Power:

Where it matters,

when it matters,
and

when it does not

g dan hutcheson

Keynote for the Berkeley Symposium on Energy Efficient Electronic Systems

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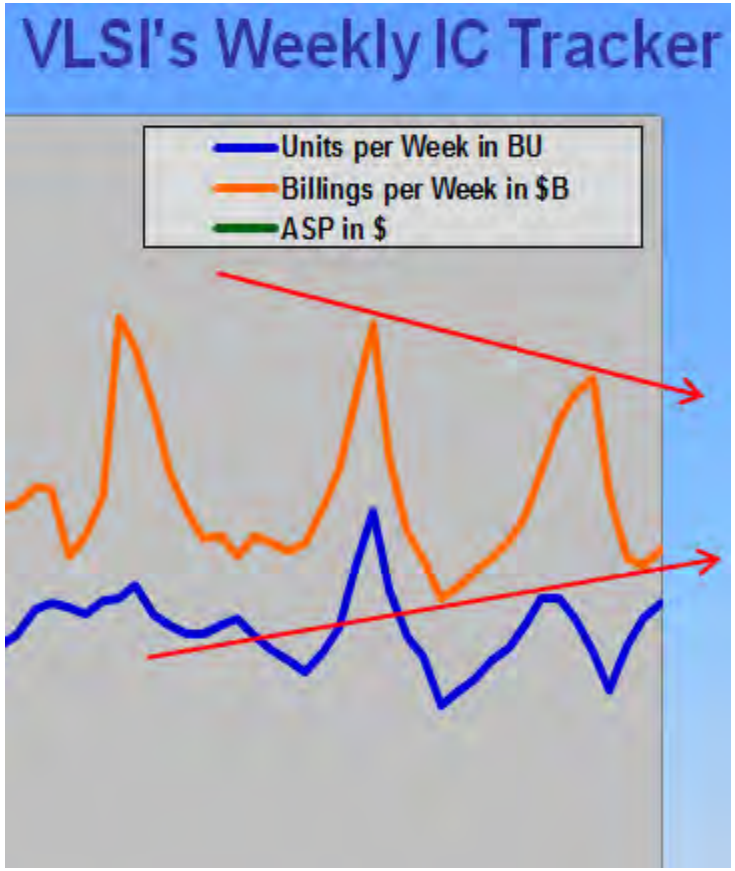
Semiconductor Analytics

- **IC Sales:** October crash ends
  - 3% growth for the last week of the month
- Semiconductor Sales Activity hits 10th week of + W/Q growth
- Electronics Sales Activity hits new high for 4th Week
  - 10th week of W/Q strength



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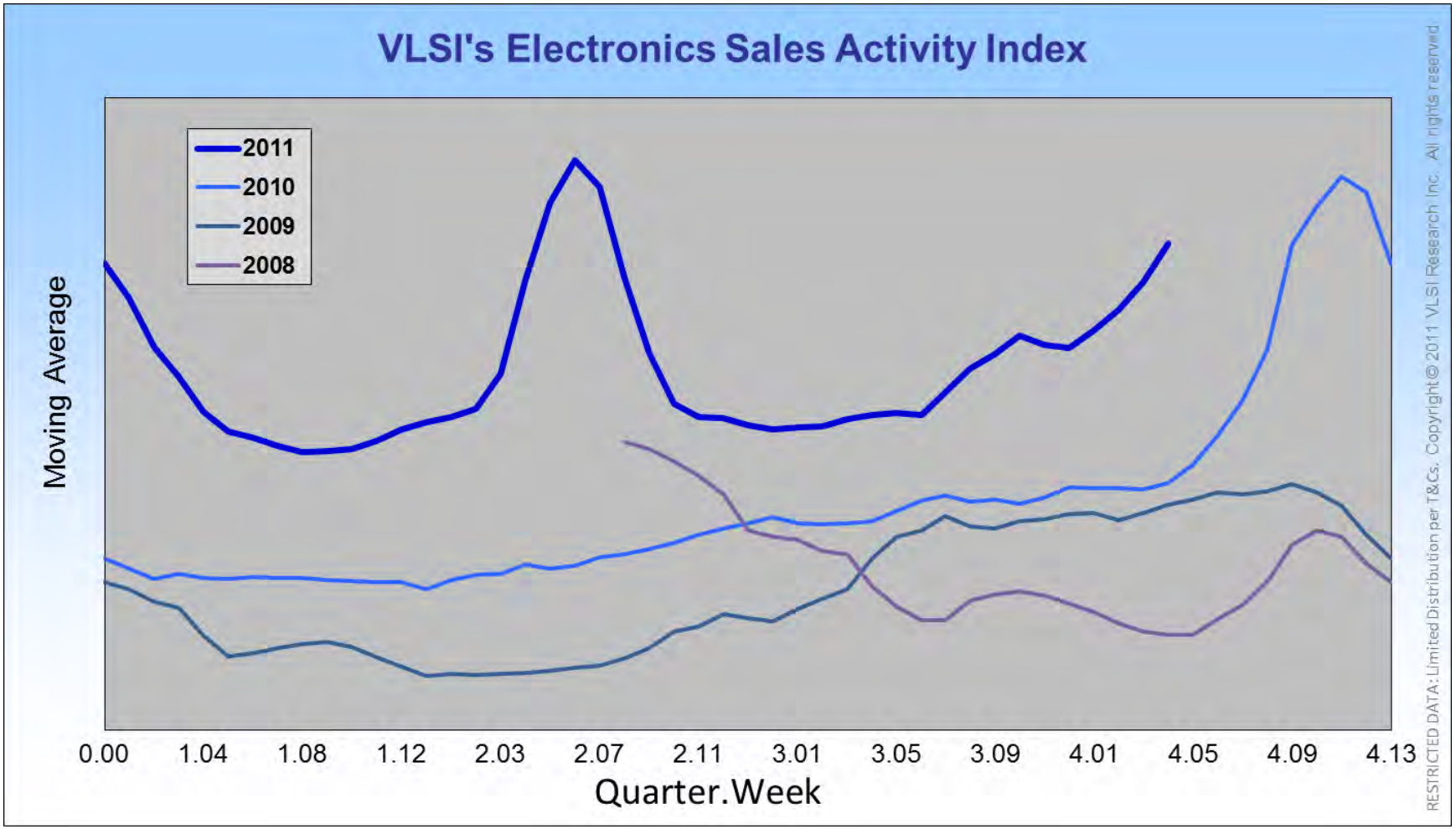
- Holiday electronics buying cycle stays on track 4 Growth
- This data series does not look recessionary



