KHRONOS® GROUP

Vulkan 1.2
Launch

15th January 2020

Vulkan 1.2 is Launched!

Specification is final and publicly available

**Multiple GPUs are passing conformance tests
First drivers are shipping today**

**Proven roadmap process includes new
functionality requested and proven by developers**

**Improved performance, enhanced visual quality
and easier development**

**Work underway to rapidly upgrade open source
ecosystem and tools to Vulkan 1.2**

**Continuing to build on significant
Vulkan industry momentum**
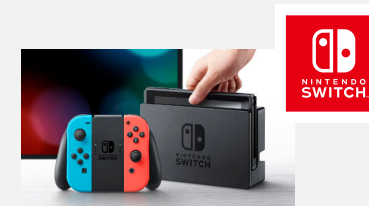
Pervasive Vulkan

Desktop and Mobile GPUs

AMD · arm · BROADCOM · Imagination · intel · NVIDIA · QUALCOMM · VeriSilicon

http://vulkan.gpuinfo.org/

Platforms

Desktop
Windows 10, Windows 8, Windows 7

Android
(Android 7.0+)
(Vulkan 1.1 required on Android Q)

Apple
(via porting layers)
iOS macOS

Media Players

Consoles
Nintendo Switch

Virtual Reality
Windows 8, Windows 10, Windows 7

Cloud Services
Windows 10

Game Streaming
NVIDIA GEFORCE NOW, STADIA

Embedded

Engines
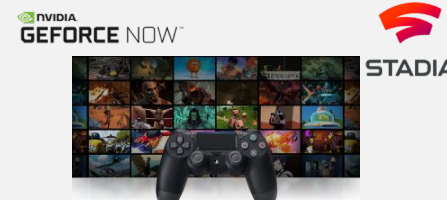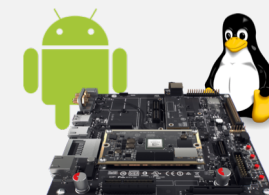
CIDER · CINDER · XENKO · GODOT · CRYENGINE · unity · source · id · UNREAL ENGINE · Croteam Serious Engine · UX3D · NetEase Games (Passion of gamers)
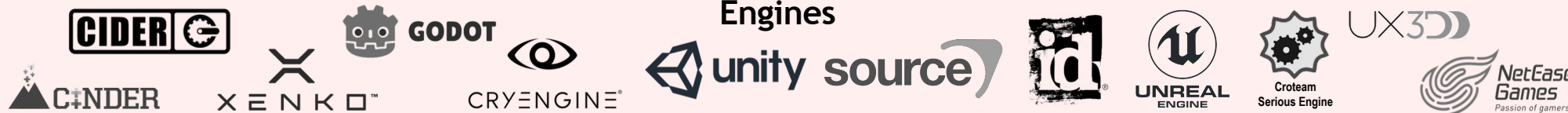
Note: The version of Vulkan available will depend on platform and vendor

Vulkan AAA Content
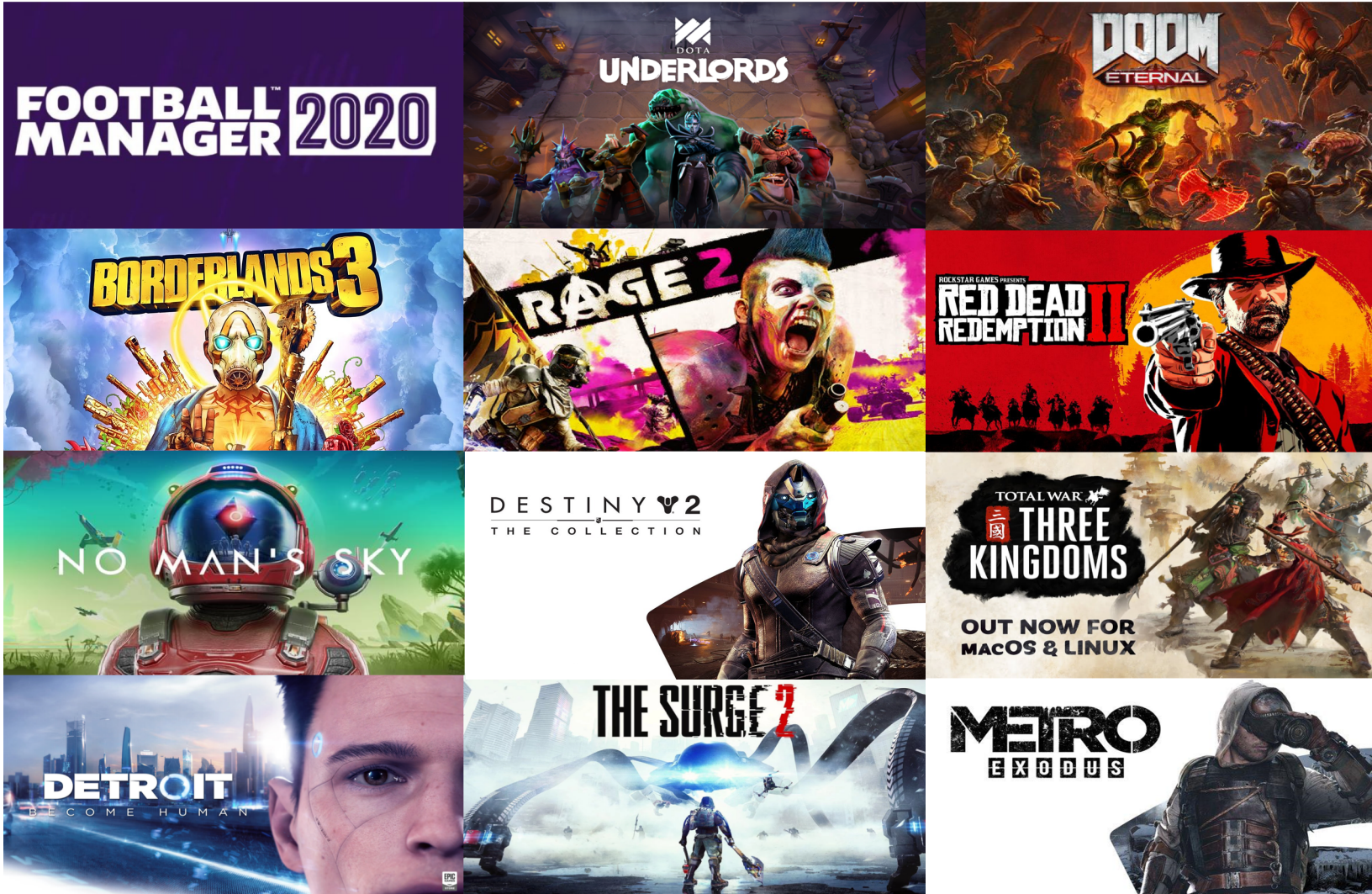
Vulkan Mobile Content

Vulkan Momentum

https://en.wikipedia.org/wiki/Vulkan_(API)

Software that supports Vulkan [edit]

Games [edit]

