- IE 407 -

Assignment #3 Solutions

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Q1)

DV's: x_{ij}: flow from i to j

x_0: flow on the artificial arc

$$\text{Max } z = x_0$$

S.to

$$x_{1,3} \leq 18$$
$$x_{1,2} \leq 18$$
$$x_{2,4} \leq 9$$
$$x_{2,5} \leq 5$$
$$x_{3,6} \leq 8$$
$$x_{3,4} \leq 5$$
$$x_{4,5} \leq 8$$
$$x_{4,7} \leq 11$$
$$x_{4,6} \leq 4$$
$$x_{5,4} \leq 3$$
$$x_{5,7} \leq 2$$
$$x_{6,3} \leq 3$$
$$x_{6,7} \leq 9$$
$$x_{6,8} \leq 12$$
$$x_{7,6} \leq 2$$
$$x_{7,8} \leq 19$$

} arc capacity constraints

$$x_0 = x_{1,2} + x_{1,3}$$
$$x_{1,2} = x_{2,4} + x_{2,5}$$
$$x_{1,3} = x_{3,6} + x_{3,4}$$
$$x_{3,4} + x_{2,4} + x_{5,4} = x_{4,5} + x_{4,6} + x_{4,7}$$
$$x_{2,5} + x_{4,5} = x_{5,4} + x_{5,7}$$
$$x_{3,6} + x_{4,6} + x_{7,6} = x_{6,3} + x_{6,7} + x_{6,8}$$
$$x_{4,7} + x_{6,7} + x_{5,7} = x_{7,6} + x_{7,8}$$
$$x_{6,8} + x_{7,8} = x_0$$

} flow balance constraints

$x_{ij} \geq 0 \quad \forall i,j$ (Sign constraints)

Q2) DV's: x_{ij} : # units of production capacity at plan i and sent to depop j

→ we use j=5 demand point as dummy dp. unit costs of it's are all zero.

Min $z = 4x_{11} + 7x_{12} + 3x_{13} + 5x_{14} + 0x_{15} +$
$10x_{21} + 9x_{22} + 3x_{23} + 6x_{24} + 0x_{25} +$
$3x_{31} + 6x_{32} + 4x_{33} + 4x_{34} + 0x_{35}$

S.to

$x_{11} + x_{12} + x_{13} + x_{14} \leq 2500$
$x_{21} + x_{22} + x_{23} + x_{24} \leq 4000$
$x_{31} + x_{32} + x_{33} + x_{34} \leq 3500$

} capacity constraints

$x_{11} + x_{21} + x_{31} \geq 2000$
$x_{12} + x_{22} + x_{32} \geq 3000$
$x_{13} + x_{23} + x_{33} \geq 2500$
$x_{14} + x_{24} + x_{34} \geq 1500$
$x_{15} + x_{25} + x_{35} \geq 1000$

} demand constraints

$x_{ij} \geq 0 \quad \forall i,j$ (sign constraints)

According to Linda Solver;

$z = 49000$

$x_{11} = 0$, $x_{12} = 2500$, $x_{13} = x_{14} = x_{15} = x_{21} = x_{22} = x_{35} = 0$,
$x_{23} = 2500$, $x_{24} = 500$, $x_{31} = 2000$,
$x_{32} = 500$, $x_{33} = 0$, $x_{34} = 1000$, $x_{25} = 1000$

Q3) Dv's: $x_i = \begin{cases} 1 \text{ if player is selected} \\ 0 \text{ o/w} \end{cases}$

$$\text{Max } z = 3x_1 + 2x_2 + 2x_3 + 1x_4 + 3x_5 + 3x_6 + 1x_7$$

S.to

$$x_1 + x_2 + x_3 + x_4 + x_5 + x_6 + x_7 = 5 \quad \} \text{ number of players constraint}$$

$$x_1 + x_3 + x_5 + x_7 \geq 4 \longrightarrow \text{Guard Constraint}$$

$$x_3 + x_5 + x_7 \geq 2 \longrightarrow \text{forward Constraint}$$

$$x_2 + x_4 + x_6 \geq 1 \longrightarrow \text{center constraint}$$

$$\left.\begin{aligned} 3x_1 + 2x_2 + 2x_3 + x_4 + 3x_5 + 3x_6 + 3x_7 &\geq 10 \\ 3x_1 + x_2 + 3x_3 + 3x_4 + 3x_5 + x_6 + 2x_7 &\geq 10 \\ x_1 + 3x_2 + 2x_3 + 3x_4 + 3x_5 + 2x_6 + 2x_7 &\geq 10 \end{aligned}\right\} \text{Average ability levels constraints}$$

$$x_3 + x_6 \leq 1 \longrightarrow \text{3-6 players Start constraint}$$

$$\left.\begin{aligned} x_1 &\leq x_4 \\ x_1 &\leq x_5 \end{aligned}\right\} \text{1 and 4-5 players Start constraints}$$

$$x_2 + x_3 \geq 1 \longrightarrow \text{2-3 players Start Constraint}$$

$$x_i \in \{0,1\} \ \forall i \quad \text{(set constraints)}$$

Q4) DV's : X_{ij} = Amount supplied from i'th plant to j'th customer

$$y_i = \begin{cases} 1 & \text{if i'th plant is selected} \\ 0 & \text{o/w} \end{cases}$$

s.to

$$\left.\begin{aligned} 10X_{11} + 17X_{21} + 15X_{31} &\geq 1200 \\ 15X_{12} + 14X_{22} + 10X_{32} &\geq 800 \\ 12X_{13} + 20X_{23} + 11X_{33} &\geq 800 \end{aligned}\right\} \text{Demand Constreints}$$

$$\left.\begin{aligned} 10X_{11} + 15X_{12} + 12X_{13} &\leq 1800 \\ 17X_{21} + 14X_{22} + 20X_{23} &\leq 1400 \\ 15X_{31} + 10X_{32} + 11X_{33} &\leq 1300 \end{aligned}\right\} \text{Supply Constraints}$$

