KHRONOS GROUP

OpenXR™ WebGL™ glTF™ Vulkan®

Press Update

SIGGRAPH, Los Angeles, July 2019

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thrive SIGGRAPH2019
LOS ANGELES • 28 JULY – 1 AUGUST

Khronos Mission

Khronos members are industry leaders from around the world that join to safely cooperate - to advance their own businesses and the industry as a whole

KHRONOS GROUP

Software

Silicon

Khronos is an open, member-driven industry consortium developing royalty-free standards, and vibrant ecosystems, to harness the power of silicon acceleration for demanding graphics rendering and computationally intensive applications

KHRONOS GROUP

Khronos SIGGRAPH News

OpenXR 1.0 specification released!
Shipping implementations freely available today

3D Commerce

3D Commerce Initiative Becomes Khronos Working Group
Industry Call for Participation!

glTF tools ecosystem expands, e.g. Import/Export in Blender 2.80
glTF Universal Texture Extension Nearing completion

WebGL Releases High-Impact Extensions
Strong development pipeline

Vulkan has new extensions and is reaching more platforms and developers
Increased Usage by both Games and CAD/Professional Tools

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Active Khronos Standards

HIGH PERFORMANCE 3D GRAPHICS

Vulkan, OpenGL ES, OpenGL, OpenGL SC, WebGL

3D ASSET AUTHORING AND DELIVERY

glTF, COLLADA

PORTABLE XR – VIRTUAL AND AUGMENTED REALITY

OpenXR

PARALLEL COMPUTATION, VISION, MACHINE LEARNING AND INFERENCING

OpenCL, SYCL, SPIR, OpenVX, NNEF

3D Commerce Working Group

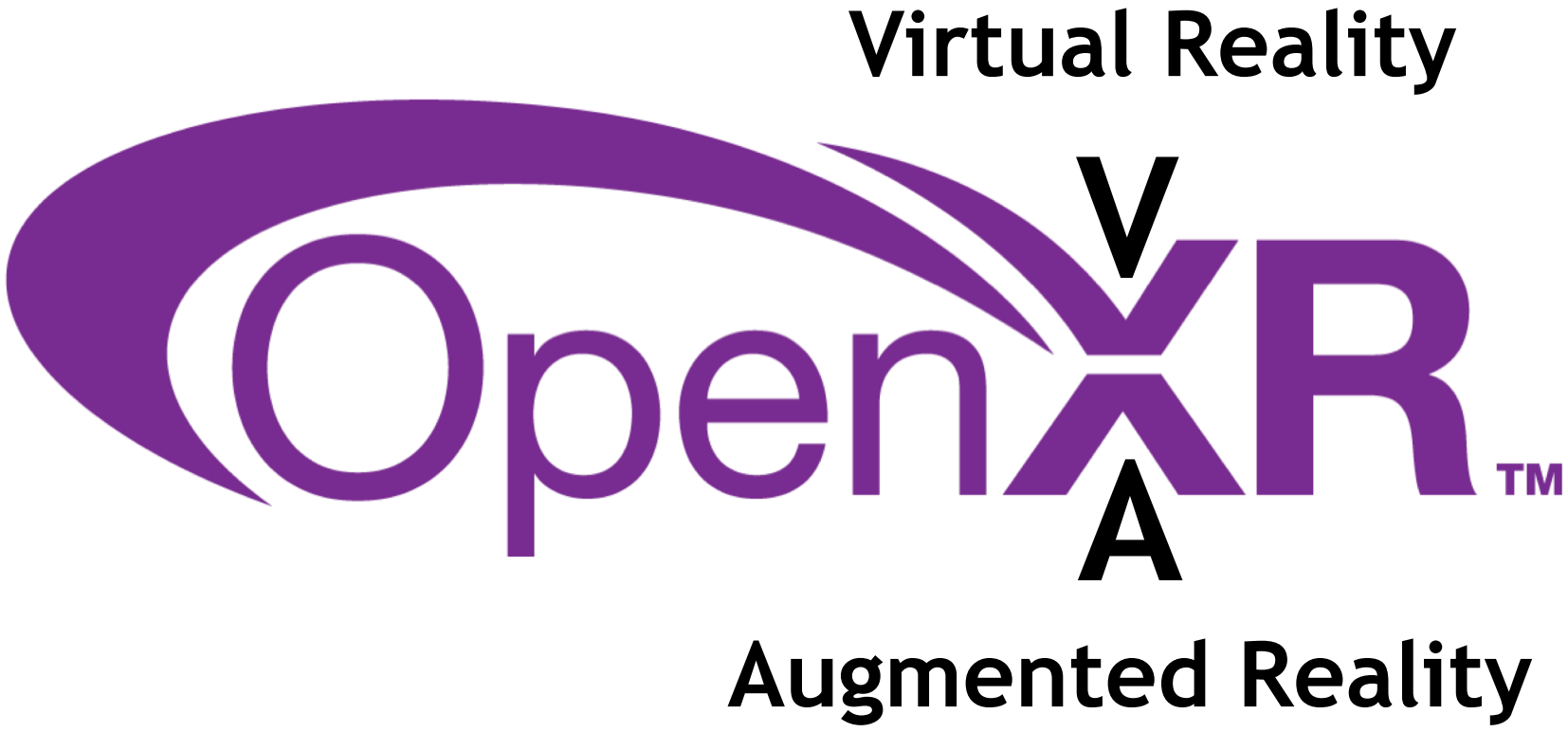
Announced at SIGGRAPH!

KHRONOS GROUP

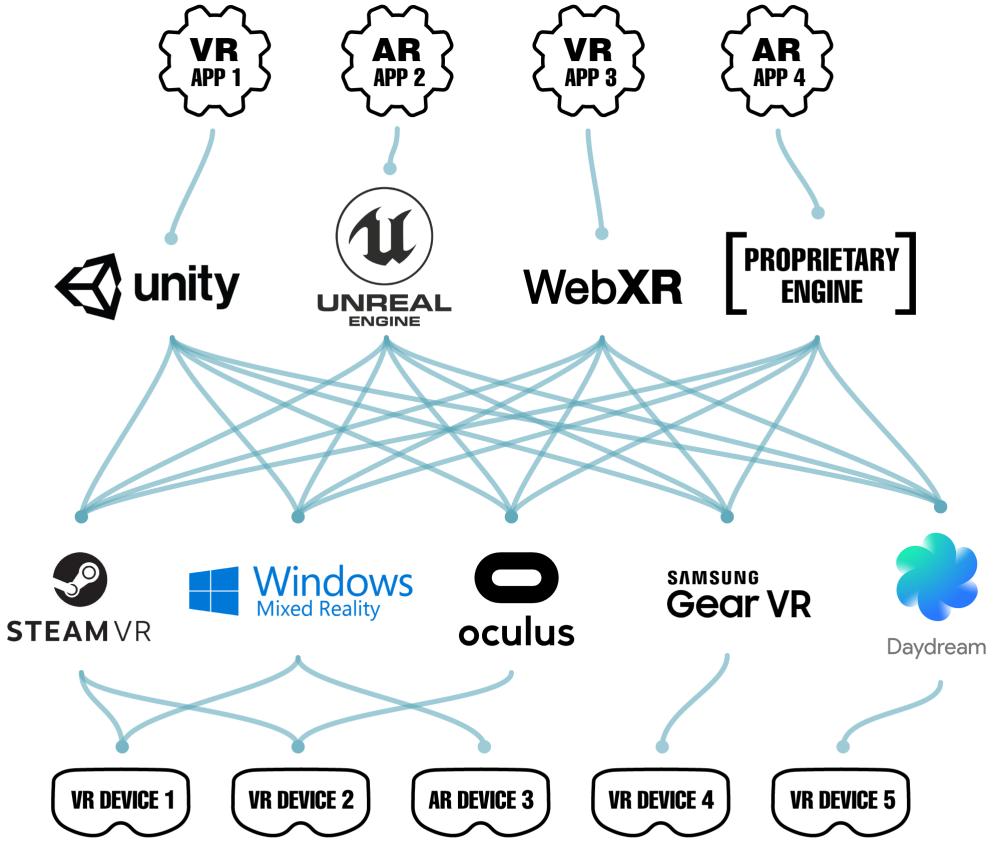
Khronos is an open, member-driven industry consortium developing royalty-free standards, to harness the power of silicon acceleration for demanding graphics rendering and computationally intensive applications

