KHRONOS GROUP

Khronos Update

Open standards in Augmented Reality

State of the AR Cloud Symposium

Neil Trevett
Khronos President
NVIDIA VP Developer Ecosystems

May 2019

ntrevett@nvidia.com | @neilt3d

OPEN AR CLOUD

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

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

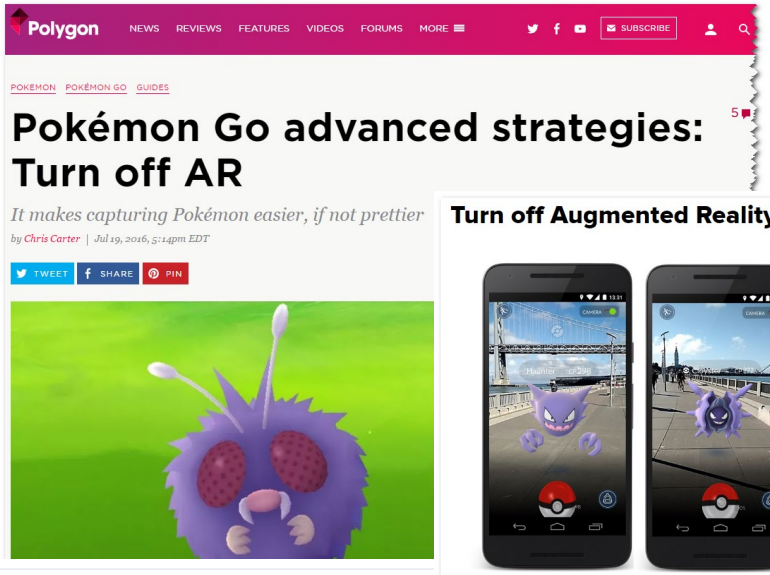
OpenCL, SYCL, SPIR, OpenVX, NNEF

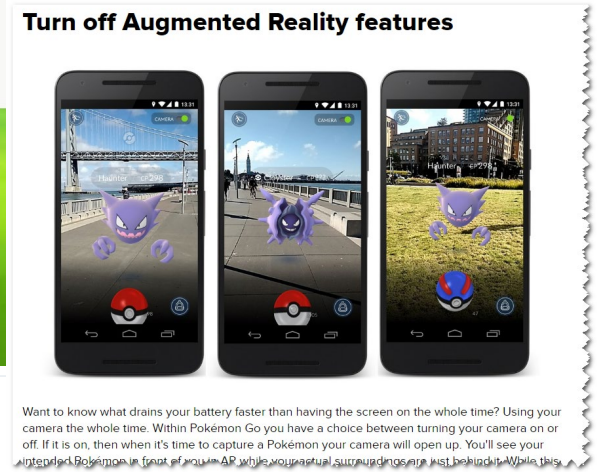
SAFETY CRITICAL FORUM: Creating API design guidelines for markets requiring safety certification

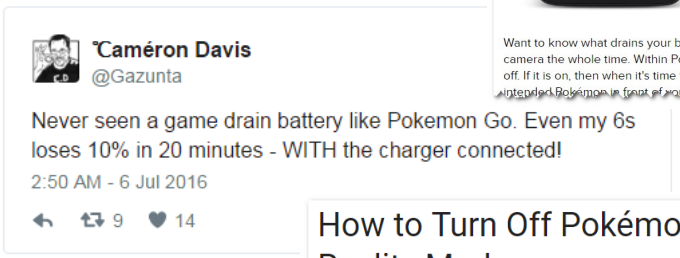
KHRONOS SAFETY CRITICAL ADVISORY FORUM SC™

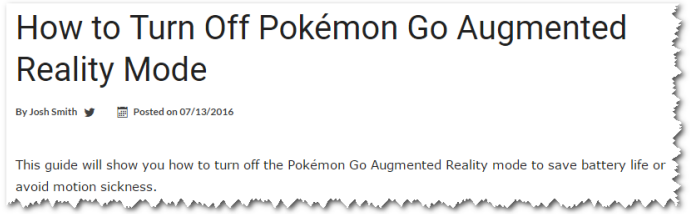
KHRONOS® GROUP

Power Efficiency and Battery Life





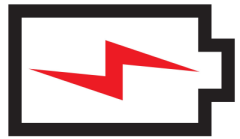




Pokémon Go AR processing runs on CPU

Offload Processors - such as GPUs - are FASTER AND more power EFFICIENT than CPUs

Everything runs on CPU



Silicon Acceleration

Developers need graphics and compute APIs to efficiently access acceleration processors

Vulkan - Now Available (Almost) Everywhere

Major GPU Companies supporting Vulkan for Desktop and Mobile Platforms

AMD arm BROADCOM Imagination intel NVIDIA QUALCOMM VeriSilicon

http://vulkan.gpuinfo.org/

Platforms

Desktop

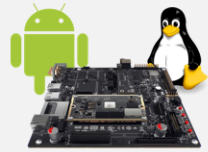
Mobile
(Android 7.0+)

