Building the Metaverse One Open Standard at a Time
Khronos APIs and 3D Asset Formats for XR

Neil Trevett
Khronos President
NVIDIA VP Developer Ecosystems
ntrevett@nvidia.com | @neilt3d

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Khronos Connects Software to Silicon

Open interoperability standards to enable software to effectively harness the power of multiprocessors and accelerator silicon

3D graphics, XR, parallel programming, vision acceleration and machine learning

Non-profit, member-driven standards-defining industry consortium

Open to any interested company

All Khronos standards are royalty-free

Well-defined IP Framework protects participant’s intellectual property

>150 Members - 40% US, 30% Europe, 30% Asia
Khronos Active Initiatives

3D Graphics
Desktop, Mobile, Web
Embedded and Safety Critical

3D Assets
Authoring and Delivery

Portable XR
Augmented and Virtual Reality

Parallel Computation
Vision, Inferencing, Machine Learning

Guidelines for creating APIs to streamline system safety certification
# Pervasive Vulkan

## Desktop and Mobile GPUs

![Logos of various companies supporting Vulkan](image)


## Platforms

- **Desktop**
- **Android** (Android 7.0+)
  - (Vulkan 1.1 required on Android Q)
- **Apple** (via porting layers)
- **Media Players**
- **Consoles**
- **Virtual Reality**
- **Cloud Services**
- **Game Streaming**
- **Embedded**

### Note:
The version of Vulkan available will depend on platform and vendor.

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Vulkan Roadmap

Vulkan 1.1 Extensions
- Maintenance updates plus additional functionality
  - Timeline semaphores
  - DX/HLSL compatibility
  - Bindless resources
  - Reduced precision arithmetic
  - Formal memory model
  - Buffer references
  - SPIR-V 1.5

Roadmap Discussions
- Ray Tracing
- Variable Rate Shading
- Accelerated Video Encode/Decode
- Machine Learning Primitives
- Mesh Shaders

January 2020

Variable Rate Shading
Enables concentration of rendering power at the foveal point in eye-tracked XR systems
Ray Tracing is a Flexible Technique

Programmers need programmable flexibility to trace rays through scenes for a wide variety of visual effects - some examples...

- Ambient Occlusion
- Reflections
- Shadows
- Global Illumination
Vulkan Ray Tracing

Two ways to launch rays into scene to generate high realistic visuals

Ray Tracing Pipelines
A new type of graphics pipeline
Implicit management of ray intersections
Application compiles a set of shaders into the pipeline to provide desired ray and material processing

Ray Queries
Any type of shader can launch a ray at any time
Shader can process intersection data however it wishes
Shader controls how traversal proceeds

Using a BVH data structure to enable efficient ray tracing through a 3D scene

1. Launch 2D/3D grid of rays into scene contained in an Acceleration Structure
2. ‘Intersection’ Shader computes ray intersections
Ray-triangle intersections are built-in
3. Invoke ‘Any Hit’ Shader if intersection is found. Multiple intersections possible - arbitrary order
4. Invoke ‘Closest Hit’ shader on the closest intersection of the ray OR Invoke ‘Miss’ Shader if no hit is found
Can trace more rays

Ray Tracing Pipeline
OpenXR - Cross-Platform Portable AR/VR

OpenXR is a collaborative design
Integrating many lessons from proprietary ‘first-generation’ XR API designs

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

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OpenXR 1.0 Availability

Significant Community Feedback
- Improved
  - Input subsystem,
  - game engine editor support, loader ...

Provisional Specification
- GDC, March 2019

Ratify and Release
- OpenXR 1.0
  - SIGGRAPH, July 2019

Finalize Conformance Test Suite
- Enable Officially Conformant Implementations

OpenXR for Windows Mixed Reality headsets and HoloLens 2
- PLUS extensions to support HoloLens 2 hand tracking, eye tracking, spatial mapping and spatial anchors

OpenXR support for Oculus Rift and Oculus Quest
- Oculus PC (for Rift) and Android SDK (for Quest)
  - include OpenXR for native C/C++ development

‘Monado’ OpenXR open source implementation
- Support OpenHMD hardware and Nova Northstar AR HMD

OpenXR 1.0 plugin for Unreal Engine v4.2.4

Many more coming!
OpenXR Win-Win-Win

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

XR ISVs
Can easily ship on more platforms for increased market reach

XR End-Users
Can run the apps they want on their system - reducing market confusion and increasing consumer confidence
OpenXR is used with a 3D API