XR = AR + VR

Cross-platform, high-performance access to AR and VR platforms and devices

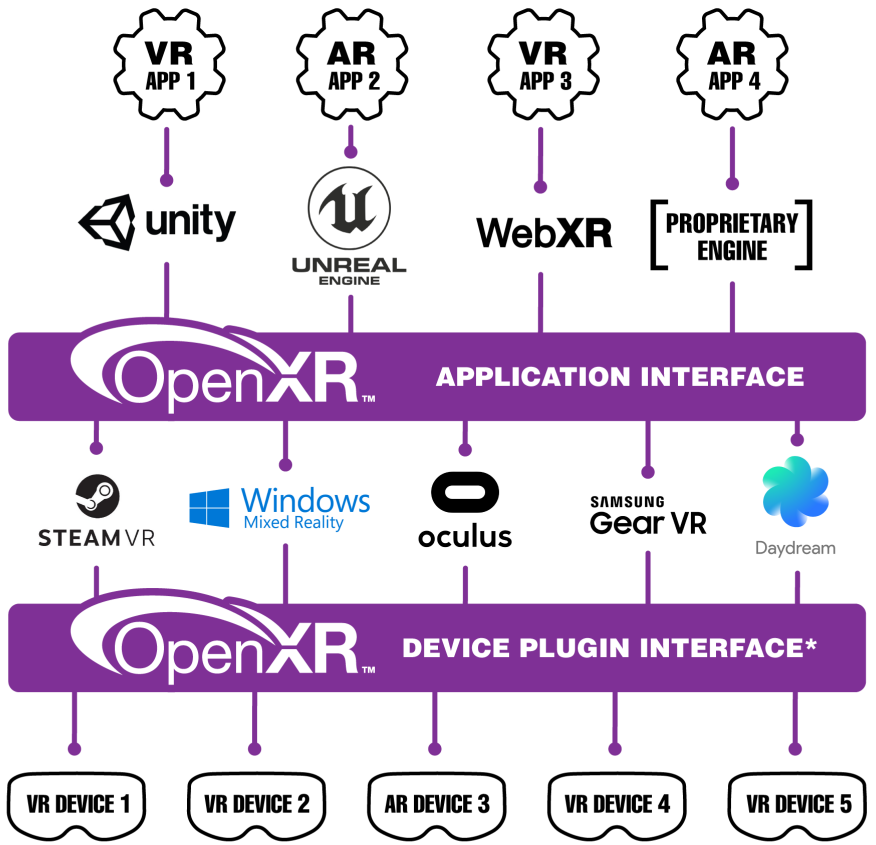


OpenXR - Solving XR Fragmentation



Before OpenXR

XR Market Fragmentation



After OpenXR

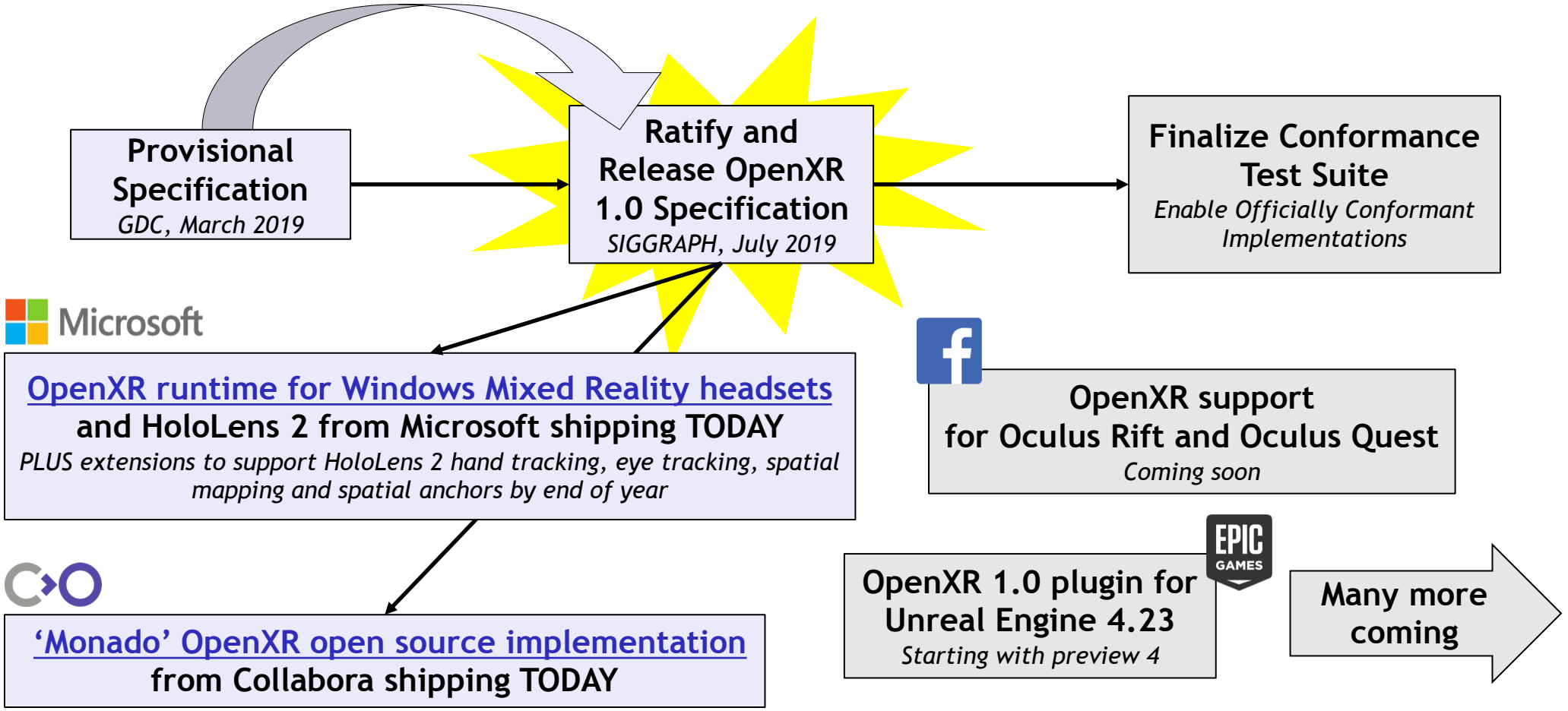
Wide interoperability of XR apps and devices

* OpenXR 1.0 is focused on enabling cross-platform applications. Optional device plugin interface will be supported post V1.0

** Check OpenXR Landing Page for exact availabiliy of OpenXR in shipping run-times and devices www.khronos.org/openxr

OpenXR 1.0 Released Here at SIGGRAPH!

Significant community feedback - thank you!
Improved OpenXR input subsystem, game engine editor support, loader …



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Companies Publicly Supporting OpenXR

OpenXR is a collaborative design

Integrating many lessons from proprietary 'first-generation' XR API designs

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Engine and Platform Support

Vinay Narayan, vice president, platform strategy, HTC

"HTC VIVE is committed to creating a viable ecosystem for the XR industry which is why we are proud to support OpenXR. Bringing the community together to help define standards and best practices, allows all of us to move forward, together."

Jules Blok, founder and CEO of Epic Games

"Unreal Engine led the way with support for the OpenXR 0.9 provisional specification, and we're excited to move the 1.0 revision forward in collaboration with our hardware partners releasing at the same time."

Nate Mitchell, Oculus Co-founder and head of VR product, Facebook

"Facebook and Oculus continue to believe in the value the OpenXR standard delivers to users and developers. We plan to provide runtime support for apps built on OpenXR 1.0 on the Rift and Quest platforms later this year."

Don Box, technical fellow, Microsoft

Microsoft is proud to release the first OpenXR 1.0 runtime for all Windows Mixed Reality and HoloLens 2 users with full support by end of year for HoloLens 2 hand tracking, eye tracking, spatial mapping and spatial anchors."

Joe Ludwig, programmer at Valve

"OpenXR is an important milestone for VR. *Valve is happy to have worked closely with other VR industry leaders to create this open standard and looks forward to supporting it in SteamVR."*

Ralph Hauwert, vice president of platforms at Unity Technologies

"Unity is committed to being an open and accessible platform, *we're excited about OpenXR and believe this is a significant step towards a more open ecosystem."*

Philippe Kalaf, CEO, Collabora

Collabora is proud to be part of bringing OpenXR 1.0 to life. We are pioneering the Monado open source runtime for OpenXR to ensure the future of XR is truly open and accessible to all hardware vendors

Khronos APIs for XR

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
- Frame timing and display composition
- Sensor tracking and pose calculation
- Input device discovery and events
- Haptics Control

Vulkan®

OpenXR™

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

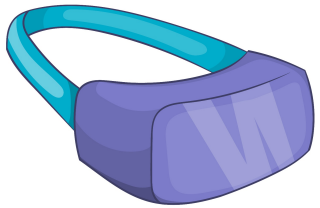
OpenXR Win-Win-Win

XR End-Users

Can run the apps they want on their system – reducing market confusion and increasing consumer confidence

XR Vendors

Can bring more applications onto their platform by leveraging the OpenXR content ecosystem



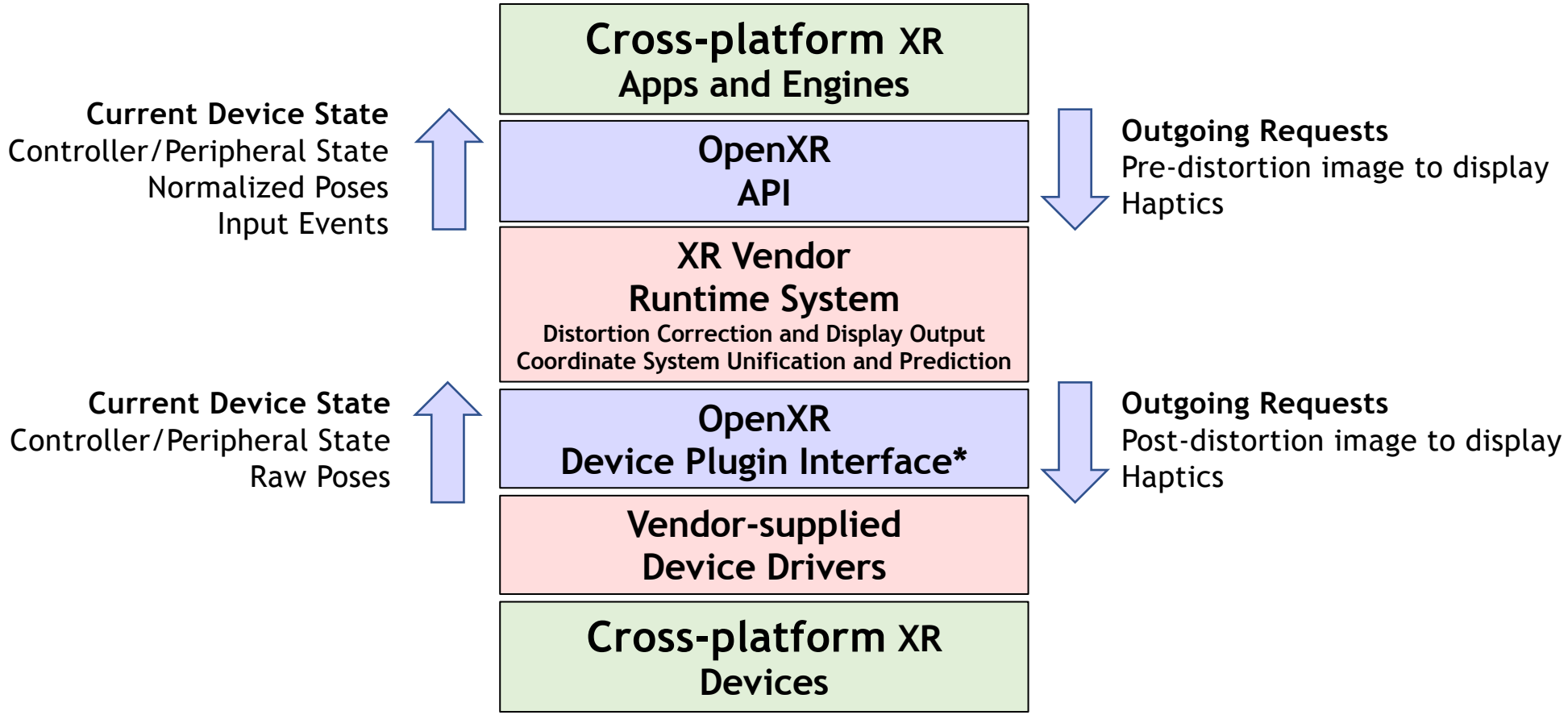
OpenXR™

XR ISVs

Can easily ship on more platforms for increased market reach

OpenXR Architecture

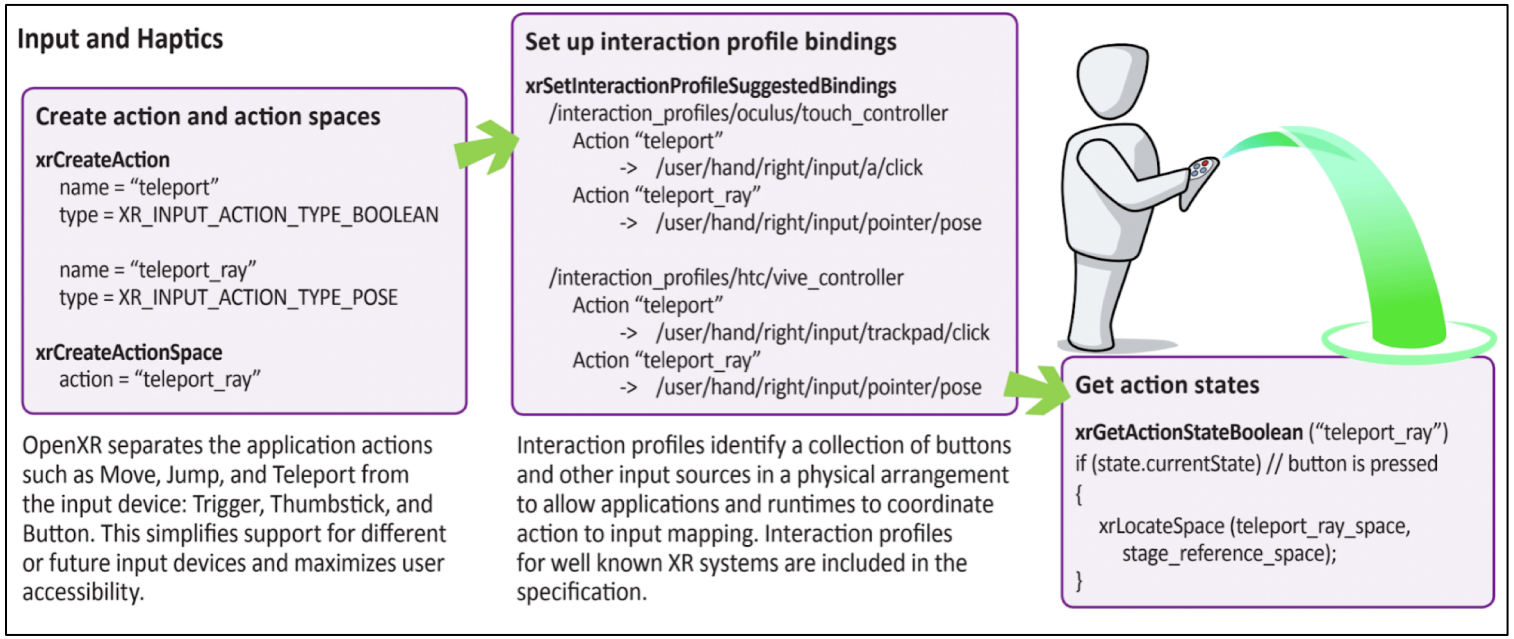
OpenXR does not replace XR Runtime Systems!
It enables any XR Runtime to expose CROSS-PLATFORM APIs to access their functionality



* OpenXR 1.0 is focused on enabling cross-platform applications. Optional device plugin interface will be supported post V1.0

