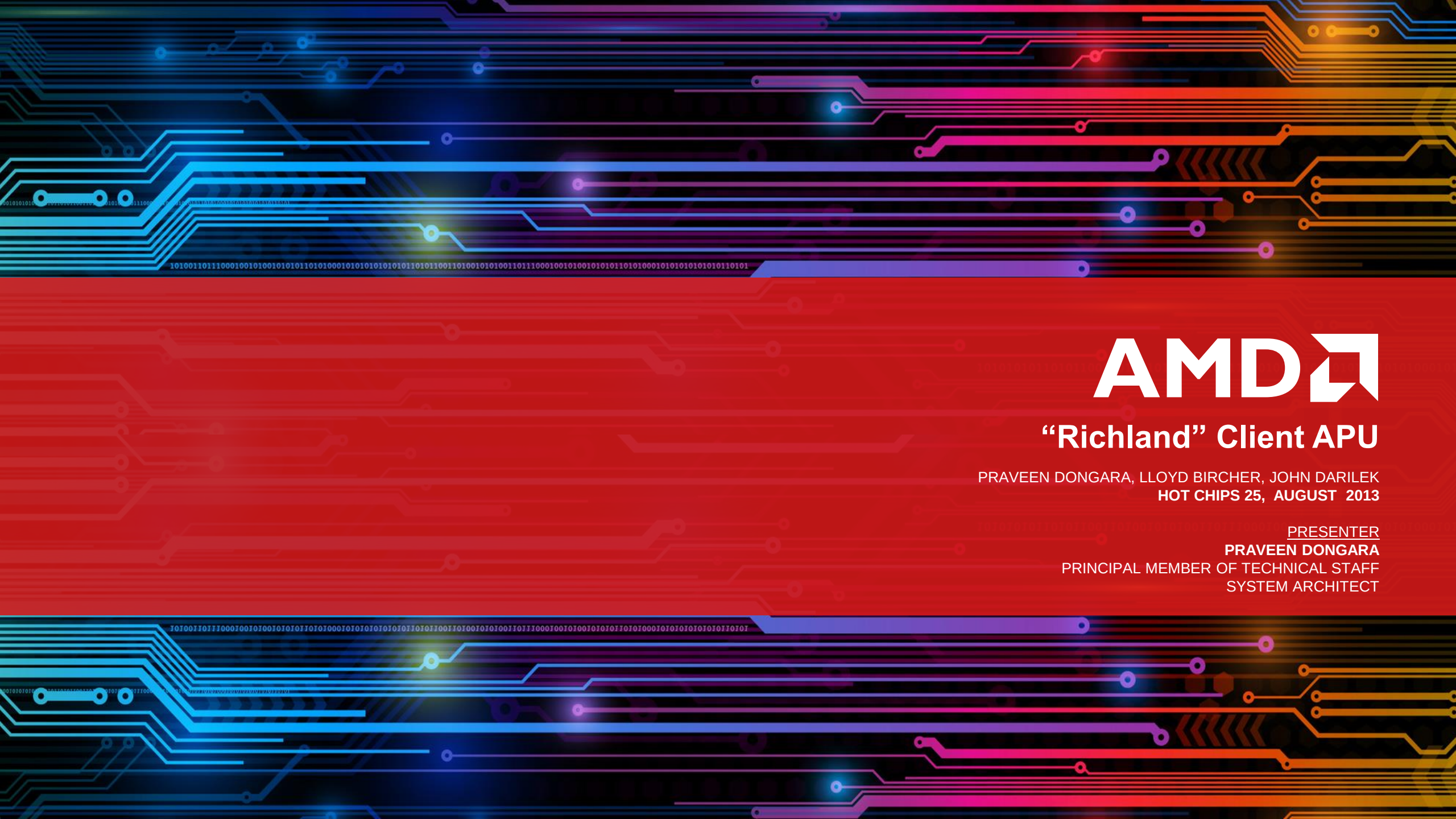


“Richland” Client APU

PRAVEEN DONGARA, LLOYD BIRCHER, JOHN DARILEK

HOT CHIPS 25, AUGUST 2013

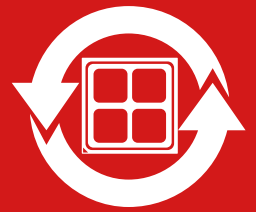
PRESENTER
PRAVEEN DONGARA
PRINCIPAL MEMBER OF TECHNICAL STAFF
SYSTEM ARCHITECT

AGENDA

- “Richland” Key Features
- Overview of AMD Turbo CORE Technology
- "Richland" Enhancements to AMD Turbo CORE Technology
  - Temperature-smart AMD Turbo CORE
  - Configurable TDP (cTDP)
  - Intelligent Boost
  - Additional boost Pstate
- "Richland" Improvements to Battery Life
- Other Salient Features
  - AMD Wireless Display
  - Dock Port Technology
- Results: Performance and Battery Life

"RICHLAND" KEY FEATURES

IMPROVED PERFORMANCE & POWER EFFICIENCY



Higher performance:* Up to 29% higher CPU performance and up to 41% higher GPU performance

- **Higher frequencies** than 2nd Gen A-Series APU (both x86 and GPU) through process node improvements
- **New AMD Turbo CORE features**
  - Temperature-smart AMD Turbo CORE, Intelligent Boost, addl. boost P-state
- **Higher memory speeds**: Up to DDR3-1866 on NB and up to DDR3-2133 on DT

Better battery life: 10 or more hours idle, 7 or more web, 4 or more video**

- **Optimized voltage/frequency**
- **Process-tuning**

DESIGNED TO ENHANCE OVERALL PERFORMANCE AND RESPONSIVENESS WHILE EXTENDING BATTERY LIFE

AMD Start Now technology ++

- **Quick S3, S4 resume** and WLAN quick connect

PROVIDES TABLET-LIKE RESPONSIVENESS, TAKING ADVANTAGE OF WINDOWS® 8 IMPROVEMENTS

FLEXIBLE DESIGN OPTIONS

Motherboard compatibility with FS1r2, FM2 packages and FCH

- Quick TTM, minimize development costs

CAN ENABLE OEM FLEXIBILITY FOR 2013 MAINSTREAM SOCKETED PLATFORMS

Configurable TDP

- **Configure TDP of APU** based on design needs

ALLOWS OEM TO TAILOR THERMAL DESIGNS BASED ON PLATFORM GOALS

ENHANCED GRAPHICS AND ENTERTAINMENT

Next-generation AMD media features

- Wi-Fi standards-based **wireless display**
- **Dock Port technology**

DELIVERING BEST VIDEO PLAYBACK EXPERIENCE

New discrete graphics support

- **AMD Radeon™ Dual graphics*** ** with the "Solar System" family

UNIQUELY SCALABLE GRAPHICS LEADERSHIP

Power-optimized for media consumption

- **Up to 51% improvement in HD video playback** power**

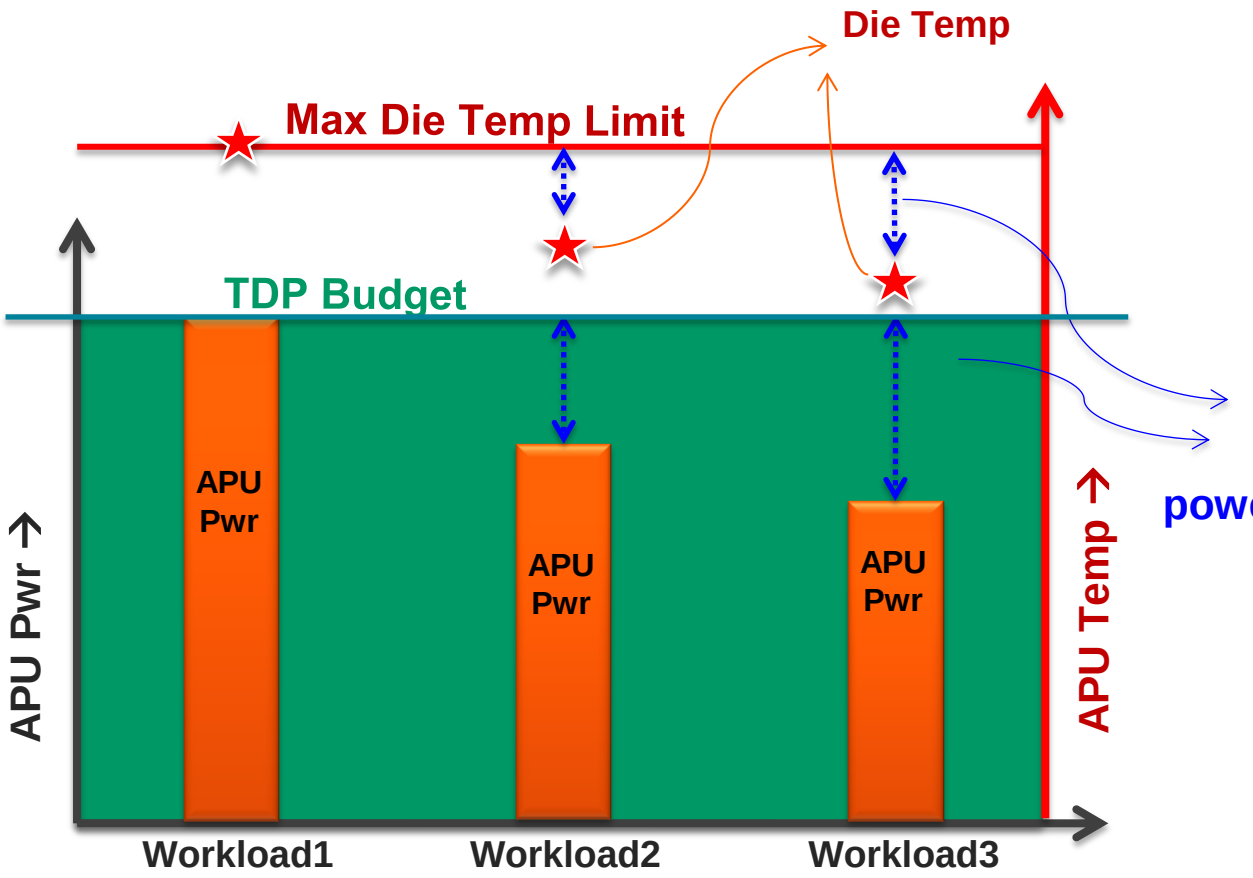
WATCH MORE MOVIES ON ONE CHARGE

*Refer to slides 22-23 for performance results; **Refer to slide 24 for power results

++AMD Start Now technology is a BIOS optimized solution designed to deliver a highly responsive system by minimizing the time to wake up the system from sleep mode, boot the system to desktop and connect to a wireless local area network. Actual times will vary based on operating system, APU, driver, disk drive and memory speed. AMD Start Now technology is available with select AMD APUs when running Windows® 7 or Windows® 8. Check with your component or system manufacturer or retailer for specific model capabilities.

