11, 13, 12, 1), [](12, 13, 11, 9, 10, 8, 1), [](11, 10, 13,
       3, 8, 9, 4), [](11, 12, 10, 7, 3, 13, 9), [](13, 11, 10, 9, 6, 1, 5),
       [](13, 8, 11, 12, 4, 10, 3), [](10, 11, 9, 8, 12, 2, 3), [](9, 11, 6, 12,
        10, 5, 13), [](9, 7, 10, 11, 12, 8, 2), [](7, 8, 9, 10, 3, 4, 1), [](7,
       6, 5, 9, 11, 2, 8), [](5, 7, 1, 8, 3, 10, 13), [](4, 1, 6, 5, 3, 2, 12),
       [](3, 2, 4, 1, 7, 11, 12), [](3, 1, 2, 6, 9, 10, 11), [](2, 4, 3, 1, 9,
       8, 6), [](2, 3, 1, 6, 7, 4, 5), [](1, 3, 2, 5, 4, 7, 6))
62 Yes (6.98s cpu, solution 1, maybe more) ? ;
63
```

```
64  T = [][[](1, 2, 3, 4, 5, 6, 7), [](2, 1, 4, 3, 6, 5, 8), [](3, 4, 1, 2, 8, 7,
        9), [](4, 3, 5, 1, 2, 9, 10), [](5, 6, 2, 7, 1, 3, 4), [](6, 5, 7, 2, 1,
        4, 11), [](6, 7, 8, 5, 2, 1, 3), [](7, 5, 6, 8, 9, 1, 2), [](8, 9, 7,
      10, 4, 11, 5), [](8, 10, 9, 6, 11, 3, 2), [](9, 8, 12, 13, 7, 2, 6),
      [](10, 9, 8, 11, 13, 12, 1), [](12, 13, 11, 9, 10, 8, 1), [](11, 10, 13,
      3, 8, 9, 4), [](11, 12, 10, 7, 3, 13, 9), [](13, 11, 10, 9, 6, 1, 5),
      [](13, 8, 11, 12, 4, 10, 3), [](10, 11, 9, 8, 12, 2, 3), [](9, 11, 6, 12,
        10, 5, 13), [](9, 7, 10, 11, 12, 8, 2), [](7, 8, 9, 10, 3, 4, 1), [](7,
      6, 5, 9, 11, 2, 8), [](5, 7, 1, 8, 3, 10, 13), [](4, 1, 6, 5, 3, 2, 12),
      [](3, 2, 4, 1, 7, 11, 12), [](3, 1, 2, 6, 9, 10, 11), [](2, 4, 3, 1, 9,
      8, 6), [](2, 3, 1, 6, 7, 4, 5), [](1, 3, 2, 5, 4, 7, 6))
65  Yes (7.31s cpu, solution 2, maybe more) ?
66  */
```

1 Code Complet, avec l'ensemble des tests

Listing 9 – "TP4"

```
1  :-lib(ic).
2
3  % Q4.1
4  getData(TailleEquipes,NbEquipes,CapaBateaux,NbBateaux,NbConf):-
5          TailleEquipes = [](5,5,2,1),
6          NbEquipes = 4,
7          CapaBateaux = [](7,6,5),
8          NbBateaux = 3,
9          NbConf = 3.
10
11 /* Tests
12 [eclipse 7]: getData(TailleEq,NbEq,CapaBat,NbBat,NbConf).
13
14 TailleEq = [](5, 5, 2, 1)
15 NbEq = 4
16 CapaBat = [](7, 6, 5)
17 NbBat = 3
18 NbConf = 3
19 Yes (0.00s cpu)
20 */
21
22 % Q4.2
23 defineVars(T,NbEquipes,NbConf,NbBateaux):-
24         dim(T,[NbEquipes,NbConf]),
25         (for(Ind1,1,NbEquipes),param(T,NbBateaux,NbConf)
26         do
27                 (for(Ind2,1,NbConf),param(T,Ind1,NbBateaux)
28                 do
29                         T[Ind1,Ind2] #:: 1..NbBateaux
30                 )
31         ).
32
33 /* Tests
34 [eclipse 8]: getData(TailleEq,NbEq,CapaBat,NbBat,NbConf),defineVars(T,NbEq,
       NbConf,NbBat).