Power is the new Fall Fashion

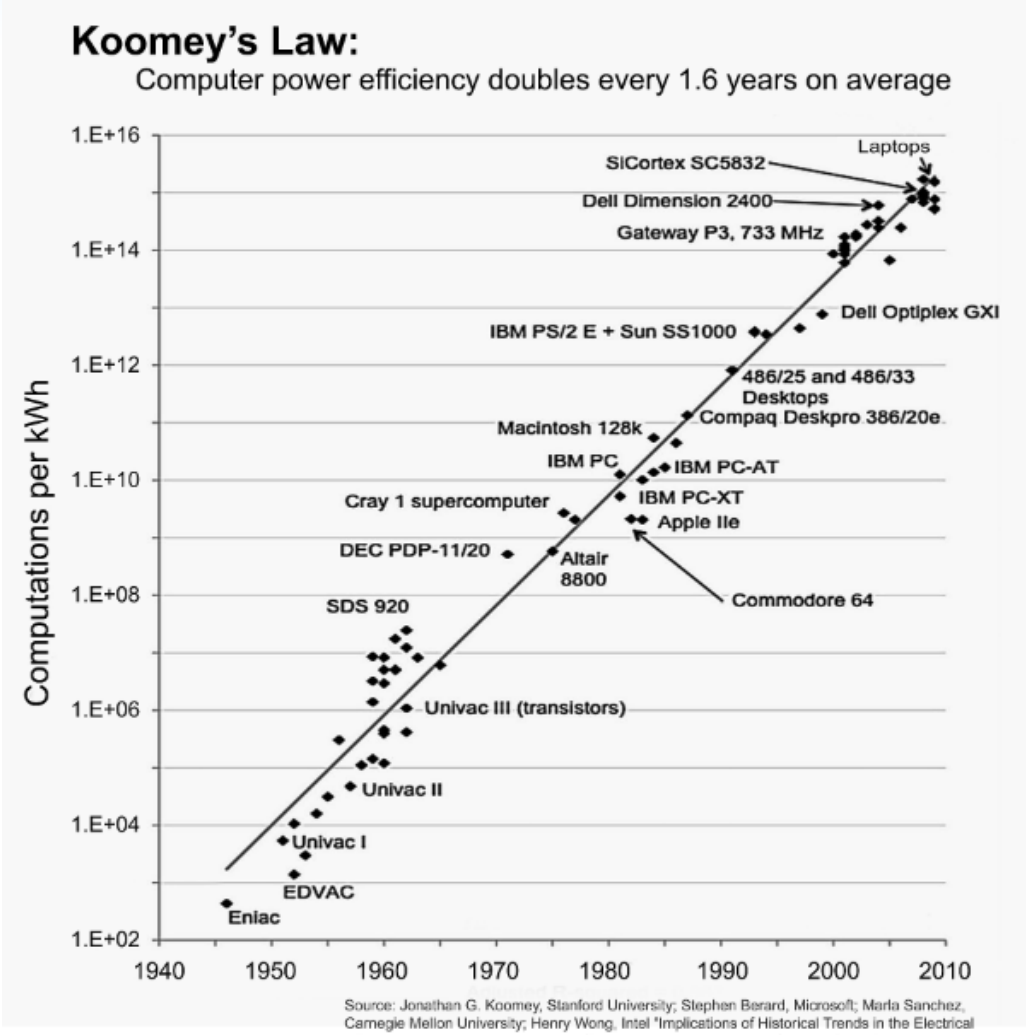
Will it Last?

Power has New Chasms to Leap

- Server Farms
  - The most expensive server…
- Mobility Explosion
- Competitively
  - 3D transistors
  - Cost of producing
    - In the 10-20nm range
- But …

Koomey's Law

- Computer power efficiency grows at a 54% CAGR
- Thus power-per-computation is declining at a 35% annual rate



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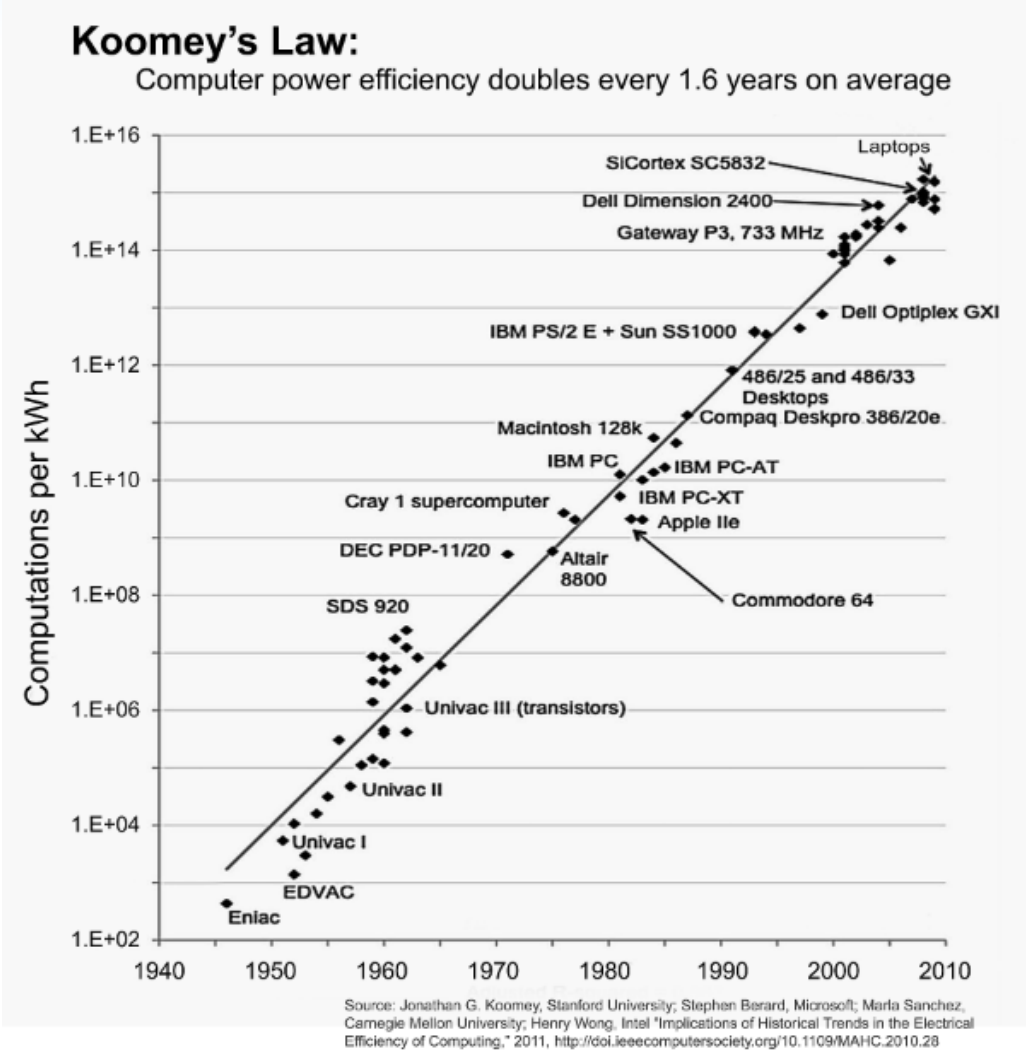
Koomey's Paradox

- **If** power efficiency has been declining at a 35% CAGR since the 1940's
- **Then** why is power in vogue today?
  - Taken 6 decades



