Update to Web3D
Los Angeles, July 2019

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WEB3D 2019
Active Khronos Standards

**HIGH PERFORMANCE 3D GRAPHICS**
- Vulkan
- OpenGL ES
- OpenGL
- OpenCL
- WebGL

**3D ASSET AUTHORING AND DELIVERY**
- COLLADA
- GLTF

**PORTABLE XR – VIRTUAL AND AUGMENTED REALITY**
- OpenXR

**PARALLEL COMPUTATION, VISION, MACHINE LEARNING AND INFERENCE**
- OpenVX
- SPIR
- SYCL

3D Commerce Working Group
Announced at SIGGRAPH!

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.
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

High-level Driver Abstraction
Layered GPU Control
Context management
Memory allocation
Full GLSL compiler
Error detection

Application
Single thread per context

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

Multiple Front-end Compilers
GLSL, HLSL etc.

Thin Driver
Explicit GPU Control

SPIR-V pre-compiled shaders

Loadable debug and validation layers

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

OpenGL vs. OpenGL ES
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OpenGL vs. OpenGL ES
Pervasive Vulkan

Major GPU Companies supporting Vulkan for Desktop and Mobile Platforms

Platforms

Desktop
Mobile (Android 7.0+)
Media Players
Cloud Services
Game Streaming
Embedded
Consoles

Game Engines

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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

**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](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

**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

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

**March 2018**
Vulkan 1.1
- Integration of 1.0 Extensions
  - plus new functionality
  - e.g. Subgroup Operations

**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

**Increasing Support for Professional Authoring Apps**
- OpenGL-class Line Rasterization
  - (stipple, smooth, Bresenham)
- OpenGL/Vulkan Interop
SPIR-V Ecosystem

Third party kernel and shader languages

GLSL
HLSL

glslang
DXC

SPIR-V (Dis)Assembler
SPIR-V Validator
SPIRV-opt | SPIRV-remap

Optimization Tools

GLSL
HLSL

SPIR-Cross

LLVM

OpenCL C Front-end
OpenCL C++ Front-end

SYCL for ISO C++ Front-end

CLSPV

LLVM to SPIR-V Bi-directional Translators

LLVM

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

Khronos cooperating with clang/LLVM Community

3rd Party-hosted Open Source Projects

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

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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
- Tessellation

https://github.com/KhronosGroup/MoltenVK

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

Open source SDK to build, run, and debug applications on macOS - including validation layer support
https://vulkan.lunarg.com/

Open source beta release for macOS

MoltenVK supports macOS 10.11 / iOS 9.0 and up

Vulkan macOS SDK

macOS / iOS Run-time
Maps Vulkan to Metal

SPIRV-Cross
Convert SPIR-V shaders to Metal Shaders

Vulkan Applications

Free to use - no fees or royalties including commercial apps

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XR = AR + VR

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

Virtual Reality

Augmented Reality
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 availability of OpenXR in shipping run-times and devices www.khronos.org/openxr
Companies Publicly Supporting OpenXR

OpenXR is a collaborative design
Integrating many lessons from proprietary ‘first-generation’ XR API designs
OpenXR 1.0 Released Here at SIGGRAPH!

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

Provisional Specification
GDC, March 2019

Ratify and Release OpenXR 1.0 Specification
SIGGRAPH, July 2019

Finalize Conformance Test Suite
Enable Officially Conformant Implementations

OpenXR runtime for Windows Mixed Reality headsets and HoloLens 2 from Microsoft shipping TODAY
PLUS extensions to support HoloLens 2 hand tracking, eye tracking, spatial mapping and spatial anchors by end of year

OpenXR support for Oculus Rift and Oculus Quest
Coming soon

‘Monado’ OpenXR open source implementation from Collabora shipping TODAY

OpenXR 1.0 plugin for Unreal Engine 4.23
Starting with preview 4
Many more coming
Khronos APIs for XR

High-performance, low-latency 3D rendering and composition*
  Multiview
  Context priority
  Front buffer rendering
  Tiled rendering (beam racing)
  Variable rate rendering

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

Display, composition and optical correction parameters

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

Native XR Apps

Web XR Apps

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

Close ongoing collaboration between WebXR and OpenXR

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

3D Engines

WebGL

WebXR

3D Engines

three.js

WebXR

OpenXR

Vuforia

unity

Vulkan
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
glTF - The JPEG of 3D!

<table>
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<tr>
<th>Audio</th>
<th>Video</th>
<th>Images</th>
<th>3D</th>
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</thead>
<tbody>
<tr>
<td>MP3</td>
<td>H.264</td>
<td>JPEG</td>
<td>glTF</td>
</tr>
</tbody>
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New market opportunities for 3D content creation and deployment!

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

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

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

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

Optional Specular-Glossiness Materials
**glTF Ecosystem Evolution**

- **Tools!**
  - Striving for native glTF import and export from every tool. Catalyzed Blender IO as exemplar.

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

- **Functionality!**
  - Balancing functionality versus complexity. glTF is extensible - only bring widely adopted extensions into core.

- **glTF 2.0 - June 2017**

**Sample Viewer** for accurate Ground Truth glTF renderings.

**glTF Mesh compression extension** provides up to 25x geometry compaction.

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Blender 2.80 Supports Full glTF Import/Export

Project driven by Mozilla, Khronos and the glTF community

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

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

- 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](https://github.com/KhronosGroup/glTF/issues/1442)
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
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**

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!

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!

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!

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

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/

Initiative Proposal

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 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

3D Asset Format

Interactive 3D on the Web

Khronos 3D Commerce

Portable AR and VR Apps

High-performance cross-platform 3D graphics

Vision processing and inferencing for AR and scanning
With Consumer Capture - 3D Will Go Social!

Social Loop
Photos -> Facebook
Videos -> YouTube
3D -> ?

Object Capture

Upload, View, Share and Comment

Print
3D Printing (e.g. Shapeways.com)

Search

Manufacturers provide 3D Object Descriptors - much more information than 2D-based image search

Inspire and Motivate
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](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](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](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 Compressorator and glTF sample models

### Mesh Compression Ratios

![Mesh Compression Ratios](image)
KTX2 and .basis files

Two complementary container formats for Basis Universal assets

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

BINOMIAL
‘Basis Universal’ texture compression technology
Enables JPG-sized textures that can be transcodced on-the-fly to natively supported compressed GPU formats

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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

- 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” 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**
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