SIGGRAPH 2024
DENVER+ 28 JUL — 1 AUG

KHRONOS GROUP

Vulkan®

Vulkan: Forging Ahead!

Tom Olson (Arm), Vulkan Working Group chair

Today's Presentations

Vulkan: Looking back, and looking forward
- Tom Olson (Vulkan Working Group Chair / Arm)

Vulkan SDK: Where we started, and where we are going
- Karen Ghavam (LunarG)

Vulkan: Crash Diagnostic Layer
- Jeremy Gebben (LunarG)

----------*10 minute BREAK*----------

Slang in Vulkan
- Hai Nguyen (NVIDIA)

EVOLVE – Next Generation Benchmarking
- Jasper Bekkers and Darius Bouma (Traverse Research)

Adding Vulkan to Pixar's Hydra Storm Renderer
- Henrik Edstrom (Autodesk), Ashwin Bhat (Autodesk), and Caroline Lachanski (Pixar)

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Vulkan®

Vulkan: Looking back, and looking forward

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Outline

Vulkan evolution, past and future

What’s new in the Vulkan API

What we’re working on for the future

What’s new in the Vulkan ecosystem

Vulkan evolution, past and future

Ten years ago in Vancouver…

OpenGL / OpenGL ES BOF, SIGGRAPH 2014

2014: The journey begins…

Problems with OpenGL today

- **Programming model doesn't match architecture of modern GPUs**
  - Especially in mobile
- **Arcane and archaic syntax**
  - Twenty years of legacy cruft
  - Needless complexity
- **CPU intensive**
  - State validation, dependency tracking, error checking
  - Hard to predict where CPU load will occur - varies with implementation
- **Not multicore-CPU-friendly**
  - Primitive threading model, inconsistently implemented
- **Implementation variability**
  - Spec looseness, performance variation, driver bugs

Initial goal – fix OpenGL's problems

The journey begins…

Next Generation OpenGL Initiative

- **An open-standard, cross-platform 3D+compute API for the modern era**
  - Compatibility break with OpenGL
  - Start from first principles
- **Goals**
  - Clean, modern architecture
  - Multi-thread / multicore-friendly
  - Greatly reduced CPU overhead
  - Architecture-neutral - full support for tile-based as well as direct renderers
  - Predictable performance
  - Improved reliability and consistency between implementations
- **Key design principle: *explicit control***
  - Application is expected to tell the driver what it wants

A protostar is born!

February 16, 2016: Vulkan 1.0 launch

Open source is AMAZING

Issues · KhronosGroup/Vulkan-Do

https://github.com/KhronosGroup/Vulkan-Docs/issues

KhronosGroup / Vulkan-Docs

Type / to search

Code | Issues 333 | Pull requests 12 | Actions | Projects | Wiki | Security

Filters | is:issue is:open

333 Open | 1,383 Closed | Author | Label

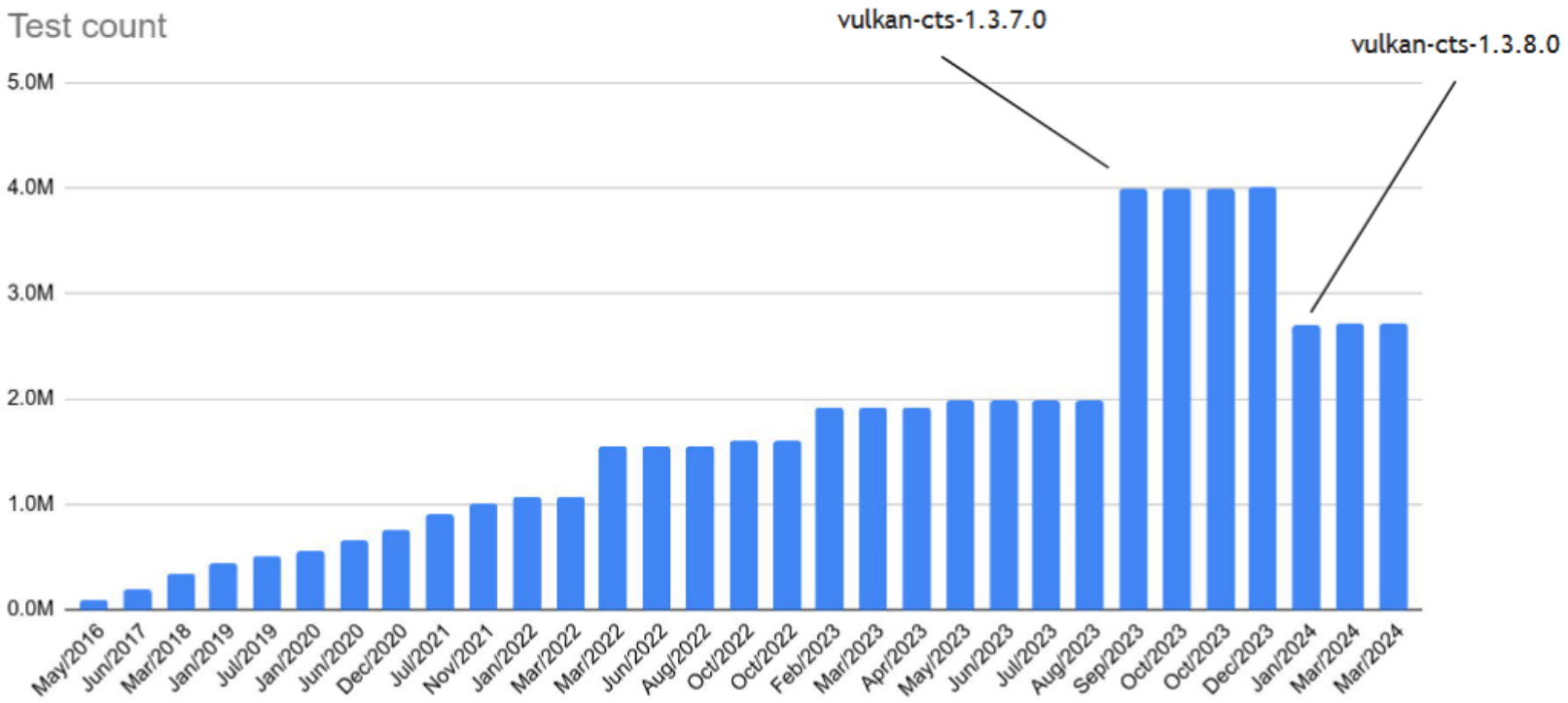
Missing query type in vkWriteMicromapsPropertiesEXT VUID 07575
#2399 opened yesterday by laurentiu-erhan-arm

