

ICS 271

Fall 2016

Student ID : 26642334

Student Name: Yu Guo

Instructor : Kalev Kask

Homework Assignment 4

Due Tuesday, 11/3

1. $X = \{v_1, v_2, v_3, v_4, v_5, v_6\}$

$D = \{D_1, D_2, D_3, D_4, D_5, D_6\}$

- $D_1 = \{\text{desk, easy, dove, else, help, kind, soon, this}\}$

- $D_2 = \{\text{eta, hat, her, him, one}\}$

- $D_3 = \{\text{at, be, he, it, on}\}$

- $D_4 = \{\text{dance, usage, first, loses, fuels, haste, given, sense, sound, think}\}$

- $D_5 = \{\text{dance, usage, first, loses, fuels, haste, given, sense, sound, think}\}$

- $D_6 = \{\text{desk, easy, dove, else, help, kind, soon, this}\}$

$C_1 = \{v_2(1) = v_1(2), v_2(2) = v_3(2), v_2(3) = v_4(3), v_5(1) = v_4(4), v_5(3) = v_6(3)\}$, $v_i(j)$ means the j -th letter in word i .

$C_2 = \{v_1 \neq v_6, v_4 \neq v_5\}$

Cost function: the number of constraints unsatisfied. (Range from 0 to 5)

Start: $v_1=\text{this}, v_2=\text{eta}, v_3=\text{at}, v_4=\text{dance}, v_5=\text{haste}, v_6=\text{dove}$, cost=4

Iter1: $v_1=\text{help}, v_2=\text{eta}, v_3=\text{at}, v_4=\text{dance}, v_5=\text{haste}, v_6=\text{dove}$, cost=3

Iter2: $v_1=\text{help}, v_2=\text{eta}, v_3=\text{at}, v_4=\text{usage}, v_5=\text{haste}, v_6=\text{dove}$, cost=2

Iter3: $v_1=\text{help}, v_2=\text{eta}, v_3=\text{at}, v_4=\text{usage}, v_5=\text{given}, v_6=\text{dove}$, cost=0

2. Assume there's a classes(subjects) list S , the number of elements in S is NoS , s_i is i -th subject in S , $i = 1, 2, \dots, NoS$. We have,

$$S = \{s_i, i = 1, 2, \dots, NoS\}$$

Same as professors(P), classrooms(C) and timeslots(T). That we have,

$$P = \{p_\alpha, \alpha = 1, 2, \dots, NoP\}$$

$$C = \{c_\beta, \beta = 1, 2, \dots, NoC\}$$

$$T = \{t_\gamma, \gamma = 1, 2, \dots, NoT\}$$

$X = \{(s_i, p_\alpha, c_\beta, t_\gamma), i = 1, 2, \dots, NoS\}$, it means that subject s_i is taught by professor p_α at classroom c_β on timeslot t_γ .

$$D_j = \{(s_i, p_\alpha, c_\beta, t_\gamma) | i, \alpha, \beta, \gamma \text{ could be any valid value}\}$$

C : - Each s_i should only appear once.

- For any two subjects $(s_{i1}, p_{\alpha1}, c_{\beta1}, t_{\gamma1})$ and $(s_{i2}, p_{\alpha2}, c_{\beta2}, t_{\gamma2})$,

if $p_{\alpha1} = p_{\alpha2}$, then $t_{\gamma1} \neq t_{\gamma2}$, it means a professor could not have two classes at same time;

if $c_{\beta1} = c_{\beta2}$, then $t_{\gamma1} \neq t_{\gamma2}$, it means one classroom could no have two classes at same time.

3. Assume big rectangle locate in a 2- D coordinate system, range from $[0, X] \times [0, Y]$.

$X = \{(x_i, y_i, dX_i, dY_i) | i = 1, 2, \dots, n\}$, each X_i represents a small rectangle with it's position(bottom

left corner) (x_i, y_i) and size (dX_i, dY_i) .