****AMD Radeon™ Dual Graphics requires an AMD "A" Series APU plus an AMD Radeon™ discrete graphics configuration and is available on Windows® 7 and/or Windows 8 OS. Linux OS supports manual switching which requires restart of X-Server to engage and/or disengage the discrete graphics processor for dual graphics capabilities. With AMD Radeon™ Dual Graphics, full enablement of all discrete graphics video and display features may not be supported on all systems and may depend on the master device to which the display is connected. AMD Radeon™ "G" series and AMD Radeon™ "G2" Dual Graphics series don not support AMD Eyefinity technology. Check with your component or system manufacturer for specific mode capabilities and supported technologies.*

AMD TURBO CORE TECHNOLOGY
MOTIVATION



Without AMD Turbo CORE technology, power and temperature headroom may be left untapped in many workload scenarios.

EVOLUTION OF AMD TURBO CORE TECHNOLOGY

Year	Processor	Boosting decision based on	Notes
2010	**AMD Phenom™ II**	▪ **Number of cores active**	▪ **Single boost Pstate** used if half or more cores are inactive ▪ Coarse-grain power margin exploited
2011	**1st-Generation AMD A-Series APU**	▪ **Calculated power**	▪ **Unidirectional power transfer** between thermal entities ▪ GPU→CPU ▪ **Exploit fine-grain power margin**

2012	**2nd-Generation AMD A-Series APU**	▪ Calculated power
		▪ **Calculated temperature**
			▪ **Bidirectional power transfer** between thermal entities
			  ▪ GPU→CPU
			  ▪ CPU→GPU
			▪ **Exploit temperature margin**

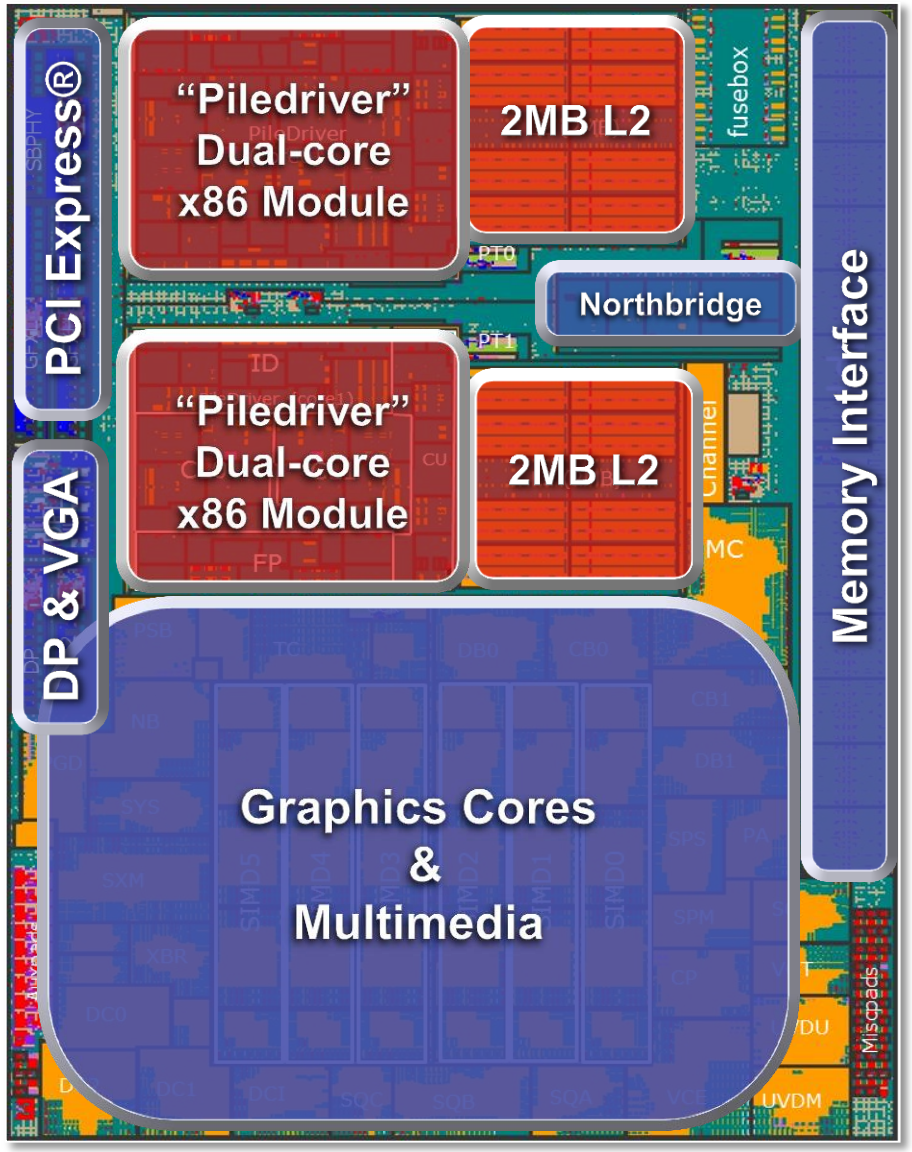
2013	**3rd-Generation AMD A-Series APU ("Richland“)**	▪ Calculated power ▪ Calculated temperature ▪ **Measured/Sensor temperature** ▪ **Efficiency of power usage** by individual entities (CPU, GPU, etc.)	▪ **Designed to more effectively exploit temperature margin** by detecting favorable thermal conditions in real time

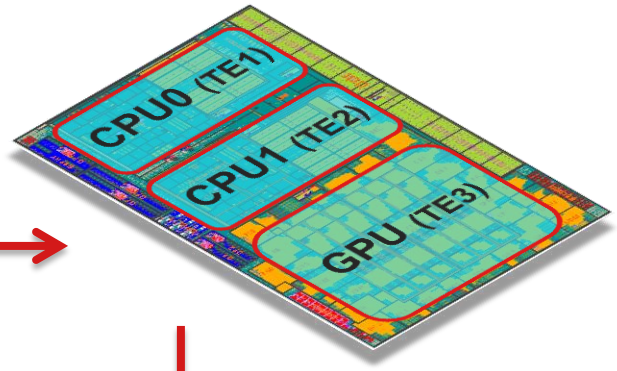
BUILDING BLOCKS OF AMD TURBO CORE TECHNOLOGY
THERMAL ENTITIES

"Richland" incorporates:

- Two “Piledriver” high-performance x86 modules (core-pairs)
- 2-MB shared L2 cache per x86 module
- AMD Radeon™ HD 8000 series DirectX®11-capable GPU with six compute units
- Next-generation media acceleration technology
- Dual 64-bit memory channel supporting up to DDR3-2133
- Integrated DisplayPort 1.2 interfaces
- PCI Express® I/O Generation 2 interfaces

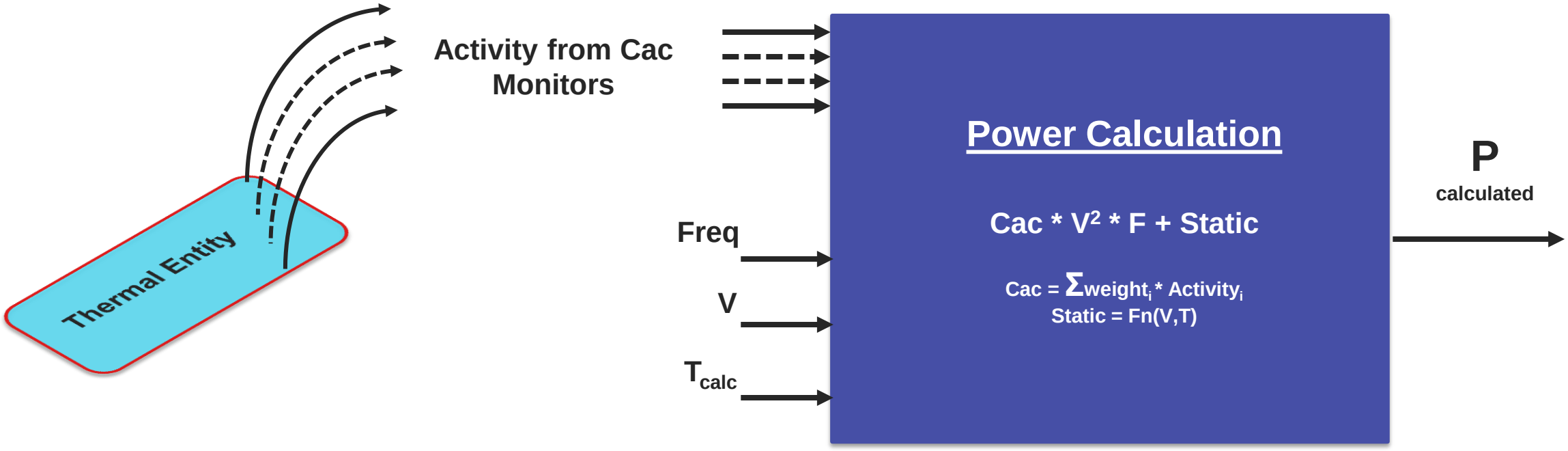
"Richland" is implemented in a 32-nm SOI node2+ high-K metal gate process technology



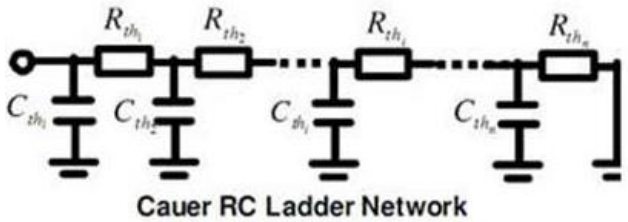


- **3 main thermal entities (TE)**
  - **TE1:** 1st x86 module + L2
  - **TE2:** 2nd x86 module + L2
  - **TE3:** Graphics + Northbridge + Multimedia
- **On each TE**
  - **Power and Temperature tracked**
  - **Frequency and Voltage controlled**
- Also account for **I/O power** influence on each of the other TEs

