SimPL VLSI

Wednesday, July 24, 2024 12:01 PM

2. Essential Concepts

Netlist : $N = (E, V)$

E = Nets (aka signal nets, hyperedges)

V = nodes (aka vertices, cells, etc.)

} Usually converted from hypergraph to graph

Node Locations : (x_i, y_i) → cartesian location of node i or V_i

$x = \{x_i\}_{i=1}^{|E|}$

$y = \{y_i\}_{i=1}^{|E|}$

$\vec{x} = \{x_i\}$ and $\vec{y} = \{y_i\}$, $\mathrm{HPWL}_{\mathcal{N}}(\vec{x}, \vec{y}) = \mathrm{HPWL}_{\mathcal{N}}(\vec{x}) + \mathrm{HPWL}_{\mathcal{N}}(\vec{y})$, where

$$HPWL_{\mathcal{N}}(\vec{x}) = \sum_{e \in E}\left[\max_{i \in e} x_i - \min_{i \in e} x_i\right] \quad (1)$$

Separable with x and y

$\Sigma_{e \in E}$ sums over all nets in netlist

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# The "netlist", or list of nets
E = [e1, e2, ..., eN]
# A net in the netlist (mathematically a hyperedge)
e = ( source: v, sinks: (v, v, ..., v) )
v = (x, y) # location of node v
objval = 0
For e in E:
    # Convert the hyperedge into edges...
    e = (v, v, ..., v)
    objval += ... # Evaluate max(v.x) - min(v.x)
```

Quadratic optimization. Consider a graph $\mathcal{G} = (E_{\mathcal{G}}, V)$ with edges $E_{\mathcal{G}}$, vertices V, and edge weights $w_{ij} > 0$ for all edges $e_{ij} \in E_{\mathcal{G}}$. The *quadratic objective* $\Phi_{\mathcal{G}}$ is defined as

$$\Phi_{\mathcal{G}}(\vec{x}, \vec{y}) = \sum_{i,j} w_{i,j}\left[(x_i - x_j)^2 + (y_i - y_j)^2\right] \quad (2)$$

Its x and y components are cast in matrix form[2, 20]

$$\Phi_{\mathcal{G}}(\vec{x}) = \frac{1}{2}\vec{x}^T Q_x \vec{x} + \vec{c}_x^T \vec{x} + \text{const} \quad (3)$$

Kraftwerk

$Q \in \mathbb{R}^{M \times M} \rightarrow W_{ij}$

$c \in \mathbb{R}^{M} \rightarrow c_i$

$e = (p, q) \in E$

Here, e is a 2-pin edge, not a hyperedge.

$\pi(p) = i \quad , \pi(q) = j$

↳ $e = (i, j)$

$W_{x,e}$ connection weight of x-direction of edge e

i and j MOVABLE:

W_{ii} += $W_{x,e}$

W_{jj} += $W_{x,e}$

i MOVABLE, j FIXED :

W_{ii} += $W_{x,e}$

c_i -= $W_{x,e} \cdot x_j$

i and j FIXED :

Q no change

c no change

$W_{ii} \mathrel{+}= W_{x,e}$

$W_{jj} \mathrel{+}= W_{x,e}$

$W_{ij} \mathrel{-}= W_{x,e}$

$W_{ji} \mathrel{-}= W_{x,e}$

$W_{ii} \mathrel{+}= W_{x,e}$

$c_i \mathrel{-}= W_{x,e} \cdot x_j$

i FIXED, j MOVABLE:

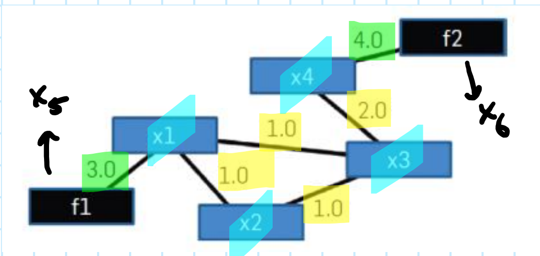
$W_{jj} \mathrel{+}= W_{x,e}$

$c_j \mathrel{-}= W_{x,e} \cdot x_i$

Q no change

c no change

$$\left.\begin{array}{l}\text{NONE FIXED: } Q \text{ PSD} \\ \text{SOME FIXED: } Q \text{ PD}\end{array}\right\} \text{Either case: } \Phi(x) \text{ convex}$$



$G = (E_G, V)$

$E_G = [e_1, e_2, \cdots, e_6]$

$e = (i, j, w_x)$ $\quad w = 1/\text{length}$

$V = [v_1, v_2, \dots, v_6]$

e1 = (x1, x5, 1.0/3.0) ✓

e2 = (x1, x2, 1.0/1.0) ✓

e3 = (x1, x3, 1.0/1.0) ✓

e4 = (x2, x3, 1.0/1.0)

e5 = (x3, x4, 1.0/2.0)

e6 = (x4, x6, 1.0/4.0)

V = [x1, x2, x3, x4, f1, f2]

$$Q = \begin{pmatrix} W_{11} & W_{12} & W_{13} & W_{14} \\ W_{21} & W_{22} & W_{23} & W_{24} \\ W_{31} & W_{32} & W_{33} & W_{34} \\ W_{41} & W_{42} & W_{43} & W_{44} \end{pmatrix} \; i \; =$$

j

1/3+1+1	-1		
-1	1+1	-1	
	-1	1+1	

$$c = \begin{pmatrix} -\frac{1}{3} \\ \\ \\ \end{pmatrix}$$