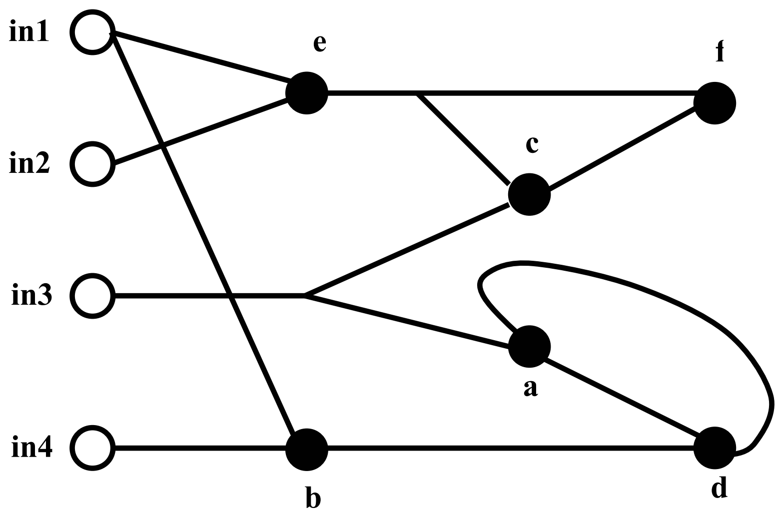
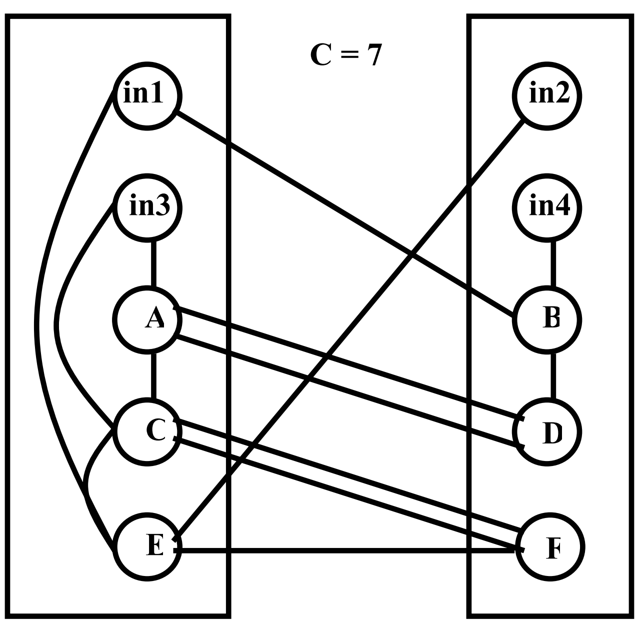
18-360 Spring 2004
Intro to Computer-Aided Design
Homework 6 Solutions

1. Partitioning

The partitioning graph is drawn below. Note that the logic gates are not shown, because the actual logic does not change the connections of the graph.

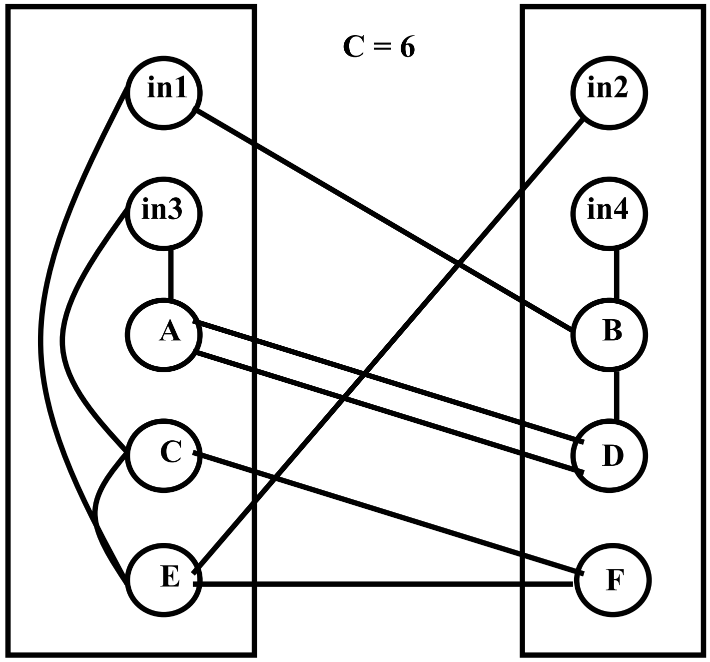


The initial partition for K&L method is



And the number of nets crossing the cut is 7.