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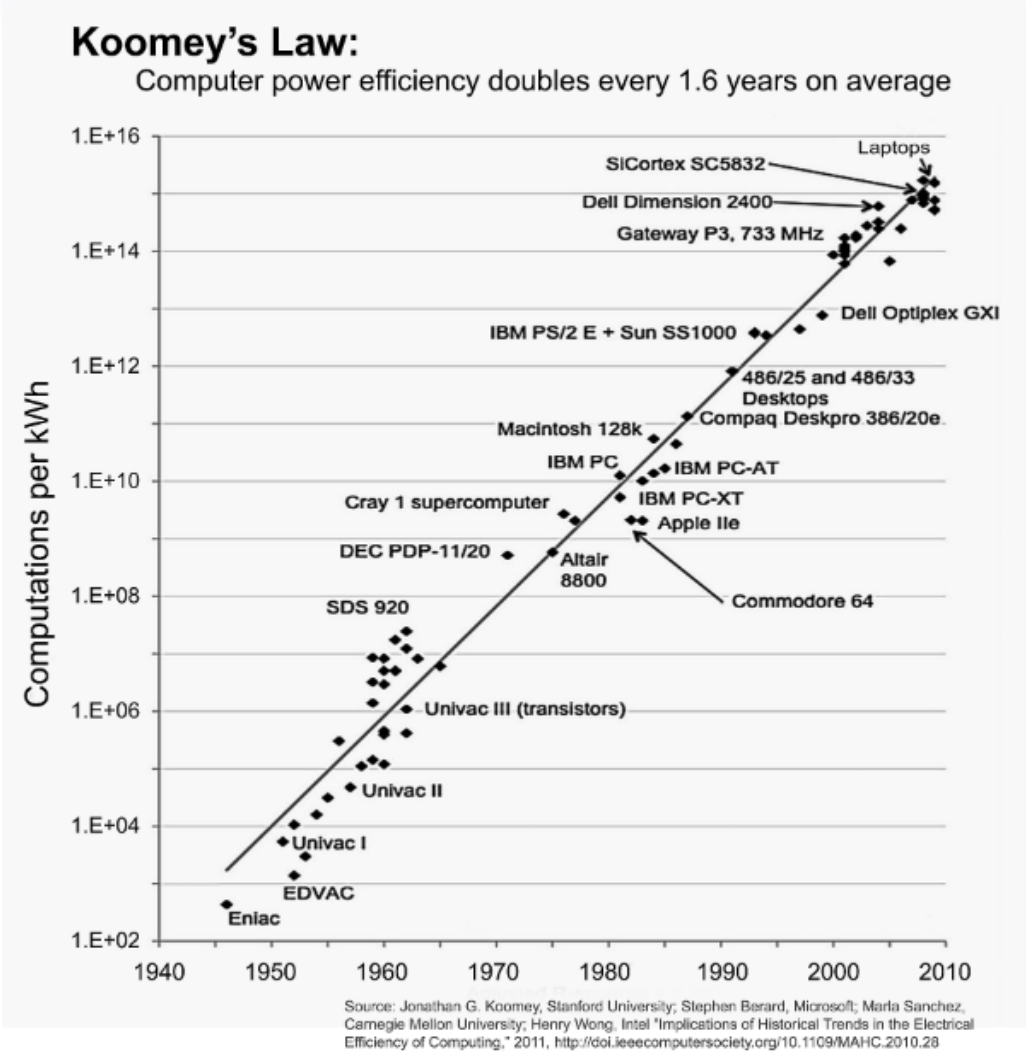
Koomey's Law or Observation?

- What are the drivers?
- Isn't it just a restatement of Moore's Law and Dennard's scaling rules?



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Moore's Law

Component density **doubles** every two years due to **geometry shrinks** for roughly the **same areal cost**

Gordon Moore - 1975

Gordon Moore in 1975 Source: Intel

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Dennard's scaling rules

Transistor **shrinks** result in

proportional power and/or

performance **gains**.