Media Players

Consoles

XR Devices

Cloud Services



Embedded

Game Engines

VALVE id CRYENGINE unity EPIC GAMES Croteam Serious Engine XENKO

XR-Related Features NOW

Multi-GPU support
Multiview Rendering
Context priority
Front buffer rendering

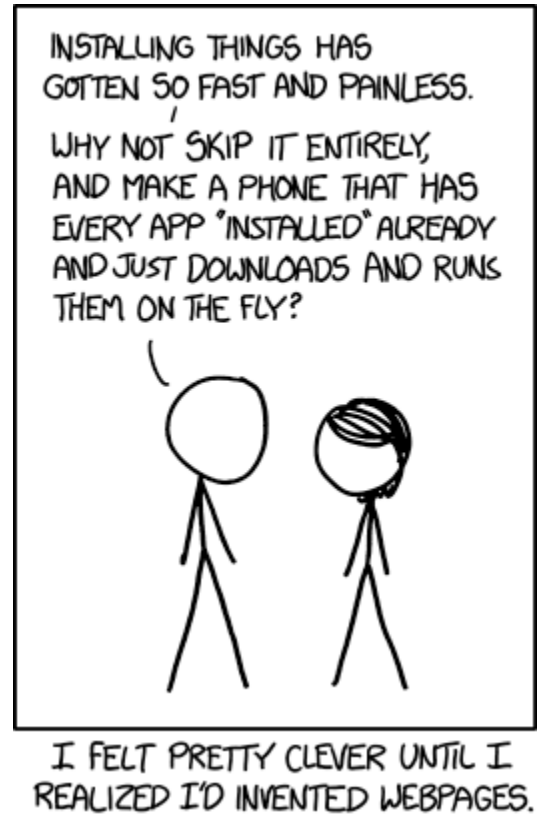
IN DISCUSSION

Variable Rate Rendering
Tiled rendering (beam racing)

KHRONOS GROUP

The Metaverse will be the Web!

https://xkcd.com/1367/



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

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

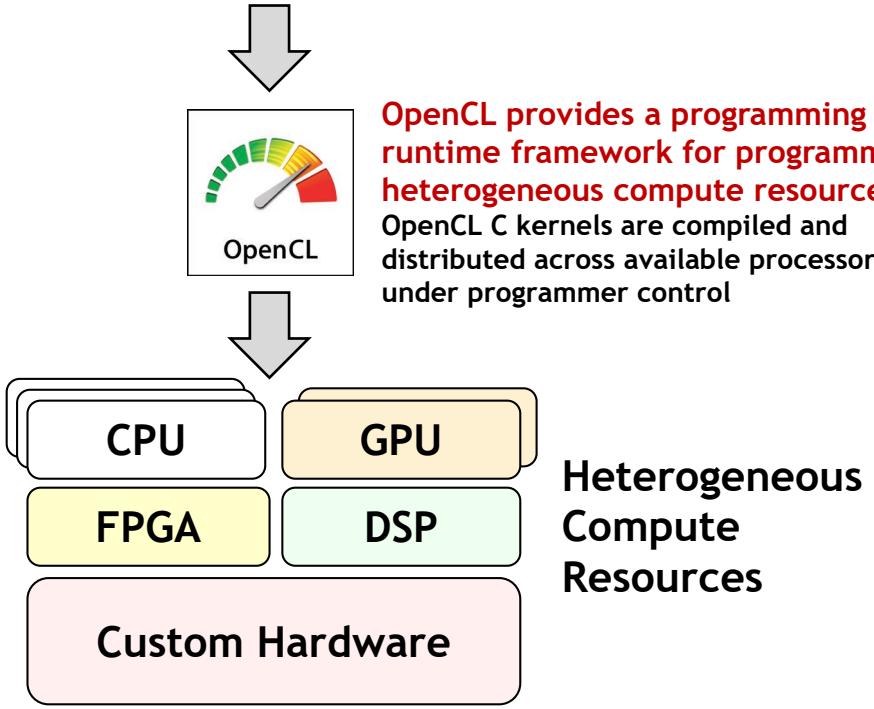
OS Provided Drivers
WebGL uses native OpenGL or OpenGL ES or Angle = OpenGL ES over DX

OpenGL ES | OpenGL

OpenCL for Heterogeneous Acceleration

Many mobile SOCs and Embedded Systems becoming increasingly heterogeneous

Autonomous vehicles, Vision and inferencing
Augmented and Virtual Reality



OpenCL provides a programming and runtime framework for programming heterogeneous compute resources

OpenCL C kernels are compiled and distributed across available processors under programmer control

Heterogeneous Compute Resources

OpenCL Hardware Implementations

OpenCL-accelerated Machine Learning Libraries

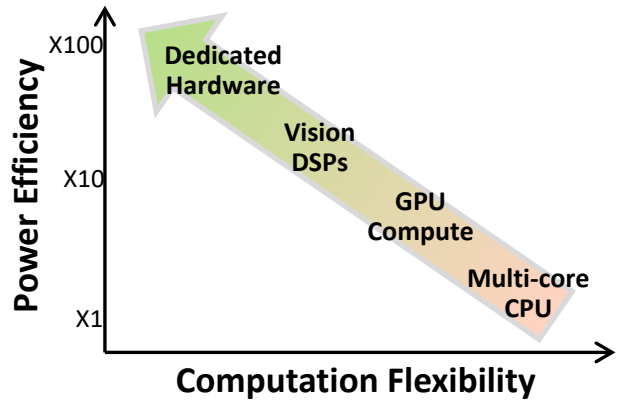
OpenCL-accelerated Machine Learning Inferencing Compilers