Typo in VkMemoryAllocateInfo description of memory import operations.
#2398 opened 5 days ago by McDaMastR

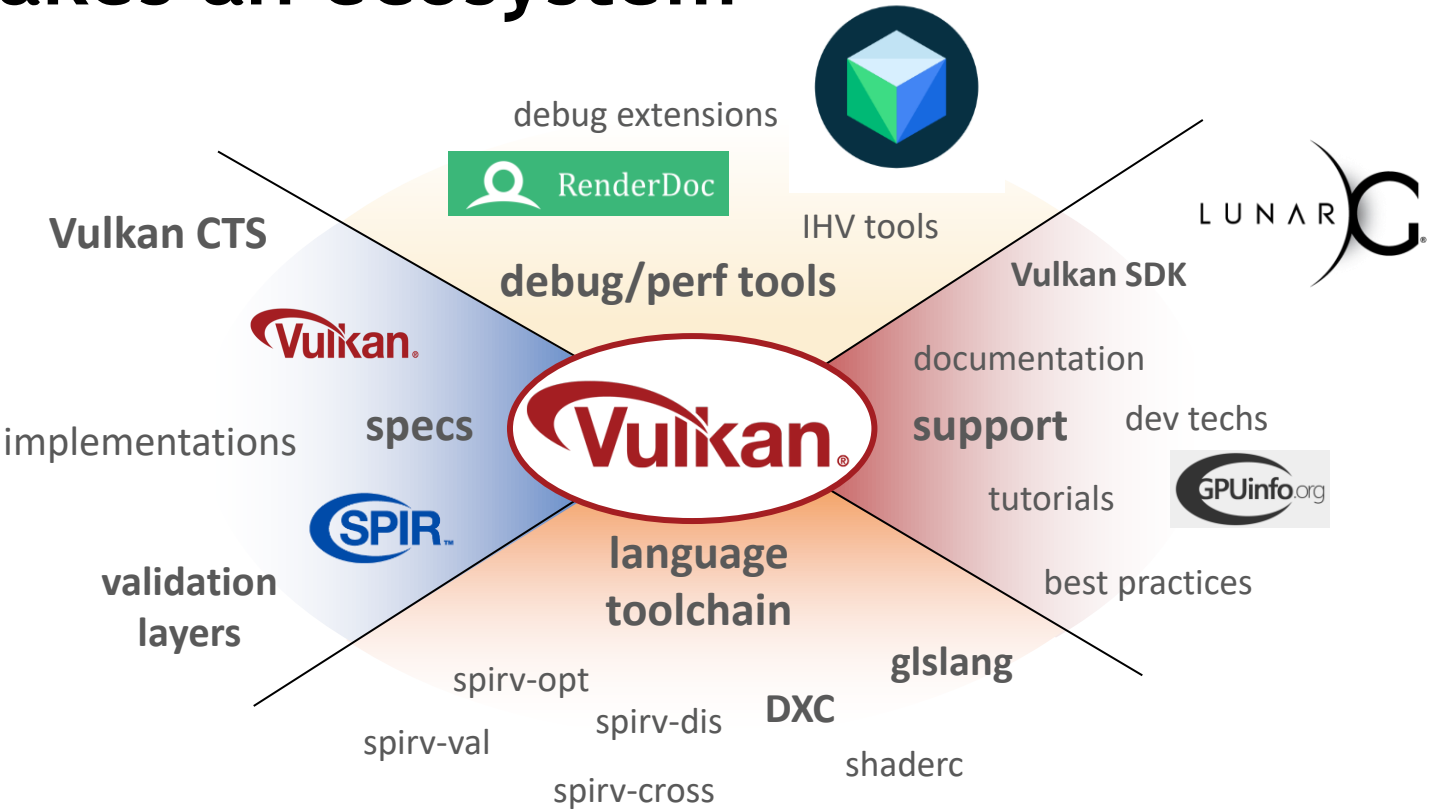
Allow DRM format modifier to be set during `vkBindImageMemory`
#2397 opened last week by yshui

[Registry] Incorrect(?) description of unused attributes
#2395 opened last week by Waffl3x

