Reinvigorating EDA in the Social Media Era

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Synopsys

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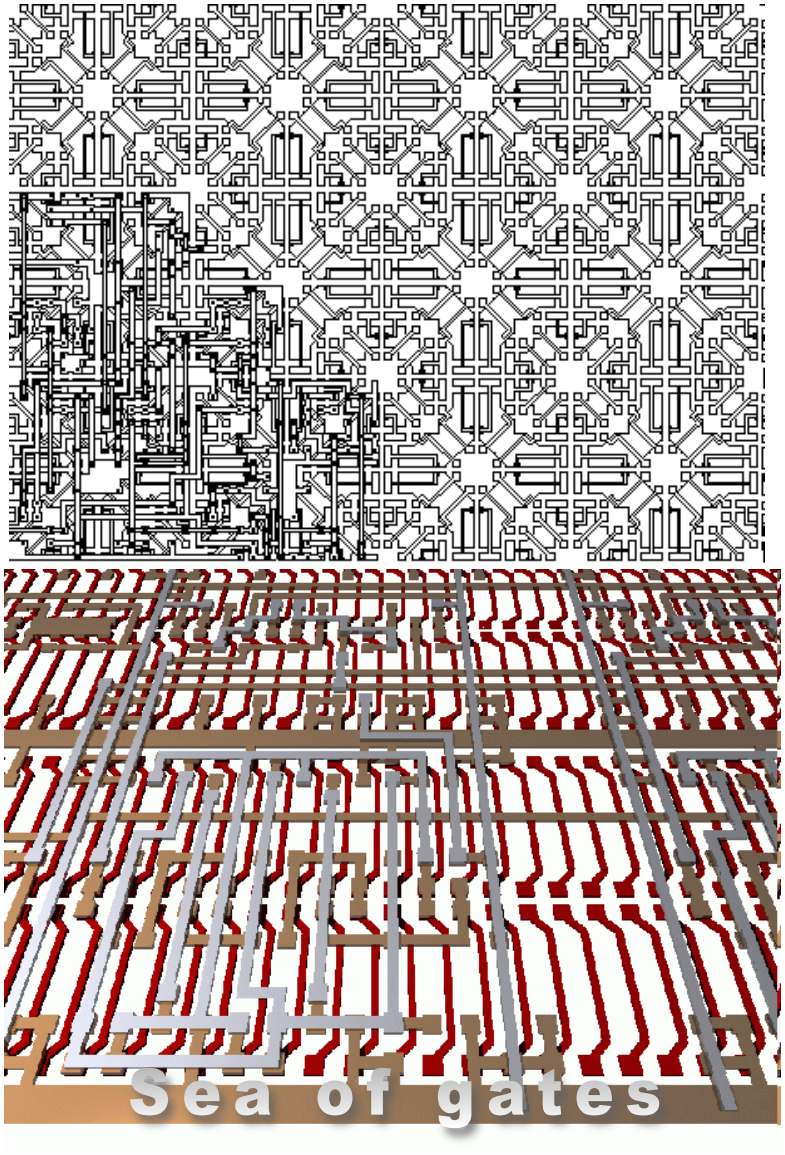
Summary

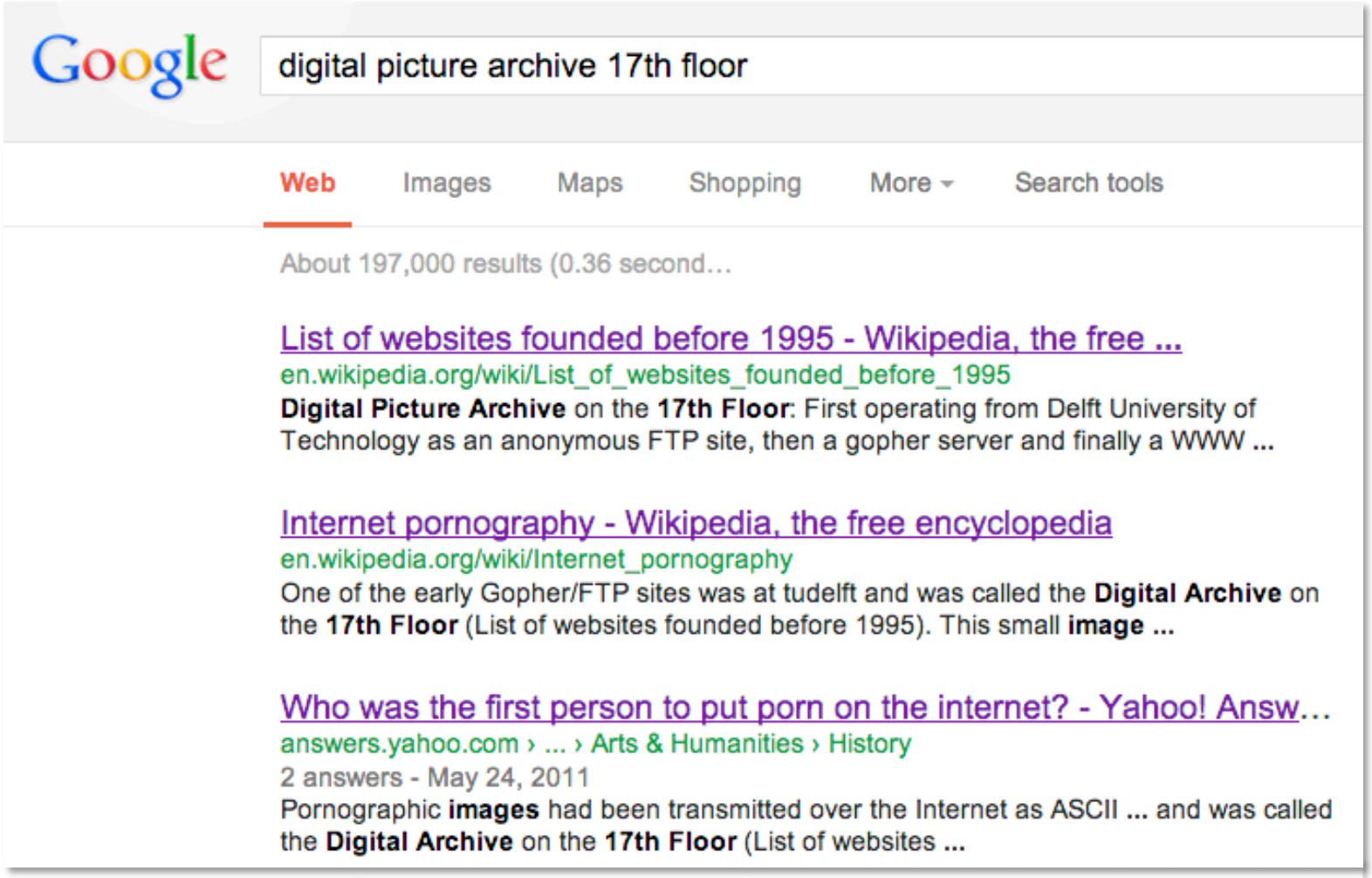
- **My history in Academic and Corporate EDA**
- **The current ‘state of the EDA’**
  - Dollars & People
  - Conferences
- **Solved and Unsolved problems**
- **Role of academia**

My EDA story, abridged
Can we replicate this for the current generation?

