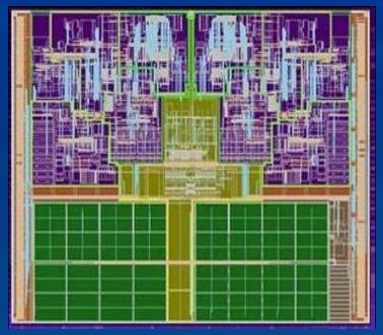
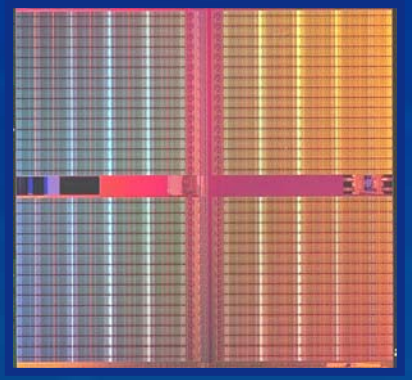
Power Delivery Challenges in Computer Platforms

Ed Stanford

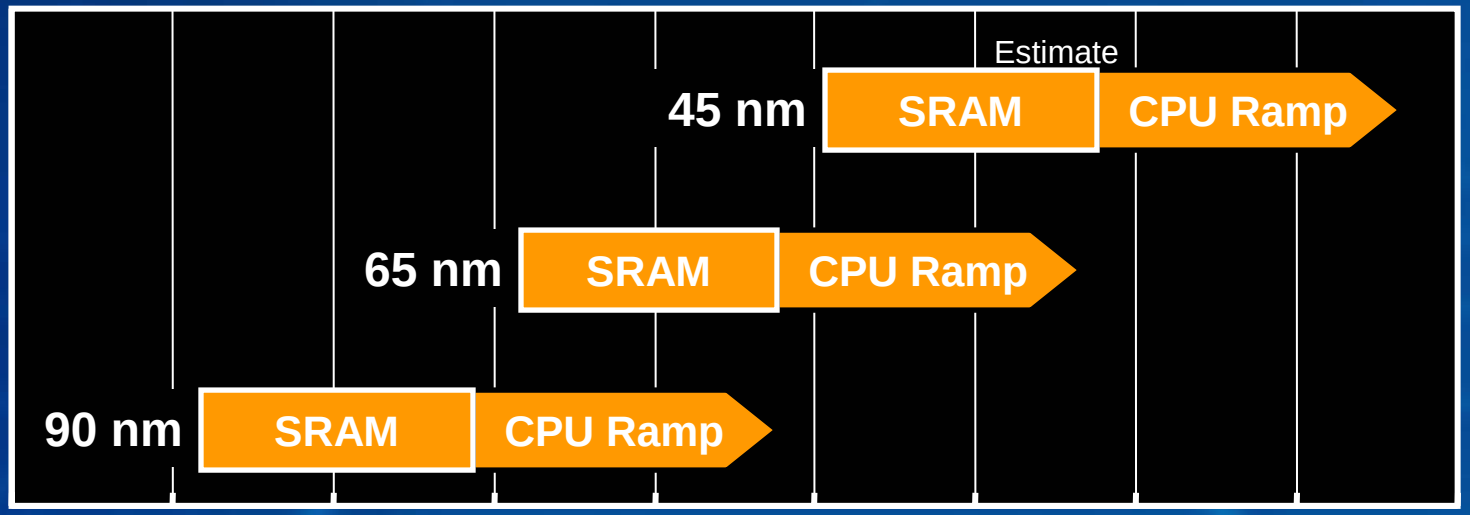
Scaling Continues

Intel® Core™ Duo
65nm process
90.3 mm2 die size
151.6 million transistors





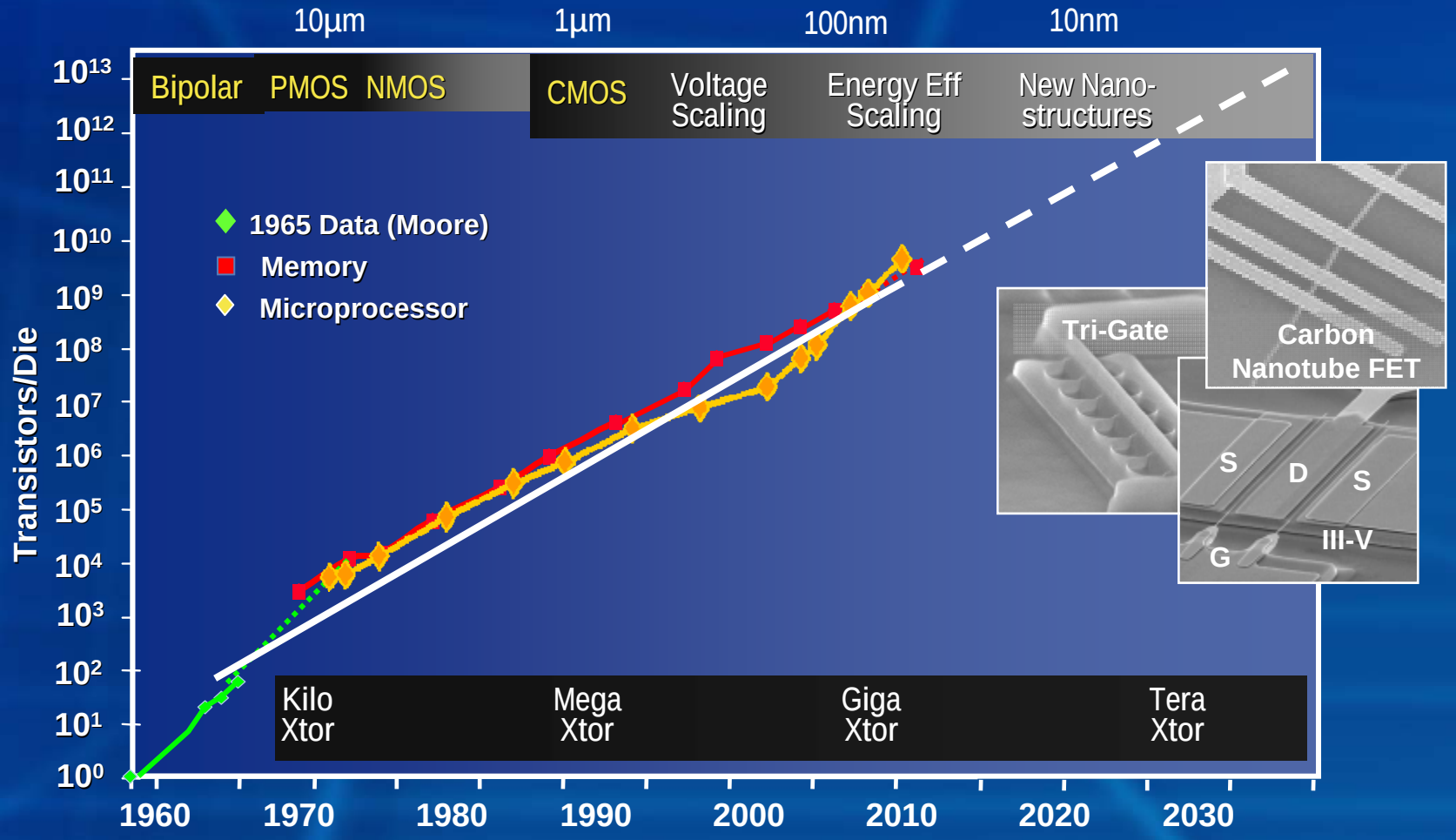
SRAM test-chip
45nm process
119 mm2 die size
>1 billion transistors



