

What Makes A Design Difficult to Route

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What Does This Man and a Router Have in Common?



Young math whiz

Discovers computer programming

Drops out of Harvard

Starts Microsoft

Works really hard

Becomes very rich

Bill's Opportunities

ASR-33 Teletype



1968: 8th grade



1968: Bill Gates (standing) and Paul Allen working at the computer terminal at Lakeside school



TRW

1955

Some Math Whiz, Computer Programmer, Hard Working Guys



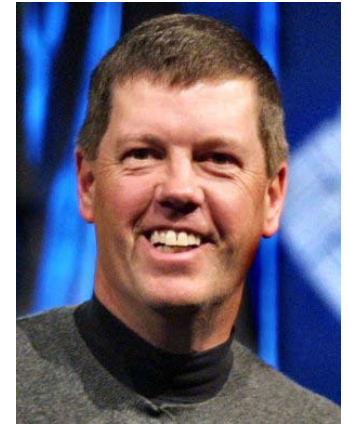
Bill Gates
Oct. 1955



Steve Jobs
Feb. 1955



Bill Joy
Nov. 1954



Scott McNealy
Nov. 1954



Eric Schmidt
Apr. 1955

What's the Difference Between These Guys?

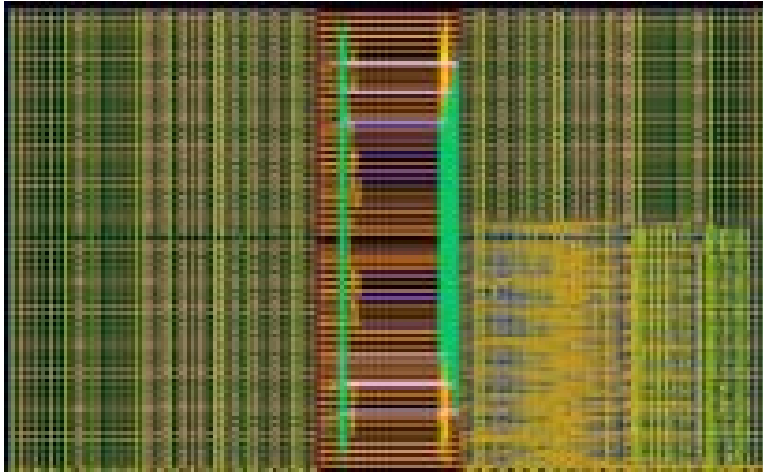


1973



1969

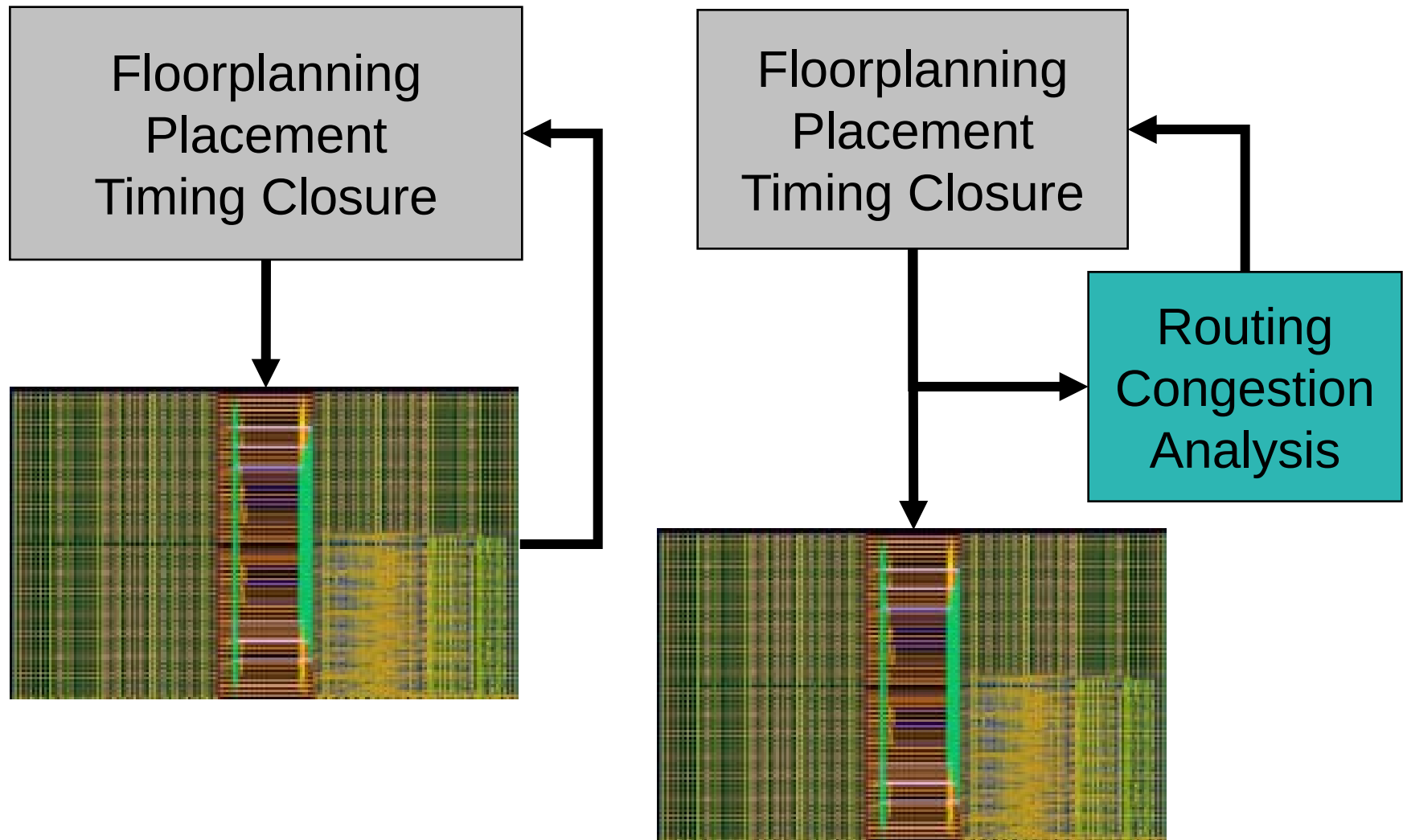
What Does a Router Have in Common with Bill Gates?



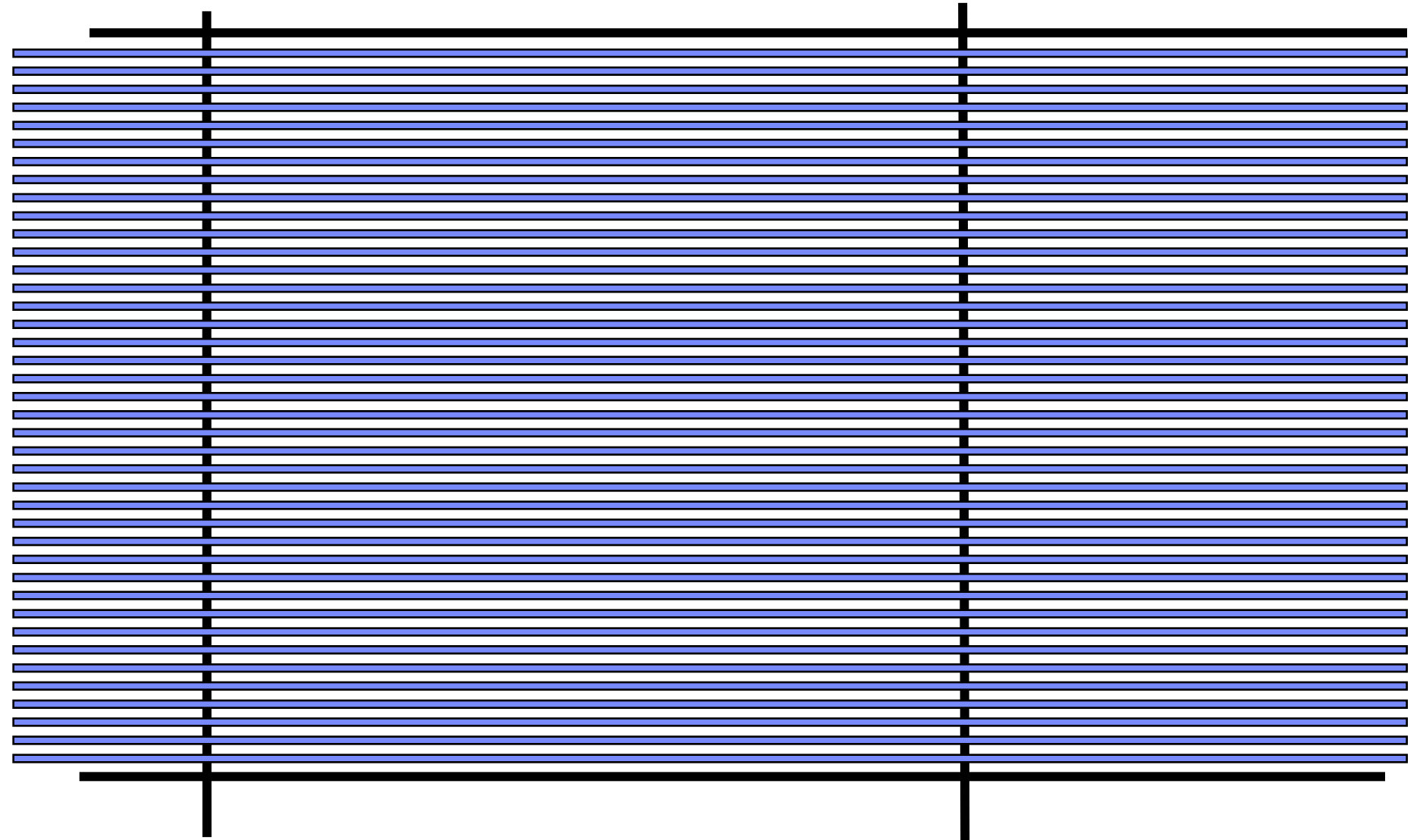
Give them the opportunity to succeed, and they will

Take away the opportunity to succeed, and they won't

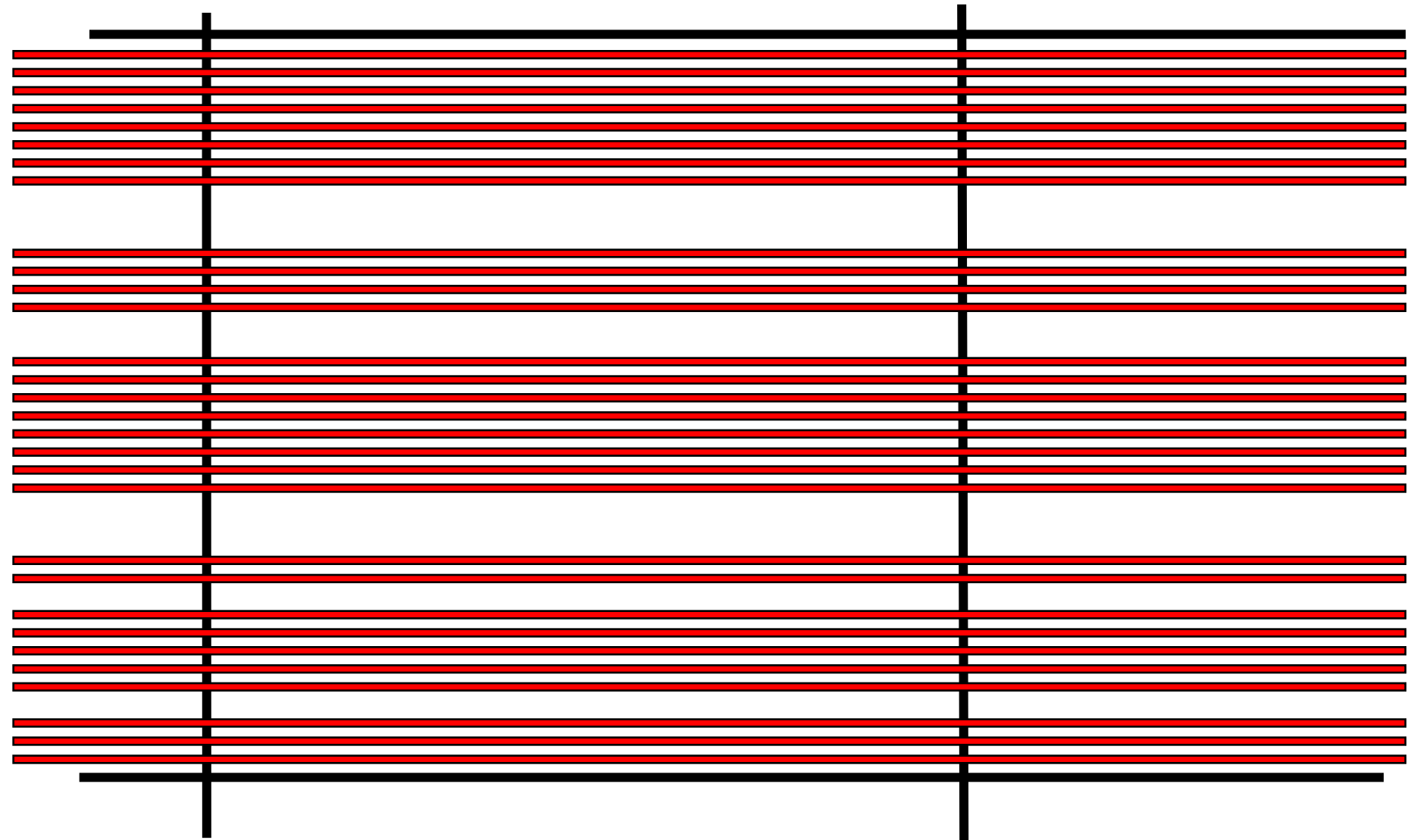
Routing is From Venus, Congestion Analysis is From Mars