- **Delft University: Routing as MSc and PhD projects**
  - Sold it to National Semiconductor, Philips, Sagantec and Cadence.
- **Post doc @ Delft: Developed 'Ocean'**
  - For university system/IC design lab, 1991-today
  - Logic to a real Sea-of-Gates chip
- **Compass**
  - Datapath synthesis
- **Magma**
  - All aspects of Physical Synthesis
- **Full professor**
  - @ Eindhoven University
- **Magma again**
- **Synopsys**



University life: My 5 minutes of fame…



Switch to the Commercial world

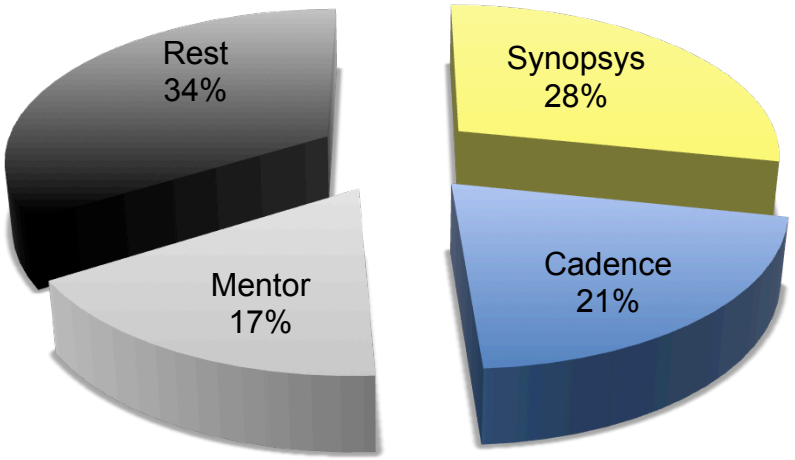
Magma, August 1997

EDA industry: a management summary

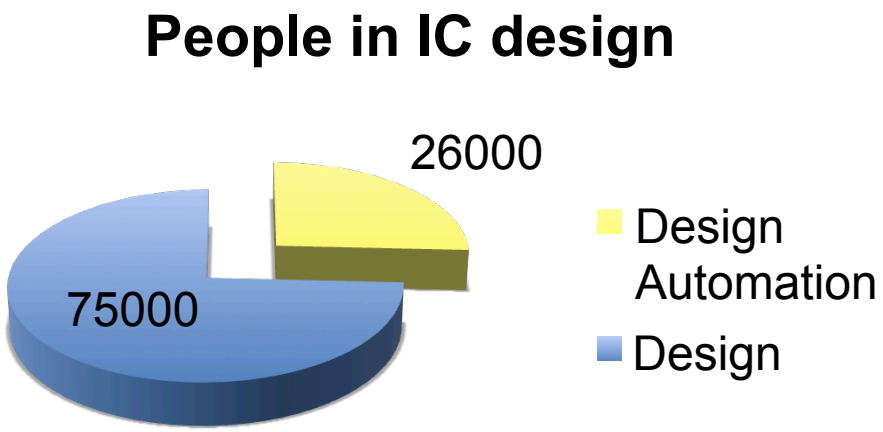
- **Dominated by 3 large companies:**
  - Synopsys: 9000 people, Value $5.29B, Revenue $1.81B
  - Cadence: 5600 people, Value $4.03B, Revenue $1.33B
  - Mentor: 4400 people, Value $1.93B, Revenue $1.09B
    - (Jasper: 100 people, Value $0.3B(?), Revenue <$0.1B)

- **Total:**
  - About 26000 people
    - 30% R&D
  - $6.4B/year
    - $4.8B core EDA

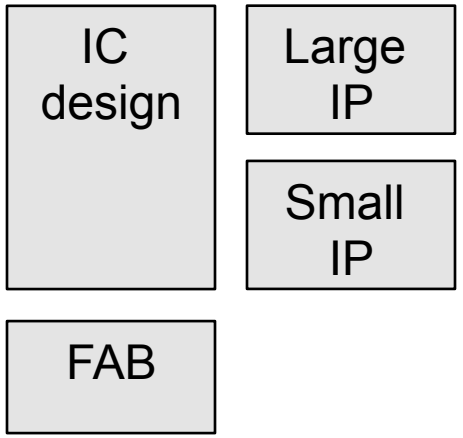
EDA industry revenue market share



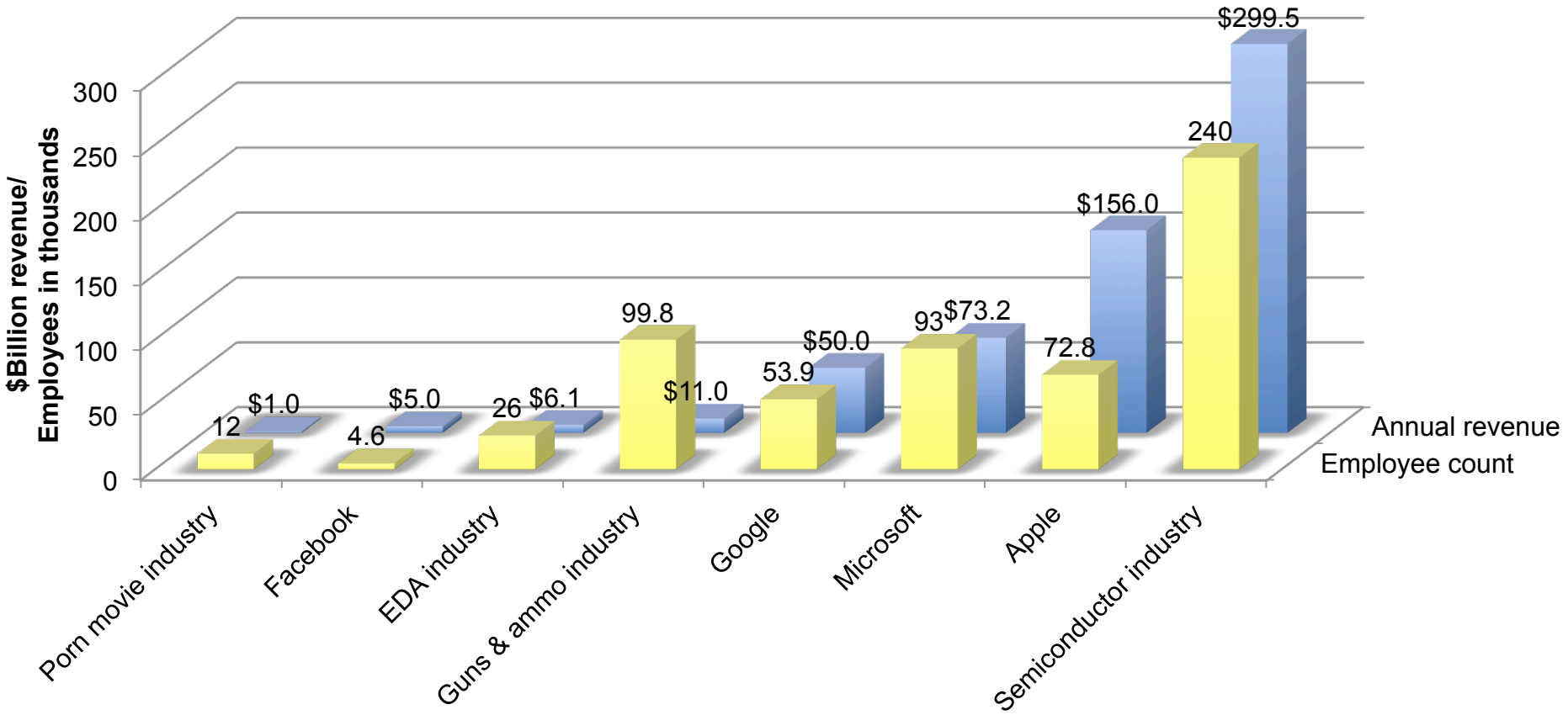
Perspective: is EDA right-sized?



