Intel® Energy Efficiency Architecture

Efraim Rotem
Client SoC Architecture, Design Engineering Group, Intel
Intel’s Mission

We create world-changing technology that improves the life of every person on the planet.

Mobile + Cloud Era
10B Cloud Connected Devices

PC Era
1B Internet Connected Devices

Empower Everyone

Mobile + Cloud Era
10B Cloud Connected Devices

Pervasive Intelligence Era
100B Edge Connected Devices

Build Technology That Matters

Measure What Matters
Experience Driven

- Purposeful Performance
- Experience First
- User Preferences
- Energy Efficiency

What Matters To A User

- Throughput Performance
- Responsiveness
- Emerging Compute Models
- Delivering Performance Costs Energy
- System Form Factor - Ergonomics
- All Day Battery Life
- Carbon Footprint
Experience Driven

Outline

Delivering Performance Costs Energy

Deliver Energy Efficient Value That Matters

- Tech to meet what matters to the user
- Spend the energy only when needed
- Conserve energy rest of the time

Measure What Matters

Purposeful Performance

Experience First

User Preferences

Energy Efficiency
Manage What Matters
Responsiveness Matters

Utilization based P-state
Fast Response While Performing Interactive Work

Dynamic Voltage and frequency scaling (DVFS) – Intel® Speed Step Technology

Detect workload transients from low to high activity, Filter short activities

Tradeoff between false positives and false negatives

Responsiveness Tracking Algorithm

- High Utilization
- Filter
- Fast Freq. Ramp

Responsive Tracking Algorithm

- Performance
- Energy

Intel® Speed Shift On vs. Off

Energy

Bursty QoS

Semi-Active

Energy

Performance
AI Driven Power Management

Characterize Usage Profile

- Characterize usage patterns (e.g. bursty, sustained, QoS etc.)
- Utilize additional Intel® Thread Director and Speed Shift technology information
- Adapt Performance and Energy to user experience
Background collaboration and:

- Word processing
- Spreadsheet
- Presentation
- Web Browsing

Advanced telemetry and AI algorithms to profile user activity, combined with Intel® Speed Shift technology & Thread Director

Workload types (Nominal Scale):
- Idle = 0
- Fixed QoS = 1
- Sustained = 2
- Bursty = 3
AI Based Workload Type Detection

Saving 10-20% energy while not impacting user experience

Workload types (Nominal Scale):
- Idle = 0
- Fixed QoS = 1
- Sustained = 2
- Bursty = 3

Background collaboration and:
- Word processing
- Spreadsheet
- Presentation
- Web Browsing
Measure What Matters
Does “Performance Per Watt” Matter?  No

“Perf/Watt” while running active load

- \( \frac{1}{PDP} \) (Power Delay Product) → First published in 1964
- Common industry metric → Ignores 50 years of PM

\[
\text{Performance} = \frac{1}{\text{Runtime [Sec]}}
\]

\[
\text{Performance} \quad \text{Watt} = \frac{1}{\text{Watt}\times\text{Sec}} = \frac{1}{\text{Energy [joules]}}
\]

- Subject to Arbitrary Work Point Choice

---

**Performance/Watt As a function of Performance**

**Energy Vs Performance – Content Creation**
What matters is Performance AND Watts

- Deliver performance when needed to meet user experience
- While energy is accumulated over the entire workday
- Performance AND Watts both important - not at the same time

Real Computer Usage In The Real World With Power Management
Real life power consumption

- TDP models remain stable over time – deliver more compute performance
- Energy efficiency comes from more efficient use of this TDP budget
Conclusion

Advanced Design & Technology
- Deliver amazing performance and user experience
- Delivers even higher performance on emerging workloads
- While mentioning highly efficient full day energy

Create Metrics That Matter
- Existing tools measure throughput compute and responsiveness
- Common industry energy efficiency metric is missing
- Call for action – measure energy efficiency that matters
Q&A
Disclaimer

- This document contains information on products and technologies in development.
- Results that are based on pre-production systems and components as well as results that have been estimated or simulated using an Intel Reference Platform (an internal example new system), internal Intel analysis or architecture simulation or modeling are provided to you for informational purposes only. Results may vary based on future changes to any systems, components, specifications or configurations.
- Performance varies by use, configuration and other factors. Learn more at intel.com/performance index.
- Performance results are based on testing as of dates shown in configurations and may not reflect all publicly available updates. See backup for configuration details. No product or component can be absolutely secure.
- Your costs and results may vary.
- Intel technologies may require enabled hardware, software or service activation.
- All product and service plans, and roadmaps are subject to change without notice. Any forecasts of goods and services needed for Intel’s operations are provided for discussion purposes only. Intel will have no liability to make any purchase in connection with forecasts published in this document. Code names are often used by Intel to identify products, technologies, or services that are in development and usage may change over time. No license (express or implied, by estoppel or otherwise) to any intellectual property rights is granted by this document. Product and technology performance varies by use, configuration and other factors. Learn more at www.Intel.com/PerformanceIndex and www.Intel.com/ProcessInnovation.
- The products and services described may contain defects or errors which may cause deviation from published specifications. Current characterized errata are available on request. Intel disclaims all express and implied warranties, including without limitation, the implied warranties of merchantability, fitness for a particular purpose, and non-infringement, as well as any warranty arising from course of performance, course of dealing, or usage in trade. Statements in this document that refer to future plans or expectations are forward-looking statements. These statements are based on current expectations and involve many risks and uncertainties that could cause actual results to differ materially from those expressed or implied in such statements. For more information on the factors that could cause actual results to differ materially, see our most recent earnings release and SEC filings at www.intc.com.
- © Intel Corporation. Intel, the Intel logo, and other Intel marks are trademarks of Intel Corporation or its subsidiaries. Other names and brands may be claimed as the property of others.