* OpenXR can be used with other 3D APIs such as Direct3D, OpenGL and OpenGL ES
Bringing XR to the Web

Native XR Apps

Web XR Apps

WebXR

Web 3D Engines

Native 3D Engines

Lifting OpenXR functionality into the Web stack

Close cooperation between WebXR and OpenXR

The Web will Evolve into the Metaverse

Khronos provides the foundation for native and Web-based 3D/XR
OpenXR and Edge Server Applications with 5G

5G

OpenXR APIs hide the 5G round trip from applications

Sensor handling

Display composition

Wireless mobile device with display and sensors

Low latency Sensor Data

5G

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

Generated Augmentations & Scenes

NVIDIA EGX

Location-aware Content Requests

Needed assets loaded to edge server

Apps and 3D Assets

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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

### Mandatory Metallic-Roughness Materials

![Mandatory Metallic-Roughness Materials](image)

### Optional Specular-Glossiness Materials

![Optional Specular-Glossiness Materials](image)
glTF Universal Textures
(imminent)
Basis Universal encoding/transcoding
KTX2 Container

Working Group is constantly balancing feature requests against the ‘glTF Prime Directive’ - remain a universal and easy to process delivery format

Second Generation Physically-Based Rendering (PBR)
Set of coherent extensions
- Clear coat (imminent)
- Absorption/attenuation
- Subsurface scattering
- Anisotropy

Inspiration from Dassault Systèmes Enterprise PBR Shading Model (DSPBR) and MDL

Wide industry cooperation

Seeking Requirements
Subdivision surfaces
Advanced Animation
LOD and Streaming
Compressed Point Clouds
Cross-asset linking
Enhanced Metadata
Composability
Instancing
CAD/BIM model support
Encryption and security
3D Printing

FlightHelmet_baseColor
2048 x 2048, RGB

JPEG must be fully decompressed into GPU memory

Universal textures can be directly transcoded to compressed GPU textures

Uncompressed
2,778,518
JPEG
315,619
ETC1S
2,097,152
Basis Universal
232,104

File Size
GPU Size

Bytes
12,582,912
7,000,000
10,500,000
14,000,000

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3D Commerce - The Opportunity

3D Commerce = E Commerce enhanced with the use of 3D Models on any platform - including VR and AR

Early Experience Shows
- Increased customer engagement!
- Strengthened brand loyalty!
- Deeper product understanding!
- More online sales!
- Fewer returns!

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

IKEA Communications AB

So why is 3D Commerce taking so long to become widespread?

= $$ $$!
3D Commerce - Today’s Reality

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!

I need the materials in my 3D models to look completely realistic!

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

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

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

Many 3D products on my ecommerce website first appear upside down! I have to hand-tune 1000s of models!

Complex retail pipeline with hundreds of companies and millions of products

Many friction points: tooling, technical and commercial

3D Commerce can’t reach industrial scale so...

Interoperability Standards to the rescue!
Khronos 3D Working Group

Announced SIGGRAPH 2019

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

Any company is welcome to join!
https://www.khronos.org/3dcommerce
3dcommerce-feedback@khronos.org

Broad Industry Participation from tooling, retail, technology and platform companies
3D Commerce - Four Initial Areas of Focus

**Asset Creation Guidelines**
For tools and product designers to create assets with consistent data to be used through the 3D Commerce pipeline.

**Product Configuration**
Universal product configurability data and guidelines on how to drive consistent product display.

**Metadata**
Structured metadata definitions and examples to consistently carry product information through the retail pipeline.

**Viewer Validation and Certification**
Test models, reference viewer, display analysis tools and capability specifications to guarantee a consistent and accurate end user experience.

**First Goals**
Helping evolve glTF to meet the needs of 3D Commerce
- Next generation PBR
- Advanced metadata

Industry cooperation to urgently develop guidelines and tools to address priority problem areas.
How To Get Involved!

• Any company or organization is welcome to join Khronos!
  - For a voice and a vote in any of these standards - membership starts at $3,500
• OR request an invite to Vulkan, OpenXR and 3D Commerce Advisory Panels/Forums
  - No fee, under Khronos NDA - and IP Framework for draft specification feedback
• We welcome your feedback
  - Khronos Forums: https://forums.khronos.org/
  - Khronos Slack Channels: https://khronosdevs.slack.com/messages
  - Khronos open source GitHub repositories: https://github.khronos.org/
• Contact Neil Trevett
  - ntrevett@nvidia.com | @neilt3d | www.khronos.org