Vulkan SDK Benefits and Enhancements Over the Past Year

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Vulkan SDK Benefits and Enhancements Over the Past Year

BIRDS OF A FEATHER

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Slides are available here:

https://www.lunarg.com/news-insights/white-papers/vulkan-sdk-enhancements-over-the-past-year/

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What is Vulkan?

Vulkan is a next-generation graphics and compute API that provides high efficiency and cross-platform access to modern GPUs used in PCs, consoles, mobile devices, and embedded platforms.

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The Vulkan SDK (vulkan.lunarg.com)

Delivered by LunarG in close coordination with the Khronos Vulkan working group

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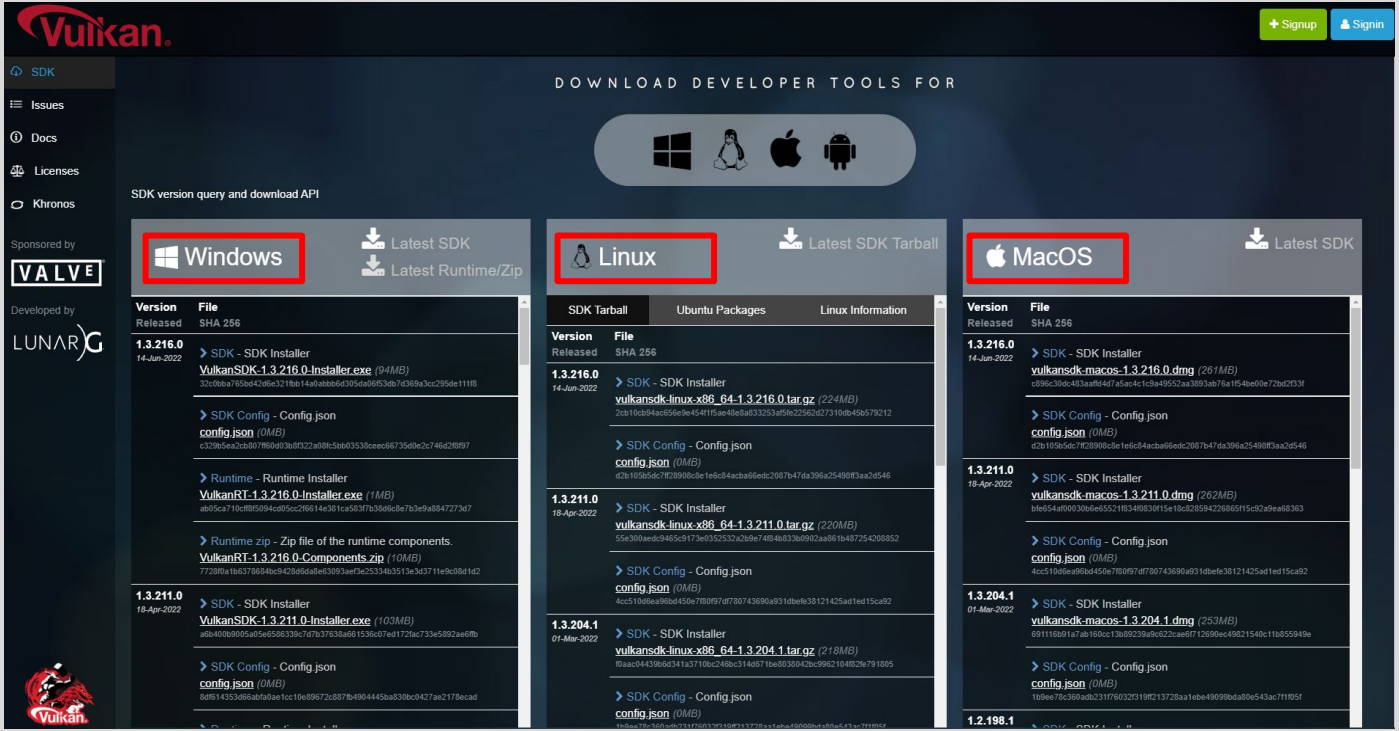
Vulkan SDK Download Page

