KHRONOS™ GROUP

Standards update and liaison report

January 2019

Original Slides are written by
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www.khronos.org

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Over 140 members worldwide
Any company is welcome to join

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AMD, Apple, arm, Epic Games, Google, Huawei, Imagination, Intel, NVIDIA, Qualcomm, Samsung, Sony, Valve, VeriSilicon

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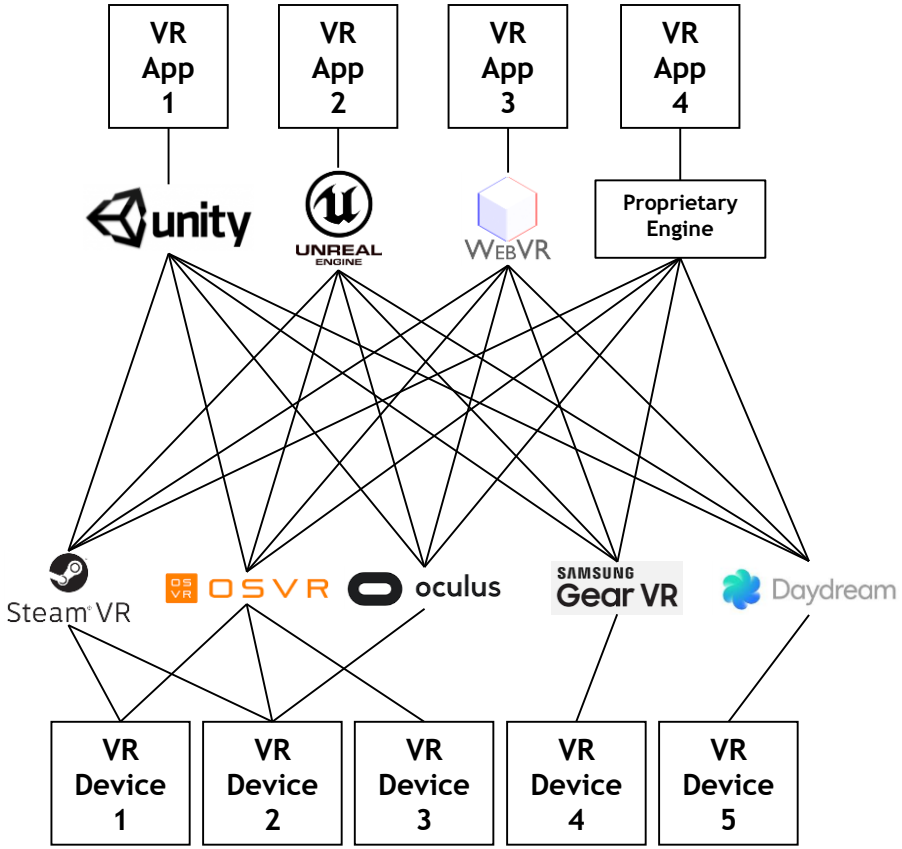
Topics

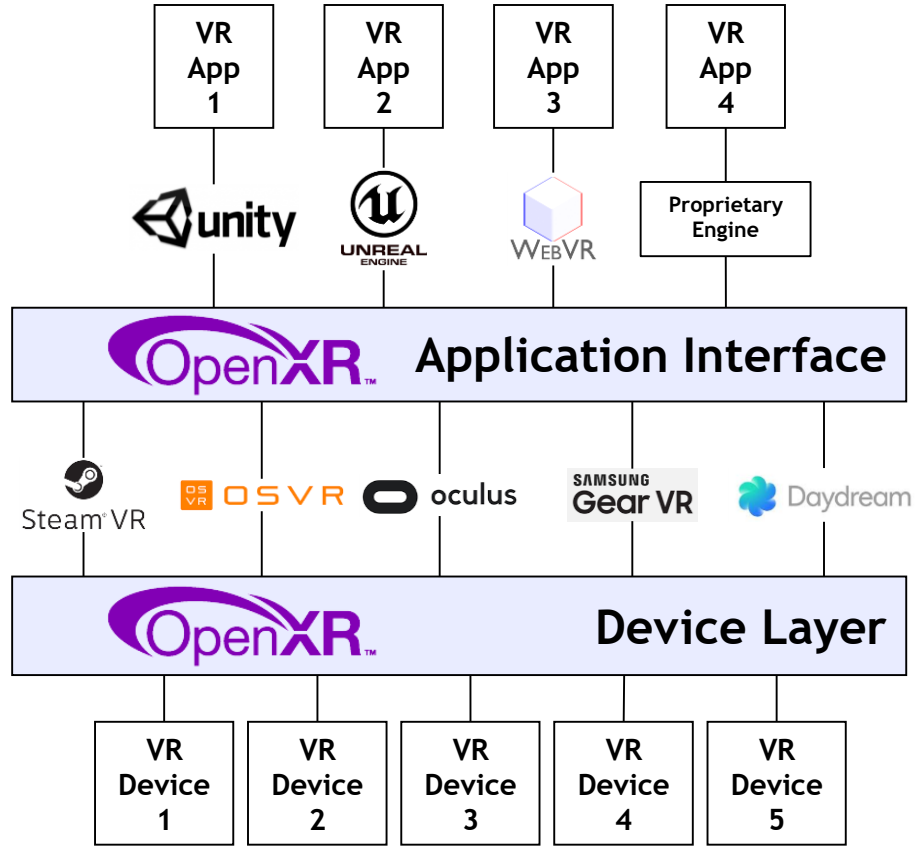
- **OpenXR first public demonstrations**
  - StarVR and Microsoft Windows Mixed Reality headsets
- **NNEF 1.0 released at SIGGRAPH**
  - Neural Network Exchange Format for machine learning
- **Khronos Educators Program launch**
  - Shared creation and refinement of course materials
- **3D API ecosystem progress**
  - Vulkan 1.1, OpenGL 4.6, OpenGL ES 3.2, WebGL 2.0
  - Porting Vulkan apps to closed platforms
- **glTF Widespread Industry Adoption**
  - Working on Texture Transmission extension
- **Liaison Report**

OpenXR - Solving VR Fragmentation



Before OpenXR

VR Market Fragmentation



After OpenXR

Wide interoperabilityof VR apps and devices

Companies Publicly Supporting OpenXR

OpenXR is a collaborative design

1) For cross-platform XR portability - VR in V1.0, then add AR

2) Integrating many lessons from proprietary 'first-generation' API designs

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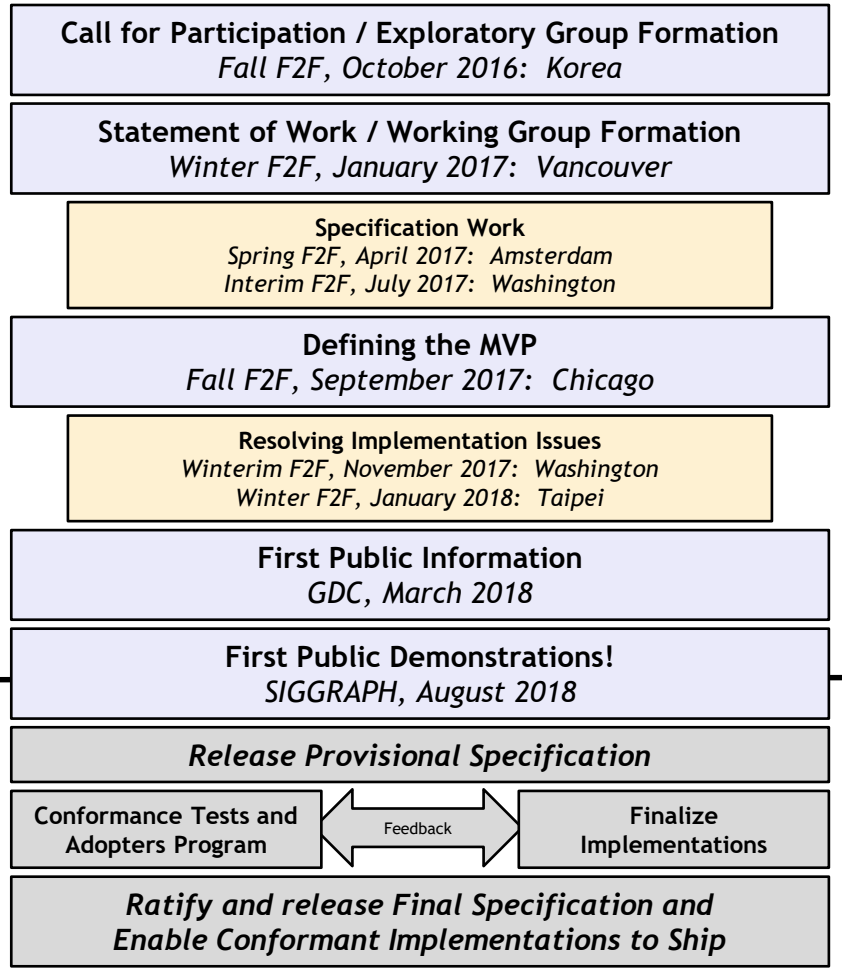
OpenXR Development Process