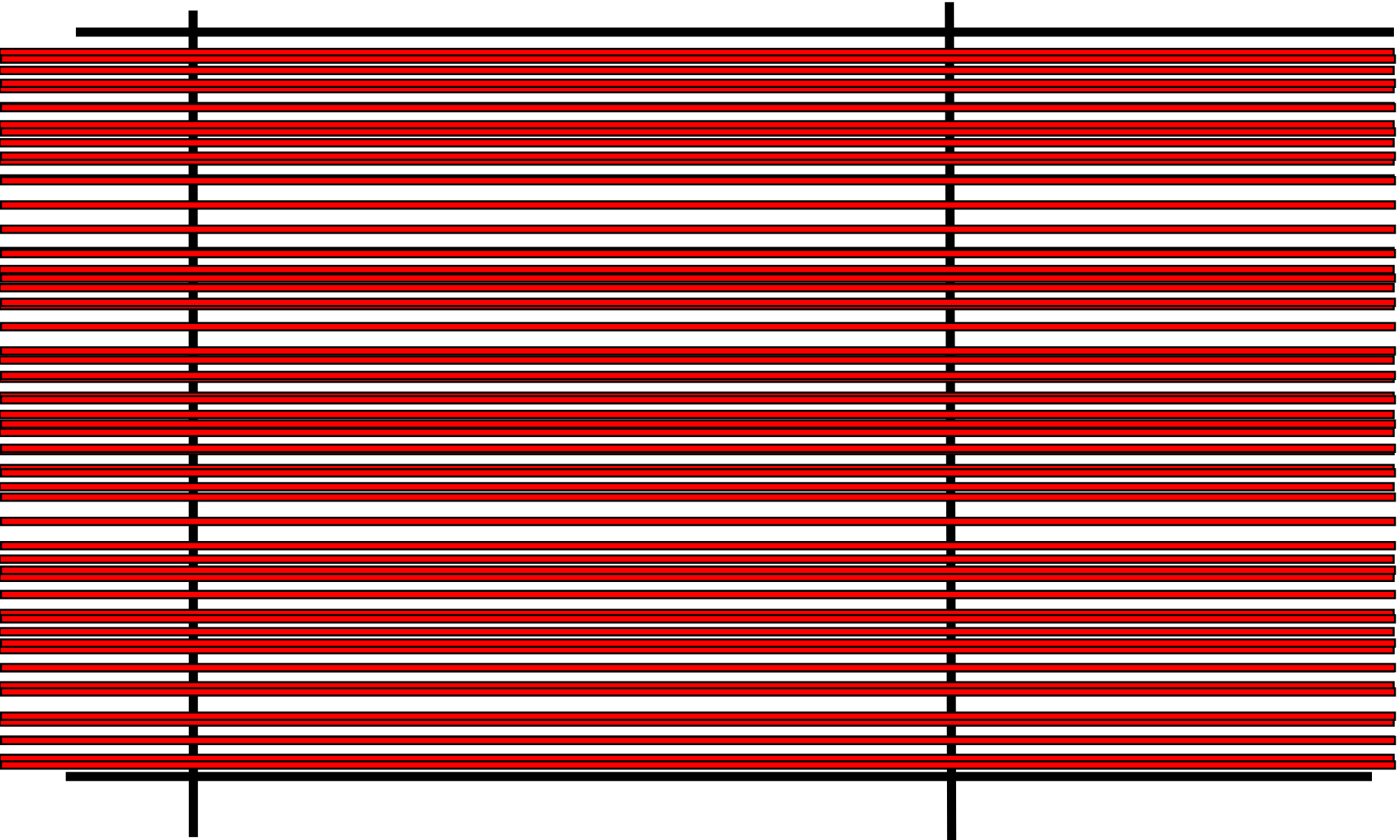
Measuring Routing Quality (40-track per gcell)



Routable gcell (75% full)

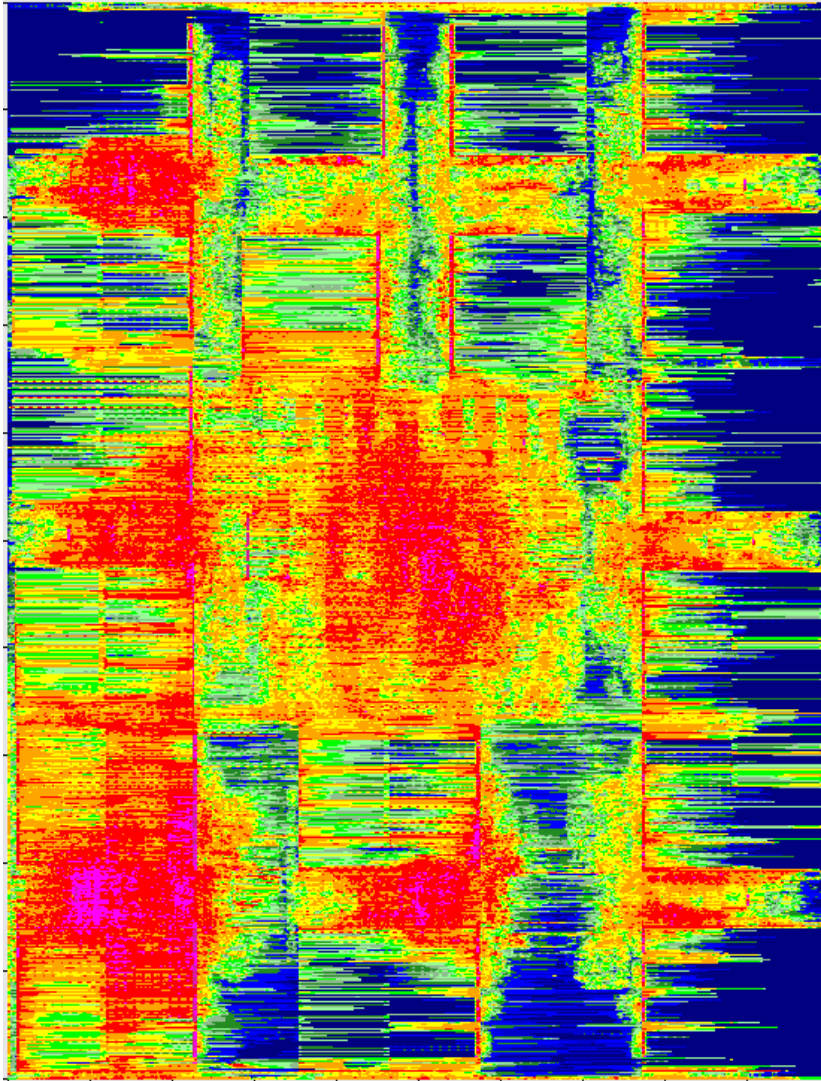


Unroutable gcell (150% full) – 20 Nets of Overflow



Example Congestion Map

Horizontal Congestion

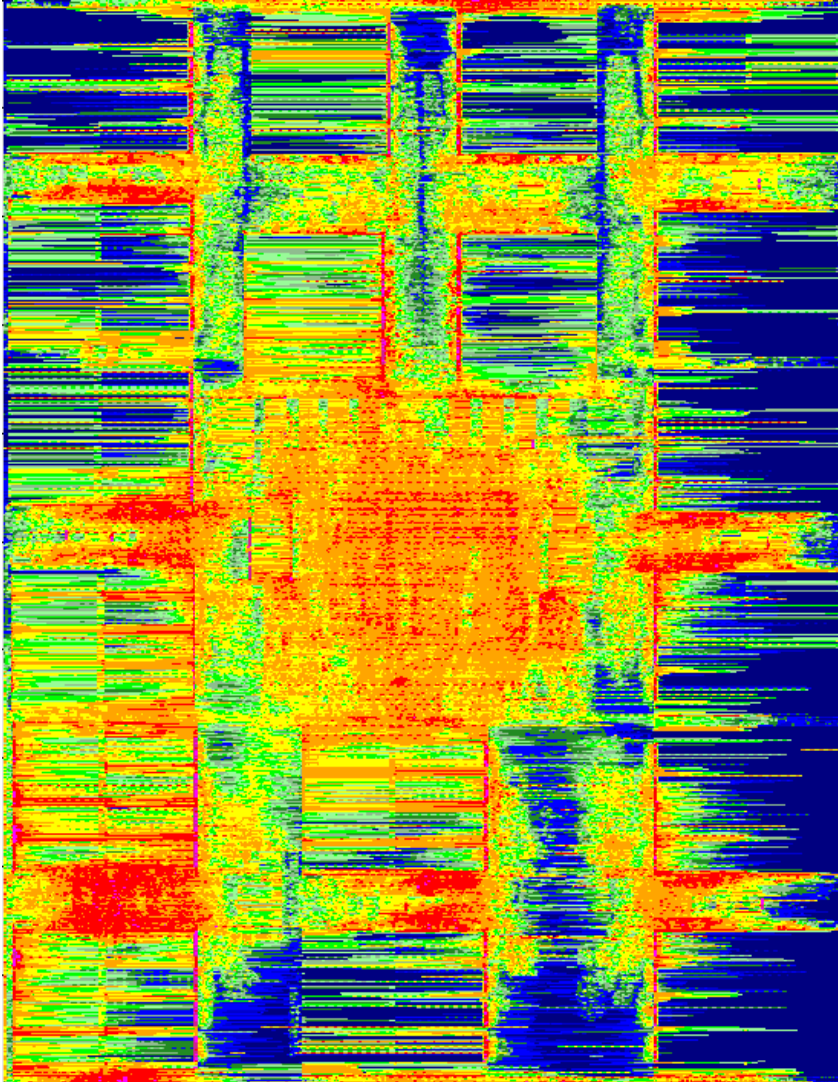


Vertical Congestion

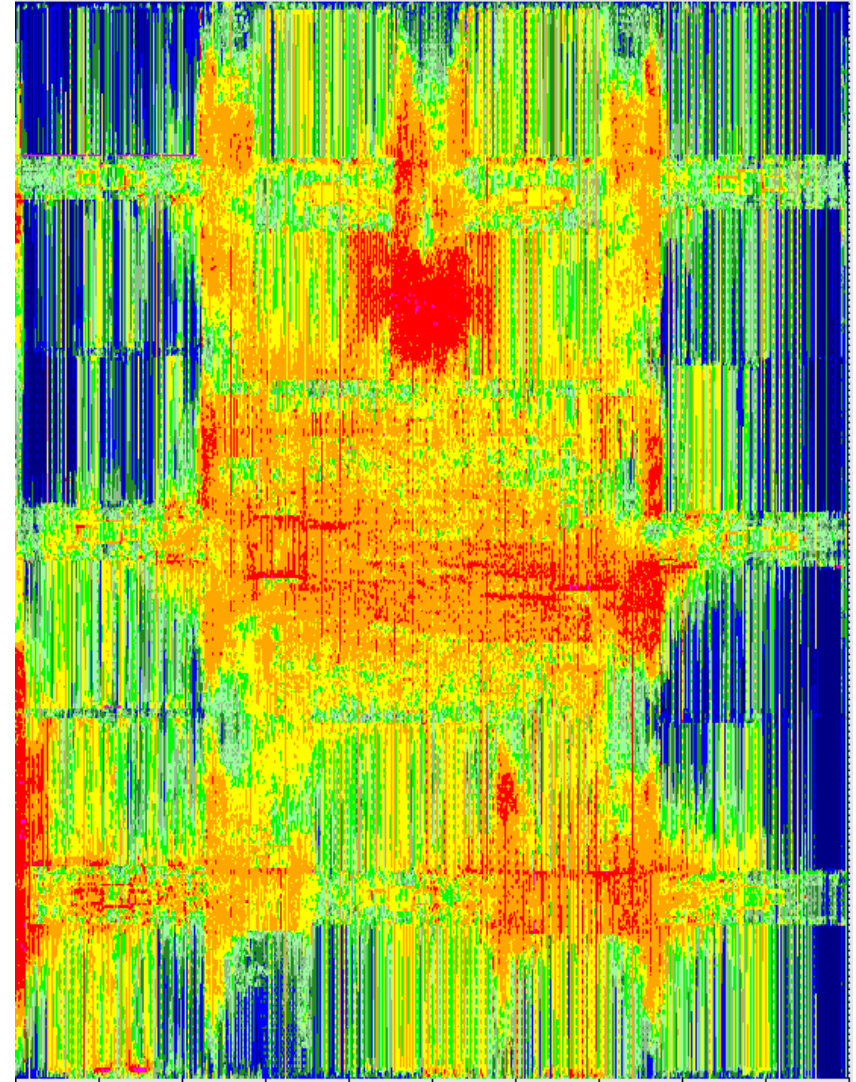


Congestion Map with Better Physical Synthesis

Horizontal Congestion



Vertical Congestion



Common Routing Metrics

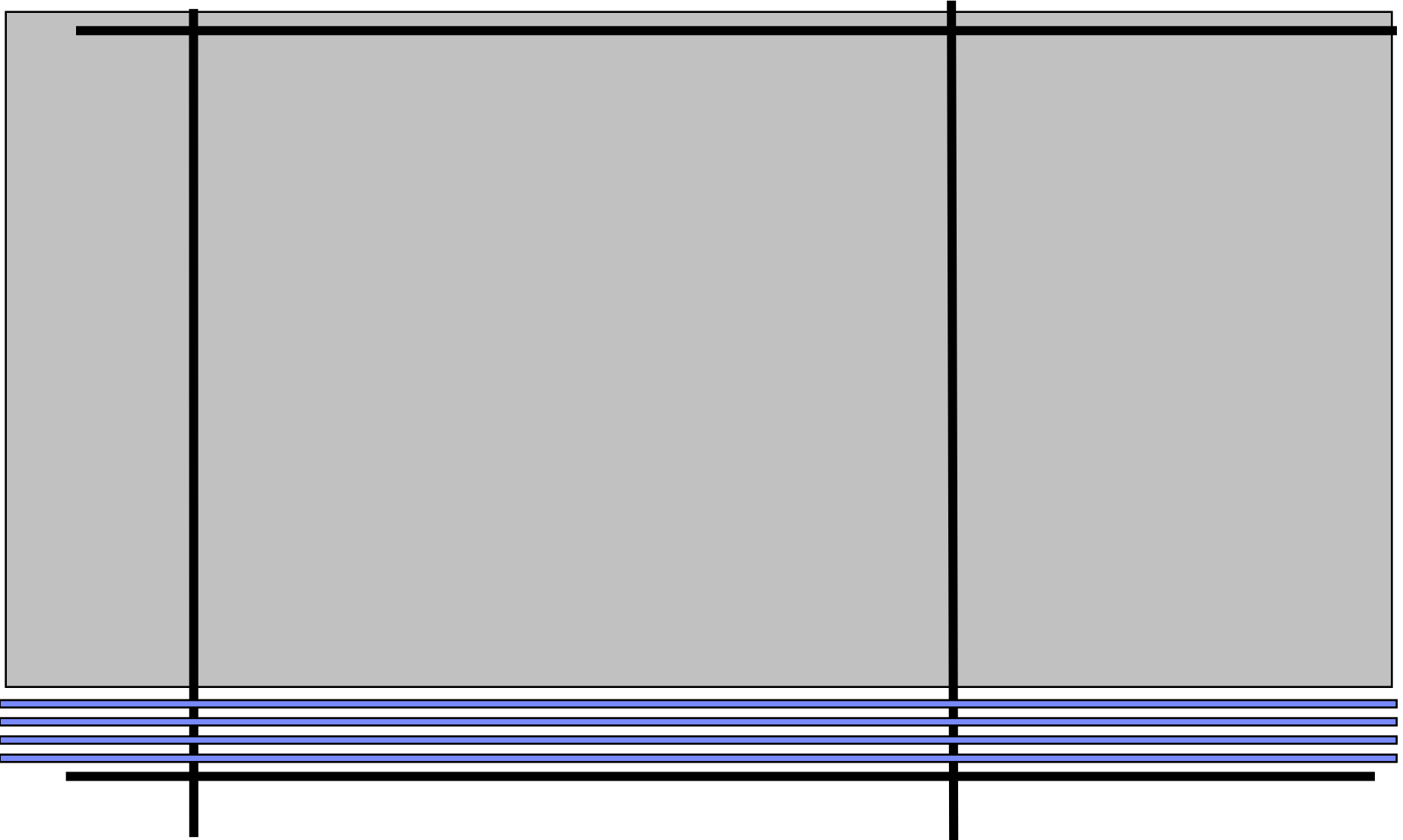
Number of Overflow Nets =
Number of Nets Over 100% Congested