Title	Original release date	Vulkan support since	Developer(s)	Publisher(s)	Windows	Linux	Android	Other
Aerofly FS 2	November 20, 2017	June 6, 2018[64]	IPACS	IPACS		✓		
Astrokill	May 27, 2016	October 23, 2017[65]	Doomsday Games	Doomsday Games		✓		
Quake	June 22, 1996	July 20, 2016	id Software	GT Interactive	✓	✓		
Quake 2	December 9, 1997	December 20, 2018	id Software	Activision	✓	✓		macOS
Quake II RTX	December 9, 1997	June 6, 2019	id Software, Nvidia Lightspeed Studios, Bethesda Softworks	Nvidia	✓	✓		
Quake III Arena	December 2, 1999	May 30, 2017[71]	id Software	Activision	✓	✓		
Roblox	2006	March 15, 2017[73]	Roblox Corporation	Roblox Corporation	✓		✓	
Dota 2	July 9, 2013	May 23, 2016[74][75]	Valve	Valve	✓	✓		macOS
The Talos Principle	September 11, 2014	February 17, 2016[76]	Croteam	Devolver Digital	✓	✓	✓	
Vainglory	November 16, 2014	August 20, 2016[78]	Super Evil Megacorp	Super Evil Megacorp			✓	
Score! Hero	August 6, 2015[79]	September 16, 2016[80]	First Touch Games	First Touch Games			✓	
Need for Speed: No Limits	September 30, 2015	August 20, 2016[78]	Firemonkeys Studios	Electronic Arts			✓	
Heroes of Incredible Tales	November 18, 2015	August 20, 2016[78][81]	NAT Games	Nexon			✓	
Dream League Soccer	February 26, 2016	October 14, 2016[82]	First Touch Games	First Touch Games			✓	
Score! Match	February 22, 2018	February 22, 2018[83]	First Touch Games	First Touch Games			✓	
Ashes of the Singularity	March 31, 2016	August 31, 2017[84]	Oxide Games, Stardock Entertainment	Stardock Entertainment	✓			
Olympus Rising	May 3, 2016	August 20, 2016[78]	Flaregames	Flaregames			✓	
Doom3 BFG	October 2012	August 12, 2017[85]	id Software	Bethesda Softworks	✓			
Doom	May 13, 2016	July 11, 2016[87]	id Software	Bethesda Softworks	✓			
Mad Max	October 20, 2016	March 30, 2017[88][89]	Avalanche Studios, Feral Interactive	Warner Bros. Interactive Entertainment, Feral Interactive		✓		
Galaxy on Fire 3 - Manticore	December 8, 2016[90]	May 18, 2017[91]	Deep Silver	Deep Silver			✓	
Ballistic Overkill	March 28, 2017	May 16, 2017[92]	Aquiris Game Studio	Aquiris Game Studio	✓	✓		
Serious Sam VR: The First Encounter	March 30, 2017	February 8, 2017[93]	Croteam VR	Devolver Digital, Croteam	✓	✓		
Serious Sam VR: The Second Encounter	April 4, 2017	February 8, 2017[93]	Croteam VR	Devolver Digital, Croteam	✓	✓		
Steel Rats	November 7, 2018	March 1, 2019[94]	Tate Multimedia	Tate Multimedia	✓			
Warhammer 40,000: Dawn of War III	June 8, 2017	June 8, 2017[95]	Relic Entertainment, Feral Interactive	Sega		✓		
X Rebirth VR Edition	July 27, 2017	July 27, 2017	Egosoft GmbH	Egosoft GmbH	✓			
nGlide compatible games[96]	November 7, 2009	December 14, 2017[97]	Zeus Software	Zeus Software	✓			
F1 2017	November 2, 2017	November 2, 2017	Codemasters, Feral Interactive	Codemasters		✓		
Serious Sam VR: The Last Hope	September 30, 2017	May 17, 2017[100]	Croteam VR	Devolver Digital, Croteam	✓	✓		
Total War: Warhammer II	September 28, 2017	November 20, 2018	Creative Assembly	Sega		✓		
Wolfenstein II: The New Colossus	October 27, 2017[103]	October 27, 2017	MachineGames	Bethesda Softworks	✓			
Serious Sam Fusion 2017	2017	March 21, 2018[106][107]	Croteam	Devolver Digital	✓	✓		
Rise of the Tomb Raider	February 9, 2016	April 19, 2018[108]	Crystal Dynamics, Feral Interactive	Square Enix, Feral Interactive		✓		
Total War Saga: Thrones of Britannia	May 3, 2018	June 7, 2018[110]	Creative Assembly, Feral Interactive	Sega, Feral Interactive		✓		
Geocore	August 1, 2015	June 1, 2017[111][112]	Anarchy Interactive	Anarchy Interactive	✓			
Strange Brigade	August 28, 2018	August 28, 2018[113]	Rebellion Developments	Rebellion Developments	✓			
X4: Foundations	November 30, 2018	November 30, 2018	Egosoft GmbH	Egosoft GmbH	✓	✓		
Artifact	November 28, 2018	November 28, 2018[115]	Valve	Valve	✓			macOS
Rage 2	May 14, 2019	May 14, 2019	id Software, Avalanche Studios	Bethesda Softworks	✓			
Wolfenstein: Youngblood	July 26, 2019	July 25, 2019[116]	MachineGames, Arkane Studios	Bethesda Softworks	✓			
The Surge 2	September 24, 2019	September 24, 2019	Deck13	Focus Home Interactive	✓			
No Man's Sky	August 12, 2016	April 16, 2019	Hello Games	Hello Games	✓			
World War Z	April 16, 2019	April 16, 2019	Saber Interactive	Mad Dog Games	✓			
Fortnite Battle Royale	September 26, 2017	August 9, 2018	Epic Games	Epic Games			✓	
Hundred Soul	November 7, 2018	November 7, 2018[118]	Hound 13	LINE Games			✓	
Lineage 2 Revolution	December 14, 2017	December 14, 2017[81]	Netmarble Neo	Netmarble Games			✓	
Traha	April 18, 2019	April 18, 2019[118]	Moai Games	Nexon			✓	
Forsaken Remastered	July 31, 2018	July 31, 2018[119]/September 12, 2018[120]	Nightdive Studios	Nightdive Studios	✓	✓		macOS
Crown Four Kingdoms	August 15, 2017	May 10, 2018	X-Legend Entertainment	X-Legend Entertainment	✓			
Warhammer 40,000: Gladius - Relics of War	July 12, 2018	July 17, 2019	Slitherine	Proxy Studios	✓	✓		
Aura Kingdom 2	August 25, 2019	August 25, 2019	X-Legend Entertainment	X-Legend Entertainment			✓	
Red Dead Redemption 2	October 26, 2019	November 5, 2019	Rockstar Studios	Rockstar Games	✓			
Life is Strange 2	September 27, 2018	December 18, 2019						

>50 Games Titles

>15 Games Engines

Game engines [edit]

- Source 2 – In March 2015, Valve announced the Source 2 engine, the successor engine to the original Source engine, would support Vulkan.[126][127]
- Serious Engine 4 – In February 2016, Croteam announced that they were supporting Vulkan in their Serious Engine.[128]
- Unreal Engine 4 – In February 2016, Epic Games announced Unreal Engine 4 support for Vulkan at Samsung's Galaxy S7 Unpacked event.[129][130]
- Torque 3D – In April 2016 the developers community announced they will include Vulkan support.[131][132]
- id Tech 3 – unofficial Vulkan support was added in May 2017.[133]
- id Tech 4 – unofficial Vulkan support was added in August 2017.[134]
- id Tech 6 – Vulkan support was added in July, 2016.[135]
- id Tech 7 – uses Vulkan on PC exclusively.
- Xenko – Vulkan support was added in July 2016.[136]
- Unity – The engine has support for Vulkan since version 5.6.[137]
- CryEngine – Support for Vulkan was added in the 5.4 release.[138]
- Intrinsic – A free and open-source cross-platform game engine that supports Vulkan.[139]
- Unigine – In April 2017, Unigine Corp announced that Vulkan support for Unigine is in the roadmap for 2017.[140]
- Abyss Engine – In May 2017, Deep Silver FISHLABS released Galaxy on Fire 3 on Android with Vulkan support.[141]
- Banshee 3D – A free and open-source cross-platform game engine that supports Vulkan.[142]
- Godot – a 2D and 3D, cross-platform, free and open-source game engine. In late February 2018, the developers announced that they will shift their focus from solely using OpenGL ES 3 to target all platforms, to instead using a combination of OpenGL ES 2 and Vulkan.[143]
- Flax Engine – Vulkan support was added in April 2019.[144]
- Apex Game Engine (from Avalanche Studios) which was used in Rage 2 uses Vulkan for rendering.[145]
- Messiah Game Engine – NetEase Games collaborated with Qualcomm to optimise their Messiah Game Engine for Vulkan.[146]

Google Trends — Vulkan API — DX12

Jan 13, 2019 — Jun 2, 2019 — Oct 20, 2019
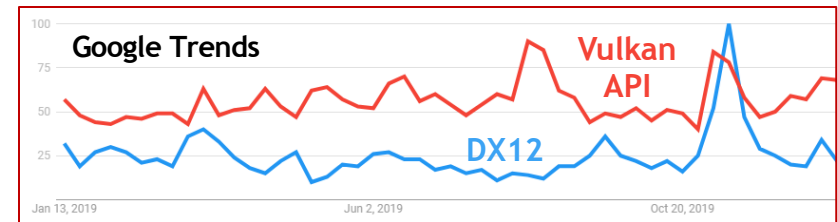
Vulkan Ecosystem Evolution