- **Steady decline of IC design starts**
  - But designs are radically more complex
- **Number of customers:**
  - Approx. 200 world-wide
  - But only 10 large ones
  - Trend: consolidation

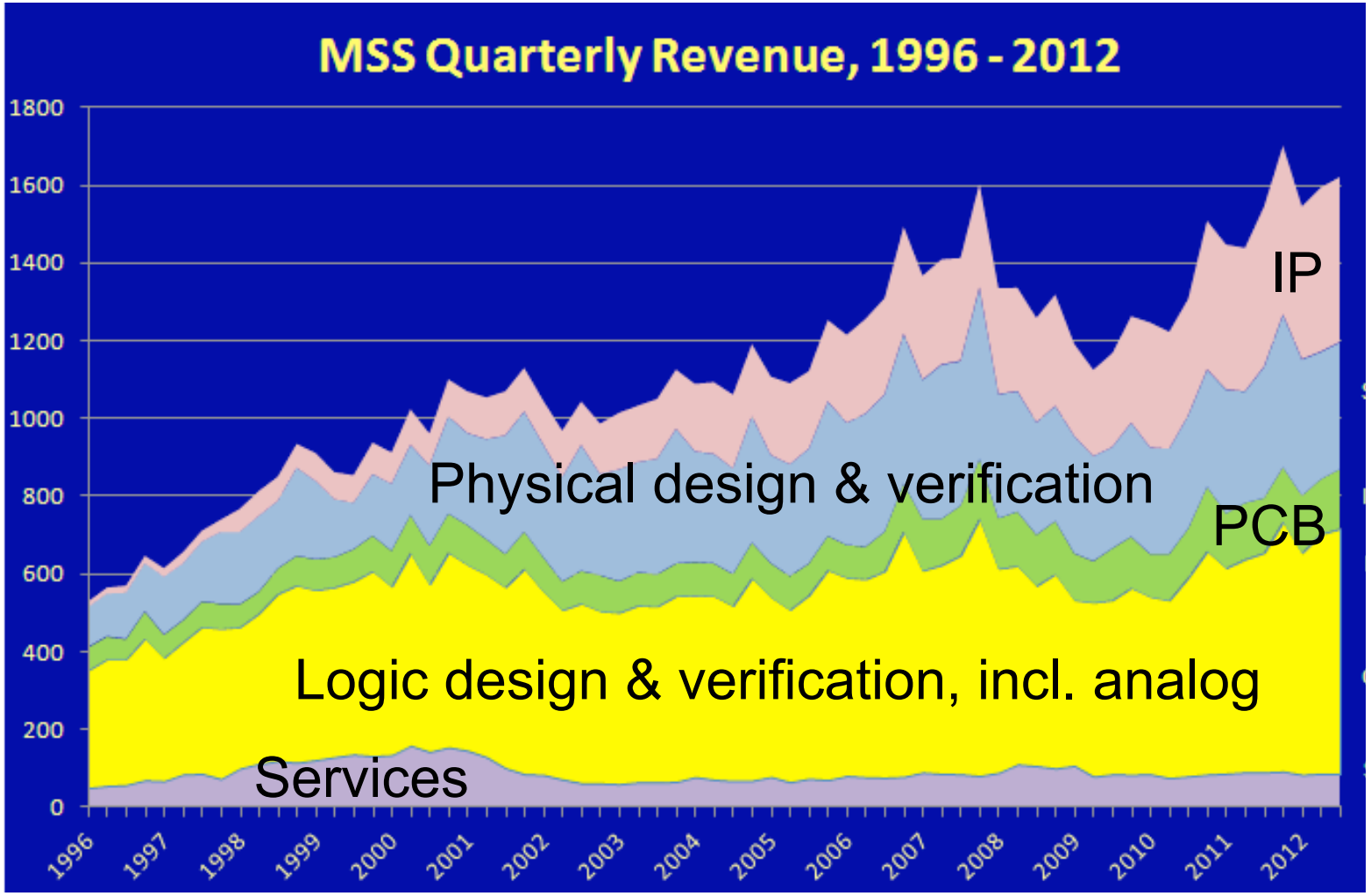


EDA Revenue: a perspective



Sources: EDAC, National Shooting Sports foundation, yahoo finance, lamatreasure.com, wikipedia

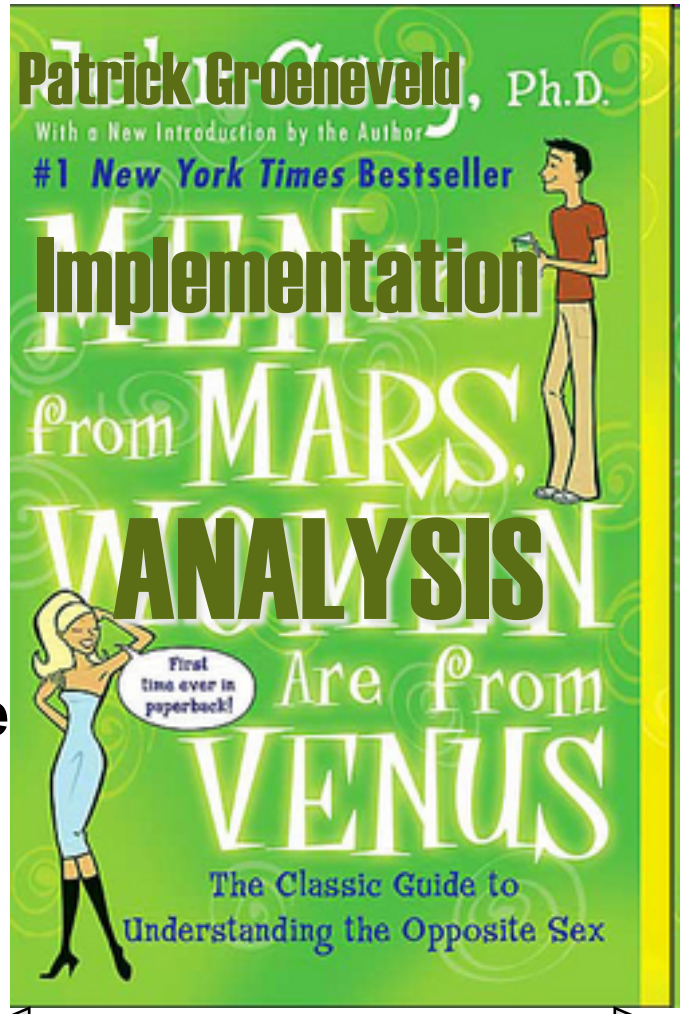
Slow EDA growth, moderate IP growth



Source: EDAC

Implementation is from Mars, Analysis is from Venus

- Sign-off tools:
- Verification, extraction, STA, spice, DRC, LVS
- Highly accurate
- Big and slow
- Is the ‘whiner’



- Implementation tools:
- RTL synthesis, Placement, Routing, Optimization, Humans
- Poor accuracy
- Lean, mean
- Is the ‘hacker’

Need to make this work

What makes money in EDA?

- **Most is sold as ‘time-based license’**
  - Package deal for all tools
  - Very few ‘Pay per Use’
- **“I need more licenses, pronto!”**
  - Happens only for sign-off tools (DRC, timing, spice)
- **Sign-off tools make disproportionate amount**
  - Synthesis is a tougher sell
  - … because tools are sold per CPU hour

DAC Conference perspective: the numbers

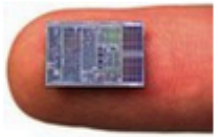
- **Exhibition:**
  - Number of companies: steady at 200
    - But its more small companies, very few mid-side and 3 giants.
  - Square footage: declining over past decade
    - Big-3 EDA are 70% of EDA revenue, but only 12% of DAC revenue!
- **Conference:**
  - Attendees: 1400 = Steady after decline since 9/11
    - All-time high was in 3500 in 2000
  - Papers: steady for many years (between 600-700)
  - Added Designer Track: target non-scientific crowd
- **Overall attendance:**
  - 2012: approx. 7200
    - All-time high was in 18000 in 2000

DAC Facebook page

Name	Status	Reach	Freq.	Social Reach	Actions	Clic
Likes Cadence – Ad		3,933	20.5	523	119	

Ad Preview Edit

50th DAC celebration



Join the 50th Design Automation Conference + Cadence is 25 years at DAC.

You like Design Automation Conference.