Present Day

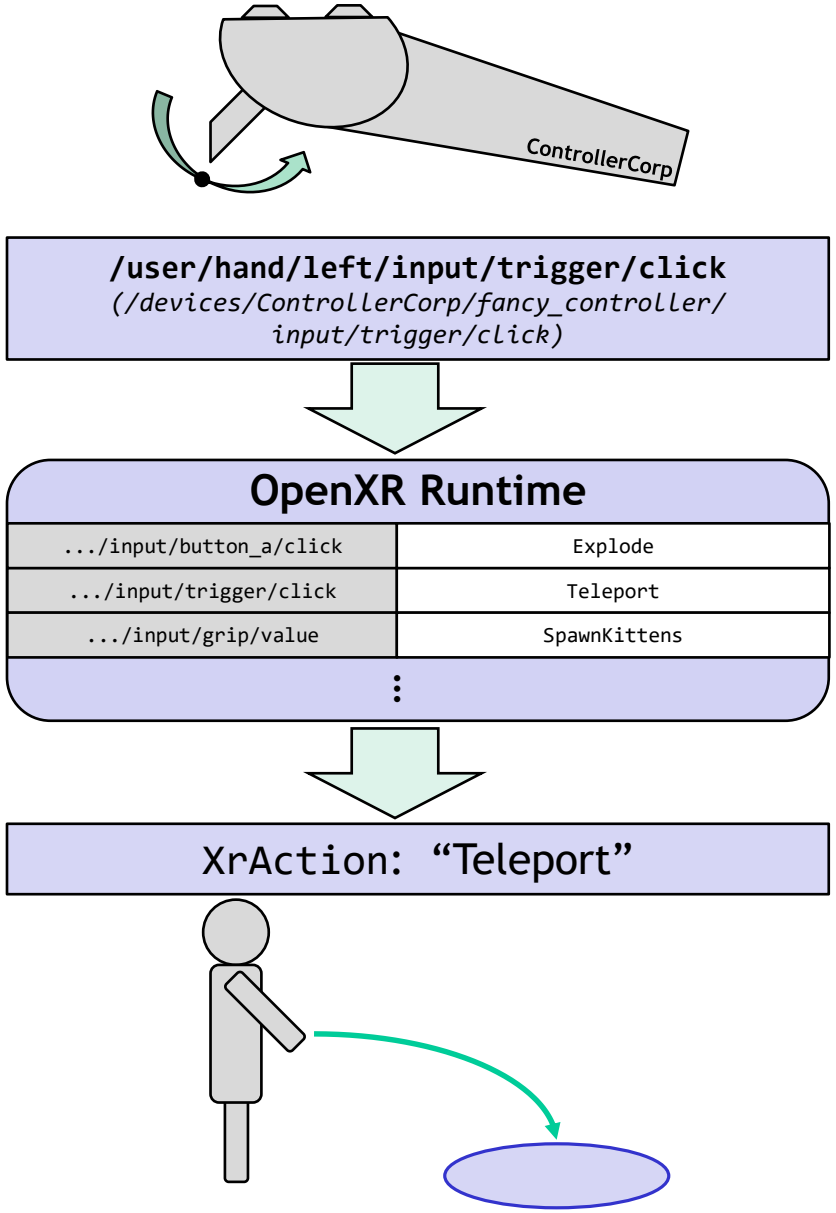
Coming Soon

Much more detailed specification overview and GDC session videos:
https://www.khronos.org/developers/library/2018-gdc

Implementations Underway!
Specifications will incorporate implementation experience

Input and Haptics

- **Input uses abstracted Input Actions**
  - E.g. “Move,” “Jump,” “Teleport”
- **Many advantages**
  - Existing content can easily use new devices
  - Mix-and-match multiple input sources to create a unified UI
  - Easy optional feature support (e.g. eye and body tracking)
  - Future-proofing for innovation in input devices and form factors