35
36 TailleEq = [](5, 5, 2, 1)
37 NbEq = 4
38 CapaBat = [](7, 6, 5)
39 NbBat = 3
40 NbConf = 3
41 T = []([](_419{1 .. 3}, _488{1 .. 3}, _557{1 .. 3}), [](_628{1 .. 3}, _697{1
       .. 3}, _766{1 .. 3}), [](_837{1 .. 3}, _906{1 .. 3}, _975{1 .. 3}), [](
       _1046{1 .. 3}, _1115{1 .. 3}, _1184{1 .. 3}))
42 Yes (0.00s cpu)
43 */
44
45 % Q4.3
46 getVarList(T,L):-
```

```
47          dim(T,[NbEquipes,NbConf]),
48          ( for(Indice1,1,NbConf),fromto([],In,Out,L),param(T,NbEquipes)
49          do
50                  ( for(Indice2,1,NbEquipes),fromto([],In2,Out2,L2),param(T,
                        Indice1)
51                  do
52                          Var is T[Indice2,Indice1],
53                          append(In2,[Var],Out2)
54                  ),
55                  append(In,L2,Out)
56          ).
57
58  /* Tests
59  [eclipse 9]:  getData(TailleEq,NbEq,CapaBat,NbBat,NbConf),defineVars(T,NbEq,
        NbConf,NbBat),getVarList(T,L).
60
61  TailleEq = [](5, 5, 2, 1)
62  NbEq = 4
63  CapaBat = [](7, 6, 5)
64  NbBat = 3
65  NbConf = 3
66  T = []([](_484{1 .. 3}, _553{1 .. 3}, _622{1 .. 3}), [](_693{1 .. 3}, _762{1
        .. 3}, _831{1 .. 3}), [](_902{1 .. 3}, _971{1 .. 3}, _1040{1 .. 3}), [](
        _1111{1 .. 3}, _1180{1 .. 3}, _1249{1 .. 3}))
67  L = [_484{1 .. 3}, _693{1 .. 3}, _902{1 .. 3}, _1111{1 .. 3}, _553{1 .. 3},
        _762{1 .. 3}, _971{1 .. 3}, _1180{1 .. 3}, _622{1 .. 3}, _831{1 .. 3},
        _1040{1 .. 3}, _1249{1 .. 3}]
68  Yes (0.00s cpu)
69  */
70
71  % Q4.4
72
73  solve1(T) :-
74          getData(_TailleEquipes,NbEquipes,_CapaBateaux,NbBateaux,NbConf),
75          defineVars(T,NbEquipes,NbConf,NbBateaux),
76          getVarList(T,L),
77          labeling(L).
78
79  /* Tests
80  [eclipse 10]: solve1(T).
81
82  T = []([](1, 1, 1), [](1, 1, 1), [](1, 1, 1), [](1, 1, 1))
83  Yes (0.00s cpu, solution 1, maybe more) ? ;
84
85  T = []([](1, 1, 1), [](1, 1, 1), [](1, 1, 1), [](1, 1, 2))
86  Yes (0.00s cpu, solution 2, maybe more) ? ;
87
88  T = []([](1, 1, 1), [](1, 1, 1), [](1, 1, 1), [](1, 1, 3))
89  Yes (0.00s cpu, solution 3, maybe more) ?
90  */
91
92  % Q4.5
93  pasMemeBateaux(T,NbEquipes,NbConf):-
```

```
94          dim(T,[NbEquipes,NbConf]),
95          ( for(Indice1,1,NbEquipes),param(T,NbConf)
96          do
97                  ( for(Indice2,1,NbConf), fromto([],In,Out,L), param(T,Indice1
                        )
98                  do
99                          Bat is T[Indice1,Indice2],
100                         append(In,[Bat],Out)
101                 ),
102                 alldifferent(L)
103         ).
104
105 solve2(T) :-
106         getData(_TailleEquipes,NbEquipes,_CapaBateaux,NbBateaux,NbConf),
107         defineVars(T,NbEquipes,NbConf,NbBateaux),
108         pasMemeBateaux(T,NbEquipes,NbConf),
109         getVarList(T,L),
110         labeling(L).