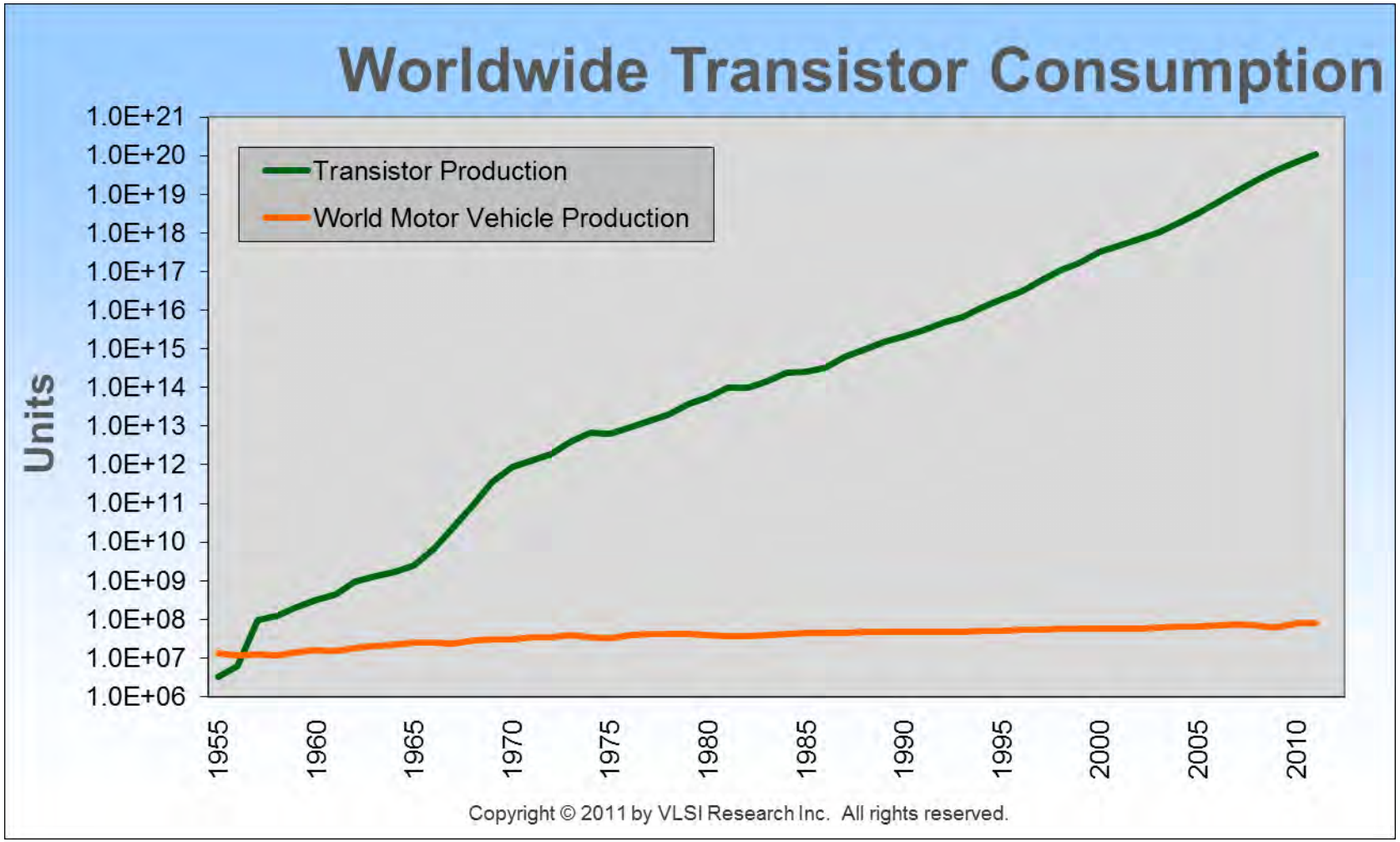
Robert Dennard - 1974

Robert Dennard Source: IBM

$$\sum_{i=5}^{mils\ to\ nm} Moore's\ Law + Dennard\ Scaling =$$

Shrinkonomics

… and the Semiconductor Industry went in Nodal Leaps and Bounds



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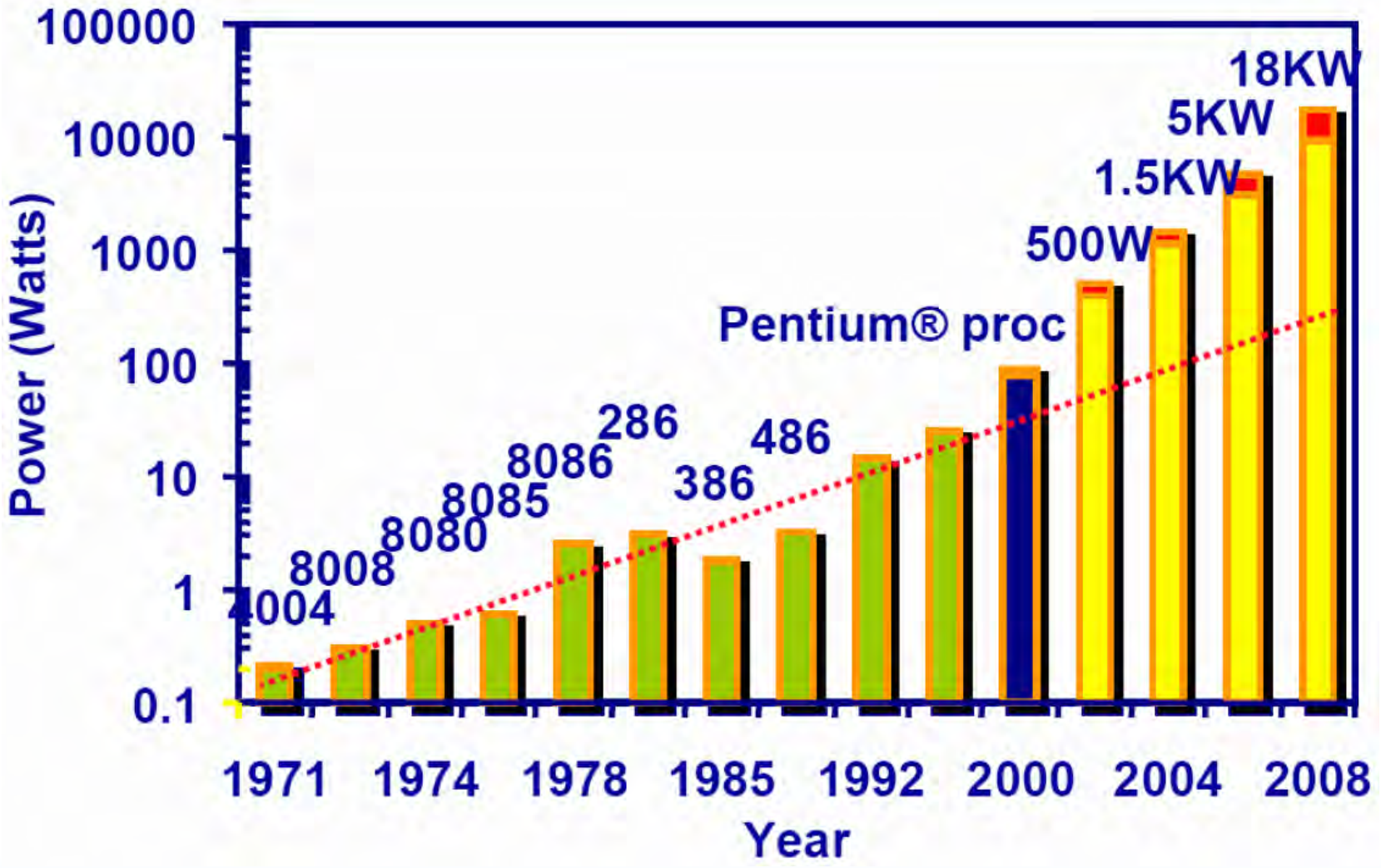
Now we did worry about power a bit back around 2000



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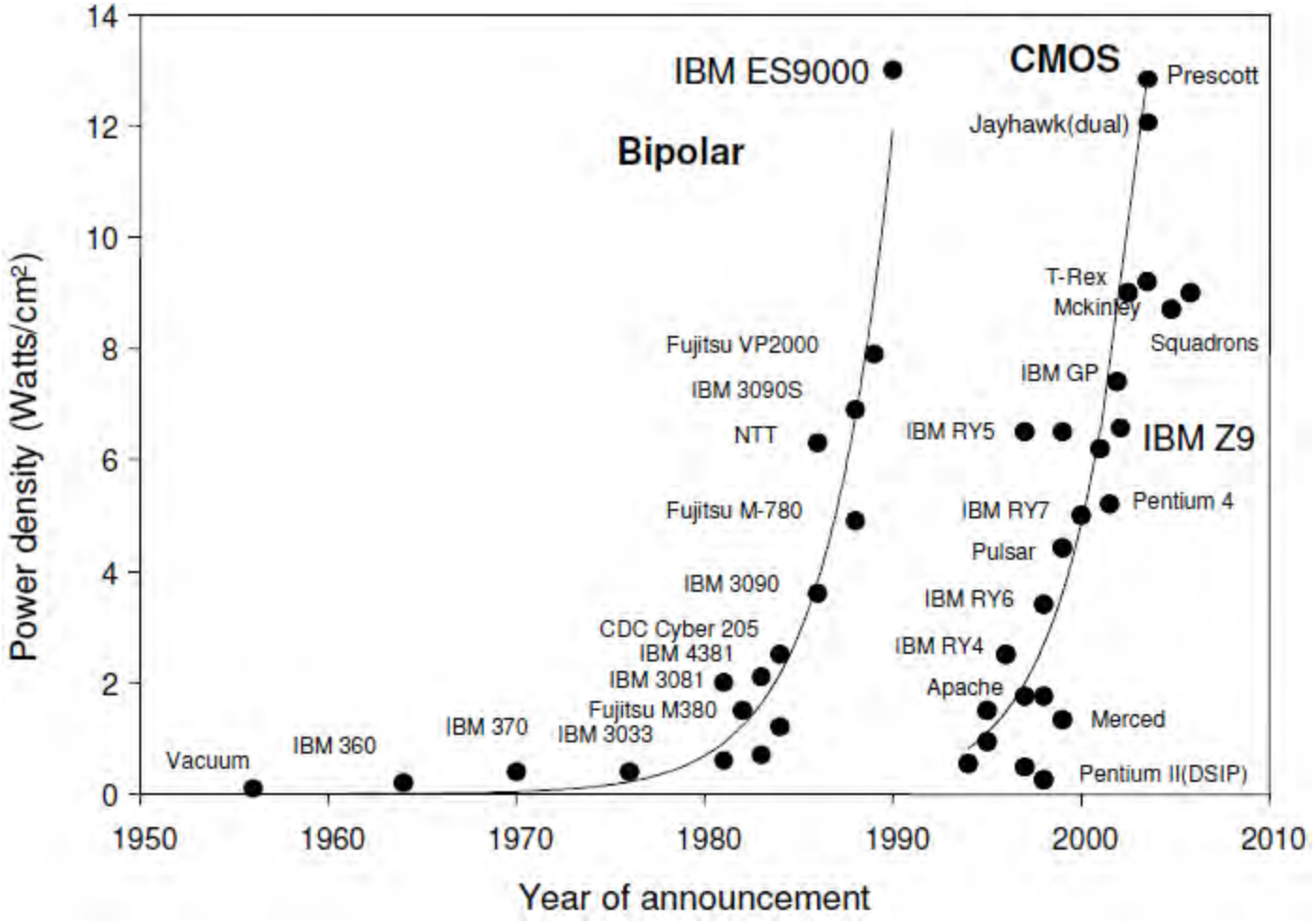
Power Density Trends

