MoltenVK

Layering Vulkan Over Metal

Vulkanised 2023

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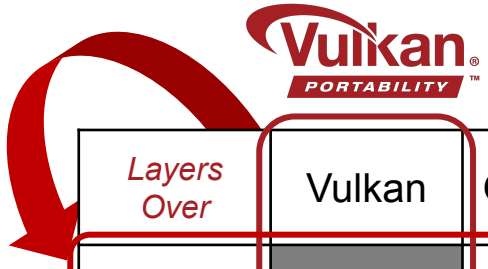
A Brief History of MoltenVK

BRENWILL		
COCOS3D	2011	OpenGL ES2 game engine Objective-C
MoltenGL	2015	OpenGL ES2 over Metal Objective-C
MoltenVK	2016	Vulkan over Metal C++
VALVE KHRONOS GROUP	2018	Open-source MoltenVK
CODE WEAVERS SOFTWARE LIBERATORS	2018	

Open-Source Layering Projects

Fighting Platform Fragmentation



Layers Over	Vulkan	OpenGL	OpenCL	OpenGL ES	DX12	DX9-11
Vulkan		Zink	clspv + clvk	Angle	vkd3d-Proton vkd3d	DXVK WineD3D
OpenGL	Ashes			Angle		WineD3D
DX12	Microsoft Dozen	Microsoft 'GLOn12'	Microsoft 'CLOn12'			Microsoft D3D11On12
DX11	Ashes			Angle		
Metal	MoltenVK		clspv + SPIRV-Cross?	MoltenGL Angle		

Vulkan as porting target for multiple APIs

ROWS: Bring more APIs to Platforms

Vulkan functionality available everywhere

COLUMNS: Making APIs available across platforms

MoltenVK Current Status (Feb 2023)

- Supports Vulkan 1.2 + extensions
- Embedded in the macOS Vulkan SDK LUNARG
- Key component of the Vulkan Portability Initiative
- Currently undergoing extensive ongoing activities to reduce CTS failures, ideally to zero to accomplish Vulkan conformance.
- Other improvements come from bug reports and enhancement requests posted to the MoltenVK GitHub repository issues list.

  https://github.com/KhronosGroup/MoltenVK/issues

KHRONOS GROUP

MoltenVK Functionality

- **Open-source project with a small dedicated team**
  - Working hard to minimize the unavoidable delay to integrate new Vulkan functionality
  - Additional contributors/contributions always welcome!

- **Supports almost all Vulkan 1.2 + extensions**
  - Main Vulkan specification is at 1.3 + more extensions

- **Development prioritizes functionality needed for games**
  - Most games find all the Vulkan functionality they need

- **Some titles do hit functionality limits**
  - AAA titles pushing tech and spec limits
  - Binary ports or emulators originating in DirectX
  - Functional limits of the underlying Metal API

- **Working towards 100% Vulkan Portability Conformance**
  - Vulkan 1.0 CTS: 174K pass, 0.2K fail (0.15%)
  - Vulkan 1.2 + extns CTS: 322K pass, 10K fail (3.2%)
  - Most failures are now edge cases with available workarounds

MoltenVK Performance

- **MoltenVK is a layered implementation of Vulkan on Metal, which adds some unavoidable memory and performance overhead**

