Yoshimura-Kuh Channel Routing

- Perform YK channel routing with $K = 100$

```
TOP = [1,1,4,2,3,4,3,6,5,8,5,9]
BOT = [2,3,2,0,5,6,4,7,6,9,8,7]
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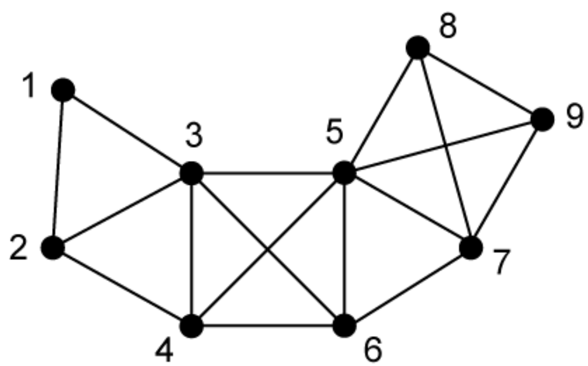
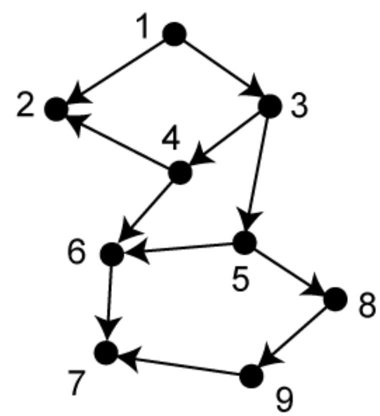


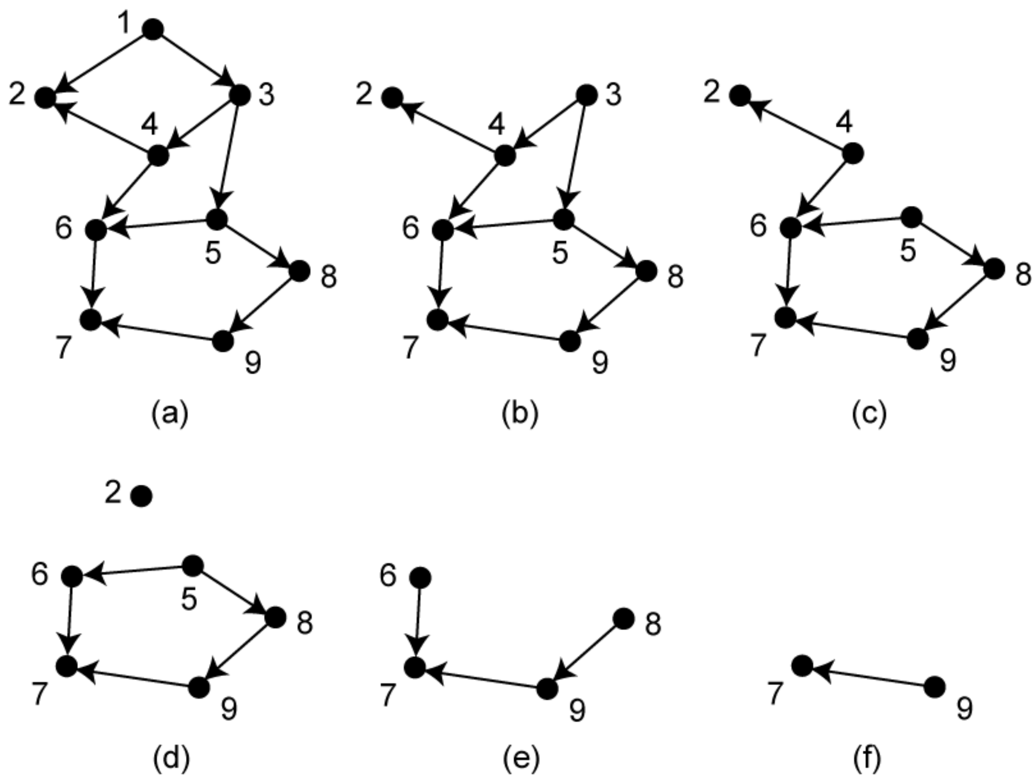
HCG

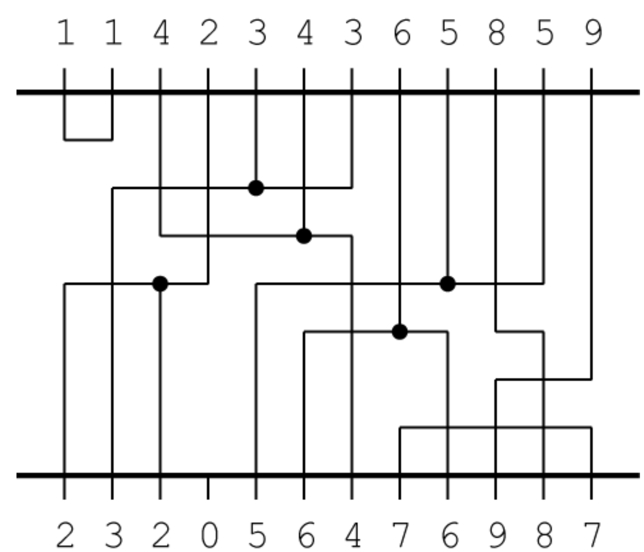


VCG

Constrained Left-Edge Algorithm

- First perform CLE on original problem (for comparison)
  - Assign VCG nodes with no incoming edge first
  - Use tracks top-to-bottom, left-to-right



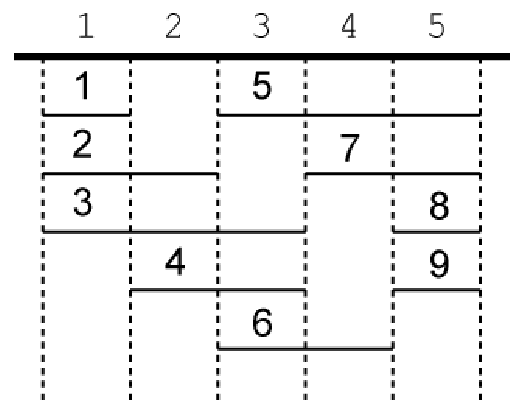


Zone Representation