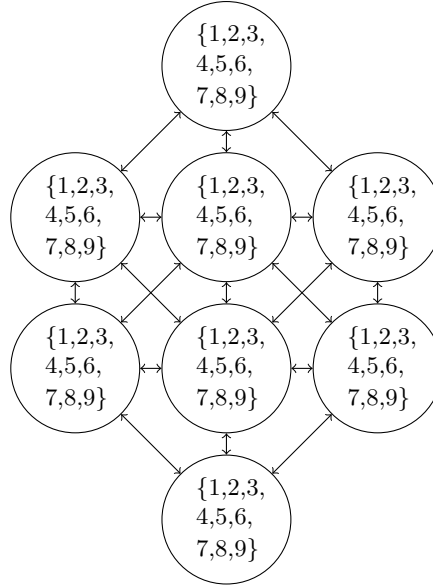
$$D_i = \{(x, y, dX, dY) | dX \leq X, dY \leq Y\}$$

C_1 : For each small rectangle (x_i, y_i, dX_i, dY_i) , we have,
 $x_i \geq 0$ and $x_i + dX \leq X$ and $y_i \geq 0$ and $y_i + dY \leq Y$

C_2 : For any of two small rectangles (x_i, y_i, dX_i, dY_i) and (x_j, y_j, dX_j, dY_j) , we have,
 $x_i + dX_i \leq x_j$ or $x_j + dX_j \leq x_i$ or $y_i + dY_i \leq y_j$ or $y_j + dY_j \leq y_i$

4. (a) For any neighboring pair of squares i and j such that $i \neq j$,

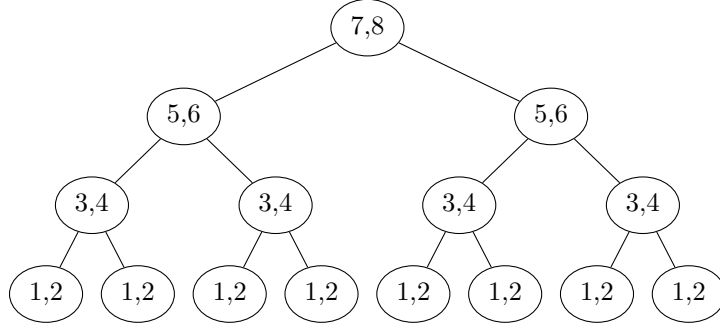
Relation	Domain
$ X_i - X_j \geq 2$	$(1,3), (1,4), (1,5), (1,6), (1,7), (1,8), (1,9),$ $(2,4), (2,5), (2,6), (2,7), (2,8), (2,9),$ $(3,1), (3,5), (3,6), (3,7), (3,8), (3,9),$ $(4,1), (4,2), (4,6), (4,7), (4,8), (4,9),$ $(5,1), (5,2), (5,3), (5,7), (5,8), (5,9),$ $(6,1), (6,2), (6,3), (6,4), (6,8), (6,9),$ $(7,1), (7,2), (7,3), (7,4), (7,5), (7,9),$ $(8,1), (8,2), (8,3), (8,4), (8,5), (8,6),$ $(9,1), (9,2), (9,3), (9,4), (9,5), (9,6), (9,7)$



- (b) Yes, it's arc-consistent.
(c) Yes, it's consistent. One solution is,

	2	
5	8	6
3	1	4
	7	

5. (a) Yes, it's arc-consistent.



(b) Yes, it's consistent. One solution is,

$$X_1 = 8 \quad X_2 = 6 \quad X_3 = 6$$

$$X_4 = 4 \quad X_5 = 4 \quad X_6 = 4 \quad X_7 = 4$$

$$X_8 = 2 \quad X_9 = 2 \quad X_{10} = 2 \quad X_{11} = 2$$

$$X_{12} = 2 \quad X_{13} = 2 \quad X_{14} = 2 \quad X_{15} = 2$$

(c) Do an in-order traversal: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15

(d) Since this is a tree the complexity is $O(nd^2)$ when n is the number of variables and d is the domain size.

