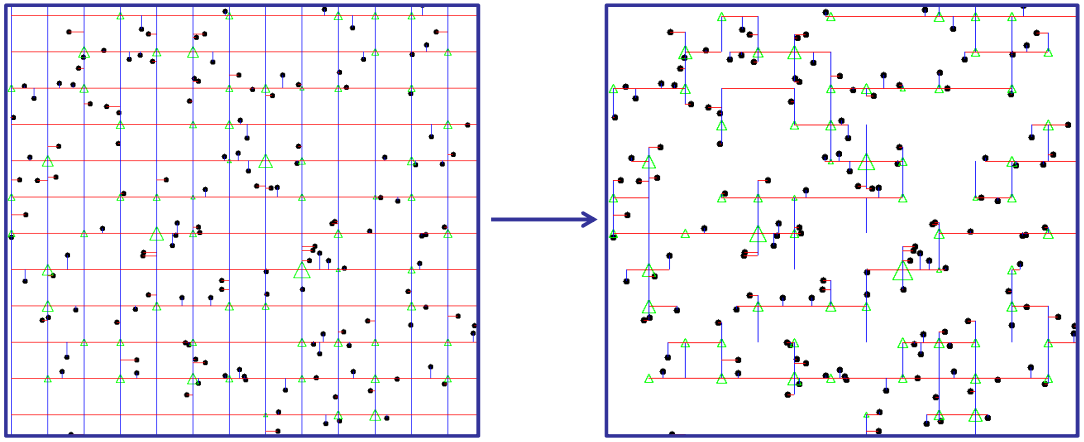
Reducing Power Consumption in Clock Grids

Creating a Clock Grid Reduction Algorithm which Removes Wires that do not Contribute Significantly to Performance

Kathryn Dobbins, Xuchu Hu, Matthew Guthaus
Michigan Technological University, University of California Santa Cruz
kmdobbin@mtu.edu, hxcu@soe.ucsc.edu, mrg@soe.ucsc.edu

1 Clock Grids

- The clock is an on-off signal in the CPU that enables the components in the processor to work together.
- It is critical to get this clock signal to all of the flip-flops in the CPU at the same time. These flip-flops are called sinks.
- One of the ways to reduce the clock skew (the time between when the first sink receives the clock signal and the last sink receives the clock signal) is by using a clock grid.
- The clock signal starts out from one wire and branches out like a tree, with the ends of the tree hitting the grid, being amplified by the buffers.
- Because there is variability in the wires and buffers, it is beneficial to have a grid of wires, which helps average out the variation.



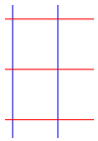
Buffers

Buffers are where wires with the clock signal are amplified and touch the grid. The size of the triangle is proportional to the amount the signal is amplified.

Sinks

Sinks are the flip-flops in the CPU that need the clock signal.

Wires



These horizontal and vertical wires connect the sinks and buffers.

2 Motivation

- Although Clock grids are good at reducing clock skew, the redundant wires use lots of power.
- It would be beneficial to be given the option to remove wires not contributing significantly to performance in order to use less power.
- There currently is a good grid reduction algorithm. However, this algorithm takes a long time to execute. (multiple hours)

3 Goal

To create a fast algorithm which will be able to remove wires in the grid in order to balance performance and power usage.

4 Relationship between Current and Skew

Each point in these graphs represent the data from a wire. The current (y axis) is the amount of current that is passing through the wire before any of the grid wires have been removed. The absolute value of the change in skew (x axis) is calculated by taking the absolute value of the difference between the skew with no wires removed and the skew with this wire removed. As can be seen, some benchmarks have a higher correlation between the current and change in skew than others.

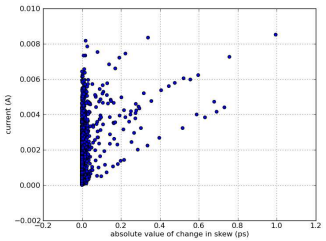


Figure 1: This shows the correlation between current and change in skew for a grid with a high density of grid wires. As can be seen, there is some correlation between current and change in skew, although it is not very high.

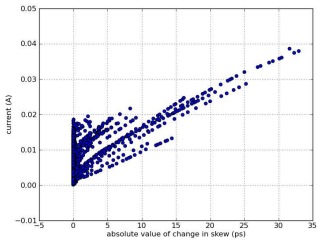


Figure 2: This graph is run on the same benchmark as Figure 1 with a less dense grid. As can be seen when comparing the two graphs, with a lower grid density there is a higher correlation between current and change in skew for this benchmark.

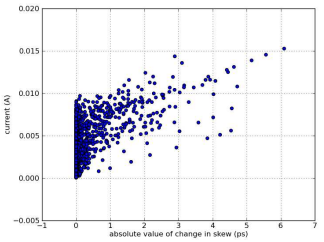


Figure 3: This graph is run on a different benchmark than what is shown in Figure 1 and Figure 2. It is run on a grid that is not very dense. As can be seen, there is some correlation between current and change in skew, although the correlation is not particularly high.

5 Results & Conclusions

- An algorithm based off of current would produce better results for some grids than others.
- The density of the grids has an impact on how much correlation there is between the current and change in skew when wires are removed.
- Although wires with higher amounts of current may or may not result in a large change in skew when removed, wires with lower currents seem to consistently result in a small change in skew when removed.