Number of nets over 90% congested

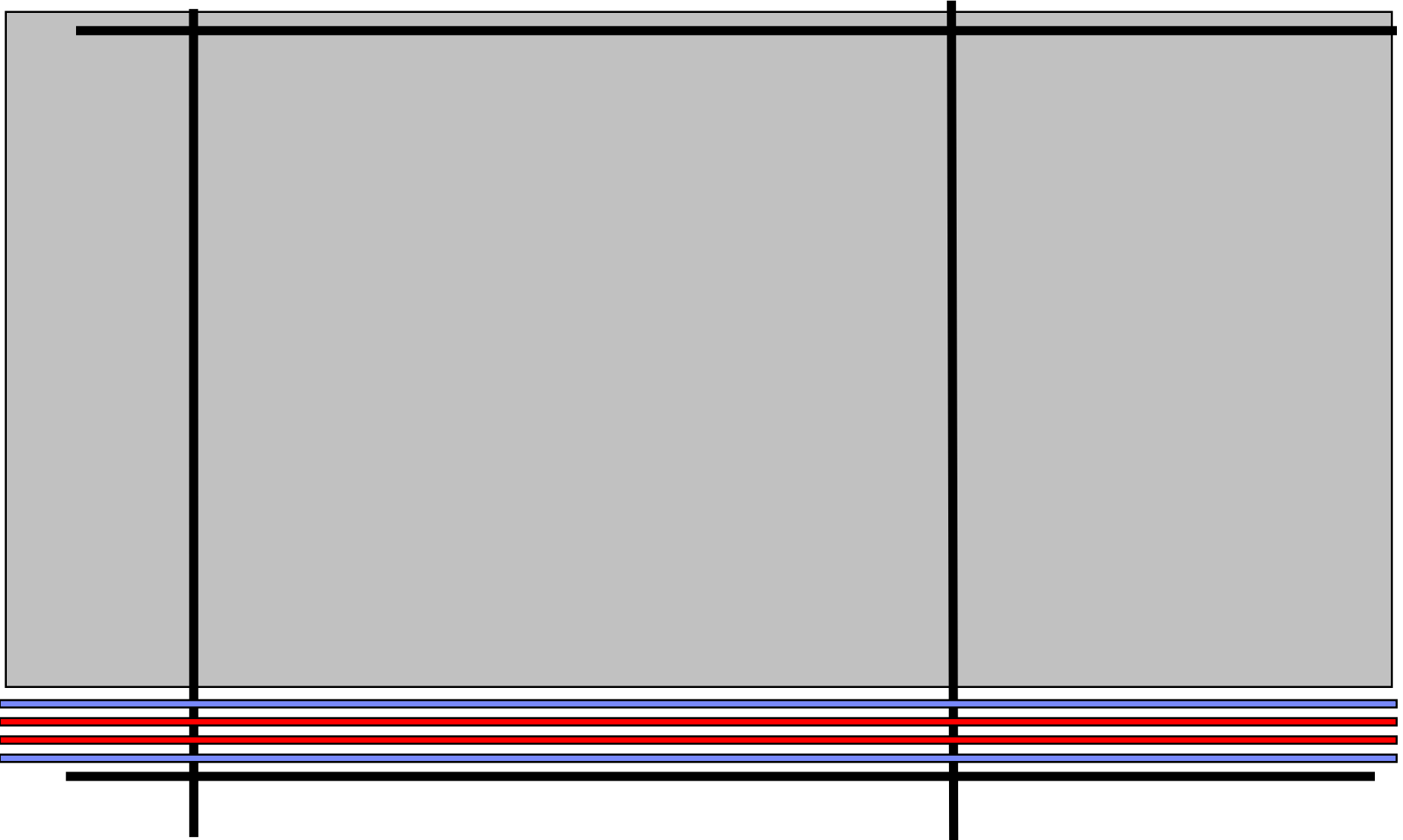
Number of nets over 80% congested

Average congestion of 20% worst gcells

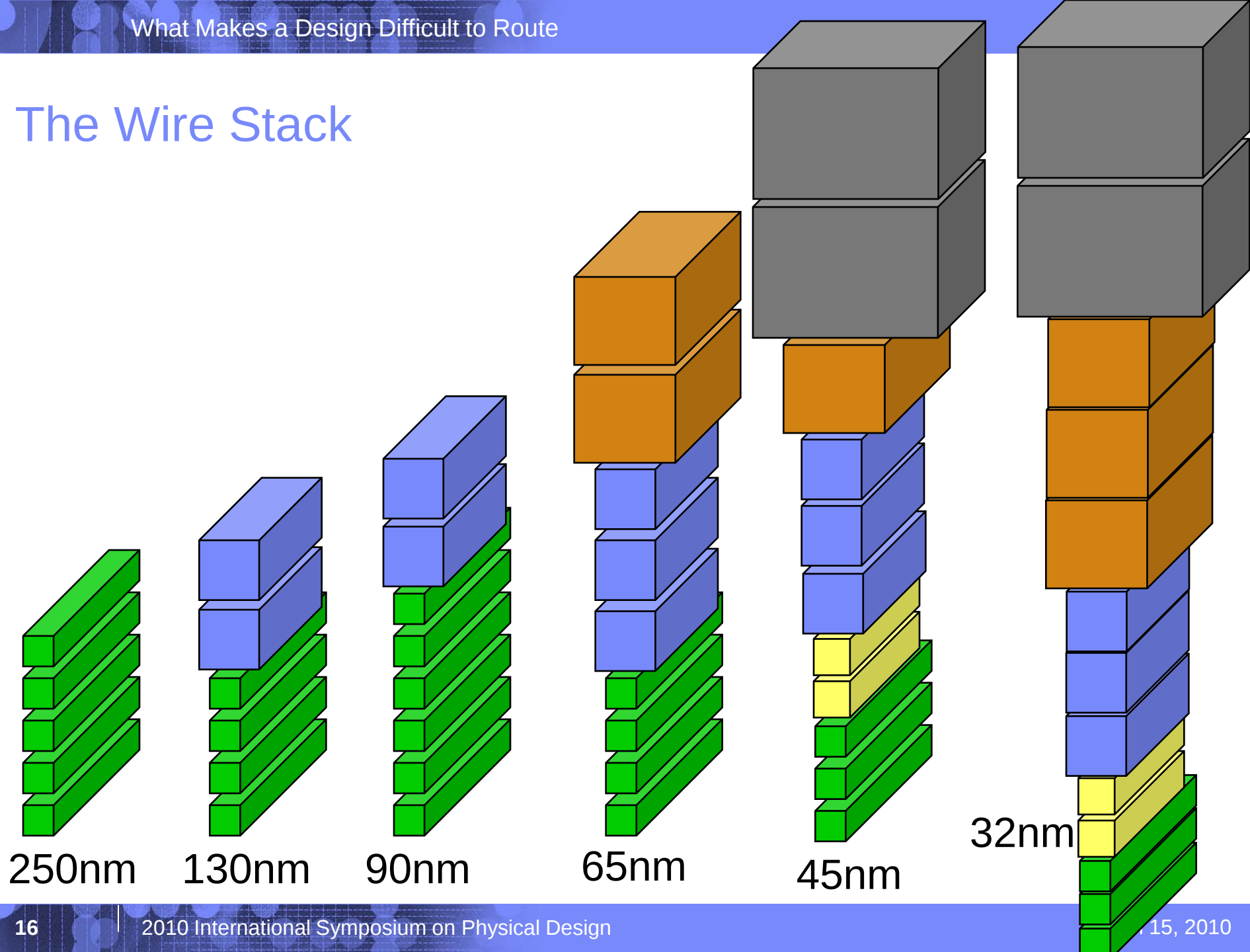
Handling Routing Blockages



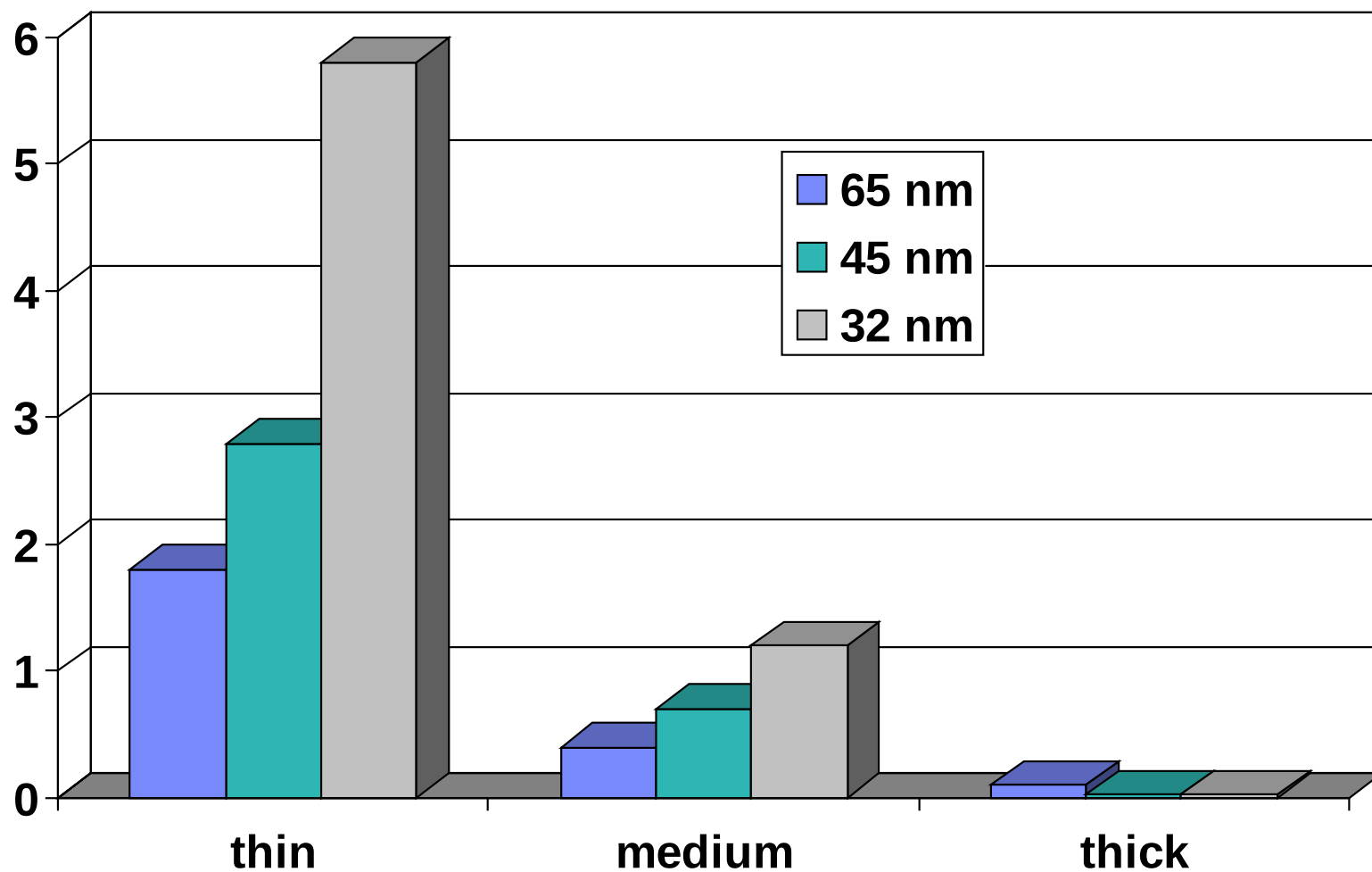
50% Full or 95% Full?