You can’t do too much testing



It takes an ecosystem



How Vulkan evolves

How Vulkan evolves

1.0

2016

1.1

2018

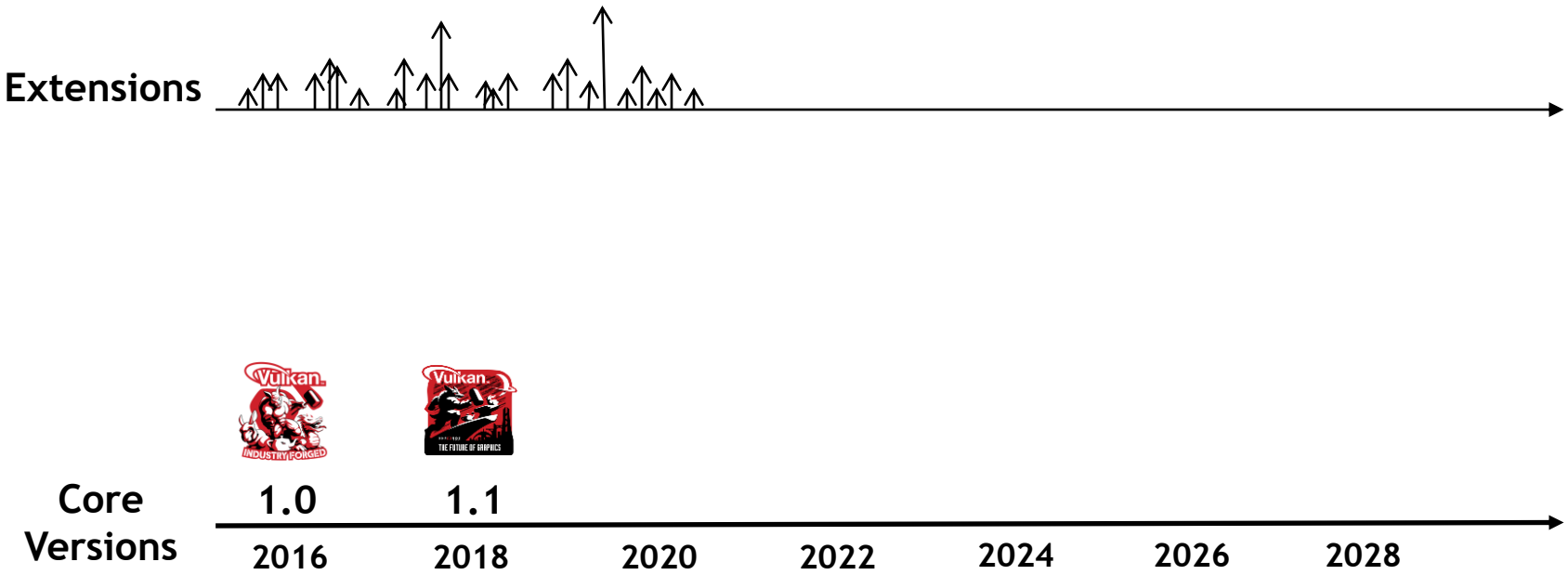
1.2

2020

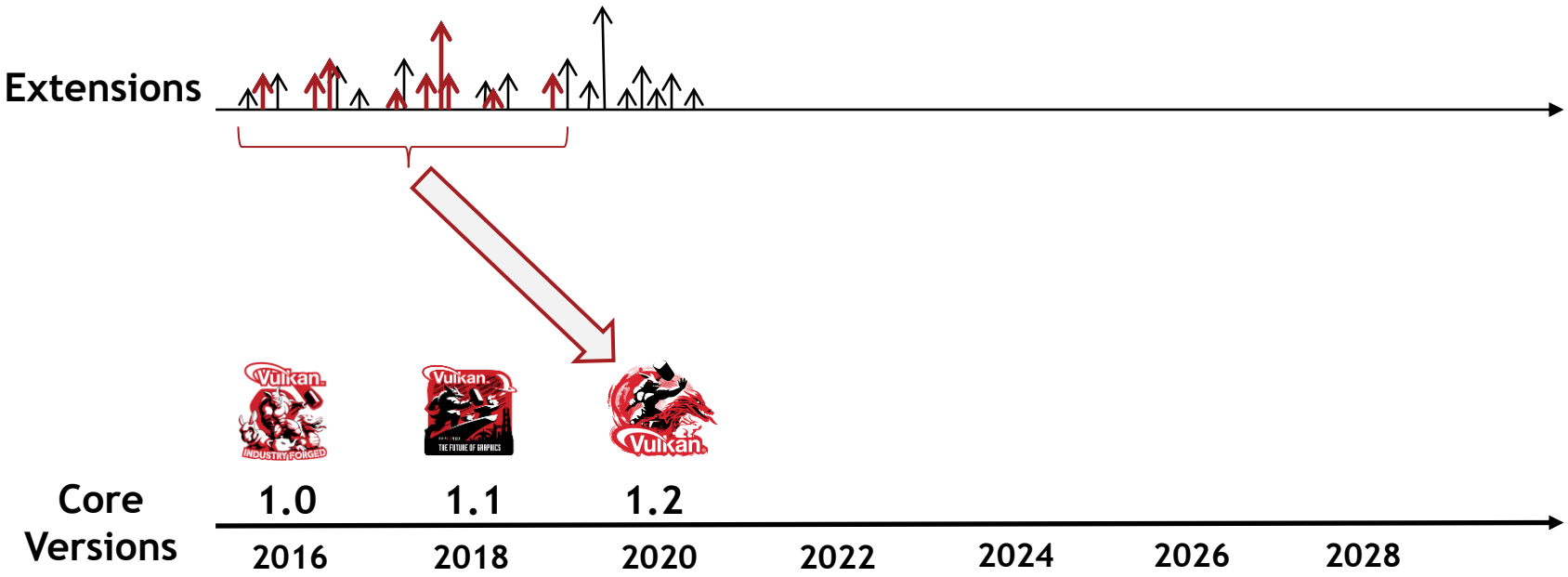
1.3

2022

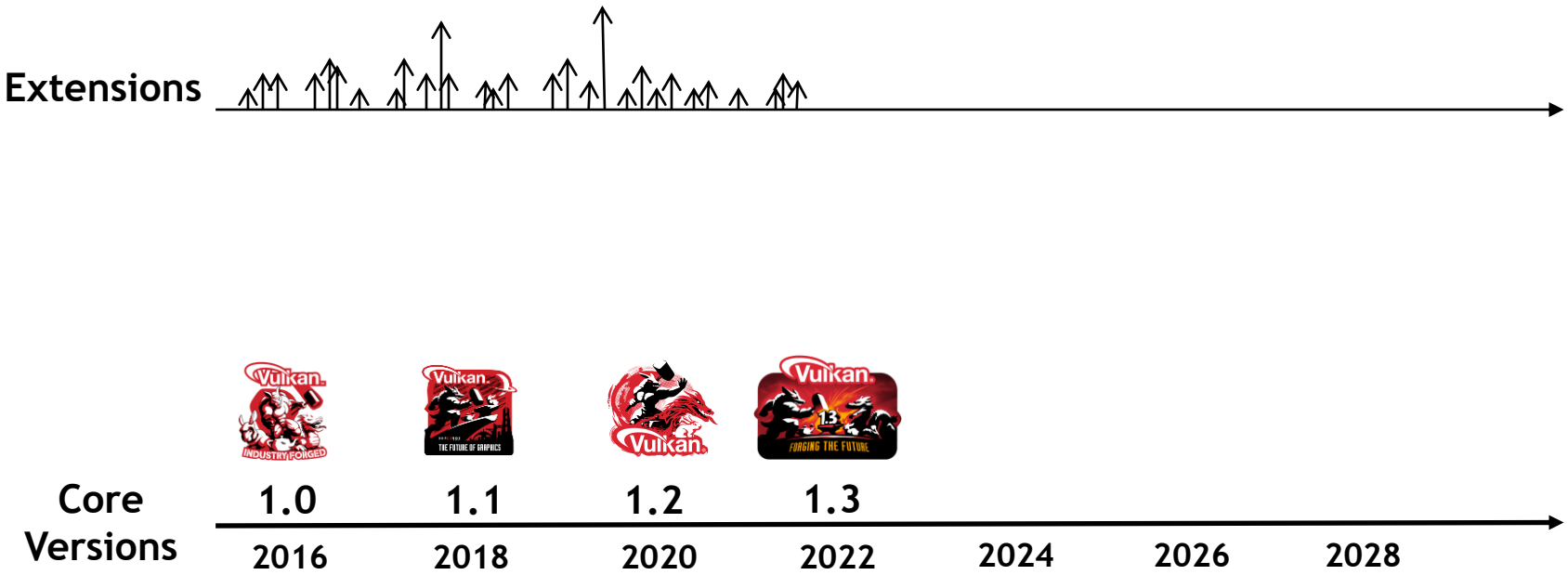