Source: Intel

Future options subject to change – Images not to scale

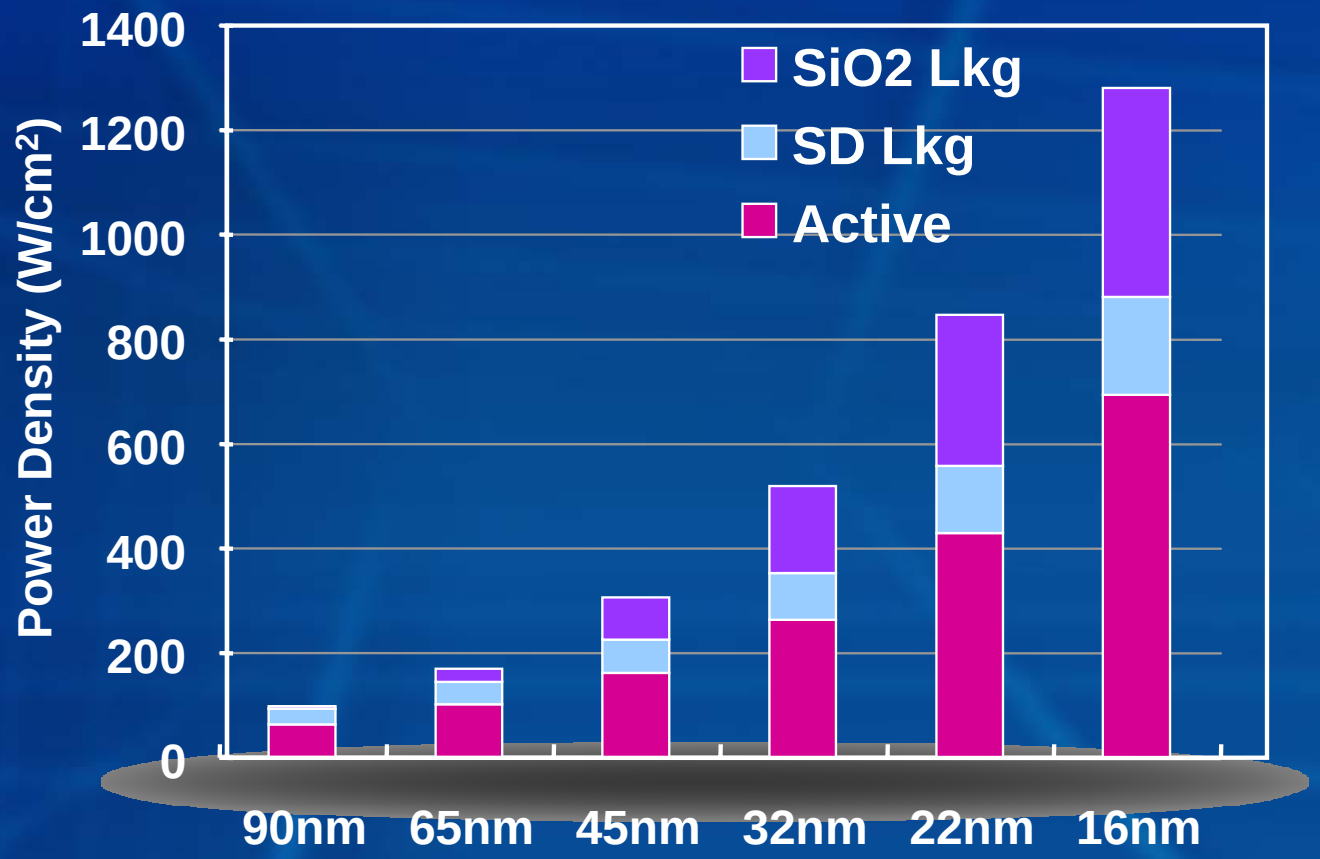
Through the Next Decade and Beyond



Source: Intel

Future options subject to change

But Power Becomes a Dominant Design Factor With Simple Scaling

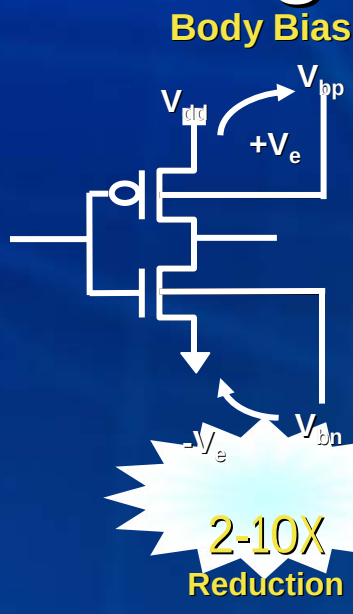


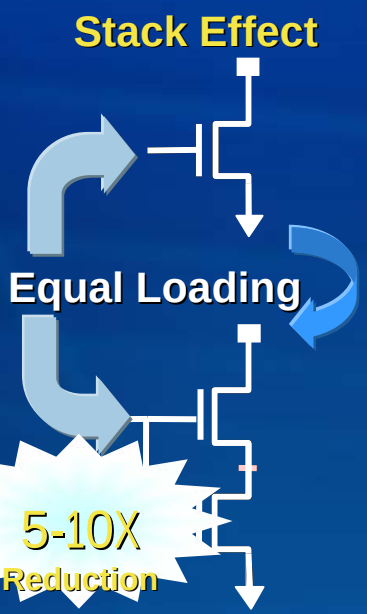
Note: Direct CMOS scaling relationships shown