Input and Haptics Abstraction

- **Apps use abstracted Input Actions**
  - E.g. “Move,” “Jump,” “Teleport”
- **Input Actions bound to Device Events**
  - For the specific system in use
- **Interaction profiles group device controls for ease of use**
- **Many Advantages**
  - Content can use new devices with no code changes
  - Future-proofing for innovation in input devices and form factors
  - Easily enable accessibility devices by rebinding actions to controls



OpenXR View & Form Factor Configurability

- **Applications can:**
  - Query for runtime-supported View and Form Factor Configurations
  - Applications can then set the View Configurations and Form Factors 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-like
		
		Photo Credit: Dave Pape
One View	Two View (one per eye)	Twelve Views (six per eye)
XR_FORM_FACTOR_HANDHELD_DISPLAY	XR_FORM_FACTOR_HEAD_MOUNTED_DISPLAY	(future support)
XR_VIEW_CONFIGURATION_TYPE_PRIMARY_MONO	XR_VIEW_CONFIGURATION_TYPE_PRIMARY_STEREO	(future support)

Bringing XR to the Web

Native XR Apps

Web XR Apps

Future versions of OpenXR will include cross-platform extended AR functionality

OpenXR

vuforia

UNREAL ENGINE

unity

3D Engines

ARCore

System-exposed AR Capabilities

WebXR

W3C

three.js

3D Engines

Close ongoing collaboration between WebXR and OpenXR

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Vulkan

OpenXR

WebGL

Khronos providing the foundation for 3D and XR in the Web and native stacks

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XR and 5G

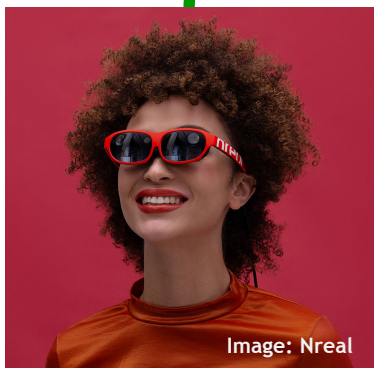
Leveraging High Bandwidth and Low Latency

MEC (Multi-access Edge Computing) Server
1. Processes sensor data, including machine learning for environmental lighting, occlusion, scene semantics, object reconstruction and UI
2. Generates imagery from 3D models, including stereo, foveal rendering, ray-tracing, optics pre-distortion, varifocal processing

5G

Rich Sensor Data

OpenXR
Sensor handling

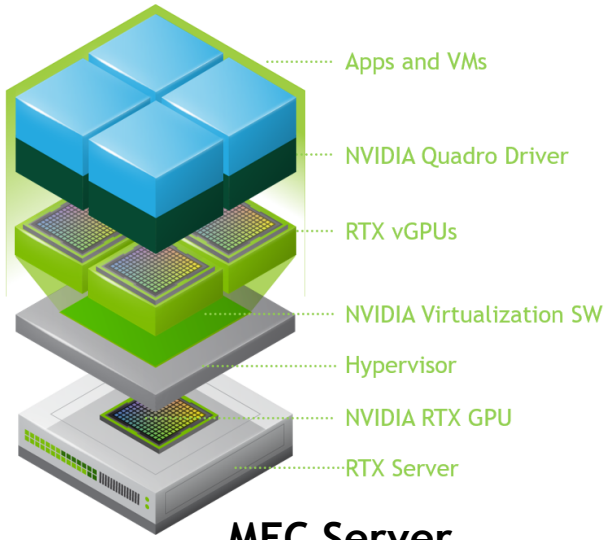


Wireless mobile device with display and sensors

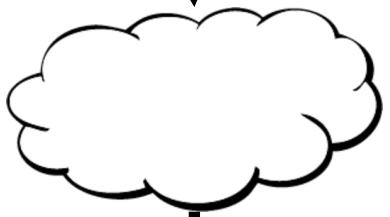
Location-aware Content Requests

Vulkan

NVIDIA CUDA



MEC Server



glTF

Apps
3D Assets

Any needed assets loaded from the cloud to edge server

OpenXR
Display composition

Generated Augmentations & Scenes

5G

OpenXR APIs can hide the 5G round trip from applications

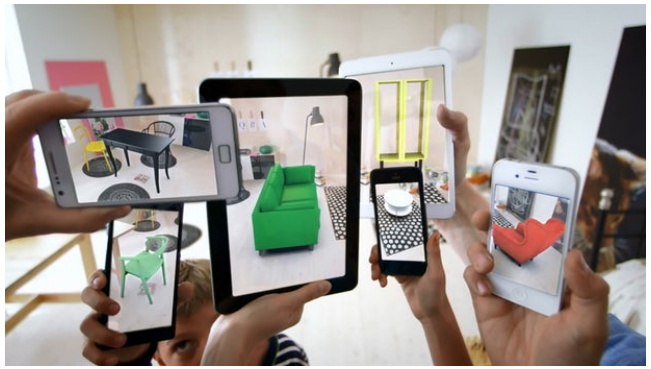
Khronos 3D Commerce Initiative

The Opportunity

Retailers have been experimenting with 3D product representations on the Web, and in Virtual and Augmented Reality applications, to enable users to view and interact with products. The results have been exciting, but thus far

NOT ACTIONABLE at an INDUSTRIAL SCALE

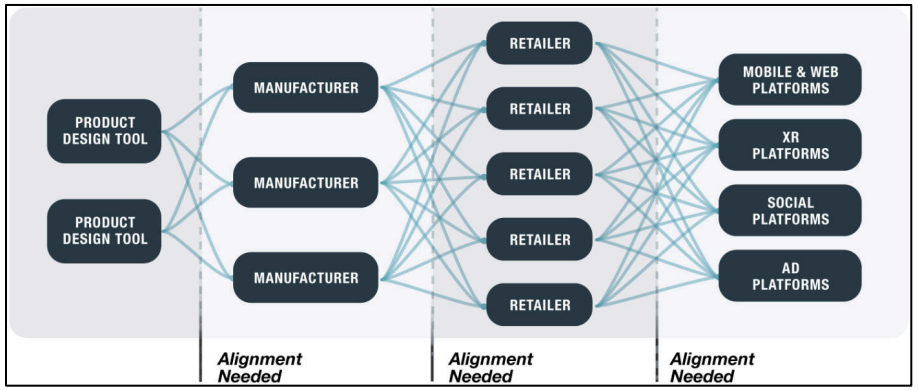
IKEA Communications AB



IKEA catalog uses augmented reality to give a virtual preview of furniture in a room - August 2013

Products don't come with 3D data - and I can't physically scan them all fast enough!

CAD tools don't let me easily generate the data I need for E Commerce!



The green couch looks blue on some devices - lots of product returns are expensive!

Many models on my e-commerce web-site first appear upside down! I have to hand tune everything!

I wish I had high quality, realistic 3D models for virtual promotional photoshoots!

Everyone defines their product data for sizes and colors differently - nothing is consistent!

Khronos New Initiative Process

Proposal
March 2019

A group of companies including Google, Unity, IKEA, Wayfair and Target identify the need for industry cooperation and makes proposal to Khronos

Initiative Proposal

KHRONOS GROUP

Exploratory Group
March-July 2019

Khronos invites any company to join an Exploratory Group to drive industry consensus on what is the problem, and what how can we work together to fix it?

Scope of Work

Working Group Announced
SIGGRAPH 2019

Detailed design work to execute SOW will start by Khronos Members

https://www.khronos.org/3dcommerce/

Broad Industry Participation

Over 70 retail AND technology companies creating an agreed Scope of Work

Open to any company under NDA, no membership fee or IP commitment

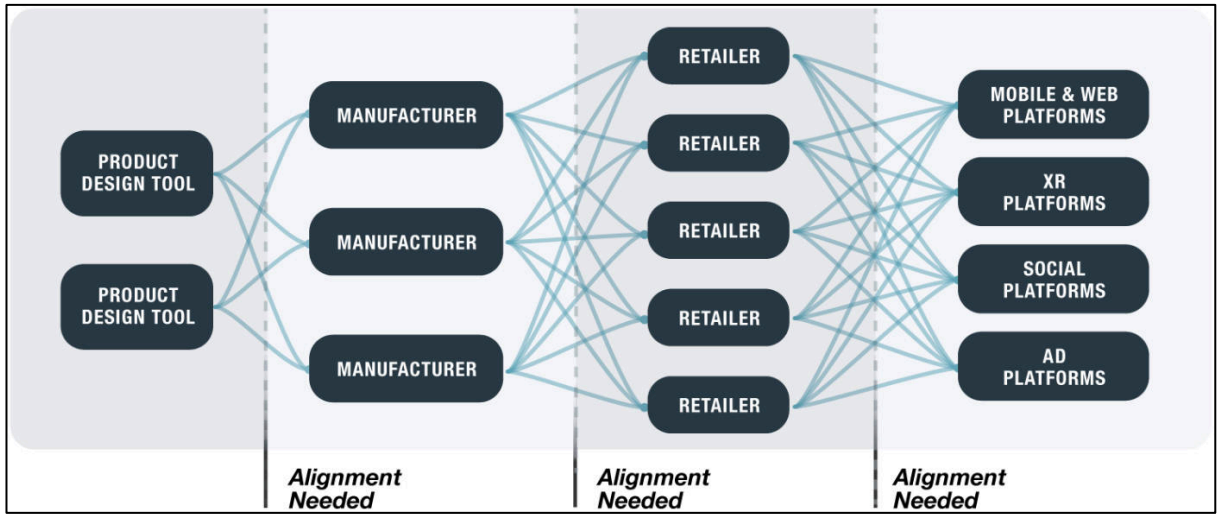
Khronos 3D Commerce Working Group Goals

Create specifications and guidelines to align the 3D asset workflow from product design through manufacturing, through each stage of retail to end-user delivery platforms

Guidelines for tools and product designers to create assets with consistent data to be used through the 3D Commerce pipeline

