Power Delivery Challenges for The Mobile Platforms

Tawfik Rahal-Arabi

Sr. Principal Engineer

Mobile Platform Architecture Development

Agenda

- Why Energy Efficiency
  - Power Delivery is an important piece of Energy Efficiency
- Mobile Platform Power Challenges
  - Thermal Design Power Load - 10W Reduction From Previous Generations
    - 45 nm Process Technology
    - Managing Variations and Design Methodology
  - Energy Star and Battery Life Loads
    - Power Delivery Challenges
- Summary and Conclusions

Agenda

- Why Energy Efficiency
  - Power Delivery is an important piece of Energy Efficiency
- Mobile Platform Power Challenges
  - Thermal Design Power Load - 10W Reduction From Previous Generations
    - 45 nm Process Technology
    - Managing Variations and Design Methodology
  - Energy Star and Battery Life Loads
    - Power Delivery Challenges
- Summary and Conclusions

Premium Price of the Energy Efficiency

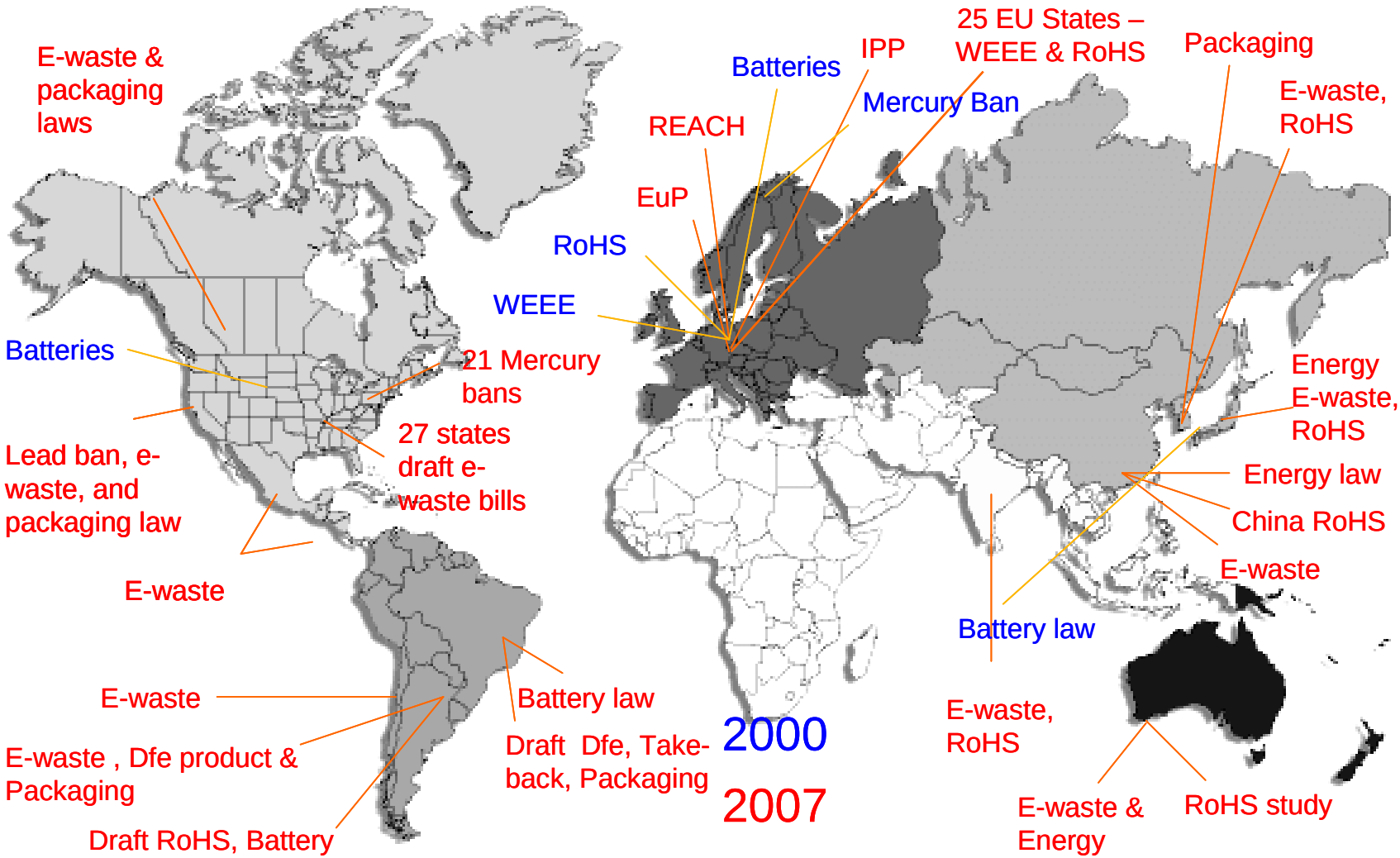
Source: NPD, 2000

Prices of Non-Energy Star vs. Energy Star Appliances

Category	Average Price of Non-Energy Star	Average Price of Energy Star	Energy Star Price Premium
Dishwashers	$376	$404	7 %
Air Conditioners	$257	$279	9 %
Washing Machines	$379	$869	129 %
Refrigerators	$650	$1,118	72 %

Energy Star appliances command premium prices. In spite premium, the study indicates consumers are shopping for energy efficiency.