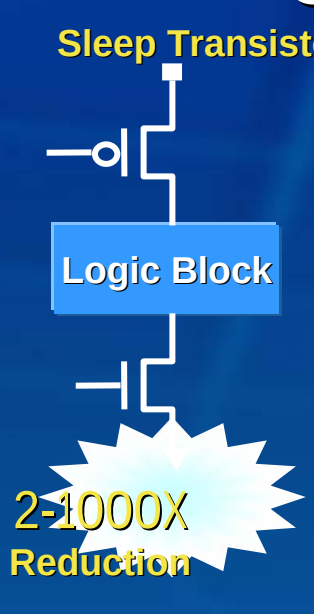
Source: Intel

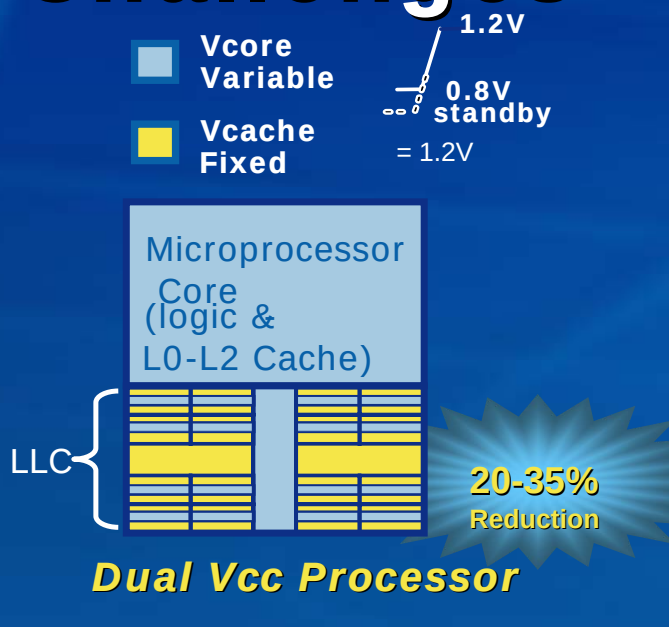
Future options subject to change

Circuits, Architecture, FAB Processes Mitigate CMOS Scaling Challenges

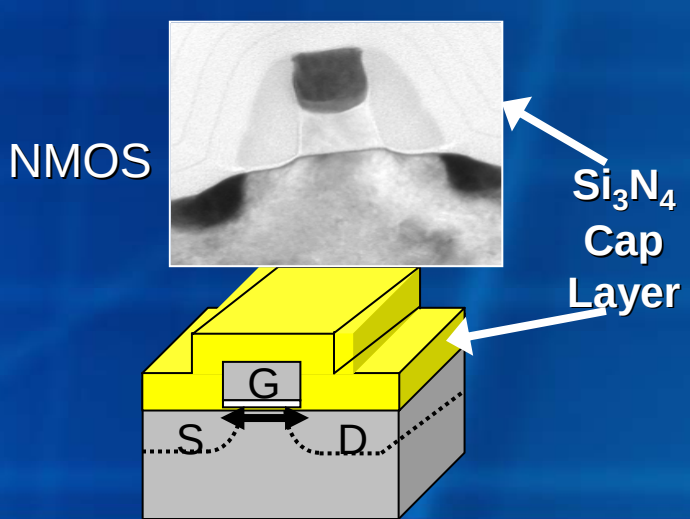


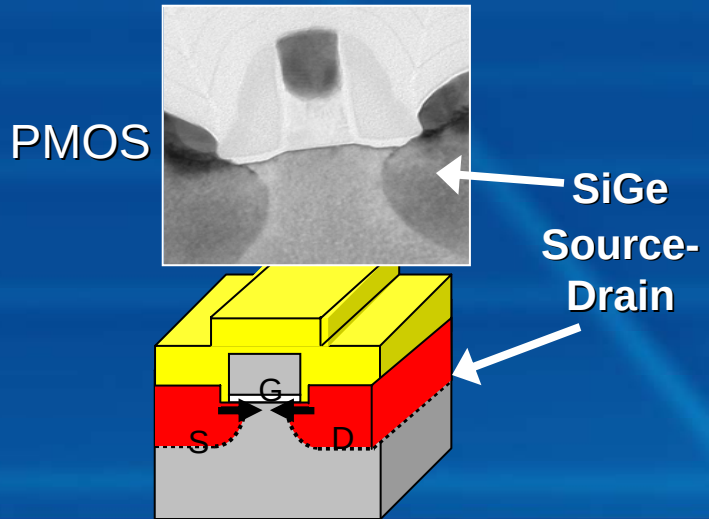