- Horizontal span of the nets and their zones

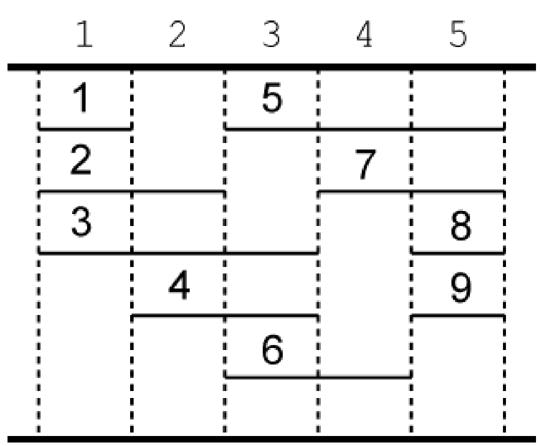
```
TOP = [1,1,4,2,3,4,3,6,5,8,5,9]
BOT = [2,3,2,0,5,6,4,7,6,9,8,7]
```

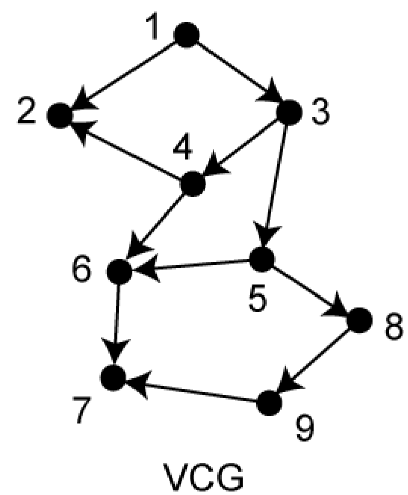
	zone 1		zone 2		zone 3			zone 4		zone 5		
net	c1	c2	c3	c4	c5	c6	c7	c8	c9	c10	c11	c12
1	1	1										
2	2	2	2	2								
3		3	3	3	3	3	3					
4			4	4	4	4	4					
5					5	5	5	5	5	5	5	
6						6	6	6	6			
7								7	7	7	7	7
8										8	8	
9										9	9	9



Net Merging: Zone 1 and 2

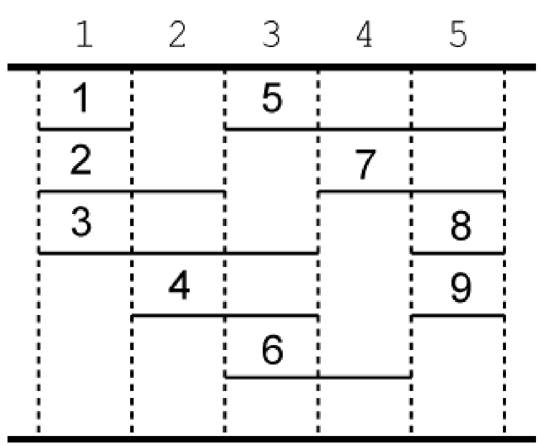
- We compute
  - $L = \{1\}$ and $R = \{4\}$
  - Net 1 and 4 are on the same path in VCG: no merging possible

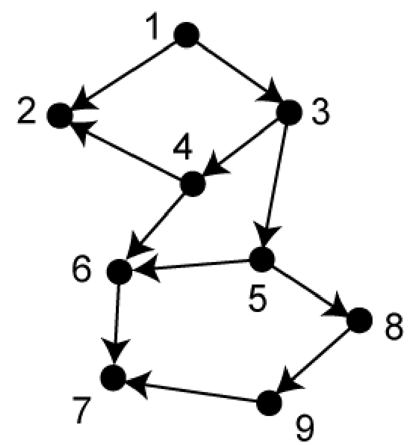