111
112 /* Tests
113 [eclipse 11]: solve2(T).
114
115 T = []([](1, 2, 3), [](1, 2, 3), [](1, 2, 3), [](1, 2, 3))
116 Yes (0.00s cpu, solution 1, maybe more) ? ;
117
118 T = []([](1, 2, 3), [](1, 2, 3), [](1, 2, 3), [](1, 3, 2))
119 Yes (0.00s cpu, solution 2, maybe more) ? ;
120
121 T = []([](1, 2, 3), [](1, 2, 3), [](1, 3, 2), [](1, 2, 3))
122 Yes (0.00s cpu, solution 3, maybe more) ?
123 */
124
125 % Q4.6
126 pasMemePartenaires(T,NbEquipes,NbConf):-
127         dim(T,[NbEquipes,NbConf]),
128         ( for(Equipe1,1,NbEquipes),param(T,NbConf,NbEquipes)
129         do
130                 Indice is Equipe1+1,
131                 ( for(Equipe2,Indice,NbEquipes), param(T,Equipe1,NbConf)
132                 do
133
134                         ( for(Conf,1,NbConf),param(T,Equipe1,Equipe2),fromto
                                (0,In,Out,Tot)
135                         do
136                                 Bateau1 is T[Equipe1,Conf],
137                                 Bateau2 is T[Equipe2,Conf],
138                                 #=(Bateau1,Bateau2,Ans),
139                                 Out #= In + Ans
140                         ),
141                         Tot #=< 1
142                 )
143         ).
144
```

```
145 solve3(T) :-
146         getData(_TailleEquipes,NbEquipes,_CapaBateaux,NbBateaux,NbConf),
147         defineVars(T,NbEquipes,NbConf,NbBateaux),
148         pasMemeBateaux(T,NbEquipes,NbConf),
149         pasMemePartenaires(T,NbEquipes,NbConf),
150         getVarList(T,L),
151         labeling(L).
152
153 /* Tests
154 [eclipse 12]: solve3(T).
155
156 T = []([](1, 2, 3), [](1, 3, 2), [](2, 1, 3), [](2, 3, 1))
157 Yes (0.00s cpu, solution 1, maybe more) ? ;
158
159 T = []([](1, 2, 3), [](1, 3, 2), [](2, 3, 1), [](2, 1, 3))
160 Yes (0.00s cpu, solution 2, maybe more) ? ;
161
162 T = []([](1, 3, 2), [](1, 2, 3), [](2, 1, 3), [](2, 3, 1))
163 Yes (0.00s cpu, solution 3, maybe more) ?
164 */
165
166 % Q4.7
167 capaBateaux(T,TailleEquipes,NbEquipes,CapaBateaux,NbBateaux,NbConf):-
168         dim(T,[NbEquipes,NbConf]),
169         ( for(Bateau,1,NbBateaux), param(T,NbEquipes,NbConf,CapaBateaux,
                TailleEquipes)
170         do
171                 ( for(Conf,1,NbConf), param(T,NbEquipes,Bateau,CapaBateaux,
                        TailleEquipes)
172                 do
173                         ( for(Equipe,1,NbEquipes),param(T,Bateau,Conf,
                                TailleEquipes),fromto(0,In,Out,Total)
174                         do
175                                 BateauI is T[Equipe,Conf],
176                                 #=(Bateau,BateauI,Cond),
177                                 Inc #= TailleEquipes[Equipe] * Cond,
178                                 Out #= In + Inc
179                         ),
180                         Capacite is CapaBateaux[Bateau],
181                         Total #=< Capacite
182                 )
183         ).
184
185 solve4(T) :-
186         getData(TailleEquipes,NbEquipes,CapaBateaux,NbBateaux,NbConf),
187         defineVars(T,NbEquipes,NbConf,NbBateaux),
188         pasMemeBateaux(T,NbEquipes,NbConf),
189         pasMemePartenaires(T,NbEquipes,NbConf),
190         capaBateaux(T,TailleEquipes,NbEquipes,CapaBateaux,NbBateaux,NbConf),
191         getVarList(T,L),
192         labeling(L).
193
194 /* Tests
```

```
195 [eclipse 13]: solve4(T).