BUILDING BLOCKS OF AMD TURBO CORE TECHNOLOGY
POWER CALCULATION

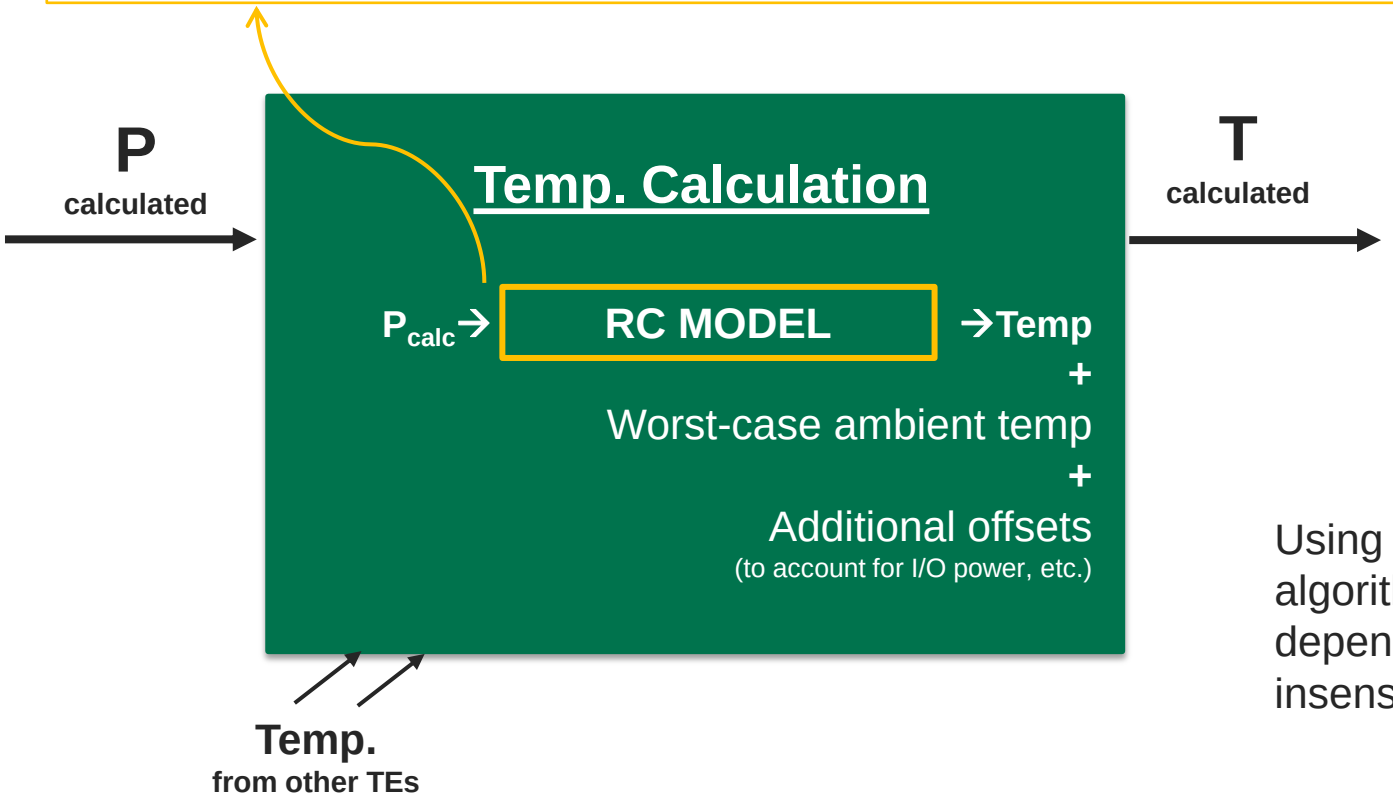


BUILDING BLOCKS OF AMD TURBO CORE TECHNOLOGY
TEMPERATURE CALCULATION



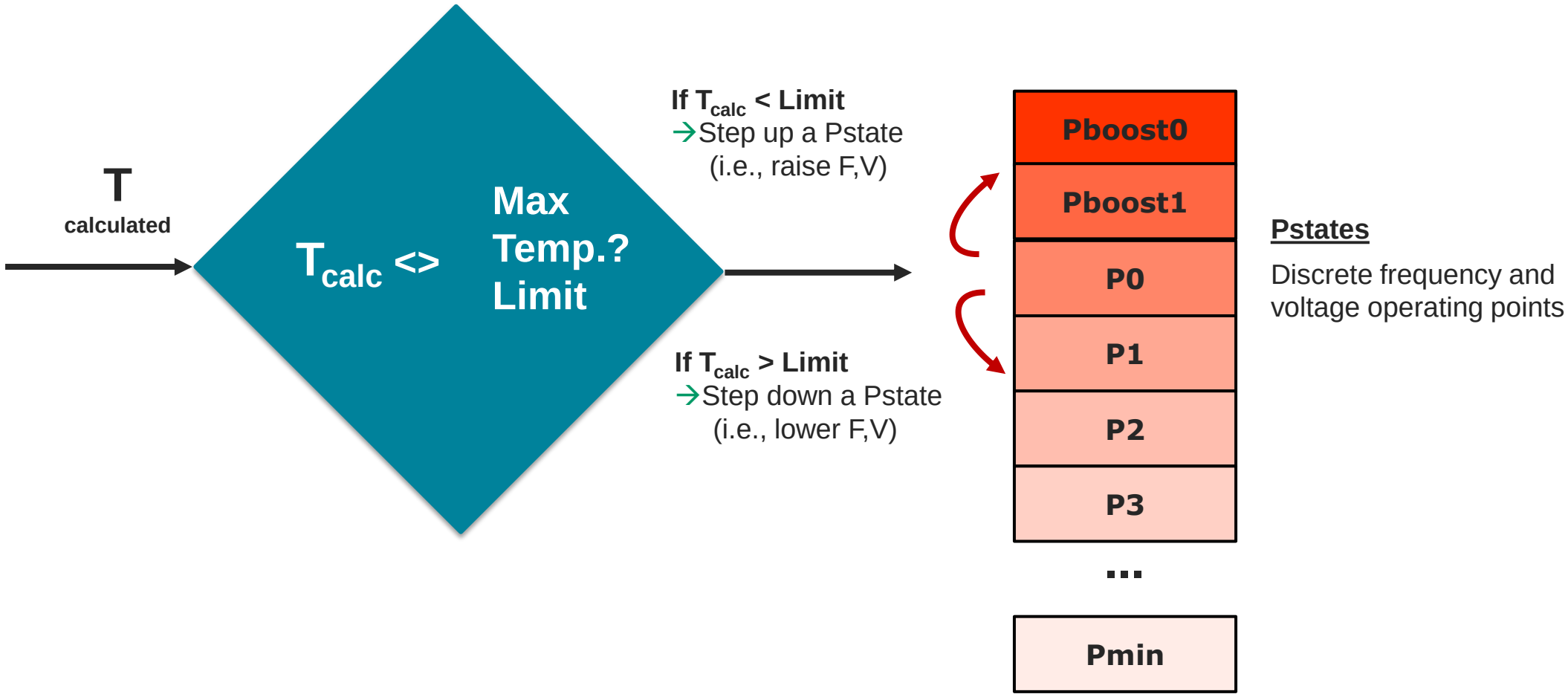
RC MODEL represents

- Cooling solution (APU heat sink, fan, etc.)
- Temperature influence of other TEs

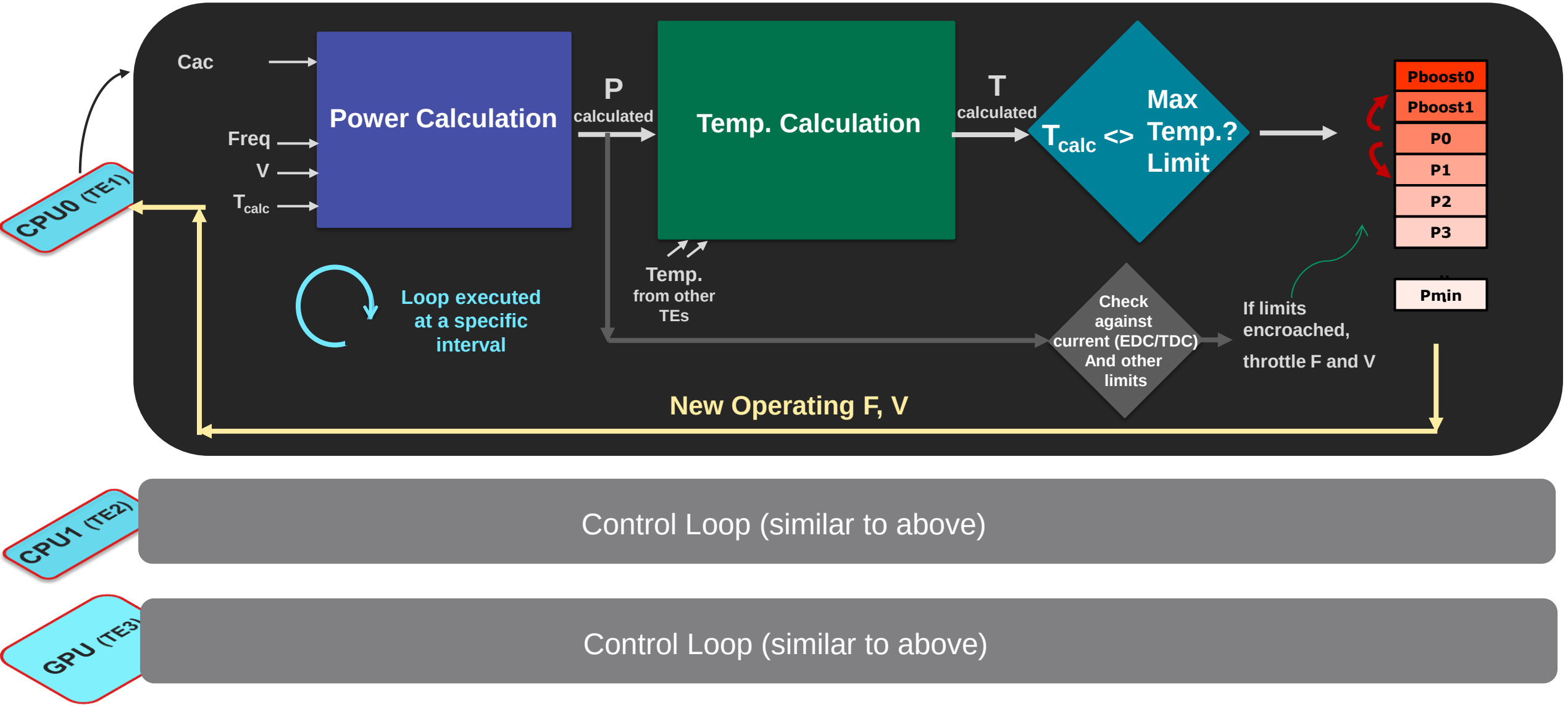


Using calculated temperature in the AMD Turbo CORE algorithm is designed to enable AMD to deliver robust, dependable, and repeatable performance that is insensitive to part variations.