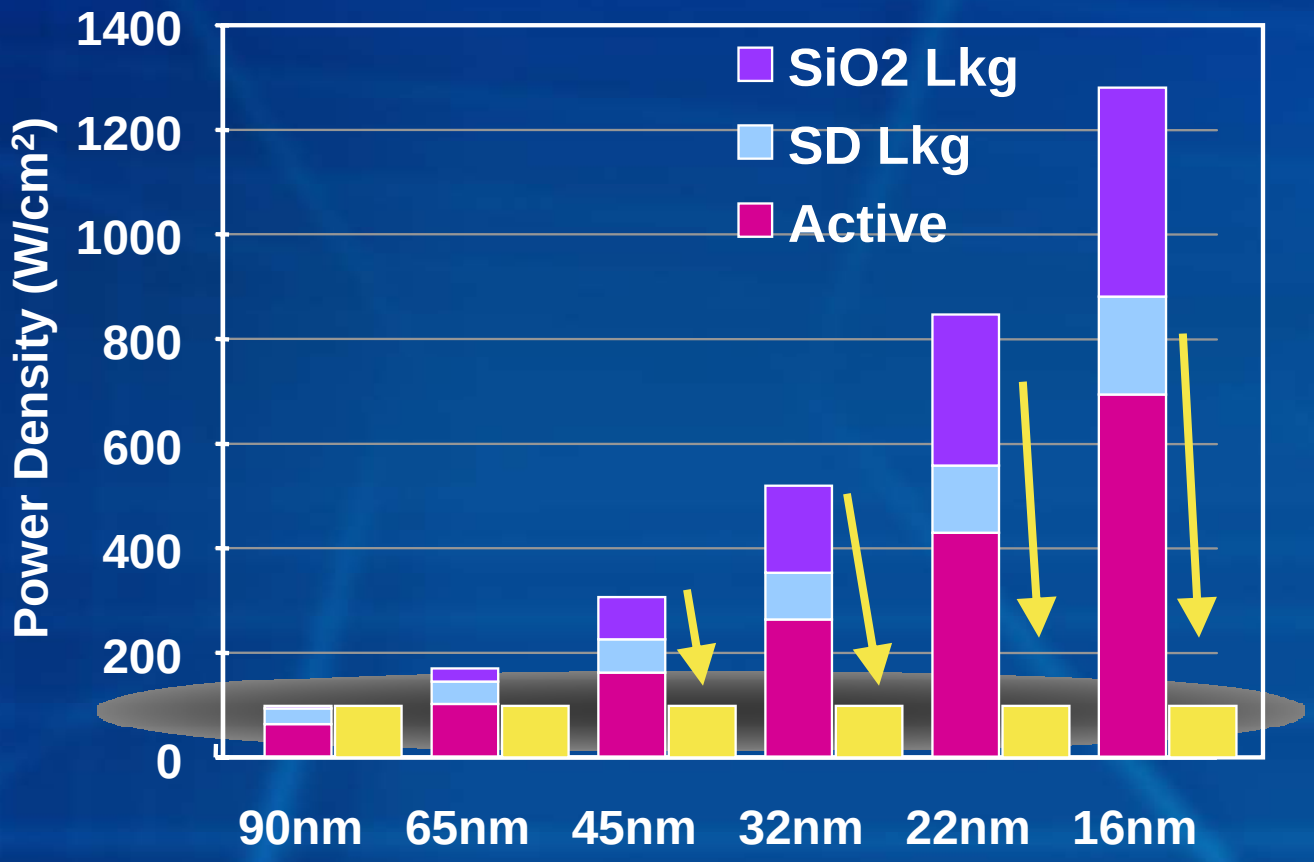


Strained Silicon





Power Constrained Through Technology, Circuits and Architecture Innovations



Source: Intel

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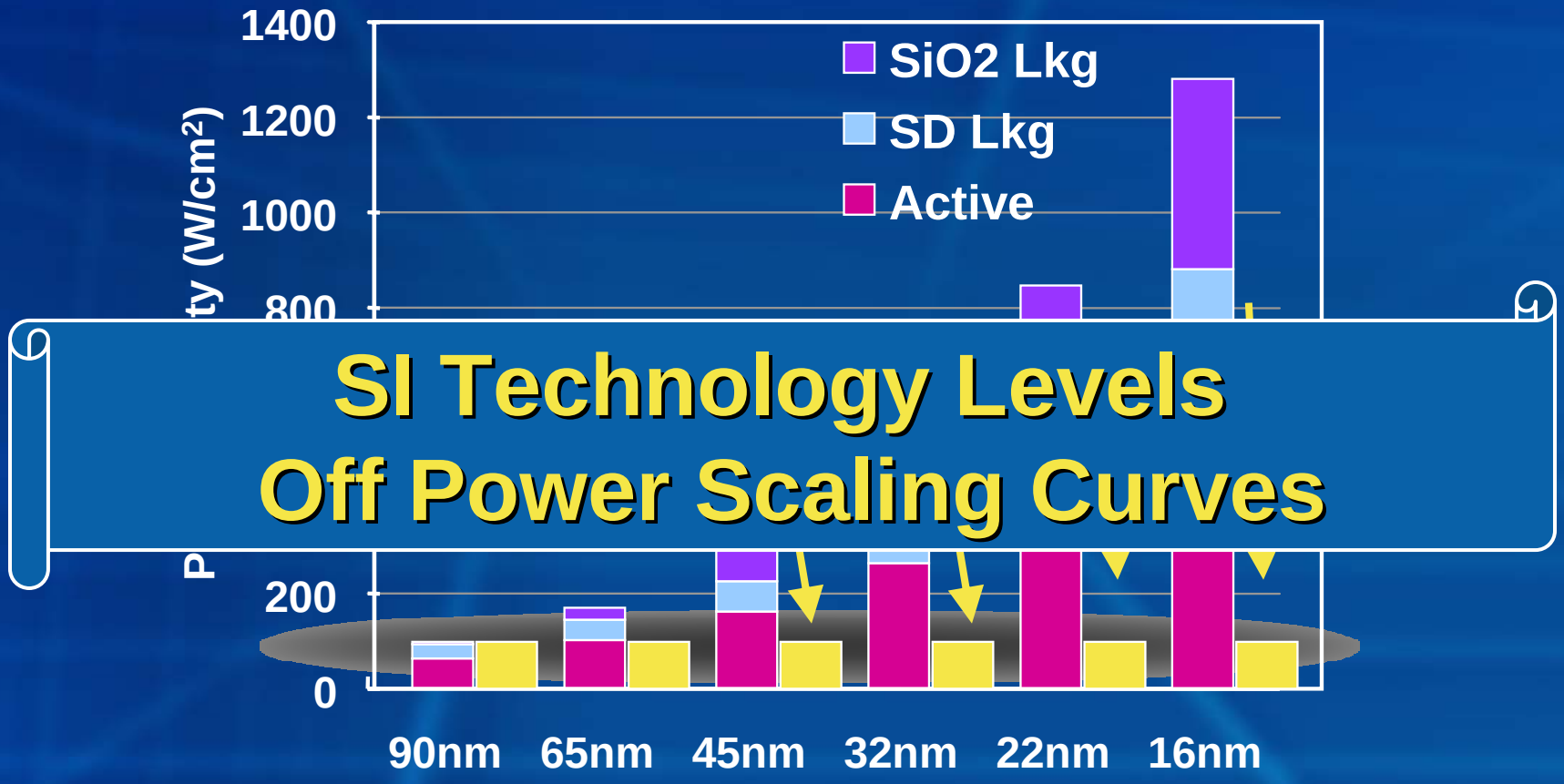
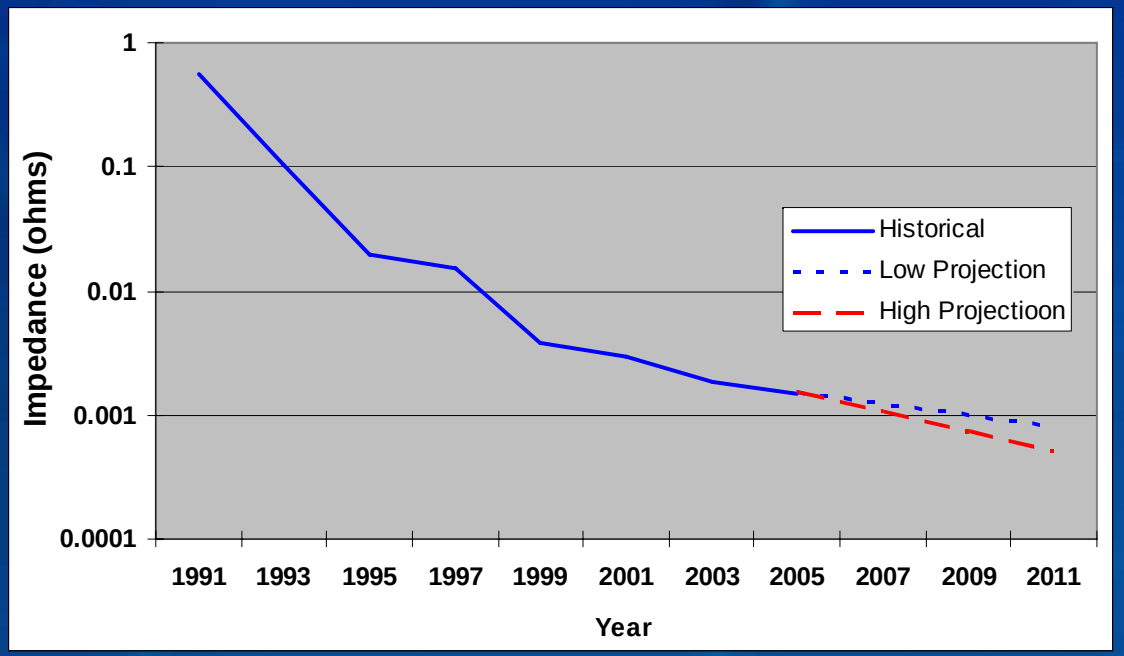