View on Site · Create a Similar Ad

Targeting Edit

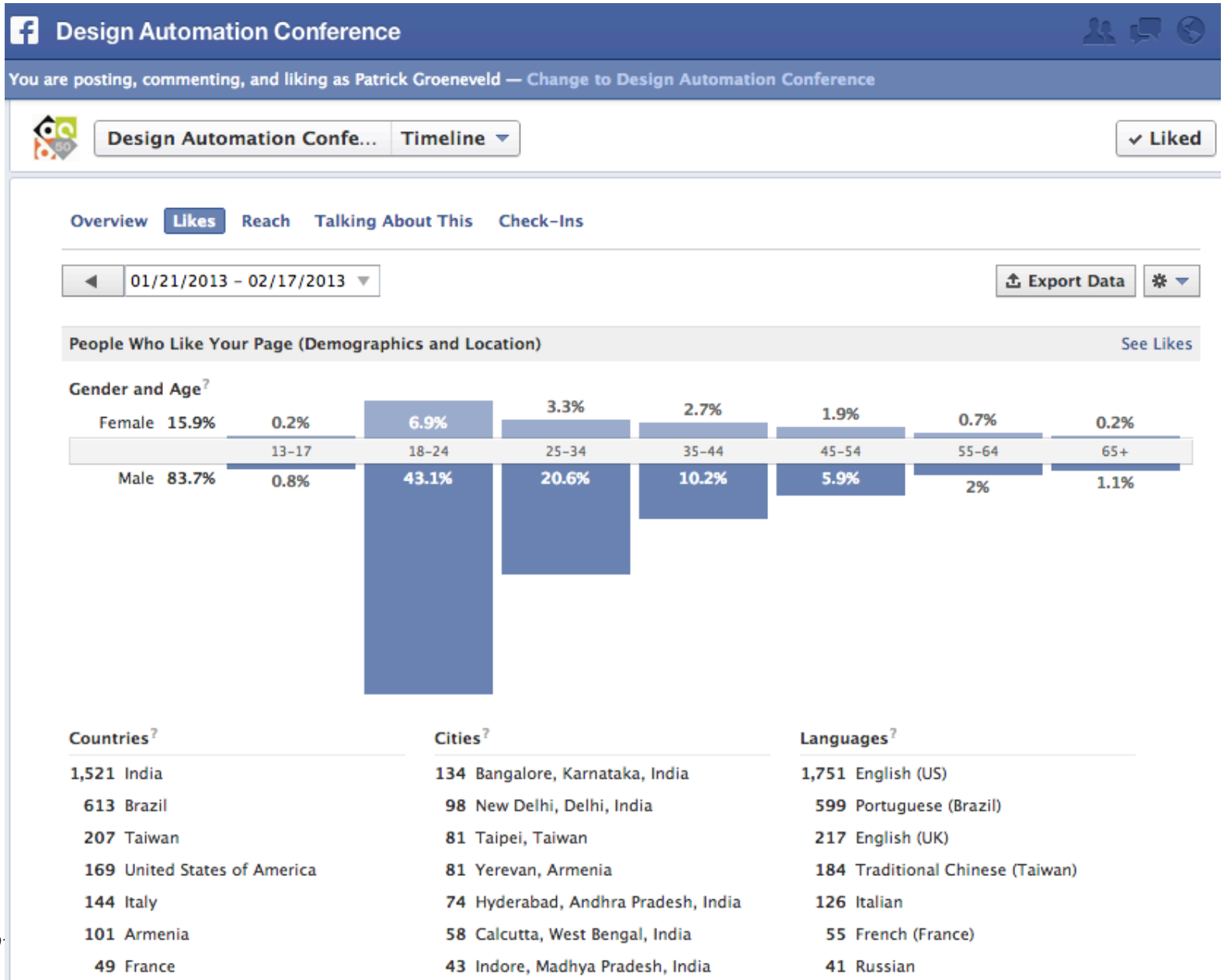
This ad targets 3,440 users:

- who live in one of the countries: United States, India, Ireland, Italy, Japan, Armenia, Netherlands, Canada, South Korea, Spain, Sweden, United Kingdom, Israel, Finland, Denmark, Belgium, Australia, Austria, Russia, Brazil, China, Taiwan, France or Germany
- age 18 and older
- who like #Cadence Design Systems

Close

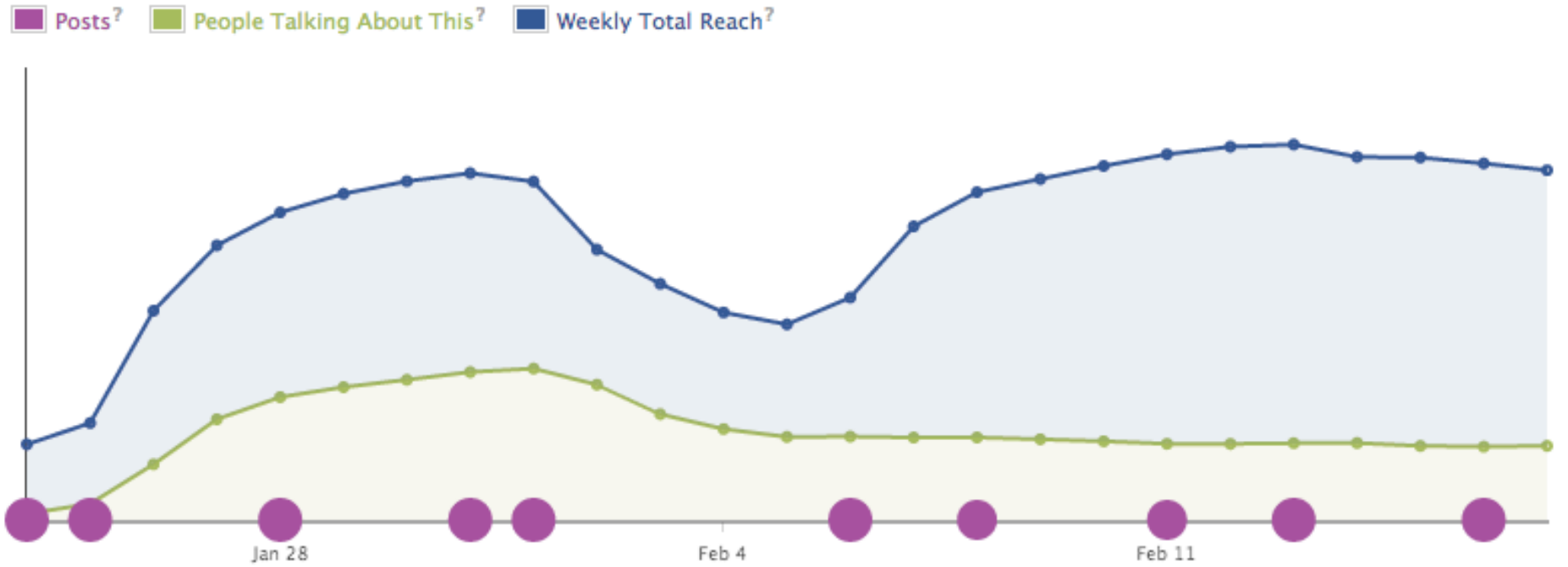
Likes Synopsys – Ad	2,572	27.6	496	70	
Likes Mentor – Ad	5,286	6.6	456	45	
Works at Synopsys – Sponsored Stories	186	7.5	183	21	
Works at Mentor – Ad	450	24.7	290	7	
Likes Synopsys – Sponsored Stories	664	13.1	648	6	
Work at EDA companies – Sponsored Stories	532	8.5	519	5	
Attend DAC through the Newton Young Student Fellow Program – Ad	545	20.7	0	2	
Likes Mentor – Sponsored Stories	310	7.5	307	1	
Work at EDA companies	259	7.4	67	1	
Works at SemiconductorCompanies	2,276	12.5	153	1	
Works at SemiconductorCompanies– Sponsored Stories	442	4.2	414	1	
Attend DAC through the Newton Young Student Fellow Program – Sponsored Stories	5	2.2	5	0	

Who likes DAC?



3250 likes

Total Likes	Friends of Fans	People Talking About This	Weekly Total Reach
3,250 ↑ 15.99%	1,246,311 ↑ 16.06%	640 ↓ -9.48%	110,101 ↓ -1.61%



Page Posts (Updated 4 minutes ago)

Observations: EDA business ecosystem

- **Trend 1: Consolidation**
- **Trend 2: Large EDA run their own shows**
  - Control message, do not want to share with competition
- **Trend 3: Outsourcing**
  - More design work is done in India
- **Japan & Europe are in decline**
  - Major companies losing the Semiconductor battle
- **Korea, China and India on the rise.**
- **Trend 4: Base EDA is 'commoditized'**
- **Embedded systems != EDA**

Observations: EDA Academia and conference

- **Paper flow steady**
  - Though fewer active research groups
  - Ivy league universities are less active in EDA
  - More from Taiwan, Korea, China
  - Less from Europe, USA and Japan
- **Paper quality steady**
  - Though less exiting than a decade ago
- **Slowly more Embedded Systems papers**
- **Major EDA employees are MIA**
  - Hardly ANY attendees from Synopsys, Cadence or Mentor at the major conferences!!!!