Strengthening Tools and Compilers

Improved developer tools (SDK, validation/debug layers)
Shader toolchain improvements (size, speed, robustness)
Shading language flexibility – HLSL and OpenCL C support
Continuously strengthening conformance testing

Building Vulkan's Future

Listening and prioritizing developer needs
Driving GPU technology

Vulkan 1.0 Extensions
Maintenance updates plus additional functionality

Multiview
Multi-GPU
Enhanced Windows Sys Integration
Increased Shader Flexibility:
16-bit storage, Variable Pointers
Enhanced Cross-Process and
Cross-API Sharing

Vulkan 1.1 Extensions
Maintenance updates plus additional functionality

Reduced precision arithmetic types in shaders
Bindless resources
HLSL-compatible memory layouts
Formal memory model
Buffer references
Timeline semaphores

Roadmap Discussions

Machine Learning
Ray Tracing
Video encode / decode
Variable Rate Shading
Mesh Shaders

February 2016
Vulkan 1.0

March 2018
Vulkan 1.1

Integration of 1.0 Extensions
plus new functionality
e.g. Subgroup Operations

January 2020
Vulkan 1.2

Integration of 1.1 Extensions
and SPIR-V 1.5

Widening Platform Support

Pervasive GPU vendor native driver availability
Open source drivers – ANV (Intel), AMDVLK/RADV (AMD)
Vulkan Portability to macOS/iOS and DX12

New Vulkan 1.2 Functionality in Core

- **Vulkan 1.2 rolls up 23 previous released extensions into a new core Vulkan API**
  - Improved performance, enhanced visual quality and easier development

- **Creates a simplified specification and development target**
  - Reduces uncertainty of extensions not being available on some platforms
  - Core features don't need individual enabling

Requests from Vulkan Developers
VK_KHR_timeline_semaphore – more manageable synchronization
VK_KHR_descriptor_indexing – reusing descriptor layouts for multiple shaders
VK_KHR_buffer_device_address – bindless resources
VK_KHR_imageless_framebuffer – framebuffer definition without images
VK_KHR_host_query_reset – easier resetting of queries

Improved Layering Support for Other 3D APIs
VK_KHR_uniform_buffer_standard_layout – support HLSL constant buffer layouts
VK_EXT_scalar_block_layout – more layout support for HLSL (optional)
VK_KHR_draw_indirect_count – for OpenGL (optional)
VK_KHR_separate_stencil_usage - to streamline DX ports
VK_KHR_separate_depth_stencil_layouts – to streamline DX ports
SPIR-V 1.4 - many HLSL features
SPIR-V 1.5 - to support Vulkan 1.2

API Usability Improvements
VK_KHR_driver_properties – reports latest passing CTS version
VK_KHR_create_renderpass2 – more extensible renderpass objects
Vulkan 1.1/1.2 unified feature and property structs

Exposing New Hardware Capabilities
VK_KHR_image_format_list – improve image view performance
framebufferIntegerColorSampleCounts –more multi-sample formats
VK_KHR_sampler_mirror_clamp_to_edge – widely supported mode (optional)
VK_KHR_sampler_filter_minmax – for newer GPUs (optional)
VK_KHR_shader_viewport_index_layer – for newer GPUs (optional)
VK_KHR_shader_float16_int8 – proper fp16 support (optional)
VK_KHR_shader_float_controls – control over rounding, etc. (optional)
VK_KHR_vulkan_memory_model – precise memory model spec (optional)
VK_KHR_shader_subgroup_extended_types – more subgroup types (optional)
VK_KHR_8bit_storage – 8-bit types in SSBOs/UBOs (optional)
VK_KHR_shader_atomic_int64 - (optional)
VK_KHR_depth_stencil_resolve – resolve modes for depth/stencil
(partly optional)

> Vulkan 1.2 deliberately does not mandate new hardware functionality so that all Vulkan GPU drivers are able to be upgraded

Timeline Semaphore Primitive

- **Before: separate VkFence and VkSemaphore for synch with host & across device queues**
  - Binary state – so many fences and semaphores often needed to synch parallel operations

- **Timeline Semaphore is much simpler to manage and much more powerful**
  - Unified - covers all synchronization across device queues and host
  - 64-bit monotonically increasing value that multiple threads can update and wait on
  - Apps use the 64-bit state to define their own thread communication protocols

- **See Khronos Timeline Semaphore Blog**
  - For more details

An open source implementation of the timeline semaphore API is also available as a layer over Vulkan 1.1
https://github.com/KhronosGroup/Vulkan-ExtensionLayer/
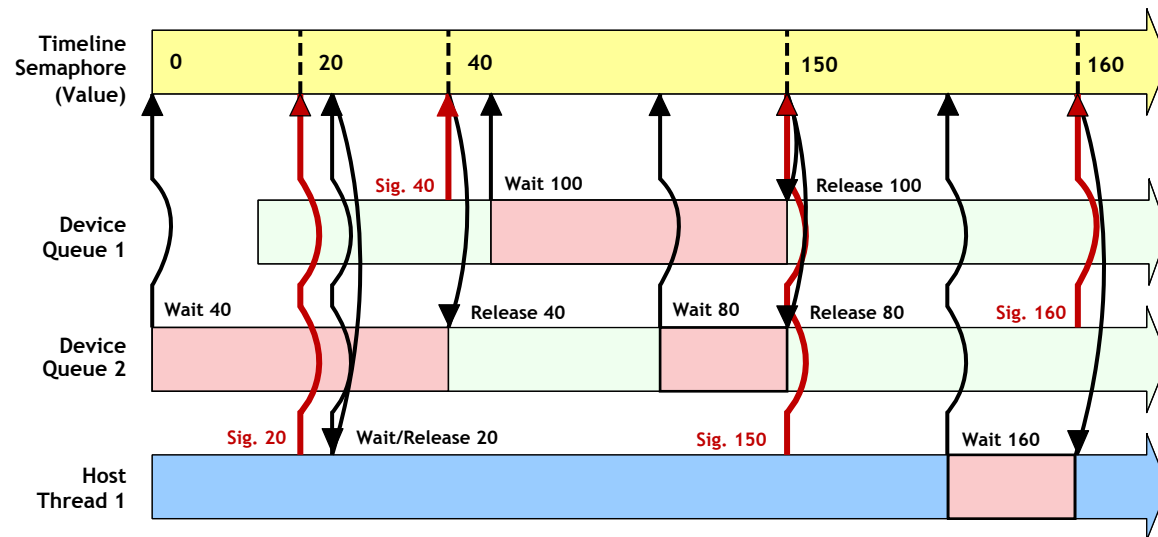
Vulkan 1.2 Hardware Support

NVIDIA's Vulkan 1.2 drivers are _available_ today with full functionality for both Windows and Linux

AMD

Imagination

NVIDIA

arm

intel
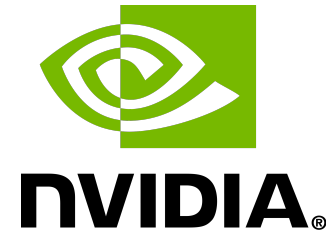
Five GPU vendors have Vulkan 1.2 implementations passing
Vulkan 1.2 conformance tests at the time of specification launch
PLUS open source Mesa RADV driver for AMD
For release status updates see the Vulkan Public Release Tracker

Open Source Ecosystem Upgrading to Vulkan 1.2

RenderDoc Debugger
Single-frame capture and detailed
introspection of any application
https://renderdoc.org/
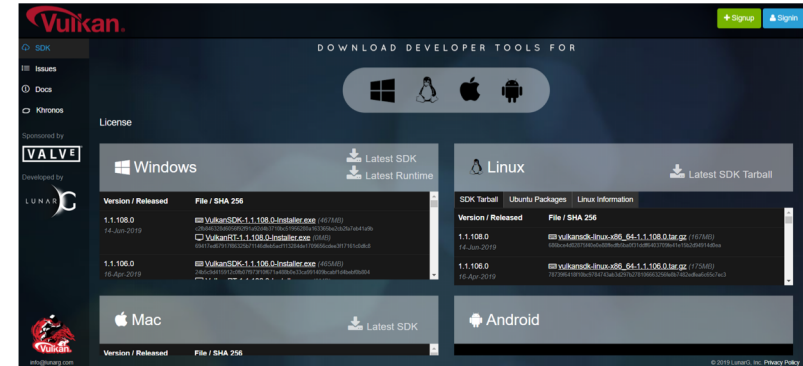
Vulkan SDK with Development/Debug Layers
Windows, Linux - Ubuntu packages, Linux- Tarball, macOS
www.vulkan.lunarg.com