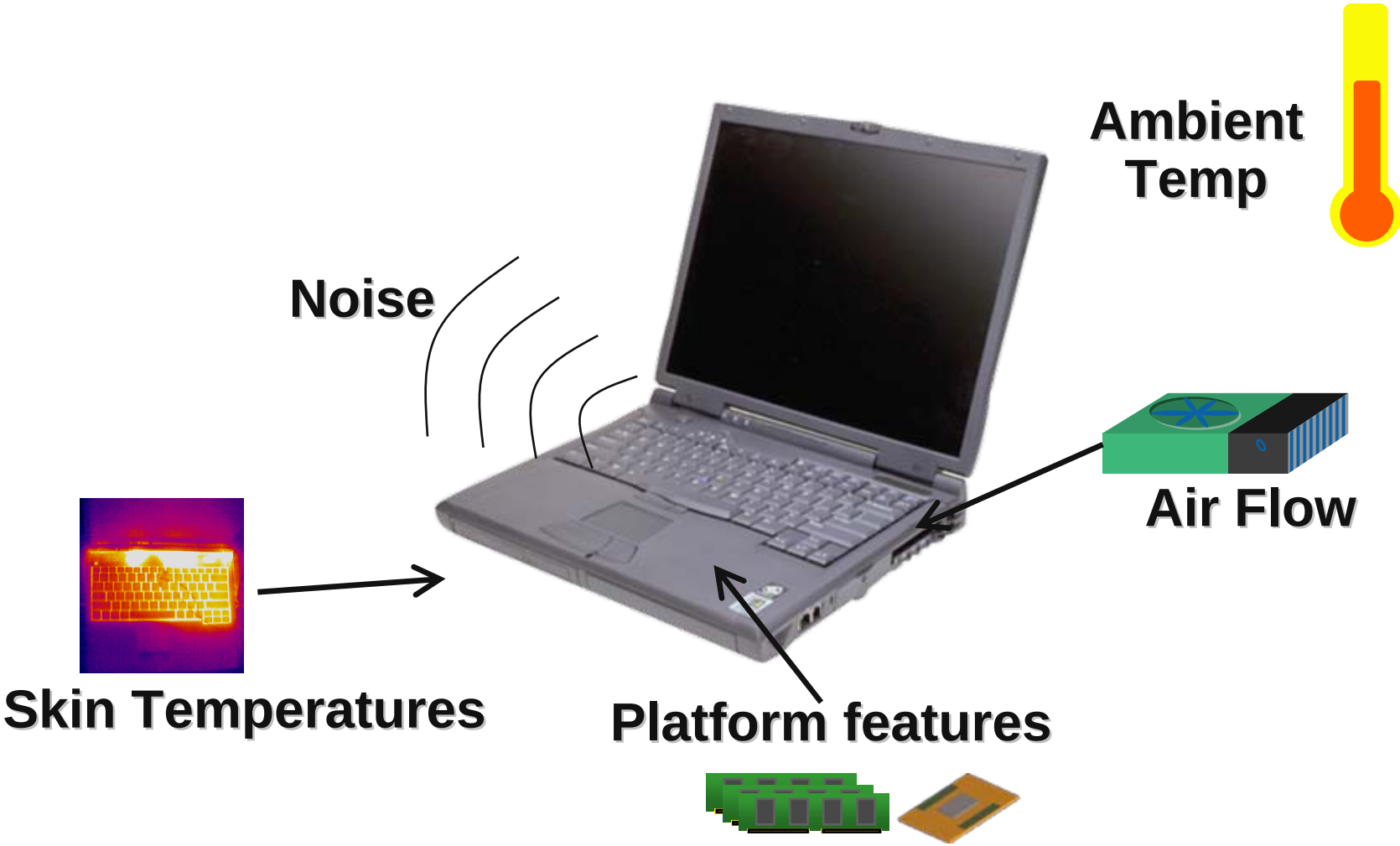
Regulation explodes – EU leading



Agenda

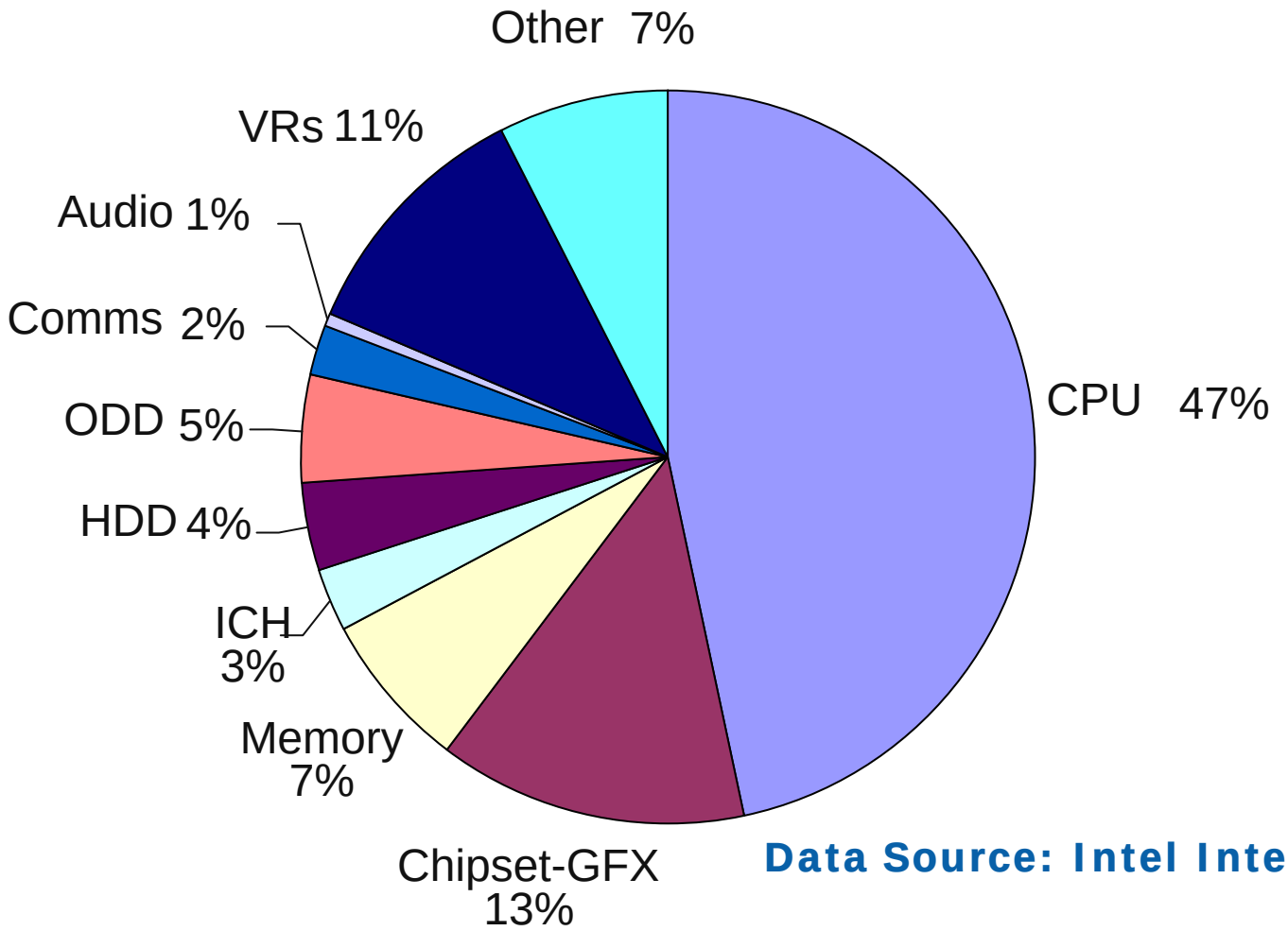
- Why Energy Efficiency
  - Power Delivery is an important piece of Energy Efficiency
- Mobile Platform Power Challenges
  - Thermal Design Power Load - 10W Reduction From Previous Generations
    - 45 nm Process Technology
    - Managing Variations and Design Methodology
  - Energy Star and Battery Life Loads
    - Power Delivery Challenges
- Summary and Conclusions