More observations: academic view

- **Weak empirical academic standards:**
  - Too few test cases
  - Test cases based on artificial data or flows
  - Many opportunities for **bias**

- **Reluctance to publish ‘negative results’**
  - Publication pressure encourages intellectual dishonesty
  - Comparisons/field tests are rare (or poor at best)

So, what is the role of academia?

- **1: Educating the next generation of engineers**
- **2: Research into radial new methods**

- **Challenge 1:**
  - Engineering is between ‘art’ and ‘science’
  - Often misunderstood by colleagues in ‘pure’ sciences
- **Challenge 2:**
  - Maintaining academic depth while being practically relevant
  - Find proper level of abstraction:
    - Not too high = useless in practice
    - Not too low = no academic depth
- **Challenge 3: (northern America and Europe)**
  - Attracting EDA students (by inspiring them)

Two-fold Design Complexity Increase

- **System complexity:**
  Dealing with the sheer size
  - 10 Billion transistors, 500M+ gate

- **Silicon complexity:**
  Dealing with the physics of manufacturing technology
  - Electrical parasitics.
  - Leakage & dynamic power
  - Process variability & manufac

Design Effort for a graphics chip family

Design Start	Technology node	Transistor count	Complexity	Front-end staff	Back-end staff
1993	0.5µ	0.75M	1x	1.0x	1.0x
1995	0.5µ	1.25M	1.5x	1.2x	3.0x
1996	0.35µ	4.0M	4x	1.6x	3.0x
1997	0.31µ	7.5M	7x	1.7x	4.0x
1998	0.25µ	9.0M	10x	1.5x	4.0x
1998	0.22µ	22M	20x	2.5x	5.0x
1999	0.18µ	25M	22x	1.5x	4.0x
1999	0.15µ	57M	30x	3.5x	6.0x
2000	0.15µ	60M	35x	1.5x	7.0x
2000	0.15µ	63M	40x	3.0x	7.0x
2001	0.13µ	120M	50x	5.0x	9.0x

Physical Design of Apple processors

- **Common technology:**
  - 45nm Samsung
- **A4: 2010**
  - iPhone 4 & iPad 1
  - 7.3mm x 7.3mm
- **A5: 2011**
  - iPhone 4s & iPad 2
  - 10.0mm x 12.0mm
- **A5x: 2012**
  - iPad 3
  - 12.9mm x 12.7mm
    = 3x as big as the A4

"The perceived usefulness of any new product is an underlying technology's logarithmic function"
(Theo Claasen, 2003)

Why is EDA so spectacularly successful in automatic design?

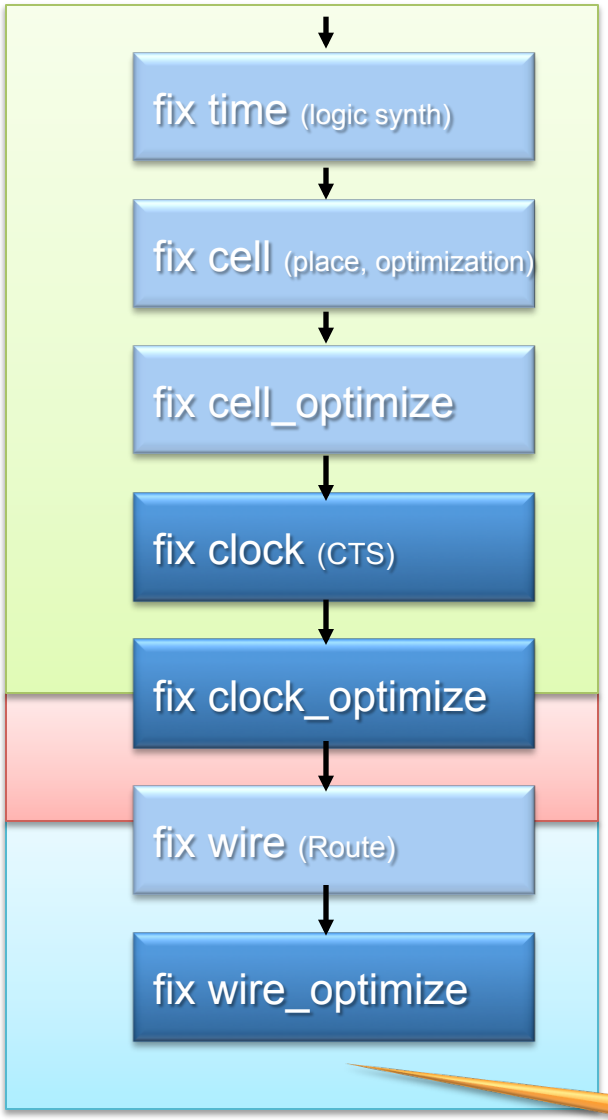
- **Unmatched when compared to any other industry:**
  - Synthesize billions of components
  - Designer productivity improvement follow exponential Moore's law for decades!
- **My view:**
  - Abstraction levels that *work*: RTL, net list, mask
  - A flow methodology that works without too much waste
  - A hierarchical decomposition that works
  - Agnostic for (most) applications
- **Recipe for success:**
  - Problem contained in a box (standard cell, macro)
  - Boxes are 'composable' using simple rules:
    - swap., Don't overlap, minimize wire length, and you're good
  - Simple model of reality is good enough for automatic optimization
  - 'Smooth' solution space

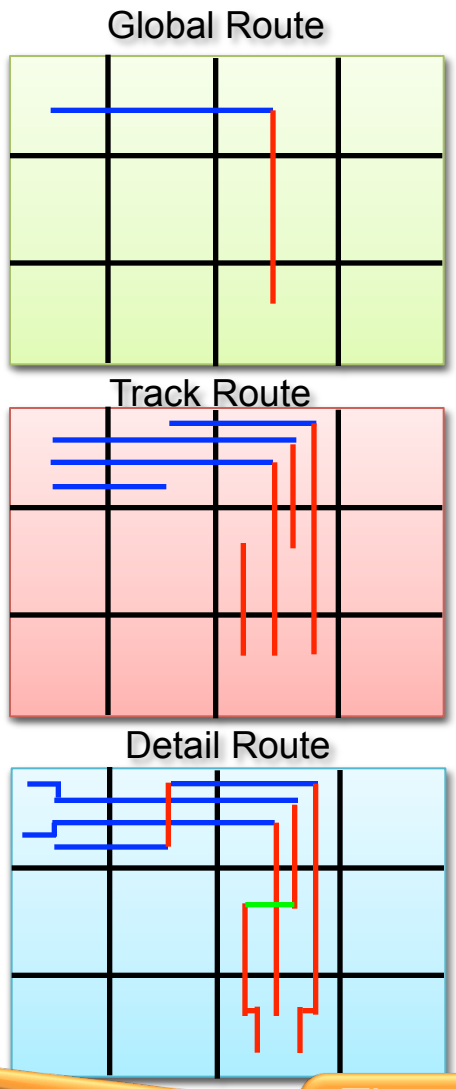
EDA handles *Many* Objectives Simultaneously

- **Correct & manufacturable mask pattern**
  - Congestion control
  - Big chip = good
- **Meets timing & electrical requirements**
  - Battle parasitics: timing, voltage drop
  - Big gates = good, compact chip = good & a little ha
- **Low power**
  - Leakage control, multi-voltage, sleep, etc
  - Small gates = good, complex floorplan = necessary evil
- **Low part cost**
  - Compact chip, dense wires = good
- **Low design effort**
  - Robust design, short tool run times, re-use
  - Simple = good, pushbutton = good