Vulkan Samples
Collection of samples and resources to aid developing
optimized Vulkan applications
https://github.com/KhronosGroup/Vulkan-Samples

Vulkan Guide
Help for developers to get up and going with the world of
Vulkan with links to many other useful resources
https://github.com/KhronosGroup/Vulkan-Guide

HLSL as First Class Vulkan Shading Language

- **DXC - Microsoft's next-gen HLSL compiler**
  - Open sourced in January 2017
  - Based on LLVM/Clang
- **Spiregg: HLSL to SPIR-V within DXC**
  - Google and others contributing
  - Same front-end and validation as D3D
- **Covers all native HLSL features**
  - Math types, Control flows, Functions, enums
  - Resource types and methods, Namespaces, structs
  - 16-bit and 32-bit types
  - Shader Model 6.2 and below
- **Adding Vulkan 1.2 and extensions support**
  - Vendors are enabled to contribute
  - E.g. VKRay extension added by NVIDIA

HLSL

DXC

Front-end Parsing
and Validation

AST
Abstract Syntax Tree

SPIR-V
Backend

DXIL
Backend

SPIR

SPIR-V

DXIL

SPIR-V Tools

DXIL Tools

Vulkan

DirectX 12
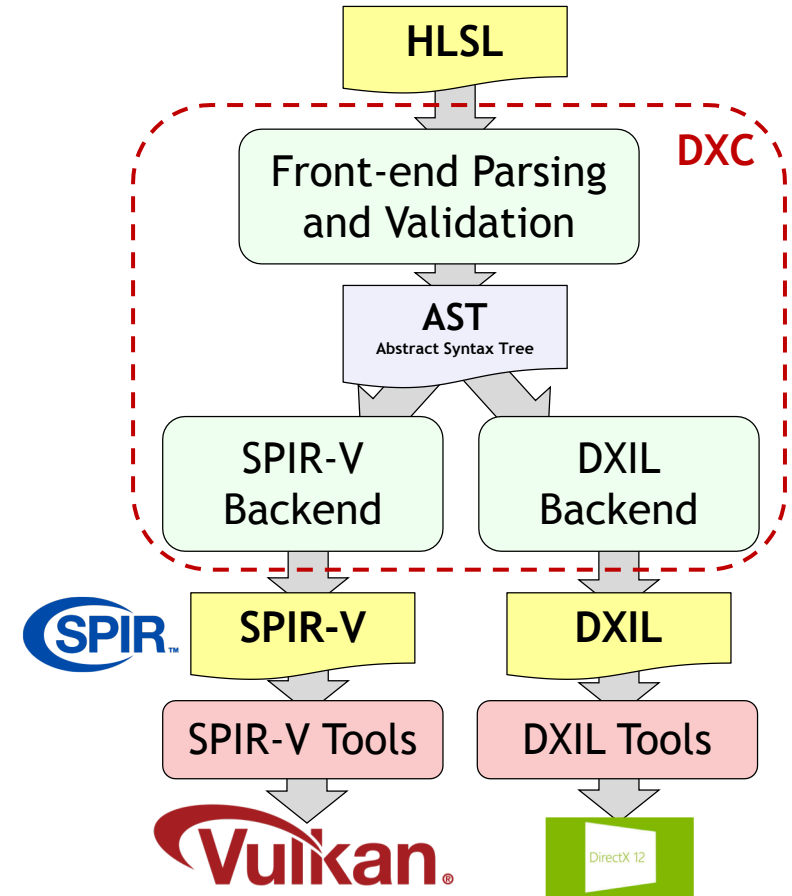
Many Vulkan Games Already Shipping Using HLSL
[Blog on using HLSL with Vulkan](#)

Vulkan and Open Source Layering Projects

Fighting Platform Fragmentation

Vulkan added OpenGL-style line extension

Vulkan adding more compute for fuller support for OpenCL kernel deployment

Vulkan adding extensions to ease layering of DX

Layers Over	Vulkan	OpenGL	OpenCL	OpenGL ES	DX12	DX9-11
Vulkan		Zink	clspv clvk	GLOVE Angle	vkd3d	DXVK
OpenGL	gfx-rs Ashes			Angle		
DX12	gfx-rs					
DX9-11	gfx-rs Ashes			Angle		
Metal	MoltenVK gfx-rs			Angle		

Vulkan is an effective porting layer for other APIs for portability and stack simplification

Demand for Vulkan everywhere, even if no native drivers on platform
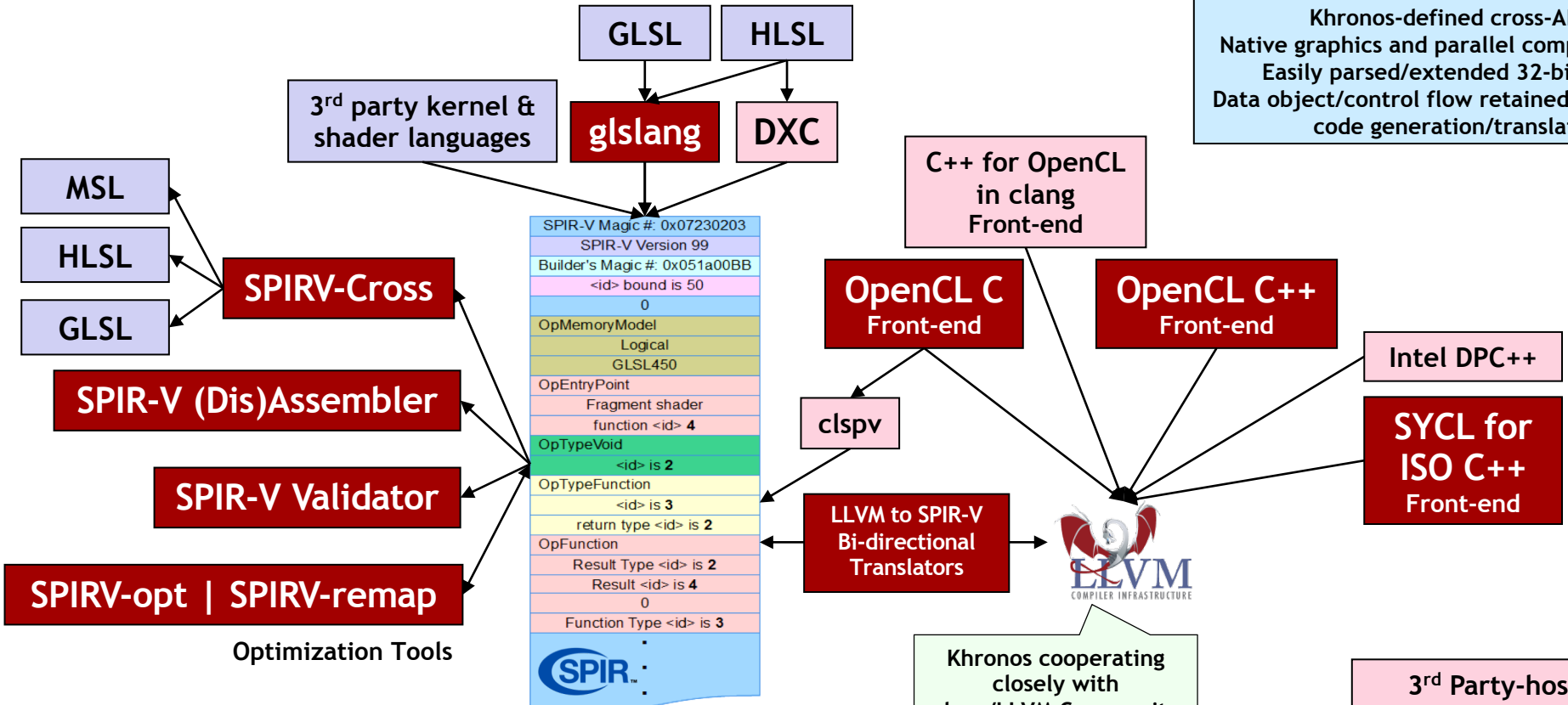
Vulkan PORTABILITY