How Vulkan evolves



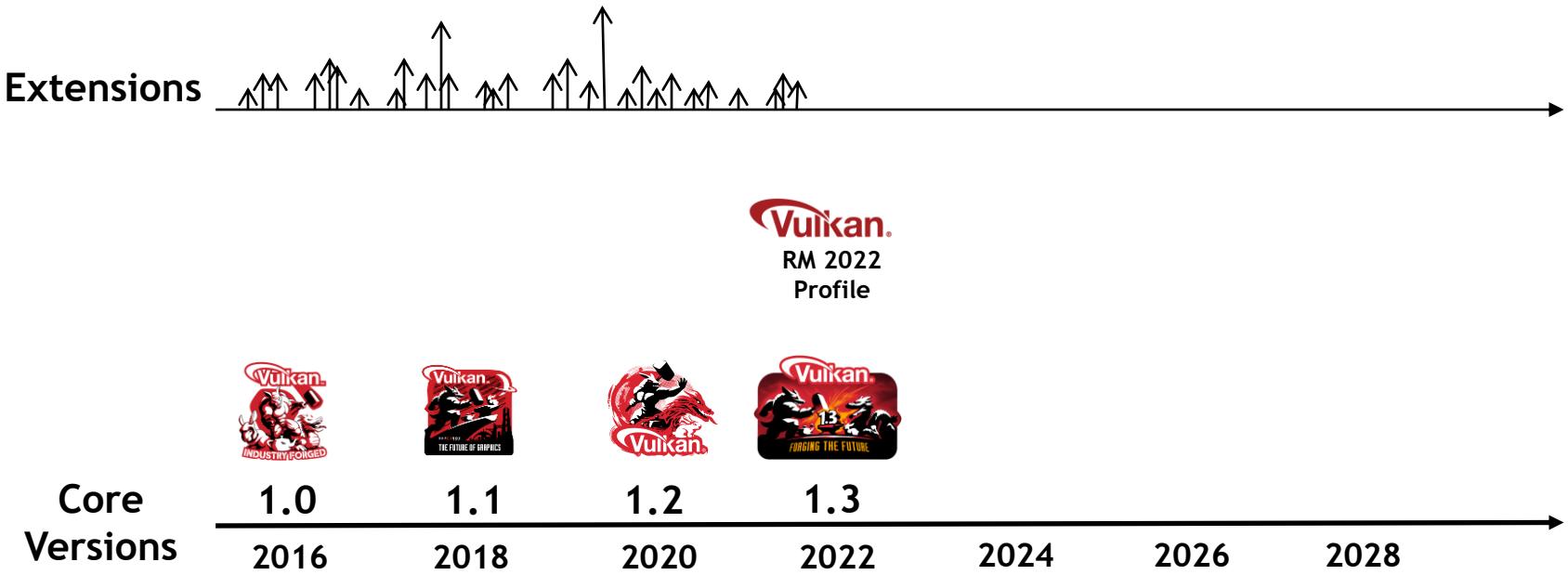
How Vulkan evolves



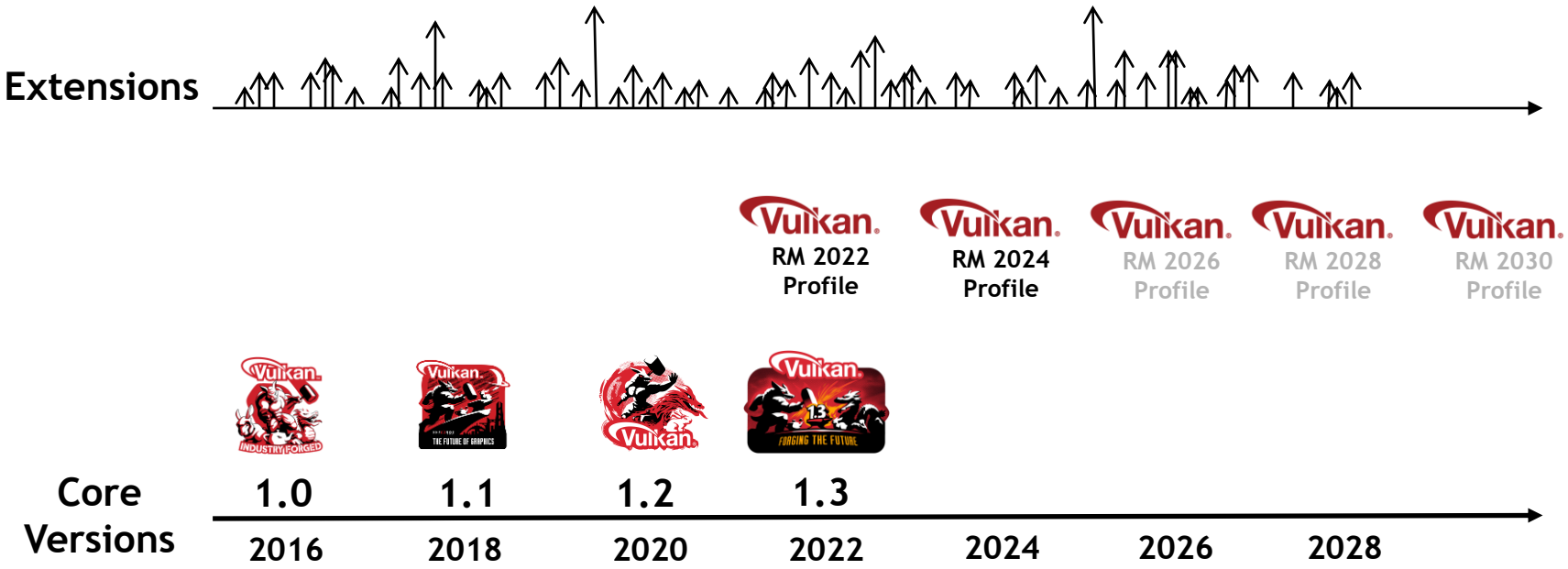
How Vulkan evolves



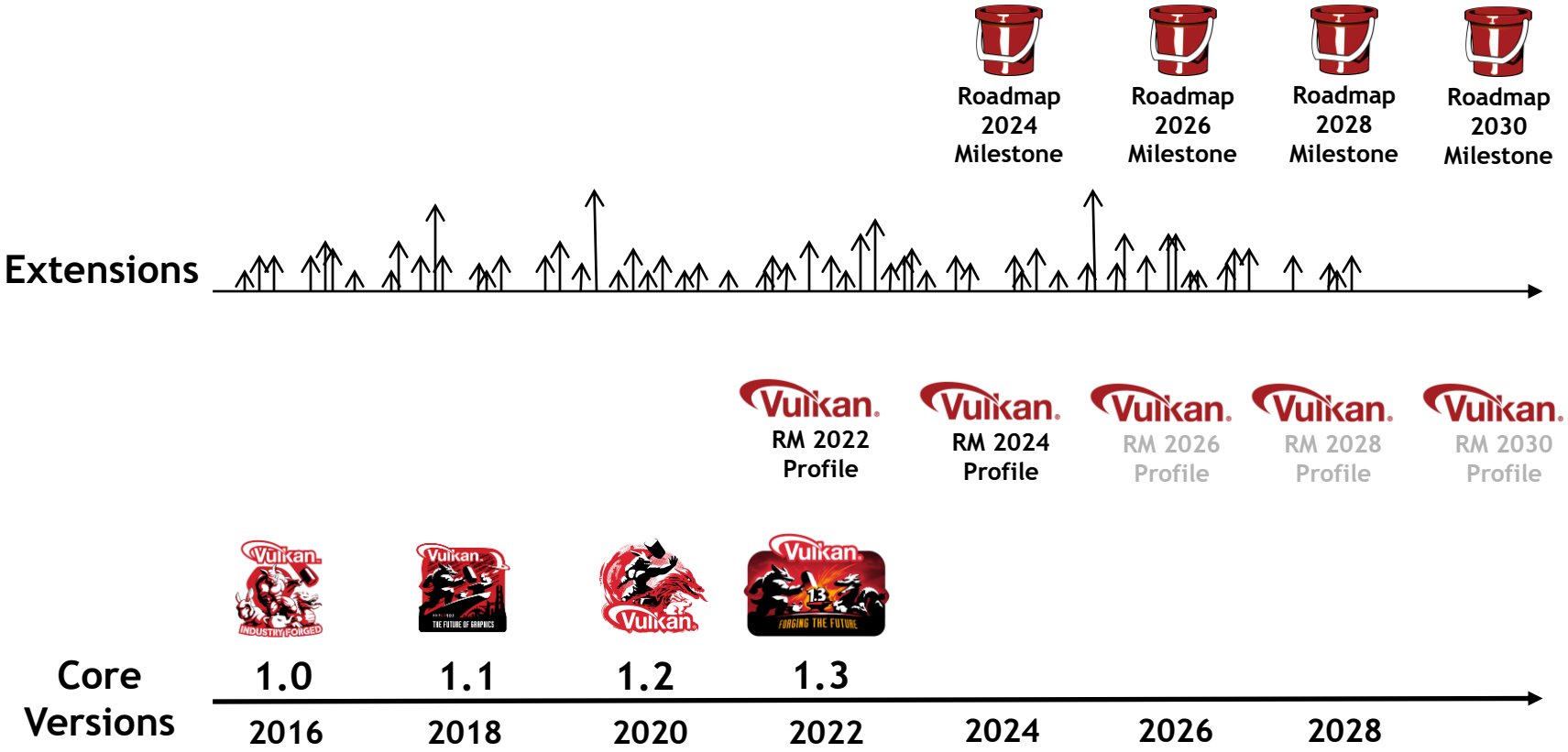
How Vulkan evolves



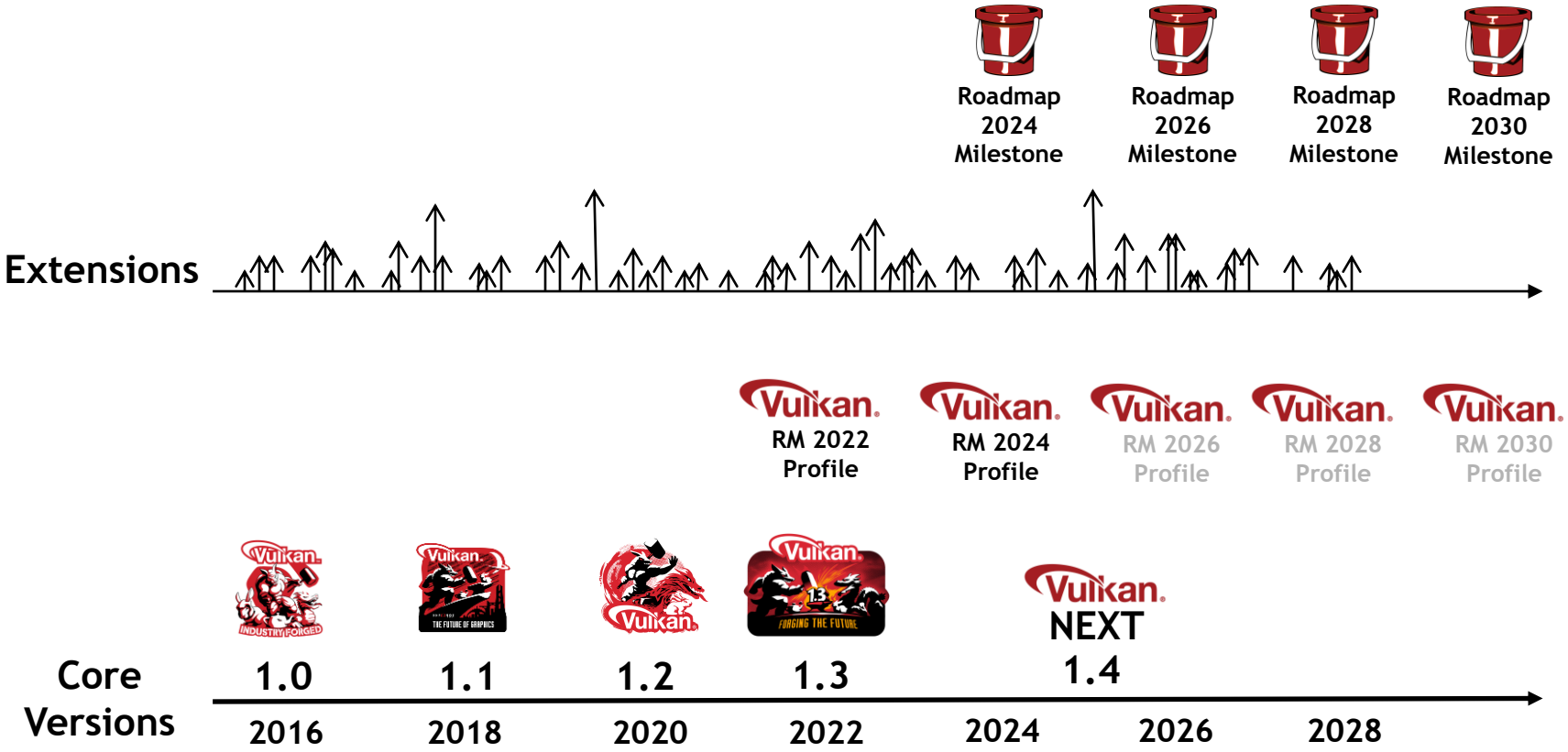
How Vulkan evolves



How Vulkan evolves



How Vulkan evolves



Vulkan Roadmap 2024 Profile

phoronix

ARTICLES & REVIEWS | NEWS ARCHIVE | FORUMS | PREMIUM | CONTACT | CATEGORIES

Vulkan Roadmap 2024 Brings Shader Quad Control, Shader Maximal Reconvergence & More

