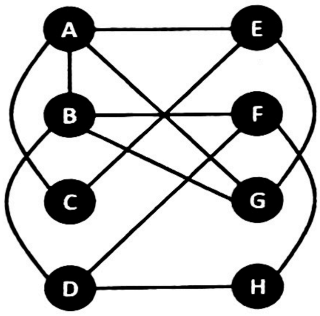
First assignment: Physical design

These take-home exercises must be solved individually and all the calculations and decisions must be shown/discussed to receive full credit of your work.

Delivery date: October 30th, 2020 (17:00h)

1 Partitioning

Given the graph in the figure, apply Kernighan&Lin to find a good bi-partition, starting from the one in the figure. Show all the steps performed during the execution of the algorithm.



2 Floorplanning

Consider the following Polish expression:

$$25V1H374VH6V8VH$$

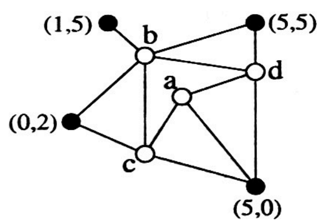
where the (width,height) of the modules 1 through 8 are:

$$\{(2,4),(1,3),(3,3),(3,5),(3,2),(5,3),(1,2),(2,4)\}$$

1. Draw the slicing tree of the floorplan assuming that V and H represent | and — cuts, respectively.
2. Calculate the minimum area of the slicing floorplan assuming that no rotation is allowed. Annotate each node of the tree with its corresponding (width,height).
3. Give a Sequence Pair representation of the same floorplan.

3 Quadratic placement

Apply quadratic placement to find the optimal location of the nodes of the following graph in order to minimize the the squared Euclidean distance of the connected nodes. The graph has some nodes with fixed locations in which the (x, y) coordinates are specified.



To solve the problem describe the following steps:

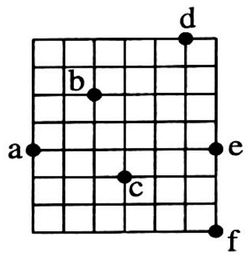
- Show the two linear system of equations for the x and y coordinates.
- Solve the systems of equations and draw the final solution in a 2D plot.

To solve the system of equations you can use any web solver. For example, select the matrix method in:

`http://wims.unice.fr/wims/en_tool~linear~linsolver.html`

4 Spanning/Steiner trees

Consider the routing problem of the figure in which all points must be connected.



- Calculate a Rectilinear Minimum Spanning Tree using Prim's algorithm. Start executing the algorithm from vertex a.
- Draw the Hannan grid and identify possible candidates for Steiner points.
- Use some heuristic algorithm to find a Rectilinear Steiner Tree with shorter wirelength than the Minimum Spanning Tree. You should use one of the algorithms published in the literature (including the ones covered in the course).

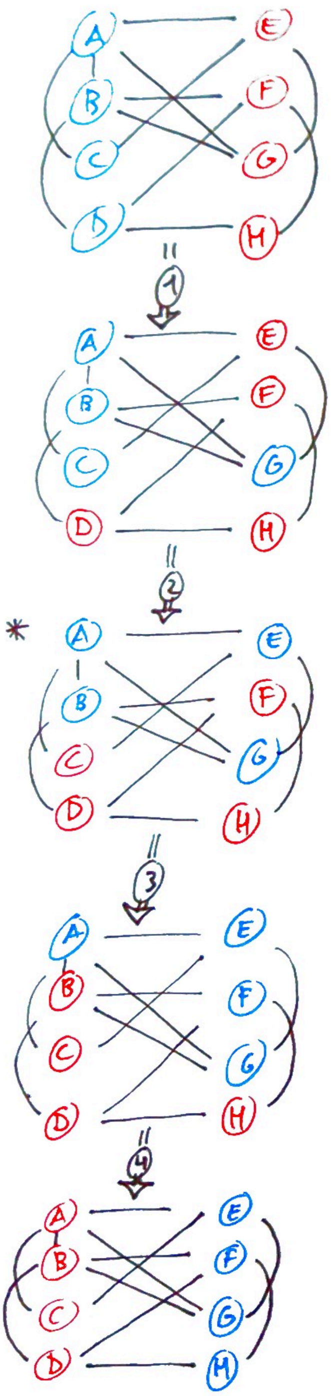
5 Channel routing

Given a channel with the following pin connections (0 means no pin):

```
TOP = [ 2 1 3 0 3 2 2 0 4 5 0 ]
BOT = [ 4 0 2 3 1 4 5 0 0 3 4 ]
```

- Determine the zone representation for the nets.
- Draw the vertical constraint graph without splitting the nets.
- Draw the vertical constraint graph with net splitting.
- Use the Dogleg Left-Edge algorithm to route this channel. For each track, state which nets are assigned. Draw the final routed channel.