Vulkan Portability enables multi-vendor layered subsets to be queryable and all present functionality to be tested for conformance

SPIR-V Ecosystem

SPIR-V
Khronos-defined cross-API IR
Native graphics and parallel compute support
Easily parsed/extended 32-bit stream
Data object/control flow retained for effective
code generation/translation

GLSL   HLSL

3rd party kernel &
shader languages

glslang   DXC

MSL

HLSL

GLSL

SPIRV-Cross

SPIR-V (Dis)Assembler

SPIR-V Validator

SPIRV-opt | SPIRV-remap

Optimization Tools

C++ for OpenCL
in clang
Front-end

OpenCL C
Front-end

OpenCL C++
Front-end

Intel DPC++

**SYCL for
ISO C++**
Front-end

clspv

**LLVM to SPIR-V
Bi-directional
Translators**

LLVM
COMPILER INFRASTRUCTURE

SPIR-V Magic #: 0x07230203
SPIR-V Version 99
Builder's Magic #: 0x051a00BB
<id> bound is 50
0
OpMemoryModel
Logical
GLSL450
OpEntryPoint
Fragment shader
function <id> 4
OpTypeVoid
<id> is 2
OpTypeFunction
<id> is 3
return type <id> is 2
OpFunction
Result Type <id> is 2
Result <id> is 4
0
Function Type <id> is 3
:
SPIR
:
:

Khronos cooperating
closely with
clang/LLVM Community

3rd Party-hosted
Open Source Projects

Khronos-hosted
Open Source Projects

Environment spec for
each target API used to
drive compilation

Vulkan.

OpenCL

OpenGL.

https://github.com/KhronosGroup/SPIRV-Tools

Running DX Games on Linux Over Vulkan

- **DXVK - Vulkan-based implementation of Direct3D 9/10/11**
  - GitHub open source by Philip Rebohle and Joshua Ashton with support from Valve

- **Vulkan has added multiple extensions to support efficient layering of D3D**
  - Removing impedance mismatches between the two APIs

- **DXVK, Wine Windows Compatibility Layer and Valve's Proton tool**
  - Enables thousands of Steam PC games on Linux

https://www.protondb.com

Vulkan 1.2 Functionality for efficient D3D layering/HLSL
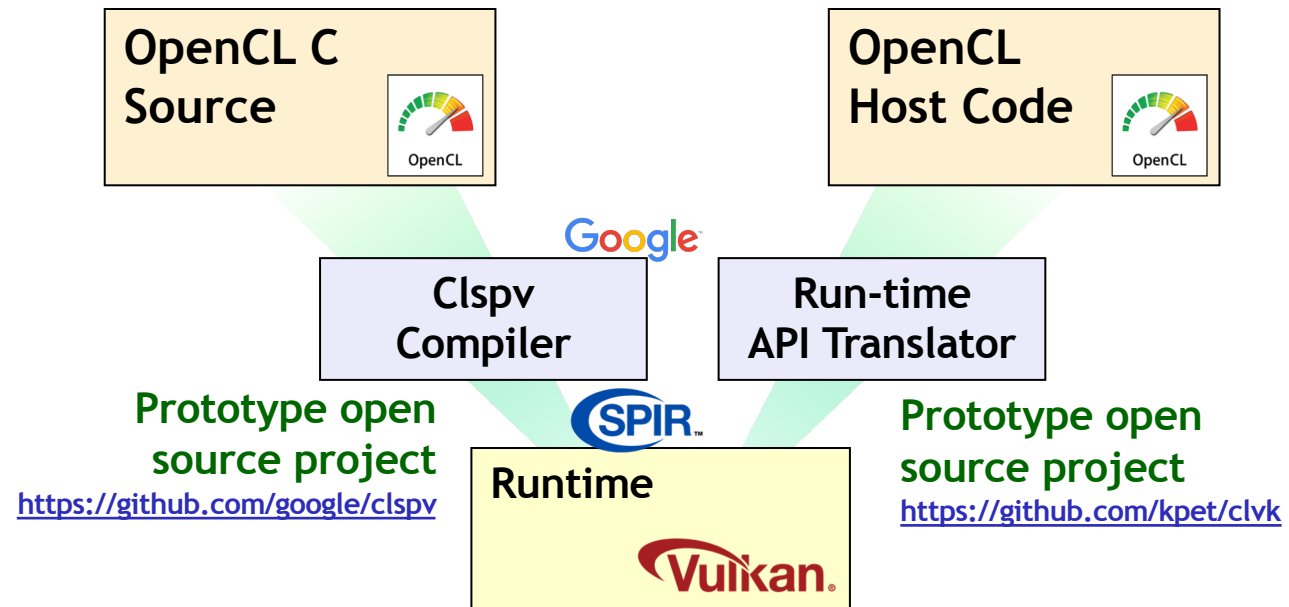
- VK_KHR_host_query_reset
  - Easier resetting of queries
- VK_KHR_uniform_buffer_standard_layout
  - To support HLSL constant buffer layouts
- VK_EXT_scalar_block_layout
  - More layout support for HLSL (optional)
- VK_KHR_separate_stencil_usage
  - Used in many DX ports
- VK_KHR_separate_depth_stencil_layouts
  - Used in many DX ports
- SPIR-V 1.4/1.5 include many HLSL features

Here is a sample of some popular games that are officially not whitelisted yet, but have received many Platinum reports on ProtonDB

66,943 reports written   11,064 games reported   6,502 games work

Deploying OpenCL C Over Vulkan

- **Clspv – Google's experimental compiler for OpenCL C to Vulkan SPIR-V**
  - Open source - tracks top-of-tree LLVM and clang, not a fork

- **Adobe Premiere Rush has 200K lines of OpenCL C kernel code**
  - Professional-quality, cross-platform video capture and editing system
  - Now shipping on Android on Vulkan

Adobe Premiere Rush — Video Editor

OpenCL C Source

OpenCL Host Code

Google

Clspv Compiler

Run-time API Translator

Prototype open source project
https://github.com/google/clspv

SPIR

Runtime

Vulkan

Prototype open source project
https://github.com/kpet/clvk
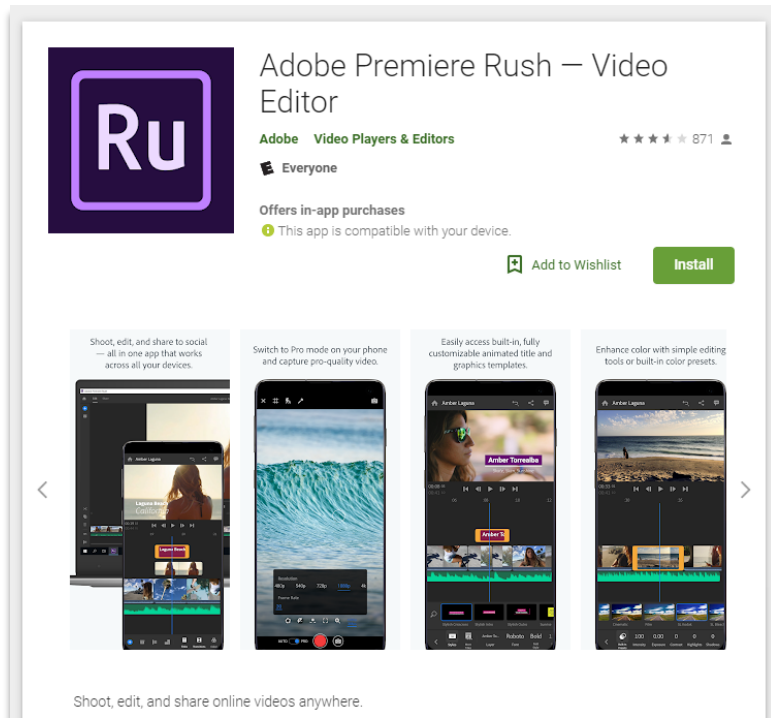
Vulkan Portability Initiative on Apple