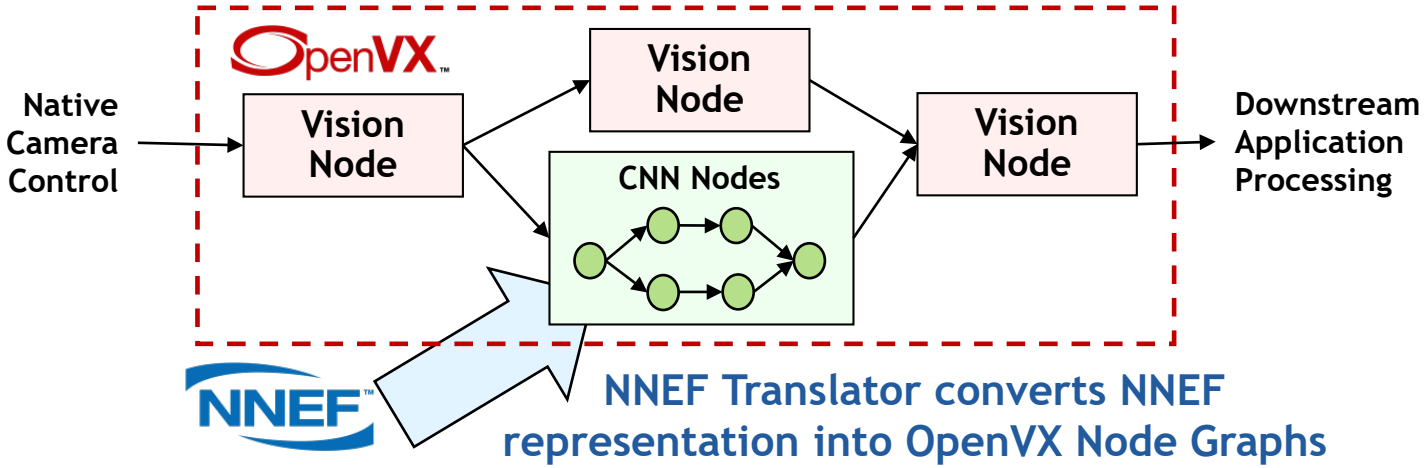
OpenCL-accelerated Vision and Imaging Libraries

Khronos OpenVX and NNEF for Inferencing

OpenVX

High-level graph-based abstraction for Portable, Efficient Vision Processing
Optimized OpenVX drivers created and shipped by processor vendors
Can be implemented on almost any hardware or processor
Graph can contain vision processing and NN nodes - for global optimization



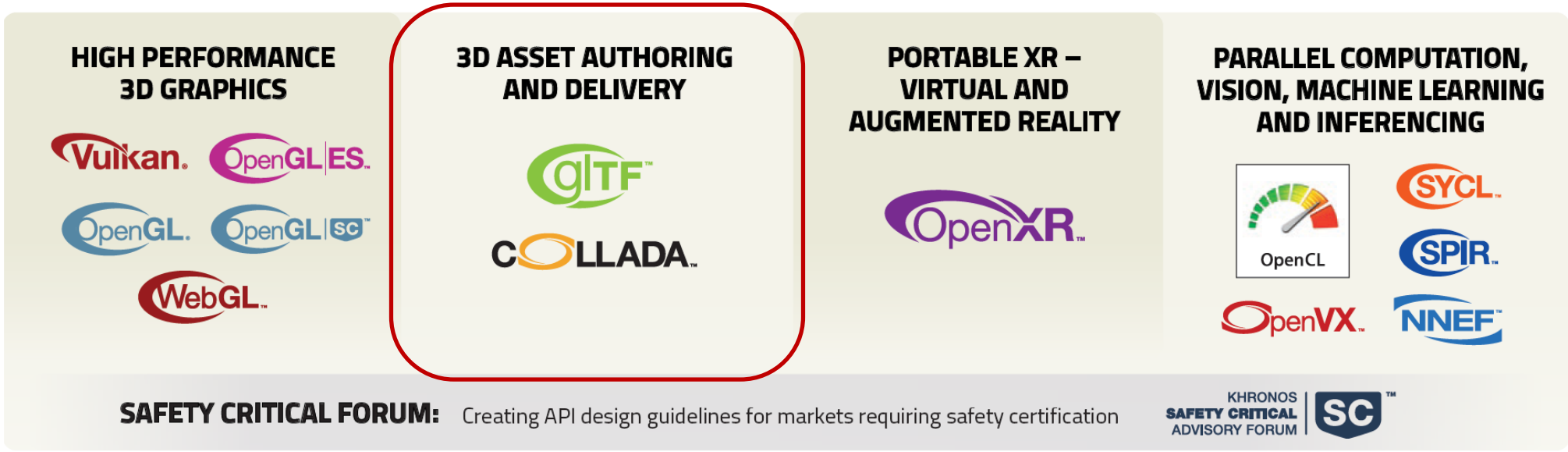


Performance comparable to hand-optimized, non-portable code

Real, complex applications on real, complex hardware
Much lower development effort than hand-optimized code

Hardware Implementations

Active Khronos Standards



glTF - The JPEG of 3D!