1 - Partitions



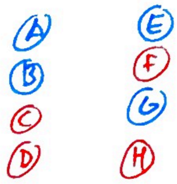
①
$$\begin{cases} D(A) = 0 & D(E) = 1 \\ D(B) = 0 & D(F) = 1 \\ D(C) = 0 & D(G) = 1 \\ D(D) = 1 & D(H) = 0 \\ \Delta g = 2 & \\ \text{Swap } (D, G) & \\ G_1 = \Delta g = 2 & \end{cases}$$

②
$$\begin{cases} D(A) = -2 & D(E) = 3 \\ D(B) = -2 & D(F) = 1 \\ D(C) = 0 & D(G) = 0 \\ \Delta g = 3 - 2 = 1 & \\ \text{Swap } (C, E) & \\ G_2 = G_1 + \Delta g = 2 + 1 = 3 & \end{cases}$$

③
$$\begin{cases} D(A) = -2 & D(F) = -1 \\ D(B) = 0 & D(G) = -3 \\ \Delta g = -3 & \\ \text{Swap } (B, F) & \\ G_3 = G_2 + \Delta g = 3 - 3 = 0 & \end{cases}$$

④
$$\begin{cases} D(A) = 0 & D(G) = -1 \\ \Delta g = -3 & \\ \text{Swap } (A, G) & \\ G_4 = G_3 + \Delta g = 0 - 3 = -3 & \end{cases}$$

* Best partition ($G_2 = 3$)



②

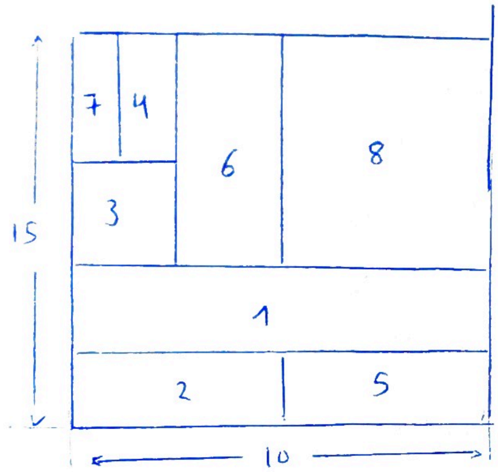
2 - Floorplanning

2.1. Slicing tree

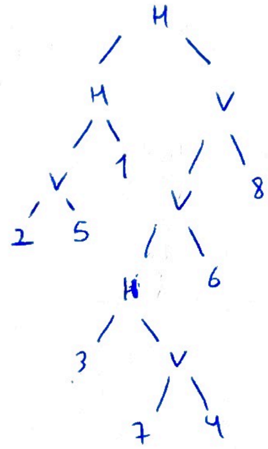
Polish Expression: 2 5 V 1 H 3 7 4 V H 6 V 8 V H

2.2. No rotation allowed

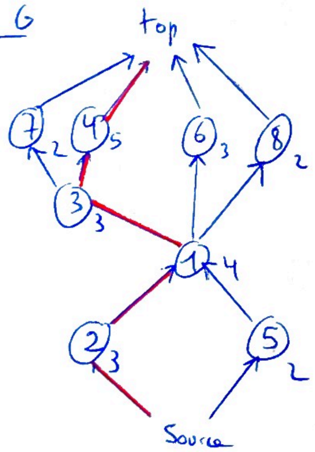
Calculate min area



Slicing tree:

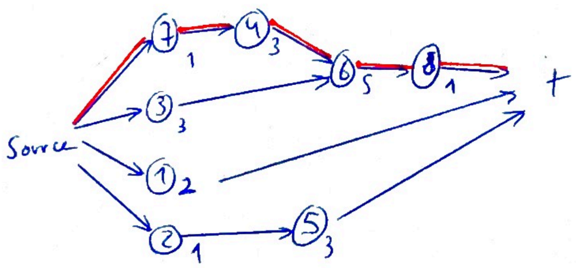


VCG



Min. height = 15

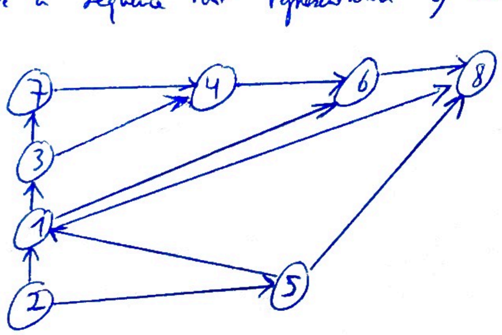
HCG



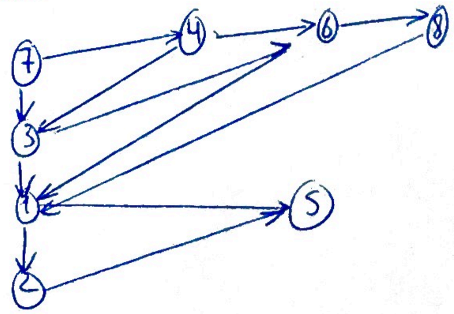
Min. width = 10

2.3 Give a Sequence Pair representation of the same floorplan

SP 2



SP 1



topological Sort = 2 5 1 3 7 4 6 8

topological Sort = 7 4 3 6 8 1 2 5

Sequence Pair = (74368125, 25137468)

3 Quadratic Placement

Suppose $\forall_{ij}\ C_{ij} = 1$ then,

$$L_x(P) = (1-b)^2 + (b-0)^2 + (b-5)^2 + (b-c)^2 + (b-d)^2 + (0-c)^2 + (5-d)^2 + (c-a)^2 + (d-c)^2 + (c-5)^2 + (a-5)^2 + (d-5)^2$$

$$\begin{pmatrix} 3 & -1 & -1 & -1 \\ -1 & 5 & -1 & -1 \\ -1 & -1 & 4 & -1 \\ -1 & -1 & -1 & 4 \end{pmatrix} \begin{pmatrix} a \\ b \\ c \\ d \end{pmatrix} = \begin{pmatrix} 5 \\ 6 \\ 5 \\ 10 \end{pmatrix}_{b_x}$$

$$\text{"} \qquad \text{"} = \begin{pmatrix} 0 \\ 12 \\ 2 \\ 5 \end{pmatrix}_{b_y}$$

$$L_x(P) \begin{cases} 3a - b - c - d = 5 \\ -a + 5b - c - d = 6 \\ -a - b + 4c - d = 5 \\ -a - b - c + 4d = 10 \end{cases}$$

$$L_y(P) \begin{cases} 3a - b - c - d = 0 \\ -a + 5b - c - d = 12 \\ -a - b + 4c - d = 2 \\ -a - b - c + 4d = 5 \end{cases}$$

$a_x = \frac{185}{22}$ $\qquad a_y = \frac{51}{11} =$

$b_x = \frac{127}{22}$ $\qquad b_y\ \frac{56}{11}$

$c_x = \frac{74}{11}$ $\qquad c_y\ \frac{226}{55}$

$d_x = \frac{85}{11}$ $\qquad d_y = \frac{259}{55}$

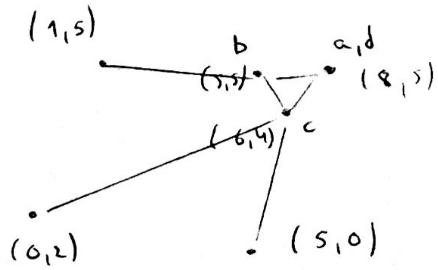
Rounding to ∞^t :

a (8, 5)

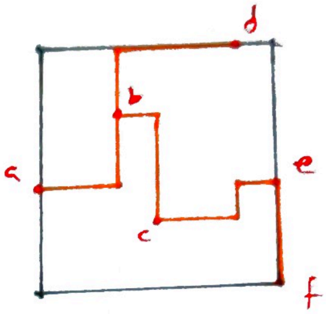
b (5, 5)

c (6, 4)

d (8, 5)