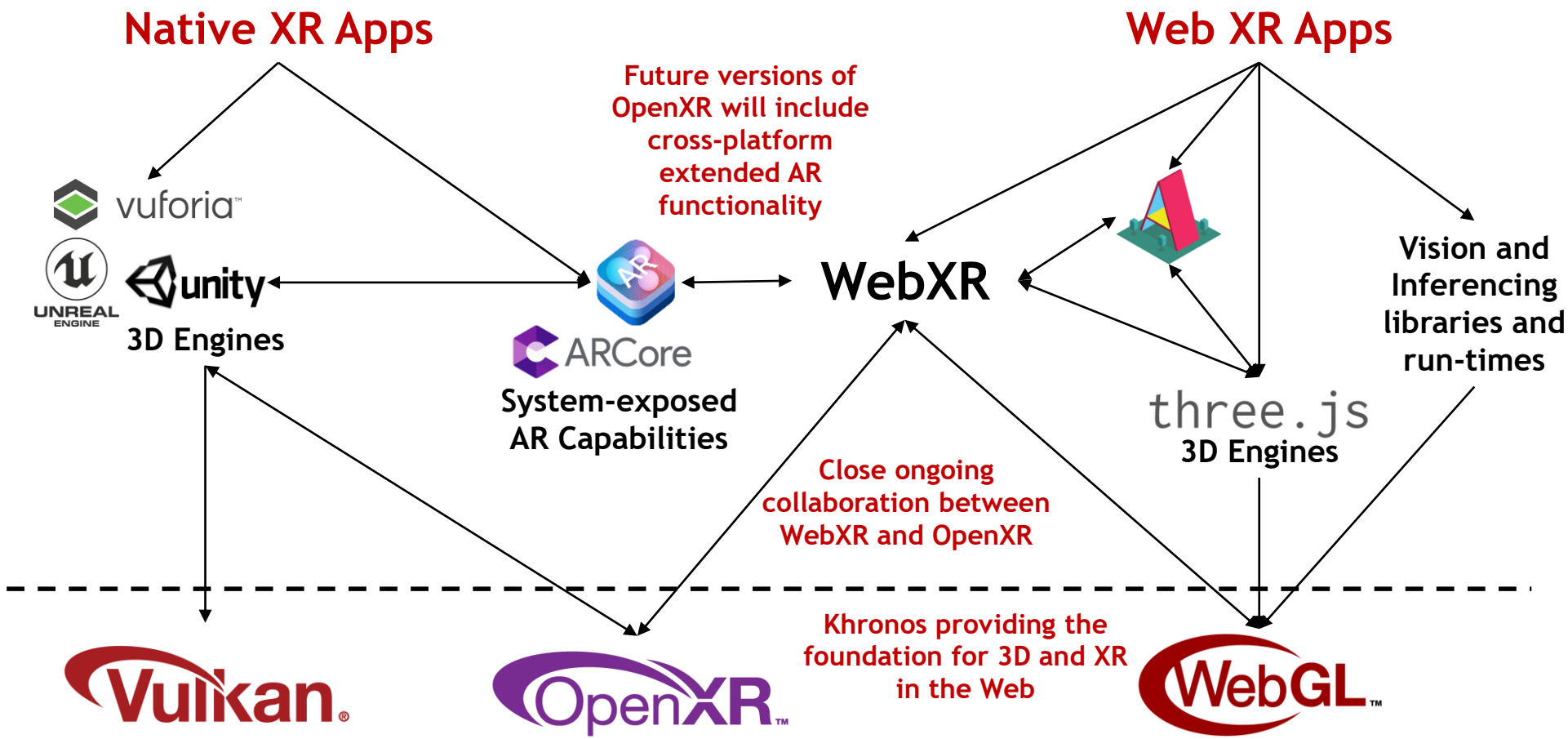


OpenXR Viewport Configurations

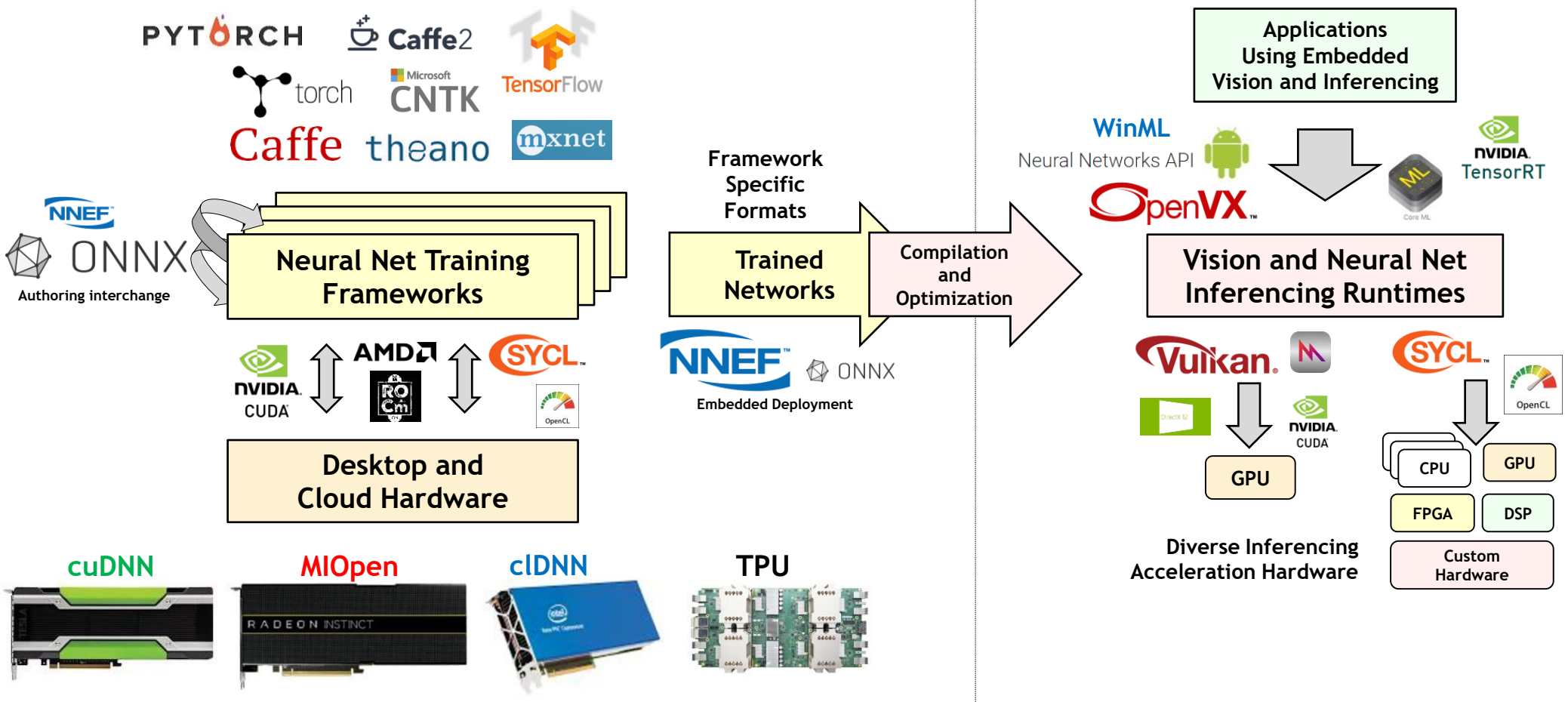
- **Applications can:**
  - Query for runtime supported Viewport Configurations
  - Applications can then set the Viewport Configurations that they plan to use
  - Select and change their active configuration over the lifetime of the session

Camera Passthrough AR	Stereoscopic VR / AR	Projection CAVE
		
		Photo Credit: Dave Pape
One Viewport	Two Viewports (one per eye)	Twelve Viewports (six per eye)
`/viewport_configuration/ar_mono/magic_window`	`/viewport_configuration/vr/hmd`	`/viewport_configuration/vr_cube/cave_vr`

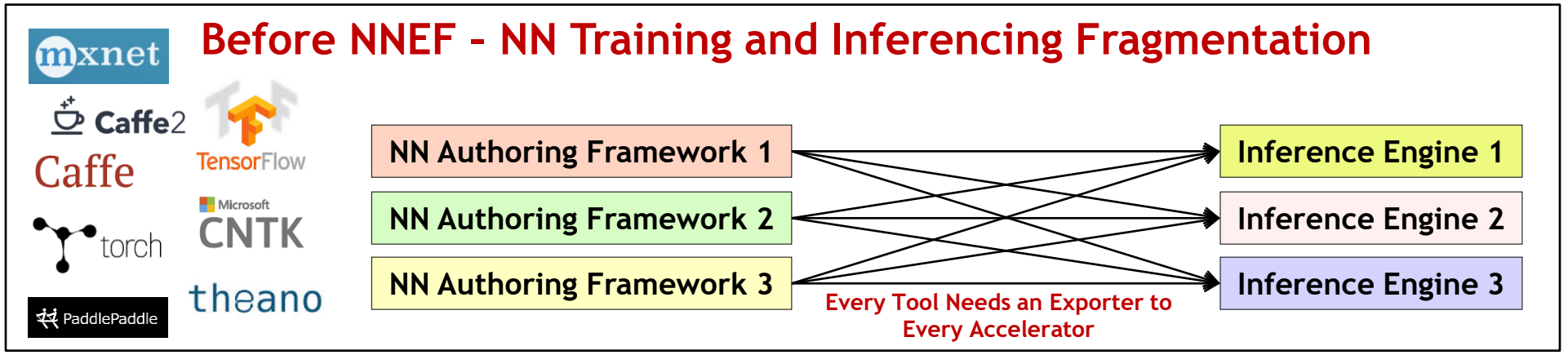
Layered XR Ecosystems

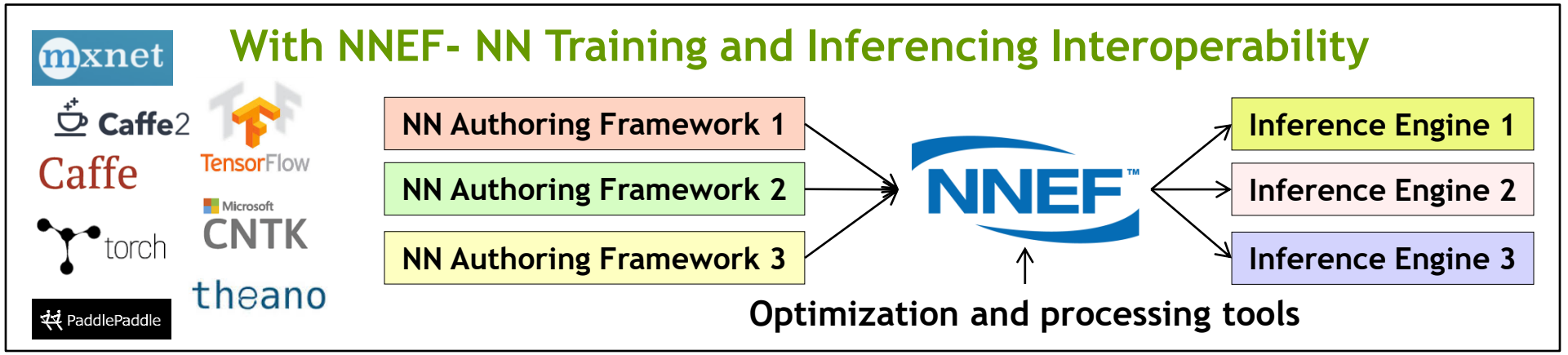


Neural Network Workflow

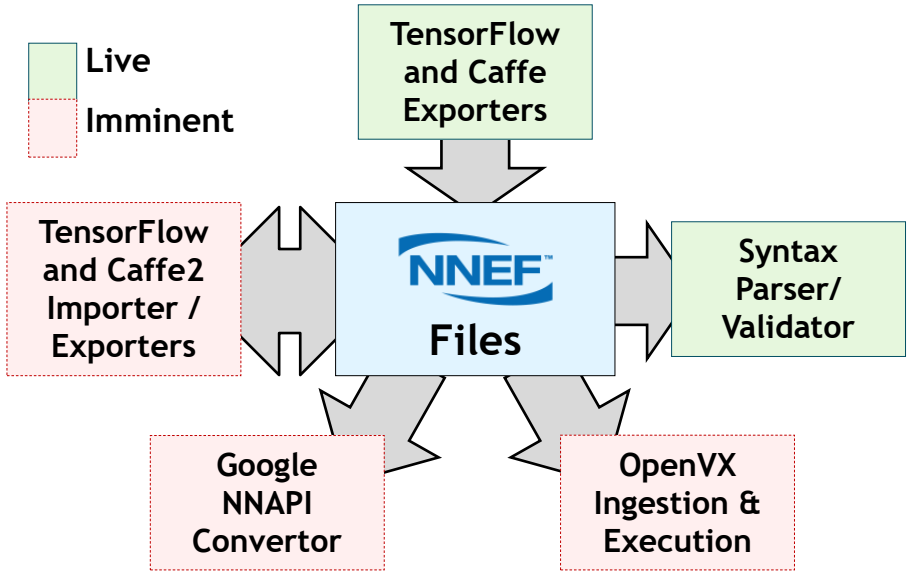


NNEF - Solving Neural Net Fragmentation





NNEF Ecosystem



NNEF open source projects hosted on Khronos NNEF GitHub repository
Apache 2.0 license
https://github.com/KhronosGroup/NNEF-Tools

NNEF = Neural Network Exchange Format

NNEF V1.0 released at SIGGRAPH!!
After positive industry feedback on Provisional specification released in December 2017