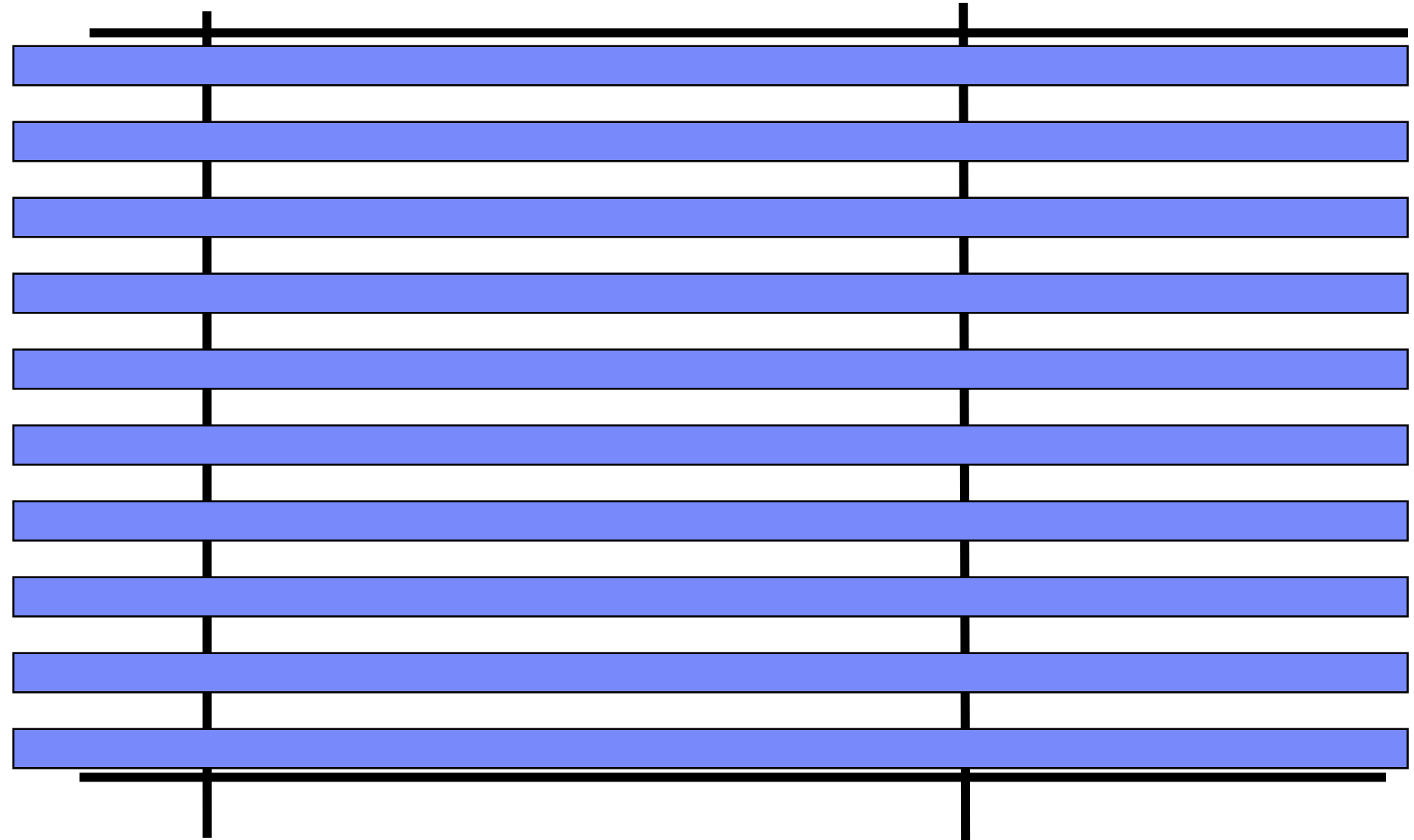
The Wire Stack



Resistance per mm



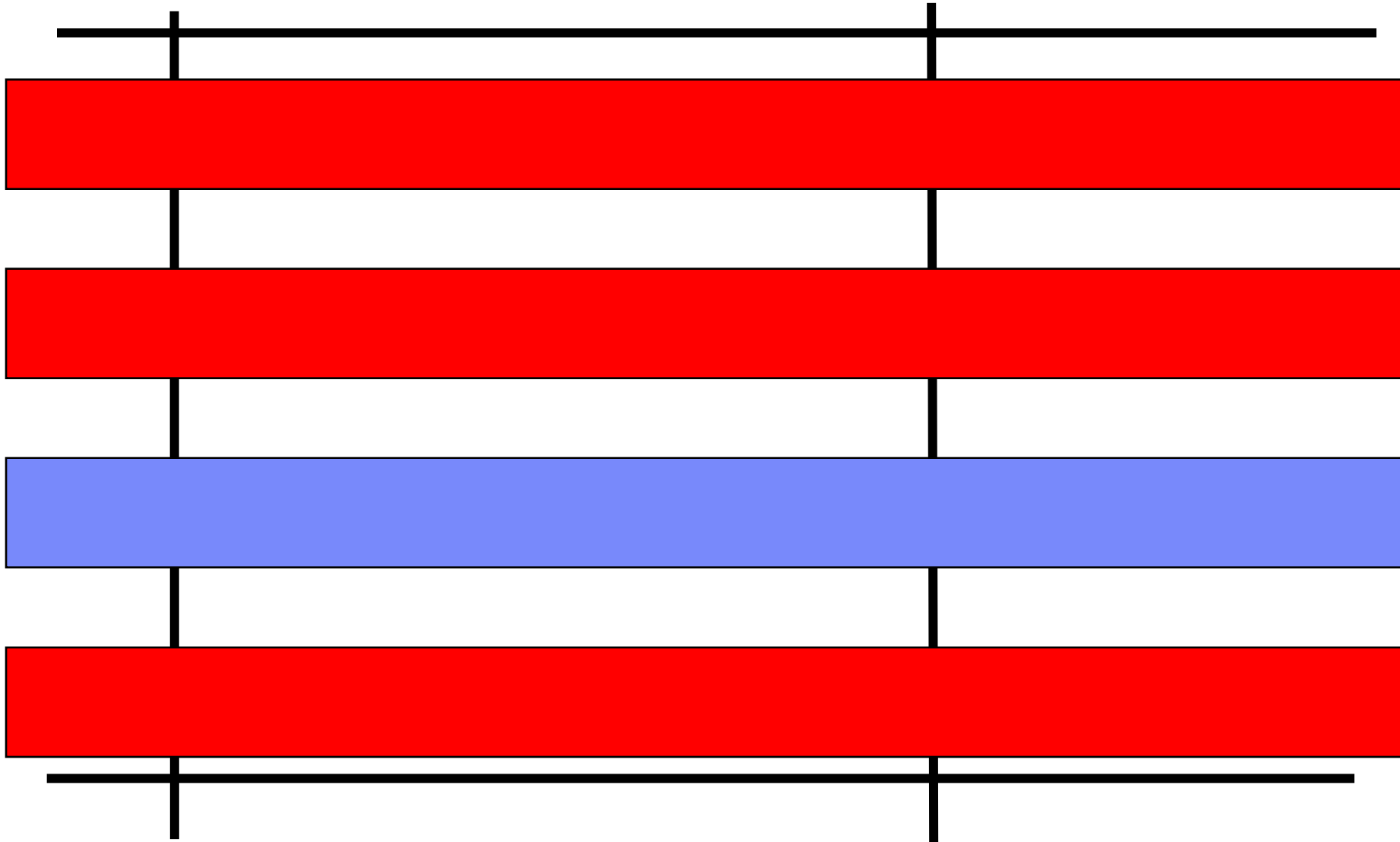
Routing Tracks on 4X Metal



Only 2 Tracks Left, but Not Congested



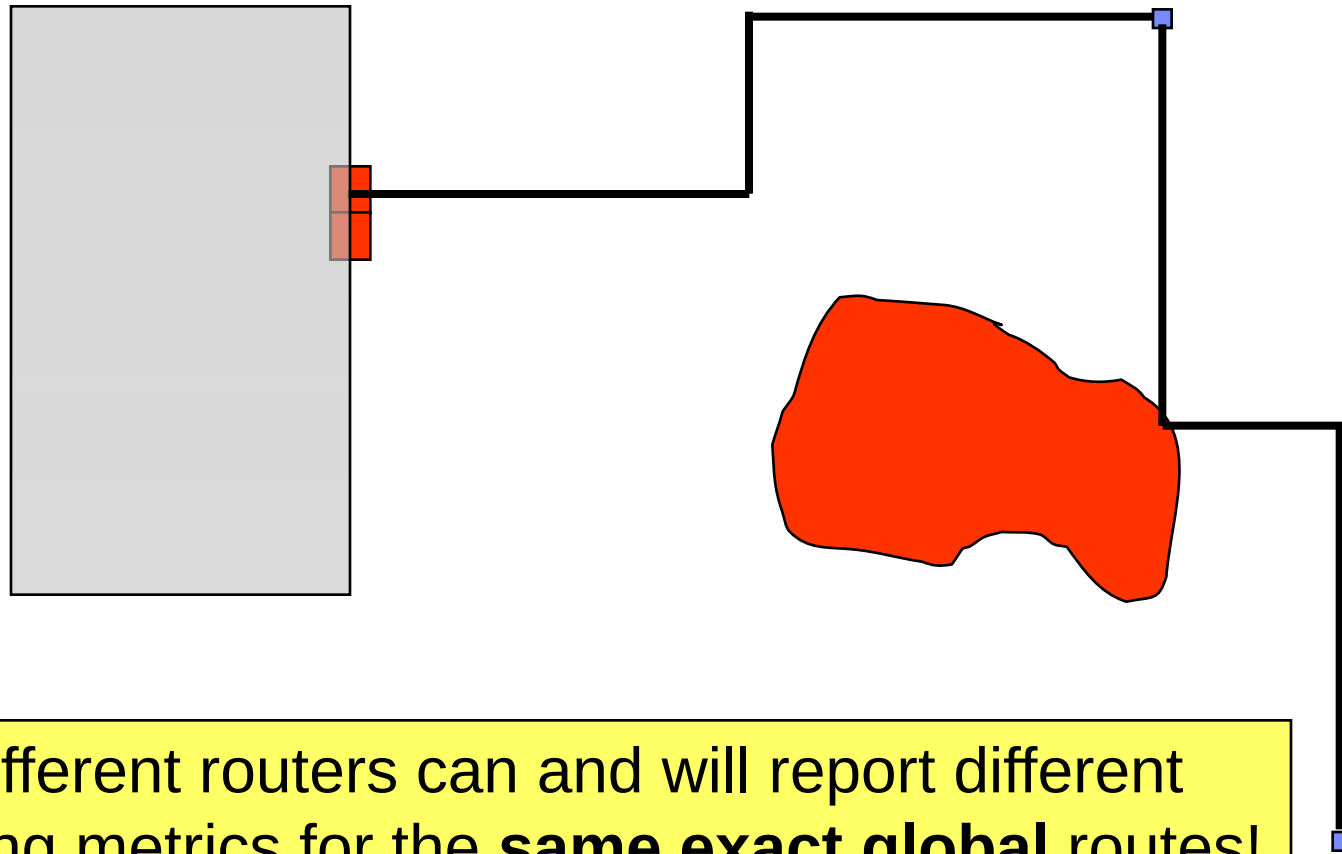
Routing Tracks on 10X Metal



Routing Tracks on 16X Metal

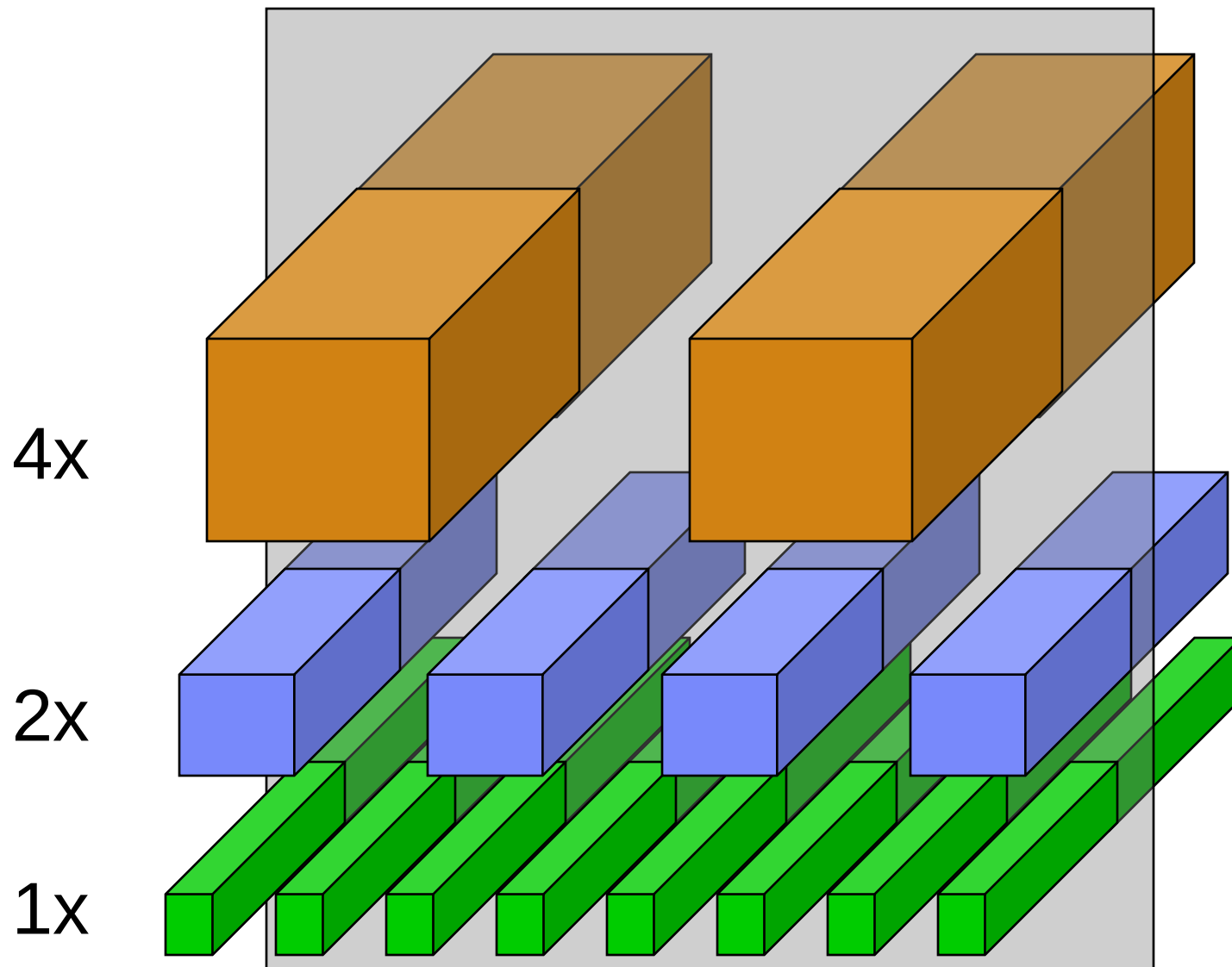


Is This Net Congested?