Almost all mandatory Vulkan 1.0 functionality is supported:
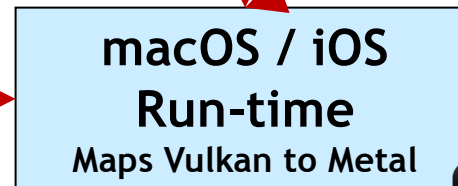No Triangle Fans
No separate stencil reference masks

Selected Optional Features and Extensions are added as required -
driven by industry input and feedback
Robust buffer access
BC texture compressed formats
Fragment shader atomics
Tesselation
https://github.com/KhronosGroup/MoltenVK

Vulkan Applications

Open source SDK to build, run, and debug applications on macOS - including validation layer support
https://vulkan.lunarg.com/

Vulkan macOS SDK

LUNAR G

SPIRV-Cross
Convert SPIR-V shaders to Metal Shaders

KHRONOS GROUP

macOS / iOS Run-time
Maps Vulkan to Metal

Open source beta release for macOS
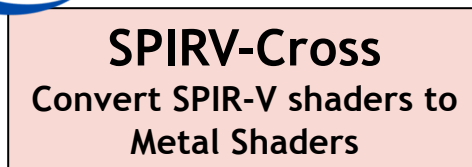
MoltenVK supports macOS 10.11 / iOS 9.0 and up

Open source for MacOS and iOS
Free to use - no fees or royalties including commercial apps

Vulkan Apps Shipping On Apple

Forsaken Remastered was just updated with **Vulkan** support! If you're on Linux, you're probably hitting 60fps with the existing OpenGL renderer, but it's good to be future proof. If you're on a Mac, though, you *definitely* want to switch. On my MacBook, the framerate goes from around 15 to a solid 60!

Initial Vulkan Performance On macOS With Dota 2 Is Looking Very Good
Written by Michael Larabel in Valve on 1 June 2018 at 05:37 PM EDT. 34 Comments

Yesterday Valve released Vulkan support for Dota 2 on macOS. Indeed, this first major game relying upon MoltenVK for mapping Vulkan over the Apple Metal drivers is delivering performance gains.

Valve Releases Artifact As Its Cross-Platform, Vulkan-Powered Digital Card Game
Written by Michael Larabel in Valve on 28 November 2018 at 04:16 PM EST. 29 Comments

Valve managed to ship their latest game today as planned and without any major delays.

Artifact is now available with launch-day support for Linux, macOS, and Windows. Artifact is a competitive digital card game is targeting Dota 2 players as well as card gaming enthusiasts. Valve still plans to evolve Artifact and its gameplay over

Production Dota 2 on Mac Ships – up to 50% more perf than Apple's OpenGL

First iOS Apps using MoltenVK ship through app store

Qt Running on Mac through MoltenVK

Multiple iOS and macOS apps shipping e.g. Forsaken Remastered

Google Filament PBR Renderer on Mac

Initial ports of DX games in progress using Vulkan on Mac

Artifact from Steam ships on MoltenVK on macOS - first Vulkan-only Valve app on Mac

RPCS3

RPCS3 PlayStation 3 Emulator on Mac

Dolphin GameCube and Wii Emulator working on MacOS

Diligent Engine runs on MacOS

Underlords from Steam ships on MoltenVK on macOS - second Vulkan-only Valve app on Mac

| June 2018 | September 2018 | November 2018 | January 2019 | June 2019 |

Vulkan and OpenGL for Professional Apps

- **Professional applications beginning to transition to Vulkan**
  - Reduced CPU bottlenecks and multi-threading
  - Parallel compute, graphics and data movement
  - Vulkan now has OpenGL-style lines extension for CAD
  - Advanced functionality coming – such as ray tracing

- **Vulkan OpenGL Interop enables incremental transition to Vulkan**
  - Modern-style, shared explicit memory objects

- **Dassault Systèmes achieves interactive object space AO in CATIA, an OpenGL application**
  - Using the NVIDIA Vulkan VKRay vendor extension for Ray Tracing
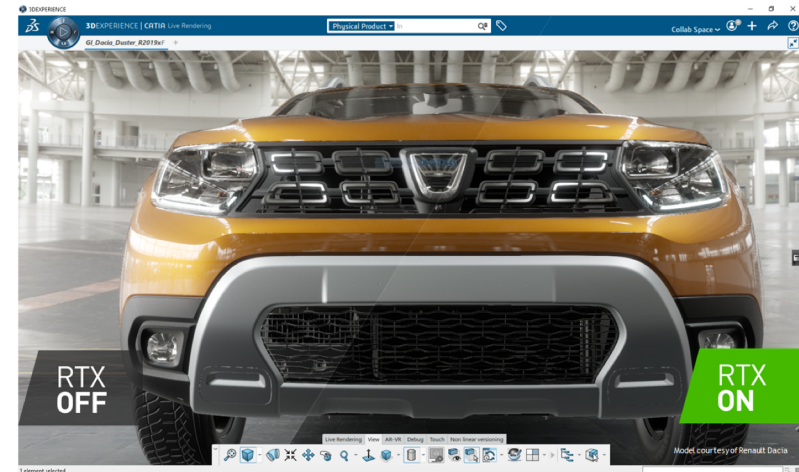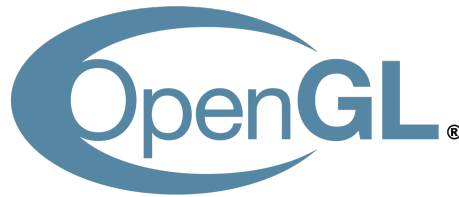
Other Vulkan Updates

January 2020

Vulkan Portability Initiative

Enabling Vulkan applications on platforms without native drivers by layering cleanly queryable subsets of Vulkan over DX12, Metal and other APIs

Multiple Layered Vulkan Implementations

Additional open source run-times over additional backends

E.g. gfx-rs for Vulkan over Metal and DX12 - useful for Vulkan on UWP platforms such as Windows 10 S, Polaris, Xbox One.
Secondary backends include OpenGL/D3D11

https://github.com/gfx-rs/gfx
https://github.com/gfx-rs/portability

Portability Extension

Layered implementations can portably expose what Vulkan functionality is not supported

TODADY

Open source tools, SDKs and libraries to bring Vulkan 1.0 applications to Apple using Metal

Extend Vulkan Conformance Test Suite

To handle layered implementations – what is present must work!

Enhanced Vulkan Layers

Extend DevSim/Validation Layers to flag or simulate queries for features not present

Khronos Standards for Immersive Computing

Download 3D object and scene data

Vision and sensor processing - including neural network inferencing for machine learning