Audio	Video	Images	3D
MP3	H.264	JPEG	
napster	YouTube	facebook	

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

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

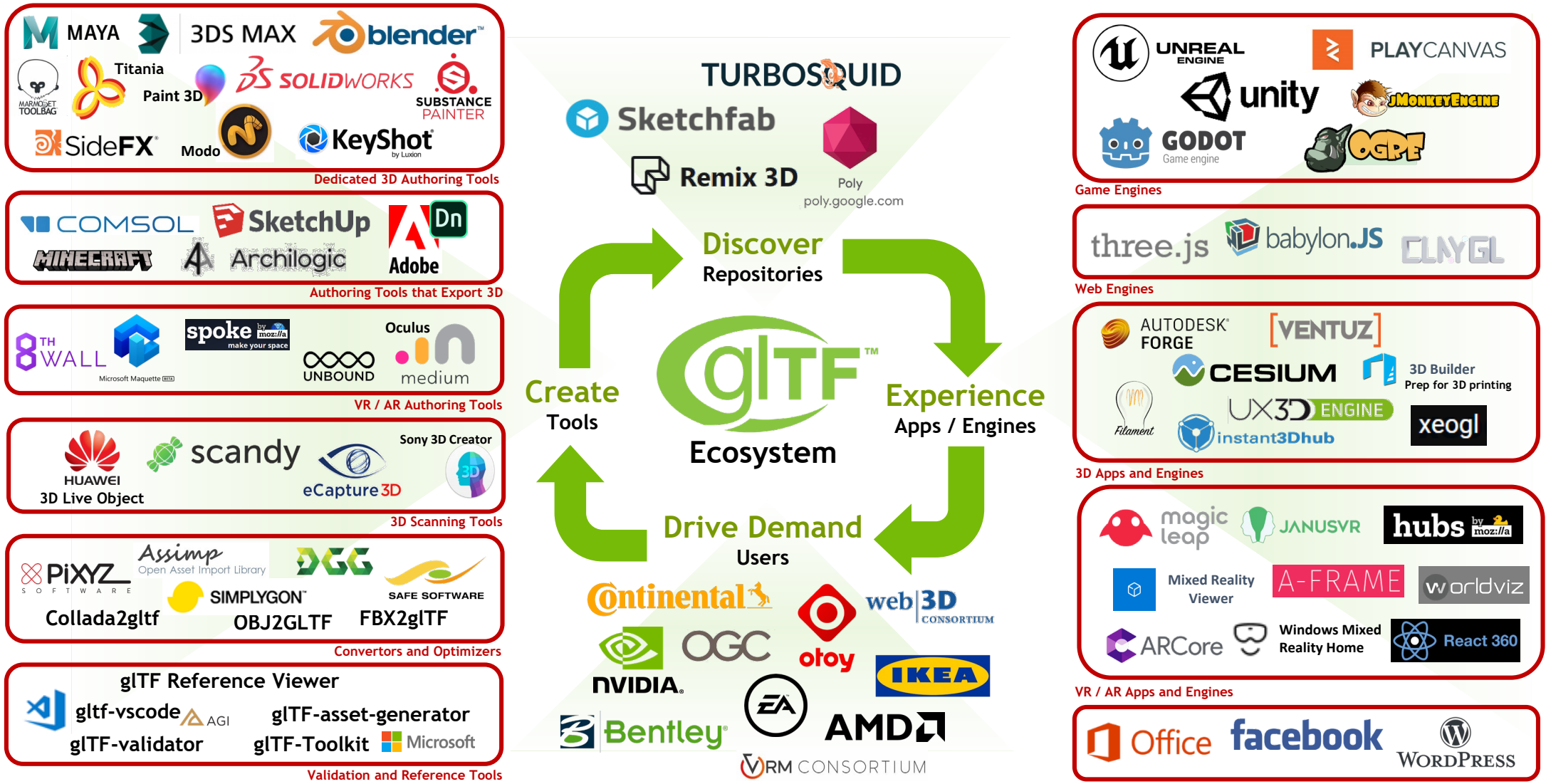
Efficient, reliable transmission
Bring 3D assets into 1000s of apps and engines

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

WebGL™ DirectX 12 Vulkan®

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

KHRONOS® GROUP


MAYA
3DS MAX
blender
Titania
Paint 3D
SOLIDWORKS
SUBSTANCE PAINTER
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
SIMPLYGON
SAFE SOFTWARE
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
Remix 3D
Poly
poly.google.com
Discover
Repositories
Create
Tools
glTF™
Ecosystem
Experience
Apps / Engines
Drive Demand
Users
Continental
web3D CONSORTIUM
NVIDIA
OGC
otoy
IKEA
Bentley
AMD
VRM CONSORTIUM
UNREAL ENGINE
PLAYCANVAS
unity
JMONKEYENGINE
GODOT
Game engine
OGRE
Game Engines
three.js
babylon.JS
CLAYGL
Web Engines
AUTODESK FORGE
VENTUZ
CESIUM
3D Builder
Prep for 3D printing
Filament
UX3D ENGINE
instant3Dhub
xeogl
3D 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 Recent Highlights

Blender 2.8 Beta ships with glTF import & export
https://www.blender.org/2-8/

Cinema 4D adds glTF export
https://labs.maxon.net/?p=3360

Houdini 17 ships with glTF import & export
http://www.sidefx.com/docs/houdini/news/17/index.html

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

OGC liaison and 3D Tiles OGC Community Standard for massive models
https://www.khronos.org/blog/liaison-between-khronos-and-open-geospatial-consortium-leads-to-3d-tiles-community-standard-built-on-gltf-for-streaming-massive-models

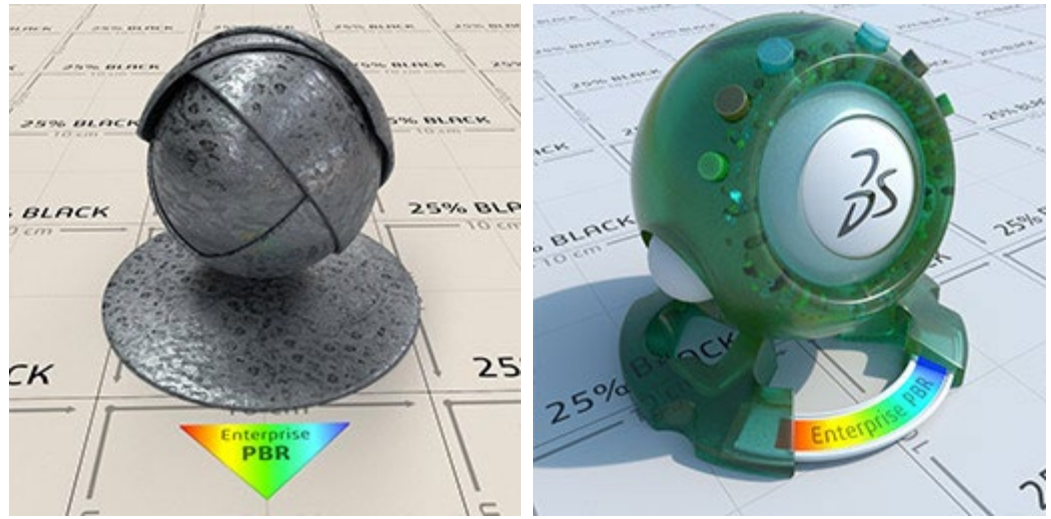
Open source WebComponent 3D model viewer
Import of glTF into AR Core apps via the Google Sceneform Tools plugin
https://github.com/GoogleWebComponents/model-viewer