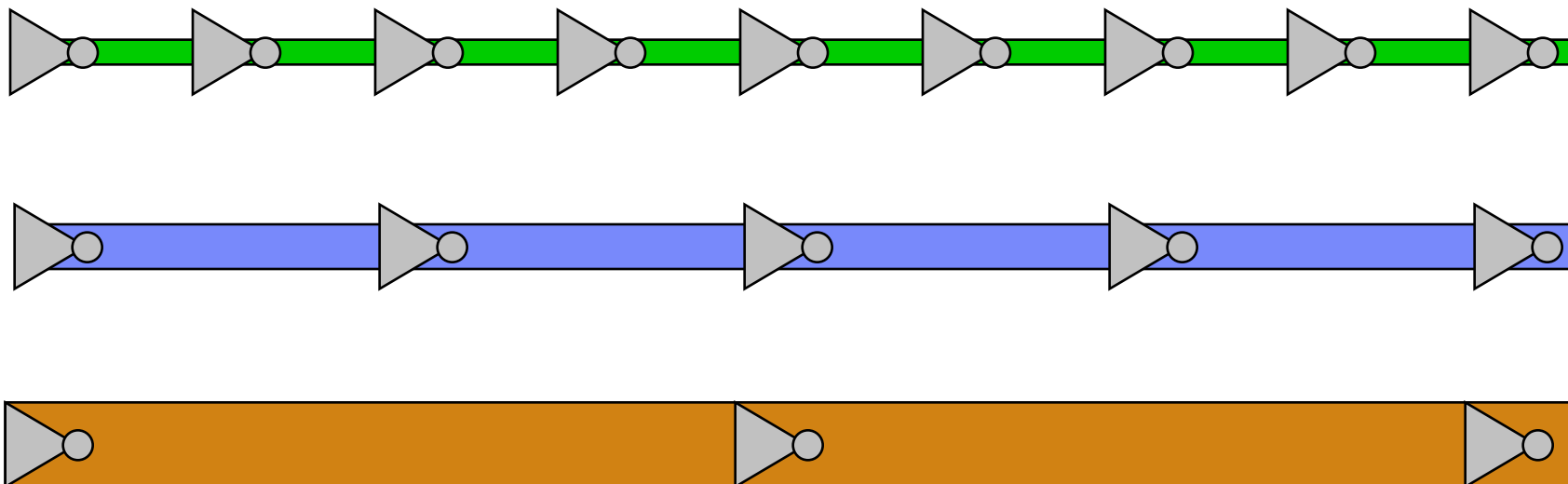


Different routers can and will report different routing metrics for the **same exact global** routes!

Cross section of a gcell

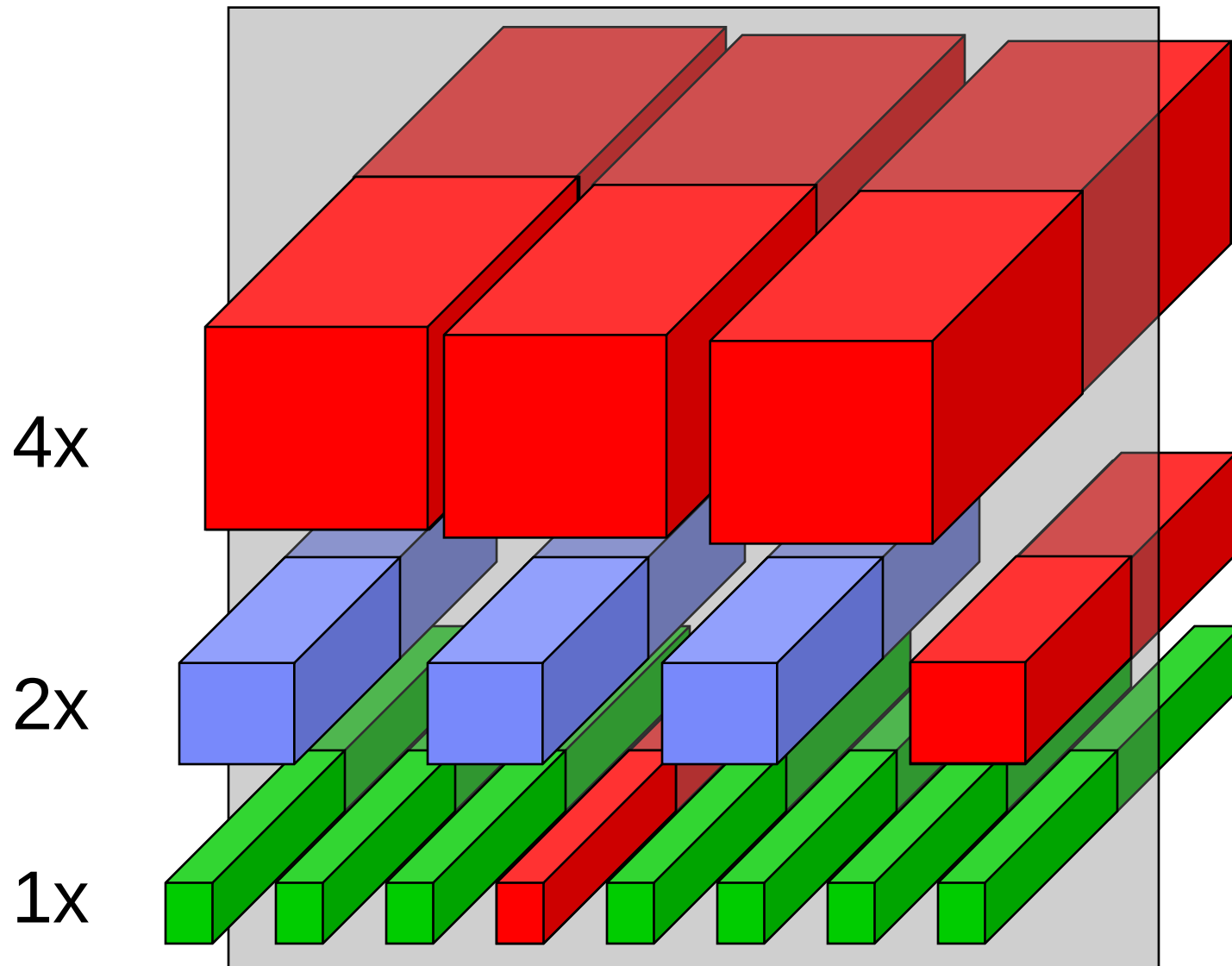


Timing Closure Constrains The Router



Layer assignment / wire sizing
assigns constraints for the router

Is This a Congestion Problem?



Is It Routable?

Avg 20% = 89.1

#nets > 100% = 9532

#nets > 90% = 25785

Avg 20% = 83.5

#nets > 100% = 532

#nets > 90% = 2785

Avg 20% = 81.7

#nets > 100% = 3942

#nets > 90% = 11880

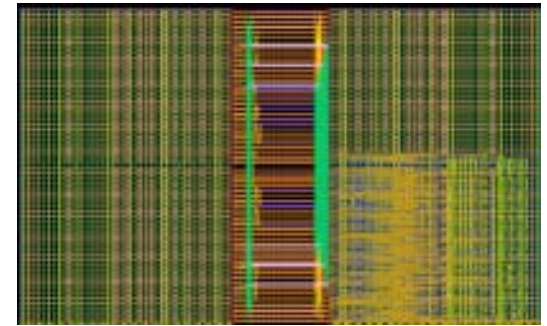
Avg 20% = 78.2

#nets > 100% = 16

#nets > 90% = 753

Congestion Analysis Versus Routing

Congestion Analysis



Probabilistic

Route Fast ✓

Route Carefully

No
Scenic

A Little
Scenic ✓

Completely
Scenic

Completely
Scenic

Over
Blockages

Around
Blockages ✓

Around
Blockages

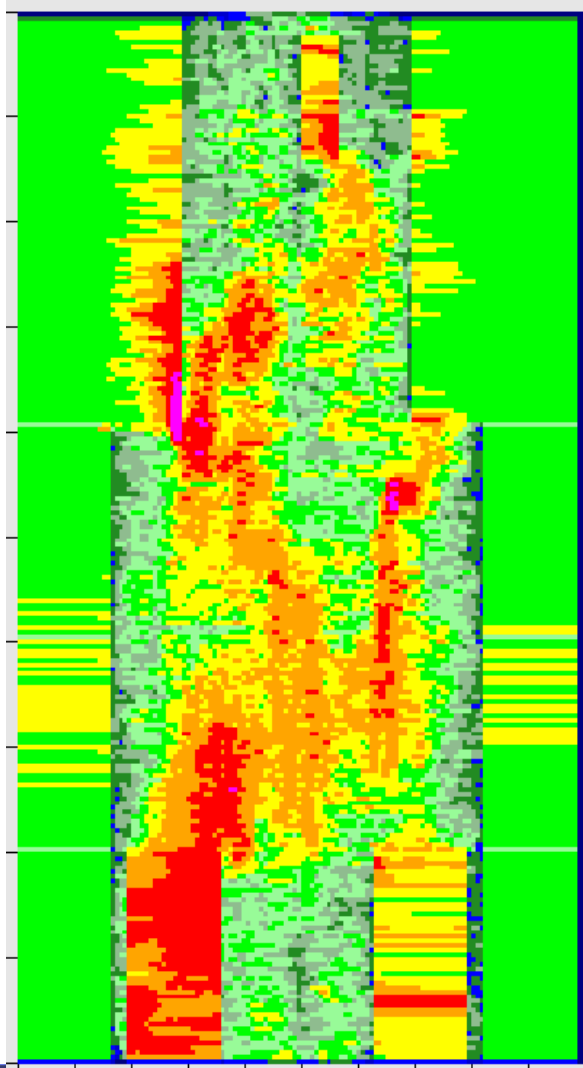
Obey layer
constraints ✓

May violate layer
constraints

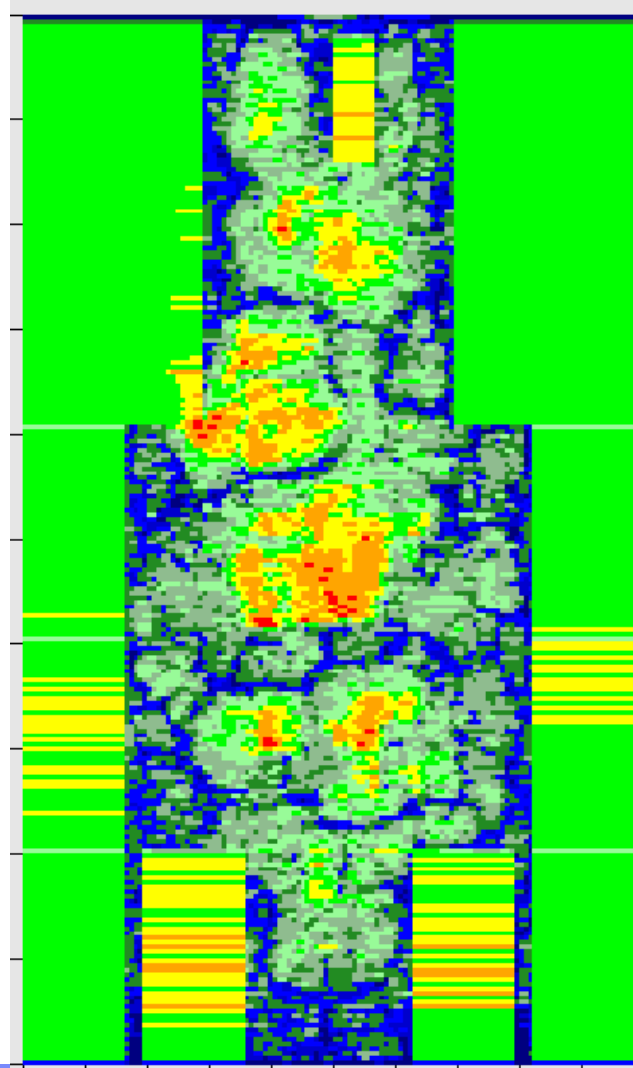
May violate layer
constraints

Minimizing Wire Generally Improves Congestion

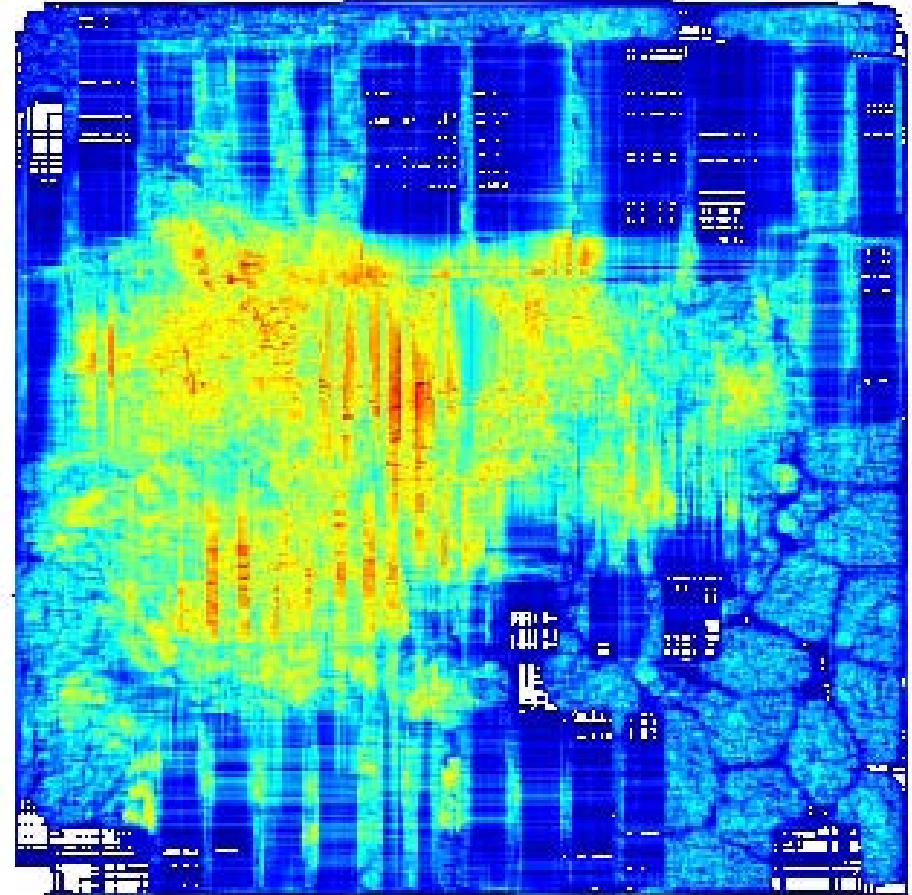
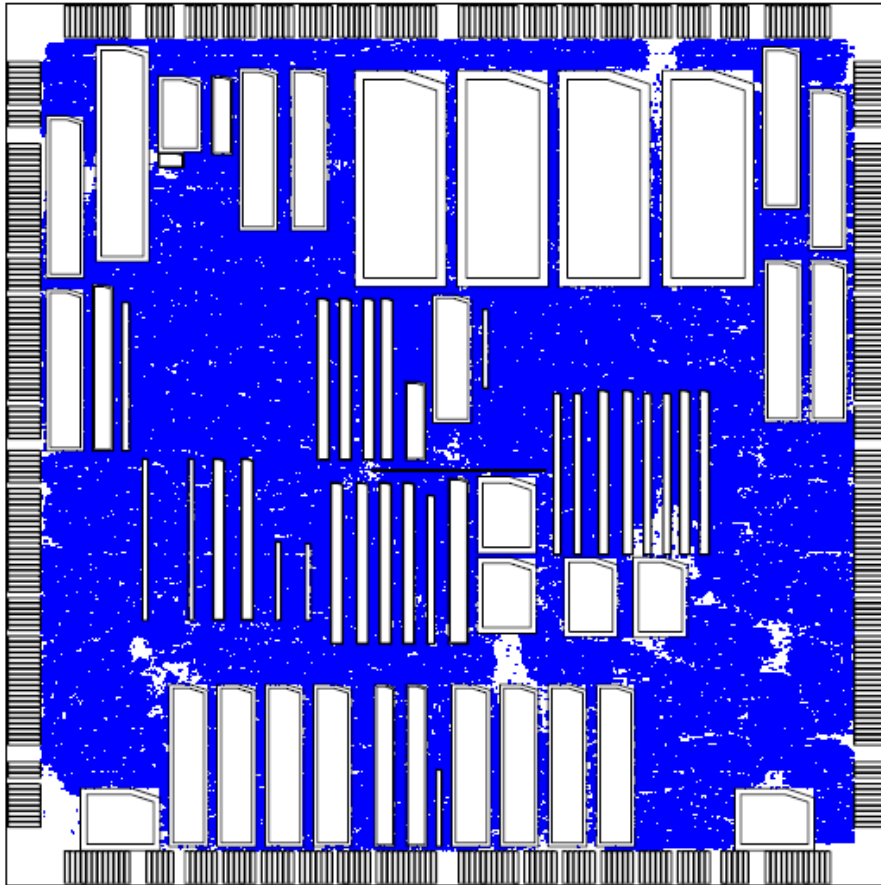
Bad placement