Structured metadata for product management and configurability of viewing

Visual realism and consistency no matter where the model is displayed



Reduce production, distribution and marketing costs

Product display configurability with consistency and authenticity

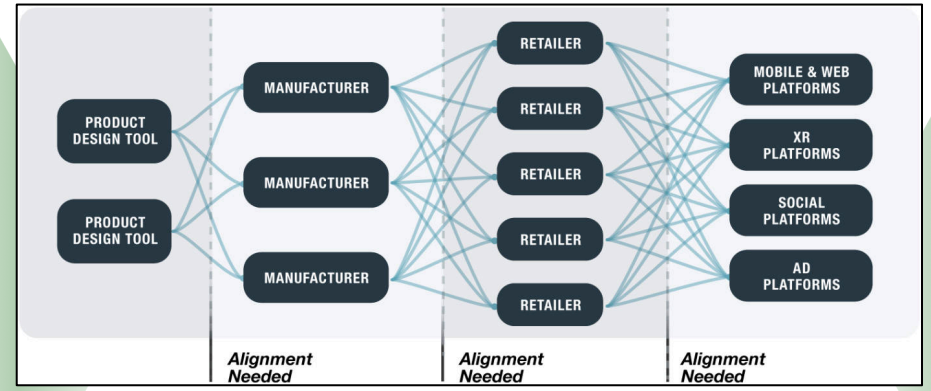
3D Commerce Khronos Synergy

glTF™

3D Asset Format

WebGL™

Interactive 3D on the Web



Khronos 3D Commerce

OpenXR™

Portable AR and VR Apps

Vulkan®

High-performance
cross-platform 3D graphics

OpenVX™

Vision processing and
inferencing for AR and scanning

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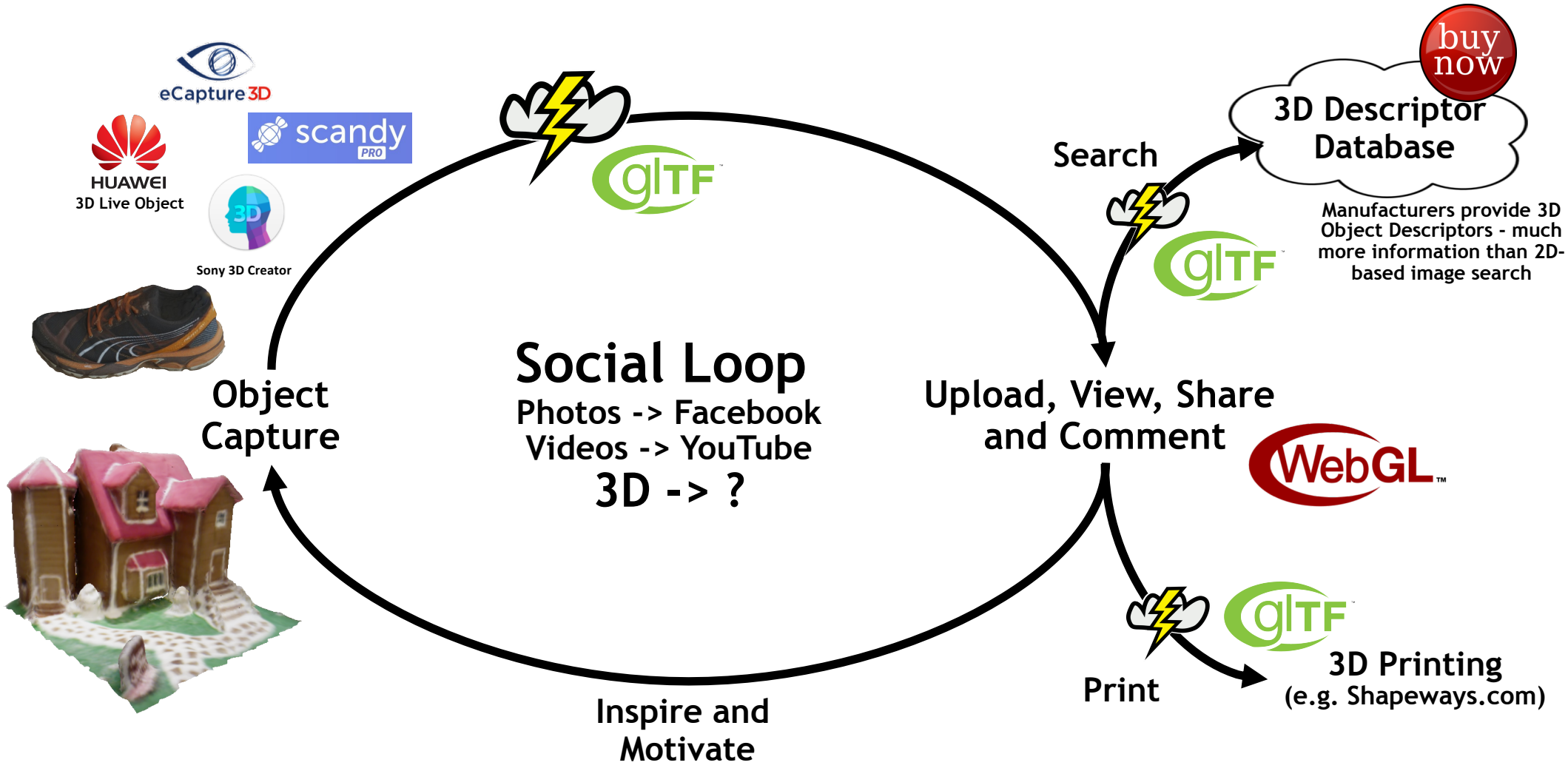
With Consumer Capture - 3D Will Go Social!



glTF - The JPEG of 3D!

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

glTF

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

Efficient, reliable transmission
Bring 3D assets into 1000s of apps and engines

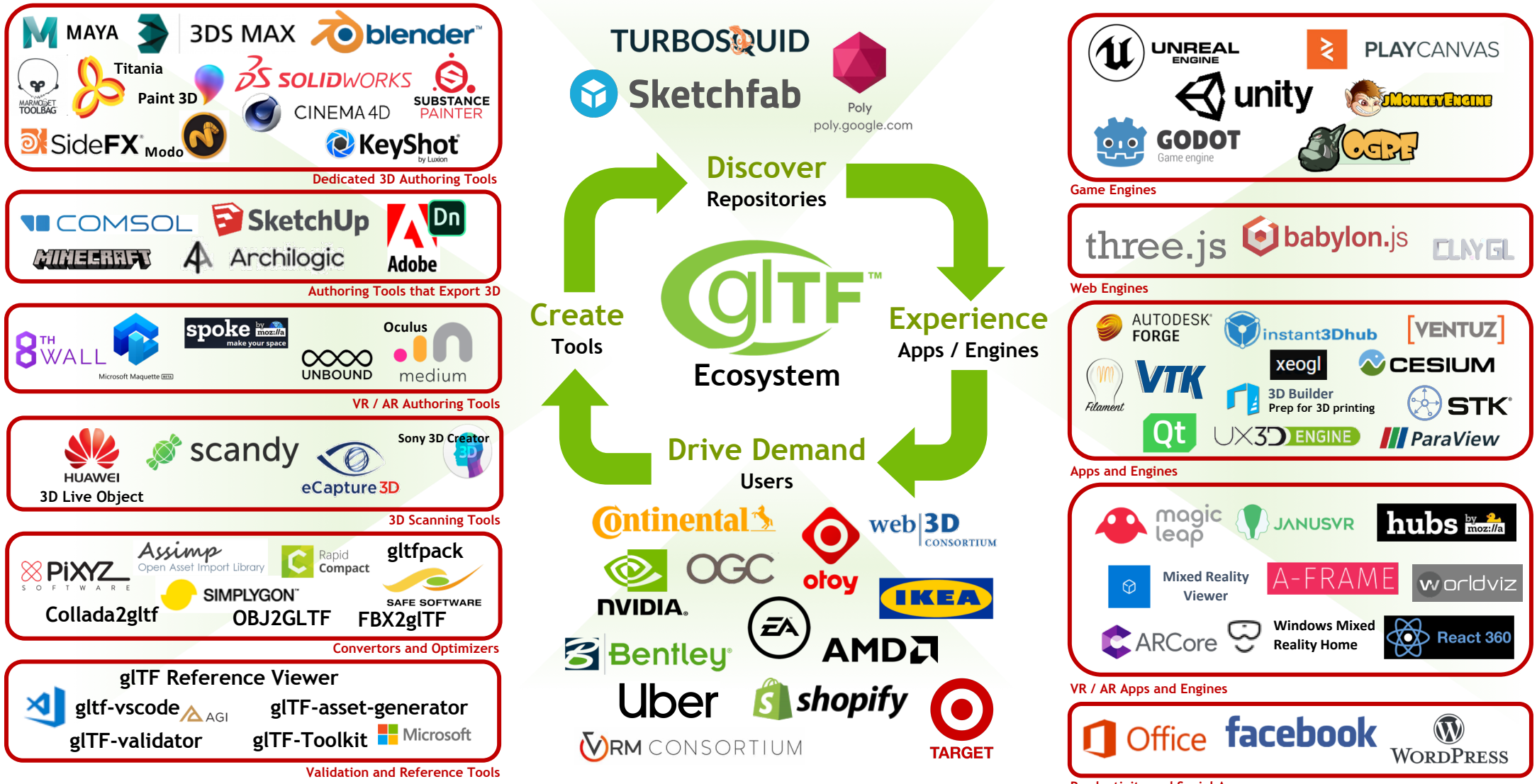
glTF

WebGL

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

glTF spec development on open GitHub - get involved!
https://github.com/KhronosGroup/glTF

glTF 2.0 - June 2017
Native AND Web APIs
Physically Based Rendering
Metallic-Roughness and Specular-Glossiness


MAYA
3DS MAX
blender
Titania
Paint 3D
SOLIDWORKS
SUBSTANCE PAINTER
CINEMA 4D
SideFX
Modo
KeyShot
Dedicated 3D Authoring Tools
COMSOL
SketchUp
MINECRAFT
Archilogic
Adobe
Authoring Tools that Export 3D
8TH WALL
Microsoft Maquette
spoke
Oculus
UNBOUND
medium
VR / AR Authoring Tools
HUAWEI
3D Live Object
scandy
eCapture 3D
Sony 3D Creator
3D Scanning Tools
PiXYZ SOFTWARE
Assimp
Open Asset Import Library
Rapid Compact
gltfpack
SAFE SOFTWARE
SIMPLYGON
Collada2gltf
OBJ2GLTF
FBX2glTF
Convertors and Optimizers
glTF Reference Viewer
gltf-vscode
AGI
glTF-asset-generator
glTF-validator
glTF-Toolkit
Microsoft
Validation and Reference Tools
TURBOSQUID
Sketchfab
Poly
poly.google.com
Discover
Repositories
Create
Tools
glTF™
Ecosystem
Experience
Apps / Engines
Drive Demand
Users
Continental
web 3D CONSORTIUM
OGC
otoy
NVIDIA
IKEA
Bentley
AMD
Uber
shopify
VRM CONSORTIUM
TARGET
UNREAL ENGINE
PLAYCANVAS
unity
JMonkeyEngine
GODOT
Game engine
OGRE
Game Engines
three.js
babylon.js
CLAYGL
Web Engines
AUTODESK FORGE
instant3Dhub
VENTUZ
xeogl
CESIUM
Filament
VTK
3D Builder
Prep for 3D printing
STK
Qt
UX3D ENGINE
ParaView
Apps and Engines
magic leap
JANUSVR
hubs by moz://a
Mixed Reality Viewer
A-FRAME
worldviz
ARCore
Windows Mixed Reality Home
React 360
VR / AR Apps and Engines
Office
facebook
WordPress
Productivity and Social Apps

glTF 2.0 Scene Description Structure

.gltf (JSON)

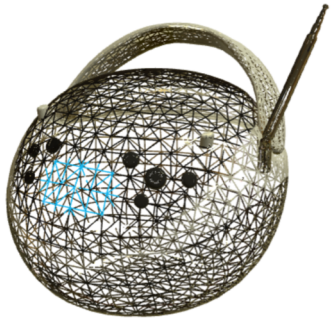
Node hierarchy, PBR material textures, cameras

.bin

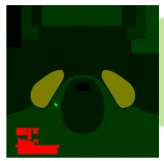
Geometry: vertices and indices
Animation: key-frames
Skins: inverse-bind matrices

.png
.jpg
.ktx2
Textures

glTF™

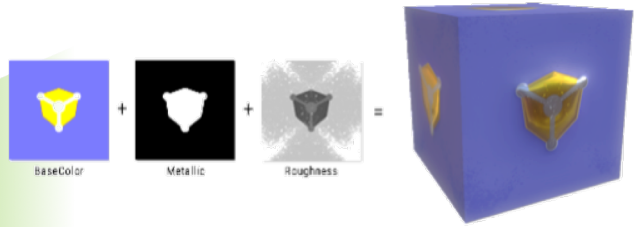


Geometry

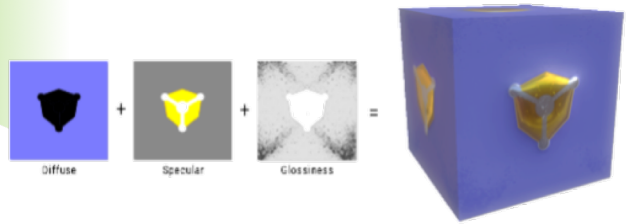


Texture based
PBR materials

Mandatory Metallic-Roughness Materials



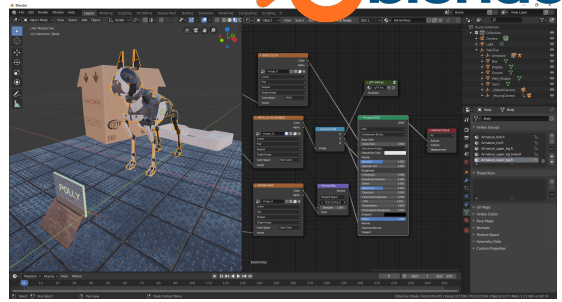
Optional Specular-Glossiness Materials



glTF Ecosystem Evolution

Tools!

Striving for native glTF import and Export from every tool. Catalyzed Blender IO as exemplar



glTF 2.0 import/export with Blender 2.80

Consistency!

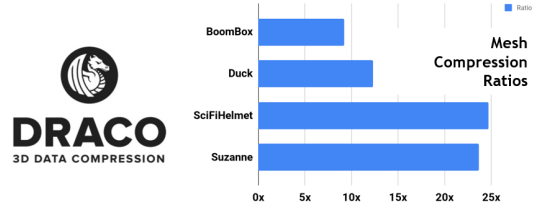
Avoid dialects at all costs! Sample viewer and Asset Validator in open source. Sample models and asset generator for unit tests

Sample Viewer for accurate Ground Truth glTF renderings

glTF 2.0 – June 2017

Functionality!

