

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  $p_\alpha$  at classroom  $c_\beta$  on timeslot  $t_\gamma$ .

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

$C$ : - 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  $(dX_i, dY_i)$ .

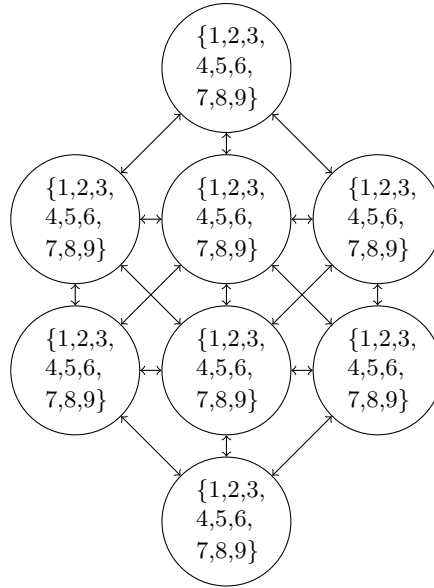
$$D_i = \{(x, y, dX, dY) | dX \leq X, dY \leq Y\}$$

$C_1$ : 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  $i \neq j$ ,

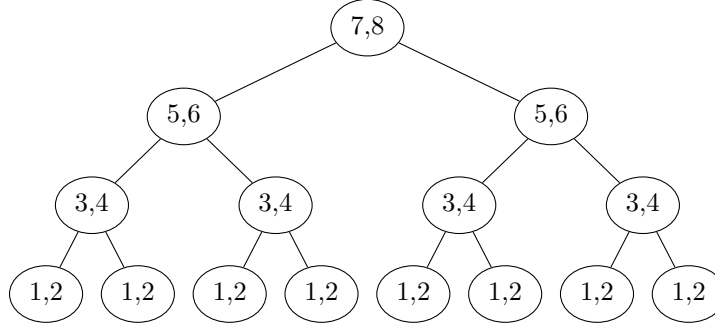
Relation	Domain
$ X_i - X_j  \geq 2$	(1,3), (1,4), (1,5), (1,6), (1,7), (1,8), (1,9), (2,4), (2,5), (2,6), (2,7), (2,8), (2,9), (3,1), (3,5), (3,6), (3,7), (3,8), (3,9), (4,1), (4,2), (4,6), (4,7), (4,8), (4,9), (5,1), (5,2), (5,3), (5,7), (5,8), (5,9), (6,1), (6,2), (6,3), (6,4), (6,8), (6,9), (7,1),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

$$\begin{aligned}
 X_1 &= 8 & X_2 &= 6 & X_3 &= 6 \\
 X_4 &= 4 & X_5 &= 4 & X_6 &= 4 & X_7 &= 4 \\
 X_8 &= 2 & X_9 &= 2 & X_{10} &= 2 & X_{11} &= 2 \\
 X_{12} &= 2 & X_{13} &= 2 & X_{14} &= 2 & X_{15} &= 2
 \end{aligned}$$

(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:

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

Constraints:

$$\begin{aligned}
 O + O &= R + 10X_1 \\
 W + W + X_1 &= U + 10X_2 \\
 T + T + X_2 &= O + 10X_3 \\
 X_3 &= F
 \end{aligned}$$

Domain:

$$\begin{aligned}
 D_F, D_{X_3} &= \{1\} \\
 D_{X_1}, D_{X_2} &= \{0, 1\} \\
 D_T &= \{1, 2, 3, 4, 5, 6, 7, 8, 9\} \\
 D_W, D_O, D_U, D_R &= \{0, 1, 2, 3, 4, 5, 6, 7, 8, 9\}
 \end{aligned}$$

A trace to a solution:

A solution:

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

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.