Written by Michael Larabel in Vulkan on 25 January 2024 at 09:0

The Khronos Group today announced their Vulk
specification for their latest API features and me
processors and other hardware. Vulkan Roadma
Vulkan Roadmap 2022 specifications to deliver

Khronos Drives Industry Support for Expanded 3D Features with Vulkan Roadmap 2024

Latest Vulkan Roadmap milestone defines the set of important shader and rasterization features that game and applications developers can rely on to be widely supported on mid-to-high-end GPUs starting this year.

Represents the second milestone on the Vulkan Roadmap

- Captures expected feature set for “immersive graphics” 2024-2026+

Vulkan Roadmap 2024 requirements

Vulkan 1.3 *plus* Vulkan Roadmap 2022 profile

- Descriptor indexing
- *Real* (non-degenerate) subgroups
- Fragment shaders stores & atomics
- Many useful drawing features

Previously optional features

- multiDrawIndirect
- shaderDrawParameters
- shaderImageGatherExtended
- shaderInt8, shaderInt16, shaderFloat16
- storageBuffer8BitAccess, storageBuffer16BitAccess
- shaderRoundModeRTEFloat16/32

More Vulkan Roadmap 2024 requirements

Implementation minima

- maxBoundDescriptorSets >= 7
- maxColorAttachments >= 8

Required extension:

- VK_KHR_push_descriptor
- VK_KHR_subgroup_uniform_control_flow
- VK_KHR_index_type_uint8
- VK_KHR_line_rasterization
- VK_KHR_load_store_op_none
- VK_KHR_vertex_attribute_divisor
- VK_KHR_map_memory2
- VK_KHR_maintenance5

New extensions required in Roadmap 2024

VK_KHR_shader_expect_assume

- Tell the compiler what typical execution paths look like
- Lets it generate faster code

VK_KHR_shader_subgroup_rotate

- A commonly used special case of permutation – faster on some HW

VK_KHR_shader_float_controls2

- Fine-grained control of floating point behavior
- Applies to many more instructions
- Gives Vulkan parity with OpenCL

New extensions in Roadmap 2024

VK_KHR_maximal_reconvergence / VK_KHR_shader_quad_control

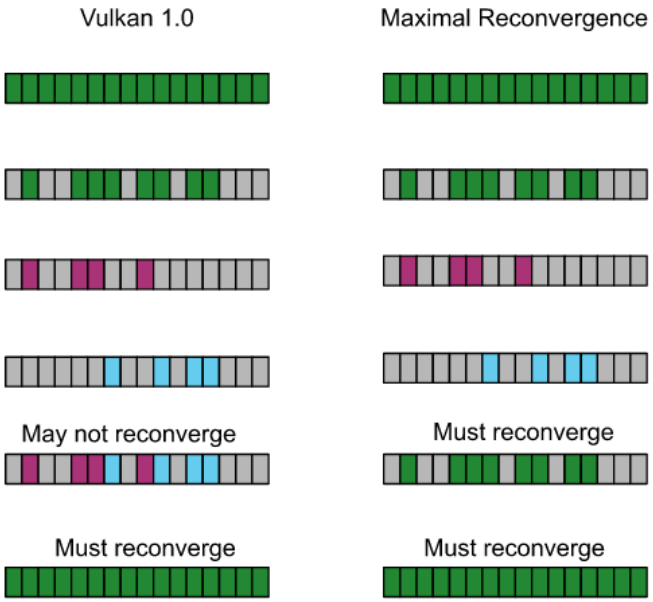
```
if (non_uniform_cond1) {
  // Block A

  if (non_uniform_cond2) {
    // A then

  } else {
    // A else

  }
  // Block B

}
```



See Alan Baker's blog: https://www.khronos.org/blog/khronos-releases-maximal-reconvergence-and-quad-control-extensions-for-vulkan-and-spir-v

New extensions in Roadmap 2024

VK_KHR_dynamic_rendering_local_read

- Allows pipeline barriers within dynamic rendering (sometimes)
- Allows a later fragment shader to read data written by previous fragments

With VK_KHR_rasterization_order_attachment_access, gives you the functionality of “framebuffer fetch” in dynamic rendering

Blog posts

- https://www.khronos.org/blog/streamlining-subpasses
- https://community.arm.com/arm-community-blogs/b/graphics-gaming-and-vr-blog/posts/framebuffer-fetch-in-vulkan

Other New Extensions, NOT in RM 2024

Vulkan Video
VK_KHR_video_encode_queue
VK_KHR_video_encode_h264
VK_KHR_video_encode_h265
VK_KHR_video_maintenance1
VK_KHR_video_decode_av1

Programming model improvements
VK_EXT_host_image_copy

Maintenance
VK_KHR_maintenance6
VK_KHR_maintenance7

Shader / compiler support
VK_KHR_shader_relaxed_extended_instruction
VK_KHR_shader_replicated_composites

Tool & debug support
VK_EXT_layer_settings
VK_EXT_frame_boundary
VK_KHR_calibrated_timestamps
VK_EXT_memory_map_placed

Legacy API support
VK_EXT_legacy_vertex_attributes

Vulkan Video Progress

VK_KHR_video_maintenance1

- Cleanup and small enhancements

Video encode stack is now final

- VK_KHR_video_encode_queue
- VK_KHR_video_encode_h264
- VK_KHR_video_encode_h265

VK_KHR_video_decode_av1

See blogs:

- Khronos Finalizes Vulkan Video Extensions for Accelerated H.264 and H.265 Encode
- Khronos Releases AV1 Decode in Vulkan Video with SDK Support for H.264/H.265…

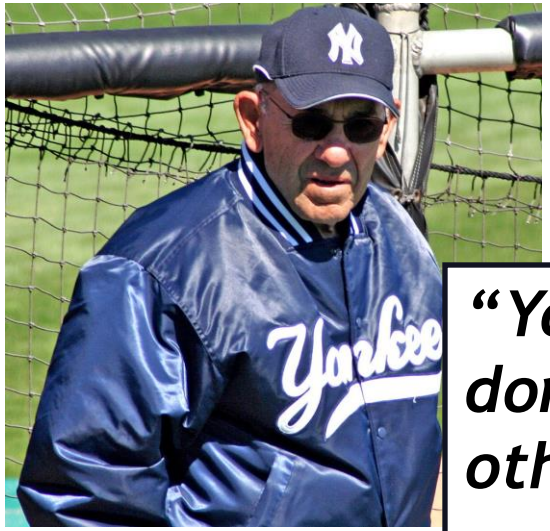
What we're working on

Obligatory disclaimer

The information contained herein constitutes forward-looking statements. There can be no assurance that these statements will prove to be accurate, as actual results and future events could differ materially from those anticipated. The reader is cautioned not to place undue reliance on forward-looking statements.