Balancing functionality versus complexity. glTF is extensible – only bring widely adopted extensions into core

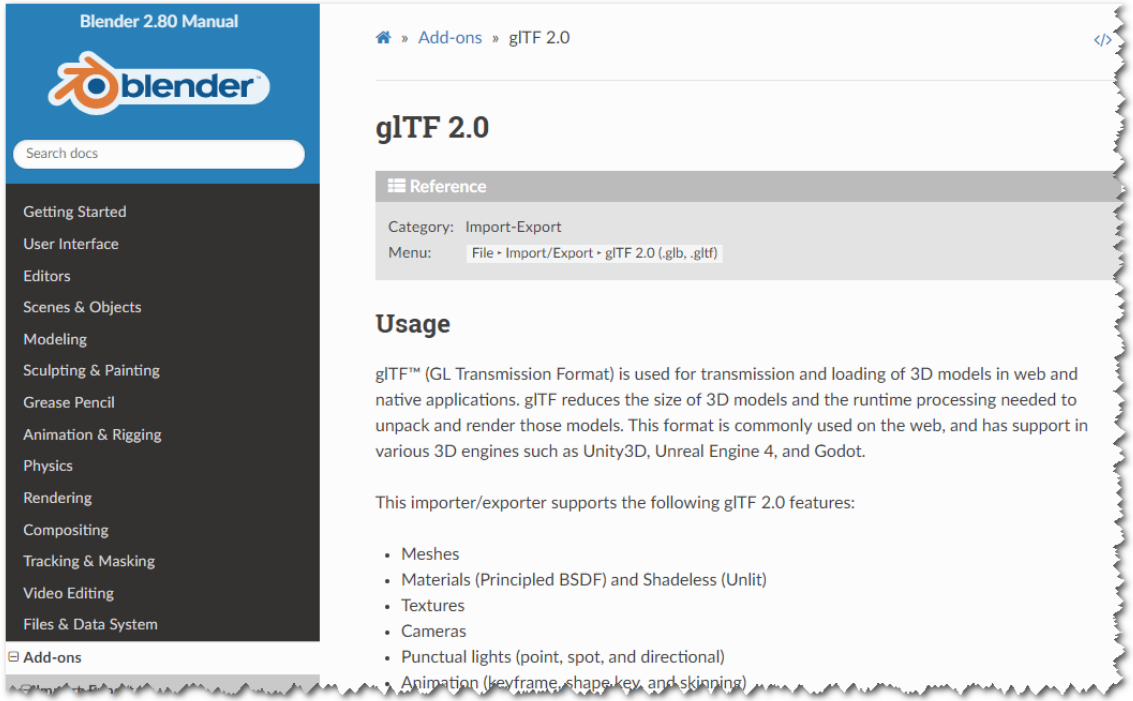


glTF Mesh compression extension provides up to 25x geometry compaction

glTF/Draco-enabled apps and engines

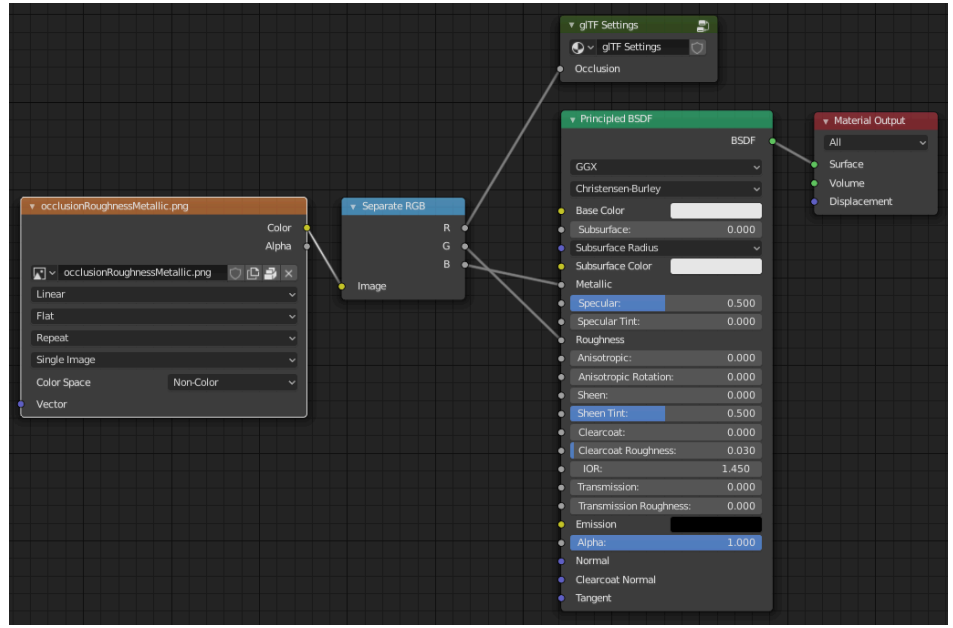
Blender 2.80 Supports Full glTF Import/Export

Project driven by Mozilla, Khronos and the glTF community



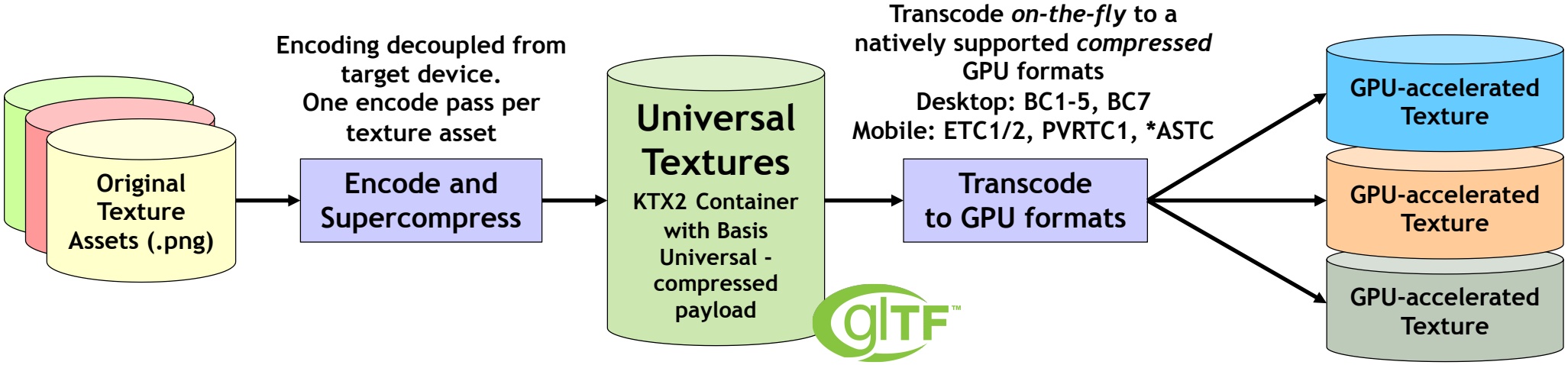
https://docs.blender.org/manual/en/2.80/addons/io_scene_gltf2.html

Blender's Principled BSDF Shader node maps to glTF's PBR materials



Universal Textures for glTF

- **Fragmentation of GPU texture formats is significant issue for developers**
  - Binomial's 'Basis Universal' technology enables JPEG-sized texture assets
  - Transcodable on-the-fly to natively supported compressed GPU formats
- **glTF Universal Texture extension uses KTX2 as a flexible container**
  - Precisely defined specification for consistent, cross-vendor generation and validation
  - Can contain wide range of texture formats used in Vulkan/DirectX/Metal
  - Supports streaming and full random access to MIP levels
  - Subset of full KTX2 - mandating supercompressed textures using Basis Universal technology



*ASTC support in development

Universal Textures - Get Involved!

- **Design discussions**
  - https://github.com/KhronosGroup/glTF/pull/1612
- **Khronos open source tools**
  - https://github.com/KhronosGroup/KTX-Software/tree/ktx2
  - toktx - create a KTX2 file from a set of .png images
  - ktxsc - convert images in KTX2 file to supercompressed images using Basis transcoder
- **Ecosystem forming around KTX2**
  - Khronos glTF texture tool with GUI for generating supercompressed textures
  - Increasing number of run-times integrating prototype KTX2 support

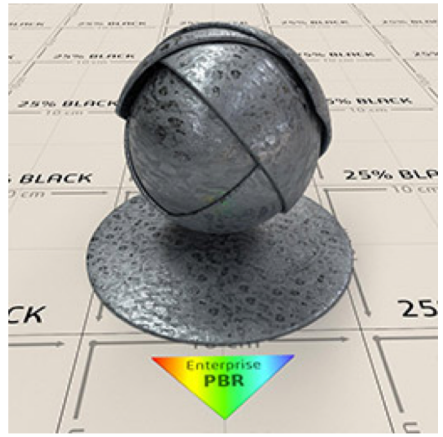
Applications and engines with prototype KTX2 support

Next Generation glTF PBR Materials

- **Demand for advanced PBR for photorealistic assets**
  - Beyond current ‘Metallic-Roughness’ and ‘Specular-Glossiness’
  - E.g. Absorption/attenuation, clear coat, subsurface scattering, anisotropy
- **Extending Metallic-Roughness parameters**
  - Consistency and fallbacks for performance for any device
- **Inspiration from Dassault Systèmes Enterprise PBR Shading Model (DSPBR)**
  - https://github.com/DassaultSystemes-Technology/EnterprisePBRShadingModel/tree/master/gltf_ext
- **Wide industry collaboration for compatibility**
  - Dassault Systèmes
  - Google Filament
  - Microsoft BabylonJS
  - NVIDIA MDL
  - OTOY Octane

Join the GitHub Discussion!
https://github.com/KhronosGroup/glTF/issues/1442

Images from https://dassaultsystemes-technology.github.io/EnterprisePBRShadingModel/

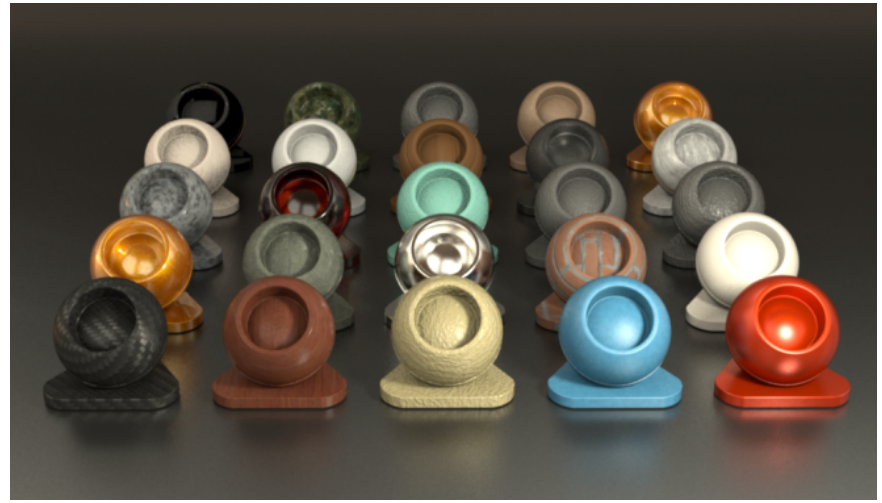


Roadmap Discussions

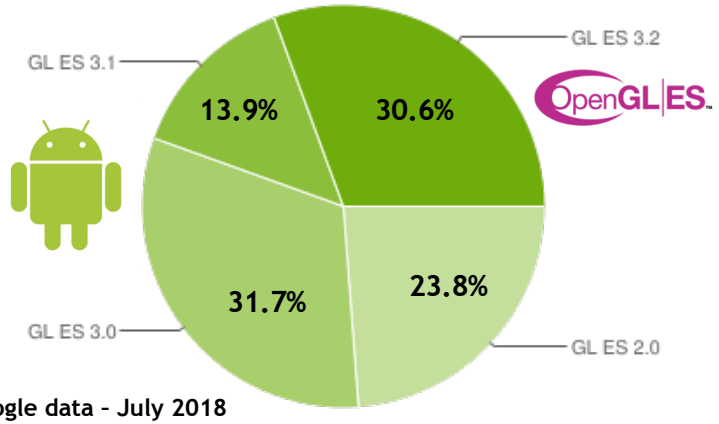
- **Many of these topics are being discussed on GitHub**
  - https://github.com/KhronosGroup/glTF
  - Come and give your views!
- **Animation 2.0**
  - Advanced Avatars and Face emoji, with compression
- **LOD and Streaming**
- **Point Clouds (with compression)**
- **Cross-asset linking**
- **Enhanced Metadata**

glTF Roadmap is Driven by Developer Feedback and Requirements

NVIDIA MDL Physically Based Rendering



WebGL's Origin Story



Google data - July 2018

1992-Today
Pervasive on Windows, Mac and Linux
Desktops and Workstations

2003-Today
Pervasive on Windows, Mac and Linux
Desktops and Workstations
AND Android and iPhone Mobile Phones

OpenGL ES is the most prevalent 3D API in history - Billions of devices!