(in Watts/cm2)



Source: Robert Dick, University of Michigan

There was no nuclear meltdown

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Everybody pretty much forgot about the power part … until now

Even Koomey's paper focused on performance efficiency, not power

Where did Koomey's System Level Performance gains come from?

- The **result of improvements** in
  - **transistor** architectures and …
  - **processor** architectures
- Systems are assemblies of chips
  - Not ground-up designs
  - like mainframe era systems

System versus Transistor Power Improvements over Time

- What do you get if you take…
  - system power efficiency
    - and
  - divide it by transistor count
    - Or transistor equivalents
    - i.e. tubes, magnetic cores, or transistors

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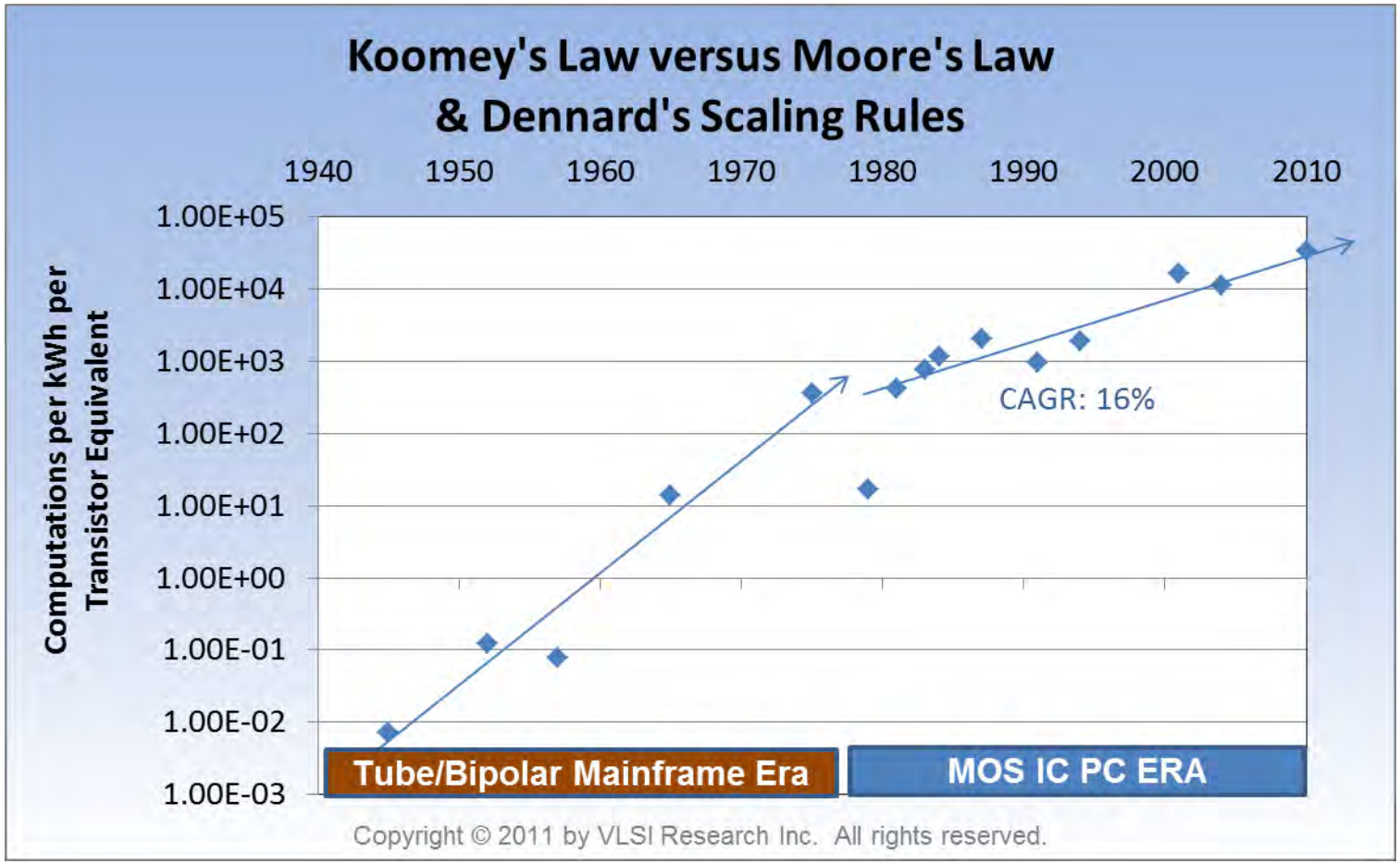
Koomey, Moore & Dennard

(Computations per kWh per Transistor Equivalent)



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Mainframe versus PC eras

- Both eras distinctly different
- Computer industry went from
  - tubes to
  - bipolar transistors, to
  - bipolar ICs, then
  - NMOS ICs, and eventually
  - CMOS ICs

Improvements in switches led to

- Huge leaps forward in power reduction
- Resulted in greater computational power efficiency
- NOT reductions in power use

Power Efficiency Improvements in the PC Era

- 54% = Koomey's Law Annual Growth Rate
- 39% = Transistors per system growth
- 16% = Transistor normalized annual growth
  - computations-per-kWh