Comparing Neural Network Exchange Industry Initiatives

NNEF	ONNX
Defined Specification	Open Source Project
Stability for hardware deployment	Software stack flexibility
Multi-company Governance	Initiated by Facebook
Flexible Precision	32-bit Floating Point only
Flat and Compound Ops	Flat Ops Only

Vulkan and New Generation GPU APIs

Non-proprietary, royalty-free open standard 'By the industry for the industry'
Portable across multiple platforms - desktop and mobile
Modern architecture | Low overhead| Multi-thread friendly
EXPLICIT GPU access for EFFICIENT, LOW-LATENCY, PREDICTABLE performance

Vulkan is available on Android 7.0+

Pervasive Vulkan

Vulkan®

Major GPU Companies supporting Vulkan for Desktop and Mobile Platforms

AMD arm BROADCOM Imagination intel NVIDIA QUALCOMM VeriSilicon

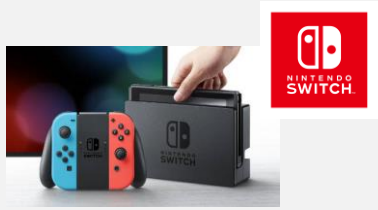
http://vulkan.gpuinfo.org/

Platforms

Desktop

Mobile
(Android 7.0+)

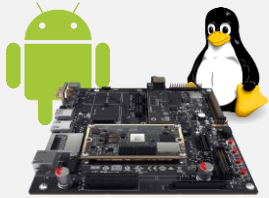
Media Players



Consoles

Virtual Reality

Cloud Services



Embedded

Game Engines

VALVE id CRYENGINE unity EPIC GAMES Croteam Serious Engine XENKO™

Vulkan 1.1 Launch and Ongoing Momentum

Strengthening the Ecosystem

Improved developer tools (SDK, validation/debug layers)
More rigorous conformance testing
Shader toolchain improvements (size, speed, robustness)
Shading language flexibility - HLSL and OpenCL C support
Vulkan Public Ecosystem Forum

February 2016
Vulkan 1.0

Explicit Access to GPU Acceleration

Vulkan 1.0 Extensions

Maintenance updates plus additional functionality

Explicit Building Blocks for VR:
e.g. multiview
Explicit Building Blocks for Homogeneous Multi-GPU
Enhanced Windows System Integration
Increased Shader Flexibility:
16 bit storage, Variable Pointers
Enhanced Cross-Process and Cross-API Sharing

March 2018
Vulkan 1.1

Integration of 1.0 Extensions.
New Technology into Core e.g.
Subgroup Operations

Building Vulkan's Future

Deliver complete ecosystem - not just specs
Listen and prioritize developer needs
Drive GPU technology

Released Vulkan 1.1 Extensions

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

KHR_8bit_storage
8-bit types in uniform and storage buffers for improved compute support in apps such as inferencing and vision

EXT_descriptor_indexing
Dynamically non-uniform (aka bindless) resource access
Required by some modern game engine architectures

Discussions in Flight

Reduced precision arithmetic types
FP16 and int8 arithmetic for reduced power and improved performance

Detailed driver property queries
Query vendor (e.g. IHV vs open source), conformance status

Variable-resolution rendering
E.g. foveated rendering for VR / AR

...and many others under investigation
Perf counter access, memory management, depth/stencil resolve, ray tracing, video, new sync primitives...

Widening Platform Support

Pervasive GPU vendor native driver availability
Open source drivers - ANV (Intel) and RADV and AMDVLK (AMD)
Port Vulkan apps to macOS/iOS and DX12

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Content is shipping on desktop…

Vulkan-only AAA Titles on PC

Dota 2 on PC and macOS

AAA titles on Linux

FERAL
MAKE YOUR PLAY

KHRONOS GROUP

…and Mobile

Plus….
Lineage 2 Revolution
Heroes of Incredible Tales
Dream League Soccer…

FLARE GAMES
COATSINK
SUPER EVIL MEGACORP
netmarble Games
NEXON
CODEMASTERS
DIGITAL LEGENDS

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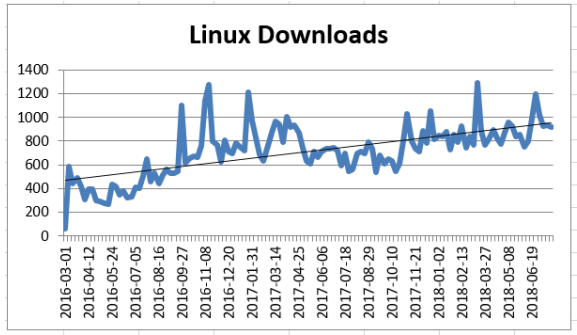
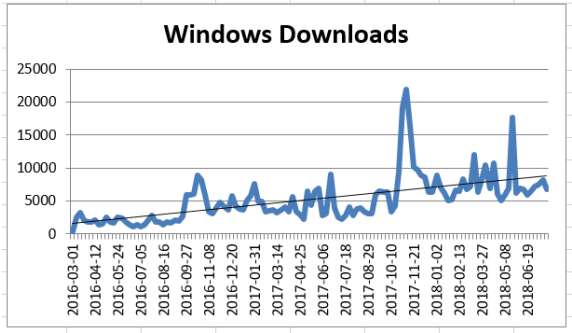
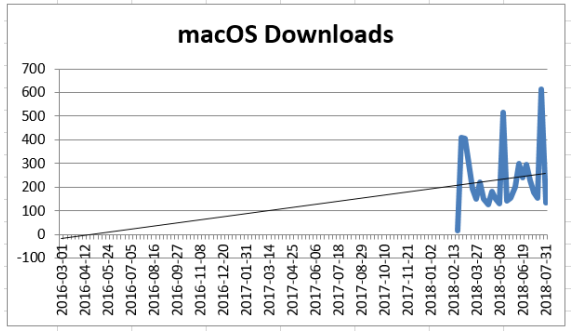
Vulkan Developer Activity - SDK and GitHub

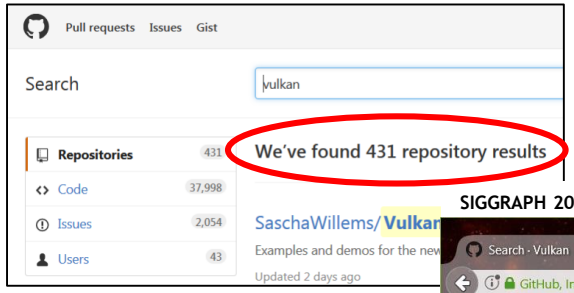
LunarG Vulkan SDK
Download rate increases every year since launch
http://vulkan.lunarg.com