196
197 T = [][](1, 2, 3), [](2, 3, 1), [](3, 1, 2), [](3, 2, 1))
198 Yes (0.01s cpu, solution 1, maybe more) ? ;
199
200 T = [][](1, 3, 2), [](2, 1, 3), [](3, 2, 1), [](3, 1, 2))
201 Yes (0.01s cpu, solution 2, maybe more) ? ;
202
203 T = [][](1, 2, 3), [](3, 1, 2), [](2, 3, 1), [](1, 3, 2))
204 Yes (0.01s cpu, solution 3, maybe more) ?
205 */
206
207 % Q4.8
208
209 getData2(TailleEquipes,NbEquipes,CapaBateaux,NbBateaux,NbConf):-
210         TailleEquipes =
              [](7,6,5,5,5,4,4,4,4,4,4,4,4,3,3,2,2,2,2,2,2,2,2,2,2,2,2,2,2),
211         NbEquipes = 29,
212         CapaBateaux = [](10,10,9,8,8,8,8,8,8,7,6,4,4),
213         NbBateaux = 13,
214         NbConf = 7.
215
216 solve5(T):-
217         getData2(TailleEq,NbEq,CapaBat,NbBat,NbConf),
218         defineVars(T,NbEq,NbConf,NbBat),
219         pasMemeBateaux(T,NbEq,NbConf),
220         pasMemePartenaires(T,NbEq,NbConf),
221         capaBateaux(T,TailleEq,NbEq,CapaBat,NbBat,NbConf),
222         getVarList(T,L),
223         labeling(L).
224
225 /* Tests
226 [eclipse 14]: solve5(T).
227
228 T = [][](1, 2, 3, 4, 5, 6, 7), [](2, 1, 4, 3, 6, 5, 8), [](3, 4, 1, 2, 7, 8,
      5), [](4, 3, 1, 5, 2, 7, 6), [](5, 6, 2, 1, 3, 4, 9), [](2, 3, 5, 1, 4,
    9, 10), [](3, 1, 2, 6, 4, 10, 11), [](6, 5, 7, 2, 1, 3, 4), [](6, 7, 5,
    8, 2, 1, 3), [](7, 5, 6, 8, 3, 2, 1), [](7, 8, 9, 6, 1, 11, 2), [](8, 7,
    6, 9, 10, 12, 2), [](8, 9, 7, 10, 11, 1, 12), [](1, 4, 8, 3, 9, 7, 10),
    [](4, 2, 8, 10, 7, 3, 9), [](5, 8, 3, 11, 6, 9, 1), [](9, 6, 4, 5, 8, 11,
     13), [](9, 8, 10, 12, 13, 2, 11), [](9, 10, 8, 11, 12, 13, 2), [](9, 11,
     12, 13, 1, 10, 3), [](10, 9, 11, 7, 12, 3, 13), [](10, 11, 9, 12, 8, 1,
    4), [](10, 12, 13, 11, 9, 2, 3), [](11, 9, 10, 13, 8, 4, 5), [](11, 10,
    12, 9, 13, 5, 1), [](11, 12, 9, 7, 10, 13, 8), [](12, 10, 13, 7, 11, 9,
    4), [](12, 13, 11, 9, 8, 2, 6), [](13, 11, 10, 7, 9, 8, 1))
229 Yes (55.23s cpu, solution 1, maybe more) ?
230 */
231
232 % Amelioration du labeling pour gagner du temps
233
234 getLast([A],A,[]).
235 getLast([A|R],B,[A|L]):- getLast(R,B,L).
236
```

```
237 debutfin([A|R],A,L,B) :- getLast(R,B,L).
238 debutfin([A,B,C],A,[A,C,B],C).
239
240 melangListe([],[]).
241 melangListe([A,B,C],[A,C,B]):-!.
242 melangListe(L,[A,B|L2]) :- debutfin(L,A,L1,B),melangListe(L1,L2).
243
244 getVarList2(T,L):-
245         dim(T,[NbEquipes,NbConf]),
246         ( for(Indice1,1,NbConf),fromto([],In,Out,L),param(T,NbEquipes)
247         do
248                 ( for(Indice2,1,NbEquipes),fromto([],In2,Out2,L2),param(T,
                        Indice1)
249                 do
250                         Var is T[Indice2,Indice1],
251                         append(In2,[Var],Out2)
252                 ),
253                 melangListe(L2,L3),
254                 append(In,L3,Out)
255         ).