SI Technology Levels Off Power Scaling Curves

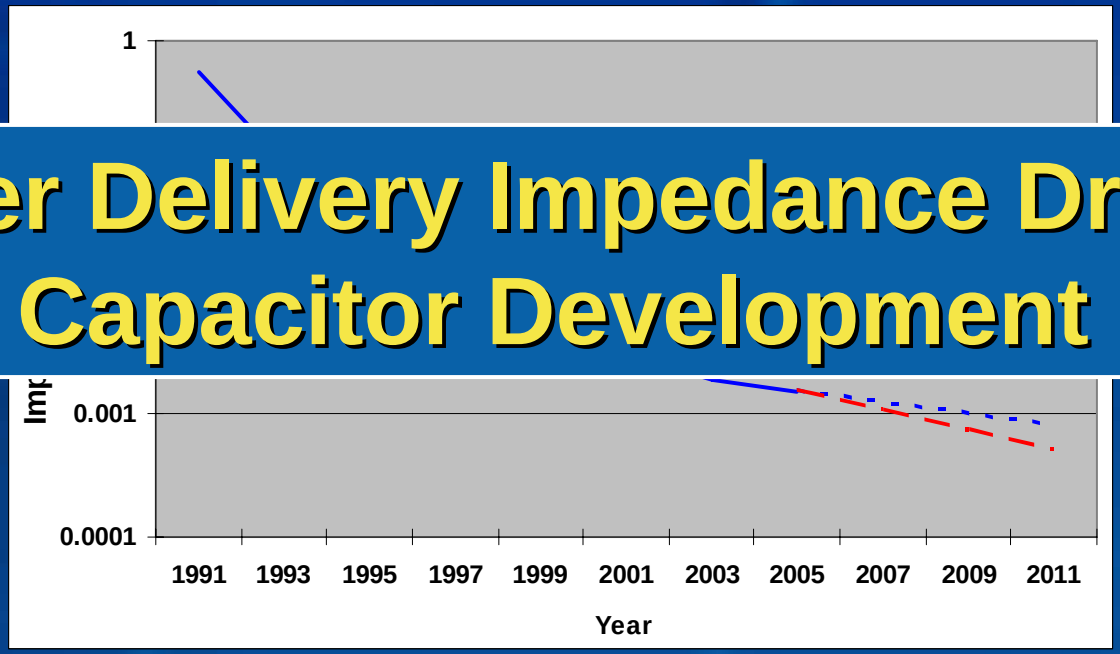
Source: Intel

CPU Power Delivery Impact



- Impedance drops with lower operating voltages
- $Z = V_{tolerance} / I_{step,}$
- < 1u dielectric layer MLCC capacitors loose ~40-60% @ 1V dc, 10mV ac bias
  - IE. 47 uF, 1206 = ~ 27 uF at use conditions

CPU Power Delivery Impact



Power Delivery Impedance Drives Capacitor Development

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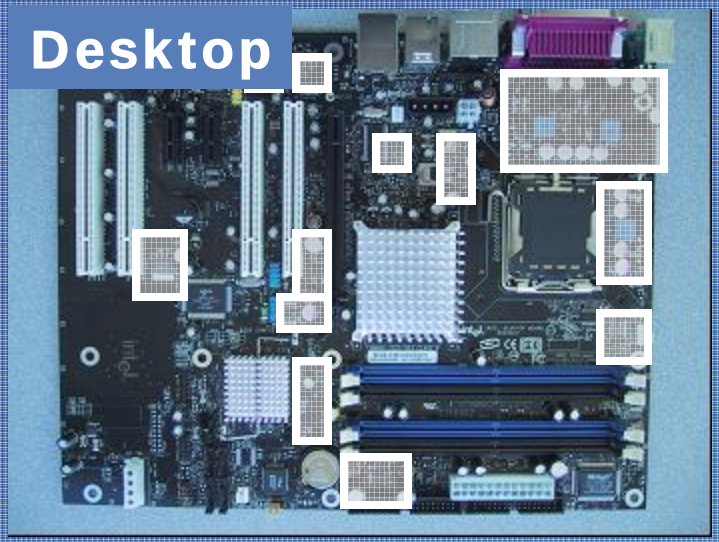
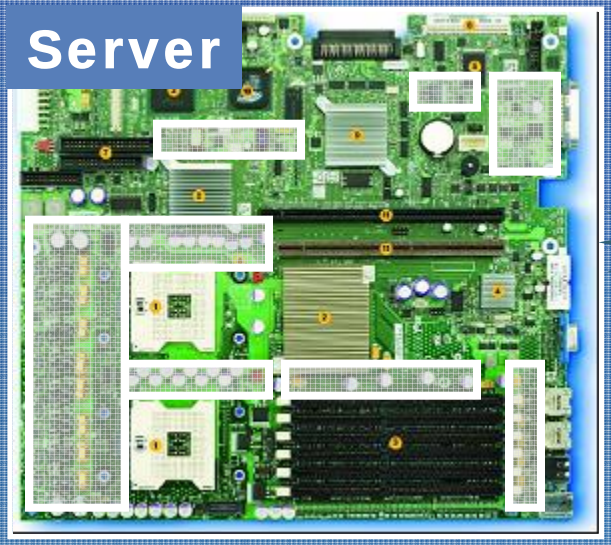
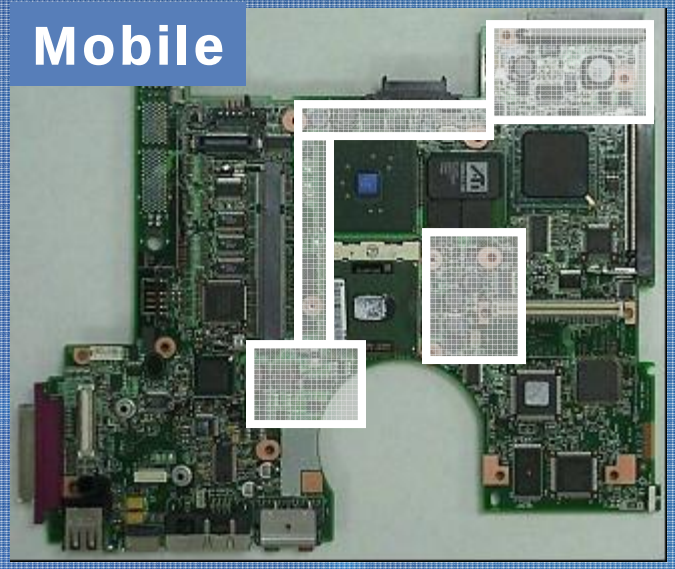
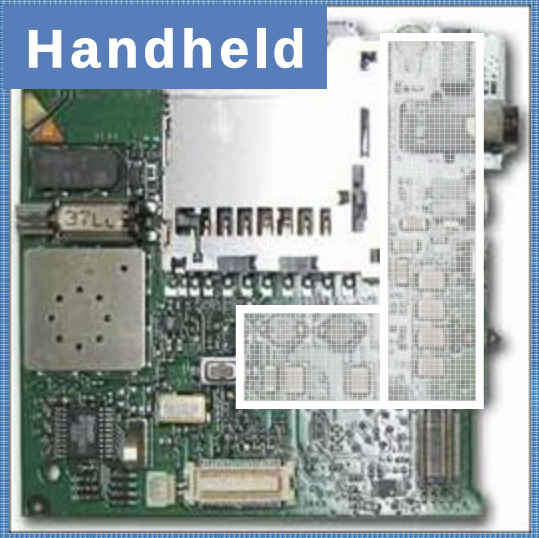
Platform Power Delivery Impact