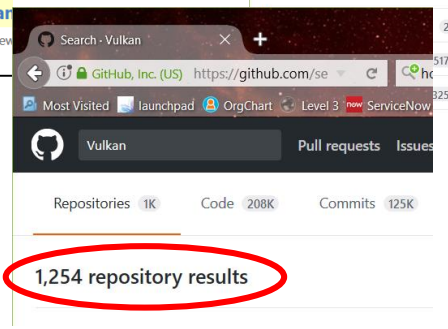




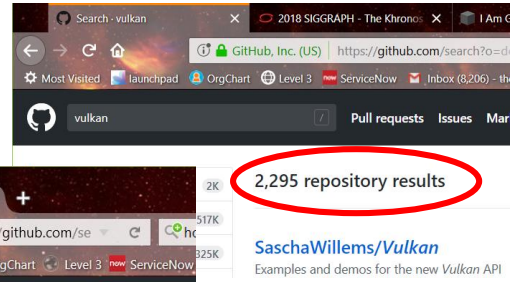
SIGGRAPH 2016



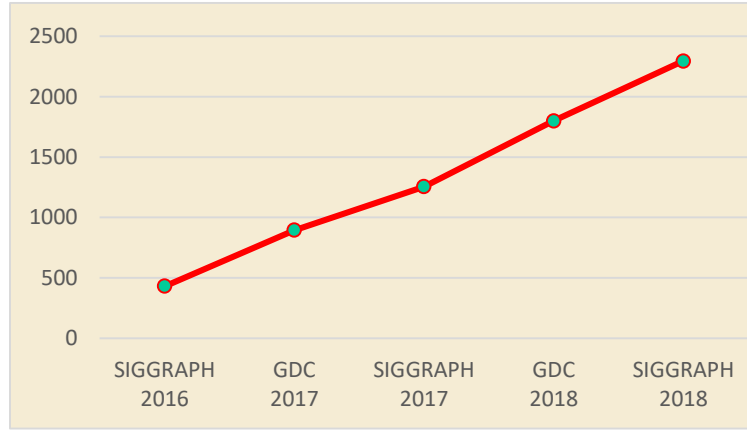
SIGGRAPH 2017



SIGGRAPH 2018

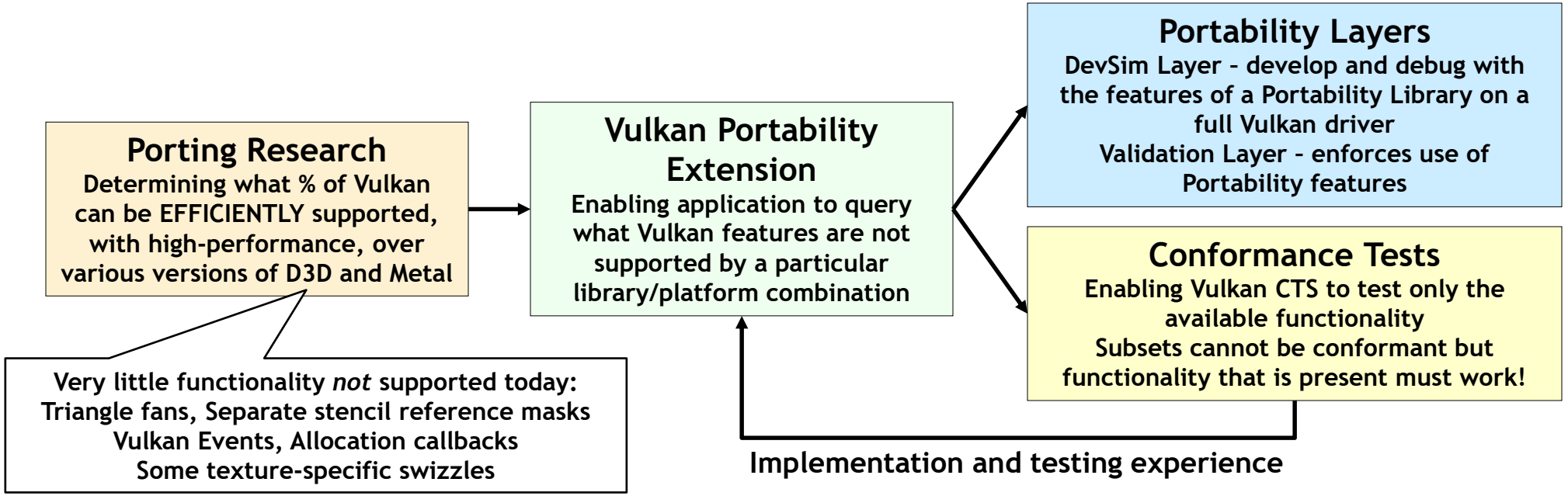


Vulkan Related GitHub Repos

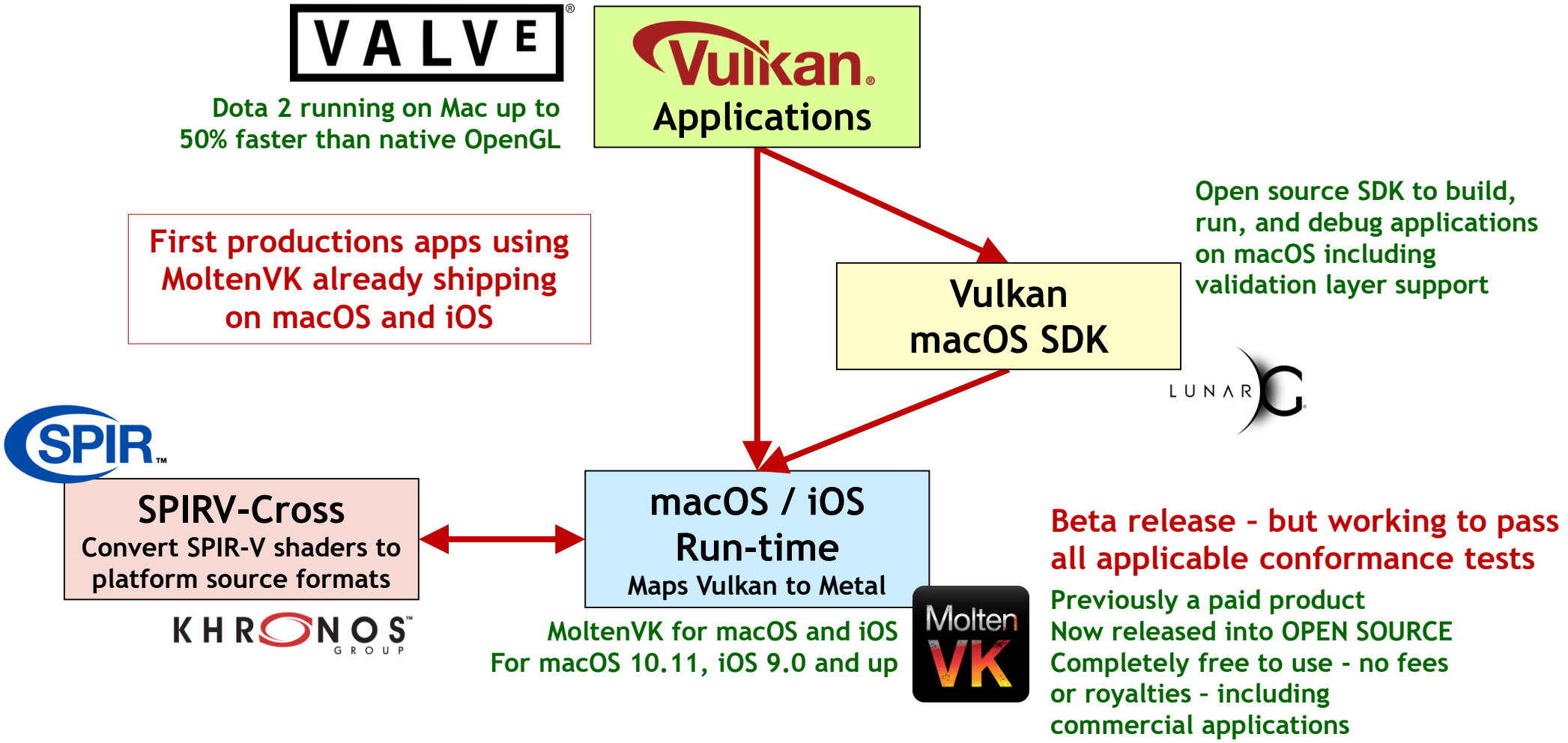


Vulkan Portability Initiative

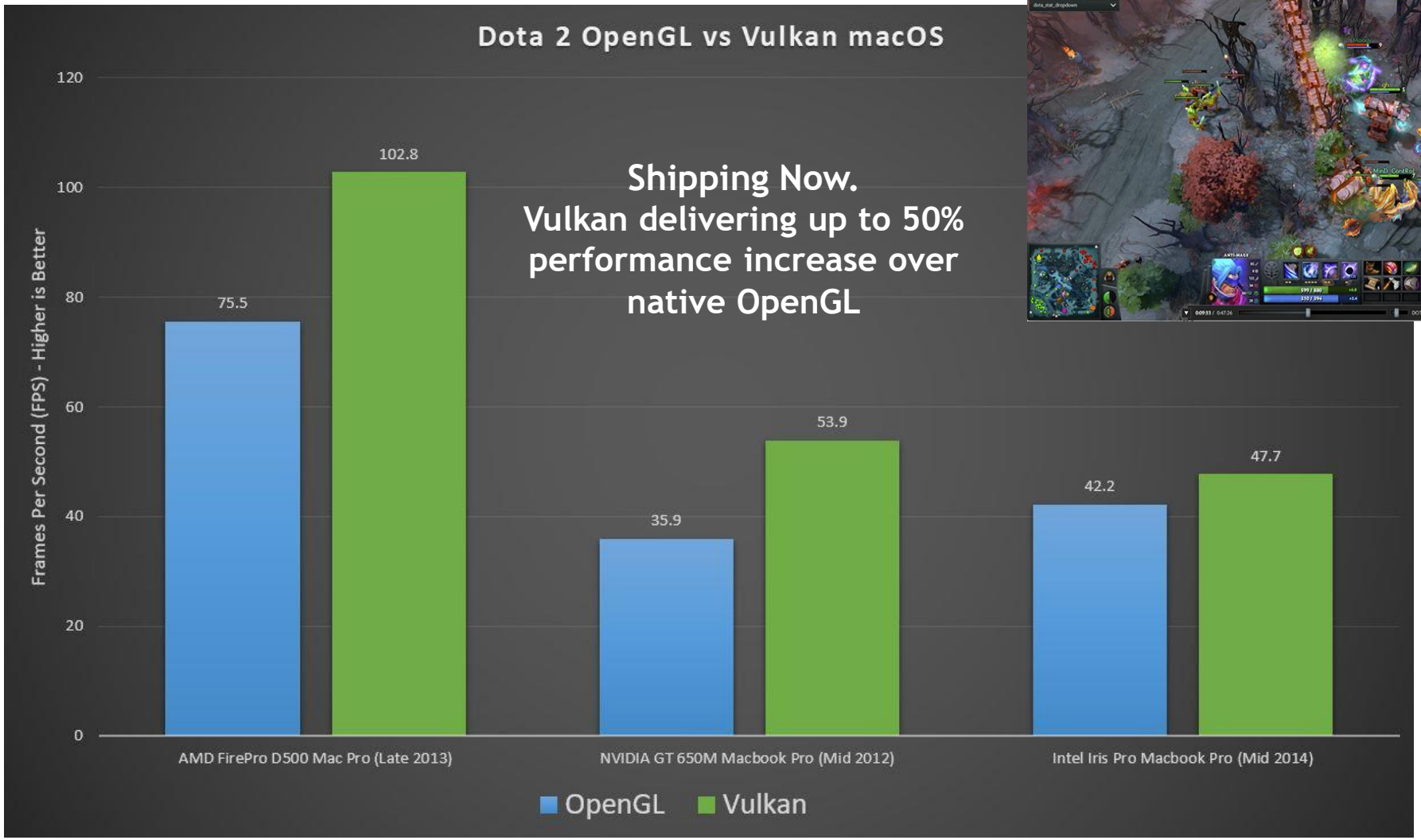
Enabling and accelerating the creation of tools and run-time libraries for Vulkan applications to run on platforms supporting only Metal or Direct3D