Available Vulkan downloads for Windows, Linux, and macOS



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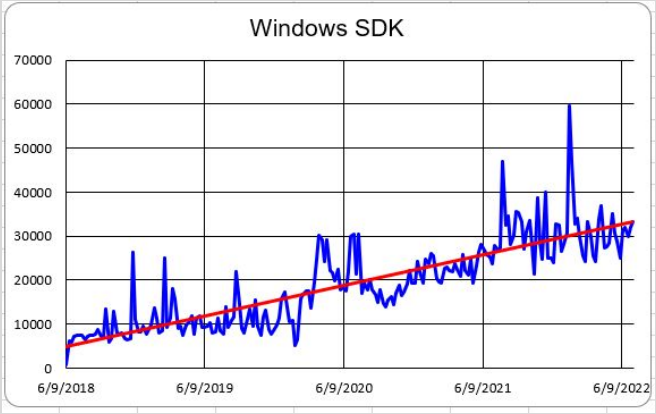
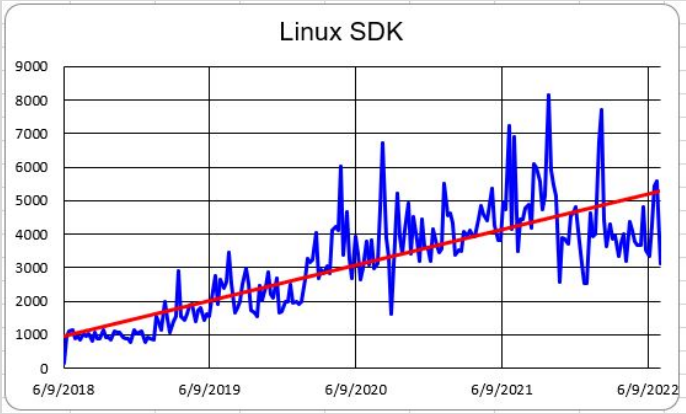
Vulkan SDK Downloads are Healthy and Continue to Grow



~32,000/week



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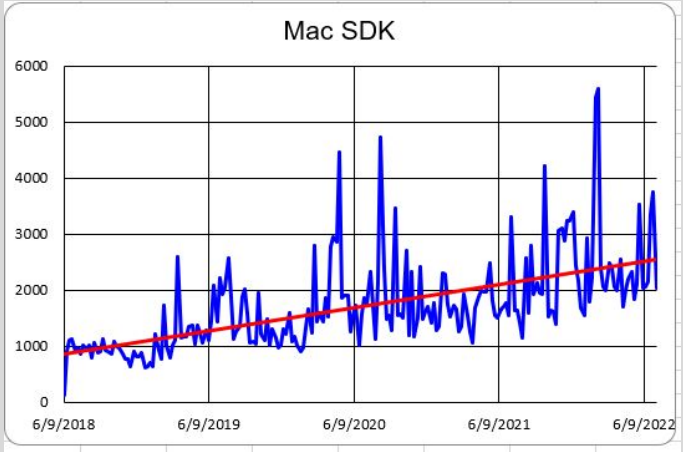

~2,500/week

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Why Use the Vulkan SDK?
– Overview –

- All SDK components come from open-source repositories
- A Vulkan application developer could build and install all of the content themselves
- However the SDK provides many benefits that save time for the application developer

See the LunarG white paper: ***Benefits of Using the Vulkan SDK***

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Why Use the Vulkan SDK?
– Easy and Convenient –

- **An installation process that is easy and fast**
  - All of the developer tools are pre-built and installed into the correct system locations, ready for use.
- **Vetted and curated content to ensure compatibility and seamless integration**
  - The SDK components come from many open-source repositories
  - Diligence needed to ensure compatible versions of dependent repositories are used
  - LunarG collaborates with repository owners to ensure critical and compatible functionality is selected
- **Ready-to-use versions of the Vulkan Configurator**
  - The layers that the Vulkan Configurator expects are installed by the SDK
- **SDK release notes and user documentation**
  - The SDK release notes clarify new functionality released with the SDK
  - User documentation included removing need for developer to search within the repositories