Integrating glTF into 'HUBS' Web VR Meeting Space and 'Spoke' VR Authoring Tool
https://www.roadtovr.com/mozillas-hubs-one-click-vr-meeting-space-ive-waiting/

PBR Next

- **Next-generation Physically-Based Rendering (PBR) materials, e.g.,**
  - Absorption/attenuation, clear coat, subsurface scattering, anisotropy
- **Extend existing Metal Roughness glTF 2.0 PBR parameters**
  - Consistency and fallbacks for performance are key topics
- **Inspiration from Dassault Systèmes Enterprise PBR Shading Model (DSPBR)**
  - https://github.com/DassaultSystemes-Technology/EnterprisePBRShadingModel/tree/master/gltf_ext
  - 3DS_materials_enterprise_pbr (draft)
- **Collaborating with engine developers:**
  - Dassault Systèmes
  - Google Filament
  - Microsoft BabylonJS
  - OTOY Octane

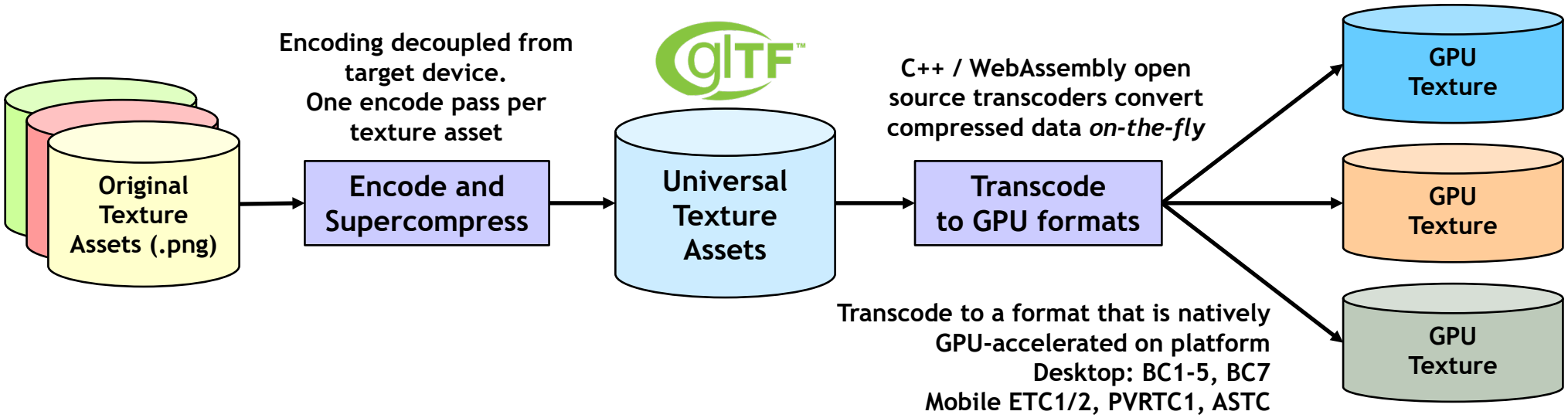
Join the GitHub Discussion!
https://github.com/KhronosGroup/glTF/issues/1442



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

CTTF Universal Textures for glTF

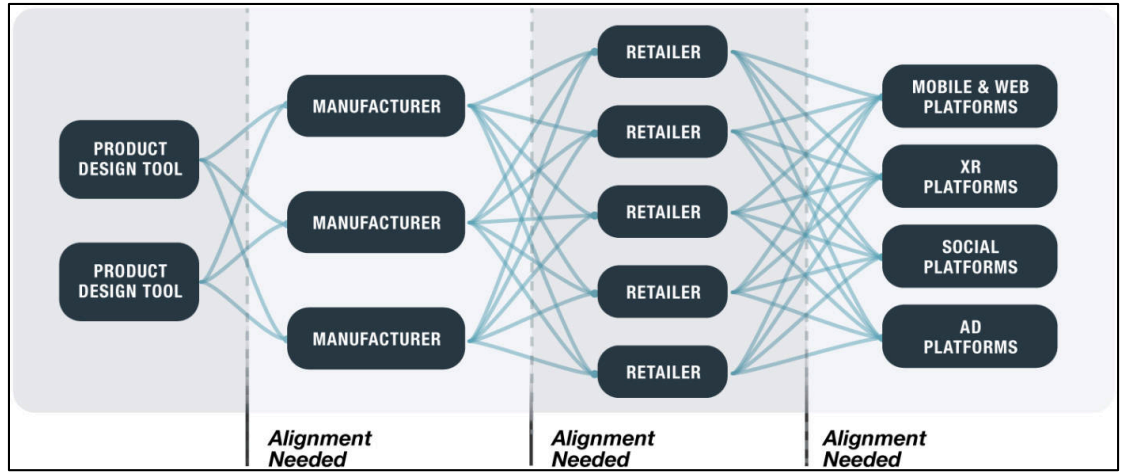
- **Binomial and Google recently open sourced 'Basis Universal' compressor and transcoder**
  - C++ and WebAssembly for code and Web stacks
  - https://github.com/binomialLLC/basis_universal
- **Basis Universal format is being contributed to glTF to enable CTTF Universal Textures**
  - CTTF = Compressed Texture Transmission Format
  - Complements Google Draco-based mesh compression already in glTF
  - (and Draco-based compressed point clouds soon)
  - Will use KTX2 as a container format
  - github.com/KhronosGroup/CTTF-Specification