Net Merging: Zone 2 and 3

- We compute
  - L = {1,2} and R = {5,6} (= net 1 inherited from last step)
  - Merge-able pairs: (2,5) and (2,6) (= not on the same path in VCG)

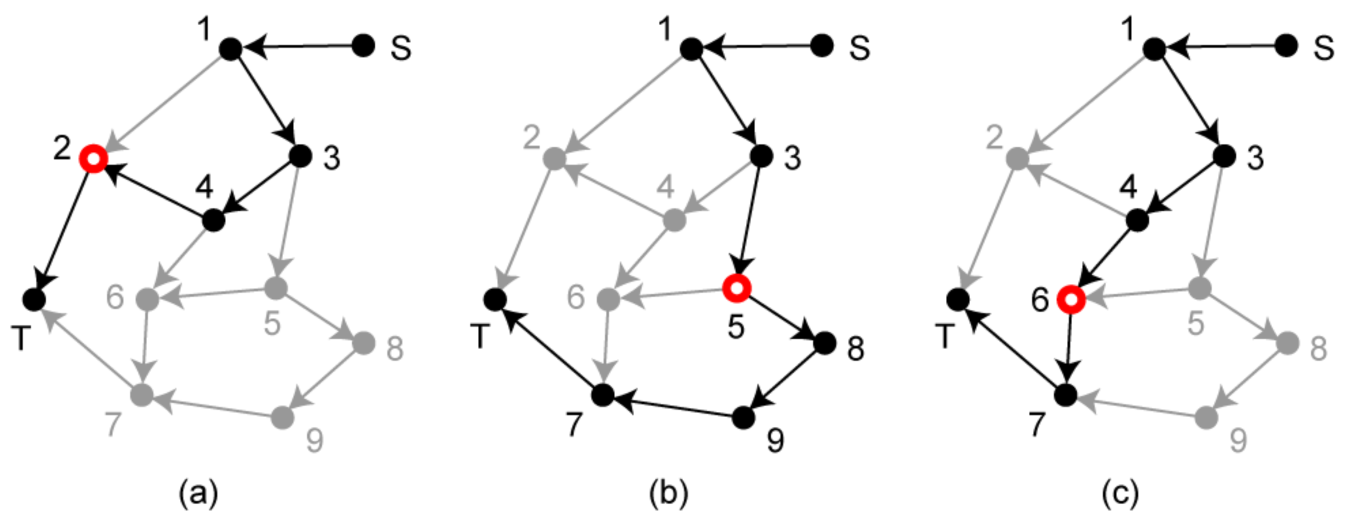




VCG

Net Merging: Zone 2 and 3 (cont)

- Choose the “best” pair between (2,5) and (2,6)
  - We form P = {5,6} and Q = {2} and choose best from each set
  - We compute
    - $u(2) = 4$, $d(2) = 1$, $u(5) = 3$, $d(5) = 4$, $u(6) = 4$, $d(6) = 2$
  - Only 1 element in Q, so m^* = net 2 trivially



Net Merging: Zone 2 and 3 (cont)

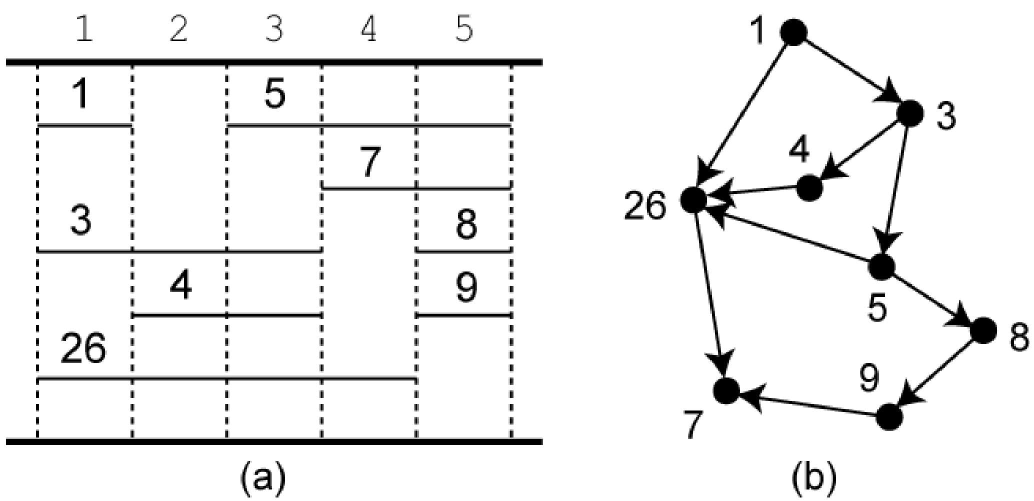
- Now choose "best" from *P*