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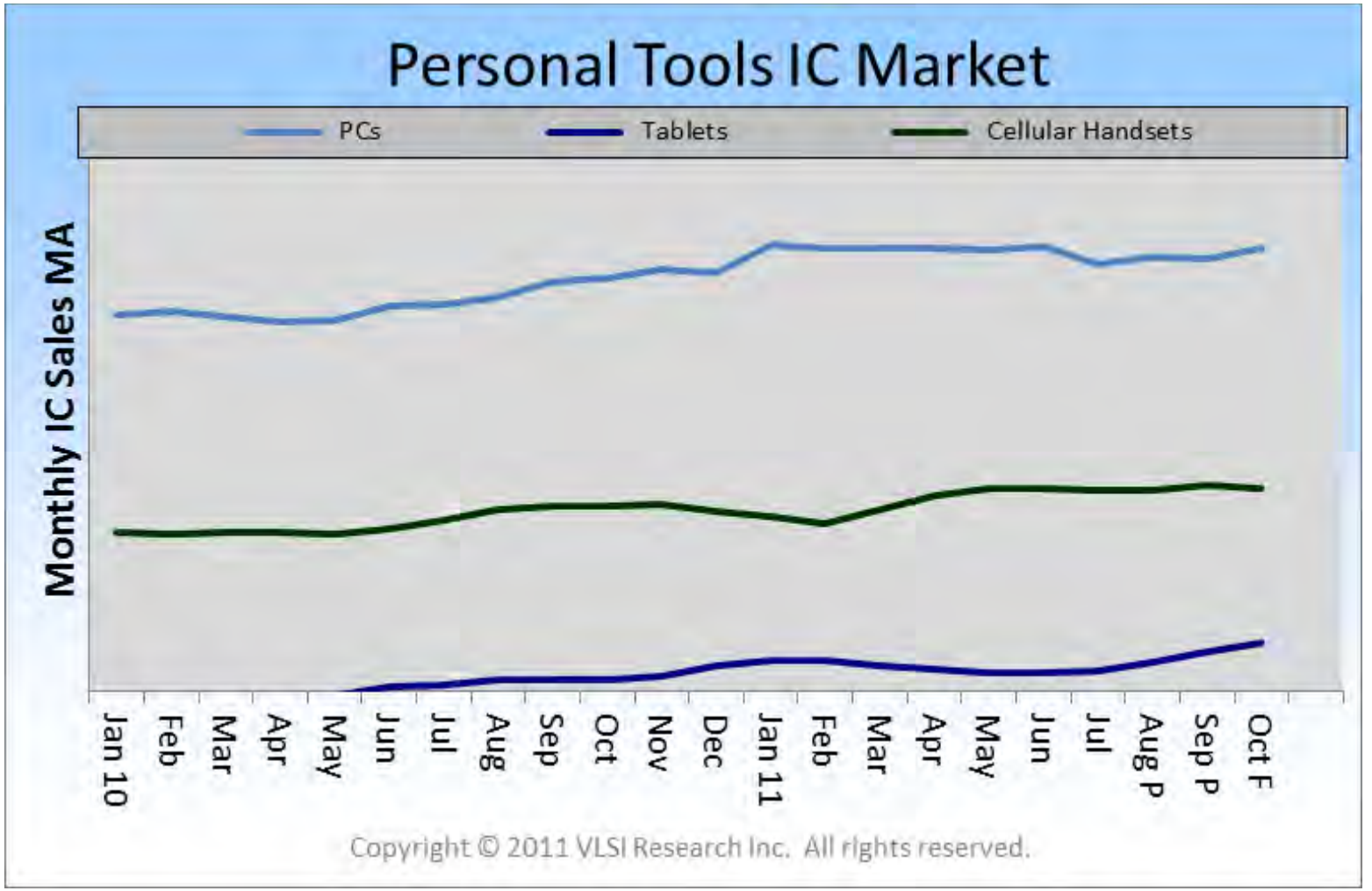
Moore's Law & Dennard's scaling rules

- **Increasing transistor density** with lower power **accounts for most** of the **computational efficiency gains since the eighties**

What this means for market drivers

- Computational power more important
  - than power use
- Why CPUs are the most profitable sector of semiconductors
- *But will this change?*

Despite reports to the contrary, PCs are still alive and well



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Marketing Power

IC Marketing 101

Power is **NOT** a market

It's an electrical parameter and a design constraint

Power's 1st Order Design Constraints

Power Source > **Black Box** < Function

Mainframe >>> to >>> Mobile

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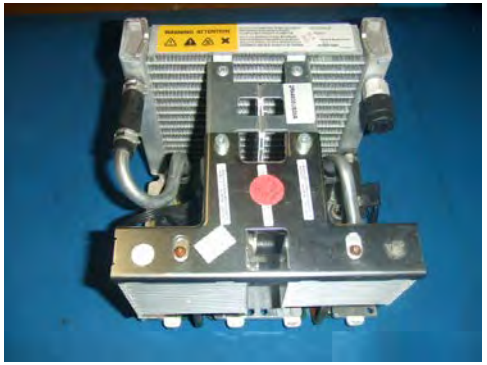
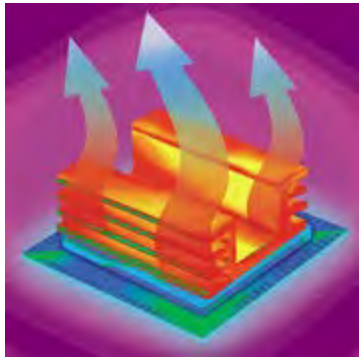
Power's Last Order Design Constraint: **Heat Dissipation**

- You have to get the heat out of the box
  - Reason why laptops are now called notebooks
  - Datacenter Power Costs rising 6-8x spending on servers



Apple Power Mac G5 Dual 2.5GHz Processor
Source: Mac2MacOnline.com



Source: Dow Corning

Source: Deep Cool

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… and the box can be a building

- Datacenter Power Costs have been rising 6-8x that of spending on servers
- Nuclear power plants don't scale with Moore's Law

Source: Horst D. Simon "From Bits to Buildings: Energy Efficiency and the Path to Exaflops" http://electronics.wesrch.com/paper-details/pdf-EL11TZUFUNCBP-energy-efficiency-and-the-path-to-exaflops

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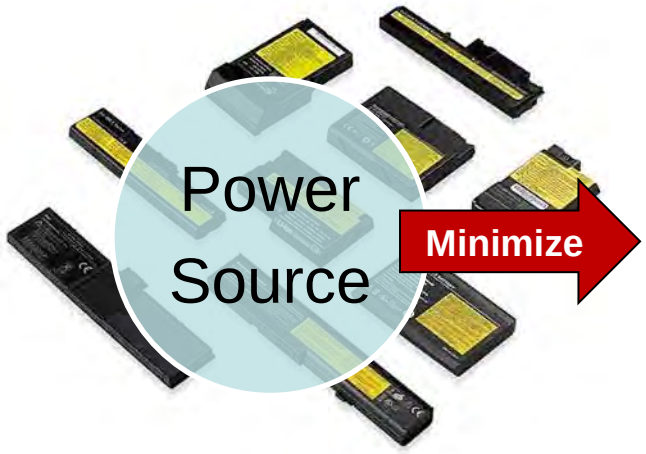
Fundamental IC Design-for-Market Boundary Conditions