2011-Today
Browsers have access to a pervasive native API for the first time. Can build a JavaScript stack for 3D that can be accelerated everywhere

WebGL Stack

Content downloaded from the Web

Content
JavaScript, HTML, CSS, ...

Middleware provides accessibility for non-expert programmers
E.g. three.js library

JavaScript Middleware
three.js babylon.JS PLAYCANVAS

Low-level WebGL API provides a powerful foundation for a rich JavaScript middleware ecosystem

Browser provides WebGL 3D engine alongside other HTML5 technologies - no plug-in required

WebGL | CSS | JavaScript | HTML5

OS Provided Drivers
WebGL uses native OpenGL or OpenGL ES or Angle = OpenGL ES over DX9/11

OpenGL ES | OpenGL

Reliable WebGL relies on work by both GPU and Browser Vendors
->
Khronos has the right membership to enable that cooperation

WebGL's Evolution

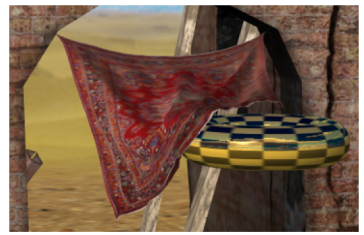
Pervasive OpenGL ES 2.0
OpenGL and OpenGL ES ships on every desktop and mobile OS.
3D on the Web is enabled!

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

Apple does not ship OpenGL ES 3.1
Cannot bring compute shaders into core WebGL

Compute Shaders



After WebGL 2.0?
W3C is working on WebGPU
Layering over Vulkan/DX12/Metal
Possibly leveraging SPIR-V IR
https://www.w3.org/community/gpu/

2007
OpenGL ES 2.0

2012
OpenGL ES 3.0

2014
OpenGL ES 3.1

OpenGL|ES™

WebGL™

4 years

2011
WebGL 1.0

5 years

2017
WebGL 2.0

Developer Driven Extensions
Compute Context
Multiview for XR
Increased Performance
Compressed Textures …

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

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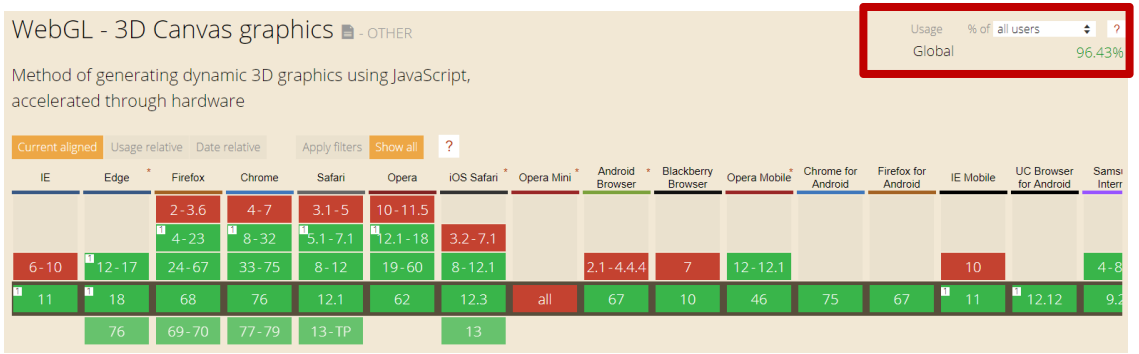
WebGL Deployment - WebGL 2.0 is Here!

Pervasive, portable access to OpenGL ES 2.0-class mobile graphics

WebGL 1.0

96.43% Globally

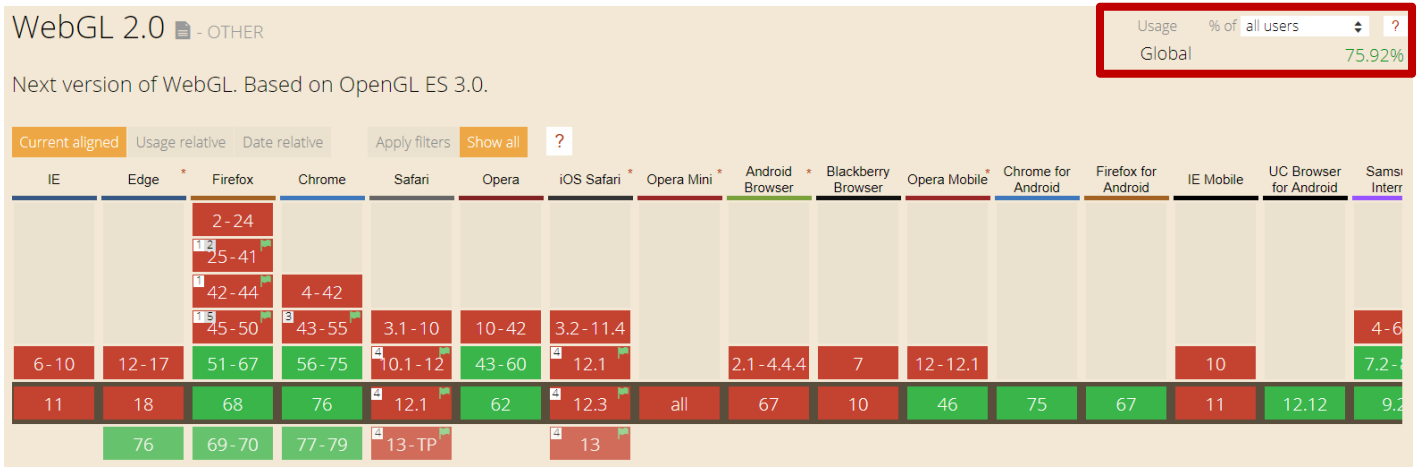


http://caniuse.com/#feat=webgl

OpenGL ES 3.0-based desktop-class graphics comes to the Web!

WebGL 2.0

75.92% Globally



WebGL 2.0 will reach WebGL 1.0 levels of availability when Safari and Edge ship enabling a new class of Web-based AR/VR 3D Apps!

WebGL Extensions

- **Delivering requested features from the developer community**
- **KHR_parallel_shader_compile extension**
  - Asynchronous shader compilation times – does not block the main WebGL thread
- **multi-draw and instanced multi-draw extensions – on track for all browsers**
  - Command batching and significantly decrease CPU overhead for larger scenes
- **Compressed texture extensions - already available in browsers**
  - RGTC (BC4 / BC5) and BPTC (BC6H / BC7) extensions
- **Extensions coming soon**
  - WebGL 2.0 GPU Compute contributed by Intel
  - WEBGL_video_texture accelerated real-time video processing
  - BaseVertex and BaseInstance flexible indexing into vertex arrays
- **WebGL 2.0 public demonstrations**
  - Including how-to enable prototype features with command-line flags in Chrome Canary

Vulkan Explicit GPU Control

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

Application
Memory allocation
Thread management
Explicit Synchronization
Multi-threaded generation of command buffers

Multiple Front-end Compilers
GLSL, HLSL etc.

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

Vulkan and New Generation GPU APIs

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

Non-proprietary, royalty-free open standard 'By the industry for the industry'
Portable across multiple platforms - desktop and mobile

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Pervasive Vulkan

Major GPU Companies supporting Vulkan for Desktop and Mobile Platforms

AMD arm BROADCOM Imagination intel NVIDIA QUALCOMM VeriSilicon

http://vulkan.gpuinfo.org/

Platforms

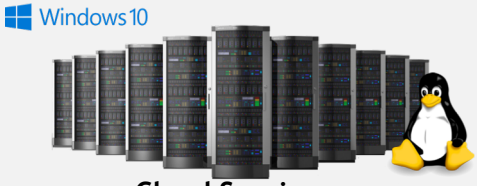
Desktop

Mobile
(Android 7.0+)

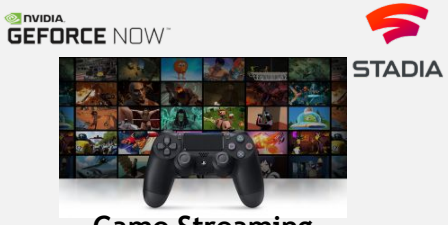
Media Players

Consoles

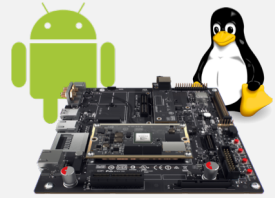
Virtual Reality



Cloud Services



Game Streaming

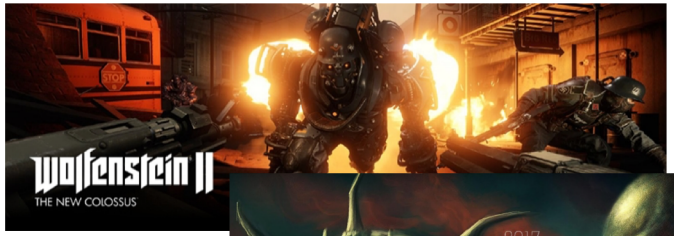


Embedded

Game Engines

VALVE id CRYENGINE unity EPIC GAMES Croteam Serious Engine XENKO

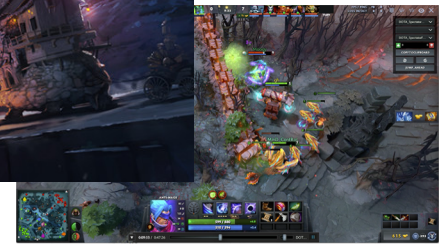
Vulkan AAA Content Shipping on Desktop…



Vulkan-only AAA Titles on PC

AAA titles on Linux

FERAL
MAKE YOUR PLAY



Titles on PC AND macOS

…and Mobile

FORTNITE

Vulkan

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

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

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Vulkan 1.1 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
More rigorous conformance testing

February 2016
Vulkan 1.0

Vulkan 1.0 Extensions

Maintenance updates plus additional functionality

Multiview
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
plus new functionality
e.g. Subgroup Operations

Building Vulkan's Future

Listen and prioritize developer needs
Drive GPU technology

Released Vulkan 1.1 Extensions

Reduced precision arithmetic types in shaders
Bindless resources
HLSL-compatible memory layouts
Formal memory model
Buffer references
https://www.khronos.org/registry/vulkan/specs/1.1-khr-extensions/html/vkspec.html#extension-appendices-list

Roadmap Discussions

Video encode / decode
Machine Learning support
Ray Tracing
Timeline semaphores
Generalized subgroup operations

