What Makes A Design Difficult to Route

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What Makes a Design Difficult to Route

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?
What Makes a Design Difficult to Route

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

Floorplanning
Placement
Timing Closure

Floorplanning
Placement
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Routing
Congestion Analysis
Routing Tracks on 10X Metal
What Makes a Design Difficult to Route

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
What Makes a Design Difficult to Route

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?
What Makes a Design Difficult to Route

The Wire Stack

- 250nm
- 130nm
- 90nm
- 65nm
- 45nm
- 32nm
Resistance per mm

- **thin**
  - 65 nm
  - 45 nm
  - 32 nm

- **medium**
  - 65 nm
  - 45 nm
  - 32 nm

- **thick**
  - 65 nm
  - 45 nm
  - 32 nm
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?

- **Green Box**
  - Avg 20% = 89.1
  - nets > 100% = 9532
  - nets > 90% = 25785

- **Orange Box**
  - Avg 20% = 83.5
  - nets > 100% = 532
  - nets > 90% = 2785

- **Yellow Box**
  - Avg 20% = 81.7
  - nets > 100% = 3942
  - nets > 90% = 11880

- **Gray Box**
  - Avg 20% = 78.2
  - nets > 100% = 16
  - nets > 90% = 753
Congestion Analysis Versus Routing

Congestion Analysis

- Probabilistic
- Route Fast
- No Scenic
- A Little Scenic
- Completely Scenic
- Over Blockages
- Around Blockages
- Obey layer constraints
- May violate layer constraints

Route Carefully

- Completely Scenic
- Around Blockages
- May violate layer constraints
Minimizing Wire Generally Improves Congestion

Bad placement

Good placement
Spread it Uniformly Doesn’t Always Work
What Makes a Design Difficult to Route

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

Density

Routing difficulty

Density
Buffering Along A Global Route
Buffer Packing
Blockage Avoidance Routing
The Corona Effect
What Makes a Design Difficult to Route

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 Makes a Design Difficult to Route

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.