6. Solve problem:

$$\begin{array}{rcccc} & & T & W & O \\ + & & T & W & O \\ \hline & F & O & U & R \end{array}$$

Constraints:

$$O + O = R + 10X_1$$

$$W + W + C_1 = U + 10C_2$$

$$T + T + C_2 = O + 10C_3$$

$$C_3 = F$$

$$alldiff(T, W, O, F, U, R)$$

Domain:

$$D_F, D_{C_3} = \{1\}$$

$$D_{C_1}, D_{C_2} = \{0, 1\}$$

$$D_T = \{1, 2, 3, 4, 5, 6, 7, 8, 9\}$$

$$D_W, D_O, D_U, D_R = \{0, 1, 2, 3, 4, 5, 6, 7, 8, 9\}$$

A solution:

$$\begin{array}{rcccc} & & 7 & 3 & 4 \\ + & & 7 & 3 & 4 \\ \hline & 1 & 4 & 6 & 8 \end{array}$$

A trace to a solution:

Node	State	Action
0	$D_F, D_{C_3} = \{1\}, D_{C_1}, D_{C_2} = \{0, 1\}, D_T = \{1, 2, 3, 4, 5, 6, 7, 8, 9\},$ $D_W, D_O, D_U, D_R = \{0, 1, 2, 3, 4, 5, 6, 7, 8, 9\}$	Initial State
1	$F = 1, D_{C_3} = \{1\}, D_{C_1}, D_{C_2} = \{0, 1\}, D_T = \{2, 3, 4, 5, 6, 7, 8, 9\},$ $D_W, D_O, D_U, D_R = \{0, 2, 3, 4, 5, 6, 7, 8, 9\}$	Assign $F = 1$
2	$F = 1, C_3 = 1, D_{C_1}, D_{C_2} = \{0, 1\}, D_T = \{5, 6, 7, 8, 9\},$ $D_W, D_O, D_U, D_R = \{0, 2, 3, 4, 5, 6, 7, 8, 9\}$	Assign $C_3 = 1$
3	$F = 1, C_3 = 1, C_2 = 0, D_{C_1} = \{0, 1\}, D_T = \{5, 6, 7, 8, 9\}, D_W = \{0, 2, 3, 4\},$ $D_O = \{0, 2, 4, 6, 8\}, D_U, D_R = \{0, 2, 3, 4, 5, 6, 7, 8, 9\}$	Assign $C_2 = 0$
4	$F = 1, C_3 = 1, C_2 = 0, C_1 = 0, D_T = \{5, 6, 7, 8, 9\}, D_W = \{0, 2, 3, 4\},$ $D_O = \{0, 2, 4\}, D_U = \{0, 2, 4, 6, 8\}, D_R = \{0, 2, 3, 4, 5, 6, 7, 8, 9\}$	Assign $C_1 = 0$
5	$F = 1, C_3 = 1, C_2 = 0, C_1 = 0, T = 6, O = 2, R = 4, D_W = \{0, 3\},$ $D_U = \{0, 8\}$	Assign $O = 2$, then $T = 6, R = 4$
6	$F = 1, C_3 = 1, C_2 = 0, C_1 = 0, T = 7, O = 4, R = 8, D_W = \{0, 2, 3\},$ $D_U = \{0, 2, 6\}$	Assign $W = 3$ or $W = 0$, no solution in D_U ; return to node 5, assign $O = 4$, then $T = 7, R = 8$
7	$F = 1, C_3 = 1, C_2 = 0, C_1 = 0, T = 7, O = 4, R = 8, D_W = \{3\}, D_U = \{6\}$	Assign $W = 0$ or $W = 2$, then no solution in D_U
8	$F = 1, C_3 = 1, C_2 = 0, C_1 = 0, T = 7, O = 4, R = 8, W = 3, U = 6$	Assign $W = 3$, then $U = 6$. Find Solution!

7. a_1 : arc consistency with domain splitting
 a_2 : variable elimination
 a_3 : stochastic local search
 a_4 : genetic algorithms

- (a) a_1 can determine that there is no solution, if the problem is inconsistent.
(b) a_2, a_3 can find a solution if one exists.
(c) a_4 can guarantee to find all solutions.