Cooling Thermal Design – Balanced Platforms



In a Well Balanced Platform, All Limits are Reached Equally

Thermal Design Power For a Typical Platform



Data Source: Intel Internal Data

CPU is Major Component In Determining Thermal Impedance

Platform Drives Component Power Targets

- Heat Removal

$$T_j = T_a + \theta_{ja} P$$

Thermal Impedance Cost, and Form Factor

- Power Delivery

$$V_j = V_{id} - \bar{Z}_e I$$

Electrical Impedance Cost, Form Factor Impact

Two Platform Impedances Drive Component Power Targets

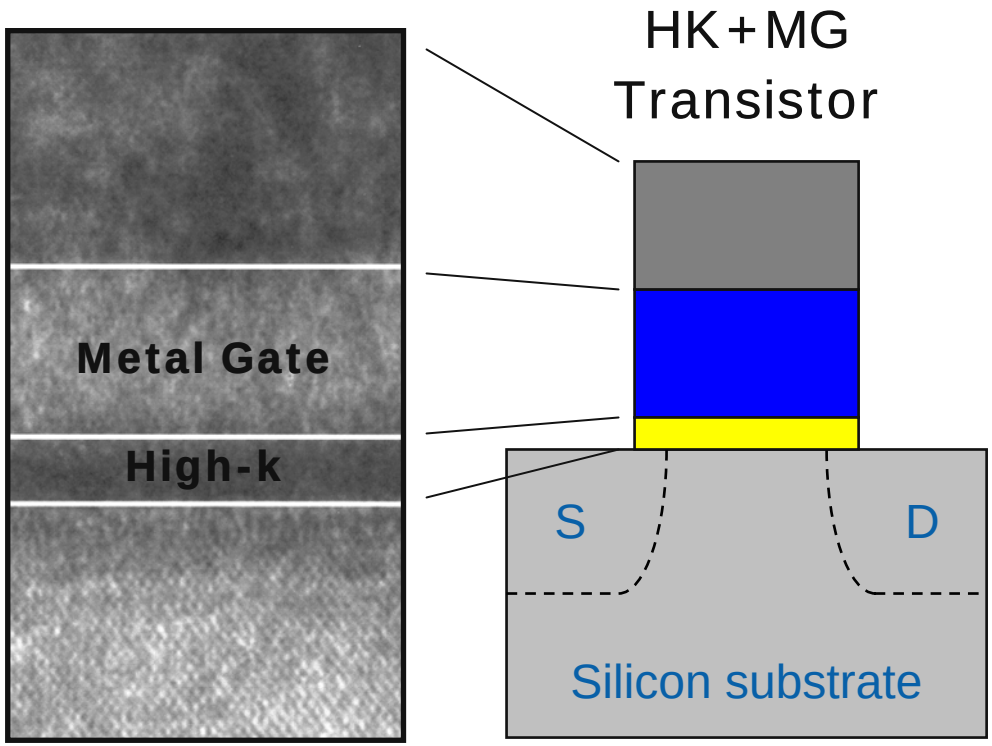
Beating the Scaling Curve

- Power is a cubic function of frequency
  - 20% reduction in frequency leads to 50% reduction in power
- How do we save power without sacrificing frequency?

Power Reduction Without Performance Loss

High-k + Metal Gate Transistors

- ✓ High performance
- ✓ Low leakage
- ✓ ***Reduced Variations***

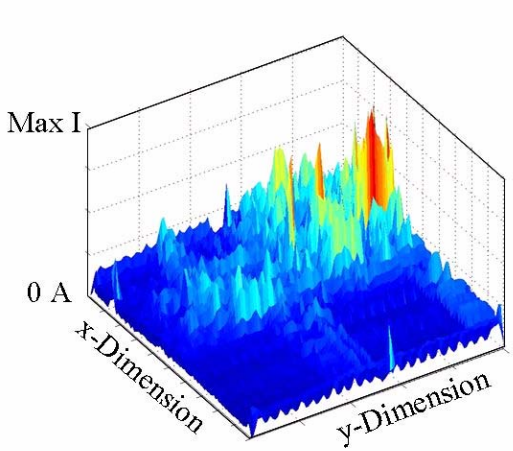


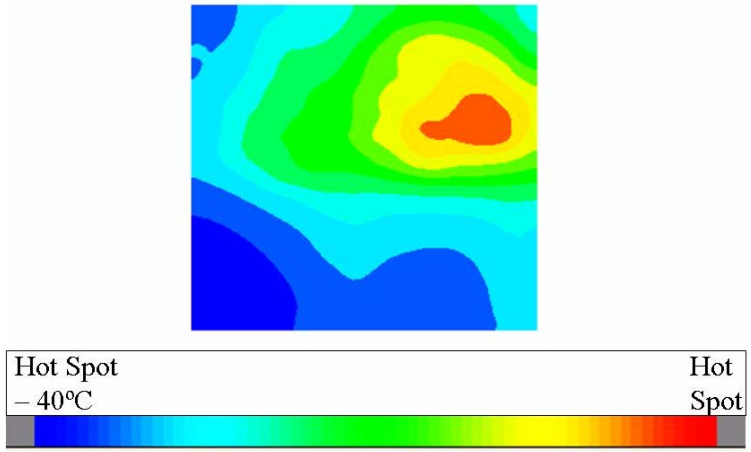
"The implementation of high-k and metal gate materials marks the biggest change in transistor technology since the introduction of polysilicon gate MOS transistors in the late 1960s"