Please don’t have one of these

Vulkan Roadmap 2026 Milestone



"You've got to be very careful if you don't know where you're going, otherwise you might not get there"

- Yogi Berra

What we plan for the third milestone on the Vulkan Roadmap

RM2026 themes: Robustness

Why

- WebGPU will be HUGE
- Support Rust / Ash

Work Items

- VK_EXT_robustness2 (all features required)
- Range-checked pointers (CHERI or something like it)
- VK_KHR_pipeline_binary (forthcoming)

RM2026 themes: Unifying compute

Why

- Support HPC use cases
- Feature parity with OpenCL

Work items

- Generic memory with physical or virtual addressing
- Replace all buffer references with device addresses
- Untyped pointers
- 64-bit addressing
- Shader Int64 support
- Reorganize SPIR-V capabilities

RM2026 themes: State management

Why

- Ongoing point of pain for developers

Work items

- Shader objects, or something like it
- Pre-validated dynamic state bundles
- Clean, simple API for descriptor management

RM2026 themes: Machine learning

Why

- Because machine learning

Work items

- Cooperative matrix
- Cooperative vector (dispatch small MLPs from a shader)
- ML-friendly types, (bfloat16 etc)

RM2026 themes: Debugging

Why

- Point of pain for developers

Work items

- VK_EXT_device_fault
- Progress markers (breadcrumbs)
- Shader abort()

RM2026: Other stuff

Fragment shading rate (aka VRS)

VK_EXT_depth_clamp_zero_one

VK_EXT_host_image_copy

Compute shader derivatives (linear)

Maintenance extensions

Vulkan Roadmap 2028 candidates

Ray tracing

- Pretty much everything available today

GPU-driven rendering

- Work graphs, or something like them

Advanced robustness features

- Language features: poison/freeze, data race handling
- Per-device address spaces

Other things in flight (not in Roadmap)

Ray tracing

- KHR versions of vendor extensions: ray reordering, etc

Video

- AV1 encode
- Various advanced encoding tools
- VP9 in plan

Machine Learning

- Additional data types and primitives

Shading Language management

Vulkan is defined to accept shaders in the SPIR-V IR

- In theory, how you generate it is up to you
- But, the ecosystem needs standards and stability

Shading Languages: it's complicated…

Vulkan is defined to accept shaders in the SPIR-V IR

- In theory, how you generate it is up to you
- But, the ecosystem needs standards and stability

GLSL is NOT going away - will live forever

- But no plan to evolve its syntax (templates, meta-programming, etc

Some developers will always prefer HLSL

- Microsoft has been very welcoming and accommodating – thanks!
- But, resourcing is a problem

Shading Languages

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Slang is an option

- NVIDIA has offered to place it under community governance
- Khronos is one possible hosting consortium – under active discussion

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We need your help!

There's a lot going on!

- Need help prioritizing
- Need help doing the work

You can help

- Talk to us
- Raise issues and share opinions on GitHub (KhronosGroup/Vulkan-Docs)
- Contribute to open-source repos

Consider joining Khronos and the Vulkan Working Group

- Not that expensive
- Associate memberships for small companies
- Academic memberships also available

What’s new in the Vulkan ecosystem

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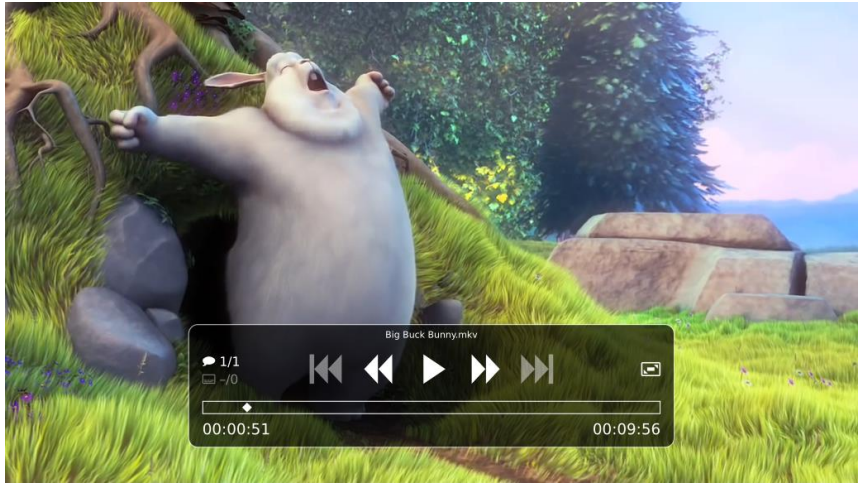
Vulkan Video is a Thing!

- **Vulkan Video expands Vulkan capabilities**
  - Accelerated processing of streamed media into the Vulkan pipeline



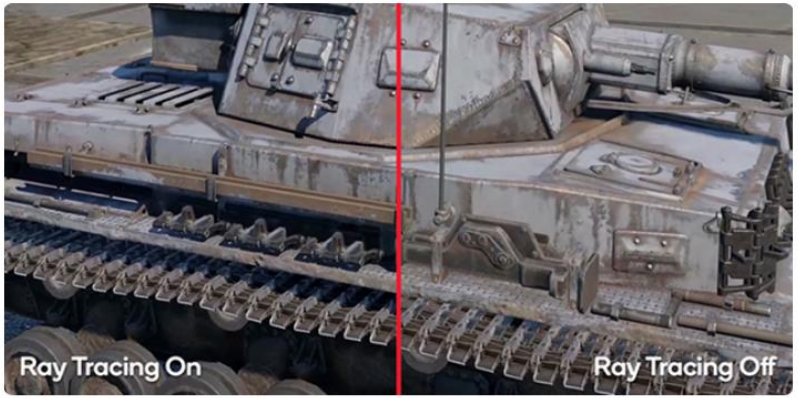
Vulkan Video is increasingly providing cross-platform media framework acceleration

Status tracked at
https://blogs.igalia.com/vjaquez/vulkan-video-status/

Ray tracing is coming to mobile!

arm

Qualcomm



SAMSUNG

Games are a given

Professional rendering

Artwork by Emily Bisset, courtesy of Adobe

Substance 3D Stager

Adobe

AUTODESK Flame

Vulkan.