The initial partition for S&L method is



And the number of nets crossing the cut is 6. Note that there is no connection between A and C, and only one connection between C and F.

2. Calculating Dnew and Dold

Before swapping a and b, the value of D for node x is

$$Dx(old) = Ex(old) - Ix(old)$$

where

Ex(old) = cost of connections from node x to the other partition (external cost)

Ix(old) = cost of connections from node x to the same partition (internal cost)

Let the cost of connections between x and a is Cxa and the cost of connections between x and b is Cxb. After the swap, a is moved to partition B and b is moved to partition A. Since x is in partition A, its external cost is increased by Cxa and reduced by Cxb, while its internal cost is increased by Cxb and reduced by Cxa. Therefore,

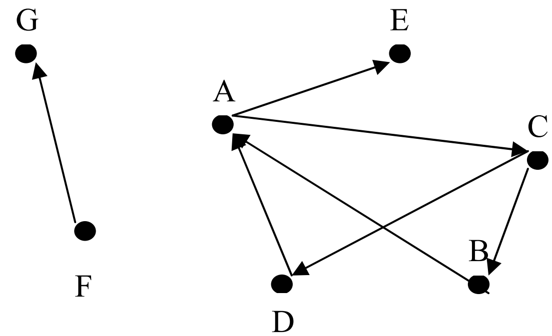
$$Ex(new) = Ex(old) + Cxa - Cxb$$
$$Ix(new) = Ix(old) + Cxb - Cxa$$

Hence,

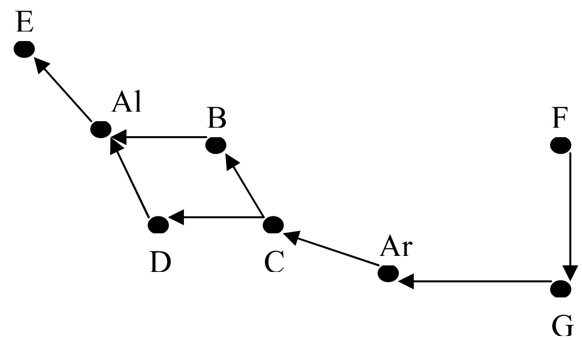
$$\begin{aligned} Dx(new) &= Ex(new) - Ix(new) \\ &= Ex(old) + Cxa - Cxb - (Ix(old) + Cxb - Cxa) \\ &= Ex(old) - Ix(old) + 2Cxa - 2Cxb \\ &= Dx(old) + 2Cxa - 2Cxb \end{aligned}$$

4. Channel Routing

a. The vertical constraint graph is drawn below:



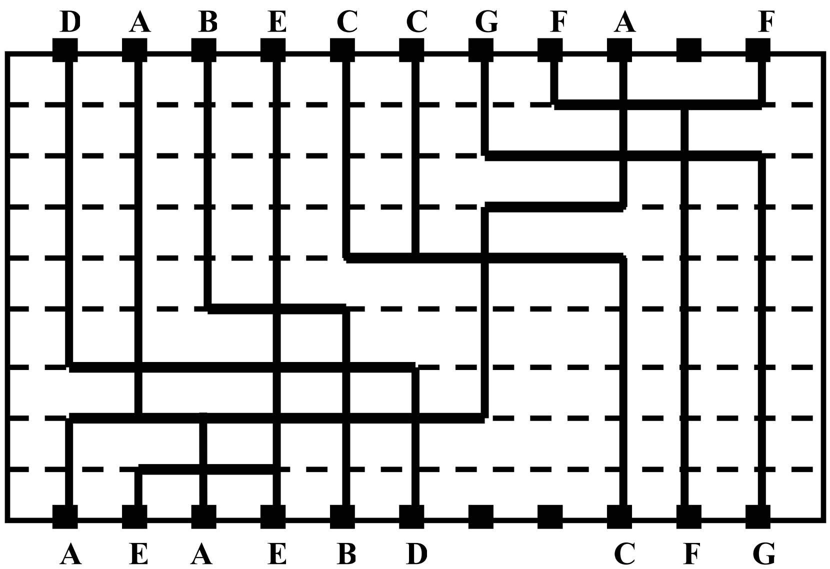
b. Choose A in the cycle A-C-D and break A into Al and Ar.