SYCL™

OpenVX™

OpenCL

NNEF™

OpenGL|ES™

OpenGL

Vulkan®

WebGL™

High-performance, low-latency 3D Graphics

Portable interaction with VR/AR sensor, haptic and display devices

OpenXR™

KHRONOS® GROUP
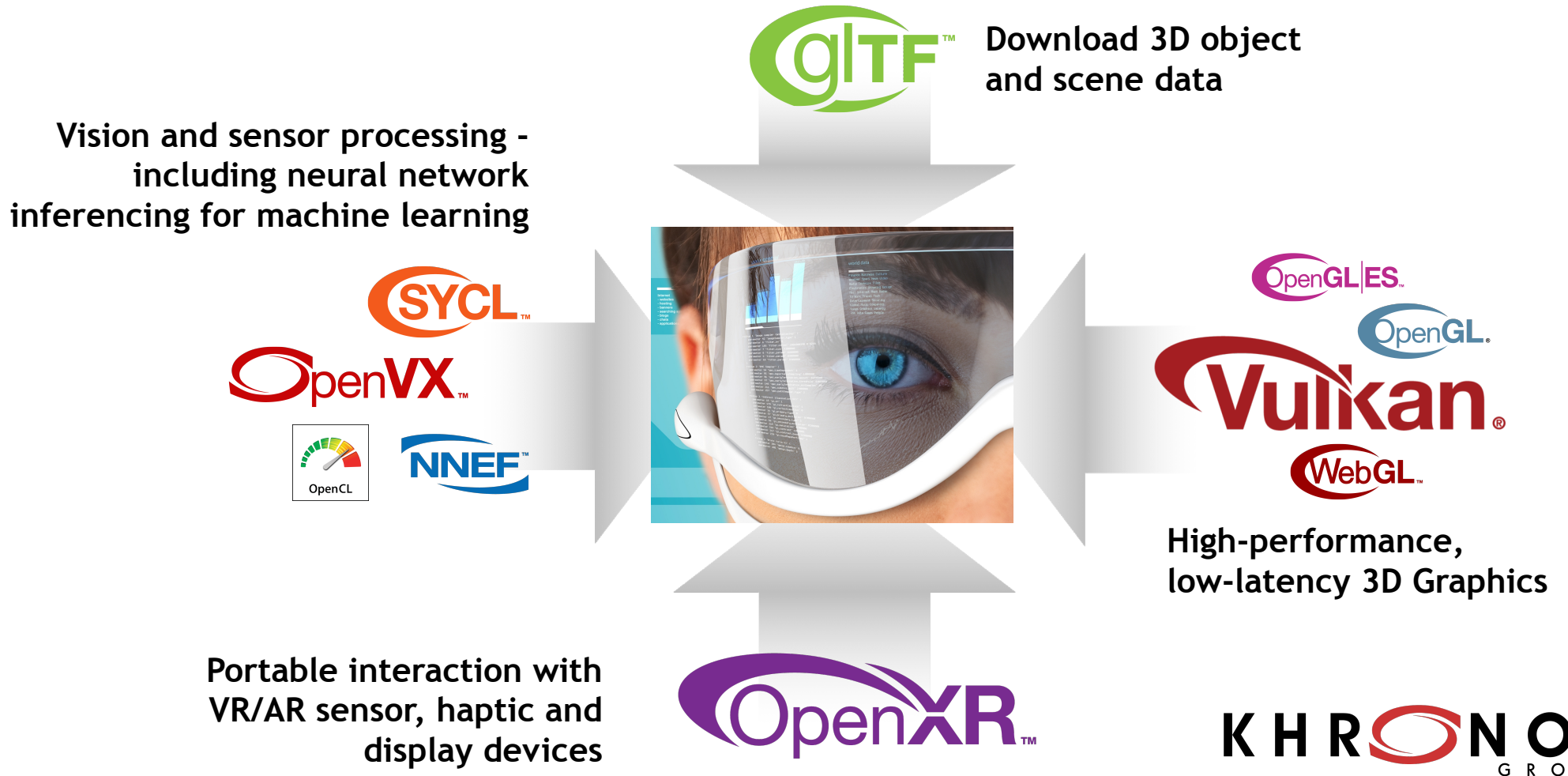
OpenXR is used with a 3D API

Application or Engine

High-performance, low-latency 3D rendering and composition*
Multiview
Context priority
Front buffer rendering
Tiled rendering (beam racing)
Variable rate rendering

Display, composition and optical correction parameters

Cross-platform access to XR HMDs and sensors
XR application lifecycle
Input device discovery and events
Sensor tracking and pose calculation
Frame timing and display composition
Haptics Control

Vulkan®

OpenXR™

* OpenXR can be used with other 3D APIs such as Direct3D, OpenGL and OpenGL ES

Analytic Rendering Exploratory Group

Analytic Rendering is image generation performed primarily to gain and communicate insights into complex data sets primarily for scientific visualization and data analytics

Is there a need for a cross-platform open standard API?

SITUATION BEFORE

SITUATION AFTER
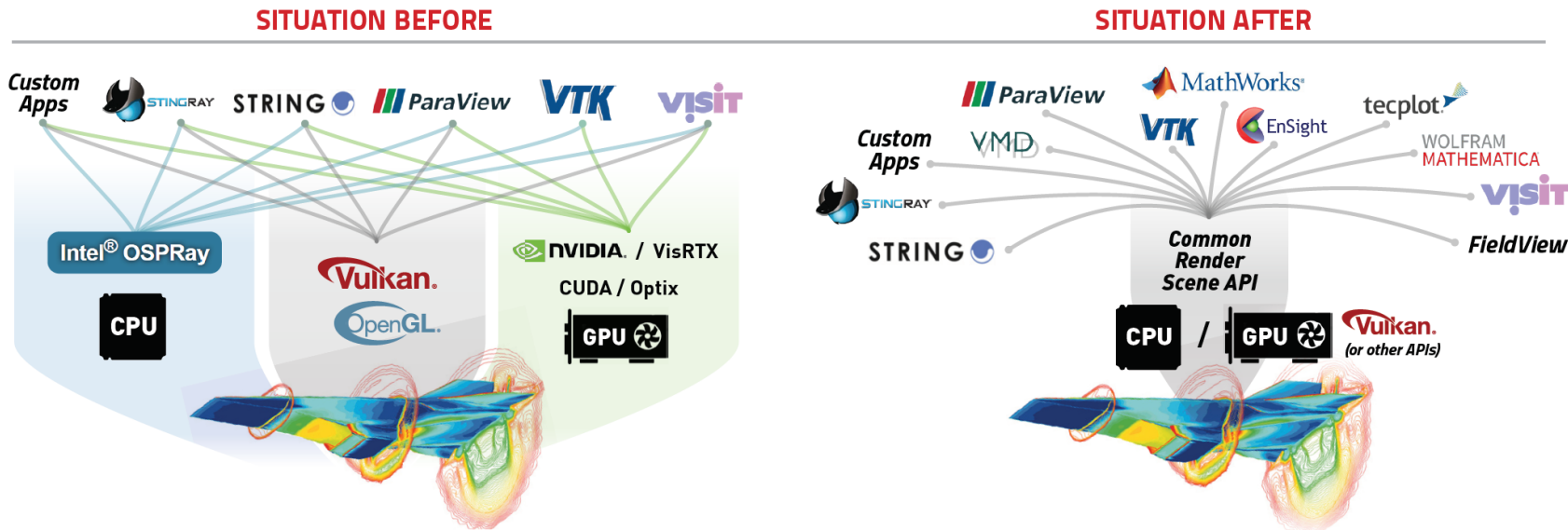
Visualization Apps and Engines have to be ported to multiple APIs

Cross-vendor API to provide access to state-of-the-art rendering across multiple platforms

Potential Analytic Rendering API Design

Rather than specifying the details of the rendering process, an Analytic Rendering API would enable a visualization application to simply describe the relationship between objects in a scene to be rendered and leave the details of the rendering process to a backend renderer
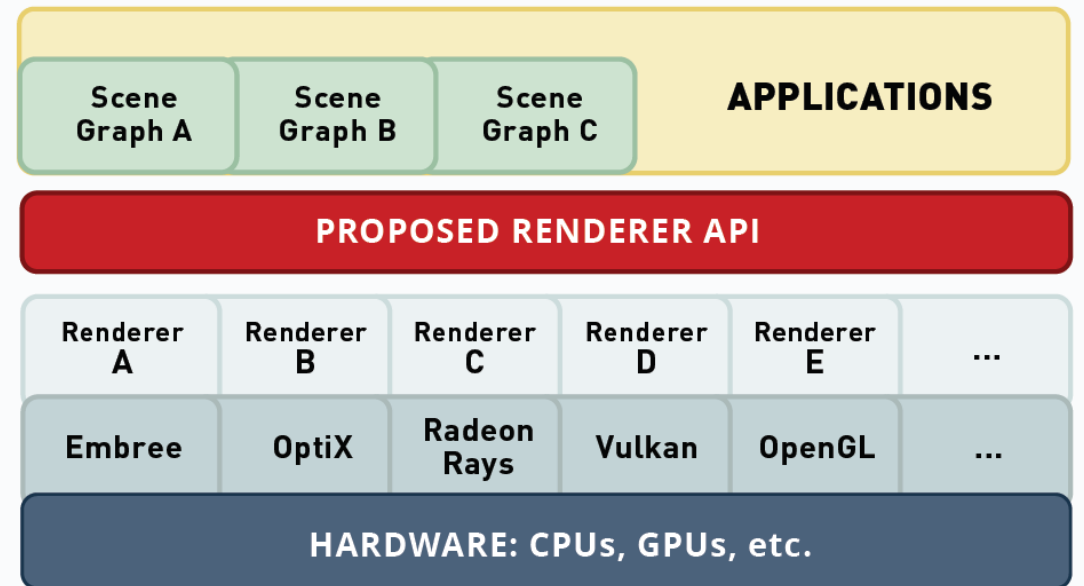
Some Initial Exploratory Group Members

