CS6135 VLSI Physical Design Automation

Final Exam: 10:10 a.m. – 13:10 p.m., January 5, 2021

Answer Sheet

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7. (a) Lee algorithm

5	4	3	4					19					
4	3	2	3				T	~~18~~	~~17~~	18	19		
3	2	1	2						16	17	18	19	
2	~~1~~	S	1			12	~~13~~	~~14~~	~~15~~	16	17	18	19
3	2					11	12	13	14	15	16	17	18
4	3					10	11	12			17	18	19
5	4	5	6	7	8	9	10	11			18	19	
6	5						11	12					
7	6						12	13	14	15			
8	7	8	9	10			13	14	15	16			

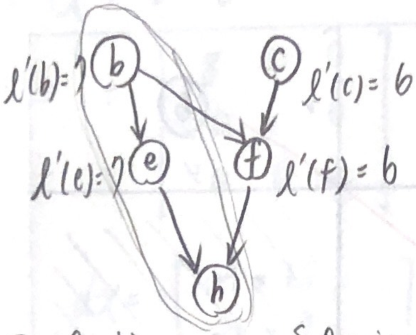
(b) Hadlock's detour algorithm S→T 右上 、detour：左下

3	2	1	1										
2	1	0	0				T	~~7~~	~~6~~	7			
2	1	0	0						6	7			
2	~~1~~	S	0			4	4	5	~~6~~	7			
3	2					4	4	5	6	7			
4	3					4	4	5					
5	4	4	4	4	4	4	4	5					
	5						5						

MD(S,T) = 5 + 3 = 7   l(p) = 7 + 2 × 6 = 19

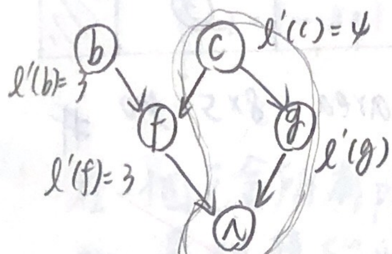
1.

① $l(h) = \max\{l_1(h), l_2(h)\} = \max\{7, \max\{6+4, 6+4\}\} = 10$ #



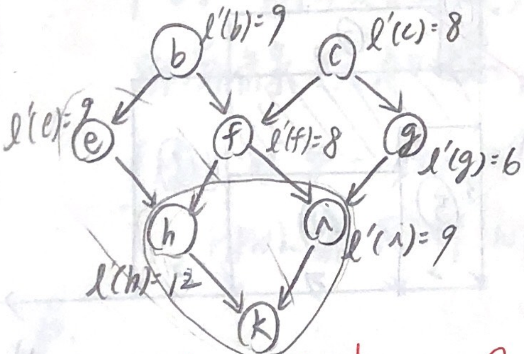
cluster $(h) = \{b, e, h\}$ #

② $l(i) = \max\{l_1(i), l_2(i)\} = \max\{4, \max\{3+4, 3+4\}\} = 7$ #



cluster$(i) = \{c, g, i\}$ #

③ $l(k) = \max\{l_1(k), l_2(k)\} = \max\{0, \max\{9+4, 8+4, 9+4, 8+4, 6+4\}\} = 13$ #



cluster$(k) = \{h, i, k\}$ #

show balance ?

2. graph G : each k-pin net as a clique

weight $= \frac{1}{k-1}$ to each edge

-2

在 $k \le 3$，轉成 graph G，每個 net 共有不超过 $\binom{3}{2} = 3$ 條 2-pin nets

並且延用 Kernighan-Lin (KL) Algorithm

因 KL 也是 reducing a vertex with weight $W(V)$ into a clique

我們假設此 G 的 vertex 皆是 unit vertex weight.