c. A dogleg on the EE column could not exist because the connection between pin E and pin E takes the whole column.

d. Adding a dogleg might cause more vertical constraints. In this case, if a dogleg is put in column BC, the resulting graph will still contain a cycle.

e. According to the left-edge algorithm, the order is: E, Al, D, B, C, Ar, G, and F. And the channel routing solution is



4. Quadratic placement
The connectivity matrix is

$$C = \begin{bmatrix} 0 & W & 0 \\ W & 0 & 1 \\ 0 & 1 & 0 \end{bmatrix}$$

The A matrix is

$$A = \begin{bmatrix} W+2 & -W & 0 \\ -W & 2W+1 & -1 \\ 0 & -1 & 3 \end{bmatrix}$$

The bx vector is

$$bx = \begin{bmatrix} 0 \\ -W \\ -1 \end{bmatrix}$$

The by vector is

$$by = \begin{bmatrix} -1 \\ -W \\ 0 \end{bmatrix}$$

The two equations are

$$Ax = -bx$$
$$Ay = -by$$

a. When W=2,

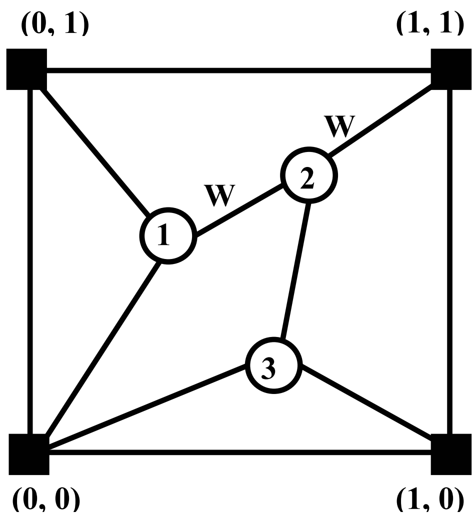
$$\begin{bmatrix} 4 & -2 & 0 \\ -2 & 5 & -1 \\ 0 & -1 & 3 \end{bmatrix}\begin{bmatrix} x1 \\ x2 \\ x3 \end{bmatrix} = -\begin{bmatrix} 0 \\ -2 \\ -1 \end{bmatrix}$$

$$\begin{bmatrix} 4 & -2 & 0 \\ -2 & 5 & -1 \\ 0 & -1 & 3 \end{bmatrix} \begin{bmatrix} y1 \\ y2 \\ y3 \end{bmatrix} = -\begin{bmatrix} -1 \\ -2 \\ 0 \end{bmatrix}$$

The placement solution is

$$\begin{bmatrix} x1 \\ x2 \\ x3 \end{bmatrix} = \begin{bmatrix} 0.3183 \\ 0.6364 \\ 0.5455 \end{bmatrix}$$

$$\begin{bmatrix} y1 \\ y2 \\ y3 \end{bmatrix} = \begin{bmatrix} 0.5909 \\ 0.6818 \\ 0.2273 \end{bmatrix}$$