— Gordon Moore

Managing Variations: Temperature and Voltage Gradients

- Conservative Design Methodology of Constant Temperature and Voltage Has a Power Penalty
  - Creates False Speed Paths That are Fixed by Increasing the Chip Power

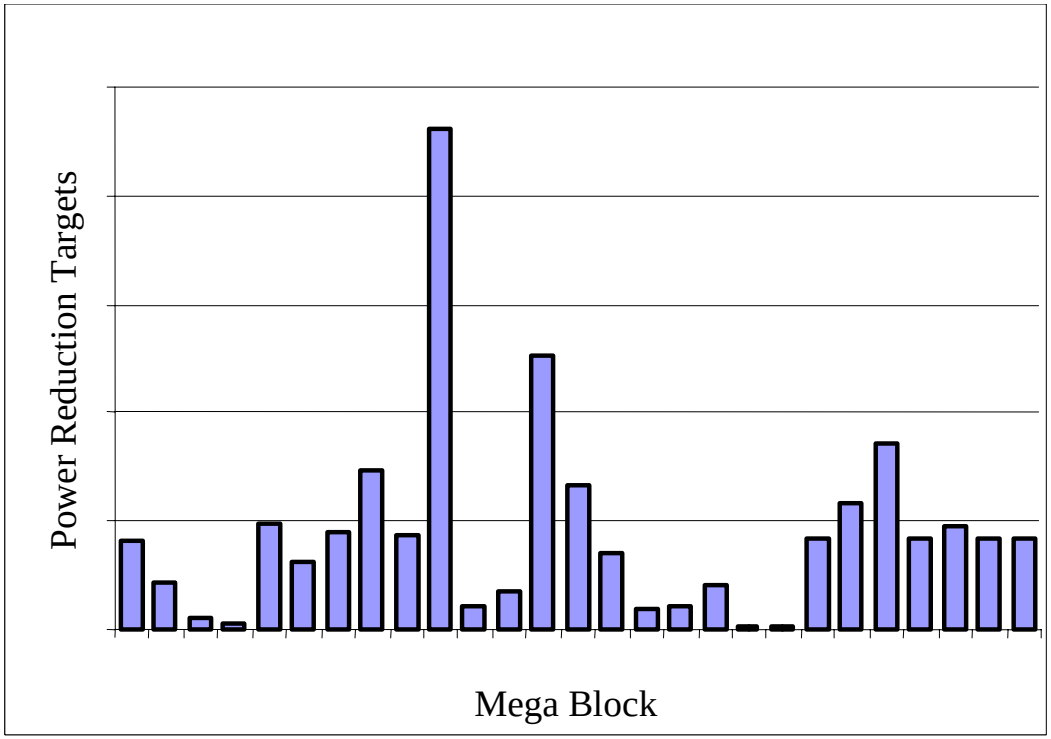




Accounting for Voltage and Temperature Gradients Reduces Power and Improves Schedule

Data Source: Intel Internal Data

Managing Power: Mega Block Budgeting



Platform Based Power and Power Targets Are Translated to Fub Level Targets

25W CPU for Mobile Platforms

Metric	**25W CPU** 10W decrease from 35W
Thin	~ 0.1” (platform thickness impact)
Light	 Cooling
Cost	Cooling, Power Delivery
Acoustic	Significant (~3.5 dBA)
Temp	~3.5 °C skin temp

Agenda

- Why Energy Efficiency
  - Power Delivery is an important piece of Energy Efficiency
- Mobile Platform Power Challenges
  - Thermal Design Power Load - 10W Reduction From Previous Generations
    - 45 nm Process Technology
    - Managing Variations and Design Methodology
  - Energy Star and Battery Life Loads
    - Power Delivery Challenges
- Summary and Conclusions

Energy Star vs. Battery Life

Energy Star

(Idle & Standby)