  - We compute $g(5,2)$ and $g(6,2)$ using $K = 100$

$$
\begin{aligned}
h(5,2) &= \max\{u(5), u(2)\} + \max\{d(5), d(2)\} \\
&\quad - \max\{u(5) + d(5), u(2) + d(2)\} = 1 \\
h(6,2) &= \max\{u(6), u(2)\} + \max\{d(6), d(2)\} \\
&\quad - \max\{u(6) + d(6), u(2) + d(2)\} = 0 \\
g(5,2) &= 100 \cdot h(5,2) - \{\sqrt{u(2) \cdot u(5)} + \sqrt{d(2) \cdot d(5)}\} \\
&= 94.5 \\
g(6,2) &= 100 \cdot h(6,2) - \{\sqrt{u(2) \cdot u(6)} + \sqrt{d(2) \cdot d(6)}\} \\
&= -5.4
\end{aligned}
$$

  - Since $g(5,2) > g(6,2)$, we choose $n^* =$ net 6
  - We merge $m^* = 2$ and $n^* = 6$
    - Likely to minimize the increase in the longest path length in VCG

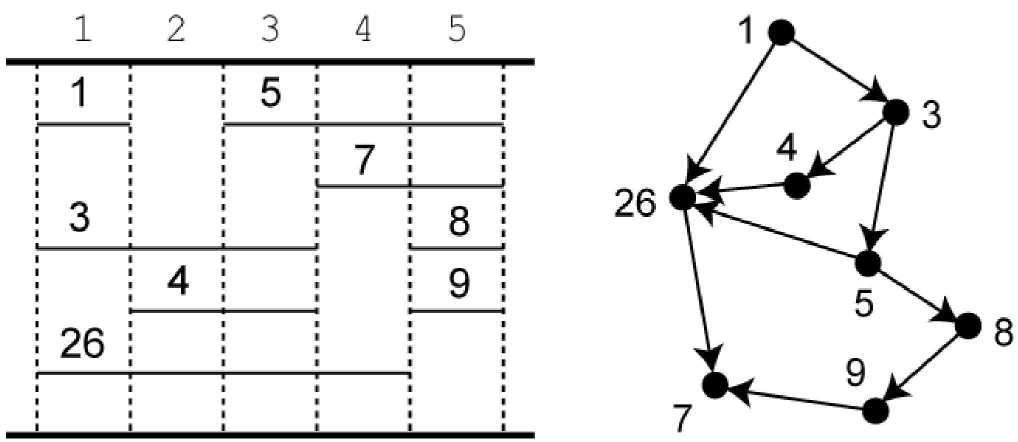
Net Merging: Zone 2 and 3 (cont)

- Merged net 2 and 6
  - We had $P = \{5,6\}$ and $Q = \{2\}$, and need to remove 2 and 6
    - Q is empty, so we are done with zone 2 and 3
  - We had $L = \{1,2\}$ and $R = \{5,6\}$, and need to remove 2 and 6
    - We keep $L = \{1\}$
  - Updated zone representation and VCG



Net Merging: Zone 3 and 4

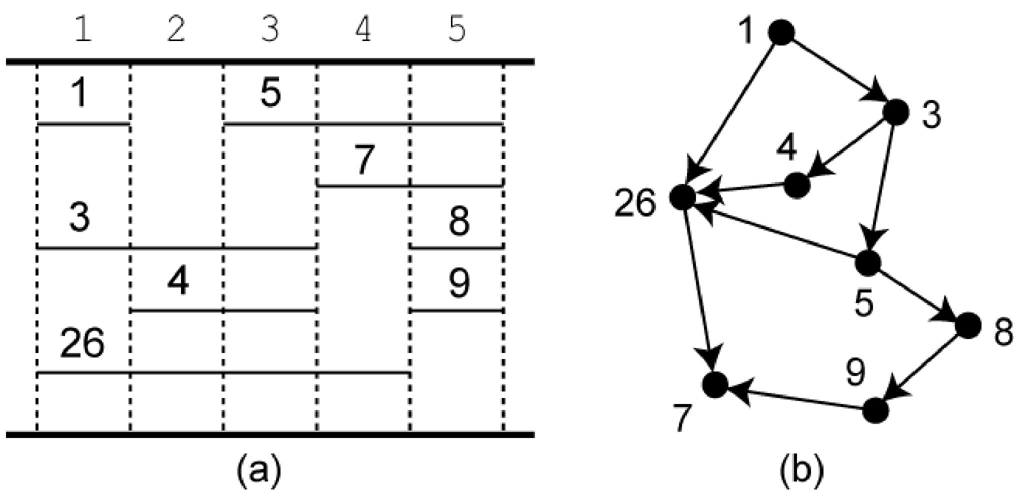
- We compute
  - *L* = {1,3,4} and *R* = {7} (= net 1 inherited from last step)
  - All nets in *L* and *R* are on the same path in VCG
    - no merging possible



(a) (b)

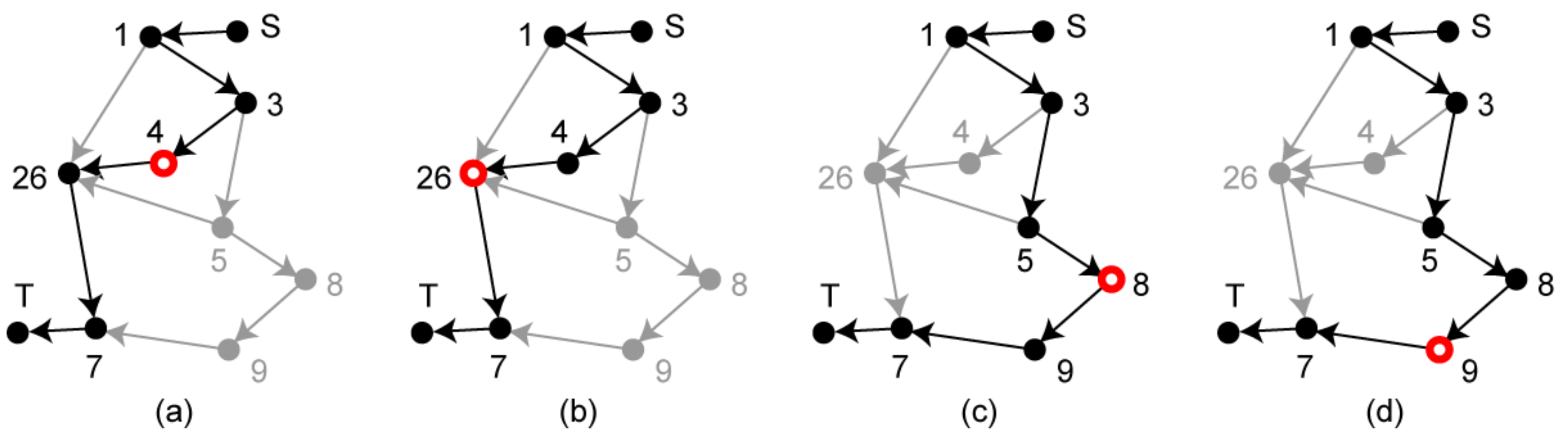
Net Merging: Zone 4 and 5