Why Use the Vulkan SDK?
– Linux –

- Most up-to-date set of Linux Vulkan components
  - Linux distributions SDK components may not be updated frequently
- Linux distributions do not include all of the SDK components
- Linux tarball: Enables SDK components on many Linux distributions via the “vulkansdk” build script

See the LunarG white paper: ***Benefits of Using the Vulkan SDK***

Why Use the Vulkan SDK?
– macOS –

- All necessary macOS binaries pre-built with an option for system-level installation of MoltenVK as an ICD
  - Enables usage of Vulkan layers such as the Validation Layers via the Loader
- Building the Vulkan Loader, MoltenVK, the layers, and the associated shader tools takes work!
  - Ensuring compatible versions takes diligence
- Binaries support both Intel and Apple Silicon processors

See the LunarG white paper: ***Benefits of Using the Vulkan SDK***

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Why Use the Vulkan SDK?
– License Registry –

A License Registry that details all of the licenses included by the SDK components

- There are many open-source licenses being used by the SDK components
- The License Registry details ALL of the open-source licenses and copyrights in use by the SDK
- Beneficial to corporations requiring license scrutiny
- Delivered via a downloadable CSV file

See the LunarG white paper: ***Benefits of Using the Vulkan SDK***

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Why Use the Vulkan SDK?
– Shader Toolchain Tools –

Complete package of available shader toolchain tools

- There are multiple workflows used for creating SPIR-V shaders to be used with Vulkan applications
  - HLSL→SPIR-V
    - The Microsoft DirectX Shader compiler
    - Glslang (for HLSL versions of version shader model 5.1 or less)
    - Google/shaderc (via glslang)
  - GLSL→SPIR-V (Glslang, Google/shaderc)
- SPIR-V shaders -> HLSL/Metal/GLSL shaders (SPIRV-cross)
- The Vulkan SDK includes the complete package of available shader toolchain tools

SDK Content and Enhancements Over the Last Year

Developer tools in the Vulkan SDK

Vulkan Configurator - GUI application to configure layers used by Vulkan applications at runtime with built-in configurations for the SDK included layers:

1. **VK_LAYER_KHRONOS_validation** - validate application correct usage of the Vulkan API
   a. **GPU Assisted Validation** - runtime validation executed on the GPU (rather than the CPU)
   b. **Best Practice** - catch correct Vulkan API usage that still could cause application issues
   c. **Synchronization Validation** - identify resource access conflicts due to incorrect synchronization operations between actions
   d. **Debug Printf** - debug shader code using printf inside a shader
2. **VK_LAYER_KHRONOS_synchronization2 -** Emulates the VK_KHR_synchronization2 API
3. **VK_LAYER_LUNARG_api_dump** - ascii output of Vulkan API calls
4. **VK_LAYER_KHRONOS_profiles** - Downgrade the Vulkan developer's system capabilities to a specified Vulkan profile
5. **GFXReconstruct:** Capture (with VK_LAYER_LUNARG_gfxreconstruct) and Replay

Note: Underlined items are new additions in the past year

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Additional developer tools in the Vulkan SDK

- **VOLK -** A meta-loader for Vulkan allowing dynamically loading of entry points required to use Vulkan without linking to vulkan-1.dll or statically linking the Vulkan loader
- **AMD Memory Allocator -** a library helping developers to manage memory allocations and resource creation
- **Vulkan Profiles Toolset**
  a. **Profiles Schema -** A JSON data format to communicate about Vulkan capabilities (extensions, features, properties, formats, and queue properties)
  b. **VK_LAYER_KHRONOS_profiles -** Downgrade the Vulkan developer's system capabilities
  c. **Vulkan Profiles Library -** A header-only C++ library to use Vulkan Profiles in Vulkan applications
- **Shader Tool chain** - offline executables and API libraries for:
  a. SPIRV-Tools (validator, optimizer, assembler, disassembler)
  b. glslang SPIR-V generator
  c. DXC (DirectX Shader Compiler)
  d. Shaderc SPIRV-Tools wrapper for better integration with build tools
  e. SPIRV-CROSS, a practical tool and library for performing reflection on SPIR-V and disassembling SPIR-V back to high level languages
- **Vulkaninfo** - Show GPU device properties and extensions, installed layers, supported image formats, properties...
- **vkvia** (Vulkan Installation Analyzer)