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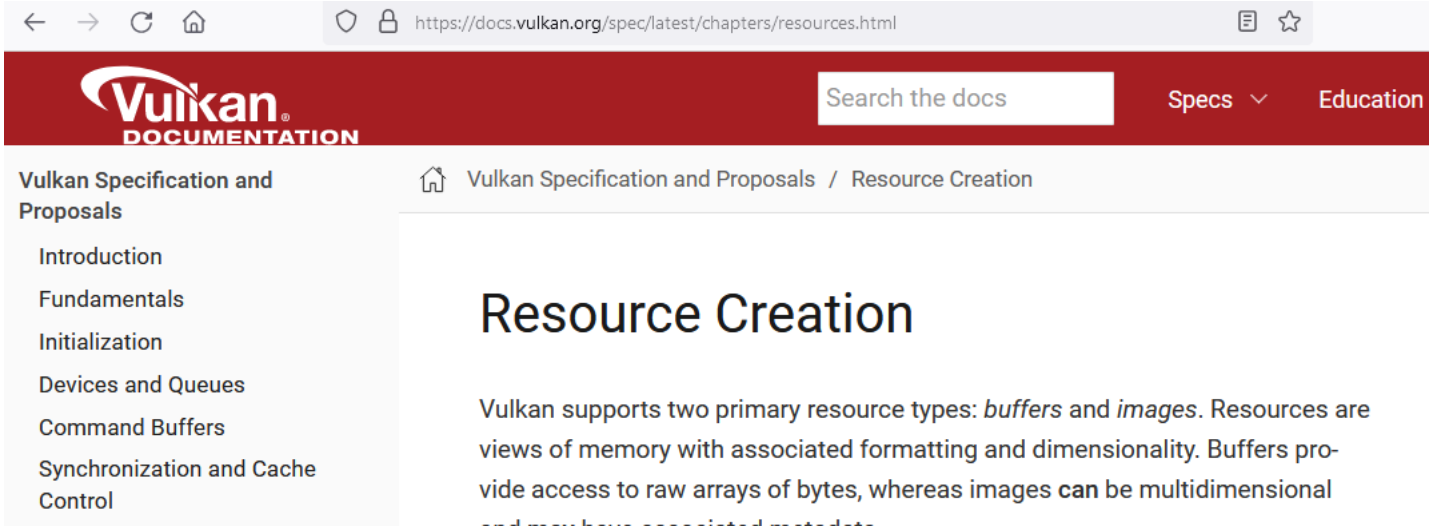
What's New:

Documentation and Developer Support

Vulkan Documentation Project

Bring Vulkan documentation together in one place

- Specification, Vulkan Guide, Proposal documents, Samples…
- Easy navigation and cross-linking
- https://docs.vulkan.org
- Please report issues at https://github.com/KhronosGroup/Vulkan-Site



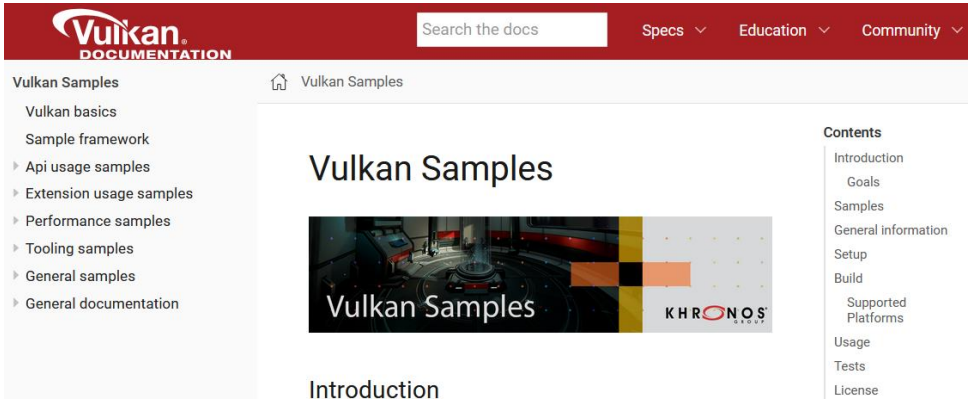
Vulkan Samples Repository

A home for Vulkan sample code

- Intended to help you learn to use Vulkan effectively
- GPU, OS, and platform neutral, well tested
- On github in open source (Apache 2.0)
- Access via docs.Vulkan.org or at github/KhronosGroup/Vulkan-Samples

A community effort

- Khronos member ISVs, IHVs, contractors
- Interested community members

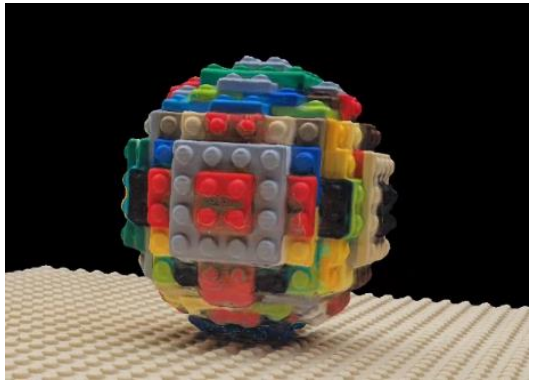


Some recently added samples

Sparse Image / virtual texture (Mobica)

OIT using per-pixel linked lists (community)

Mobile NeRF (Qualcomm)



https://developer.qualcomm.com/blog/generating-3d-scenes-2d-images-more-efficiently-mobile-nerf-rendering-using-vulkan-adreno-gpu

Vulkanised!

First full-scale Vulkanised was held in February 2023

- Hosted by Google in Munich, Germany
- Three days of talks, panels, demos, and a Vulkan course
  - All on line at https://vulkan.org/learn#videos

Second in February 2024

- Hosted by Google in Sunnyvale, California

Vulkanised 2025

Vulkanised 2025

The 7th Vulkan Conference | Cambridge, UK | Feb 11-13, 2025

The Premier Vulkan Developer Conference

To be hosted by Arm in Cambridge, UK - submissions due Oct. 11

Final thoughts

Seriously, it’s been *ten years*?

Yes, it has

I’m retiring in October

New leadership coming!

Thanks!

Thanks!