Widening Platform Support

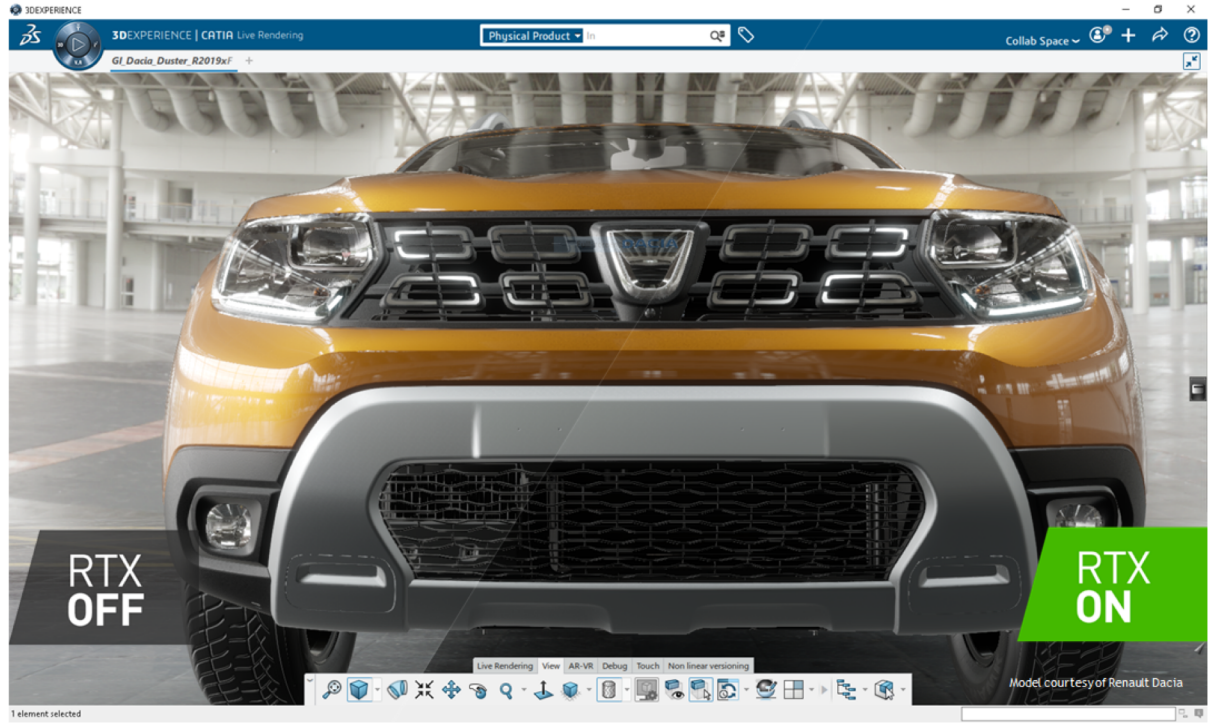
Pervasive GPU vendor native driver availability
Open source drivers - ANV (Intel), AMDVLK/RADV (AMD)
Vulkan Portability to macOS/iOS and DX12

Increasing Support for Professional Authoring Apps

OpenGL-class Line Rasterization
(stipple, smooth, Bresenham)
OpenGL/Vulkan Interop

OpenGL Vulkan Interop

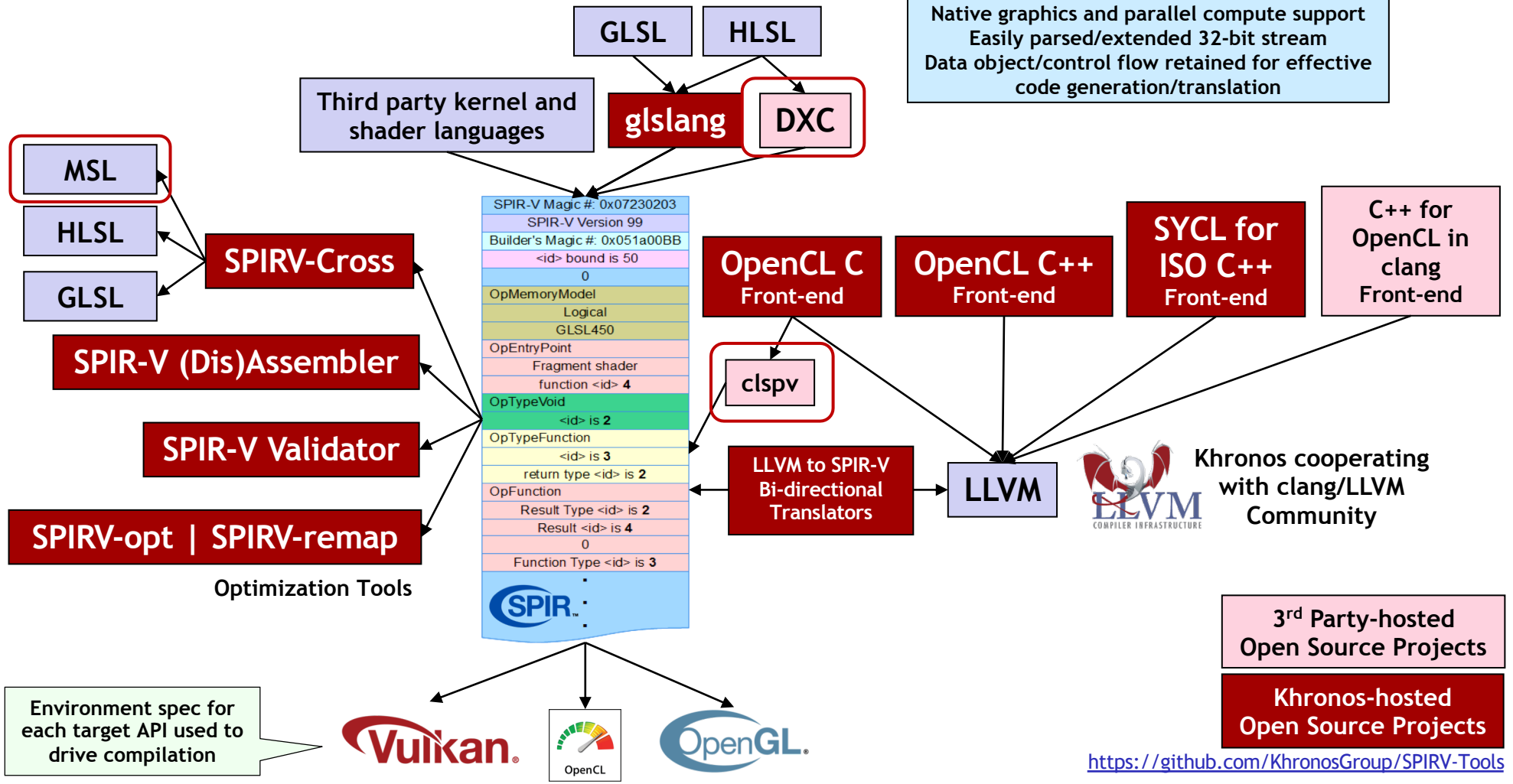
- **Enables OpenGL applications to incrementally leverage Vulkan functionality**
  - Shared explicit memory objects
- **Dassault Systèmes achieves interactive object space AO in CATIA, an OpenGL application**
  - Using the NVIDIA Vulkan VKRay vendor extension for Ray Tracing
  - See the Demo at the NVIDIA booth