- We compute
  - $L = \{1,3,4,26\}$ and $R = \{8,9\}$
  - Merge-able pairs: (4,8), (4,9), (26,8), (26,9)



Net Merging: Zone 4 and 5 (cont)

- Choose m^* from Q
  - We form $P = \{4,26\}$ and $Q = \{8,9\}$
  - We compute
    - $u(4) = 3$, $d(4) = 3$, $u(26) = 4$, $d(26) = 2$, $u(8) = 4$, $d(8) = 3$, $u(9) = 5$, $d(9) = 2$



Net Merging: Zone 4 and 5 (cont)

- Choose m^* from Q (cont)
  - We find m^* from Q that maximizes
    - $f(8) = 100 \cdot \{u(8) + d(8)\} + \max\{u(8), d(8)\} = 704$
    - $f(9) = 100 \cdot \{u(9) + d(9)\} + \max\{u(9), d(9)\} = 705$
  - So, $m^* = 9$

Net Merging: Zone 4 and 5 (cont)

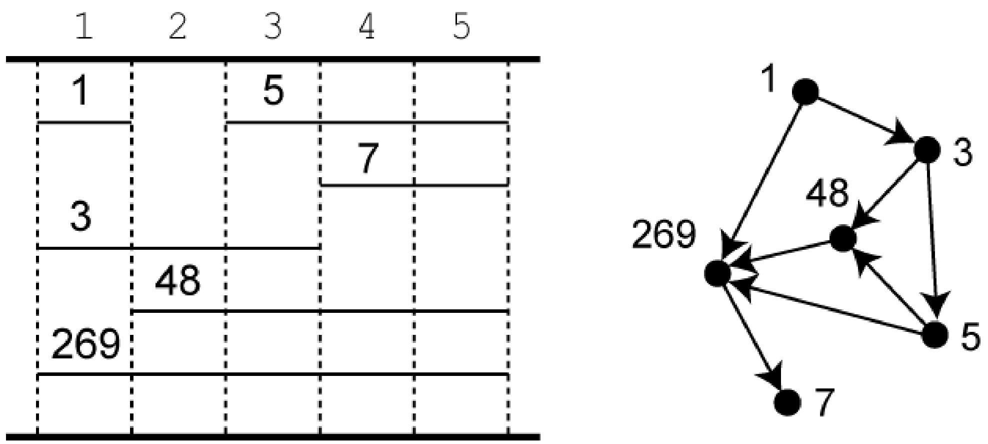