Note: Underlined items are new additions in the past year

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New with Vulkan 1.3: Vulkan Profiles

- A mechanism that enables the precise specification of capabilities
- Enables communication of capabilities between participants in the Vulkan Ecosystem
  - Streamline the development and deployment of portable applications
- Each profile specifies
  - A set of required extensions, with supported limits, features, and formats for
  - A core version of Vulkan

Vulkan Profiles Toolset

- Creating portable Vulkan applications in terms of Vulkan capabilities
  - Vulkan Profiles: Explicit Vulkan capability requirements and/or supports
    - Nothing groundbreaking, just a data convention and a toolset.
    - Not targeting homogeneity of the ecosystem, specifying a domain of relevance.
- Easier Vulkan development for a selected range of actual ecosystem devices

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Example Profiles Usages

- Roadmap profiles: To express guidance on the future direction of Vulkan devices
  - In the Vulkan Specification: **Vulkan Roadmap 2022**
  - In the SDK: **VP_KHR_roadmap_2022**
- Platform profiles: To express the Vulkan support available on different platforms
  - In the SDK: **VP_LUNARG_desktop_portability_2021**
- Device Profiles: To express the Vulkan support of a single Vulkan driver for a Vulkan device
  - **Gpuinfo.org** provides device profiles
- Architecture Profiles: To express the Vulkan support of a class of GPUs
  - For example, all Nvidia RTX 2000 GPUs
- Engine Profiles: To express some requirements of the rendering code path

The Vulkan Profiles Toolset Components

- **The Vulkan Profiles schema**
  - A JSON data format to communicate about Vulkan capabilities: extensions, features, properties, formats, and queue properties.
  - Each revision of Vulkan API is represented by a schema that supersedes older versions of Vulkan API.
- **The Vulkan Profiles comparison table**
  - A markdown table representation comparing Vulkan Profiles in the SDK
- **The Vulkan Profiles layer**
  - Downgrade the Vulkan developer's system capabilities
  - Replaces the devsim layer
- **The Vulkan Profiles library**
  - A header-only C++ library for using Vulkan Profiles in Vulkan applications
  - Checking Profiles support on a device and creating a vkDevice instance with the profile features and extensions enabled
- Coming soon: **Profile combining tool**
  - Intersection and Union

The Vulkan Profiles Toolset - More information

See the LunarG white paper, ***The Vulkan Profiles Toolset Solution***

See the SIGGRAPH Birds of a Feather (BoF) session:
Vulkan SDK tools to use and create Vulkan Profiles

- August 9, 8 AM Pacific

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Repackaged SDK

- The initial Windows SDK was released as one large blob
  - Didn’t allow for managing the SDK size
  - Couldn’t track usage of optional SDK components
- Repackaging applied to both the Windows SDK and the macOS SDK
  - Qt Installer framework (richer feature set)
  - Consistent look and feel
- Core packages
  - Validation Layers, Vulkan Configurator
  - …
- Optional packages
  - 32-bit versions of libraries, debuggable shader tool chain libraries
  - …
- **For more details**, see the LunarG white paper, “***The Repackaged Windows Vulkan SDK***”

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Validation Layer
Performance Improvement Initiative

- Performance regression test suite
  - Catches performance regressions (avoid performance degradation over time)
- Primary Problem areas
  - Many active threads in Vulkan applications; but a single lock per Validation Object in the Validation Layer
  - Large “bindless” DescriptorSets
- Some performance optimizations done in the last year
  - Fine grained locking in the Validation Layer - Huge Gains!
  - Linear memory allocation for GPU-AV (**VMA documentation**)
- Current focus area
  - Bindless descriptor validation (moving it to GPU-AV and off of the CPU)