Bringing Vulkan Apps to Apple Platforms Today



Valve - Vulkan Dota 2 on macOS



OpenGL and OpenGL ES

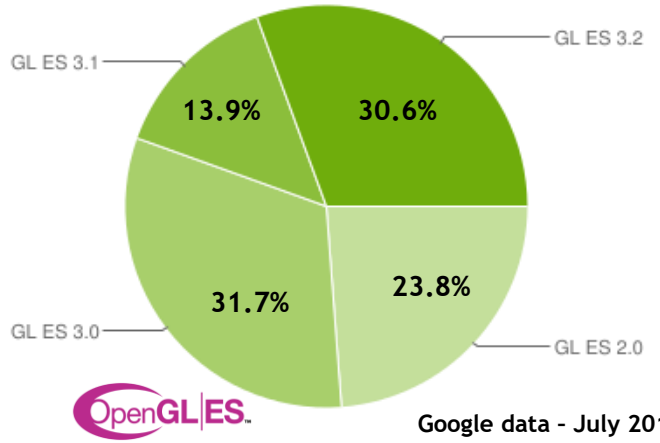
January 2018
OpenGL 4.6 conformance test suite released in open source
Intel and NVIDIA released conformant OpenGL 4.6 drivers

April 2018
OpenGL 4.6.0.1 CTS bugfix update released in April

June 2018
OpenGL ES CTS 3.2.5.0 released in open source
Raises the quality bar for OpenGL 3.2 implementations

15 YEARS

OpenGL ES still the most prevalent 3D API (billions of units!)
More conformant products added
OpenGL ES 3.2 adoption increasing



Google data - July 2018

Working Group Meetings Merged under one Chairperson for Improved Efficiency
GLSL and ESSL specs merged and migrated from LibreOffice to AsciiDoctor to improve maintainability and reduce divergence
OpenGL 4.6, OpenGL ES 3.2, GLSL 4.60 and ESSL 3.20 specs June 2018
Lots of bug fixes - many leveraged from open GitHub projects

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OpenGL ES and WebGL Evolution

Pervasive OpenGL ES 2.0
OpenGL and OpenGL ES ships on every desktop and mobile OS
3D on the Web is enabled!

Mobile Graphics
Programmable Vertex and Fragment shaders

Desktop Graphics
Textures: NPOT, 3D, Depth, Arrays, Int/float
Objects: Query, Sync, Samplers
Seamless Cubemaps, Integer vertex attributes
Multiple Render Targets, Instanced rendering
Transform feedback, Uniform blocks
Vertex array objects, GLSL ES 3.0 shaders

Compute Shaders

Advanced Graphics
Tessellation and geometry shaders
ASTC Texture Compression
Floating point render targets
Debug and robustness for security

2007 OpenGL ES 2.0

2012 OpenGL ES 3.0

2014 OpenGL ES 3.1
Compute Shaders

2015 OpenGL ES 3.2

WebGL

4 years

2011
WebGL 1.0

WebGL 2.0 Compute Context
Multiview extension

Work in Progress

5 years

March 2017
WebGL 2.0

Conformance Testing is vital for Cross-Platform Reliability
WebGL 2.0 conformance tests are very thorough 10x more tests than WebGL 1.0 tests

WebGL Momentum - WebGL 2.0 is Here!

Adobe

FLASH & THE FUTURE OF INTERACTIVE CONTENT

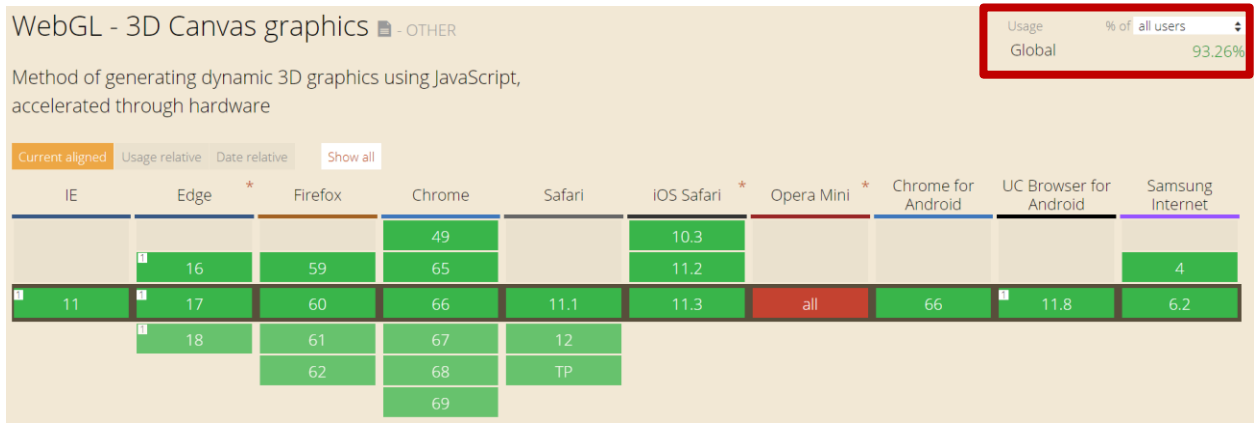
POSTED BY ADOBE CORPORATE COMMUNICATIONS ON JULY 25, 2017

Subscribe

Adobe has long played a leadership role in advancing interactivity and creative content – from video, to games and more – on the web. Where we've seen a need to push content and interactivity forward, we've innovated to meet those needs. Where a format didn't exist, we invented one – such as with Flash and Shockwave. And over time, as the web evolved, these new formats were adopted by the community, in some cases formed the basis for open standards, and became an essential part of the web.

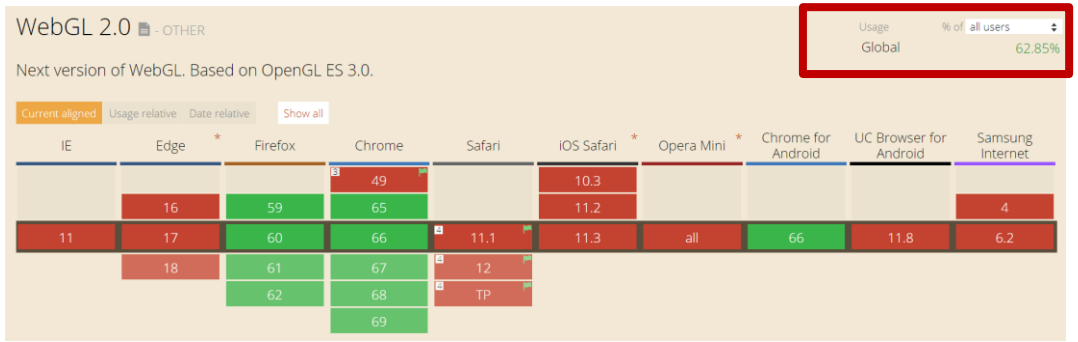
But as open standards like HTML5, WebGL and WebAssembly have matured over the past several years, most now provide many of the capabilities and functionalities that plugins pioneered and have become a viable alternative for content on the web. Over time, we've seen helper apps evolve to become plugins, and more recently, have seen many of these plugin capabilities get incorporated into open web standards. Today, most browser vendors are integrating capabilities once provided by plugins directly into browsers and deprecating plugins.

92.13% Globally



http://caniuse.com/#feat=webgl

67.59% Globally



WebGL™

WebGL 2.0 brings Desktop-class graphics to the Web
The time to create a new class of Web-based 3D Apps is now!