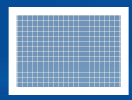


Up to 30% Board Area





Power delivery components



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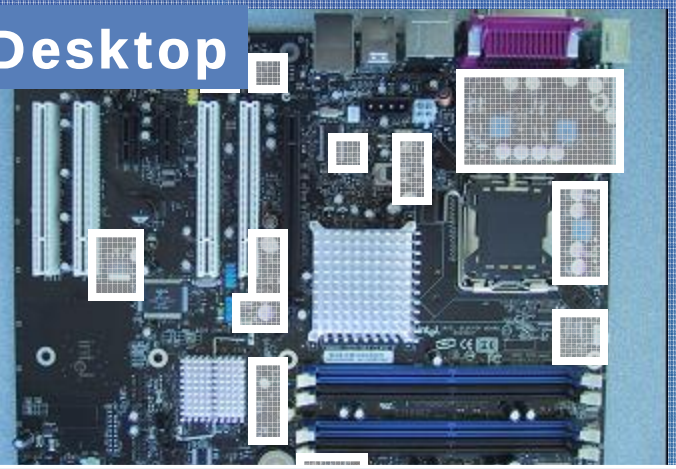
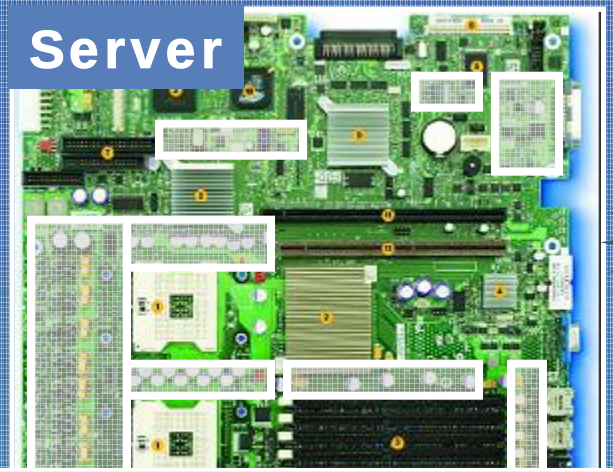
Platform Power Delivery Impact