Minimize

Energy to Function Conversion

Maximize

Minimize

Heat out

This is why processor power never went nuclear

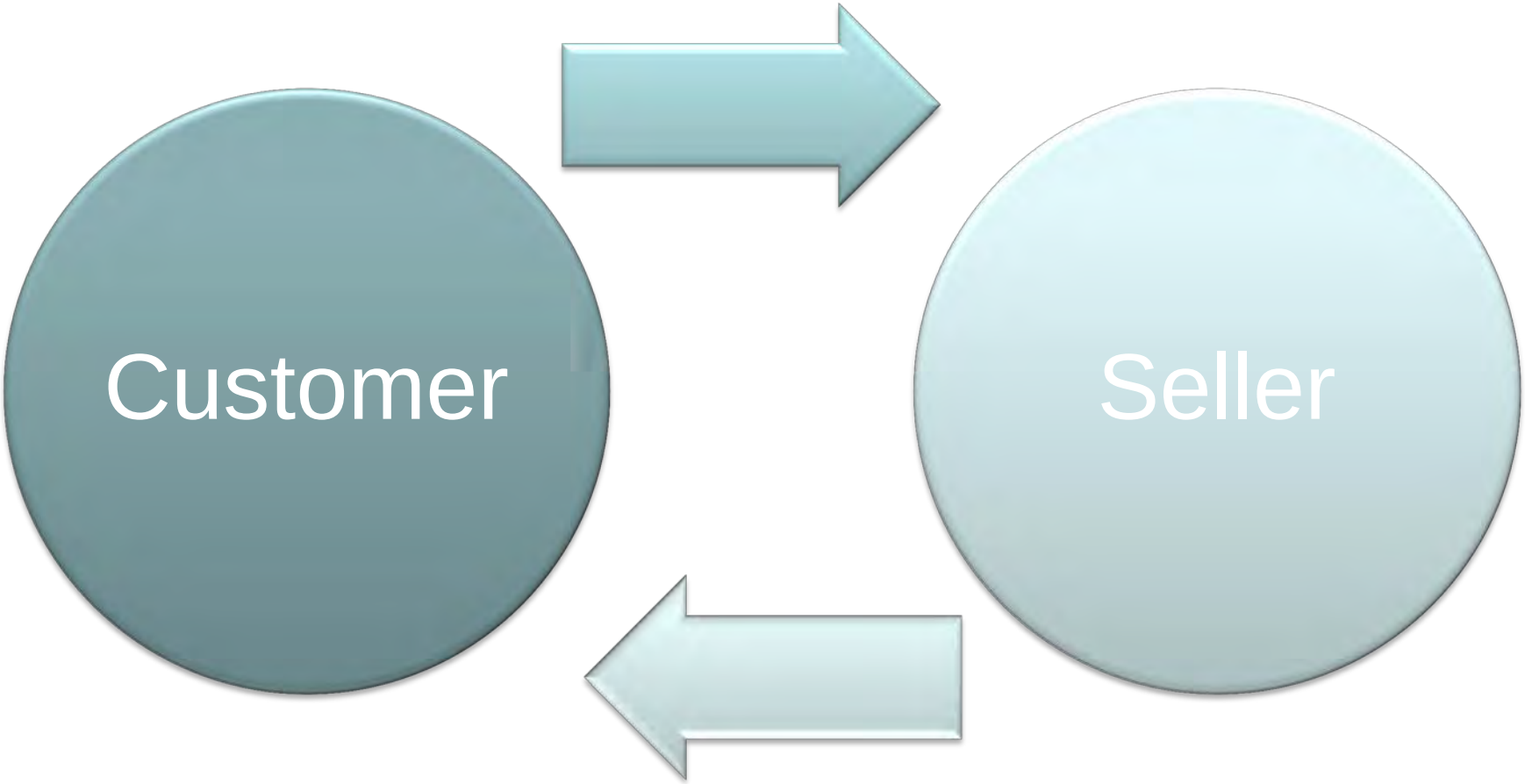
You must pick your market and design to its constraints or you go out of business

Market Constraints are Why

- Laptops have typically burned up their battery power after 2-4 hours
  - 5 lb. laptops have brick power supplies
- Cell phones burn them up in less than a day

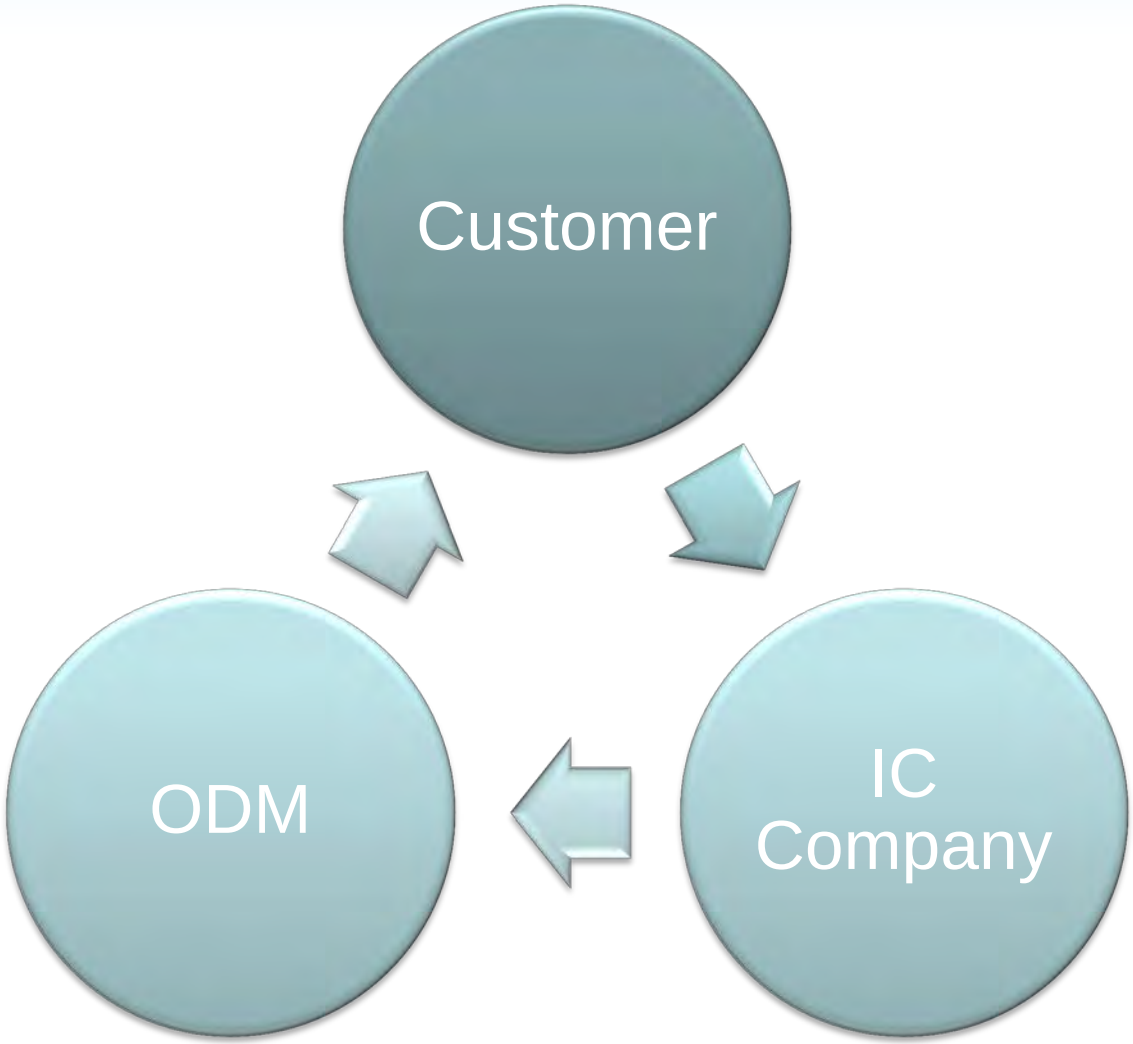
- *Battery life promises are like politicians' promises to reduce the deficit*