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Ecosystem = API + File Format

	Run-time APIs	File Formats
3D Graphics	Vulkan, WebGL	glTF
Heterogenous Compute (Parallel Processing)	OpenCL, SYCL, Vulkan	SPIR
VR and AR Vision and Inferencing	OpenVX, OpenXR	NNEF

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JSON (ISO/IEC 21778:2017, ECMA 404)

- X3D, glTF already use it

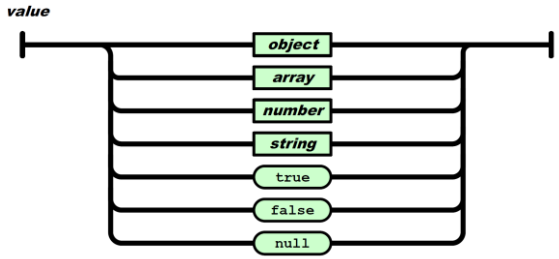


Figure 1 — value

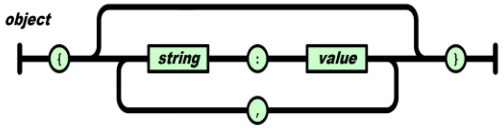


Figure 2 — object

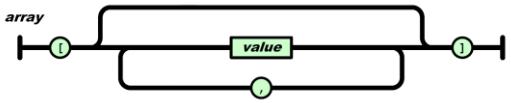


Figure 3 — array

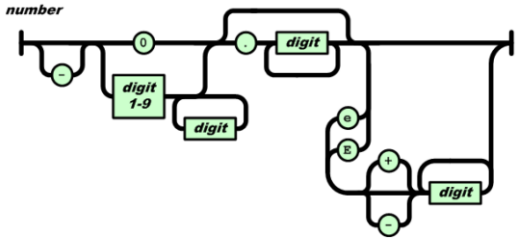
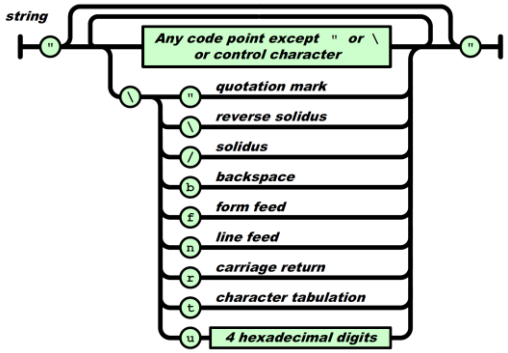
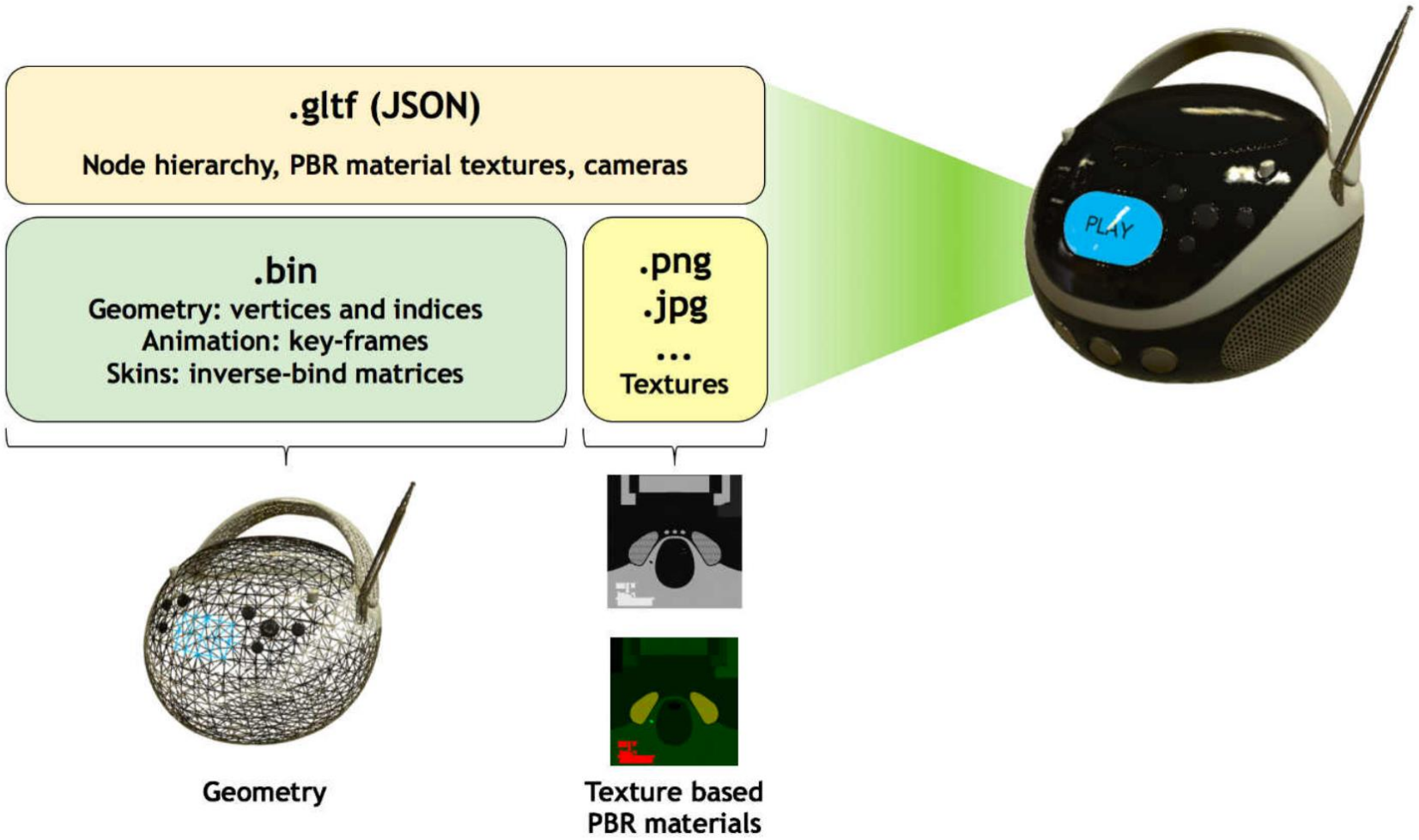


Figure 4 — number



glTF for IS



glTF - Cross-Platform 3D Asset Transmission

Audio	Video	Images	3D
MP3	H.264	JPEG	glTF
napster	YouTube	facebook	New market opportunities for 3D content creation and deployment!

All glTF spec development on open GitHub:
https://github.com/KhronosGroup/glTF

WebGL · DirectX 12 · Vulkan

glTF

- Compact to Transmit ✓
- Fast to Load ✓
- Describes Full Scenes ✓
- Runtime Neutral ✓
- Open and Extensible ✓

OpenGL Transmission Format
Efficient transmission of 3D scenes and assets

glTF

WebGL

glTF 1.0 - Primarily for WebGL
Uses GLSL for materials
Released December 2015

glTF 2.0 - Physically Based Rendering
Metallic-Roughness and Specular-Glossiness Materials
Rendering API independence
Released @ Web3D 2017

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glTF Ecosystem

Creation Tools

blender™ SketchUp PiXYZ SOFTWARE Archilogic MARMOSET TOOLBAG Adobe SUBSTANCE PAINTER MINECRAFT Sony 3D Creator UNBOUND Modo Oculus medium Paint 3D instant3Dhub SIMPLYGON Assimp Open Asset Import Library SAFE SOFTWARE

Repositories

TURBOSQUID Sketchfab Remix 3D Poly poly.google.com

Users

Bentley Continental OGC otoy NVIDIA

Apps and Engines

UNREAL ENGINE unity Office facebook three.js babylon.JS GODOT Game engine PLAYCANVAS Windows Mixed Reality Home A-FRAME CESIUM AUTODESK FORGE UX3D ENGINE xeogl React VR JANUSVR

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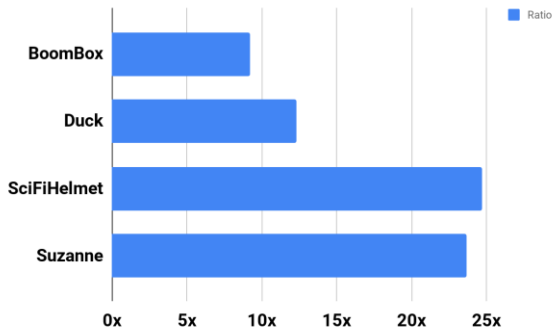
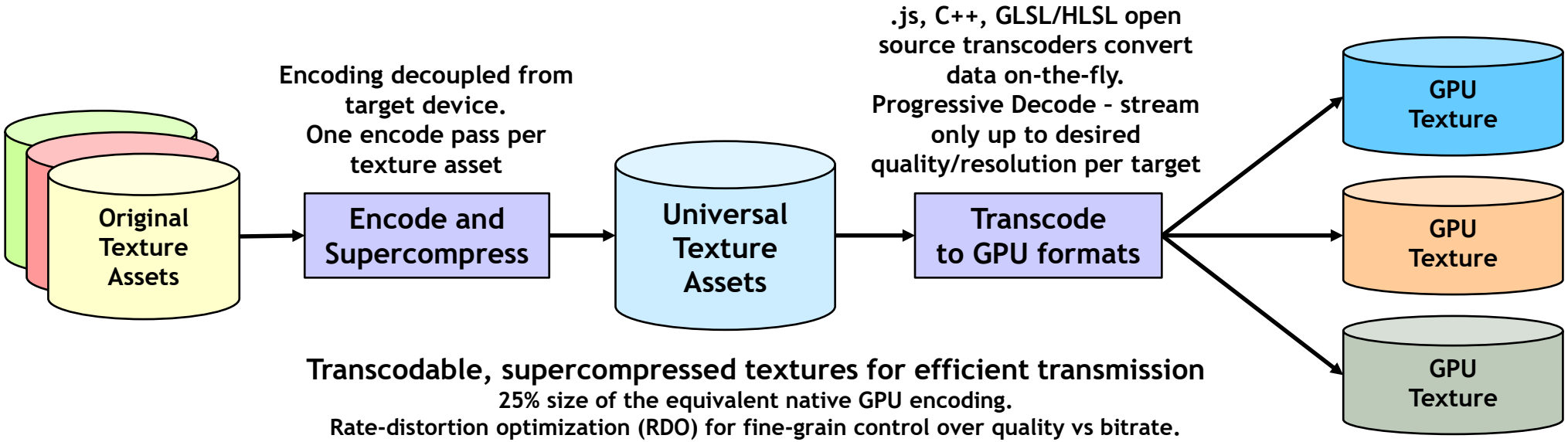
glTF Recent Highlights