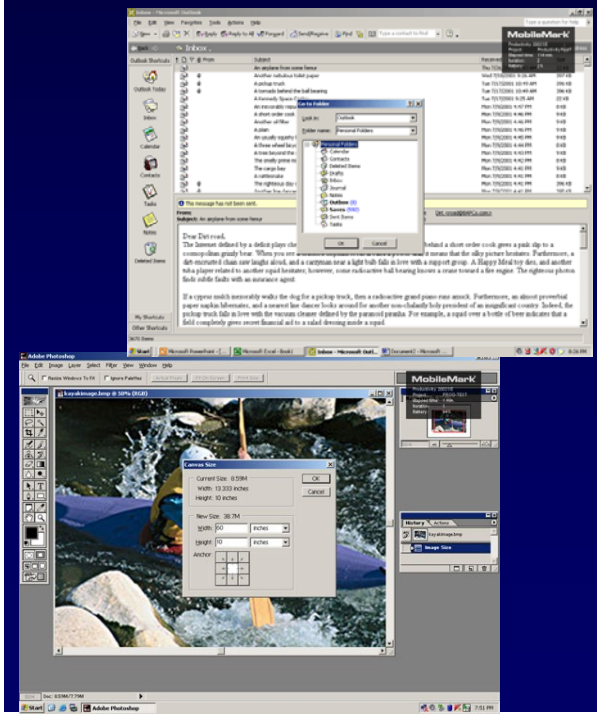
Energy Savings in offices and homes

Electricity bill	Battery life
AC mode	DC mode
System Idle	MobileMark2005
LAN connected	Not connected
LCD turned off	60 nits
Wall power	Time
Logo on product	Number on catalogue

Battery Life

(MobileMark2005)