BUILDING BLOCKS OF AMD TURBO CORE TECHNOLOGY
PSTATE SELECTION



AMD TURBO CORE CONTROL LOOPS
PUTTING THE PIECES TOGETHER



"RICHLAND" ENHANCEMENTS TO AMD TURBO CORE TECHNOLOGY

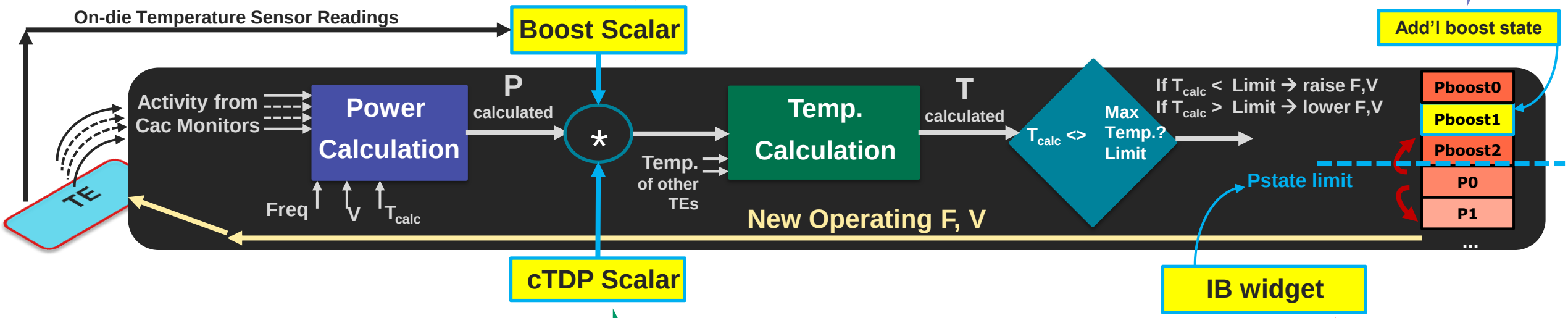
AMD

Temperature-smart AMD Turbo CORE

- Designed to enable achievement of repeatable higher performance for typical operating conditions
- Designed to supplement the previous AMD generation's power-driven temperature calculations with on-die temperature sensors

ADDITIONAL BOOST STATE

- Designed to enable the core to improve the power manager's ability to settle on the optimal operating point and deliver the right performance for each workload



CONFIGURABLE TDP (cTDP)

- Designed to provide system design flexibility to OEMs
- Designed to provide flexibility to processors to fit well in platforms that have thermal solutions designed for higher or lower TDP than nominal

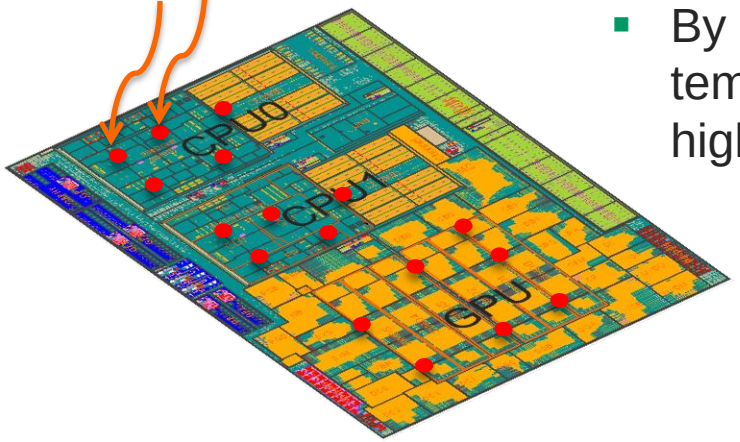
Intelligent Boost (IB)

Designed to ensure that the power budgets allocated to CPU and GPU entities are based on whether the individual entities can efficiently translate the power (and corresponding frequency) to higher performance

TEMPERATURE-SMART AMD TURBO CORE

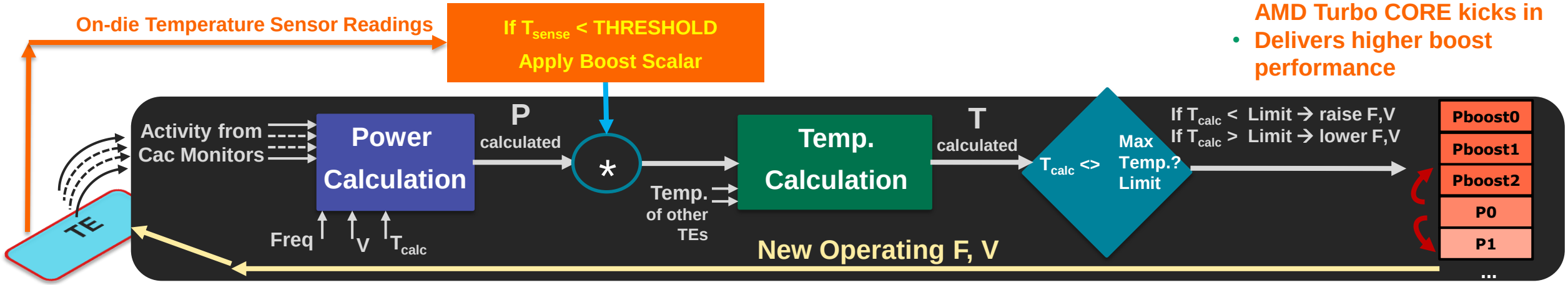
- The real-time, power-based temperature calculations (T_{calc}) include many conservative assumptions about the nature of the cooling solution and ambient conditions (e.g., 35°C external ambient).
- By supplementing our power-driven temperature calculations with on-die temperature sensors (T_{sense}), this feature is designed to deliver repeatable higher performance for typical operating conditions.

On-die Temperature Sensors (T_{sense})



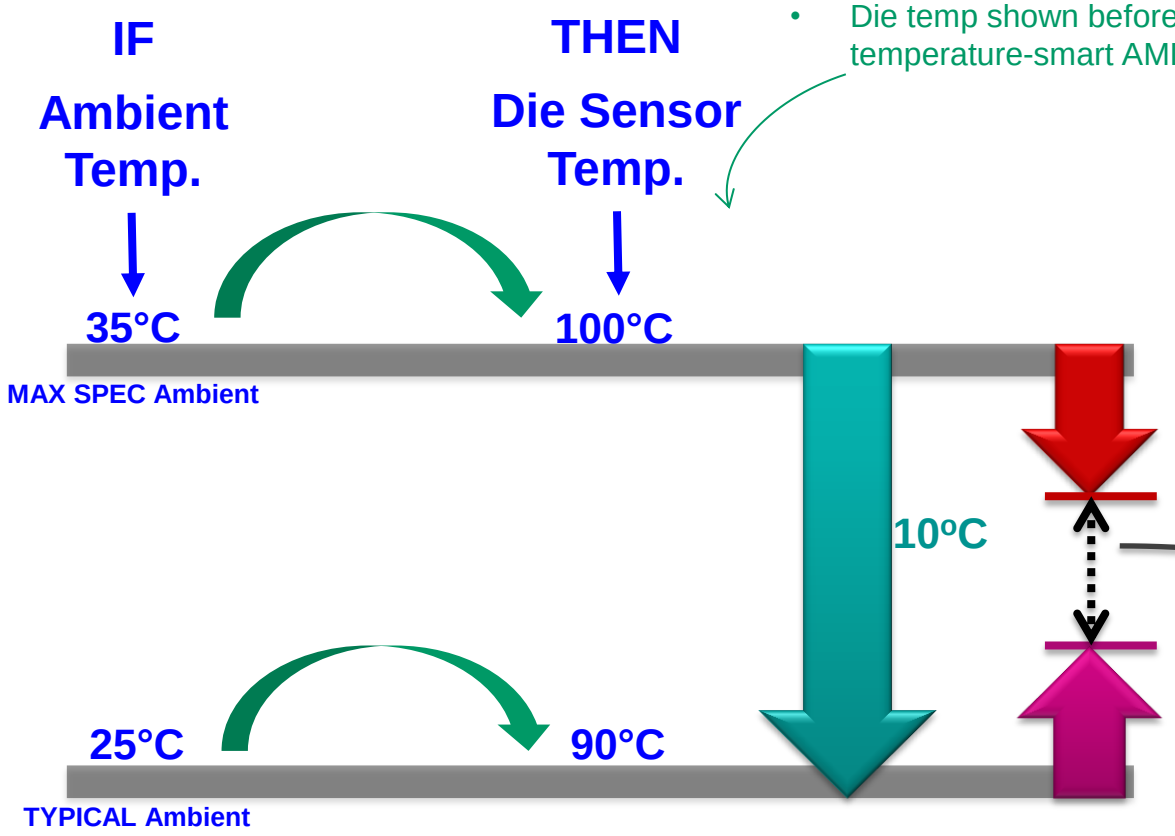
Thermal Environment/ Condition	Die Temp (in steady state)
Worst-case (max of spec) (e.g., 35°C ext. ambient)	T_{calc} == Max Temp. Limit T_{sense} == Max Temp. Limit
Typical (e.g. 25°C ext./room ambient)	T_{calc} == Max Temp. Limit **T_{sense} < Max Temp. Limit**

- **Temperature-smart AMD Turbo CORE kicks in**
- **Delivers higher boost performance**



USING TEMPERATURE SENSORS
FACTORING IN UNDER/OVER-REPORTING ERRORS

- After AMD Turbo CORE control loops reach **steady state**
- Die temp shown before application of temperature-smart AMD Turbo CORE



