VLSI CAD spring 2021

Assignment 2 – Placement & Routing

Tips: Choose 2 of the 3 programming problems

1. Considering the following netlist.

   NL_1: $n_1 = a - b - c$, $n_2 = b - d - e - f$, $n_3 = c - f - g$, $n_4 = a - g$, $n_5 = d - e - h$, $n_6 = f - h$.

   Given an inital partition $P_1 = \{a, b, c, d | e, f, g, h\}$.

   (a) Model NL_1 with an edge-weighted undirected graph G_1. The edge weight is $\frac{1}{k-1}$, where k is the number of gates, e.g., $\frac{1}{2}$ for n_1 and $\frac{1}{3}$ for n_2. For P_1, perform a single pass of KL algorithm. Given the cut size after each swap.

   (b) Model NL_1 with a non-weighted hypergraph H_1. For P_1, calculate the initial cell gain and setup buckets for block 0 and 1. Perform a single pass of FM algorithm with area constraint [3, 5], i.e., min is 3 and max is 5 for either side. Ties should be broken in alphabetical order. Give the cut size after each move.

   (c) Perform edge coarsening on NL_1 and derive the corresponding coarsened netlist. Visit gates in alphabetical order and coarsen edges based on its weight. Break ties with the same weight based on alphabetical order. Perform Modified Hyperedge coarsening on NL_1 and derive the corresponding coarsened netlist. Visit nets based on their weights and break ties based on their indices.

   (d) Model NL_1 with a flow network, where $(s, t) = (a, h)$, with edge in flow/capacity format. Compute an augmenting path and the maximum amount of flow that can be pushed on it. Update the flow network after the additional flow.

2. (programming) Implement a 2-way FM algorithm.

   code : `hw2_pnr/partition`

3. (programming) Implement the sequence pair and recover the floorplans from the input.

   code : `hw2_pnr/sequencepair`

4. (writing) Prove the convexity of the following objective functions:

   (a) HPWL (hint: pointwise maximum preserves convexity)

   (b) Euclidean clique model (hint: norm)

   (c) LSE (hint: composition with scalar function preserves convexity)

5. (programming) Implement the one of the following wirelength operators and its gradient for a single net. (hint: be careful about numerical overflow)
   (a) log-sum-exp wirelength operator
   code : `hw_pnr/wirelength/LSE`
   (b) bi-variant wirelength operator
   BiG: A Bivariate Gradient-Based Wirelength Model for Analytical Circuit Placement
   code : `hw_pnr/wirelength/BiG`

6. (writing) Formulate an ILP-based global routing problem and solve with Gurobi (Free academic license). Netlist: $\{n_1 = B_2 - B_4 - B_6, n_2 = B_3 - B_4, n_3 = B_1 - B_2 - B_5 - B_6, n_4 = B_2 - B_5\}$. Assume that the capacity of each boundary is as follows: $\{B_1 - B_2 : 3, B_2 - B_3 : 4, B_4 - B_5 : 5, B_5 - B_6 : 4, B_1 - B_4 : 7, B_2 - B_5 : 5, B_3 - B_6 : 3\}$. You do not really need to write a program to solve it. Simply write down the ILP formulation in Gurobi's LP format and feed to the solver.

B_1	B_2	B_3
B_4	B_5	B_6