Good placement

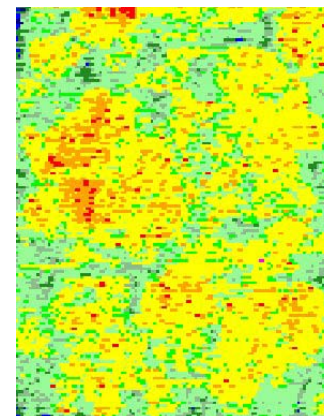
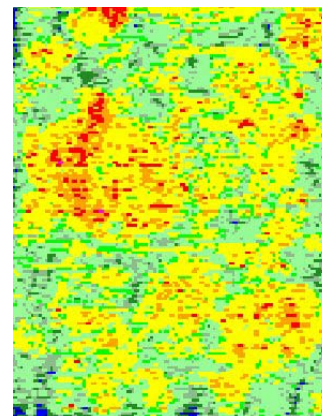
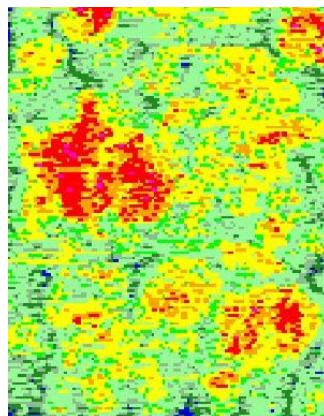
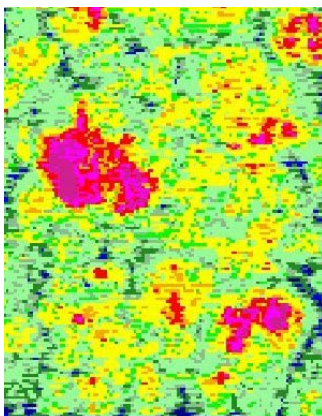


Spread it Uniformly Doesn't Always Work

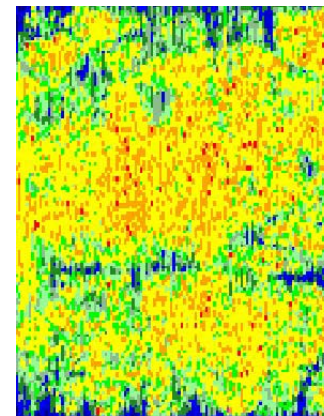
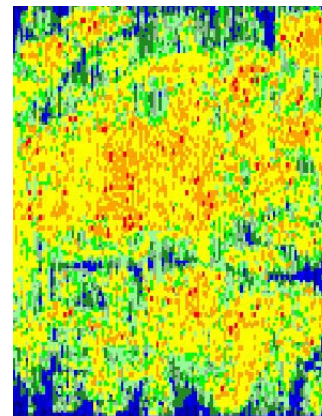
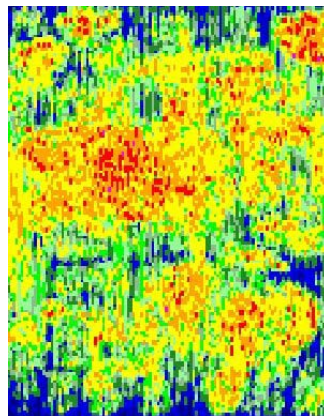
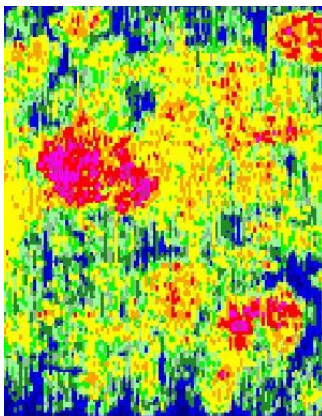