Khronos Exploratory Groups discuss the need for a new standard with no cost or IP Implications
Open to all – even non-members - more details
https://www.khronos.org/exploratory/analytic-rendering/

Khronos and Vulkan Background

January 2020

Connecting Software to Silicon

>150 Members ~ 40% US, 30% Europe, 30% Asia

Open, non-profit, member-driven industry consortium creating advanced, royalty-free interoperability standards for 3D graphics, augmented and virtual reality, parallel programming, vision acceleration and machine learning

Khronos Active Initiatives

3D Graphics
Desktop, Mobile, Web
Embedded and Safety Critical

3D Assets
Authoring
and Delivery

Portable XR
Augmented and
Virtual Reality

Parallel Computation
Vision, Inferencing,
Machine Learning

Guidelines for creating APIs to streamline system safety certification

Exploratory Groups

Heterogeneous Communications
between offload compute devices

Making High-Level Languages more
effective at acceleration offload

Rendering for scientific
visualization and data analytics

Vulkan and New Generation GPU APIs

Modern architecture | Low overhead| Multi-thread friendly
EXPLICIT GPU access for EFFICIENT, LOW-LATENCY,
PREDICTABLE performance

Vulkan Porting Tools

**Vulkan is a non-proprietary, royalty-free open standard
Portable across multiple platforms – desktop, mobile and embedded**

Note: The version of Vulkan available will depend on platform and vendor

Vulkan for Direct GPU Control

OpenGL ES
OpenGL

Complex drivers cause overhead and inconsistent behavior across vendors

Always active error handling

Full GLSL preprocessor and compiler in driver

OpenGL vs. OpenGL ES

Application
Single thread per context

High-level Driver Abstraction
Layered GPU Control
Context management
Memory allocation
Full GLSL compiler
Error detection

GPU

A Graphics API

Vulkan®

Application
Memory allocation
Thread management
Explicit Synchronization
Multi-threaded generation of command buffers
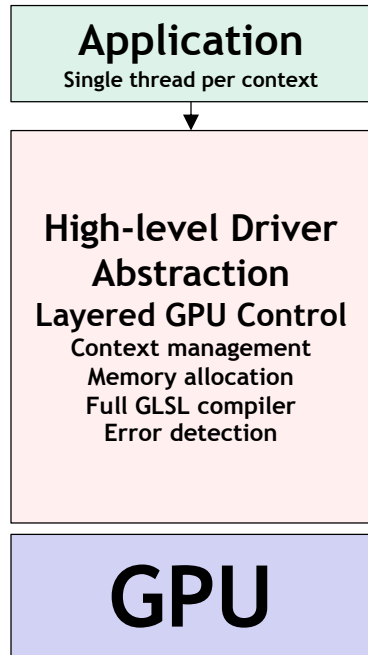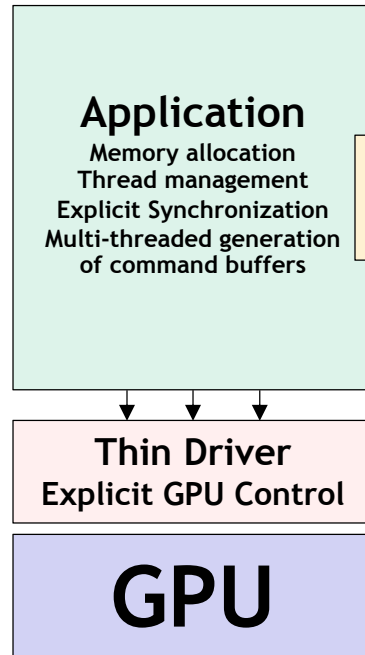
Multiple Front-end Compilers
GLSL, HLSL etc.

SPIR
SPIR-V
pre-compiled shaders

Thin Driver
Explicit GPU Control

Loadable debug and validation layers

GPU

A GPU API

Simpler drivers - application has the best knowledge for holistic optimization – no 'driver magic'

Explicit creation of API objects before usage – efficient, predictable execution

Easier portability - no fighting with different vendor heuristics

Validation and debug layers loaded only when needed

SPIR-V intermediate language: shading language flexibility

Unified API across mobile and desktop platforms

Multiple graphics, command and DMA queues

Khronos Ecosystem Engagement

$0 Open to all!
https://community.khronos.org/
www.khr.io/slack

$0 Spec fixes and suggestions made under the Khronos IP Framework. Open source contributions under repo's CLA – typically Apache 2.0
https://github.com/KhronosGroup

Khronos Forums and Slack Channels

Contribute to open source specs, CTS, tools and ecosystem

$0 Advisors under the Khronos NDA and IP Framework can comment and contribute to requirements and draft specifications
https://www.khronos.org/advisors/

Advisory Panels

$ Khronos members under Khronos NDA and IP Framework participate and vote in working group meetings
https://www.khronos.org/members/

Working Groups

Khronos New Initiative Process

Khronos members and/or non-members → **Idea for a new Khronos Initiative**

No IP Commitments
High-level requirements and use case discussions

Khronos organizes a discussion forum
Open to all

Initiative Proposal

Khronos establishes an Exploratory Group to CREATE a Statement of Work
Open to all
Under NDA

SOW

Khronos Working Group
Khronos Members
Work and participants protected by Khronos IP Framework

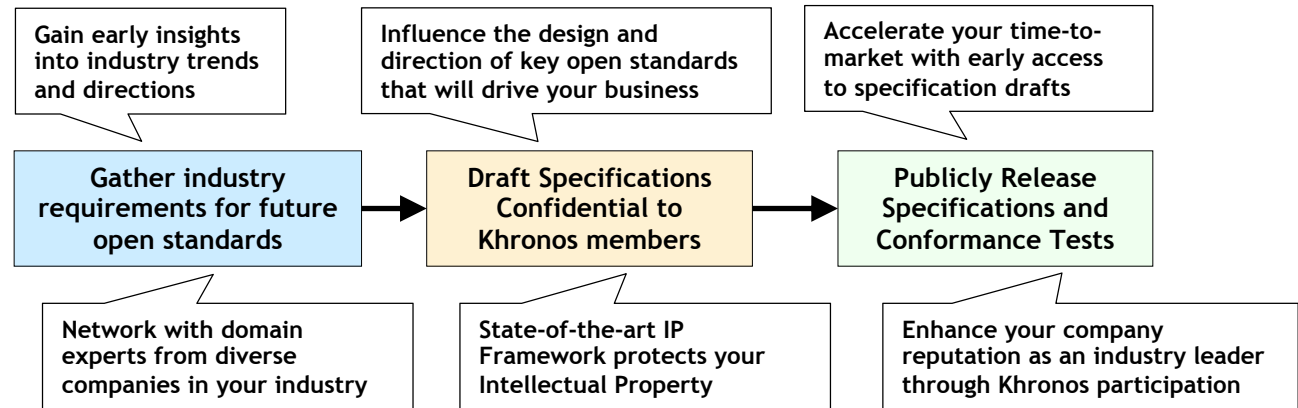Khronos extends an open invitation to any Embedded Vision Alliance members that have business needs for new industry open standards to make a New Initiative Proposal

Get Involved!

- **Khronos is creating cutting-edge royalty-free open standards**
  - For 3D, compute, vision, inferencing acceleration
- **These slides and information on Khronos Standards:** www.khronos.org
- **Any company is welcome to join Khronos:** https://www.khronos.org/members/
- **Khronos Developer Forum:** https://community.khronos.org/
- **Khronos Developer Slack Channel:** www.khr.io/slack
- **Neil Trevett:** ntrevett@nvidia.com | @neilt3d

Gain early insights into industry trends and directions

Influence the design and direction of key open standards that will drive your business

Accelerate your time-to-market with early access to specification drafts

Gather industry requirements for future open standards → **Draft Specifications Confidential to Khronos members** → **Publicly Release Specifications and Conformance Tests**

Network with domain experts from diverse companies in your industry

State-of-the-art IP Framework protects your Intellectual Property

Enhance your company reputation as an industry leader through Khronos participation

Benefits of Khronos membership