DASSAULT SYSTEMES

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



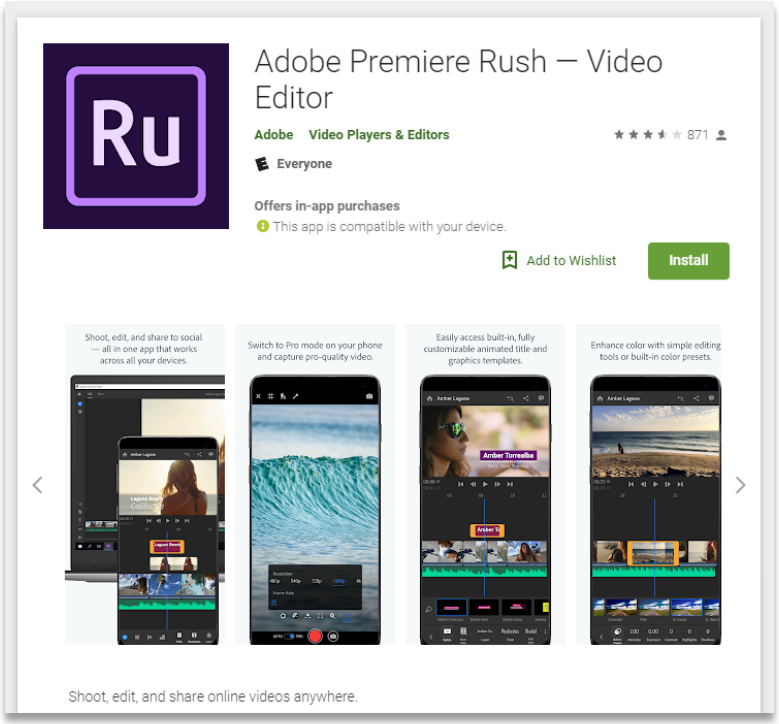
3rd Party-hosted Open Source Projects

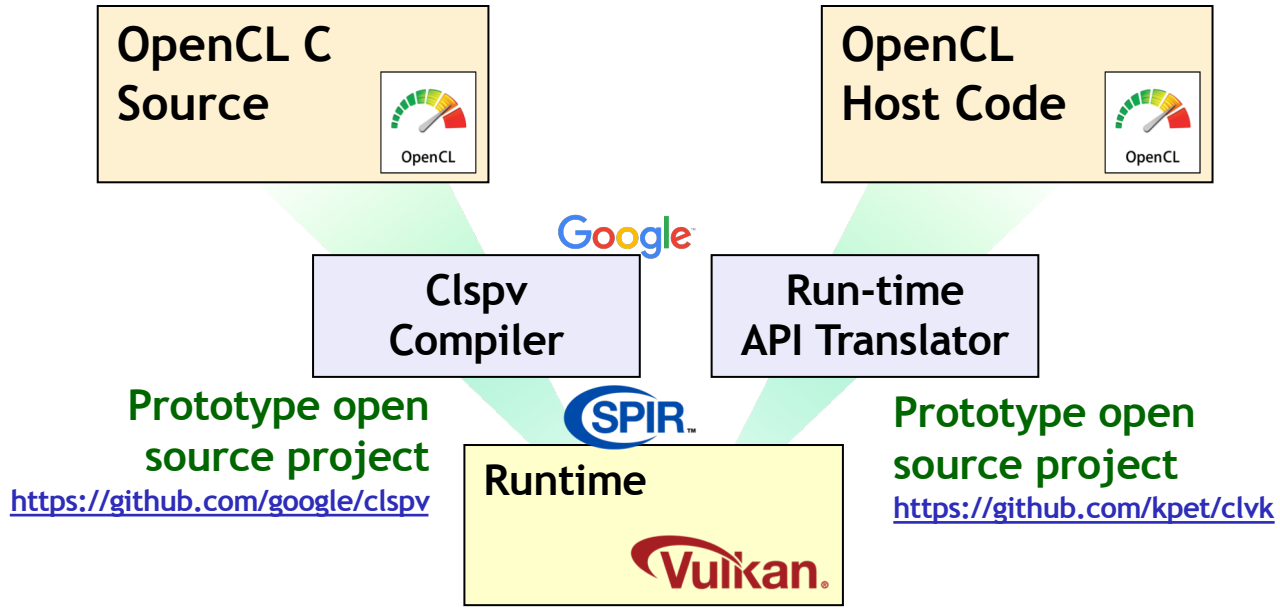
Khronos-hosted Open Source Projects

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

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



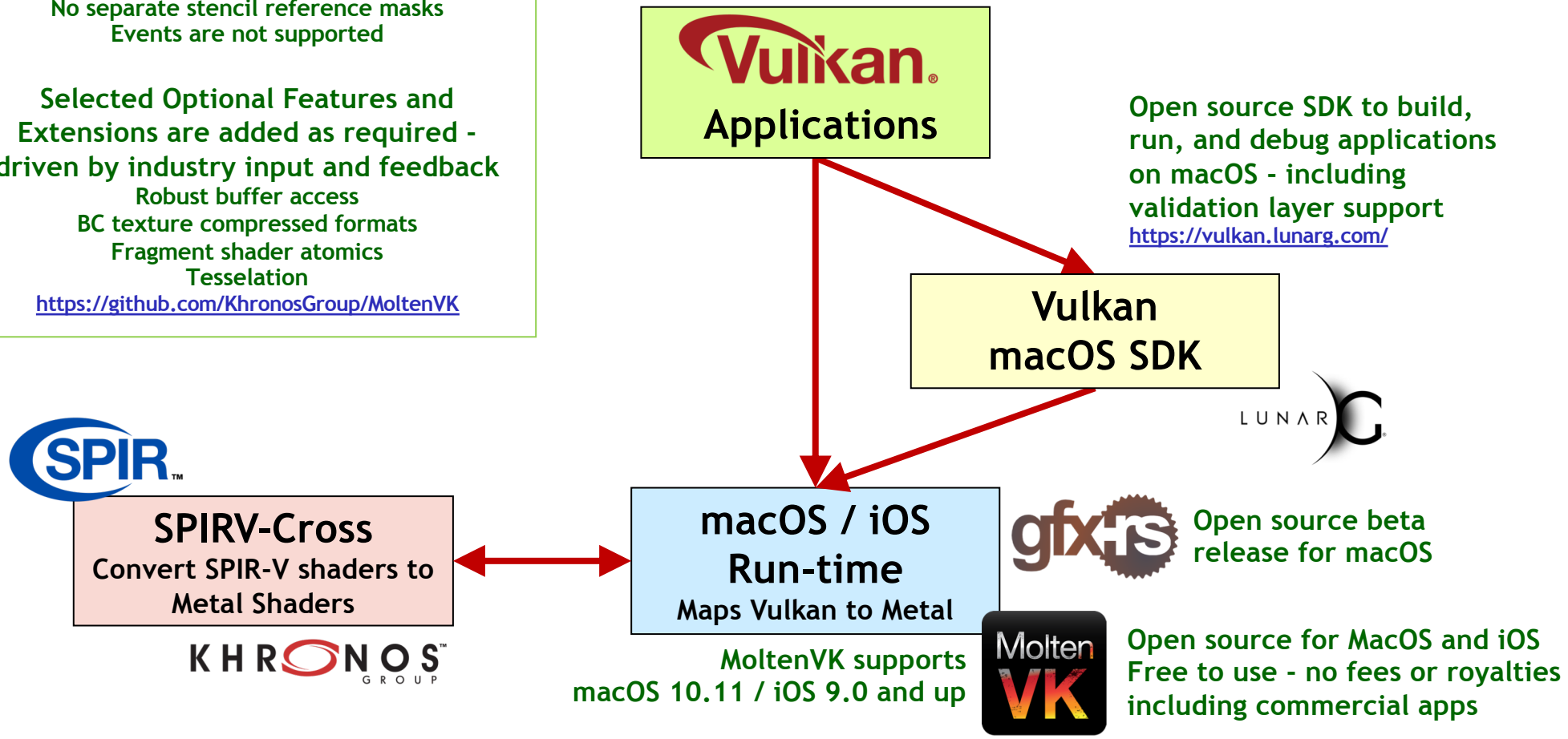


Vulkan Portability Initiative on Apple

Almost all mandatory Vulkan 1.0 functionality is supported:
No Triangle Fans
No separate stencil reference masks
Events are not supported

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

Khronos and MoltenVK/gfx-rs working on passing Vulkan Conformance Testing for all implemented functionality



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; game is targeting Dota 2 players as well as card gaming enthusiasts. Valve still plans to evolve Artifact and its gameplay mor

DOTA 2 — 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 — Qt Running on Mac through MoltenVK

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

Filament — Google Filament PBR Renderer on Mac

WINE — Initial ports of DX games in progress using Vulkan on Mac

ARTIFACT — 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 Graphics — Diligent Engine runs on MacOS

DOTA UNDERLORDS — Artifact from Steam ships on MoltenVK on macOS - second Vulkan-only Valve app on Mac

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

Running DX Games on Linux Over Vulkan

- **DXVK – Direct3D 10/11 emulator running over Vulkan**
  - Open source on GitHub - developed by Philip Rebohle 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 Emulator and Valve Proton tool**
  - Enable thousands of PC games on Linux

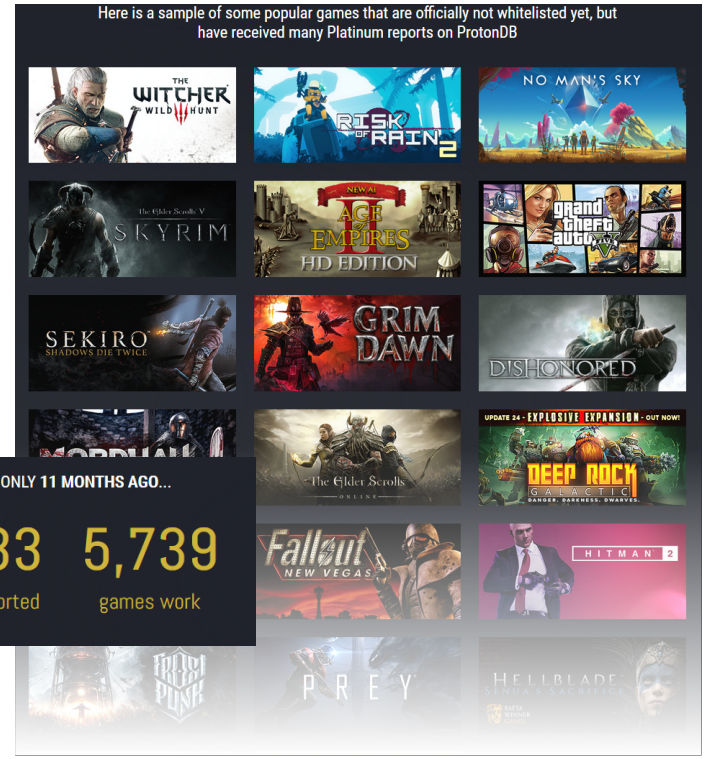
Extensions created in response to DXVK issues

VK_EXT_transform_feedback
VK_EXT_depth_clip_enable
VK_EXT_host_query_reset
VK_EXT_texel_buffer_alignment
VK_EXT_shader_demote_to_helper_invocation

Other extensions used by DXVK

VK_EXT_conditional_rendering
VK_EXT_memory_budget
VK_EXT_memory_priority
VK_EXT_shader_viewport_index_layer
VK_EXT_vertex_attribute_divisor
VK_KHR_draw_indirect_count
VK_KHR_shader_draw_parameters

https://www.protondb.com



Khronos at SIGGRAPH 2019

- **Khronos BOF Sessions**
  - Wednesday, July 31 in the Diamond Ballroom 7-10 at the JW Marriot LA Live
  - No SIGGRAPH Badge needed!
  - 9AM Khronos Fast Forward
  - 10AM glTF
  - 11AM WebGL
  - 1PM OpenXR
  - 2PM Vulkan
- **5:30PM Khronos Networking Reception – all welcome!**
- **3D Commerce BOF**
  - 10AM Thursday, August 1 in Room 507 of the Convention Center
  - SIGGRAPH badge is needed for the Thursday 3D Commerce session
- https://www.khronos.org/events/2019-siggraph

glTF Background Materials

Draco glTF Mesh Compression Extension

- **Library for compressing and decompressing 3D geometric meshes and point clouds**
  - Draco designed and built for compression efficiency and speed - great fit with glTF!
  - https://github.com/google/draco
- **Draco glTF extension launched in February 2018**
  - https://github.com/KhronosGroup/glTF/blob/master/extensions/2.0/Khronos/KHR_draco_mesh_compression/README.md
- **Google has released Draco encoders and decoders in open source**
  - C++ source code encoder to compress 3D data
  - C++ and JavaScript decoders for the encoded data
  - https://github.com/google/draco/tree/gltf_2.0_draco_extension
- **glTF/Draco compression already in use**
  - Blender, three.js, BABYLON.JS, Adobe Dimension, glTF pipeline, FBX2glTF, AMD Compressonator and glTF sample models

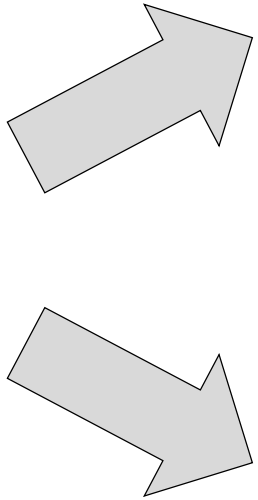
KTX2 and .basis files

Two complementary container formats for Basis Universal assets

BINOMIAL

'Basis Universal' texture compression technology

Enables JPG-sized textures that can be transcoded on-the-fly to natively supported *compressed* GPU formats



Binomial and Google open sourced 'Basis Universal' compressor and transcoder

C++ or WebAssembly code for handling '.basis' format textures in native apps and web sites

https://github.com/binomialLLC/basis_universal

Fine if you are in full control of your texture assets and rendering

Binomial's 'Basis Universal' technology contributed to glTF

Rigorously-defined KTX2 container format supports wide range of texture formats used in Vulkan/DirectX/Metal with streaming and full random access to MIP levels

glTF extension uses KTX2 subset with supercompressed payload using Basis Universal Technology

Great for cross-vendor distribution of textures to multiple applications and engines

glTF™

Focus on glTF Ecosystem Robustness

- **Khronos constantly working on improving ecosystem's consistency**
  - Rendering (reference viewer, reference environment)
  - Technical low-level issues (validator & asset generator)
- **If you are CREATING glTF Files**
  - Ensure generated files are validator clean
    - https://github.com/KhronosGroup/glTF-Validator
  - Help the community understand what your exporter supports
    - https://github.com/KhronosGroup/glTF/issues/1271
- **If you are LOADING glTF files**
  - Ensure loader can correctly load all sample models (integration tests)
    - https://github.com/KhronosGroup/glTF-Sample-Models
  - Ensure loader can correctly load all asset generator models (unit tests)
    - https://github.com/KhronosGroup/glTF-Asset-Generator

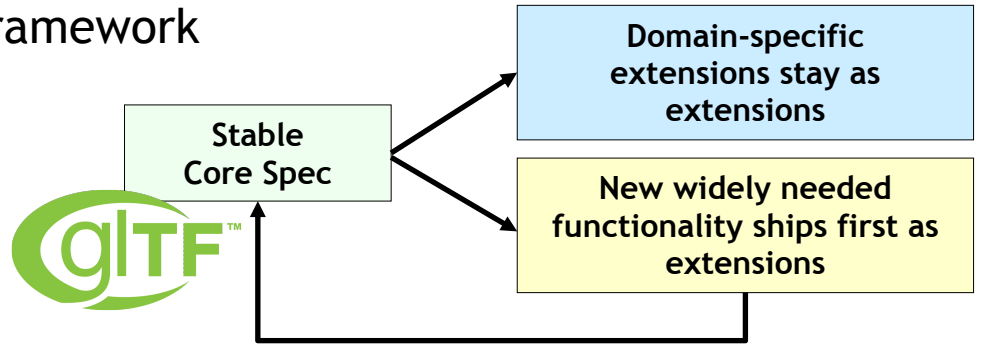
Users of glTF can help to keep glTF reliable and consistent!

glTF Sample Viewer

- **Generates accurate Ground Truth renderings of glTF Models**
  - https://github.com/KhronosGroup/glTF-WebGL-PBR/tree/reference-viewer
- **Not all glTF apps and engines need visual consistency**
  - But is critical to key use cases such as online retail
- **Headless mode, generates images**
  - Compare against offline path-traced renderings
  - For regression testing
- **Can be embedded in Visual Studio Code for live model previews**

glTF Evolution Philosophy

- **glTF manages its roadmap very carefully – complexity is the enemy**
  - Mission #1: ensure widespread, consistent, reliable usage
- **Extension for your own use – create a Vendor Extension**
  - Register your PREFIX by submitting a GitHub Issue
- **Multiple applications from multiple vendors need an extension**
  - Create a multi-vendor "EXT" extension
- **Broadly applicable across all apps/platforms - propose a "KHR" extension**
  - Need at least two implementations
  - Discussed and agreed by glTF working group
  - Covered by Khronos Intellectual Property Framework
- **Always have a fallback to core spec**
  - Avoid breaking compatibility with broader ecosystem
  - If you choose to not have a fallback list your extension in *extensionsRequired*



Integrate extensions into new core spec only when:
1) Widespread need is confirmed by the industry
2) Widespread reliable implementation is enabled (e.g. open source)

VRM - Using glTF 2.0

“VRM” is a file format for handling 3D humanoid avatar (3D model) data for VR applications

It is based on glTF 2.0

Anyone is free to use it. In addition, a standard implementation (UniVRM) in c# that can import and export VRM file in Unity is released as open source

26 Companies based primarily in Japan

https://vrm.dev/en/

Resources

- glTF Home Page
  - https://www.khronos.org/gltf/
- glTF GitHub
  - https://github.com/KhronosGroup/glTF
- PBR 2.0 – advanced materials
  - https://github.com/KhronosGroup/glTF/issues/1442
- Khronos 3D Commerce Working Group
  - https://www.khronos.org/3dcommerce
- More Information
  - www.khronos.org
  - ntrevett@nvidia.com
  - @neilt3d

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