Desktop



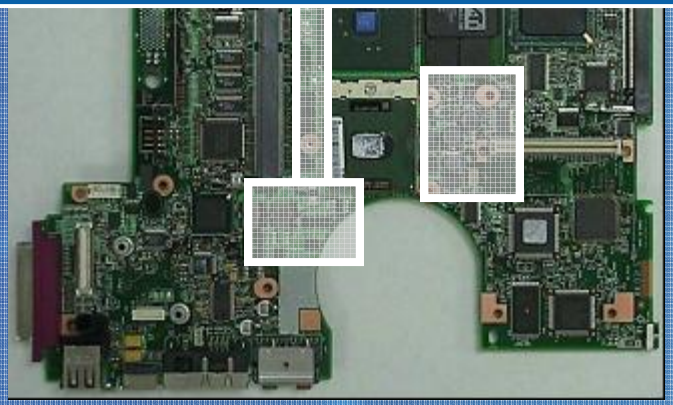
Server



Up to 30% Board Area

Large Number of Regulators Drive dc-dc Density and Efficency

r delivery
components



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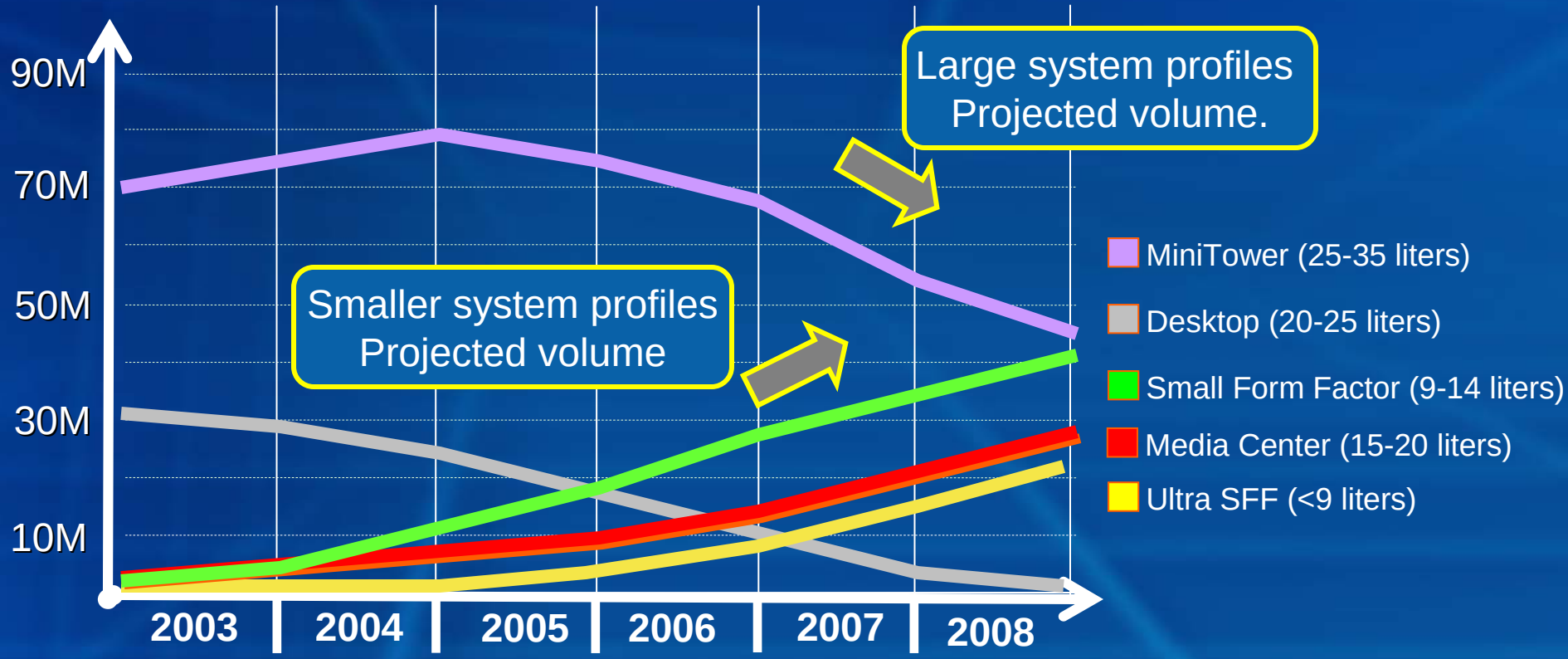
Desktop PC System Trends

Worldwide Desktop PC Form Factor Shipments, 2002-2008



SOURCE: IDC, Worldwide PC Client Form Factor Forecast: 2004-2008, April 2004.

Desktop PC System Trends

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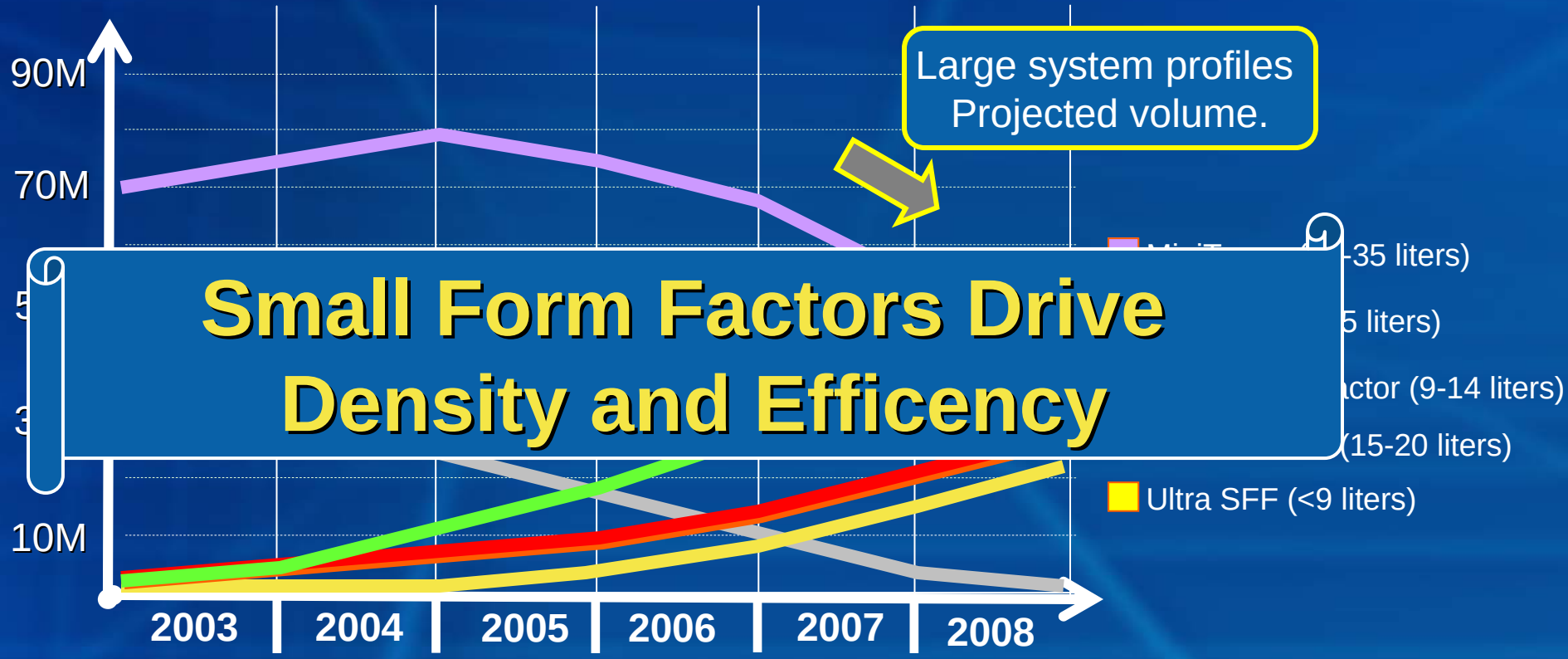

