CAD of Digital Circuits — Physical Design

Spring 2014, Homework # 3
Due Date: Monday, April 14 (in class)

1) *Analytical and Stochastic approaches to a min-wirelength placement:* [This one is a thinking problem. The answers will depend on your formulation, so make sure you describe your answer very clearly, and mathematically.] (60 points)

   Consider a 3×3 grid, and 8 cells $C_1, \ldots C_8$ of equal sizes that have to be placed in this square grid. The cell C_9 is actually fixed to location $(3,3)$. The placement objective is the minimization of *the sum total of all wire-lengths*. The netlist is given as follows:

   $$N_1 = (C_9, C_8); N_2 = (C_3, C_8); N_3 = (C_1, C_9); N_4 = (C_4, C_3); N_5 = (C_5, C_3); N_6 = (C_7, C_6); N_7 = (C_2, C_8);$$

   Assume that the routing grid has infinite capacity, and any module m can be place in any (i,j) location, except of course, cell C_9 and location $(3,3)$.

   a) Can such a placement problem be modeled as a *mixed integer-linear program* (MILP)? If yes, then describe your program, and generate a placement for the above netlist. If you believe that such a placement cannot be modeled as a MILP, then give the reason as to why the program is not linear.

   b) Write a simulated annealing based computer program to derive a placement for the above netlist. Your program should contain a (simplified ?) version of the Metropolis function, should implement pairwaise cell interchange, should perform some hill climbing (cannot be totally greedy), and you may use the following parameters: i) Initial placement: random; ii) Initial temperature T = 10; iii) Cooling rate $\alpha = 0.9$; iv) constant $\beta = 1.0$; v) M = time until next parameter update in Metropolis = 10; vi) Termination criteria: T reduces to 50% of its original value. *Does your approach need any legalization at all?* Provide a brief write-up of your approach and your program. Attach your program output and solution. How many hill climbing moves does your program make?

2) (10 points) Solve the following Channel routing problem, clearly showing your zone representation (or HCG), VCG, and any needed modifications to the VCG. How many tracks does your solution utilize? The channel is given as:

   TOP = [1, 4, 2, 0, 2, 3, 4, 5]

   BOTTOM = [2, 0, 3, 3, 1, 4, 5, 5]

3) (30 points) Using the net/node merging techniqe of Yoshimura and Kuh, solve the following channel routing problem:

   TOP = [0,1, 0, 2, 1, 5, 5, 6, 8, 0, 1, 9, 8, 10, 11, 12]

   Bottom = [2, 3, 1, 4, 4, 3, 6, 3, 1, 9, 9, 11, 10, 11, 12, 12]

   Show your work clearly.