CRISP Progression

Horizontal
Congestion



Vertical
Congestion



Initial
Placement

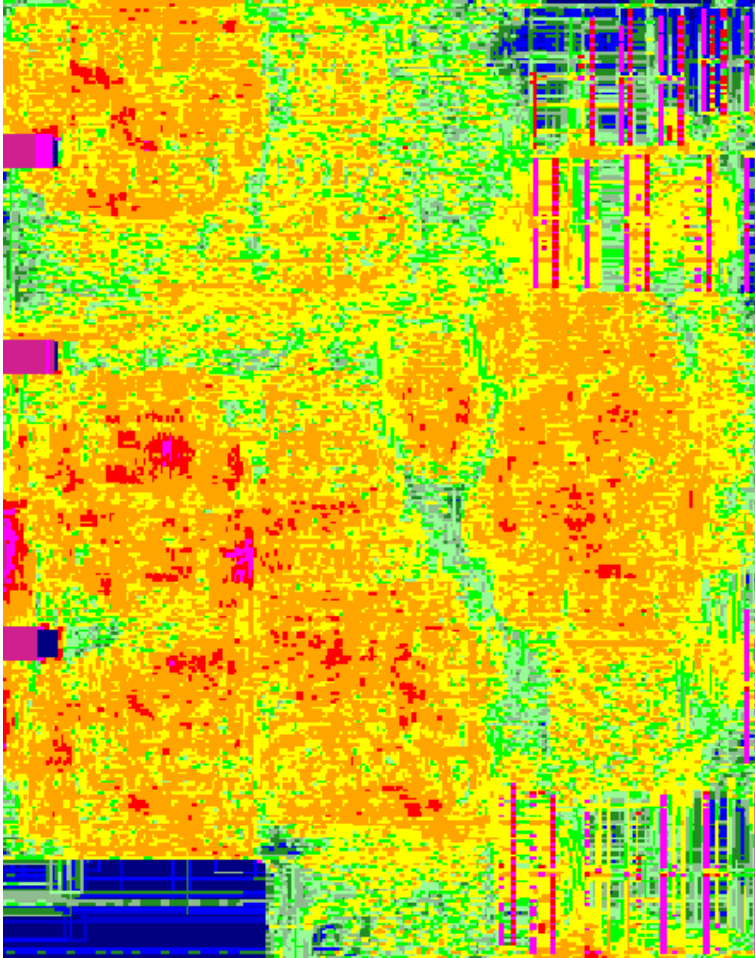
Iteration 5

Iteration 10

Iteration 15

Effect of Timing Driven-Placement

Initial placement

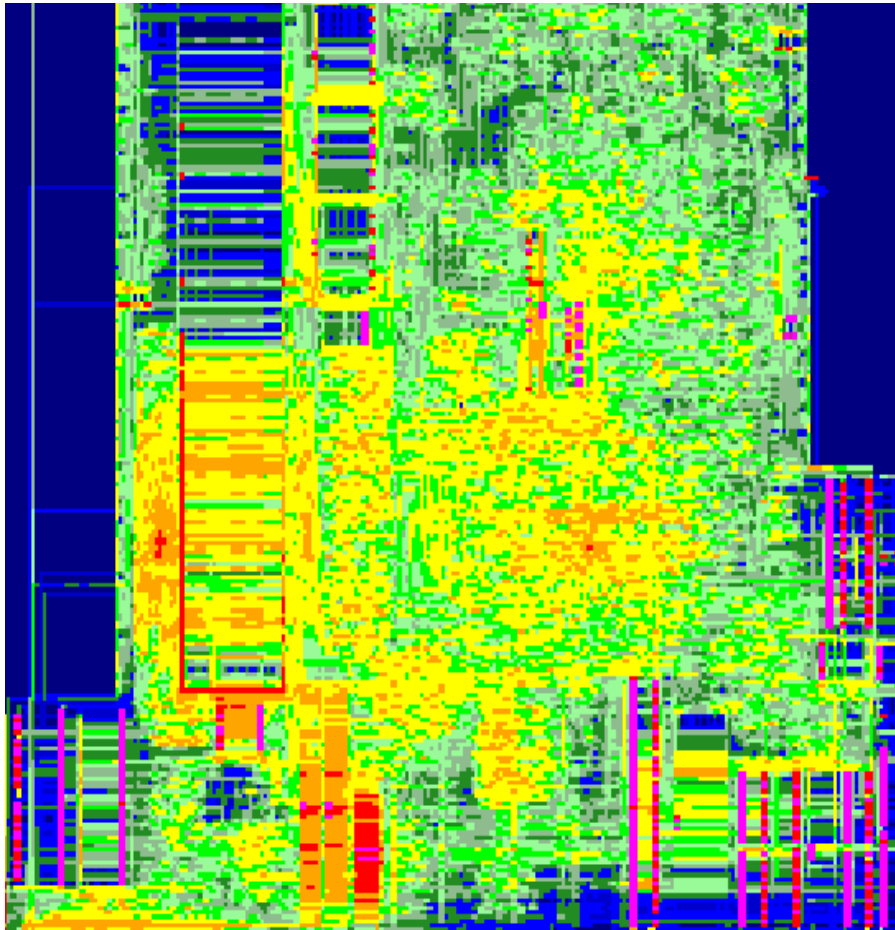


Timing-driven placement

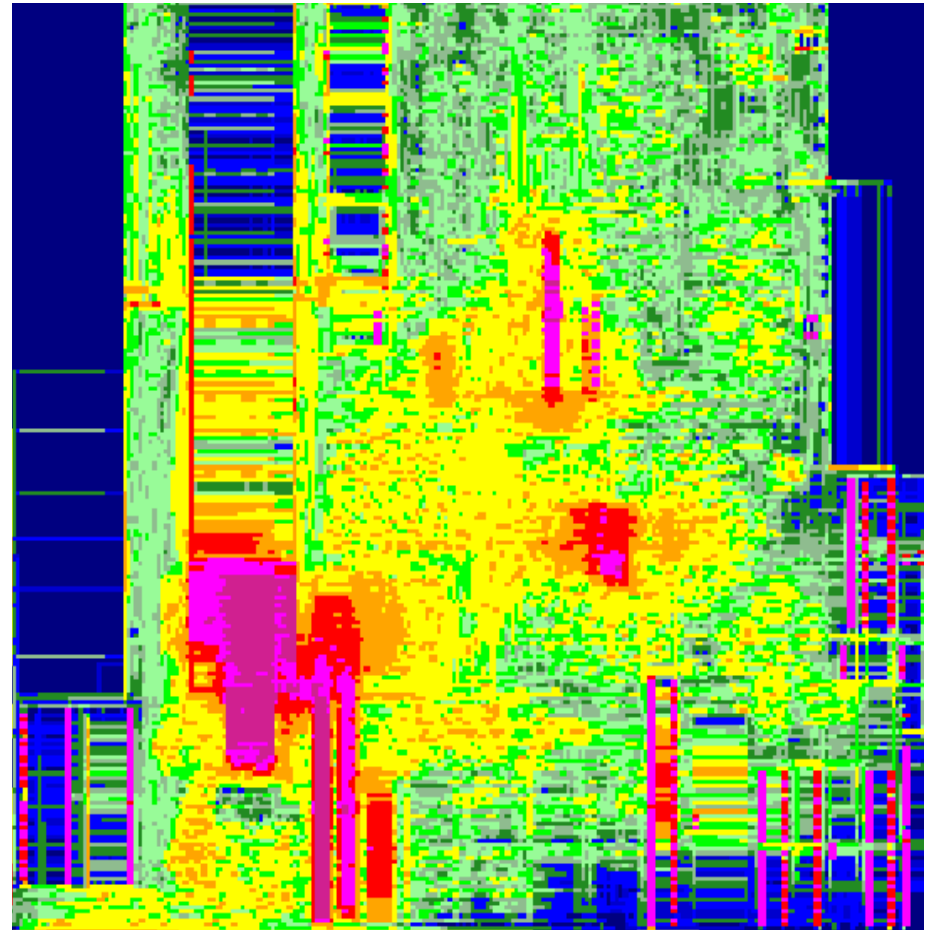


Effect of Timing Driven-Placement

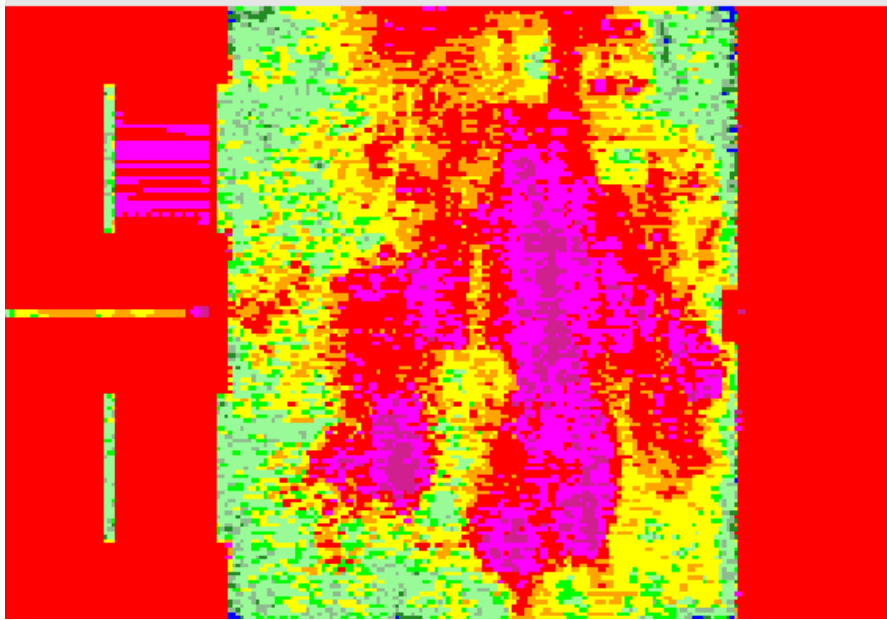
Initial placement



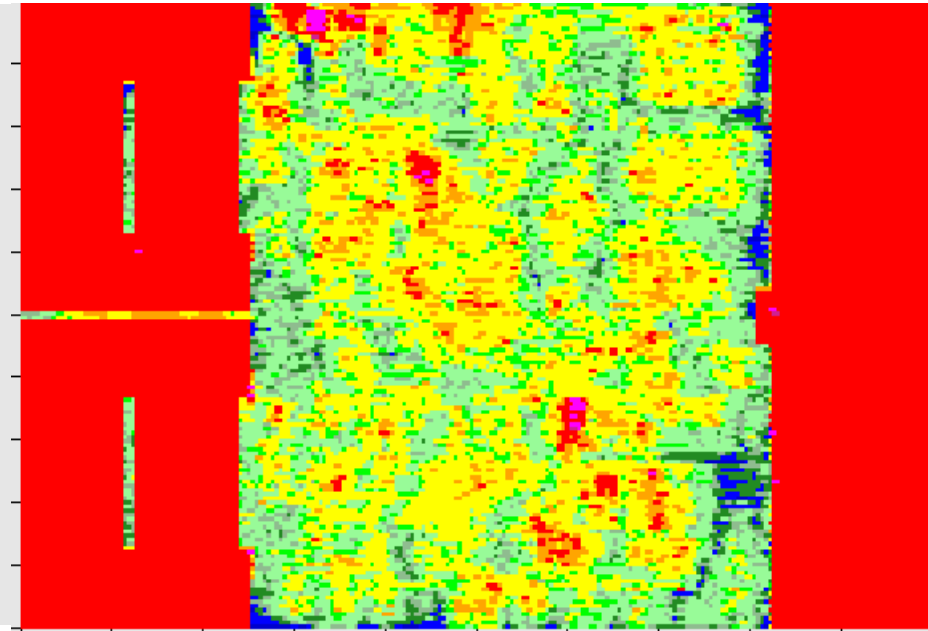
Timing-driven placement



Impact of More Efficient Area Usage



Avg 20%: 108.06
>90% nets: 37855
>100% nets: 21364

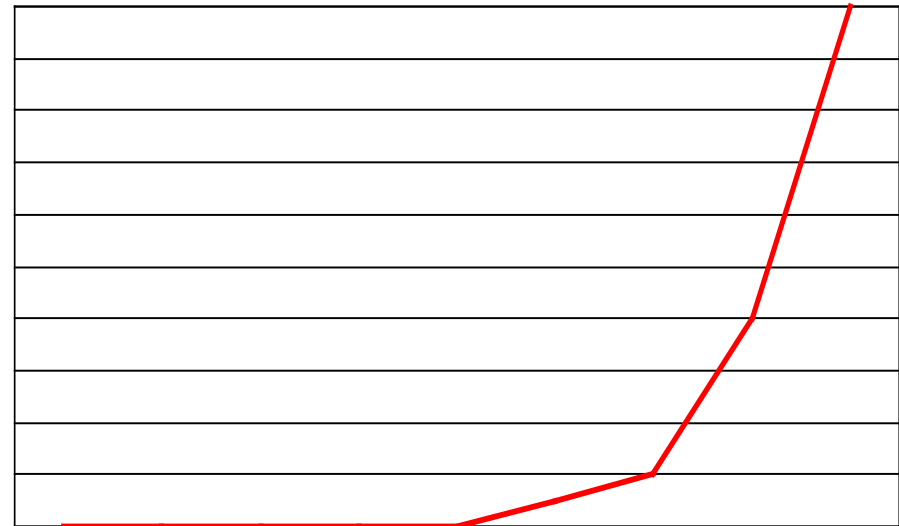


Avg 20%: 86.89
>90% nets: 7307
>100% nets: 1147

“Sitting” in the Student Section

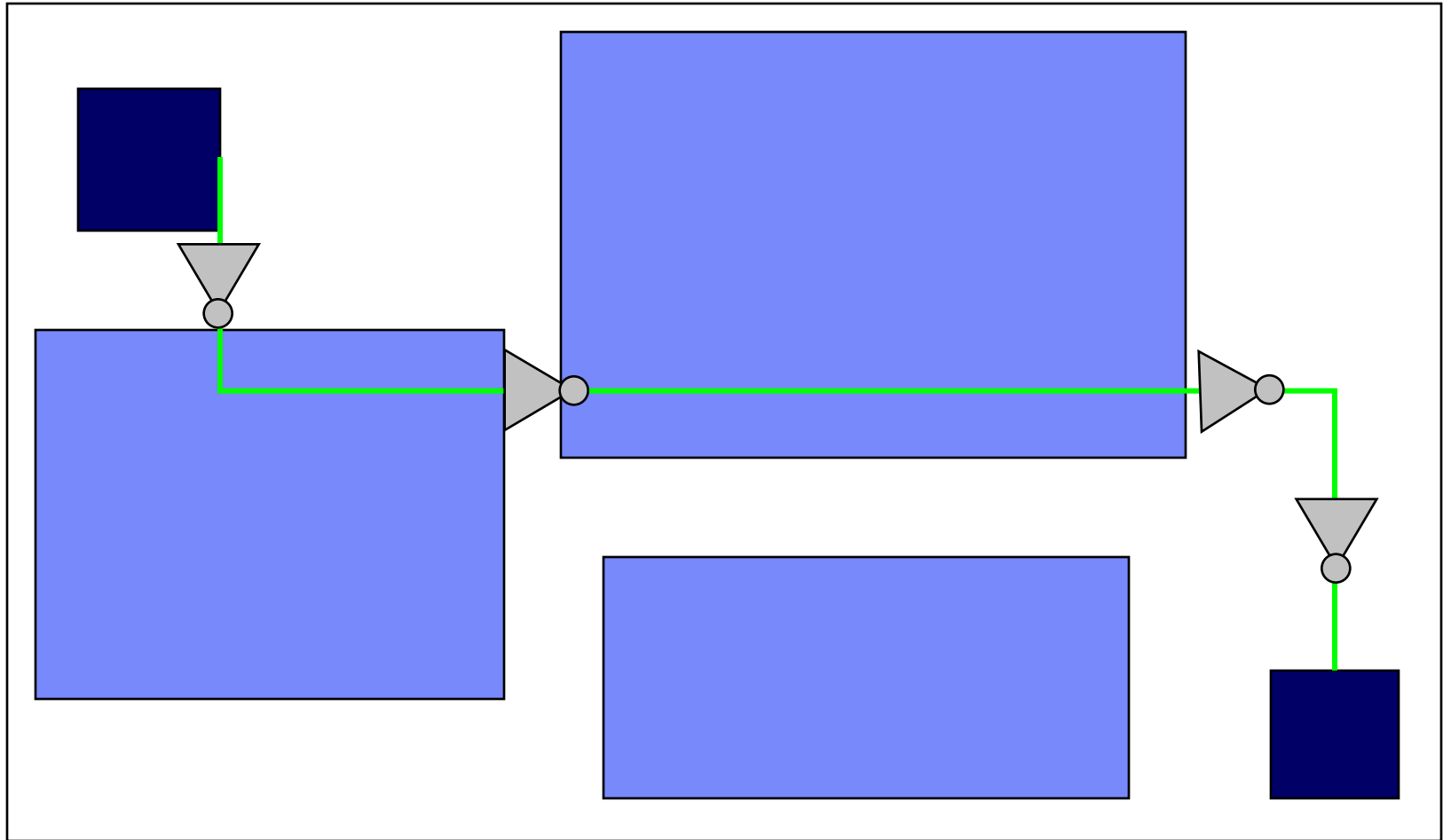


Routing difficulty

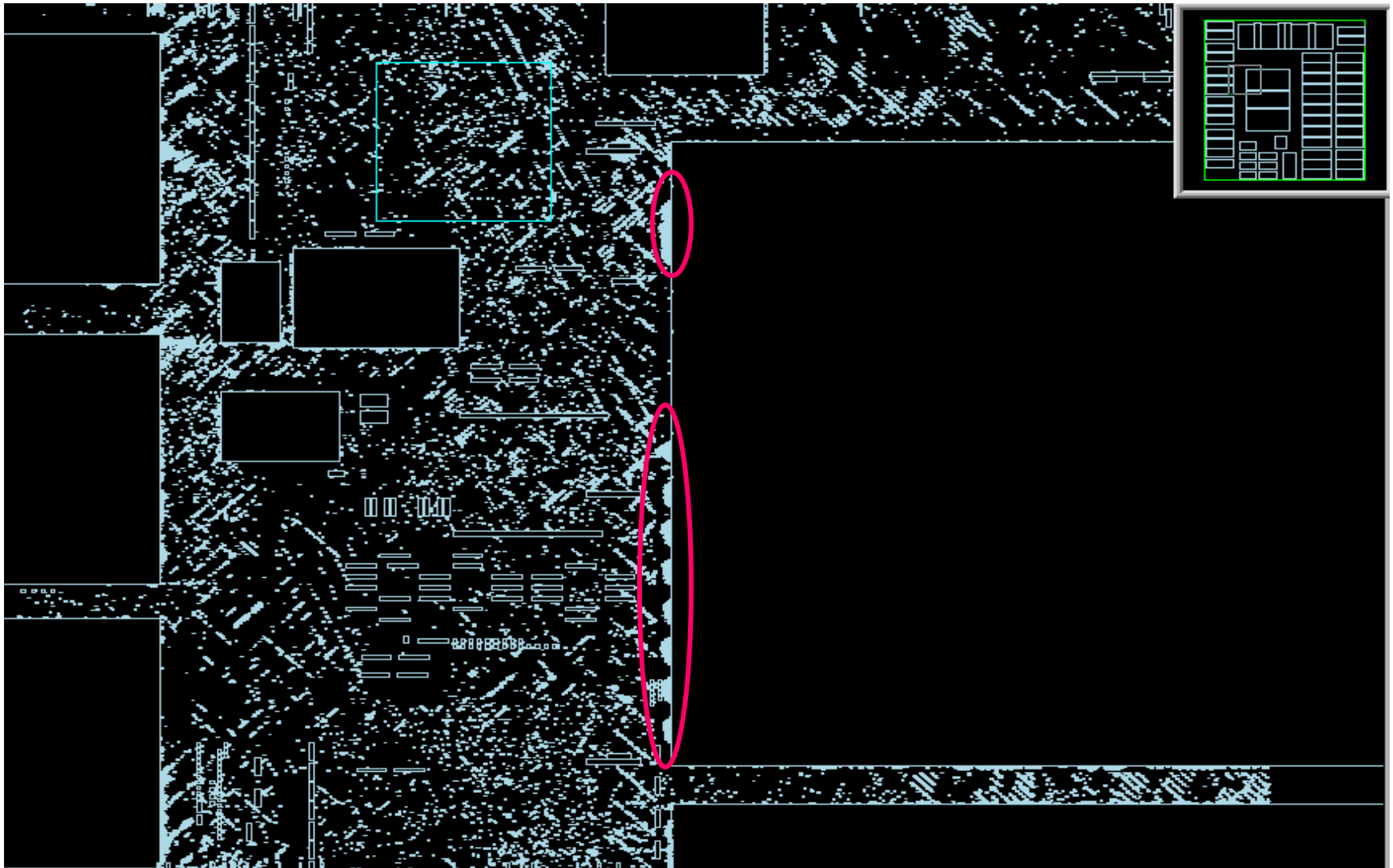


Density

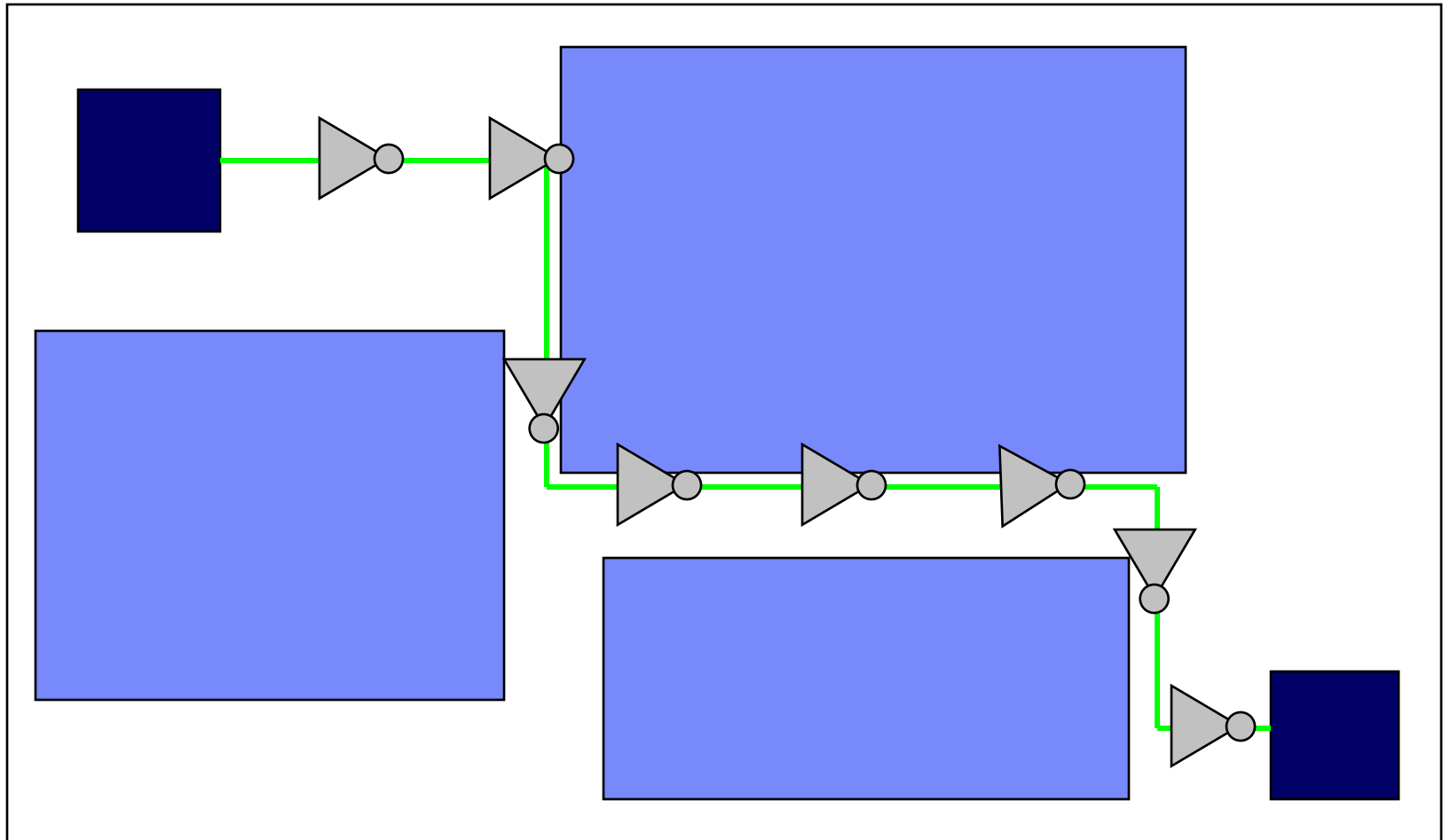
Buffering Along A Global Route