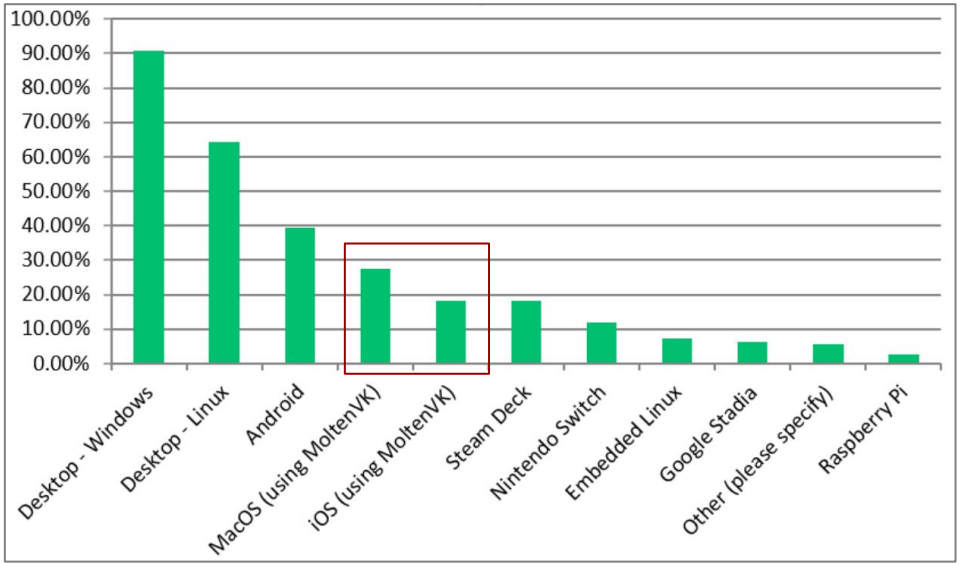
- **Metal is a higher-level API than Vulkan**
  - Not always a 1:1 mapping between Vulkan & Metal calls and functionality
  - Metal lacks some of the fine-tuning performance controls of Vulkan

- **Transpiling shaders from SPIR-V to MSL can sometimes introduce shader inefficiencies (vs hand-tuned shader code)**

- **We are committed to improving performance when made aware of it**
  - Performance issues often only show up in particular game contexts, depending on how a game's use of Vulkan maps to Metal

- **Some titles hit performance limits**
  - AAA titles pushing tech and spec limits
  - Binary ports or emulators originating in DirectX
  - Some issues solvable with MoltenVK development focus
  - Some issues hit performance effects described above

ISVs Shipping with MoltenVK on Apple



Commercial Vulkan Developers

From LunarG 2021 Developer Survey

AUTODESK® FUSION 360™

CODE WEAVERS SOFTWARE LIBERATORS

NAP

FINAL FANTASY XIV ONLINE

DOTA UNDERLORDS

Diligent Graphics

WINE

ARTIFACT

Qt

DOTA 2

FORSAKEN REMASTERED

Filament

RPCS3

Using MoltenVK

Testing 15 games with MoltenVK support
https://youtu.be/xDGQcjqpYqI

- **Games shipping with MoltenVK:**
  - DOTA 2
  - Metro Exodus
  - Final Fantasy XIV
  - Dark Souls: Remastered
  - Dark Souls III
  - DOTA Underlords
  - Aerofly Flight Simulator 2
  - Path of Exile
  - Raft
  - The Elder Scrolls Online
  - Celeste
  - Transport Fever 2
  - Shadow Warrior 2
  - Streets of Rage 4
  - Jupiter Hell
  - Wreckfest
  - Victoria 3
  - Artifact
  - GZDOOM
  - vkQuake & vkQuake2
- **Games runnable by users via Crossover and MoltenVK:**
  - Halo: Combat Evolved
  - God of War (2018)
  - Grand Theft Auto V
  - World Of Tanks
  - Forsaken Remastered
  - Elder Scrolls V Skyrim: SE
  - Guild Wars 2
  - Battlefield 1
  - Battlefront II
  - Age of Empires II: Definitive Edition
  - Witcher 3
- **Applications shipping with MoltenVK:**
  - Autodesk Fusion 360
- **Engines using MoltenVK:**
  - Google Filament
  - Defold
  - Ultra Engine
  - Diligent Engine
  - Blender Vulkan (PoC)
  - ncnn
  - Clausewitz Engine (Paradox)
- **Platform emulators using MoltenVK:**
  - VKD3D (Direct3D 12)
  - DXVK (Direct3D 9/10/11)
  - Google Android Emulator
  - Dolphin (Wii & GameCube)
  - Ryujinx (Switch)
  - Cemu (Wii U)
  - RPCS3 (PS3)
  - PCSX2 (PS2)

MoltenVK and Metal 3

- Buffer device address (`VK_KHR_buffer_device_address`)
- Improved descriptor indexing support on macOS and iOS via significant argument buffer enhancements.
- Mesh shaders
- Geom shaders and faster Tess shaders via Mesh shaders