3D Graphics with Vulkan and OpenGL

The Khronos Group
August 15, 2018
## Schedule

<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
<th>Presenters</th>
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<tr>
<td>2:00</td>
<td>Vulkan and OpenGL Updates</td>
<td>Tom Olson (Arm), Neil Trevett and Piers Daniell (NVIDIA)</td>
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<tr>
<td>2:40</td>
<td>Vulkan Shader Compiler Updates</td>
<td>Lei Zhang and Ehsan Nasiri (Google)</td>
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<td>3:10</td>
<td>Running OpenCL C Kernels on Vulkan for Fun and Profit</td>
<td>Eric Berdahl (Adobe)</td>
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<td>3:40</td>
<td>Vulkan: Mark My DWORDS</td>
<td>Hai Nguyen (Google)</td>
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<td>4:10</td>
<td>State of the Art Engines in Vulkan</td>
<td>Dan Baker (Oxide Games)</td>
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<td>4:45</td>
<td>Porting Unity to Vulkan</td>
<td>Mikko Strandborg (Unity)</td>
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<td>5:30</td>
<td>Khronos Networking Reception</td>
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Vulkan and OpenGL ES Updates

Vulkan Today and Tomorrow
- Tom Olson (Arm), Vulkan WG chair

Vulkan Portability Initiative
- Neil Trevett (NVIDIA) Khronos President and VPI TSG chair

OpenGL and OpenGL ES Update
- Piers Daniell (NVIDIA), OpenGL / OpenGL ES WG chair
Vulkan Today: Availability

Support from the major GPU vendors
Now standard in desktop driver drops

Hardware and Drivers

- AMD
- Arm
- ANV
- Broadcom
- Imagination
- Intel
- NVIDIA
- Qualcomm
- RADV
- VeriSilicon

Platforms

- Android
- Red Hat
- SteamOS
- Ubuntu
- Windows 7
- Windows 8
- Windows 10
- iOS
- macOS

Supported on the major open OSes
Hundreds of millions of Android devices
Game Engines

Vulkan rendering paths in most of the leading engines
Content is shipping on desktop

Vulkan-only AAA Titles on PC

AAA titles on Linux

Dota 2 on PC and macOS
It’s not just about games...

“PocketStudio is designed to allow filmmakers to easily create, play, and stream 3D animation sequences in real time using real-time collaborative editing, a unified workflow, and other real-time technologies, such as augmented reality”

https://s2018.siggraph.org/conference/conference-overview/real-time-live/

PocketStudio with Vulkan support
Featured at Realtime Live! - SIGGRAPH 2018
Content is shipping on Mobile too!

Plus....
Lineage 2 Revolution
Heroes of Incredible Tales
Dream League Soccer...
Breaking News: Fortnite on Vulkan on Android

Fortnite on Android uses Vulkan on select phones for optimal performance, including the best-performing Samsung - the Galaxy Note9.
Developer Activity - SDK

LunarG Vulkan SDK
Download rate increases every year since launch
http://vulkan.lunarg.com
Developer Activity - GitHub Projects

SIGGRAPH 2016

We've found 431 repository results

SIGGRAPH 2017

SIGGRAPH 2018

1,254 repository results

Trend over time

GitHub adds 2.5 Vulkan-related projects per day!
Vulkan Roadmap Philosophy

What do Vulkan developers need to be successful?

It’s not just about the specification...

- API and shading language functionality
- Ease of use, tools, support
- Implementation quality / reliability
- Availability on target hardware and platforms
- ...

Everything we do is driven by developer and ecosystem priorities
Challenge: Functionality

Vulkan 1.1 is here!

Multiview (KHR_Multiview)
- Render to multiple image views simultaneously

Multi-GPU support (KHR_device_group*)
- Transparent access to homogeneous multi-gpu systems

Advanced Compute Functionality (KHR_16bit_storage, KHR_variable_pointers, ...)
- Read and write 16-bit quantities stored in GPU memory; restricted pointers
- Subgroup operations

Better HLSL support (KHR_relaxed_block_layout)
- Match HLSL memory data layout constraints

Cross-process/API sharing (KHR_external_*)
- Share memory & sync primitives across API / process boundaries
Functionality: New KHR extensions

**KHR_draw_indirect_count**
- Source draw count parameter from a buffer in GPU-writable memory
- Greater flexibility for GPU-generated work

**KHR_8bit_storage**
- Allow 8-bit types in uniform and storage buffers
- Improved compute support (clspv etc)

**EXT_descriptor_indexing**
- Dynamically non-uniform (aka bindless) resource access
- KHR version in progress
Under Discussion