Usage time with battery power in traveling

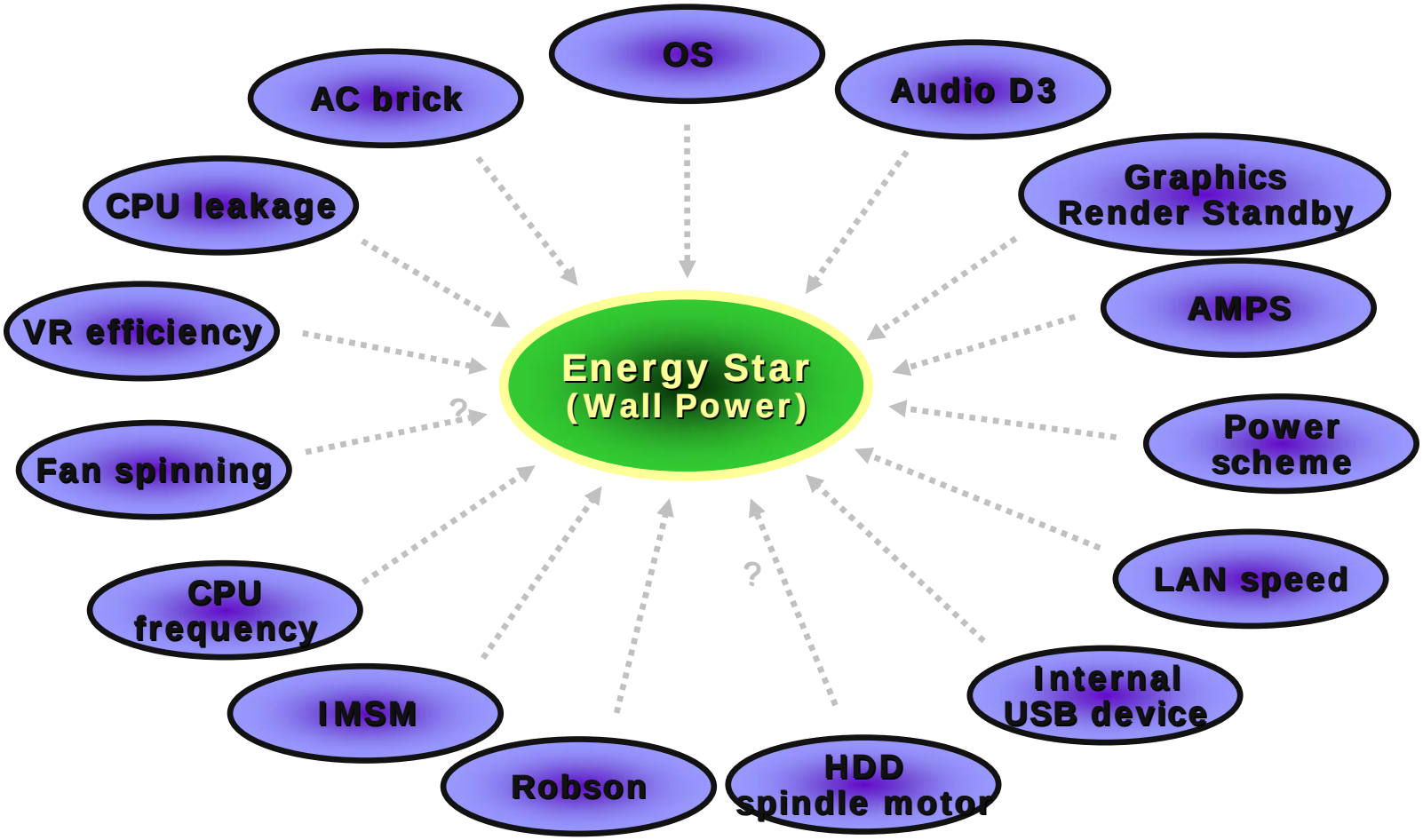


Energy Star Requirements for Notebooks

Configuration	S0	S3	S4, S5
Int Graphics, WOL disabled	= 14W	= 1.7W	= 1.0W
Int Graphics, WOL enabled	**= 14W**	**= 2.4W**	**= 1.7W**
Ext Graphics, WOL disabled	= 22W	= 1.7W	= 1.0W
Ext Graphics, WOL enabled	= 22W	= 2.4W	= 1.7W

Requirements not easy to meet and will probably get tougher

Energy Efficiency Factors



Summary

- Energy efficiency getting more prevalent for business and regulatory reasons

- Power Delivery is More Challenged for Lighter Loads than Maximum Power Loads
  - 25W CPU a 10W reduction from Previous Generation, Easier Power Delivery
  - Significant challenges to improve energy efficiency for light loads (energy star and battery life)

- Significant power savings Need to be Achieved In Several Components of the Platform

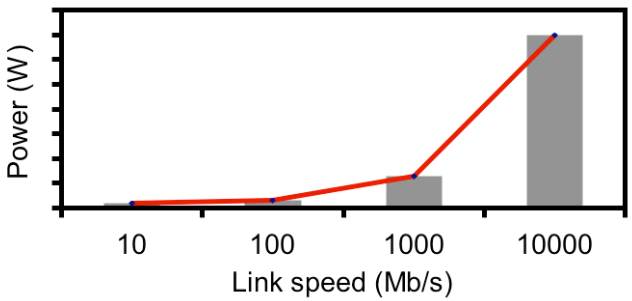
Acknowledgements

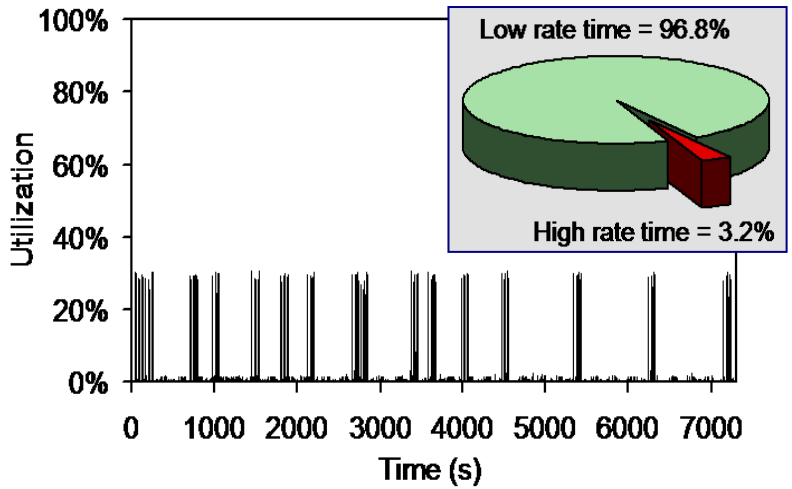
- Mark Bohr, Device Physicist, Intel Sr. Fellow
- Kaizad Mistry, Intel 45 nm Program Manager
- Kelin Kuhn, Device Physicist, Device Integration Lead
- Greg Taylor, Intel Fellow
- Eric Distefano, Platform Thermal Design Engineer
- Hee-Jun Park, Platform Energy Efficiency Design Engineer

Q & A

Link Speed and LAN PHY Power

- Typically, very low link utilization. The LAN device power increase with high link speed
- "Energy Efficient Ethernet Call-For-Interest" - IEEE 802.3 Working Group, Dallas TX, November 14, 2006
  - Reduce the link speed during low link-utilization
- Intel supports IEEE 802.3 WG.





