“Powering” the Energy Efficiency Revolution

Wen-Hann Wang
Vice President, Intel Labs
Director, Circuits and Systems Research
Innovations Across the Platform

Circuits

Architecture

Platform

Broad set of innovations enable dramatic improvements in energy efficiency
Dynamic Variation Problem

- Multitude of dynamic variations constantly present
- Guardbands must be applied to ensure correct operation
- **Result:** Processors are slowed and run at higher power
Resilient Circuits

- All guardbands removed
- Detection circuits applied to select critical timing paths
- Potential errors detected, brief re-execution at slower speed
- Normal operation resumes
Resilient Circuits Prototype

21% Throughput Gain

37% Power Reduction
Power Demand/Delivery Mismatch

Rare, intermittent power peaks

65 W max power from BRIC or battery

17.5 W average power

Power supply and battery designs constrained by peak power
Super Capacitor Augmentation

- Enables processor turbo mode operation of (70 W) for brief periods
- Reduces cost of power source (BRIC) and improves nominal efficiency
- Enables use of higher density batteries (typically 20% more storage)

10 W continuous power source/BRIC
Energy Harvesting

- Alternative power sources
- “off the grid” operation

Solar Panel (roll)

![Diagram of the energy harvesting system]

Architecture
Power Problem: Networked Devices

- 15B internet devices by 2015
- Devices ~50% power efficient
- Devices increasingly left on and in high power idle state

Remote Media Access
Forecast to grow >500% over next 3 years.

Source: Parks & Associates

Low power “always on” solution needed
Low Power Network Agent

Step 1: Platform Ready to Sleep

Step 2: Network & Security Context Transferred

Step 3: Platform Enters Sleep/Standby

Step 4: Agent maintains Network Access during Sleep (e.g. WiFi, mDNS)

Step 5: Packet arrives Interesting?...NO!

Step 5: Packet arrives Interesting?...YES!

Step 7: Packet Forwarded

Idle power of 22 W reduced to 0.8 W on prototype notebook
# Network Agent Benefit

<table>
<thead>
<tr>
<th></th>
<th>Annual Energy</th>
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<tbody>
<tr>
<td>PC left “always on”</td>
<td>430-610 kWh*</td>
</tr>
<tr>
<td>PC with Network Agent (70% of time asleep)</td>
<td>150-210 kWh</td>
</tr>
<tr>
<td>Annual Energy Savings</td>
<td>400 kWh ($40)</td>
</tr>
<tr>
<td>150+ Million PCs</td>
<td>60+ TWh ($6B)</td>
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Holistic Approach
Managing power across the platform

- Core Logic
- Operating Systems and VMMs
- Manageability
- Interconnects and Peripherals
- Telemetry
- Power Delivery and Cooling
Platform Power Management

- Fundamentally new framework
- Introduces HW power management
- Fine grain control at HW speeds
- Sustainable improvements in energy efficiency
Platform Power Management in Product

- **Menlow**
- **MooRESTown**

**Power (mW)**

- **Standby**
- **Video 720p**
- **Audio Playback**

- **50x** Standby Power Reduction
- **3x - 30x** Active Power Reduction
Dramatic Innovations Bring Dramatic Benefits

- **Circuits**: 37% Active Power Reduction
- **Architecture**: 60+ TWh Annual Power Savings
- **Platform**: 50x Idle Power Reduction
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