Khronos 3D Commerce Exploratory Group

Khronos 3D Commerce Exploratory Group

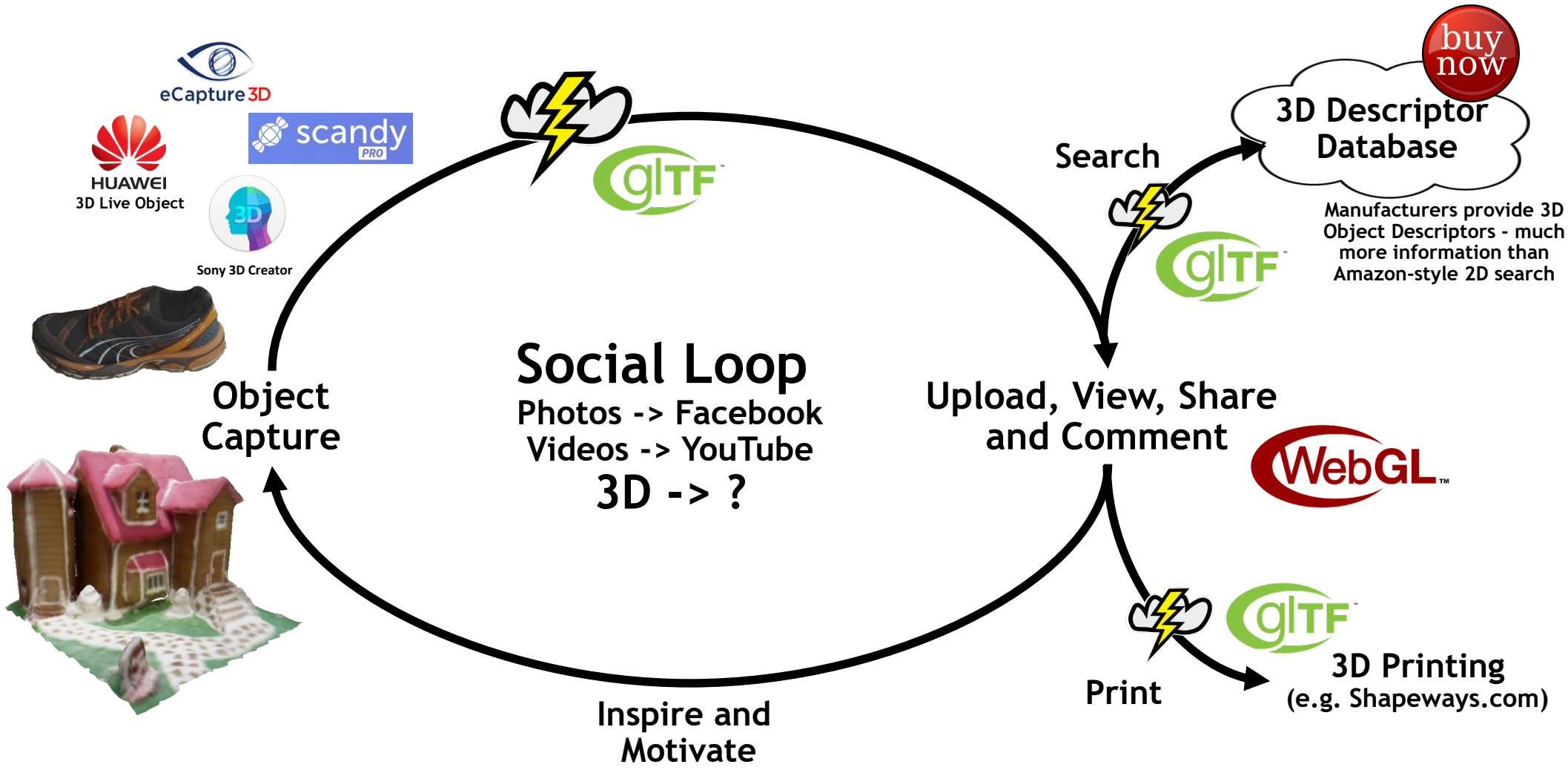
Retail AND Technology companies making virtual 3D product representations possible on an industrial scale



Open to any company under NDA during exploratory phase

https://www.khronos.org/exploratory/3d-commerce/

With Consumer Capture - 3D Will Go Social!



