California Institute of Technology
Department of Computer Science
Electronic Design Automation

CS286.5b, Winter 2000 Assignment #1 revised Tuesday, January 11

Due: Friday, January 28, 11:59pm.

Note

This replaces my original draft for assignment 1. In retrospect, doing it "Right" would have been much harder than I intended. Some of the questions here are targeted at illuminating the characteristics of the problem.

I will weight this problem set a bit less than the original assignment 1 and weight the second assignment (which will be a programming assignment) more heavily to balance it out. I'm giving you until the original assignment deadline to finish this, but expect this is significantly less work and you should reasonably finish this a week earlier.

Resources You are free to use any books, articles, notes, or papers as references. Provide citations in your writeup as appropriate.

Collaboration I expect these to be individual work.

Writeup Writeup should be in an electronicly readable format (HTML or PDF preferred).

Problems

1. In class, we have assumed our target netlists have multiple outputs. If our function only has a single output, does that simplify any of the problems we have been addressing? (*e.g.* does optimal covering for area still remain NP-hard?, or can I exploit this restriction to get an optimal solution in reasonable time?) Explain why or why not. [10]

2. Show an example where all three optimization criteria would give rise to different optimal coverings. [10]

   (a) area in LUTs

   (b) delay in LUT delays (you may assume fanout does not affect delay)

(c) energy in total switching activity on LUT outputs (you may assign switching activities to outputs as you need to create your example)

3. The following underscore why area optimization (even under the duplication-free restriction) is more complicated than delay mapping. I did not do this point justice in class. You may want to take a look at [1]. This is also the core to why the problem is more involved than I originally envisioned.

   (a) Show an example where taking the min-height, K-feasible cut is **not** the optimal covering for area. [10]

   (b) Show an example where the mincut from a target node is 3 but the best cut to use for K=4-LUT area minimization is of size 4. [15]

   (c) Give the (trivial) $\Theta(n^K)$ algorithm for exploring all K-feasible cuts. (Note that the aforementioned paper gives a more complicated algorithm which is much better in practice). [10]

4. In LUT covering/cluster for power, does exposed switching activity have a monotone property? Explain why or why not? [5]

5. Develop a dynamic-programming based algorithm for LUT covering to minimize energy consumption (exposed switching activity).

   (a) Give pseudocode for your algorithm (in the style of [1] or [2]). [25]

   (b) Analyze the complexity/running time for your algorithm. [5]

   (c) Explain the optimality of your solution (for what classes of problems is it optimal? in what cases is it non-optimal and why?). [10]

References

[1] Jason Cong and Yuzheng Ding. On area/depth trade-off in lut-based fpga technology mapping. *IEEE Transactions on VLSI Design*, 2(2):137–148, June 1994.

[2] Thomas Cormen, Charles Leiserson, and Ronald Rivest. *Introduction to Algorithms*. MIT Press, 1990.