RDNA™ 2 GAMING ARCHITECTURE

ANDREW POMIANOWSKI
RADEON PRODUCT ARCHITECT
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AMD RDNA™ VISION

DESIGNED FOR THE FUTURE OF GAMING

PERFORMANCE
For Diverse Modern Gaming Workloads

EFFICIENCY
For Optimal Power and Bandwidth Utilization

SCALABILITY
From Mobile to Cloud Gaming

FEATURES
And Ecosystem Enablement
RDNA 2
GAMING ARCHITECTURE

BREAKTHROUGH HIGH-SPEED DESIGN
- High frequencies and superb power efficiency

REVOLUTIONARY AMD INFINITY CACHE
- 128MB cache with extreme bandwidth at lower power

ADVANCED FEATURES
- DX12° Ultimate and support for DirectStorage API

MORE PERFORMANCE, LESS POWER!
RDNA 2
BREAKTHROUGH HIGH-SPEED DESIGN

HIGH FREQUENCY IN THE DNA
- Leverages world-class CPU design methodologies
- Streamlined micro-architecture with heavy emphasis on reduced switching capacitance

PERFORMANCE-POWER SCALABILITY
- Up to 1.3X frequency at same power per CU
- Up to 50% per CU power at same frequency

SAME 7nm TECHNOLOGY, HUGE GAINS

> 1.3X Frequency
< 0.5X Power
CACHE IN RADEON™ RX 5000 SERIES
GREAT BANDWIDTH BUT LOW HIT RATES

L0 localized to each CU

L1 private in each shader engine with exclusive L2 access

4MB L2 shares data between Shader Engines and Command Processor

256b of 14Gb/s GDDR6 for 448GB/s BW

CHALLENGE FOR AMD RDNA™ 2
Double the CU count at 1.3X the frequency without being bandwidth starved
SOLVING THE BANDWIDTH PROBLEM
FRAME DATA CONTAINED IN A LARGE CACHE

- Our GPU Caches in RDNA were focused on supporting the high bandwidth demands of the engine
- The capacities were low, in the 4MB range
- A larger cache could provide compelling bandwidth amplification for common gaming
NEW CACHE HIERARCHY
LOCAL CACHE TO GLOBAL CACHE

CAPTURES SPATIAL AND TEMPORAL DATA RE-USE, MINIMIZING DATA MOVEMENT, LATENCIES, AND POWER
AMD INFINITY CACHE BENEFITS

Bandwidth/Watt

Up to
2.4X MORE

Infinity Cache

Delivered bandwidth  Typical power

256b G6  384b G6  512b G6  Infinity Cache + 256b G6

Memory Latency (nS)

Average of
34% LESS

1.3 pJ

Infinity Cache Access

7-8 pJ

GDDR6 Access

1.00X

0.80X

0.60X

0.40X

0.20X

0.00X

GDDR6

RX 5700

Average

IC hit

GDDR6

RX 6800

Source: AMD internal lab measurements of GDDR6 phy + DRAM power. See endnotes RX-535, RX-548.
PERFORMANCE-PER-WATT ACHIEVEMENT

PERFORMANCE-PER-WATT GAIN

- Up to +54%
- Up to +50%

PERFORMANCE CONTRIBUTORS

- 16% Design Frequency Increase
  - Leverage CPU high frequency expertise
  - High speed performance libraries
  - Streamlined micro-architecture and design
  - Aggressive re-pipelined logic for speed

- 17% CAC and Power Optimizations
  - Pervasive fine-grain clock gating
  - Clock tree splitting and gating
  - Redesigned for minimal data movement
  - Aggressive pipeline rebalancing

- 21% Performance per Clock Enhancement
  - Infinity Cache amplified low latency/power bandwidth
  - TLB streamlined for latency reductions
  - Redesign 32b pixel pipe and included new HDR format
  - Optimized geometry distribution and tessellation

See endnotes RX-325, RX-549, and RX-566.
AMD RDNA™ 2 ENHANCED VISUALS
ARCHITECTED FOR DIRECTX® 12 ULTIMATE

<table>
<thead>
<tr>
<th>Feature</th>
<th>Description</th>
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<tbody>
<tr>
<td>MESH SHADERS</td>
<td>Unlocking more detailed environments</td>
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<tr>
<td></td>
<td>Ultra high-performance geometry pipelines</td>
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<tr>
<td></td>
<td>Advanced culling and work creation</td>
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<tr>
<td>SAMPLER FEEDBACK</td>
<td>Advanced data streaming</td>
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<tr>
<td></td>
<td>Moving beyond traditional memory limitations</td>
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<td></td>
<td>Richly defined worlds</td>
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<tr>
<td>RAYTRACING</td>
<td>Increased realism</td>
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<td></td>
<td>More accurate modeling of light interactions</td>
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<tr>
<td></td>
<td>Balance with rasterization for desired quality and framerate</td>
</tr>
<tr>
<td>VARIABLE RATE SHADING</td>
<td>High efficiency while maintaining quality</td>
</tr>
<tr>
<td></td>
<td>Focus work where it provides benefits</td>
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</tbody>
</table>

AMD RDNA™ 2 GAMING ARCHITECTURE
AMD RDNA™ 2 RAYTRACING

AMD RDNA 2 implements a high-performance raytracing intersection acceleration architecture:

- The Ray Accelerator handles intersection of rays with the BVH, and sorting of ray intersection times.
- It provides an order of magnitude increase in intersection performance compared to a software implementation.

Traversal of the BVH and shading of ray results is handled by shader code running on the Compute Units.

AMD Infinity Cache can hold a very high percentage of the BVH working set, reducing intersection latency.
AMD RDNA™ 2 VARIABLE RATE SHADING

AMD RDNA 2 variable rate shading is designed to deliver the maximum usability and flexibility for developers.