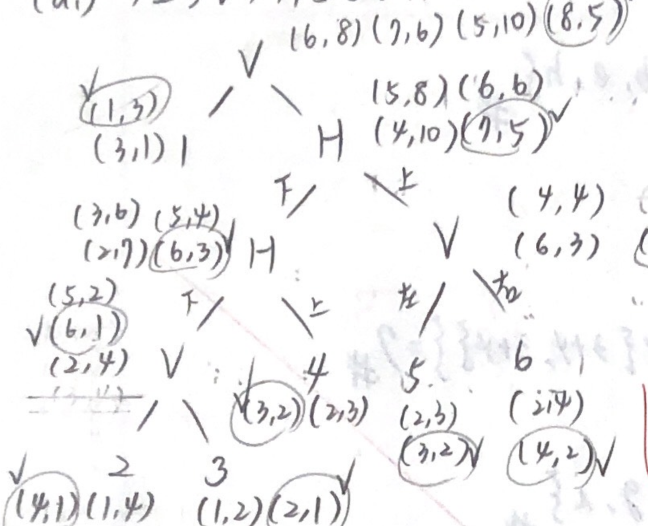
因此 if each net in C has at most 3 pins,

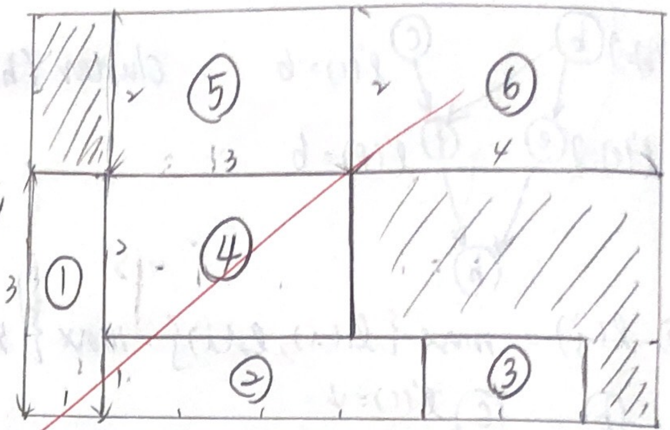
an optimal balanced two-way partitioning of G corresponds

to an optimal balanced two-way partitioning of C. #

3.

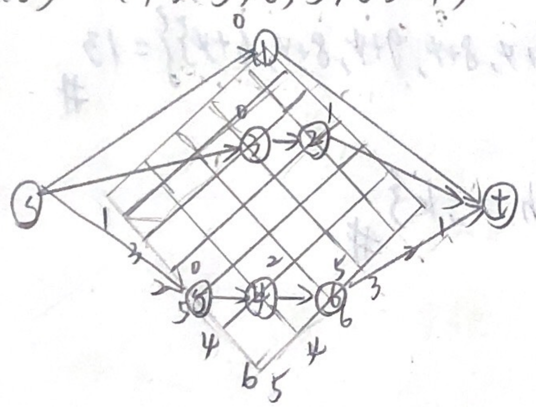
(a.) 123V4H56VHV

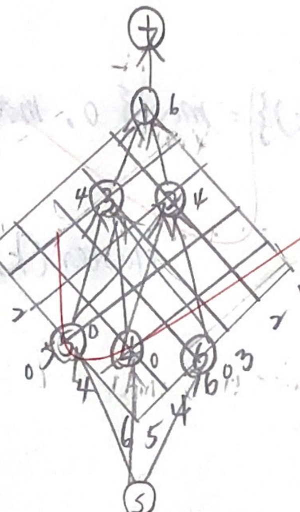


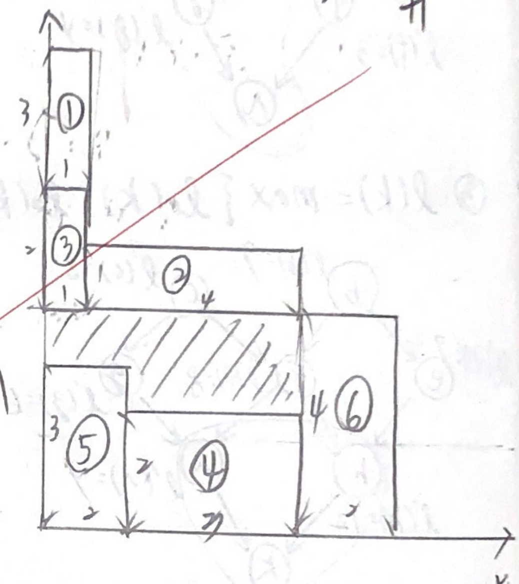


area = 8×5 = 40 #

(b.) (132546, 546321)