- Choose n^* from P
  - We compute $g(4,9)$ and $g(26,9)$ using $K = 100$

$$
\begin{aligned}
h(4,9) &= \max\{u(4), u(9)\} + \max\{d(4), d(9)\} \\
&\quad - \max\{u(4) + d(4), u(9) + d(9)\} = 1 \\
h(26,9) &= \max\{u(26), u(9)\} + \max\{d(26), d(9)\} \\
&\quad - \max\{u(26) + d(26), u(9) + d(9)\} = 0 \\
g(4,9) &= 100 \cdot h(4,9) - \{\sqrt{u(9) \cdot u(4)} + \sqrt{d(9) \cdot d(4)}\} \\
&= 93.7 \\
g(26,9) &= 100 \cdot h(26,9) - \{\sqrt{u(9) \cdot u(26)} + \sqrt{d(9) \cdot d(26)}\} \\
&= -6.5
\end{aligned}
$$

  - Since $g(4,9) > g(26,9)$, we get n^* = net 26
  - We merge $m^* = 9$ and $n^* = 26$

Net Merging: Zone 4 and 5 (cont)

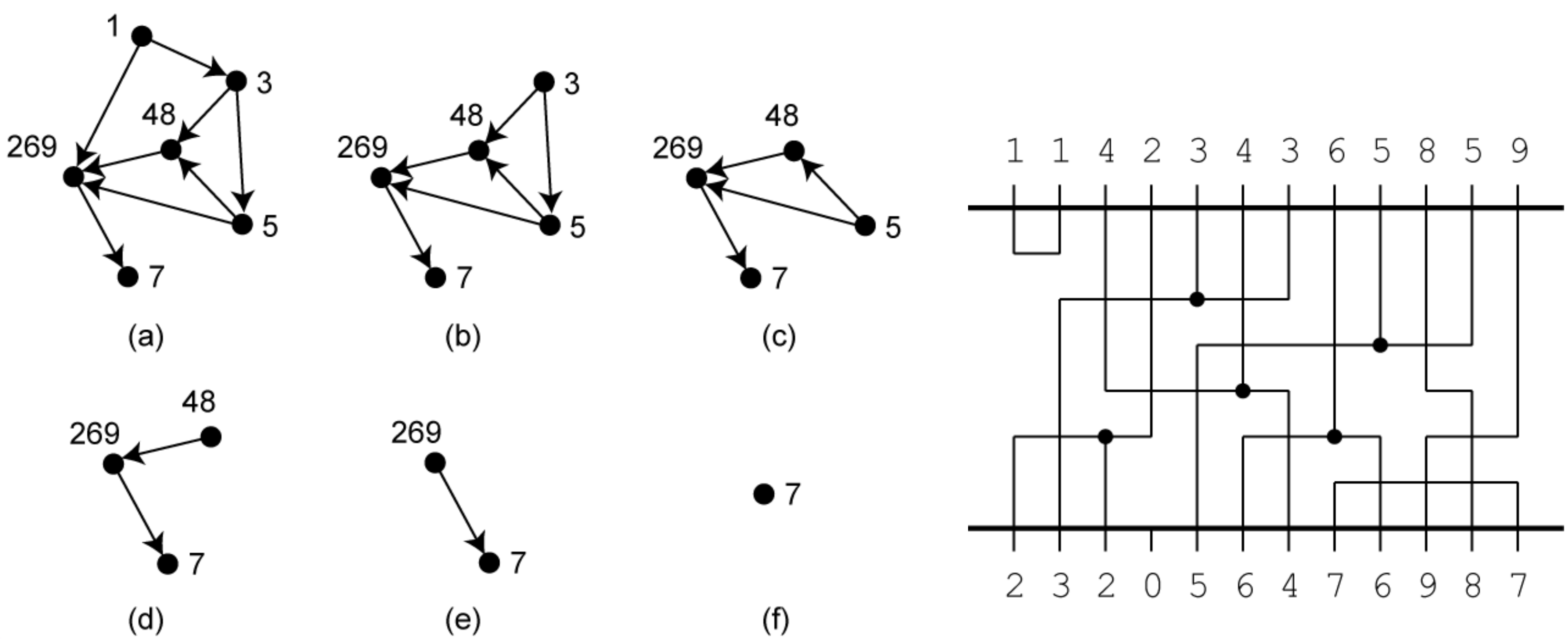
- Merged net 26 and 9
  - We had *P* = {4,26} and *Q* = {8,9}, and need to remove 26 and 9
    - *Q* is not empty, so we repeat the whole process
  - Updated *P* = {4} and *Q* = {8}
    - Trivial to see that $m^* = 8$ and $n^* = 4$, so we merge 8 and 4
  - Updated zone representation and VCG



(a) (b)

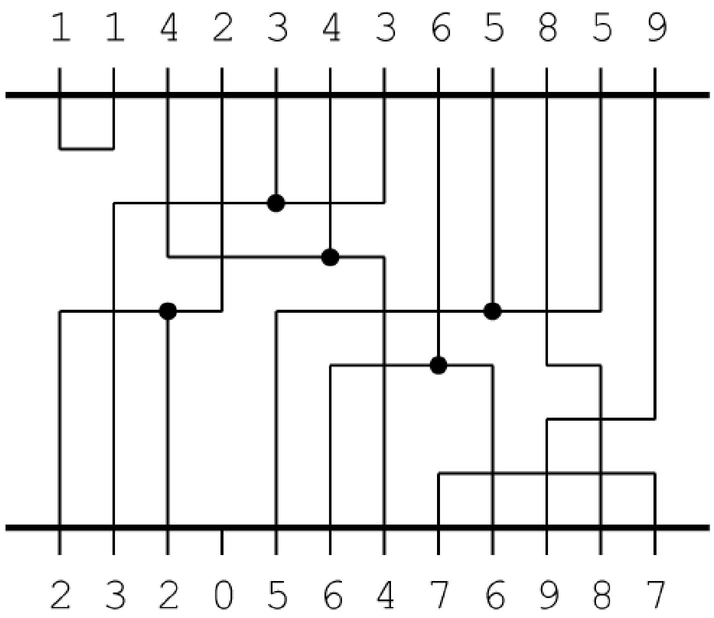
Routing with Merged Nets

- Perform CLE on merged netlist
  - Use tracks top-to-bottom, left-to-right

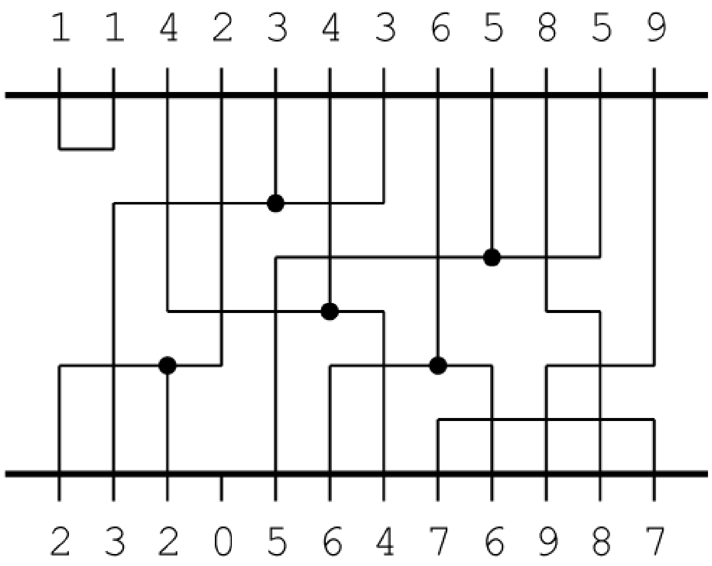


Comparison

- Net merging helped
  - Reduce channel height by 1



without net merging



with net merging