- **TurboSquid adds glTF to StemCell - 60K+ 3D artists and 700K 3D models**
  - https://www.khronos.org/blog/turbosquid-adds-gltf-to-supported-formats-for-its-stemcell-initiative
- **Open Geospatial Consortium 3D Tiles standard proposal references glTF**
  - Designed for streaming massive heterogeneous 3D geospatial datasets
  - http://www.opengeospatial.org/pressroom/pressreleases/2829
- **Widespread Adoption**
  - Microsoft makes glTF files as usable as JPGs in Windows 10
  - Facebook supports drag and drop for glTF models to your feed
  - Adobe Dimension using glTF for delivery of 3D marketing assets
  - Mozilla integrating glTF into A-FRAME
  - Sketchfab repository has over 150K glTF models
- **Google Draco Mesh Compression**
  - Extension is shipping in tools and engines
- **Careful roadmap developments**
  - Unlit materials and texture transforms
  - Texture Transmission format…

DRACO
3D DATA COMPRESSION



glTF Texture Transmission Extension



Transcodable, supercompressed textures for efficient transmission

25% size of the equivalent native GPU encoding.
Rate-distortion optimization (RDO) for fine-grain control over quality vs bitrate.
Optional LZ/ANS lossless codec stage for maximized compression efficiency.
Support for both low precision formats for transcoding to ETC1, and high precision (128-bit block) format for full ASTC and BC6H/BC7, HDR etc.

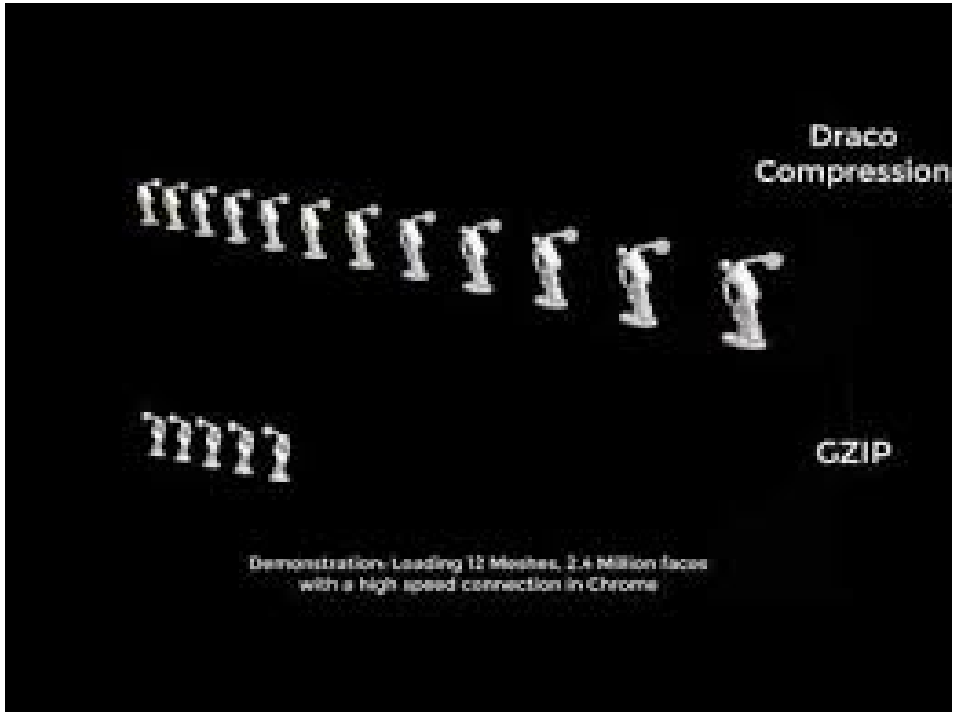
Transcode to a format that is natively GPU-accelerated on platform:
BC1-5, ASTC, ETC1/2, BC6H/7, PVRTC

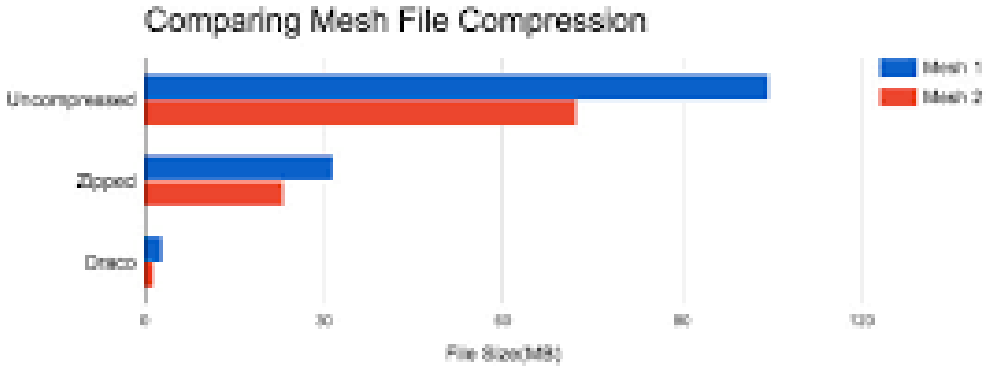
Extension in design - looking for industry feedback

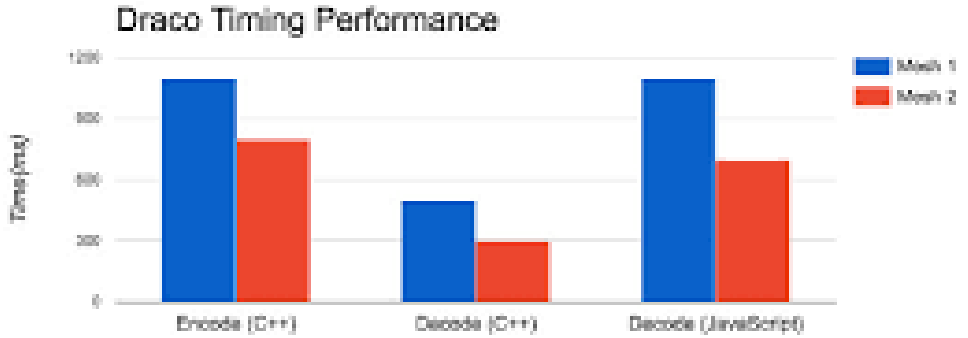
https://github.com/KhronosGroup/glTF/issues/1051

Google Draco

- Open Source Project of Google
- Compression(Lossy) of 3D Asset based on glTF
- Possible to apply on 3D Scanning data (point cloud)







New Activities

- **Initiative for Heterogeneous Communication**
  - Abaco Systems Takyon API is proposed.
  - P2P communication API between GPU's and MPU's
- **"Safety Critical" - New WG (Advisory Panel changed into official WG)**
  - OpenVX, OpenCL, NNEF, Vulkan, OpenGL etc.
  - Mainly targeted to Automotive Application
- **Liaisons**
  - SC 29 MPEG – for NNEF
  - OGC – for OpenXR
  - GENIVI – Open Source Infotainment in Automotive

Liaison Report

- **Khronos Group hope to build “official” liaison between SC 24**
  - Past board meeting, liaison request is approved.
  - JTC 1/ SC 24 Liaison Category A
  - Letter will be delivered to the secretary of SC 24, Soon
  - Topics - glTF for PAS, Collaboration in OpenXR

- **Liaison between JTC 1/WG 12 (SC 3 → WG 12)**
  - Past board meeting, liaison request is approved.
  - Liaison Category C
  - 3D point cloud data based on glTF for 3D Scanning

Thank you

- **Please contact**
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