Intricate trade-off

Magma Flow: guided by ‘best available’ data



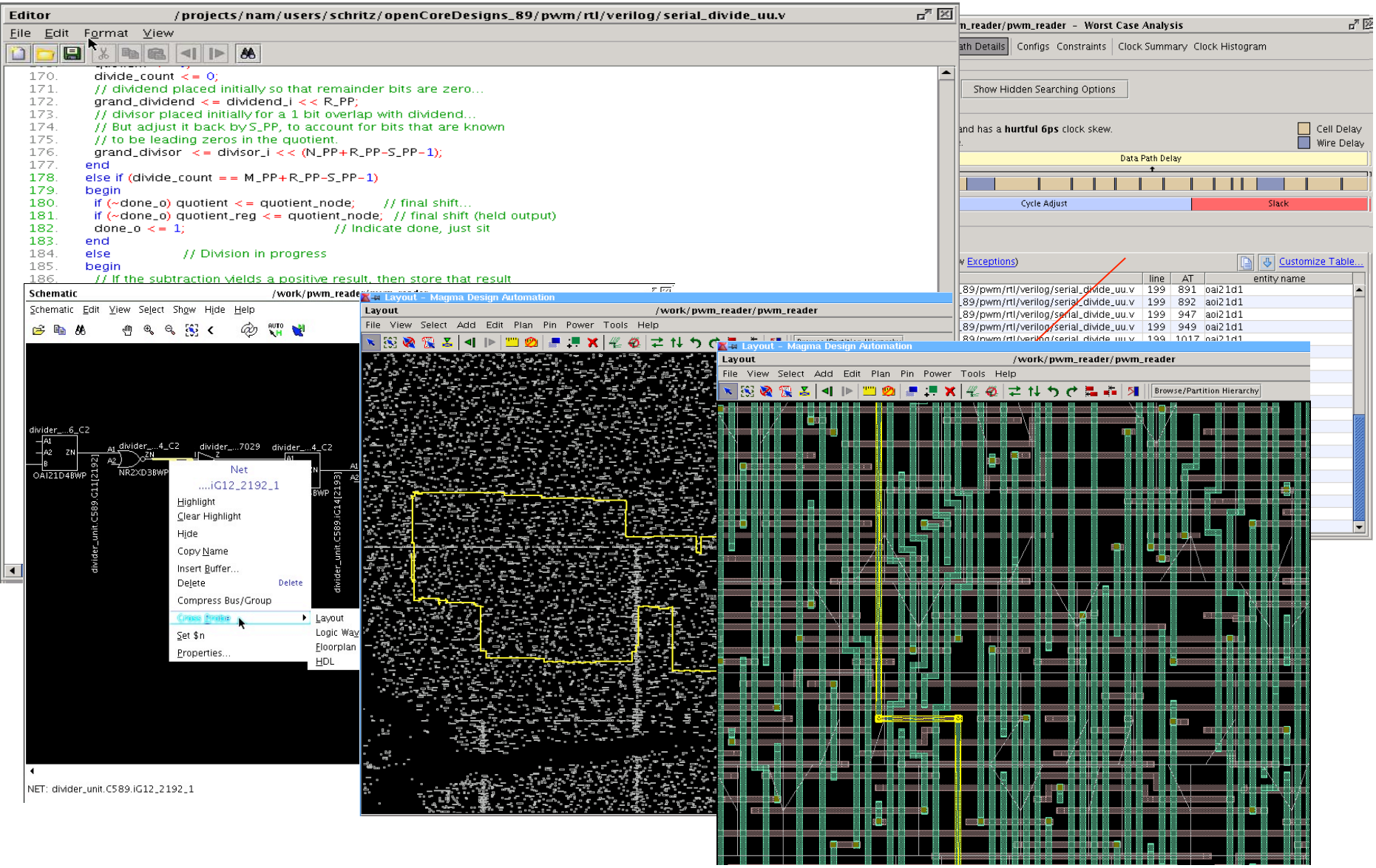


- Global route:
  - Layer assignment
  - Congestion
  - Resource contention
  - Detours
- Track route:
  - Refines global route
- Detail route
  - Copies track route
  - Fixes opens
  - Ripup & Reroute

The only thing that matters is the quality at the end!

MAGMA

Layout Design at different levels of abstraction



What EDA does not particularly well

- **Analog circuit synthesis**
  - Same old Spice & layout with limited automation
- **Blocks of various shapes and sizes**
  - Requires extensive manual tweaking
- **Speedup by parallel design algorithms**
  - Stuck at 4x
- **Higher levels of design abstraction**
  - Gets domain-specific
  - Many-objective flows