Performance Improvements from Fine Grained Locking

Application	API	FGL disabled (FPS)	FGL enabled (FPS)	perf improvement
Ashes of the Singularity: Escalation	DX12 / VKD3D-Proton	24.16	59.36	145.70%
Deus Ex: Mankind Divided	DX11 / DXVK	33.3	31.3	-6.01%
Deus Ex: Mankind Divided	DX12 / VKD3D-Proton	17.7	31.9	80.23%
F12020	DX11 / DXVK	43	50	16.28%
Hitman2	DX11 / DXVK	28	29.54	5.50%
Hitman2	DX12 / VKD3D-Proton	13.77	32.73	137.69%
Rise of the Tomb Raider	DX12 / VKD3D-Proton	17	60	252.94%
Serious Sam Fusion 2017	Vulkan	112	115	2.68%
Sid Meier's Civilization VI	DX12 / VKD3D-Proton	4.3	11	155.81%
Strange Brigade	DX12 / VKD3D-Proton	19.6	54.5	178.06%
Strange Brigade	Vulkan	19.5	45.6	133.85%
AOE4	DX12 / VKD3D-Proton	120	110	-8.33%
Death Stranding	DX12 / VKD3D-Proton	10	25	150.00%
Market Of Light (UE5 demo)	DX12 / VKD3D-Proton	15	24	60.00%
Farming Simulator 22	DX12 / VKD3D-Proton	15	40	166.67%

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Performance Improvements from Linear Memory Mapping in GPU-AV

Application	linear alloc OFF (FPS)	linear alloc ON (FPS)	performance improvement
gfxrecon DoomEternal	0.614	1.842	**200.00%**
gfxrecon RDR2	11.35	33.52	**195.33%**
DoomEternal homescreen	16	19	**18.75%**
Strange Brigade	7	29	**314.29%**
DOTA2	2.9	5.2	**79.31%**

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Portability Enumeration

- Deploy Vulkan applications on systems without native Vulkan drivers
- More information about the Vulkan Portability Initiative: https://www.vulkan.org/porting#vulkan-portability-initiative
- Required extensions to use the portability solution
  - VK_KHR_portability_enumeration
    - Receive portable implementations during physical device enumeration
  - VK_KHR_portability_subset (currently provisional)
    - Identify differences between a portable implementation and a fully-conformant Vulkan implementation.
    - Enables writing applications to be portable
- As of SDK release 1.3.216.0, the VK_KHR_portability_enumeration extension support is included in the Vulkan Loader

Vulkan Loader Improvements

- **Improvements to assist developers in resolving difficult issues**
- **Loader Identification**
  - VK_LOADER_DEBUG=info (“all” will also identify the loader)
  - Identify loader version and where it was built from (Loader Git history)
- **Enhanced layer debugging**
  - VK_LOADER_DEBUG=layer
  - Identify which layers are enabled and their type (explicit vs. implicit)
- **Linux Consistent Device Ordering**
  - Consistent order of devices from run to run

For more details, see the LunarG white paper: ***1.3 Vulkan Loader Improvements***

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Synchronization Validation

- **By design, Vulkan is an explicit API**
  - The programmer must tell Vulkan when 2 commands depend on each other
  - This is done by defining barriers
  - **Execution Dependencies**
    - Most Vulkan commands are started in queue submission order but may execute in any order
    - Even commands using the same pipeline stages!
  - **Memory Dependencies**
    - GPUs have lots of caches and are accessed by pipeline stages

Synchronization Validation - Phase II

Phase I implementation (August 2020)

- Identifies resource access conflicts due to missing or incorrect synchronization operations between actions (draw, copy, dispatch, blit) reading or writing the same regions of memory
- Functionality includes commands within a single buffer

Phase II implementation (Available soon!)

- Same as phase I, but adding multiple command buffers
- Becoming available as I speak. Will be available as alpha quality in the next SDK delivery

See the SIGGRAPH BOF:

Vulkan Synchronization Validation: Tutorial and Update

- August 10, 8-9:30 AM Pacific

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In Summary…

- The benefits of using the Vulkan SDK
- The developer tools in the SDK
- New developer tools enabled over the last year
  - The Vulkan Profiles Tool set
  - VOLK - the meta-loader
  - AMD Memory Allocator - management of memory allocations and resources
  - Repackaged SDK for modularity and optional packages for download
  - Validation Layer Performance improvements over the last year
  - The Portability Enumeration extension
  - Vulkan Loader improvements
  - Phase II Synchronization Validation

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Questions?

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