Under-reporting error needs to be accounted for to ensure max temp. reliability limit is not exceeded

XºC
Sensor's potential under-reporting error

YºC
Sensor's potential over-reporting error

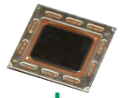
Temp. margin that temperature-smart AMD Turbo CORE can leverage
= 10 ºC – X ºC – Y ºC

Over-reporting error needs to be accounted for to allow deterministic higher performance at typical thermal environments

The temperature values above
- *are for illustrative purposes only*
- *may not reflect actual product implementation*

CONFIGURABLE TDP (cTDP)

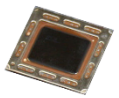
- TDP of the APU can be configured to match the cooling capabilities of the system
- Provides system design flexibility to OEMs



A10-5745M Default TDP = 25W

System with
25W Cooling Solution

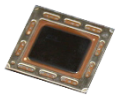
+



A10-5745M
left to operate at
default TDP of 25W

System with
20W Cooling Solution

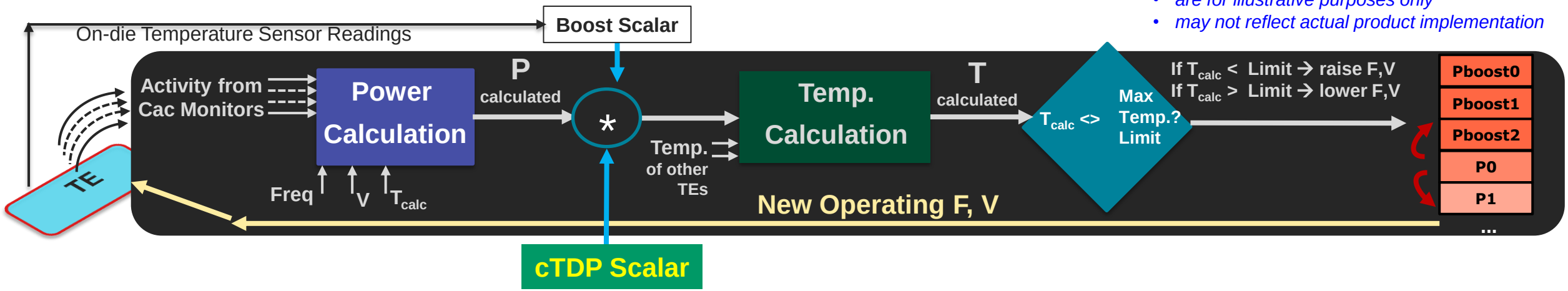
+



A10-5745M
cTDP value set to 20W
(typically via SBIOS)

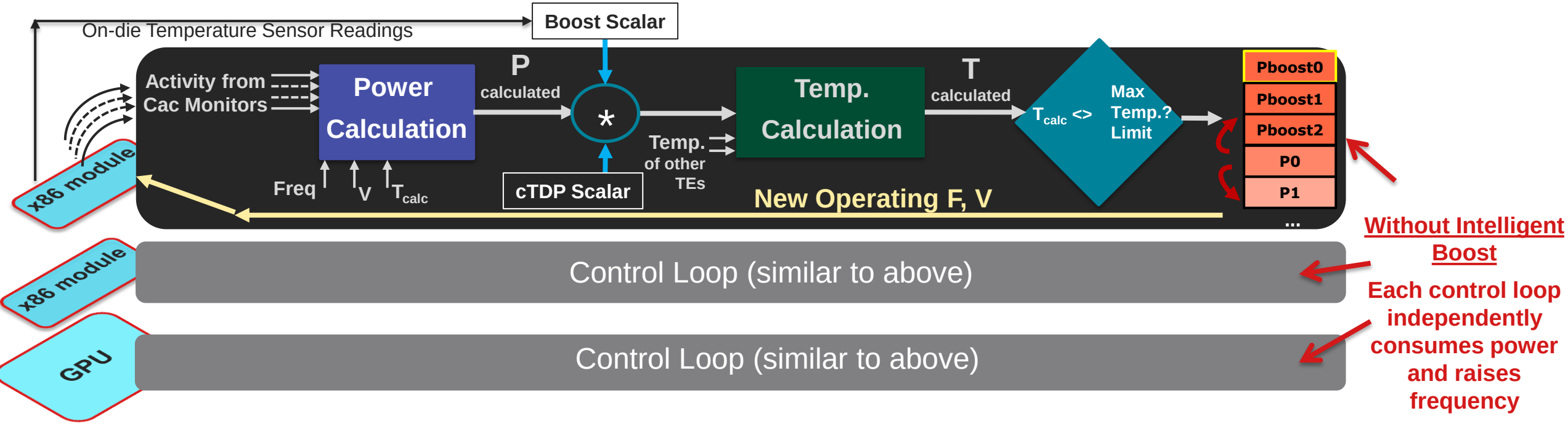
The TDP & cTDP values above

- *are for illustrative purposes only*
- *may not reflect actual product implementation*

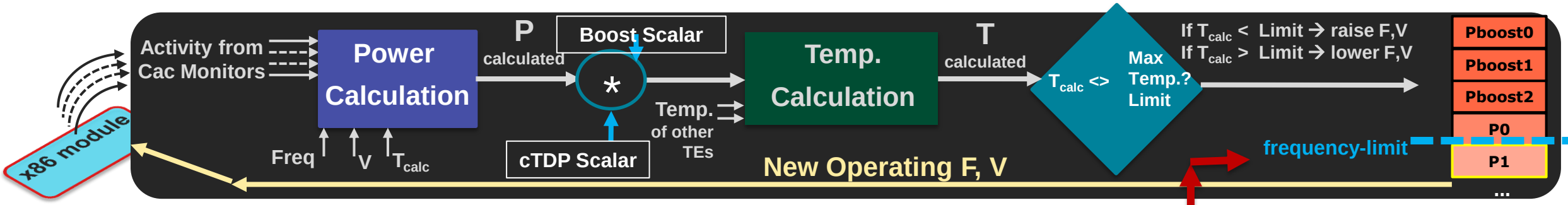


INTELLIGENT BOOST
MOTIVATION

- CPU and GPU share a cooling solution, which means that when one burns more power, the other must burn less.
- Without Intelligent Boost:
  - Each thermal entity uses the following approach:
    - CPU and GPU entities raise frequency (and power) as high as possible, within their thermal/other limits (or until the highest Pstate is reached).
    - Computational efficiency (whether freq translates well to perf) is not considered.
  - Power and frequency that CPU ends up with may be more than is needed for GPU-centric workloads.
  - Can affect power efficiency (performance/watt).



INTELLIGENT BOOST
IMPLEMENTED ON "RICHLAND"



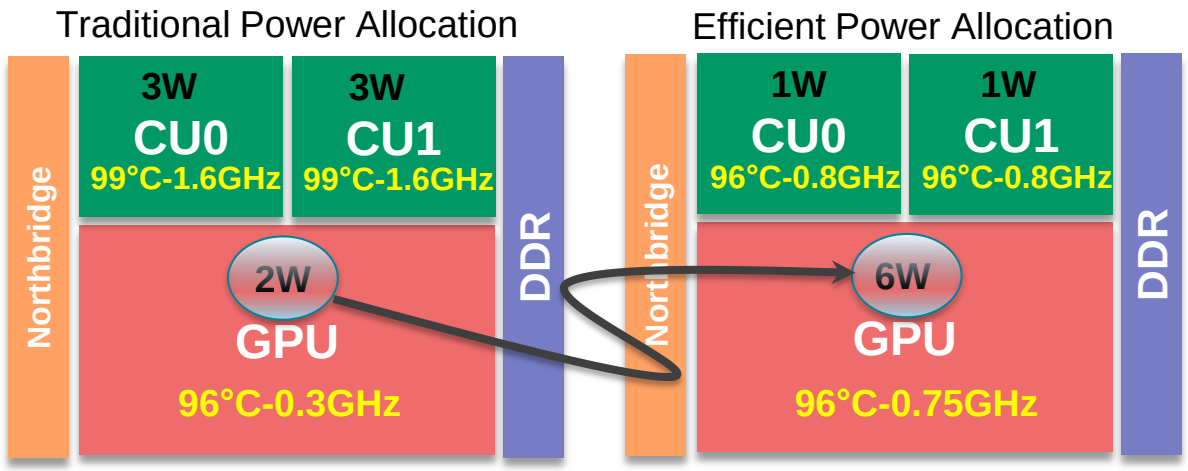
Intelligent Boost Design

- Monitor activity on GPU
- Detect cases when app code running on CPU is not sensitive to frequency and apply frequency limit on x86 CPU modules
  - GPU "reclaims" the saved CPU power through lower effective CPU temperature
  - System performance should be improved because the GPU is able to operate at a higher frequency

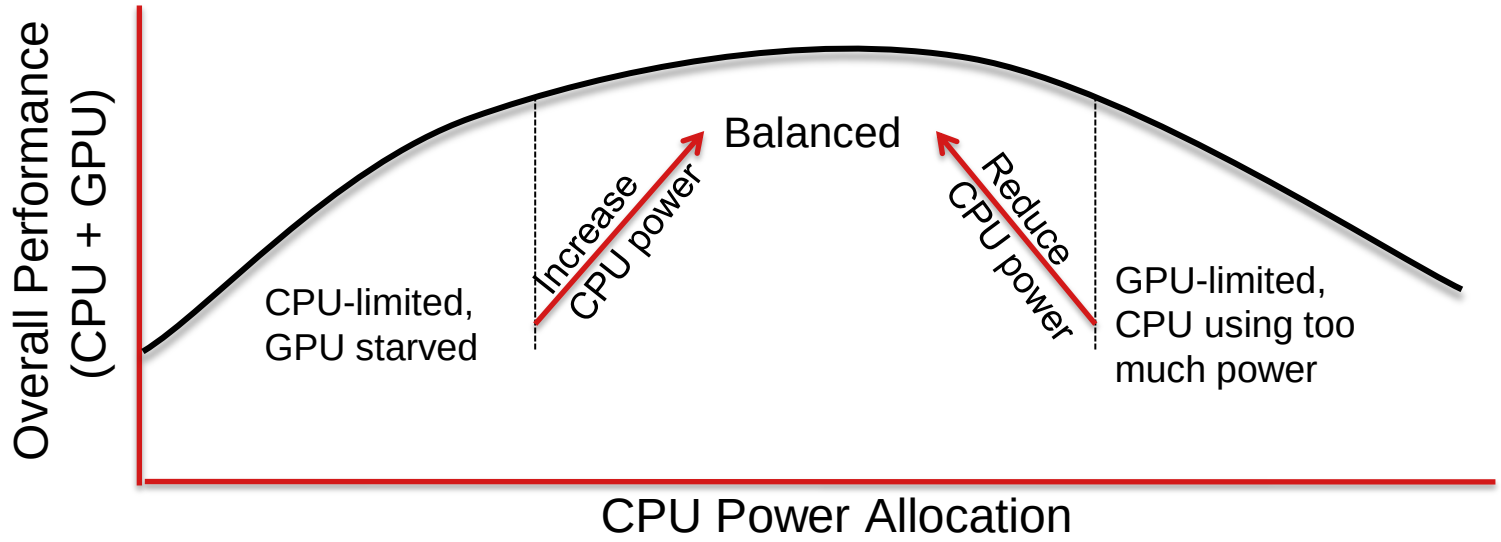
GPU

Control Loop (similar to above)