256
257 solve6(T):-
258         getData2(TailleEq,NbEq,CapaBat,NbBat,NbConf),
259         defineVars(T,NbEq,NbConf,NbBat),
260         pasMemeBateaux(T,NbEq,NbConf),
261         pasMemePartenaires(T,NbEq,NbConf),
262         capaBateaux(T,TailleEq,NbEq,CapaBat,NbBat,NbConf),
263         getVarList2(T,L),
264         labeling(L).
265
266 /* Tests
267 [eclipse 15]: solve6(T).
268
269 T = []([](1, 2, 3, 4, 5, 6, 7), [](2, 1, 4, 3, 6, 5, 8), [](3, 4, 1, 2, 8, 7,
        9), [](4, 3, 5, 1, 2, 9, 10), [](5, 6, 2, 7, 1, 3, 4), [](6, 5, 7, 2, 1,
        4, 3), [](6, 7, 8, 5, 2, 1, 11), [](7, 5, 6, 8, 9, 1, 2), [](8, 9, 7,
       10, 4, 11, 5), [](8, 10, 9, 6, 11, 3, 2), [](9, 8, 12, 13, 7, 2, 6),
       [](10, 9, 8, 11, 13, 12, 1), [](12, 13, 11, 9, 10, 8, 1), [](11, 10, 13,
       3, 8, 9, 4), [](11, 12, 10, 7, 3, 13, 9), [](13, 11, 10, 9, 6, 1, 5),
       [](13, 8, 11, 12, 4, 10, 3), [](10, 11, 9, 8, 12, 2, 3), [](9, 11, 6, 12,
        10, 5, 13), [](9, 7, 10, 11, 12, 8, 2), [](7, 8, 9, 10, 3, 4, 1), [](7,
       6, 5, 9, 11, 2, 8), [](5, 7, 1, 8, 3, 10, 13), [](4, 1, 6, 5, 3, 2, 12),
       [](3, 2, 4, 1, 7, 11, 12), [](3, 1, 2, 6, 9, 10, 11), [](2, 4, 3, 1, 9,
       8, 6), [](2, 3, 1, 6, 7, 4, 5), [](1, 3, 2, 5, 4, 7, 6))
270 Yes (6.98s cpu, solution 1, maybe more) ? ;
271
272 T = []([](1, 2, 3, 4, 5, 6, 7), [](2, 1, 4, 3, 6, 5, 8), [](3, 4, 1, 2, 8, 7,
        9), [](4, 3, 5, 1, 2, 9, 10), [](5, 6, 2, 7, 1, 3, 4), [](6, 5, 7, 2, 1,
        4, 11), [](6, 7, 8, 5, 2, 1, 3), [](7, 5, 6, 8, 9, 1, 2), [](8, 9, 7,
       10, 4, 11, 5), [](8, 10, 9, 6, 11, 3, 2), [](9, 8, 12, 13, 7, 2, 6),
       [](10, 9, 8, 11, 13, 12, 1), [](12, 13, 11, 9, 10, 8, 1), [](11, 10, 13,
       3, 8, 9, 4), [](11, 12, 10, 7, 3, 13, 9), [](13, 11, 10, 9, 6, 1, 5),
       [](13, 8, 11, 12, 4, 10, 3), [](10, 11, 9, 8, 12, 2, 3), [](9, 11, 6, 12,
```

```
        10, 5, 13), [](9, 7, 10, 11, 12, 8, 2), [](7, 8, 9, 10, 3, 4, 1), [](7,
        6, 5, 9, 11, 2, 8), [](5, 7, 1, 8, 3, 10, 13), [](4, 1, 6, 5, 3, 2, 12),
        [](3, 2, 4, 1, 7, 11, 12), [](3, 1, 2, 6, 9, 10, 11), [](2, 4, 3, 1, 9,
        8, 6), [](2, 3, 1, 6, 7, 4, 5), [](1, 3, 2, 5, 4, 7, 6))
273 Yes (7.31s cpu, solution 2, maybe more) ?
274 */
```