

University of Pennsylvania
Department of Electrical and System Engineering
Computer Organization

ESE534, Spring 2012

Assignment 9: Mesh Interconnect

March 26

Due: Monday, April 2, 12:00PM

For this assignment, you will model direct-drive, unidirectional mesh interconnect and explore design parameters for mesh networks using Toronto's placement and routing tool `vpr`. We will look at the characteristics of two specific designs (`des`, `clma`).

1. Use `vpr` in global route mode to determine the minimum global channel width and number of used segments for each design.
2. Create a model for the switching energy consumed by the network when using fully interconnected switchboxes¹ and length one segments. This is the model that can achieve the minimum global channel width identified above. Writeup should describe the composition and derivation of your model.
3. Use your model and data above to estimate the network switching energy required for each design.
4. Use `vpr` in route only mode to determine how the channel width, number of used segments, and delay varies when the segment length is increased from 1 to 10 when using a unidirectional network with wilton switchboxes. For each design, make a table with segment length, delay, channel width, and segment count (total wire segments used) columns. Plot each of {delay, channel width, segment count} versus segment length for each design.
5. Create a model for the switching energy consumed by the detailed routing network using the wilton switchbox² with a unidirectional (single-driver, direct drive) mesh architecture. You will need to use this model to estimate energy of various architectural and design cases, so parametrize it appropriately. Writeup should describe the composition and derivation of your model.
6. Use your model and `vpr` route results to estimate the network switching energy required for each design at each segment length. Make a table of results and plot energy versus segment length for each design.
7. Identify the segment length that minimizes the network switching energy for each design.

¹Each wire can connect to any of the wires in any of the 3 adjacent channels with no directional constraints..

²Important feature for modeling is that this is a linear-population switchbox with $F_s = 3$.

8. How does the minimum energy of the wilton switchbox population at the energy minimizing segment length compare to the energy for the fully connected switchbox design?
9. How could leakage energy change your selection of the network energy minimizing segment length in 7? What segment length(s) would you choose under what conditions? We are asking for a qualitative answer that discusses the trends. We are not providing enough information to answer fully quantitatively.
 - Active devices (like LUTs and switch buffers) leak continuously.
 - Assume your design runs as fast as interconnect delay allows.
 - If you were only minimizing leakage energy per cycle, which segment length would you pick? How is it different from what you selected in Problem 7. What does this suggest about where the minimum total energy point might be?

We are deliberately giving you less guidance for models on this assignment.

- We are using a $k = 4$, $n = 10$ CLB. That is, each logic block contains 10 4-input LUTs.
- Designs are in: `/home1/e/ese534/hw9/nets/`
- Associated placements are in: `/home1/e/ese534/hw9/place/`
- Assume $V_{dd} = 0.75\text{V}$
- Assume equal switching probability on all LUT outputs of 15%.
- Assume each logic-block length metal wire has $C_{metal} = 3.0 \times 10^{-15}\text{F}$.
- Assume each switchbox or connection box buffer input that touches a segment contributes $C_{sw} = 0.4 \times 10^{-15}\text{F}$.
- Assume any used switch box or connection box mux provides an additional (internal) switched load of $C_{sw} = 2.0 \times 10^{-15}\text{F}$.
- Pay attention to the Logic Block to channel IO population as described in the architecture file. (Note $F_{cin}=0.25$, $F_{cout}=1.00$) This should be reflected in your linear population energy model.

vpr notes:

- You can find a copy of the vpr executable on the CETS computing systems:
/project/ese/ic/usr/vpr5/vpr
- You can find the manual for vpr:
/home1/e/ese534/hw9/vpr_manual_500.pdf
- To perform this experiment, you will need to create a separate architecture file for each segment length. The architecture file is described in Section 6.2 of the vpr manual.
- A base, segment length 1, architecture file is provided in:
/home1/e/ese534/hw9/arch/k4-n10.xml
- VPR is particular about the consistency of the placement file and architecture file. If the architecture file listed on the first line of the placement file does not exactly match the one used in your invocation, it will terminate. As such, you may need to make a copy of the placement file and edit the first line to match your architecture file. This will certainly be necessary in Problem 4 where you need to create and use different architecture files.
- A typical command for invoking vpr in detail route mode (Problem 4) will look like:
vpr des.net k4-n10.xml des.place des.seg1.route -nodisp -route_only
-router_algorithm breadth_first

Where:

- des.net is the design (the netlist)
- k4-n10.xml is the architecture file
- des.place is a placement for the design
- des.seg1.route is the file in which to store the route for the design
- -nodisp tells it not to bring up the interactive X display
- -route_only tells it not to perform placement (use the given placement)
- -route_algorithm breadth_first tells it to use a channel minimizing router
- If you drop the -nodisp option, you can interact with vpr and it will show you pictures of the design. See the vpr manual for further detail on this and other vpr options. This may be particularly useful in disambiguating any uncertainty you may have about how vpr makes the connection box and switchbox patterns.
- Note that the vpr output tells you the channel width, delay, and number of segments used. You want “physical segments”.
- A typical command for invoking vpr in global route mode (Problem 1) will look like:
vpr des.net k4-n10.xml des.place des.seg1.route -nodisp -route_only
-router_algorithm breadth_first -route_type global
- -route_type global tells it to perform global rather than detail routing