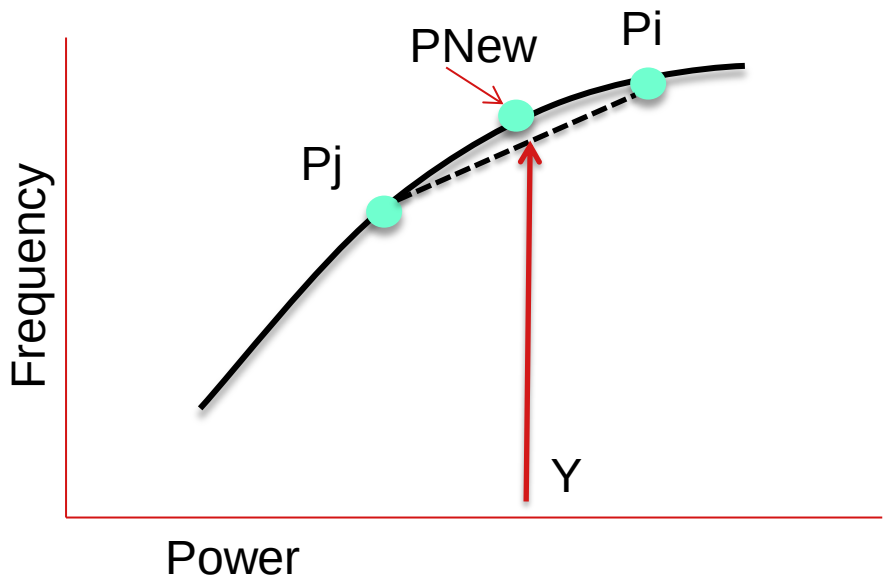
INTELLIGENT BOOST
EFFICIENT ALLOCATION OF POWER TO INCREASE GPU PERFORMANCE



- CPU power budget at minimum level to keep GPU fully utilized
- Reduced CPU temperature designed to allow GPU to sustain higher power level
- Total system performance increases

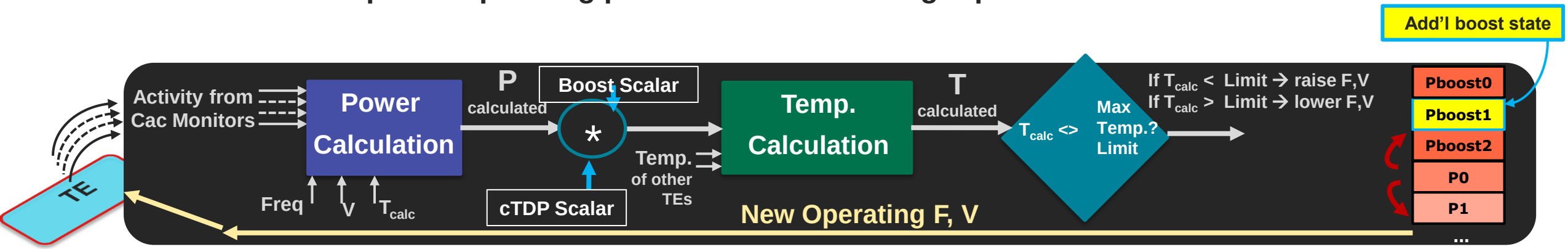


ADDITIONAL BOOST PSTATE



We added additional operating points to enable more optimal power/frequency pairing and greater overall efficiency.

These new operating points are designed to enable the core to improve the power manager's ability to settle on the optimal operating point and deliver the right performance for each workload.



"RICHLAND" BATTERY LIFE IMPROVEMENTS

- Additional power-optimized energy-saving features
- Product voltage/frequency/margin optimization
- Fabrication process-tuning for power
- Additional system-level improvements

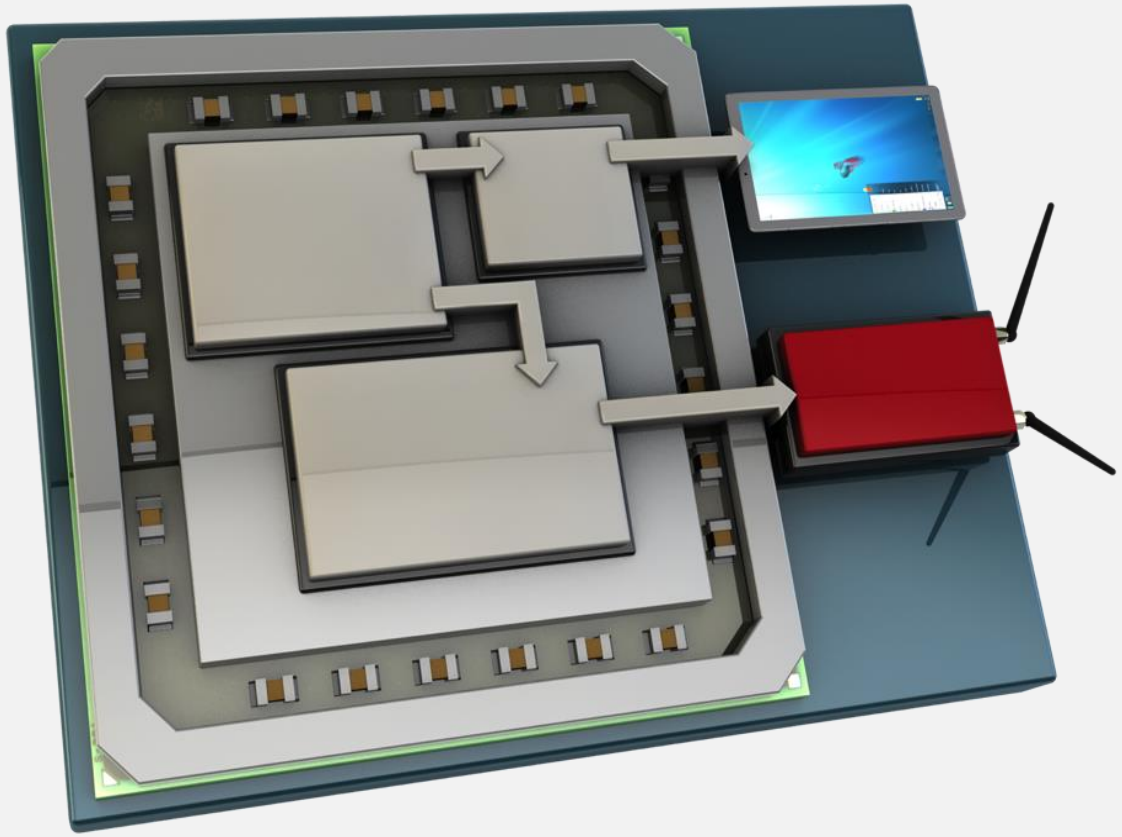
**Up to 51% more efficient than previous generation in HD video playback*
(APU+FCH)**

AMD INTERNAL TESTING. System Configurations: Data based on AMD proprietary "Pumori" Reference Design A10-5757M / AMD A10-4600M, AMD Radeon™ 8650G / AMD Radeon™ 7660G, (35W), 2x 2GB, DDR3L-1600, 1.35V, 14.0" eDP 1366x768/ LED Backlight set at 100 nits, HDD (SATA) - 250GB 5400rpm and Windows® 8 64bit. PC manufacturers may vary configuration yielding different results.

*Video Playback workload - average power when system is playback 720p video from HDD over 30 minutes, with screen set to 100 nits and Wi-Fi on. See slide 24 for backup.

2013 AMD ELITE PERFORMANCE APU PLATFORM

AMD WIRELESS DISPLAY FOR WINDOWS® 8.1 – SUPPORTED ON 2013 CLIENT PRODUCTS



AMD WIRELESS DISPLAY

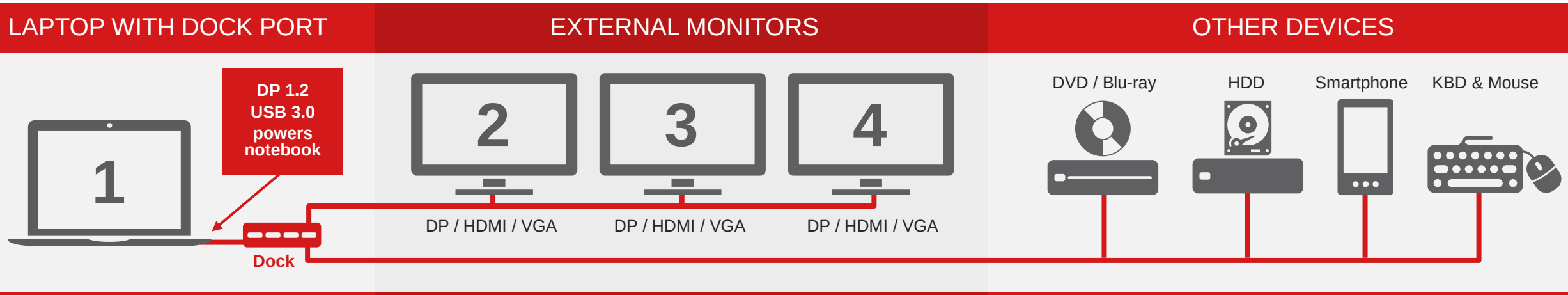
- Up to 3.9X greater responsiveness than competition for best, low-latency user experience!*
  - As low as 41ms vs. competition's 201ms
- Vivid HD playback with 1080p 60Hz (4:2:0)
- Rich audio playback

*Testing conducted by AMD Performance Labs. PC manufacturers may vary configuration yielding different results. The 2013 AMD A10 "Richland" platform showed latency using **AMD Wireless Display** of 41 milliseconds (41ms) while the Intel WiDi system showed 201ms. Test used was a browser based stopwatch showing the time difference between the PC screen and display. Systems used were an ASUS N56DY with the AMD A8-5550M APU with AMD Radeon(tm) HD 8550G Graphics, 2x2048 MBytes of DDR3-800.0 MHz (PC3-12800) RAM, Microsoft® Windows® 8 Professional (x64) Build 9200; a LENOVO ThinkPad X230 with Intel(R) Core(TM) i7-3520M CPU @ 2.90GHz with Intel(R) HD Graphics 4000 graphics, 2x2048 MB DDR3-800.0 MHz (PC3-12800) RAM, Microsoft® Windows® 8 Professional (x64) Build 9200. Both platforms used the Netgear PTV3000 to connect to the HDTVs.