b. When W=10,

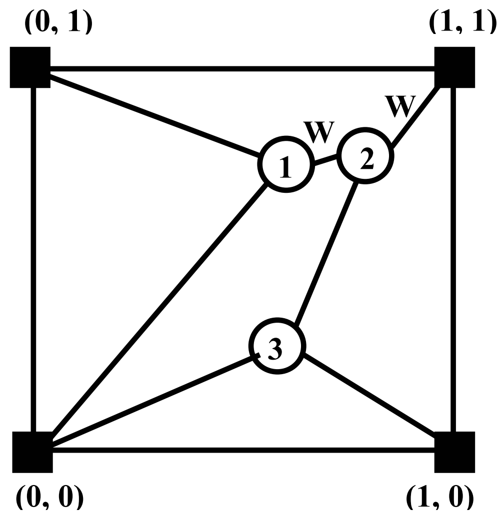
$$\begin{bmatrix} 12 & -10 & 0 \\ -10 & 21 & -1 \\ 0 & -1 & 3 \end{bmatrix} \begin{bmatrix} x1 \\ x2 \\ x3 \end{bmatrix} = -\begin{bmatrix} 0 \\ -10 \\ -1 \end{bmatrix}$$

$$\begin{bmatrix} 12 & -10 & 0 \\ -10 & 21 & -1 \\ 0 & -1 & 3 \end{bmatrix} \begin{bmatrix} y1 \\ y2 \\ y3 \end{bmatrix} = -\begin{bmatrix} -1 \\ -10 \\ 0 \end{bmatrix}$$

The placement solution is

$$\begin{bmatrix} x1 \\ x2 \\ x3 \end{bmatrix} = \begin{bmatrix} 0.6982 \\ 0.8378 \\ 0.6126 \end{bmatrix}$$

$$\begin{bmatrix} y1 \\ y2 \\ y3 \end{bmatrix} = \begin{bmatrix} 0.8153 \\ 0.8184 \\ 0.2928 \end{bmatrix}$$



c. When W=2 and the pad location changes from (1, 1) to (1, 0.5),

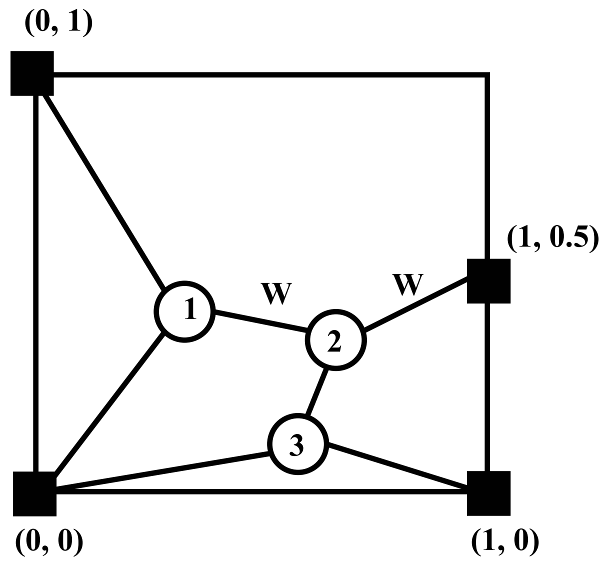
$$\begin{bmatrix} 4 & -2 & 0 \\ -2 & 5 & -1 \\ 0 & -1 & 3 \end{bmatrix}\begin{bmatrix} x1 \\ x2 \\ x3 \end{bmatrix} = -\begin{bmatrix} 0 \\ -2 \\ -1 \end{bmatrix}$$

$$\begin{bmatrix} 4 & -2 & 0 \\ -2 & 5 & -1 \\ 0 & -1 & 3 \end{bmatrix}\begin{bmatrix} y1 \\ y2 \\ y3 \end{bmatrix} = -\begin{bmatrix} -1 \\ -1 \\ 0 \end{bmatrix}$$

The placement solution is

$$\begin{bmatrix} x1 \\ x2 \\ x3 \end{bmatrix} = \begin{bmatrix} 0.3183 \\ 0.6364 \\ 0.5455 \end{bmatrix}$$

$$\begin{bmatrix} y1 \\ y2 \\ y3 \end{bmatrix} = \begin{bmatrix} 0.4545 \\ 0.4091 \\ 0.1364 \end{bmatrix}$$



d. Intuitively, assigning more weight (larger W) to a net makes it shorter. Changing pad locations affects b vector(s), but not [C] or [A] matrix, and the placement solution will be changed, too.