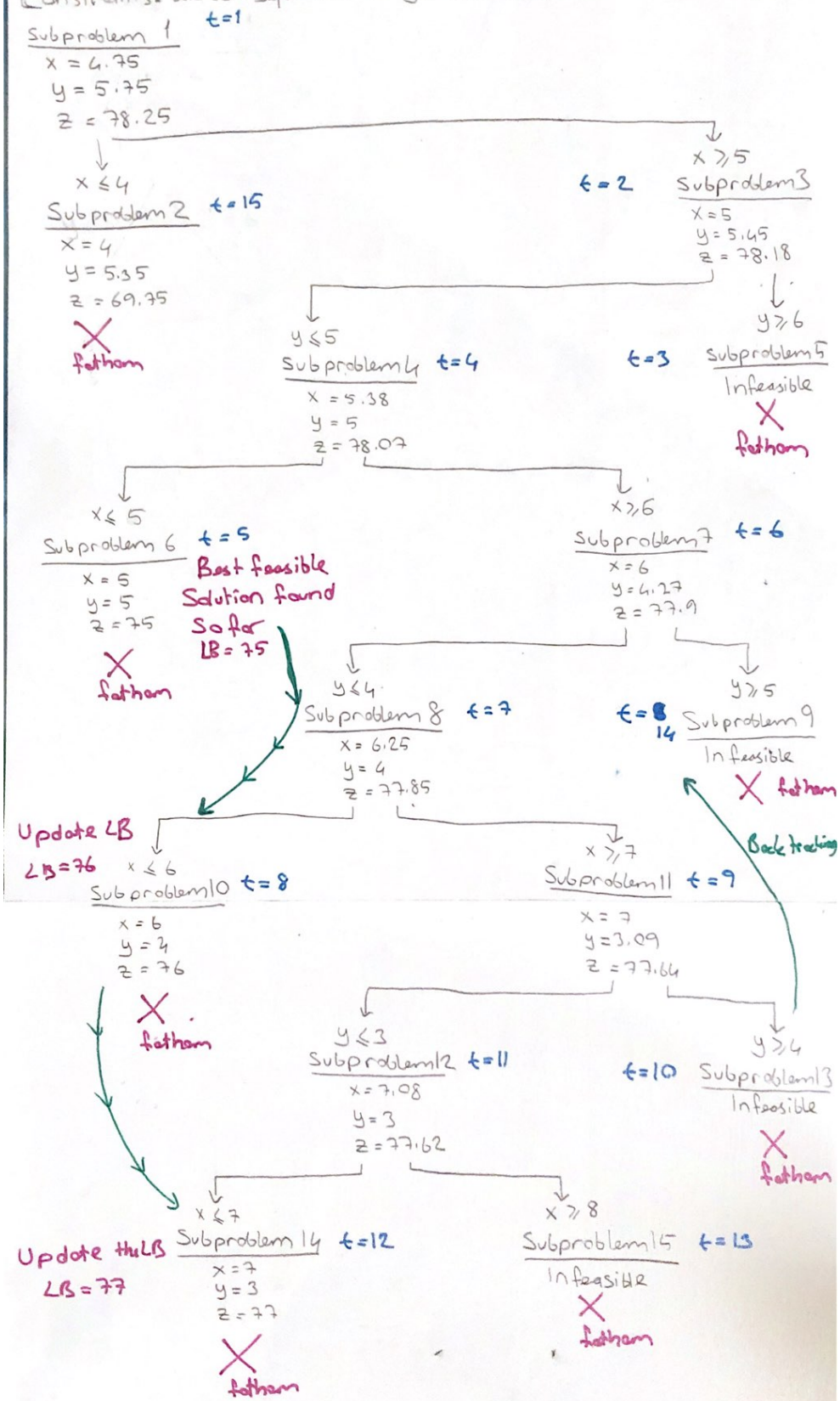
$$\left.\begin{aligned} 10X_{11} + 15X_{12} + 12X_{13} &\leq y_1 \cdot 1800 \\ 17X_{21} + 14X_{22} + 20X_{23} &\leq y_2 \cdot 1400 \\ 15X_{31} + 10X_{32} + 11X_{33} &\leq y_3 \cdot 1300 \end{aligned}\right\} \begin{array}{l} \text{if } y = 0 \\ \#\text{ supplied must be } 0 \\ \text{Binary Constraints} \end{array}$$

$$\begin{aligned} \text{Min } z = {} & 10X_{11} + 15X_{12} + 12X_{13} + \\ & 17X_{21} + 14X_{22} + 20X_{23} + \\ & 15X_{31} + 10X_{32} + 11X_{33} + \\ & 12000y_1 + 11000y_2 + 12000y_3 \end{aligned}$$

$X_{ij} \geq 0$ and $y_i = \{0, 1\}$ $\forall ij$ (sign and set constraints)

Q5)

→ We used backtracking method at this question, and choosed the Lindo solver to solve integer problem without integer constraints. We used separation to get new subproblems.



→ In necessary cases (e.g. infeasible) we used fathoming.

→ At the end, we found the solution as $x = 7$, $y = 3$

$z = 77$

→ We are adding ours solution and the model to the Submission.