- Reduced precision arithmetic types
- Detailed driver property queries
- Variable-resolution rendering
- Device-independent performance counter queries
- Memory residency management
- Depth / Stencil resolve
- New synchronization primitives
- Ray tracing
- Video

... the list goes on

Everything we do is driven by developer and ecosystem priorities
Challenge: Tools - Validation

Changes in our validation workflow

- Working Group has begun handling basic validation for new KHR extensions
- Frees up LunarG to tackle more challenging validation cases
Validation: Coming Soon

GPU Assisted Validation
- Runtime resource access checking
  - EXT_descriptor_indexing (bindless) resource references
  - Array index and buffer offset validation

Synchronization Validation
- Validate synchronization valid usages as defined by specification
Challenge: Implementation Quality

Vulkan CTS investments

- Khronos’s largest engineering project
- Adding 100K test cases / year

Raising the bar

- Old tests are now withdrawn on a rolling basis

You can help!

- Raise issues and PRs at https://github.com/KhronosGroup/VK-GL-CTS
Challenge: Availability on closed platforms

- Vulkan Portability Initiative
  - Enable running a subset of Vulkan over another API via shim library
- MoltenVK shim available for macOS / iOS
  - Open source library: https://github.com/KhronosGroup/MoltenVK
- gfx-rs shim in development for multiple backends: inc. Metal and DX12
  - https://github.com/gfx-rs/portability
- macOS SDK
  - https://vulkan.lunarg.com/
- Give us feedback
  - https://khr.io/vulkanpifeedback
- Caveat Coder - WIP
  - Conformance test program in development
Challenge: Issues we don’t know about

This is where you come in...

- What (if anything) makes it hard for you to use Vulkan successfully?
- What are the most important problems for us to focus on?

We’ll take feedback anywhere, any time

- General issues: https://github.com/KhronosGroup/Vulkan-Ecosystem
- Spec issues: https://github.com/KhronosGroup/Vulkan-Docs
- SDK issues: LunarXchange (http://vulkan.lunarg.com)
- Here, on the street, slack, reddit, in the hotel bar, ...

We look forward to hearing from you!
Vulkan Platform Availability

Vulkan is available on Android 7.0+
Vulkan Portability Initiative

Enabling and accelerating the creation of tools and run-time libraries for Vulkan applications to run on platforms supporting only Metal or Direct3D

Porting Research
What % of Vulkan can be EFFICIENTLY supported by run-time layer over D3D and Metal

Vulkan Portability Extension
Standardizes app queries for Vulkan features NOT supported on library/platform combination

Multiple third party implementations
Of Vulkan Portability run-time libraries and tools

Portability Layers
DevSim Layer - develop and debug with the features of a Portability Library on a full Vulkan driver
Validation Layer - enforces use of Portability library features

Conformance Tests
Vulkan CTS will skip tests for missing functionality
Subsets cannot be officially conformant but functionality that is present must work!

Implementation and testing experience

Most functionality supported.
E.g. Metal 1.0 supports everything except:
- Triangle fans, Separate stencil reference masks, Vulkan Events, Allocation callbacks,
- some texture-specific swizzles
Metal 2.0 reduces this list

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Bringing Vulkan Apps to Apple Platforms Today

**V A L V E**

Dota 2 running on Mac up to 50% faster than native OpenGL

Open source SDK to build, run, and debug applications on macOS including validation layer support

First productions apps using MoltenVK already shipping on macOS and iOS

Beta release - working to pass all applicable conformance tests

Previously a paid product
Now released into OPEN SOURCE
Completely free to use - no fees or royalties - including commercial applications

**Applications**

**macOS / iOS Run-time**
Maps Vulkan to Metal

MoltenVK for macOS and iOS
For macOS 10.11, iOS 9.0 and up

**SPIRV-Cross**
Convert SPIR-V shaders to platform source formats

**Vulkan macOS SDK**
Valve - Vulkan Dota 2 on macOS

Dota 2 OpenGL vs Vulkan macOS

Shipping Now. Vulkan delivering up to 50% performance increase over native OpenGL

Frames Per Second (FPS) - Higher is Better

- AMD FirePro D500 Mac Pro (Late 2013): 75.5
- NVIDIA GT 650M Macbook Pro (Mid 2012): 35.9
- Intel Iris Pro Macbook Pro (Mid 2014): 42.2

OpenGL: 75.5, 35.9, 42.2
Vulkan: 102.8, 53.9, 47.7
gfx-rs

- Vulkan Portability over D3D, Metal, and OpenGL
  - D3D layer useful for Vulkan on UWP platforms such as Windows 10 S, Polaris, Xbox One
  - https://github.com/gfx-rs/gfx
  - https://github.com/gfx-rs/portability

Efficiently running Dota 2 on Mac - working to increase conformance coverage
Khronos Education Forum

Support educators to teach Khronos technologies!