CHANGING THE PARADIGM WITH DOCK PORT
BIG EXPERIENCE FROM AN ULTRATHIN

Dock your laptop and get virtually any other device or peripheral with USB 3.0* speed, **up to four external monitors***, and charging power…

All at the same time…
All through a single connection++



NOW YOU CAN:

- Get an experience that was once only possible on a desktop tower
- Get AMD Eyefinity Technology gaming**
- 3D stereoscopic gaming and 3D movie playback
- Dedicated back-up to external HDD
- Sync to smartphone
- Sync to other USB devices – tablets, media players
- Download and edit photos and video from cameras
- Multi-monitor photo editing, productivity app, multi-tasking – ideal for SOHO/SMB
- DVD and Blu-ray protected playback and streaming with virtually any media player

*Use of 4 1920x1200 external monitors does not support simultaneous USB 3.0 speed.
**AMD Eyefinity technology supports up to six DisplayPort™ monitors on an enabled graphics card. Supported display quantity, type and resolution vary by model and board design; confirm specifications with manufacturer before purchase. To enable more than two displays, or multiple displays from a single output, additional hardware such as DisplayPort-ready monitors or DisplayPort 1.2 MST-enabled hubs may be required. A maximum of two active adapters is recommended for consumer systems. See www.amd.com/eyefinityfaq for full details.
++Requires Dock Port compatible platform, a docking station and industry standard mini-DP or full sized DP connector.

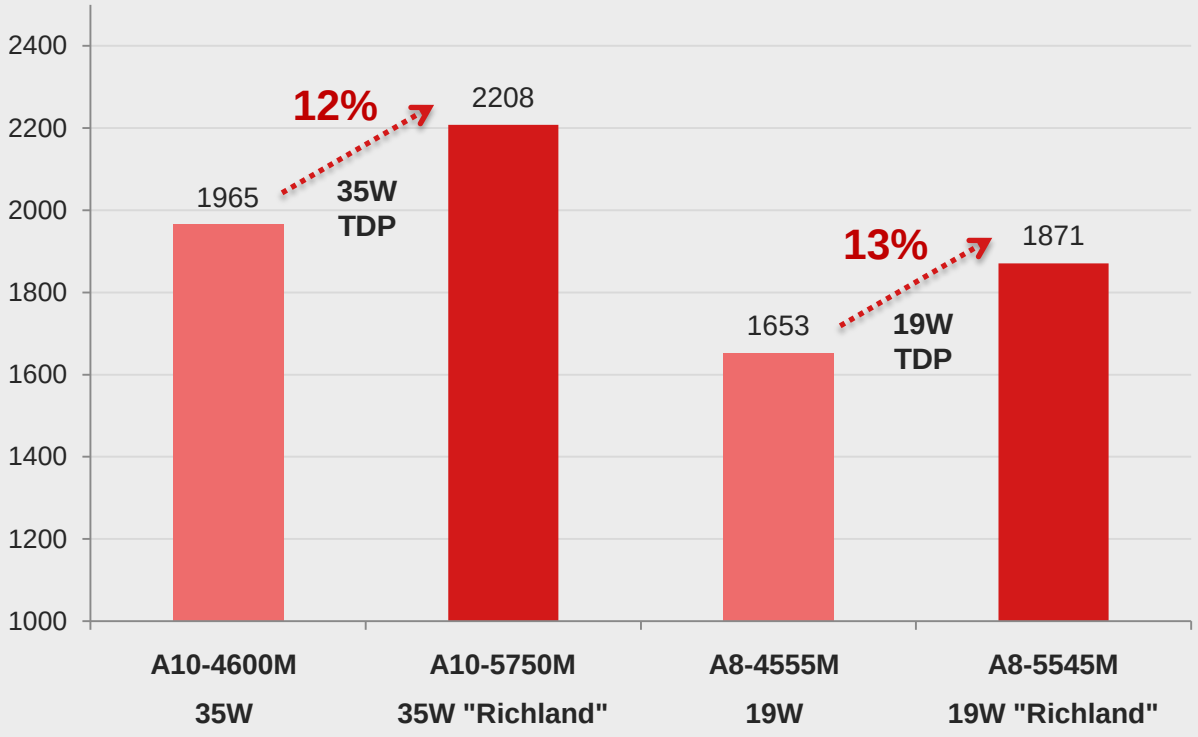
GENERATIONAL CPU PERFORMANCE UPLIFT

"RICHLAND" (AT LAUNCH) VS. AMD 2ND-GENERATION A-SERIES APU (AT LAUNCH)