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

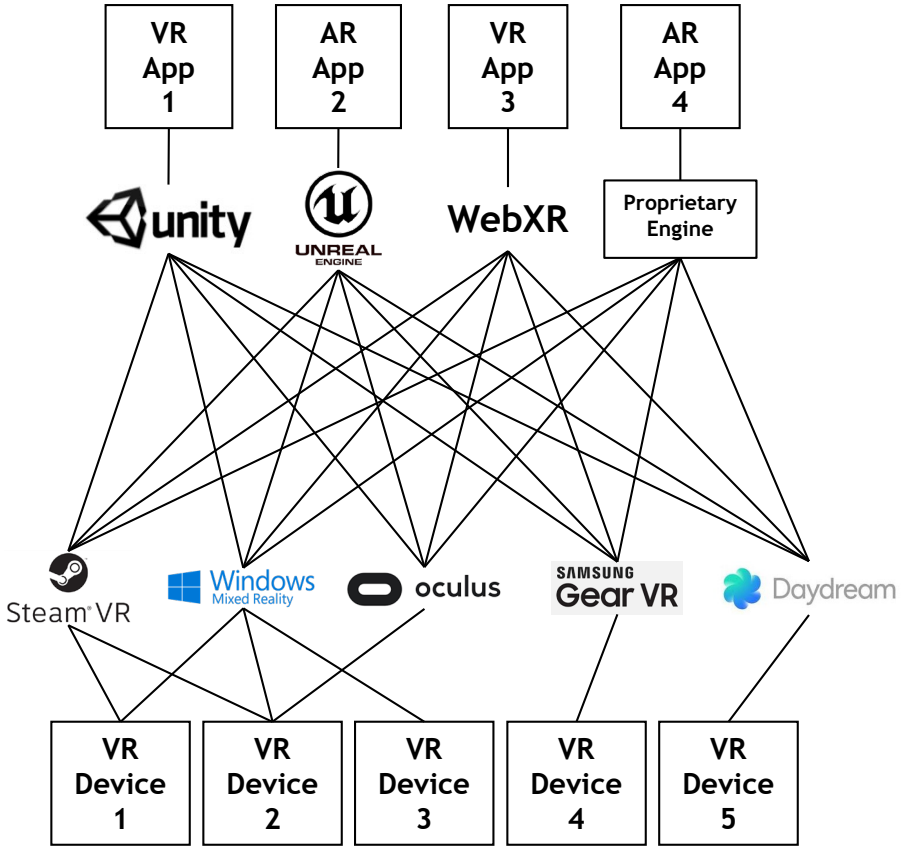
PARALLEL COMPUTATION, VISION, MACHINE LEARNING AND INFERENCING

OpenCL, SYCL, SPIR, OpenVX, NNEF

SAFETY CRITICAL FORUM: Creating API design guidelines for markets requiring safety certification

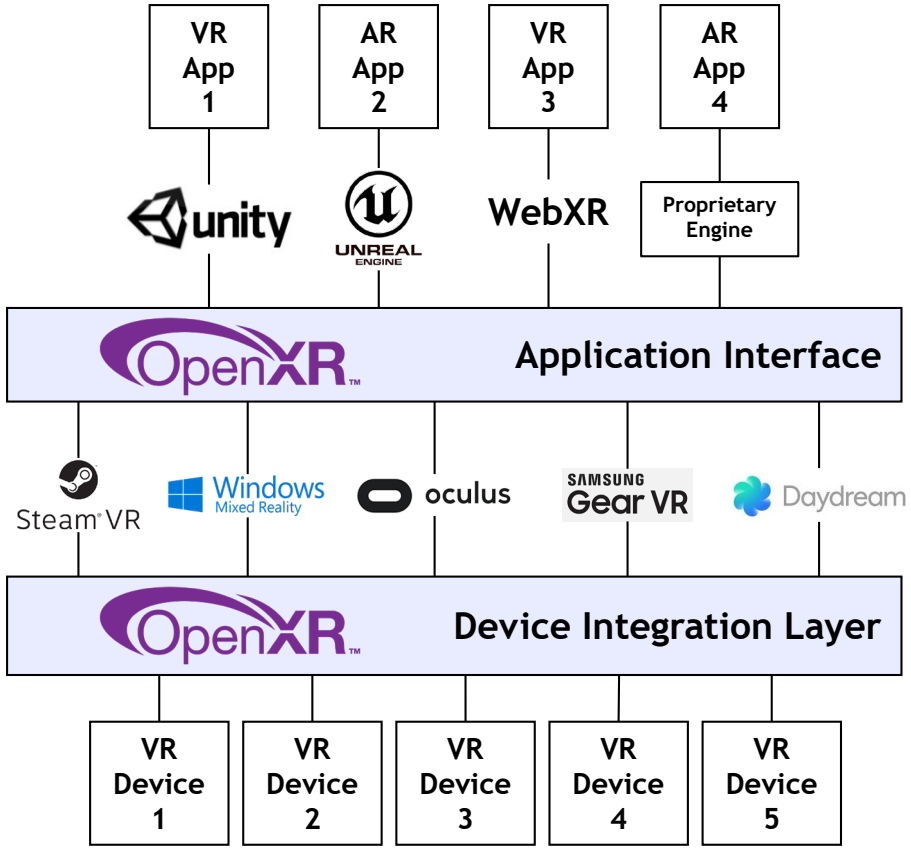
KHRONOS SAFETY CRITICAL ADVISORY FORUM SC™