4. Spanning / Steiner trees



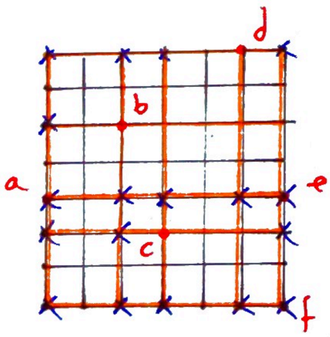
Prim's algorithm :

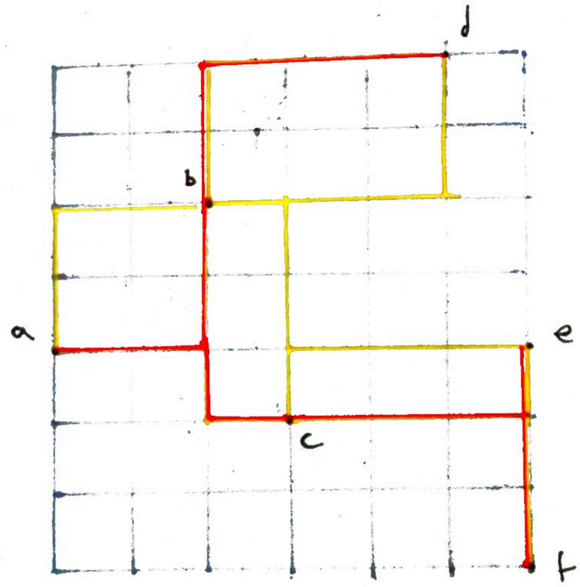
```
A = ϕ
for each v ∈ V
    Key[v] = ∞
    parent[v] = null

Key[r] = 0
Queue = V
while (Queue not empty)
    u = min(Queue)
    Q = Q − u
    if parent(u) != null
        A = A ∪ (u, parent(u))
    for each v ∈ Adj(u):
        if v ∈ Q and w(u,v) < Key[v] :
            parent[v] = u
            Key[v] = w

return A
```

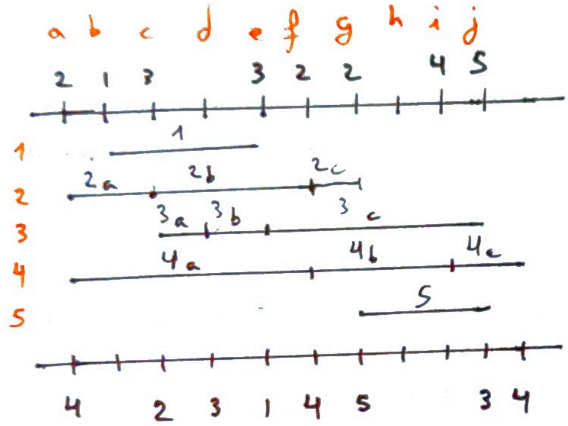
Hannah Grid :





Sequential Steiner tree Heuristic

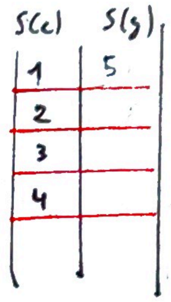
5. Channel Routing



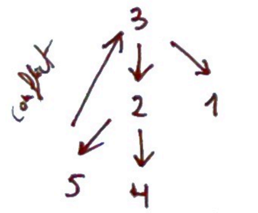
$S(c) = \{1,2,3,4\}$

$S(g) = \{3,4,5\}$

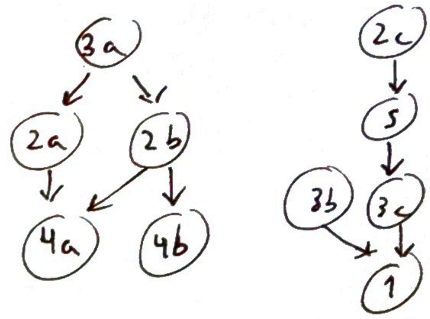
Zone representation :



Vertical Constraint Graph (without net splitting)



Vertical Constraint Graph (with splitting)



Dogleg Left-Edge algorithm