Connected
3D Standards for a Hyperconnected World

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What is An Open Standard?

An INTEROPERABILITY STANDARD enables two entities to COMMUNICATE
E.g. Software <-> Hardware

**Standards Grow Markets**
By reducing consumer confusion and increasing capabilities and usability

**Standards Speed Time to Market**
With well-proven testing and interoperability

**Standards Reduce Costs**
By sharing development between many companies and driving volume

**Standards Do Not Stifle Innovation**
Companies can compete on implementation quality, performance, power etc. etc.

**True OPEN Standards**
Are not controlled by a single company - but by the industry
Typically through a Standards Developing Organizations (SDOs)
Well defined participation, governance and intellectual property frameworks
Constellation of Connected 3D Standards

Widespread 3D will take a constellation of industry standards

- **OGC**
  - Geospatial 3D
    - e.g. 3D Tiles

- **IEEE**
  - 3D Verticals and Security
    - e.g. 3D Body Processing P3141

- **3D PDF Consortium**
  - 3D in Documents

- **ISO**
  - 3D in IT
    - e.g. 3D printing and scanning

- **IEC**
  - 3D in IT

- **VR Video Formats**
  - e.g. MPEG-I
  - Integrating 3D with streaming

- **W3C**
  - 3D and XR in the Browser
    - e.g. WebXR

- **VESA**
  - Display and HMD Connectivity
    - e.g. DisplayLink

- **KHRONOS Group**
  - 3D and XR Hardware APIs

- **ITU**
  - Wireless and 5G

- **3DPDF Consortium**
  - 3D in Documents
Web3D and Khronos Synergy

Khronos and Web3D Creating Formal Liaison
Each organization will enable selected liaisons to participate in their meetings to coordinate deeper cooperation

Higher-level semantics and vertical value

Low-level APIs and file formats

Real-Time 3D Communication on the Web

3D and XR Hardware APIs
Web3D and Khronos

Congratulations to Web3D for 25 years of conferences!

Web3D Consortium and Khronos Group Share a Booth at SIGGRAPH 2003

Web3D Consortium Board 2001
Khronos Connects Software to Silicon

Open interoperability standards to enable software to effectively harness the power of 3D and multiprocessor acceleration

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

Founded in 2000

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

Guidelines for creating APIs to streamline system safety certification
Topics for Today

- Low-level 3D in the Browser
- WebGl
- glTF
- Real-time 3D Asset Transmission Format
- 3D in E-Commerce at industrial scale
- 3D Commerce
- Portable access to AR and VR Hardware
- OpenXR
WebGL 2.0 Universal Availability

- WebGL 2.0 is finally coming to all major operating systems
  - iOS in particular!
- Collaboration with Apple since June 2019
  - Integrated ANGLE project into WebKit as the WebGL backend
- Available for testing now (October 2020):
  - Safari Technology Preview on macOS
  - Safari in iOS 14.2 betas
  - Follow progress of the project
- Upgrade your applications to WebGL 2.0 now!

Lots of great WebGL sites and products archived on this Working Group maintained Blog
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

2007
OpenGL ES 2.0

2012
OpenGL ES 3.0

2014
OpenGL ES 3.1

4 years
2011
WebGL 1.0

5 years
2017
WebGL 2.0

2020
Pervasive WebGL 2.0

Performance and quality of WebGL implementations will continue to be the highest priority for the Khronos WebGL working group

After WebGL 2.0?
W3C is working on WebGPU
Layering over Vulkan/DX12/Metal
Leveraging Khronos SPIR-V IR
WebGPU Community Group

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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**
  - Base Color + Metallic + Roughness

- **Optional Specular-Glossiness Materials**
  - Diffuse + Specular + Glossiness

Geometry

Texture based PBR materials
3DS MAX®
Paint 3D
Houdini
MAYA
Titania
SUBSTANCE
PAINTER
KeyShot
SketchUp
Minecraft
Adobe
Modo
bender®
SOLIDWORKS
Cinema 4D
RealityServer®
Dust3D
Archilogic

3D Authoring Tools

WALL
wave engine
VECTOR
Unbound
medium
Sony 3D
Creator
scandy

VR / AR Authoring Tools

VNTANA
Simplygon
RapidCompact
Collada2glTF
CrossManager
OBJ2GLTF
FBX2glTF

3D Scanning Tools

glTF Sample Viewer
glTF-Toolkit
glTF-validator
glTF-asset-generator

Converters, Optimizers and Loaders

Validation and Reference Tools

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glTF Draco Mesh Compression Extension

- glTF extension for compressed geometry
  - Typically 10-25x geometry size reduction

- Google Draco technology - designed for decompression efficiency and speed
  - [https://github.com/google/draco](https://github.com/google/draco)

- Draco geometry encoders and decoders in open source
  - C++ source code encoder
  - C++ and JavaScript decoders
  - [https://github.com/google/draco/tree/gltf_2.0_draco_extension](https://github.com/google/draco/tree/gltf_2.0_draco_extension)

- glTF Draco compression adoption is growing in tools, applications and engines
  - glTF pipeline, FBX2glTF, AMD Compressonator and glTF sample models

![Mesh Compression Ratios](chart.png)
glTF Universal Texture Extension

- Supercompressed textures that can be transcoded for native acceleration on any GPU
  - Eliminates need for multiple texture assets for different target platforms

- Uses ‘Basis Universal’ compression technology from Binomial
  - Compressed textures transcodable on-the-fly to native GPU-accelerated texture formats
  - RDO-encoded, block-compressed UASTC with optional zstd compression - for highest quality
  - Block-compressed ETC1S with custom LZ supercompression - for JPEG-sized textures
    - https://github.com/BinomialLLC/basis_universal