OpenXR - Solving VR/AR Fragmentation



Before OpenXR

XR Market Fragmentation



After OpenXR

Wide interoperability of XR apps and devices

Companies Publicly Supporting OpenXR

OpenXR is a collaborative design

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

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

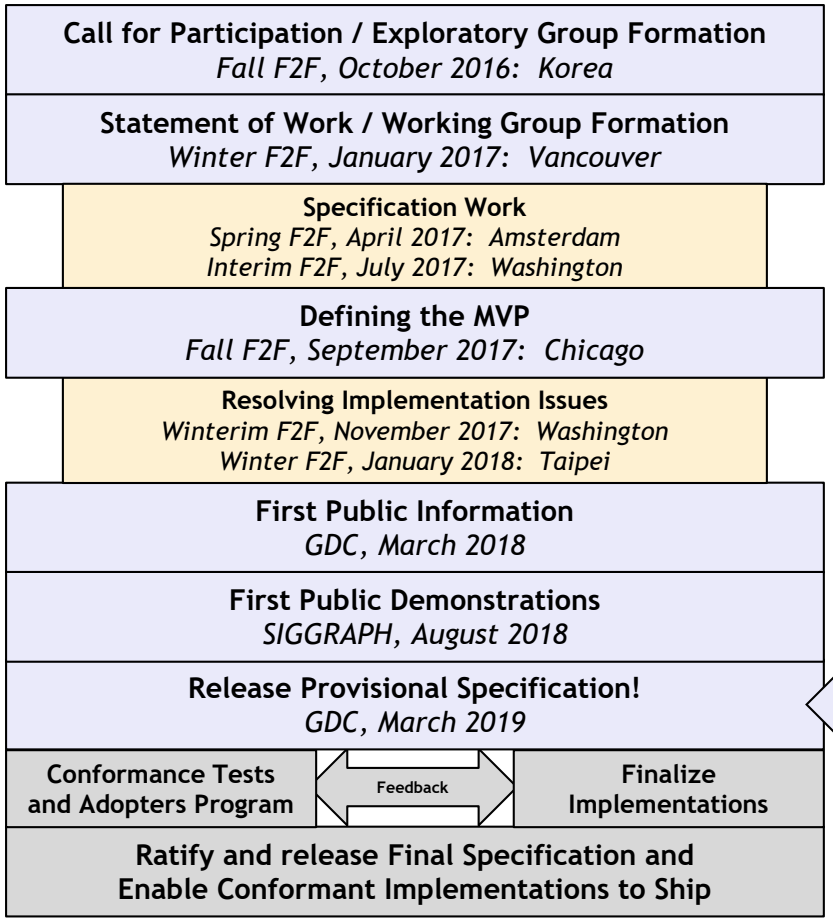
Cross-platform access to XR HMDs and sensors
- XR application lifecycle
- Frame timing and display composition
- Sensor tracking and pose calculation
- Input device discovery and events
- Haptics Control

Vulkan®

OpenXR™

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

OpenXR Specification Released Here at GDC!



OpenXR™

High-performance access to AR and VR platforms and devices

OpenXR 0.90 Provisional Specification Released
Enables industry review and feedback
First prototype implementations shipping

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."

Tim Sweeney, founder and CEO of Epic Games

"Epic believes that open standards like OpenXR are essential foundations for a vibrant, multi-platform VR and AR industry in the coming years. Epic plans to continue supporting OpenXR in Unreal Engine 4."

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."

Alex Kipman, technical fellow, Microsoft

"Microsoft believes that for mixed reality to thrive, it must be open for everyone: open stores, open browsers and open developer platforms. We're dedicated to supporting the launch of OpenXR this year on Windows Mixed Reality and HoloLens 2. To help developers provide feedback, we're releasing today a developer preview of our OpenXR runtime with support for Windows Mixed Reality headsets."

Philippe Kalaf, CEO, Collabora

Collabora is excited to announce Monado, an open source implementation of the newly released OpenXR spec. More than just a vendor SDK, Monado is an open source project and codebase to harness and focus wider community effort around XR technologies.

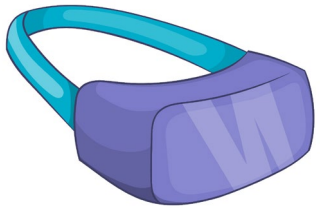
OpenXR Win-Win-Win

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

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

three.js

3D Engines

Close ongoing collaboration between WebXR and OpenXR

KHRONOS GROUP

Vulkan

OpenXR

WebGL

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

KHRONOS GROUP

XR and 5G

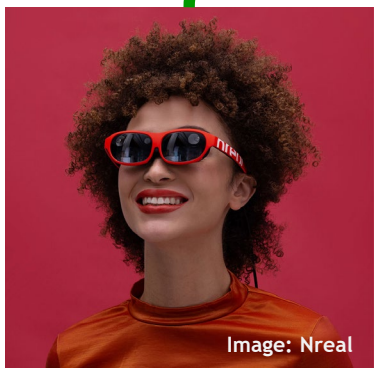
Leveraging High Bandwidth and Low Latency

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

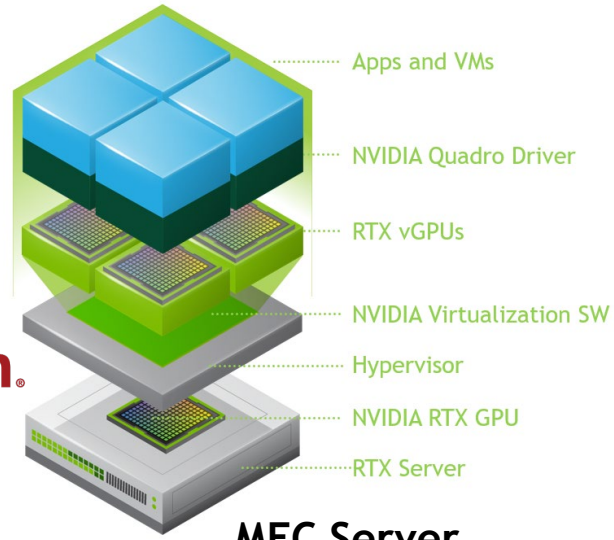


Wireless mobile device with display and sensors

NVIDIA CUDA

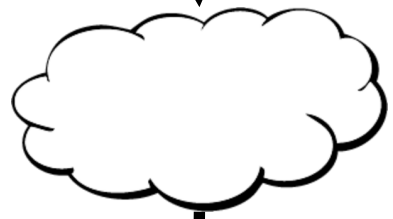
OpenCL

Vulkan



MEC Server

Content Requests Location



glTF

Apps 3D Assets

OpenXR

Generated Augmentations & Scenes

5G

OpenXR APIs can hide the 5G round trip from applications

KHRONOS GROUP

Any Questions?

- **Standards will be key to pervasive XR**
  - Compute, XR and content interoperability
- **Khronos is creating cutting-edge royalty-free open standards**
  - For 3D, VR/AR, Compute, Vision and machine learning
  - Any company welcome to join and help steer the direction of the industry
- **More Information**
  - www.khronos.org
  - ntrevett@nvidia.com
  - @neilt3d

KHRONOS GROUP