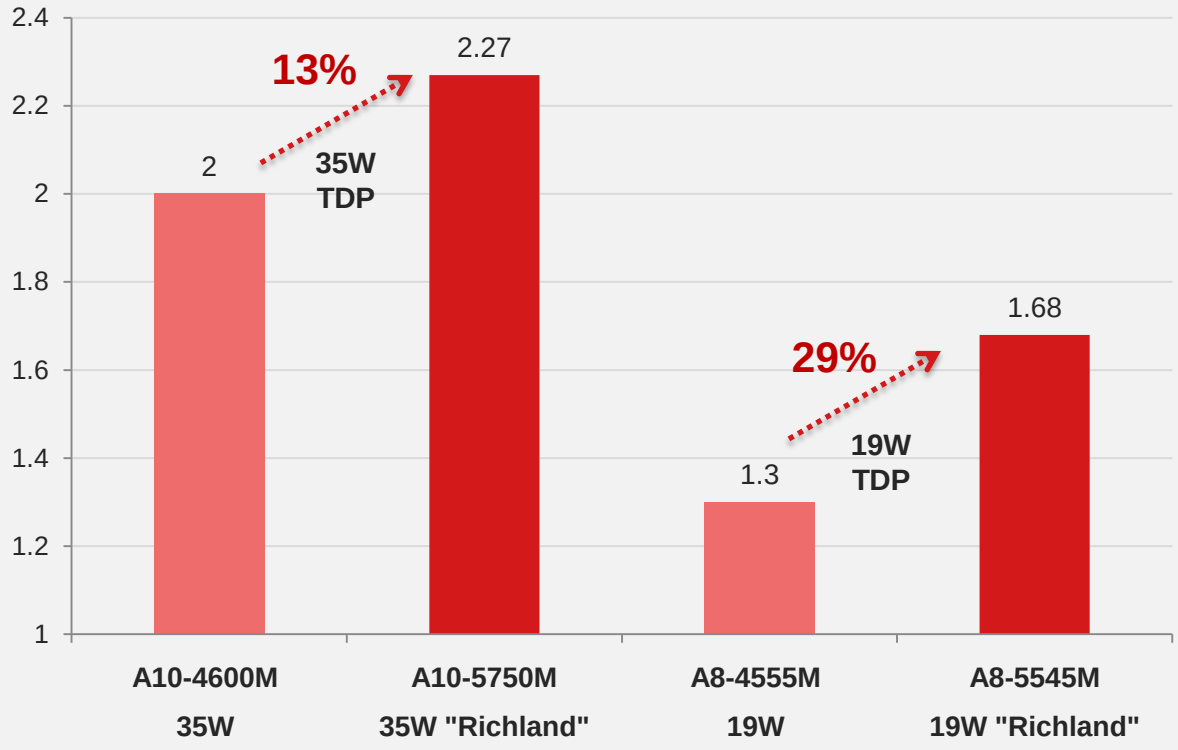
Up to **29%+ CPU Uplift!**

AMD

PCMARK® 7



CINEBENCH R11.5 MULTI CPU

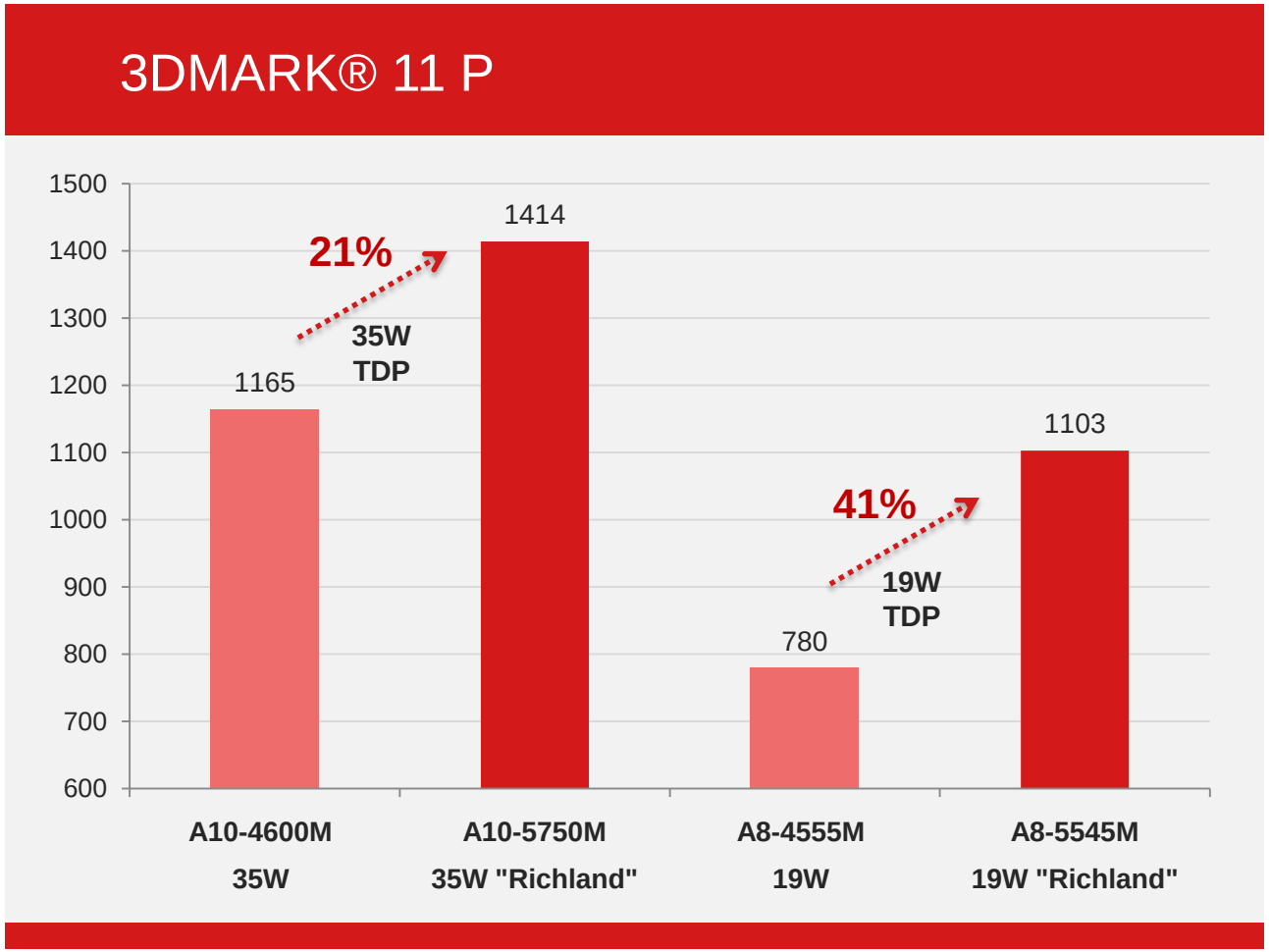


Testing conducted by AMD Performance Labs on AMD reference systems. PC manufacturers may vary configuration yielding different results. Specific product configurations used:

- AMD 2nd-Generation A-Series APU A10-4600M: AMD "Pumori" reference platform with an AMD A10-4600M Quad Core APU, AMD Radeon™ HD 7660G series graphics, 4GB DDR3-1600 memory, Microsoft® Windows® 7 64bit, Hitachi HTS545025B9A300
- AMD "Richland" A10-5750M: AMD "Pumori" reference platform with an AMD A10-5750M Quad Core APU, AMD Radeon™ HD 8650G series graphics, 4GB DDR3-1866 memory, Microsoft® Windows® 8 64bit, Hitachi HTS545025B9A300
- AMD 2nd-Generation A-Series APU A8-4555M: AMD "Manaslu" reference platform with an AMD A8-4555M Quad Core APU, AMD Radeon™ HD 7600G series graphics, 4GB DDR3-1333 memory, Microsoft® Windows® 7 64bit, Hitachi HTS545025B9A300
- AMD "Richland" A8-5545M: AMD "Manaslu" reference platform with an AMD A8-5545M Quad Core APU, AMD Radeon™ HD 8510G series graphics, 4GB DDR3-1333 memory, Microsoft® Windows® 8 64bit, Hitachi HTS545025B9A300

GENERATIONAL GPU PERFORMANCE UPLIFT

"RICHLAND" (AT LAUNCH) VS. AMD 2ND-GENERATION A-SERIES APU (AT LAUNCH)

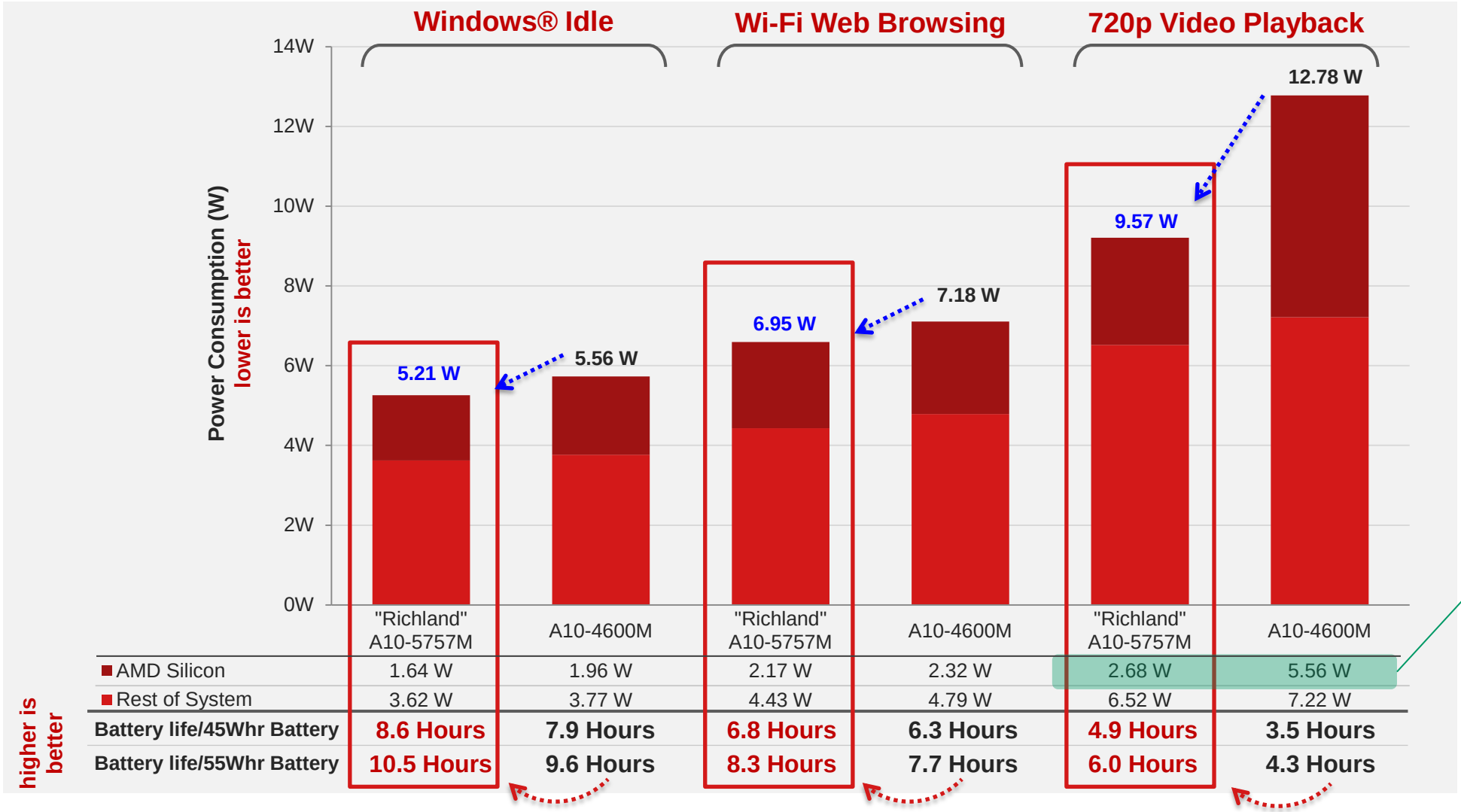


Up to **41%+ GPU Uplift!**

Testing conducted by AMD Performance Labs on optimized AMD reference systems. PC manufacturers may vary configuration yielding different results. Specific product configurations used for 3DMark®11-P:

- AMD 2nd-Generation A-Series APU A10-4600M: AMD "Pumori" reference platform with an AMD A10-4600M Quad Core APU, AMD Radeon™ HD 7660G series graphics, 4GB DDR3-1600 memory, Microsoft® Windows® 7 64bit, Hitachi HTS545025B9A300 HDD, 8.94RC2 Graphics driver (launch configuration)
- AMD "Richland" A10-5750M: AMD "Pumori" reference platform with an AMD A10-5750M Quad Core APU, AMD Radeon™ HD 8650G series graphics, 4GB DDR3-1866 memory, Microsoft® Windows® 8 64bit, Hitachi HTS545025B9A300 HDD, 12.100.0.0 Graphics driver
- AMD 2nd-Generation A-Series APU A8-4555M: AMD "Manaslu" reference platform with an AMD A8-4555M Quad Core APU, AMD Radeon™ HD 7600G series graphics, 4GB DDR3-1333 memory, Microsoft® Windows® 7 64bit, Hitachi HTS545025B9A300 HDD, 8.94RC2 Graphics driver (launch configuration)
- AMD "Richland" A8-5545M: AMD "Manaslu" reference platform with an AMD A8-5545M Quad Core APU, AMD Radeon™ HD 8510G series graphics, 4GB DDR3-1333 memory, Microsoft® Windows® 8 64bit, Hitachi HTS545025B9A300 HDD, 12.100.0.0 Graphics driver

NEXT-GENERATION APU "RICHLAND" POWER DATA



"Richland" draws lower power for typical use cases
(compared to AMD 2nd-Generation A-Series APU)

Up to a 51% more efficient
in HD video playback
(APU+FCH)

Improved battery life

AMD INTERNAL TESTING. System Configurations: Data based on "Pumori" Reference Design A10-5757M / AMD A10-4600M, AMD Radeon™ 8650G / AMD Radeon™ 7660G, (35W), 2x 2GB, DDR3L-1600, 1.35V, 14.0" eDP 1366x768/ LED Backlight set at 100 nits, HDD (SATA) - 250GB 5400rpm and Windows® 8 64bit. PC manufacturers may vary configuration yielding different results.

Video Playback workload - average power when system is playback 720p video from HDD over 30 minutes, with screen set to 100 nits and Wi-Fi on.

Web Browsing workload – average power when system is web browsing 20 popular web sites over a 40 minutes (2 minutes per page, 20 web pages) with screen set to 100 nits.

SUMMARY

- Greater performance and power efficiency via new AMD Turbo CORE technology features
- Improved battery life via product definition optimizations
  - Significant improvement in video playback power
- Configurable TDP feature introduced to provide system design flexibility to OEMs
- Dock Port technology introduced
- Support added for Wi-Fi standards-based wireless display

ACKNOWLEDGEMENTS

Acknowledging the entire "Richland" team at AMD for successful product development and launch !

DISCLAIMER & ATTRIBUTION

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