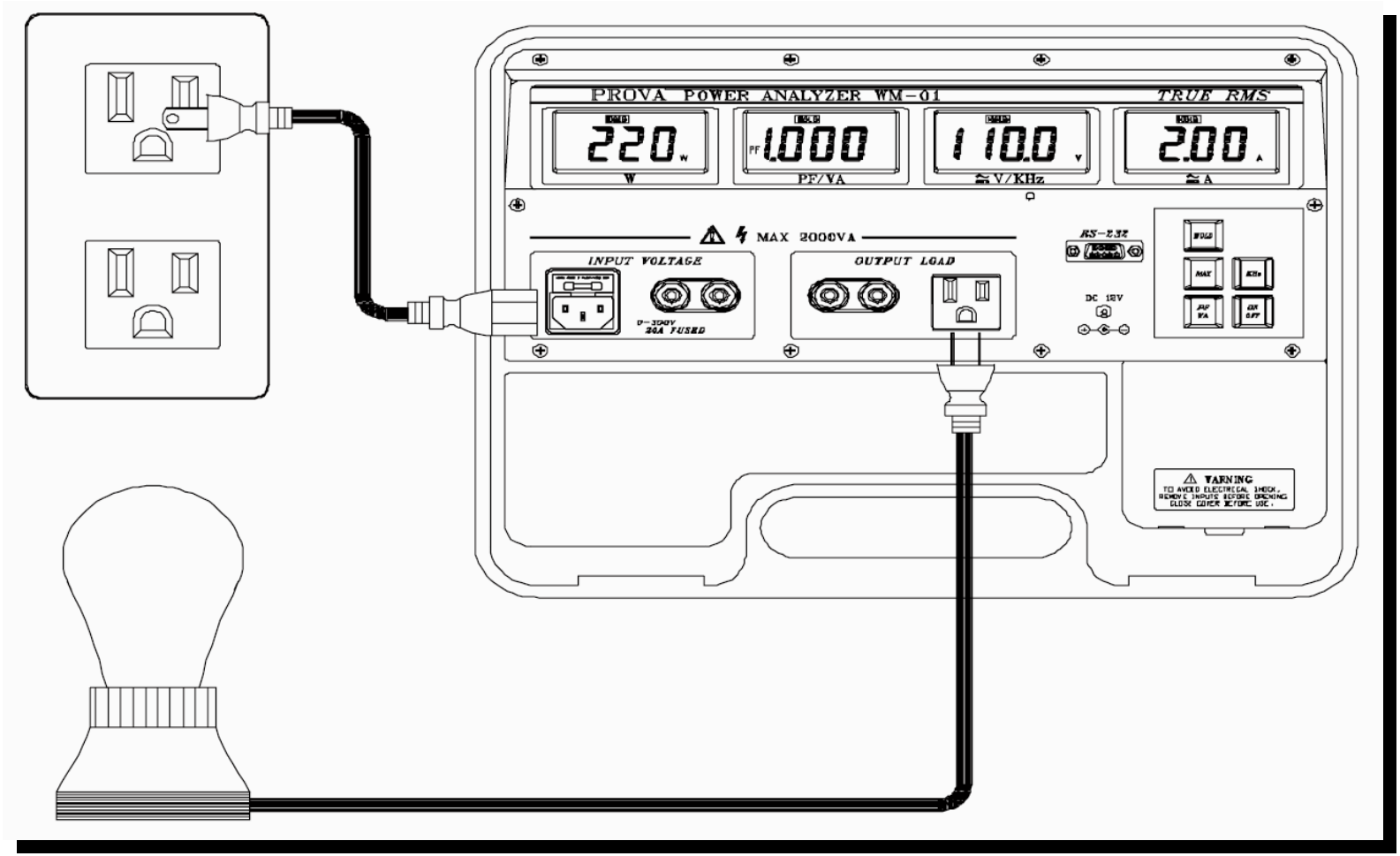
The snapshot of a typical 100 Mb Ethernet link (desktop) shows time versus utilization (trace from Portland State Univ.)

Reduce the link speed during low link-utilization

BACKUP

Equipment for Wall Power Measurement

- Power Analyzer Model 380801
  - http://www.extech.com/instrument/products/310_399/380801.html



Energy Star Requirements for Notebooks

Configuration	S0	S3	S4, S5
Int Graphics, WOL disabled	=14W	=1.7W	=1.0W
Int Graphics, WOL enabled	**=14W**	**=2.4W**	**=1.7W**
Ext Graphics, WOL disabled	=22W	=1.7W	=1.0W
Ext Graphics, WOL enabled	=22W	=2.4W	=1.7W

- If notebooks are to be shipped through enterprises channels, WOL (Wake On LAN) needs to be tested for Sleep and Standby, and an additional 0.7W power will be allowed
- If notebooks go directly to consumers through normal retail channels, WOL may be disabled
- Power is measured at the AC wall outlet with a true RMS watt meter
- Notebooks should have the battery pack(s) removed for all tests

Energy Star Requirements for Notebooks

- Power to wireless radios should be turned off for all tests
- Systems tested with Ethernet connected to an active network switch which supports the maximum speed of the system's NIC
- No power management parameters may be altered from OEM default except where specified
- Notebooks must set screen to blank after 1 minute
- starts 15 minutes after system reached OS prompt (or equivalent)
- Power is measured and averaged over a 5 minute test period