Khronos Education Forum
Online Hub for collaboration
https://www.khronos.org/education
Shared course materials under permissive license
Open to all - no fees or membership required
Just send an email to education@khronos.org

Educators can connect to share and discuss course materials

Direct contact with Khronos working groups and industry for review and feedback

Oregon State University Graphics Class with Vulkan Ref Cards
OpenGL/ES Update

Piers Daniell
OpenGL and OpenGL ES WG Chair
August 15, 2018
OpenGL/ES Collaboration

OpenGL and OpenGL ES meetings merged

- Same chairperson for both groups
  - Piers Daniell (NVIDIA)
- OpenGL and OpenGL ES remain separate working groups
  - Market focus of each group remains the same
- Improved efficiency
  - Member overlap leveraged
OpenGL/ES Spec updates

OpenGL and OpenGL ES spec fixes

- Our primary activity over the last year
- OpenGL 4.6 and OpenGL ES 3.2 updated in June, 2018
- Extensive use of GitHub for easier collaboration with the community

GLSL and ESSL spec source merged

- Converted to asciidoc
- Improves maintainability and reduces divergence
- Newly generated specs released June, 2018
Happy Birthday OpenGL ES!

OpenGL ES celebrates 15 years

- OpenGL ES 1.0 shipped June 2003
- The most prolific 3D API ever and still growing!
- Ships on billions of devices
OpenGL ES 3.2 Adoption

OpenGL ES 3.2.5 Conformance Test Suite released

- Encapsulates multi-year Khronos investment
- Removes legacy testing code and is now 100% open source

OpenGL ES 3.2 adoption still growing

Data collected during a 7-day period ending on November 9, 2017

<table>
<thead>
<tr>
<th>OpenGL ES Version</th>
<th>Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.0</td>
<td>37.0%</td>
</tr>
<tr>
<td>3.0</td>
<td>45.5%</td>
</tr>
<tr>
<td>3.1</td>
<td>17.5%</td>
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Data collected during a 7-day period ending on July 23, 2018

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<th>Distribution</th>
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<tbody>
<tr>
<td>2.0</td>
<td>23.8%</td>
</tr>
<tr>
<td>3.0</td>
<td>31.7%</td>
</tr>
<tr>
<td>3.1</td>
<td>13.9%</td>
</tr>
<tr>
<td>3.2</td>
<td>30.6%</td>
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OpenGL ES Ecosystem

New vendor extensions registered

- GL_EXT_clip_control
- GL_EXT_texture_mirror_clamp_to_edge
- GL_MESA_tile_raster_order
- GL_QCOM_texture_foveated
- GL_MESA_program_binary_formats
- GL_NV_clip_space_w_scaling
- GL_NV_stereo_view_rendering
- GL_NV_conservative_raster_pre_snap
- GL_EXT_EGL_image_external_wrap_modes
- GL_EXT_texture_format_sRGB_override
- GL_INTEL_blackhole_render
- GL_EXT_EGL_image_storage
- GL_MESA_framebuffer_flip_y
- GL_AMD_framebuffer_multisample_advanced
OpenGL 4.6 Adoption

OpenGL 4.6 Conformance Test Suite released

- Initial release in January and updated in April
- Open-source available on GitHub
- Intel, NVIDIA and soon AMD are OpenGL 4.6 adopters
OpenGL Adoption

New OpenGL 4.3 Adopter

• Amazon Web Services, Inc. - Amazon EC2 Elastic GPUs
OpenGL Ecosystem

New vendor extensions registered

- GL_MESA_tile_raster_order
- GL_MESA_program_binary_formats
- GL_NV_conservative_raster_pre_snap
- GL_NV_conservative_raster_underestimation
- GL_AMD_gpu_shader_half_float_fetch
- GL_EXT_shader_framebuffer_fetch
- GL_EXT_shader_framebuffer_fetch_non_coherent
- GL_INTEL_blackhole_render
- GL_EXT_EGL_image_storage
- GL_AMD_framebuffer_multisample_advanced
NVIDIA OpenGL Update

New Turing Extensions coming soon

- Variable Rate Shading
- Texture Space Shading
- New Shader Extensions
- And more…
NVIDIA Demos

Khronos Networking Reception 5:30pm

- Vulkan Raytracing with Turing
- Nsight Graphics with Vulkan Raytracing support