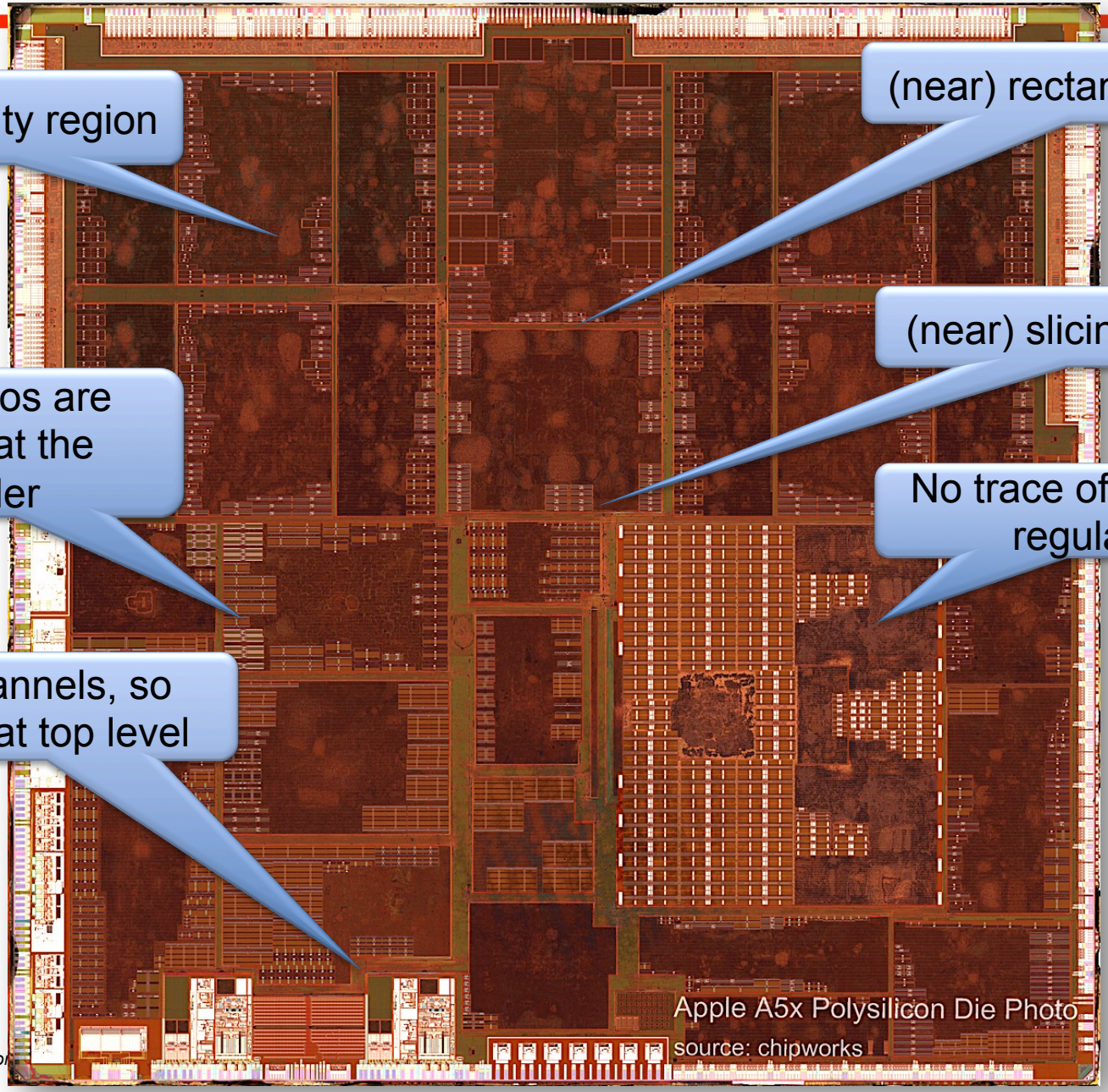
Hopeless

Hopeless

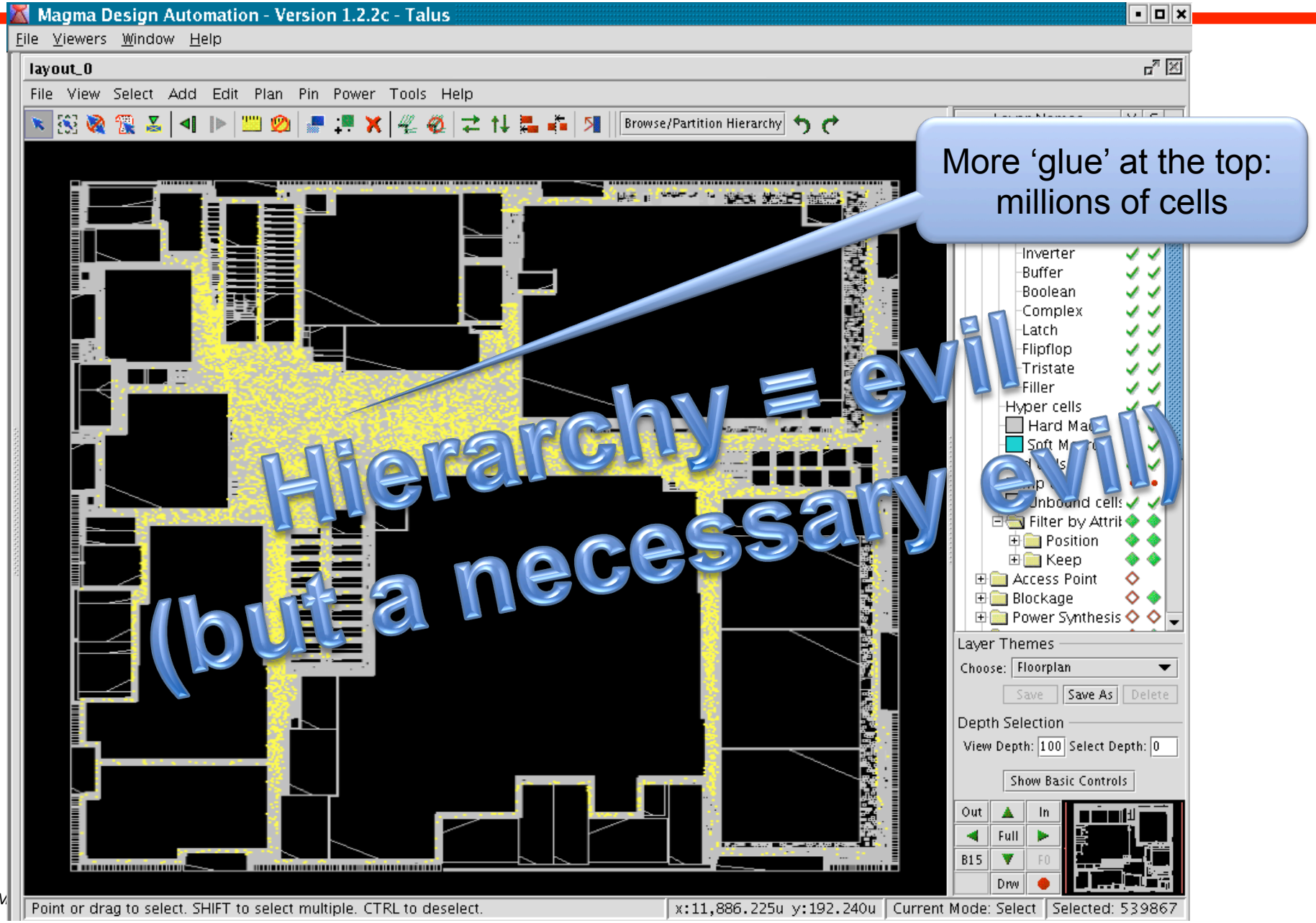
Hopeless

Must address

A closer look at the Apple's physical design style



“Many-Cell” Top-Level design



Analysis(verification) tools: They were *not* the key to EDA success

- **Verification tools are overhyped. They are straightforward programming jobs:**
  - Use brute-force parallelism & cloud computing
  - Use tricks to keep memory usage low
  - Correlate to make result trustworthy
  - Use GPU if needed

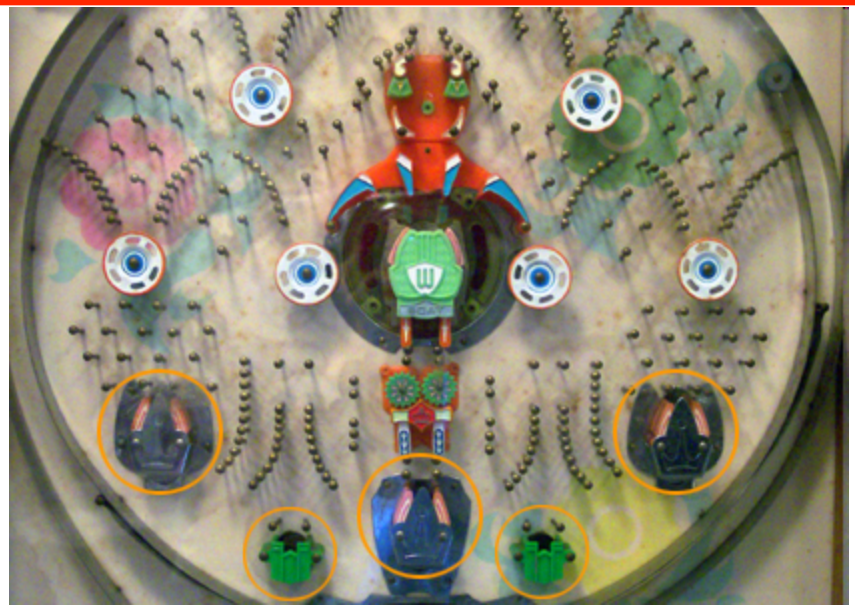
- **Such tools exist in other domains as well:**
  - Mechanical CAD with finite element methods
  - Animation
  - Architecture

A few suggestions for good EDA research topics

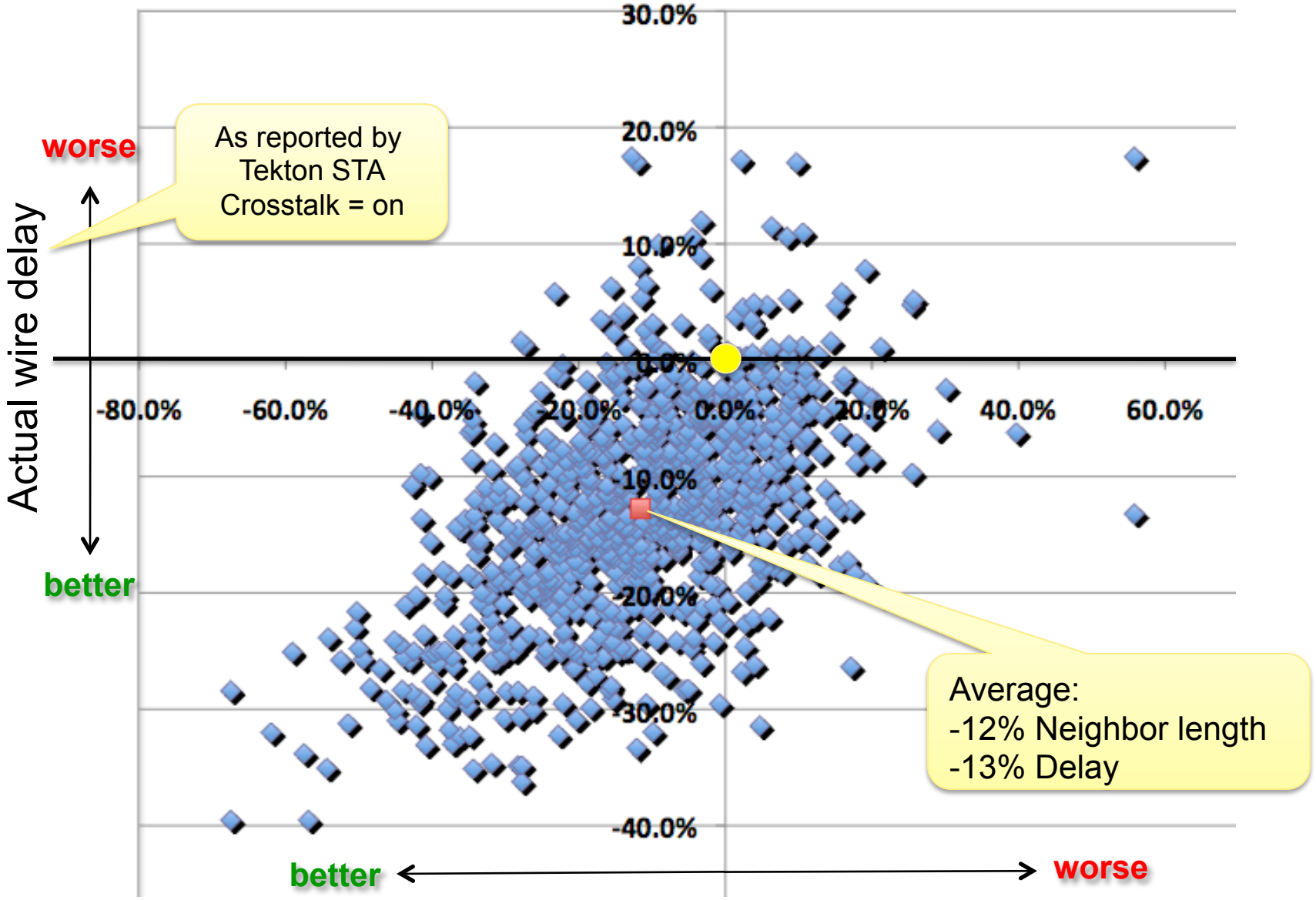
- **Better understanding the nature the beast:**
  - Bridging the Analysis – Implementation gap
  - Dealing with the noise of unreliable predictions
- **Radically new design paradigms**
  - Platforms, GALS/NoC
- **Radically new technologies**
- **Focus on 'verticals'**
  - Automotive, mobile, aerospace, bio