Basic Business Model



Consumer's view of power

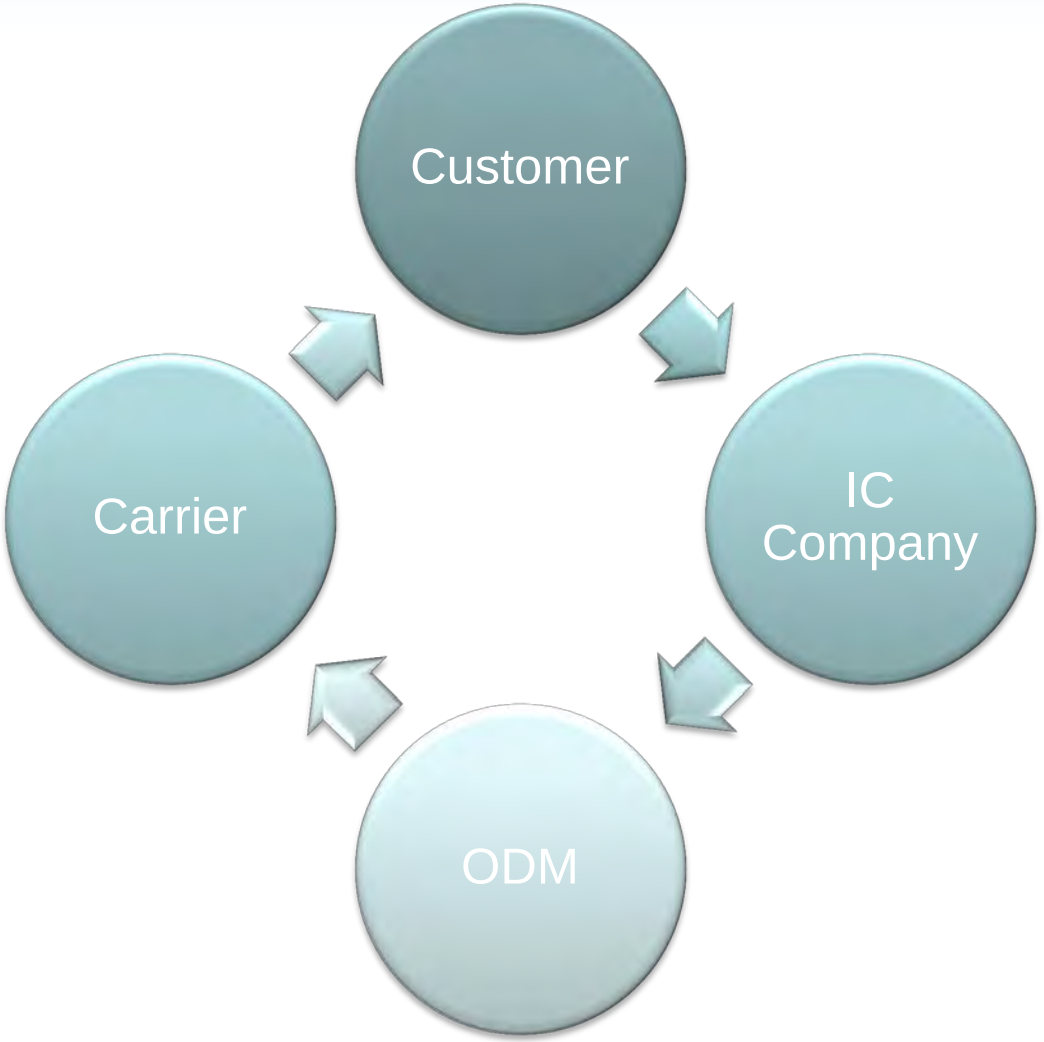
Basic IC Business Model



ODMs often don’t get it

- Apple presented with ability to lock-up a critical battery patent
    - It was between Steve Jobs’ tenures
- CTO’s response was:
  - “Batteries are not a core technology for us.”
- ODMs are often focused on doing more of the same better or cheaper
  - Look at Apple’s battery life today vs the average laptop

Basic Mobile IC Business Model



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Carrier's view of power

- Accessories extremely profitable – *instant cash*
- Phones are loss leaders

Samsung Galaxy S™ 4G

FREE

(365 reviews)

The Bottom Line

- There are a lot of sinkholes on the power landscape to step into
- Power tends to come free with every transistor generation

… or does it?

Fabs are not Free

- They are not even cheap
- $4-5B for the Fab + $3-5B in Development

Beyond Dennard … Less is Moore

- New alternatives for staying cool
- It's *Back to the Transistor*
- For example:
  - Mears Technologies
  - SOITEC
  - Suvolta
- New life for old fabs

Questions?

... and about VLSI

This presentation will be available at

http://www.**weSRCH**.com

If you have further questions, e-mail us at:
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VLSI Corporate Backgrounder

- VLSI Research Inc is a leading provider of market research and economic analysis of high tech industries
- Known for its sharply focused insight into the rapidly changing landscapes of the industries covered.
- VLSI has been the only market research firm to consistently gauge the direction of growth since the early eighties.
- VLSI Research was founded in 1976.

Appendix: *Web sites*

VLSIresearch.com

- VLSI's market research page
- For research on the semiconductor supply chain

ChipHistory.org

- Education site on semiconductors
- Virtual history museum
- Based on industry donations

weSRCH.com

- Where Technology = Opportunity
- A virtual science & engineering conference
- >10M Page Views and >700K visitors per month
  - 15-20mins & 35 page views / visit, >1 visit / week
  - High signature authority and income viewership
  - High Yield on Targets for your business

45

Appendix: *Product Offerings*

- **Semiconductor Analytics**
  - *weekly market updates*
- **Chip Market Research Services**
  - *The Chip Insider®, ForecastPro, Semi & FPD*
- **PV Solar**: *The Database on PV Manufacturing Markets*
- **Critical Subsystems** *for Semiconductor, Flat Panel Display & Data Storage Manufacturing Equipment*
- INDUSTRY PULSE PRO® *entry level datapacket*
- **Customer Satisfaction** *Custom Internet surveys in multiple languages*

about Semiconductor Analytics

- This is a new offering
  - Addresses the semiconductor supply chain
  - End demand focus
- Single Stop for Industry Fundamentals
  - All Industry Fundamentals readily available
    - Weekly and Monthly
  - Only source of
    - Weekly IC Sales statistics
    - Monthly capacity statistics
  - Knowing what's happening now with little latency
    - 3 business days instead of a month or quarter
  - Eliminate costly searching for "free data" — *Dan*

Semiconductor Analytics' TOC

- **This Week** in the Supply Chain
  - IC Billings, Units, and ASP's
  - Semiconductor Sales
  - Electronics Sales Activity
  - Electronics Price Trends
- **This Month** in the Supply Chain
  - Electronics Sales and Growth with 3/12 - 12/12 Charts
  - Personal Tools: PC's, Tablets & Handsets
  - Consumer
  - IT Infrastructure
  - Automotive
  - Foundry capacity and production

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