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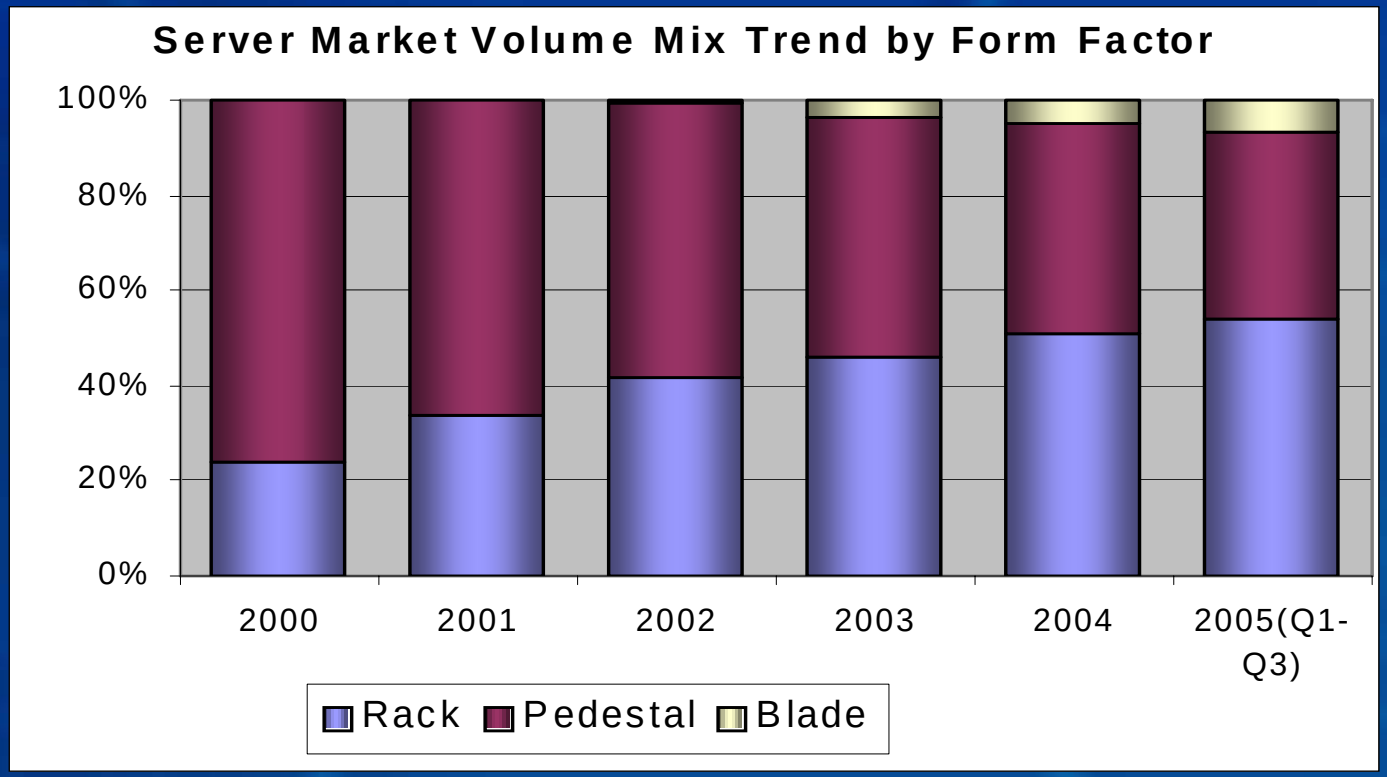
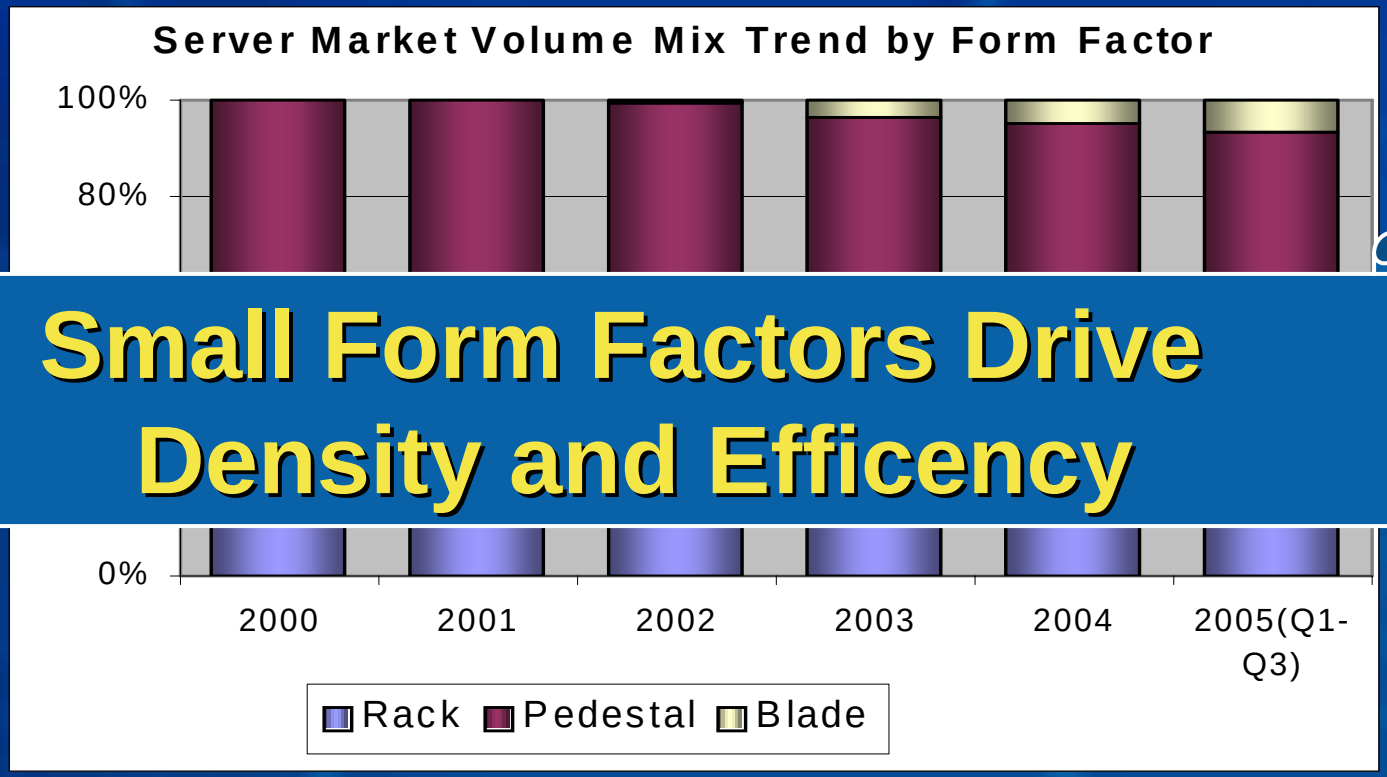
Similar Trends for Server Platforms



Source: IDC WW Quarterly Server and Workstation Trackers, Nov 2005

Similar Trends for Server Platforms



Small Form Factors Drive Density and Efficency

Source: IDC WW Quarterly Server and Workstation Trackers, Nov 2005

Power Supply Density

- Desktop Power Supplies
  - 3 – 6 W/in^3 * typical
  - 68 -70 % efficient typical
  - 80+ and other programs driving to > 80%
- Server Power Supplies
  - 6 – 12 W/in^3 typical *
  - 18 W/in^3 state of art *
- EPA is currently revising efficency targets for both Desktop and Server products

* including fan and EMI filter

Summary

- Multi-Core Architecture and Other Techniques level Off CPU Power Consumption
- Regulator Impedance Driving New Decoupling Capacitor Technologies
- Smaller systems and more features per system drive up density and require higher efficency
- Government Regulations Driving up Power Supply Efficency Requirements