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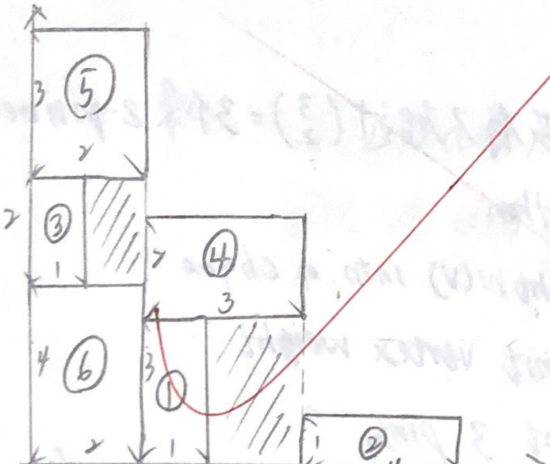
(c.) DFS = 613542



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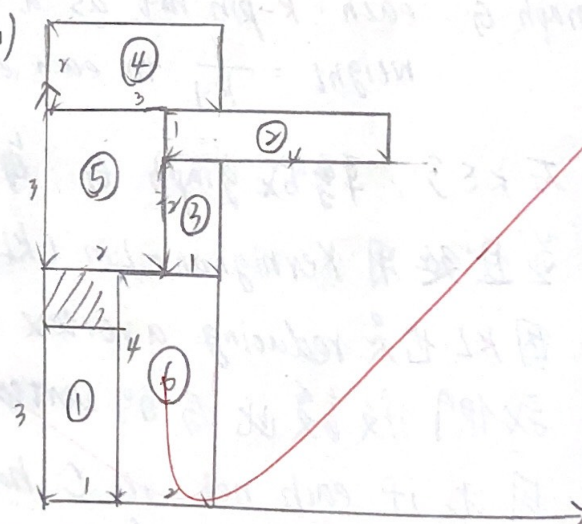
(d.)



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4.

$$Q = D - C$$

$$= \begin{bmatrix} 8 & 0 & 0 \\ 0 & 6 & 0 \\ 0 & 0 & 6 \end{bmatrix} - \begin{array}{c|ccc} & 1 & 2 & 3 \\ \hline 1 & 0 & 4 & 3 \\ 2 & 4 & 0 & 0 \\ 3 & 3 & 0 & 0 \end{array} = \begin{bmatrix} 8 & -4 & -3 \\ -4 & 6 & 0 \\ -3 & 0 & 6 \end{bmatrix} \#$$

$$dx = \begin{bmatrix} -1\times 15 \\ -2\times 9 \\ -1\times 9 - 2\times 1 \end{bmatrix} = \begin{bmatrix} -15 \\ -18 \\ -11 \end{bmatrix} \# \quad dy = \begin{bmatrix} -1\times 2 \\ -2\times 11 \\ -1\times 11 - 2\times 7 \end{bmatrix} = \begin{bmatrix} -2 \\ -22 \\ -25 \end{bmatrix} \#$$

5. 在一個包含所有pin的Bounding Box中，欲建一個RSMT連接所有pin，最理想的情況就是：任一x or y座標，最多只會被此RSMT中的一條線段經過，在此情況下將RSMT上水平及垂直方向的所有線段加總，可分別得(Max of x − Min of x)和(Max of y − Min of y)，兩者相加即為HPWL

∴ HPWL 為 RSMT WL 的 lower bound #

6.