Buffer Packing



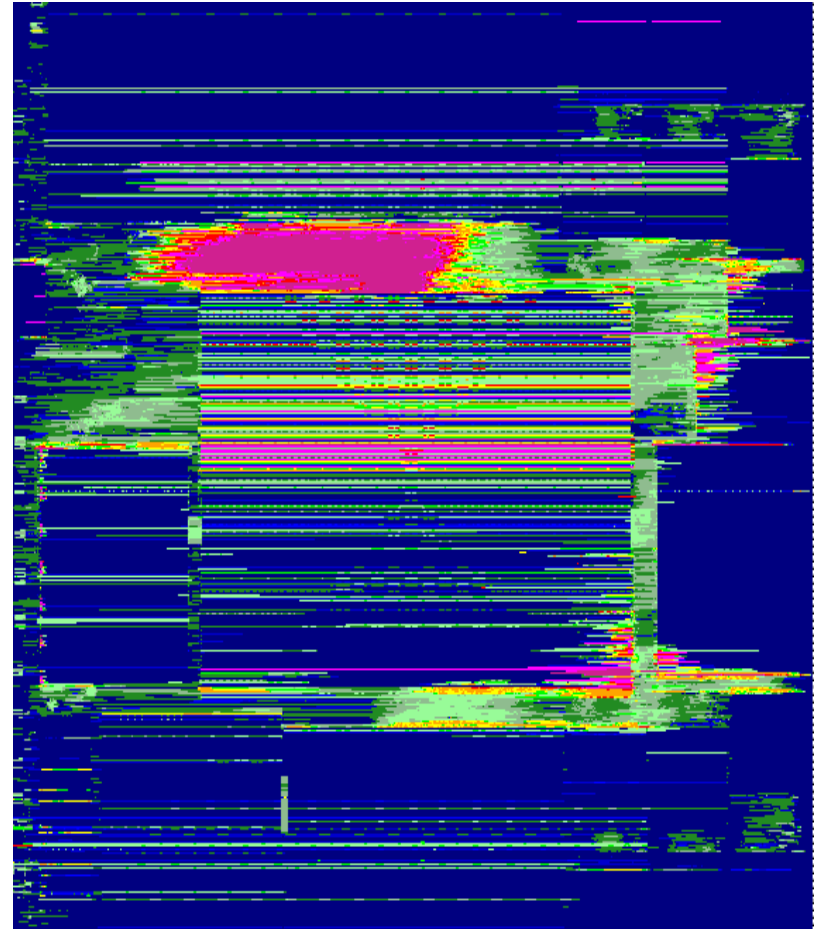
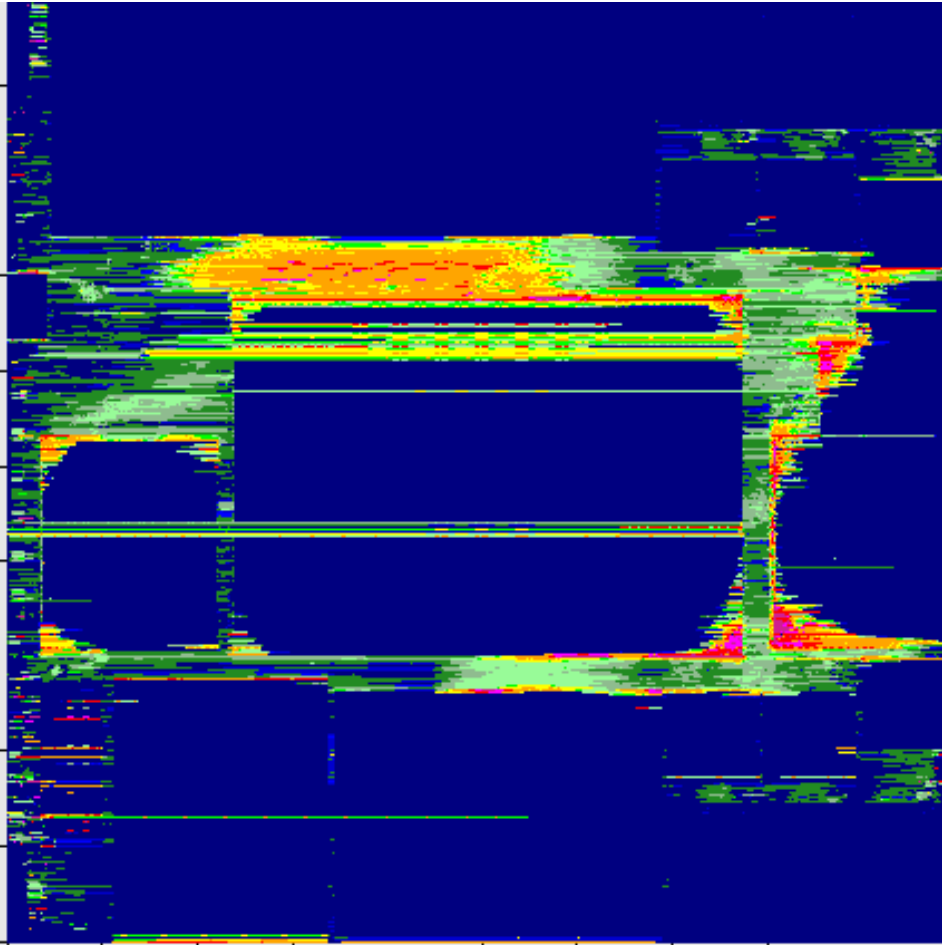
Blockage Avoidance Routing



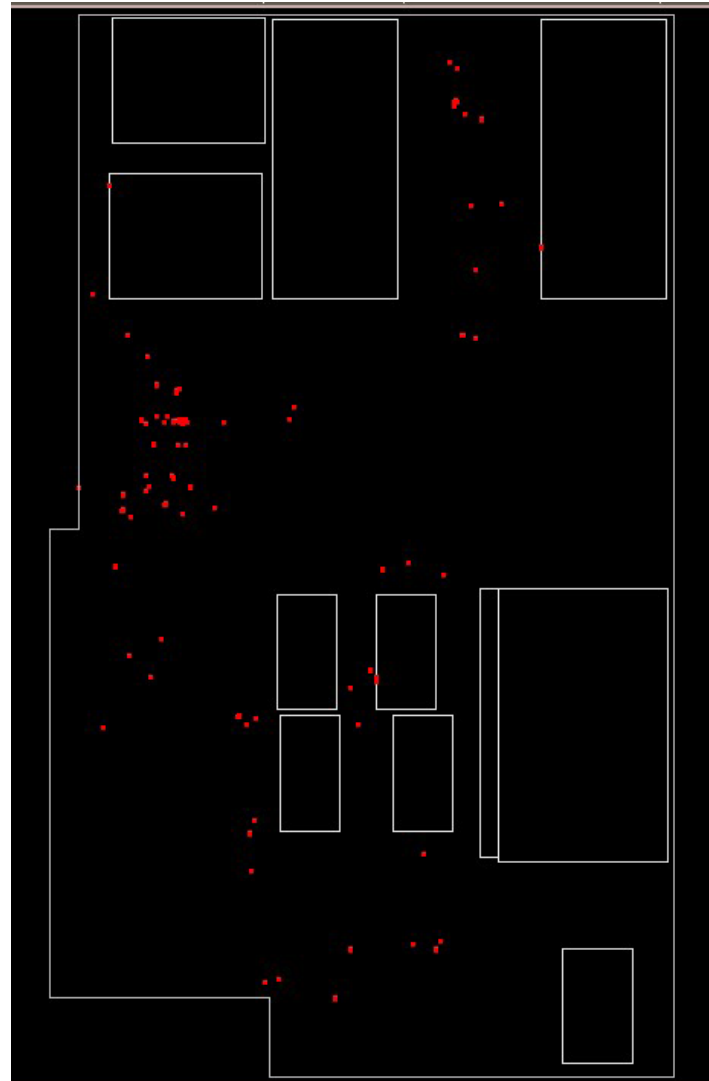
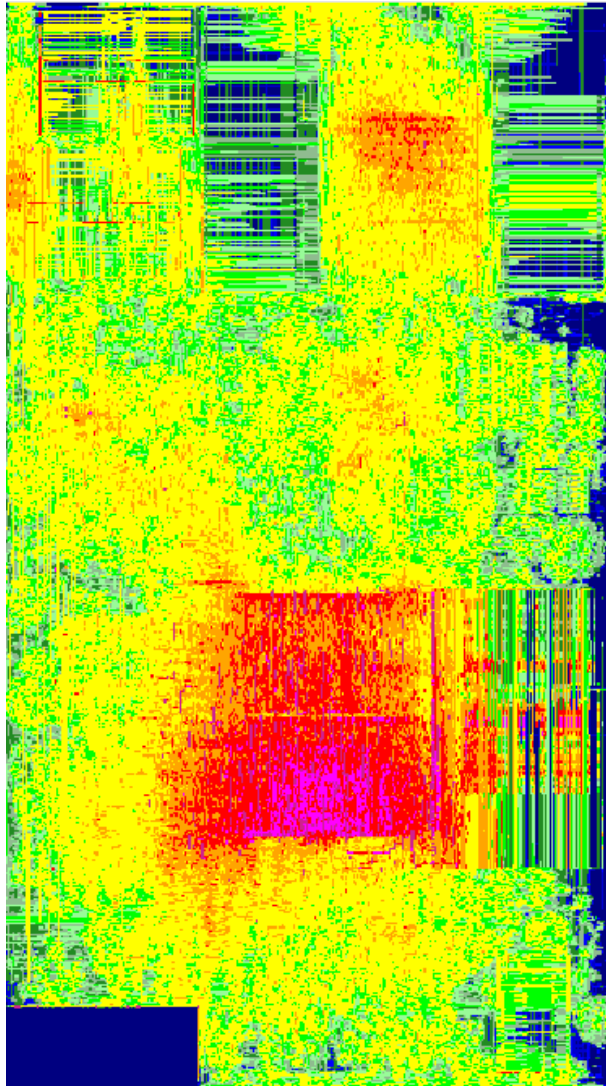
The Corona Effect



Corona Effect + Too Much Thick Metal



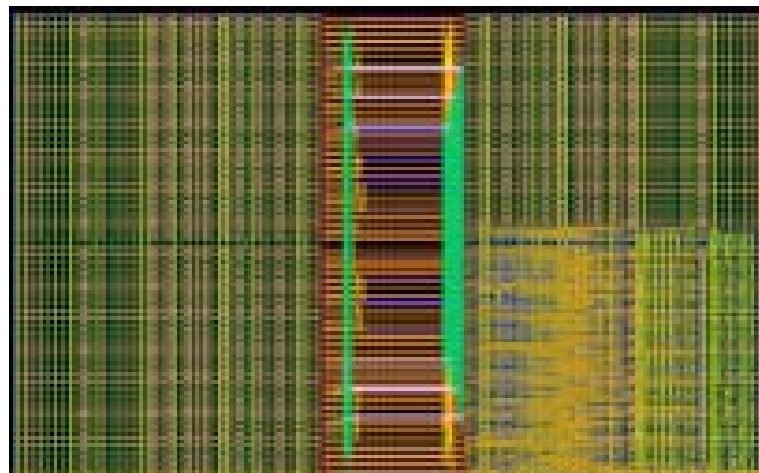
Hot Spots versus Opens and Shorts



What Makes a Design Difficult to Route?

- **Bad floorplan**
- **Over packing dense logic**
- **Inefficient area minimization**
- **Over weighting for timing-driven placement**
- **Buffering too packed**
- **Over-constraining router**
- **Not capturing local routing issues**
- **Even if successful, don't mess up timing too much**

What Does a Child Have in Common with a Router ?



We want to create opportunities to succeed.

Just because opportunity is provided,
they may not take advantage.

We don't really know what the best opportunities are.