- KTX 2.0 container for consistent, cross-vendor asset generation and validation
  - Open source tools to create, transcode and upload to WebGL, OpenGL and Vulkan
    - https://github.com/KhronosGroup/KTX-Software/tree/ktx2

Original Texture Assets (.png) → Encoded and Supercompressed Universal Texture
Basis Universal supercompressed texture in KTX container → Transcoded on-the-fly to platform-supported compressed GPU format → GPU-accelerated Texture

Desktop: BC1-5, BC7
Mobile: ETC1/2, PVRTC1/2, ASTC

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glTF Universal Textures: Compression Ratios

FlightHelmet_baseColor
2048 x 2048, RGB

PNG and JPEG must be fully decompressed into GPU memory

Universal textures can be directly transcoded to compressed GPU textures

File Size
GPU Size

Uncompressed
PNG
JPEG
ETC1S
Basic Universal

12,582,912
2,778,518
335,619
2,097,152
232,104

0
3,500,000
7,000,000
10,500,000
14,000,000

Bytes
KTX and .basis Container Formats

Two complementary container formats for Basis Universal assets

‘Basis Universal’
texture compression technology
Supercompressed JPG-sized textures that can be transcoded on-the-fly to natively supported compressed GPU formats
https://github.com/BinomialLLC/basis_universal

.Basis
Binomial and Google open sourced ‘Basis Universal’ compressor and transcoder
C++ or WebAssembly code for handling
‘.basis’ format textures in native apps and websites
https://github.com/binomialLLC/basis_universal
Works if developer is in full control of their own texture assets and rendering

Khronos KTX
Precisely-defined container supporting wide range of texture formats used in Vulkan/DirectX/Metal with streaming and full random access to MIP levels.
glTF Universal Texture extension uses KTX 2.0.
Open-source tools to create, transcode and upload Universal Textures to WebGL, OpenGL and Vulkan
https://github.com/KhronosGroup/KTX-Software/
Great for cross-vendor distribution of textures to multiple applications and engines
PBR in Core glTF 2.0 since June 2017

PBR stands for “Physically-Based Rendering”

glTF 2.0 PBR material:
Base Color (Albedo)
Metal
Roughness
Emission
Normal Map
Baked Ambient Occlusion

Additional material parameters are added via extensions
glTF New Generation PBR

Transmission
KHR_materials_transmission
Transmission sample model is CC0, by Adobe

Clearcoat
KHR_materials_clearcoat
Clearcoat (presence)
Clearcoat Roughness
Clearcoat Normal
Clearcoat sample CC-BY Analytical Graphics, Inc

Sheen
KHR_materials_sheen
Sheen Color
Sheen Roughness
Cloth sample is CC0, by Microsoft
Chair sample CC-BY Wayfair LLC

Extensions and Integration in glTF Sample Viewer in next few months
glTF Mid-Term Future PBR Roadmap

Subsurface Scattering
Attenuation
Index of Refraction (IOR)
Thickness
Specular Color
Anisotropy
Translucency
Thin Film (iridescence)
...and more

Input welcome on GitHub from implementers, engines, and artists. Let us know which parameters are important to you!
Enable 3D Commerce to achieve deployment at industrial scale
Industry cooperation between technology and retail leaders
Interoperability standards, guidelines and Certification Programs
Leading Technology & Commerce Companies...

World-Leading 3D Technology Companies

World-Leading E Commerce Companies
... Working Together at Khronos on 3DCommerce™

World-Leading 3D Technology Companies

World-Leading E Commerce Companies

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Khronos 3D Commerce 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 Certification
Test models, reference viewer, display analysis tools and capability specifications to guarantee a consistent and accurate end user experience

Asset Creation Guidelines 1.0 Released

glTF KHR_materials_variants Extension

glTF’s first new generation PBR materials enable realistic and reliable display of many household goods. Next wave glTF requirements may include realistic rendering and animation of apparel

glTF KHR_xmp adds support for XMP (Extensible Metadata Platform) (ISO 16684-1) metadata to glTF

https://belcour.github.io/blog/research/2017/05/01/brdf-thin-film.html

https://modelviewer.dev/fidelity/

https://google.github.io/filament/Filament.md.html

https://belcour.github.io/blog/research/2017/05/01/brdf-thin-film.html
XR Portability

OpenXR provides cross-platform, high-performance access directly into XR device runtimes across multiple platforms.
## OpenXR Widespread Industry Adoption

### Conformant Implementations

<table>
<thead>
<tr>
<th>Microsoft HoloLens 2</th>
<th>Oculus Rift S</th>
<th>HTC Vive Cosmos</th>
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</thead>
<tbody>
<tr>
<td>Windows Mixed Reality Headsets</td>
<td>Quest and Quest2</td>
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### Developer Preview Implementations

<table>
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<tr>
<th>Valve SteamVR</th>
<th>Varjo</th>
<th>Collabora</th>
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<tr>
<td>Transitioning from OpenVR to OpenXR</td>
<td>High-resolution HMD</td>
<td>Opensource Implementation</td>
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### Engine Support

<table>
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<tr>
<th>Unreal Engine</th>
<th>Unity</th>
<th>Chromium for Chrome and Edge Browsers</th>
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<tr>
<td>Support in 4.24. Optimizations in 4.25</td>
<td>Support early 2021</td>
<td>OpenXR is default backend for WebXR</td>
</tr>
</tbody>
</table>
Bringing XR to the Web

Native XR Apps

Web XR Apps

Native 3D Engines

Web 3D Engines

Khronos provides the foundation for native and Web-based 3D/XR

Lifting OpenXR functionality into the Web stack

Close cooperation between WebXR and OpenXR

WebXR

three.js

WebGL

OpenXR

Vulkan

unity

vuforia

UNREAL
Thank You!

Any Questions?

www.khronos.org