(a.) Clique

$\begin{cases} \binom{k}{2} = \frac{k(k-1)}{2} \text{ 個 2-pin nets} \\ \text{the \# of extra } x \text{ and } y \text{ variables} = 0 \end{cases}$ #

(b.) Star

$\begin{cases} k \text{ 個 2-pin nets} \\ \text{the \# of extra } x \text{ variable} = 1 \\ \text{the \# of extra } y \text{ variable} = 1 \end{cases}$ (for star module) #

(c.) Hybrid

if $k \le 3$ $\begin{cases} \frac{k(k-1)}{2} \text{ 個 2-pin nets} \\ 0 \text{ extra } x \text{ \& } y \text{ variables} \end{cases}$

if $k \ge 4$ $\begin{cases} k \text{ 個 2-pin nets} \\ 1 \text{ extra } x \text{ variable} \\ 1 \text{ extra } y \end{cases}$ #

(d.) Bounding Box

$\begin{cases} 2k-3 \text{ 條 2-pin nets} \\ 0 \text{ extra } x \text{ \& } y \text{ variables} \end{cases}$ #

8.

(a.) $t_{m_1p_1} = r_{m_1,p_1}\left(\frac{c_{m_1p_1}}{2} + c_1\right)$

$= 10 \times 0.2\left(\frac{10\times0.1}{2} + 4\right) = 2 \times 4.5 = 9$

$t_{m_1p_2} = 8 \times 0.2\left(\frac{8\times0.1}{2} + 2\right) = 1.6\,(2.4) = 3.84$

$t_{m_3m_1} = 10\times0.2\left(\frac{10\times0.1}{2} + 18\times0.1 + 6\right) = 2\times(0.5 + 1.8 + 6) = 16.6$

$t_{m_2p_3} = 10\times0.2\left(\frac{10\times0.1}{2} + 2\right) = 2\times(2.5) = 5$

$t_{m_2p_4} = 8\times0.2\left(\frac{8\times0.1}{2} + 1\right) = 1.6\,(1.4) = 2.24$

$t_{m_3m_2} = 4\times0.2\left(\frac{4\times0.1}{2} + 18\times0.1 + 3\right) = 0.8\,(0.2 + 1.8 + 3) = 4$

$t_{m_3p_1} = 16.6 + 9 = 25.6$ $\quad t_{m_3p_3} = 4 + 5 = 9$

$t_{m_3p_2} = 16.6 + 3.84 = 20.44$ $\quad t_{m_3p_4} = 4 + 2.24 = 6.24$

delay $= 25.6$ # $\quad$ skew $= 25.6 - 6.24 = 19.36$ #

(b.)

$t_{m_3m_1} = r_{m_3m_1}\left(\frac{c_{m_3m_1}}{2} + c_{bm_1}\right) + r_{bm_1}(c_{m_1} + c_1 + c_2)$

$= 10\times0.2\left(\frac{10\times0.1}{2} + 0.2\right) + 0.1\,(18\times0.1 + 6)$

$= 2\,(0.7) + 0.1\,(7.8) = 1.4 + 0.78 = 2.18$

$t_{m_3m_2} = 4\times0.2\left(\frac{4\times0.1}{2} + 0.2\right) + 0.1\,(18\times0.1 + 3)$

$= 0.8\,(0.2 + 0.2) + 0.1\,(4.8) = 0.32 + 0.48 = 0.8$

$t_{m_3p_1} = 2.18 + 9 = 11.18$ $\quad t_{m_3p_3} = 0.8 + 5 = 5.8$

$t_{m_3p_2} = 2.18 + 3.84 = 6.02$ $\quad t_{m_3p_4} = 0.8 + 2.24 = 3.04$

$$\begin{cases} \text{delay} = 11.18 \\ \text{skew} = 11.18 - 3.04 = 8.14 \end{cases}$$ #