RADV: Are we there yet?

Status of RADV the Mesa Vulkan driver, in 2025

Daniel Schürmann, Timur Kristóf

2025

VALVE Linux Open-Source Graphics Drivers Group

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Mission: imrove Linux
gaming experience
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What is RADV and ACO?

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What is RADV?

RADV: Vulkan driver for AMD Radeon GPUs

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What is ACO?

ACO: Shader compiler for AMD Radeon GPUs
(technically, a shader compiler back-end)

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RADV supported hardware

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- Initially VI (GCN 3 - Fiji, Tonga)
- Soon also SI, CIK, Polaris
- Vega not much later
- Navi 1x soon after launch
- Navi 2x, 3x, 4x: slightly before launch

RADV Vulkan conformance

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Vulkan

- GCN 1, 2 - Vulkan 1.3
- GCN 3 and newer - Vulkan 1.4
- Optional features as the HW supports them

RADV, ACO history

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RADV, ACO - history, current team

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- June 2016 - Bas Nieuwenhuizen and Dave Airlie started hacking
- Oct 2016 - RADV mainlined
- Jan 2017 - Samuel Pitoiset joined
- Feb 2018 - Daniel Schürmann joined
- Apr 2018 - ACO started
- Sep 2018 - Rhys Perry joined
- Jul 2019 - Timur Kristóf joined
- Sep 2019 - ACO mainlined
- Jun 2020 - ACO the default in RADV (all gens)
- Dec 2021 - Georg Lehmann joined
- Oct 2022 - Konstantin Seuer joined
- Oct 2022 - Natalie Vock joined
- Dec 2024 - ACO the default in RadeonSI (GFX6-9)

RADV, ACO - also thanks to

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- Alyssa Rosenzweig
- Autumn Ashton
- Connor Abbott
- David Rosca
- Faith Ekstrand
- Ishi Tatsuyuki
- Marek Olsák
- Martin Roukala
- Mike Blumenkrantz
- Tony Wasserka
- Vitaliy Kuzmin

And everyone else who contributed.

What's new in the driver

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RADV recent features

Day-one support of most new HW releases (Thanks, AMD!)

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RADV recent features

New HW support

- RDNA 3
- RDNA 3.5
- RDNA 4
- CDNA (community contributions)

RADV recent Vulkan features

Day-one support of most Vulkan extensions
(Participation in Khronos)

RADV recent Vulkan features

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- Ray tracing
- Graphics pipeline libraries
- Shader objects
- Device generated commands
- Vulkan video
- Transfer queue (wip...)
- Host image copy (wip...)

RADV recent features

CPU overhead improvements
(vkoverhead - thanks, Mike!)

RADV recent features

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Combatting shader compilation stutter

- Fossilize
- ACO
- Pipeline libraries, shader objects

Ray tracing

- More
- Better
- Faster

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Ray tracing

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- BVH build: common code
  shared with anv, turnip, lavapipe
- Vulkan conformance on all HW
- Games are expected to work out-of-the-box
- Future work:
  new HW features
  new compiler features (function calls)

Device generated commands

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GPU-driven rendering

- Draw calls generated on the GPU
- Fewer CPU bubbles
- Necessary for VKD3D-Proton API translation
- Implemented using a meta shader

How do we test this?

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How do we test this?

Mesa CI
(Thanks, Martin!)

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How do we test this?

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Mesa CI coverage for all GPU generations

- Pre-merge on RDNA 2, 3, 4
- Post-merge on all older HW
- RADV, Zink+RADV

Sharing code between RADV and RadeonSI

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AMD common code

- ac_surface
- addrlib
- shader utilities
- SQTT (used for RGP support)
- lowering passes
- descriptors
- preambles
- command buffers (wip...)

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What's new in the compiler?

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What's new in ACO?

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- Decoupled from Vulkan (thanks, Qiang!)
- Works with OpenGL
- New HW support: GFX11, 11.5, 12
- Post-RA optimizer
- Reworked pre-RA optimizer (wip...)
- ILP scheduler (also for VOPD)
- Pre-RA scheduler improvements

What's new in ACO?

- Ray tracing, BVH8
- Mesh shading
- Cooperative matrix, bfloat16, float8
- Shader float controls (2)
- Dot products (fp, int)
- Branch chaining
- Function calls (wip...)
- Shader prologs, epilogs
- Trap handler shader (wip...)
- Scalar FPU
- RA improvements
- Fragment shader interlock

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Supporting FSR4

- Reverse engineering (thanks, Hans-Kristian!)
- Cooperative matrix implementation
- Community effort (thanks, LGD)
- Countless optimizations
- Now works with good perf

What did we do in NIR core?

- Memory model optimizations
- Load / store vectorizer optimizations
- nir_opt_algebraic improvements
- Better shader linking with nir_opt_varyings
- Address calc optimization with nir_opt_offsets
- Improve compilation time of Mesa itself

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Better way to handle I/O, etc.

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- Less in the compiler backend
- More in common code:
  HW-specific NIR
  Core NIR
- Necessary for decoupling from VK

What did we do in AMD-common NIR?

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- Lower I/O intrinsics in NIR
- Lower memory accesses in NIR
- Implement primitive culling in NIR
- ...
- Backend only gets intrinsics like
  load_buffer_amd / store_buffer_amd
  load_shared / store_shared

What did we do in AMD-common NIR?

ac_nir_lower_

- global_access
- image_opcodes
- intrinsics_to_args
- mem_access
- resinfo
- sin_cos
- tex

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What did we do in AMD-common NIR?

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ac_nir_lower_

- ngg_nogs / ngg_gs / ngg_mesh
- tess_io_to_mem
- esgs_io_to_mem
- tess_io_to_mem
- ps_early / ps_late
- legacy_vs / legacy_gs

Lessons learned

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Lessons learned

Let the developers make choices
and come up with solutions to specific problems

Lessons learned

More common code is better

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More common code is better

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- RadeonSI + RADV benefit from AMD common improvements
- All drivers benefit from NIR core improvements
- Old HW still benefit from driver and compiler optimizations

Where is the code?

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Show me the code

mesa main:

- src/amd/vulkan
- src/amd/compiler
- src/amd/common
- src/amd/addrlib
- src/amd/nir

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So, are we there yet?
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So, are we there yet?

Linux can be a good gaming platform

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How can you help

- Daily drive an AMD GPU (GCN or RDNA)
- Play games
- Report bugs, talk to us
  on OFTC in #radeon or #dri-devel

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Thanks

Questions, suggestions, discussion?

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dschuermann, Venemo @ #dri-devel, #radeon, ...
https://docs.mesa3d.org/drivers/radv.html

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