Fine grained rate selection (per 8x8 pixels) makes it easier to select the appropriate shading rate for each region:

- Larger regions could cause more image quality or performance compromises.

AMD RDNA 2 supports coarse shading rates up to 2x2 with consistent and predictable performance improvements:

- Up to 4x improvements in effective shading throughput are attainable.
# RDNA 2 VARIANTS

<table>
<thead>
<tr>
<th></th>
<th>RADEON RX 6800/6900 SERIES</th>
<th>RADEON RX 6700 SERIES</th>
<th>RADEON RX 6600 XT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max Compute Units &amp; Ray Accelerators</td>
<td>80</td>
<td>40</td>
<td>32</td>
</tr>
<tr>
<td>Game Clock (up to)</td>
<td>2015 MHz</td>
<td>2424 MHz</td>
<td>2359 MHz</td>
</tr>
<tr>
<td>Infinity Cache</td>
<td>128MB</td>
<td>96MB</td>
<td>32MB</td>
</tr>
<tr>
<td>Memory Bandwidth</td>
<td>256 bit</td>
<td>192 bit</td>
<td>128 bit</td>
</tr>
<tr>
<td>Max Board Power</td>
<td>300W</td>
<td>230W</td>
<td>160W</td>
</tr>
<tr>
<td>Transistor Count</td>
<td>26.8B</td>
<td>17.2B</td>
<td>11.1B</td>
</tr>
<tr>
<td>Process</td>
<td>7nm</td>
<td>7nm</td>
<td>7nm</td>
</tr>
<tr>
<td>Target Experiences</td>
<td>4K</td>
<td>1440p</td>
<td>1080p</td>
</tr>
</tbody>
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WRAP UP
**ENDNOTES**

RX-325
Testing done by AMD performance labs 6/1/19, using the Division 2 @ 25x14 Ultra settings. Performance may vary based on use of latest drivers. RX-525

RX-535
Measurement calculated by AMD engineering, on a Radeon RX 6600 series card with 128 MB AMD Infinity Cache and 256-bit GDDR6. Measuring 4k gaming average AMD Infinity Cache hit rates of 58% across top gaming titles, multiplied by theoretical peak bandwidth from the 16 64B AMD Infinity-Fabric channels connecting the Cache to the Graphics Engine at boost frequency of up to 1.94 GHz. RX-535

RX-536
AMD Internal modeling based on graphics-engine only measured average gaming power consumption and 30Mark11 power consumption vs. frequency for RX5700 XT and RX 6900 XT divided by the number of compute units (40 and 80 respectively). RX-536

RX-543
AMD Internal modeling based on the average CAC of 33 apps tested on the RX 5700 XT and RX 6900 XT divided by the number of active compute units 40 and 80 respectively. Performance will vary. RX-543

RX-548
AMD Internal modeling based measured AMD Infinity Cache uplifts and extrapolation based on CAC count. Performance will vary. RX-548

RX-549
Testing done by AMD performance labs 10/16/20, using Assassins Creed Odyssey (DX11, Ultra), Battlefield V (DX12, Ultra), Borderlands 3 (DX12, Ultra), Control (DX12, High), Death Stranding (DX12 Ultra), Division 2 (DX12, Ultra), Far Cry 5 (DX11, Ultra), Gears of War 5 (DX12, Ultra), Hitman 2 (DX12, Ultra), Horizon Zero Dawn (DX12, Ultra), Metro Exodus (DX12, Ultra), Resident Evil 3 (DX12, Ultra), Shadow of the Tomb Raider (DX12, High), Strange Brigade (DX12, Ultra), Total War Three Kingdoms (DX11, Ultra), Witcher 3 (DX11, Ultra) HairWorks) at 4k. System comprised of an RX 6800 XT with AMD Radeon Graphics driver 27.20.12031.1000 and an RX 5700 XT with AMD Radeon Graphics driver 26.20.13001.9005. Performance may vary. RX-549

RX-558
Testing done by AMD performance labs October 18 2020 on AMD Ryzen 9 5900X (3.7GHz) CPU, 16GB DDR4-3200MHz, Win10 Pro x64. Radeon RX 6800 was using 20.45-201013m, RTX 2080 Ti using 456.71. Following games were tested at 4k at max settings: Battlefield V DX11, Doom Eternal Vulcan, Forza DX12, Resident Evil 3 DX11, Shadow of the Tomb Raider DX12. Performance may vary. RX-558

RX-564
Based on AMD internal modeling and testing done by AMD engineering labs 10/5/2020 on Radeon RX 6800 XT with 128 MB of AMD Infinity Cache vs a Radeon RX 5700 XT graphics card measuring memory latency. Performance may vary. RX-564

RX-565
Measurement calculated by AMD engineering, on a Radeon RX 6000 series card with 128 MB AMD Infinity Cache and 256-bit GDDR6. Multiplying 16 64B AMD Infinity-Fabric channels connecting the Cache to the Graphics Engine with a boost frequency of up to 1.94 GHz and a base frequency of 1.4 GHz. RX-565

RX-566
Based on AMD internal modeling and testing done by AMD engineering labs 10/5/2020 on a Radeon RX 6800 XT vs a Radeon RX 5700 XT, using measurements taken of CAC, frequency at same power uplifts, and AMD Infinity Cache uplifts. Performance may vary. RX-566

RX-568
Based on AMD internal modeling and testing done by AMD engineering labs 10/5/2020, measuring AMD Infinity Cache uplifts across 44 apps in 4K, using at 2100 MHz engine clock and then extrapolating from that frequency point. Performance may vary. RX-568

AMD RDNA™ 2 GAMING ARCHITECTURE
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