Synthesis flow (or life) as a pachinko machine

- **Run complex flow:**
  - End up an one of the local optima.
- **Re-run:**
  - typically get same results
    - (Multi-processing alert!!)
- **Re-run with small change**
  - Could be huge difference
- **Changes:**
  - Irrelevant order changes
  - Additional steps/algorithms
  - Changing constraints, tuning, etc.

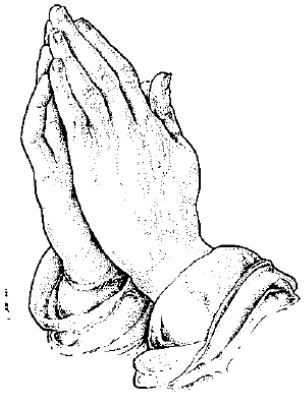


You always get what you want (not even close….)



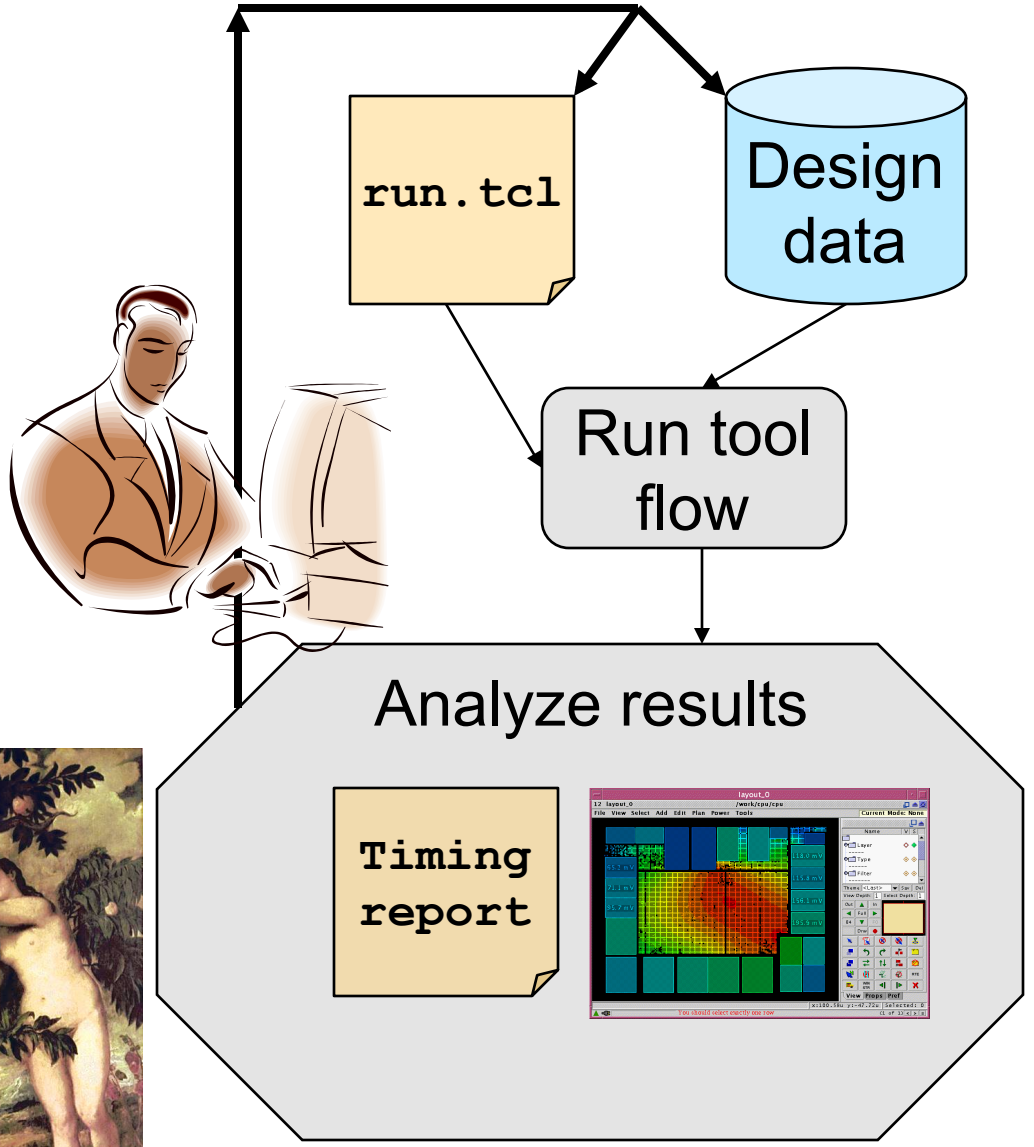
How to the better results from a noisy design system

- **Run again and pray**



- **Run many times**
  - Pick the best

- **Attempt to understand**
  - Cause, effect



Philosophical angle: Finding 'truth' in Engineering

- **With enough effort, its *always* possible to understand**
  - There are no miracles, only challenges to understand better
- **All decisions can be based on rational trade-offs on tte best-available data:**
  - Effort vs quality
  - Power vs speed
  - Interest rate vs economic growth
  - CO2 output vs economic growth
  - Individual freedom vs taxes/abortion/
- **Shortcuts are necessary, because data is noisy/not understood**
  - But choices may not become dogma
- ***The great thing about science is it remains true whether you choose to believe it or not.***
  - Neil deGrasse Tyson

Using skeptical wisdom

- **"Humans are amazingly good at self-deception"**
  - This looks soooo good, therefore this *must* work
- **"If it has no side effects, it probably has no effects either"**
  - Example: improving temperature gradients is gonna cost you! So is improving yield. Are you really willing to pay based on the evidence?
- **"Do not confuse association with causation"**
  - "I took this airborne pill, and I did not get sick"
  - "I used this DFM optimizer, and the chip yields!
- **"The plural of 'anecdote' is 'anecdotes', *not* data"**
  - Result could be a random effect, or another side effect
  - No substitute for unbiased placebo-controlled tests
  - Only large data sets are statistically relevant

Summary

- **EDA is maturing, but far from solved!**
  - Main issue: keeping up with Moore's law
- **Academia has unique chance to set research direction for EDA**
- **Advice:**
  - Less algorithms, more methodologies
    - EDA requires a 'holistic' methodology across many abstraction levels
    - …rather than 'optimal' point tool solutions
  - Resist temptation to do too much short-term development work
  - Focus on big problems that matter:
    - Paradigms to deal with design scale
    - Understanding and controlling complex flows
- **Best way: Start a new company yourself**